UNIVERSIDADE DE LISBOA

FACULDADE DE MEDICINA DENTÁRIA

THE INFLUENCE OF LE FORT 1 MAXILLARY ADVANCEMENT OSTEOTOMY ON NASAL MORPHOLOGY AND AESTHETICS

Natascha Lília Margarida de Sequeira Fernandes

Orientador: **Professor Doutor Luís Filipe de Almeida e Silva Jardim**

Co-orientador: **Professor Doutor Rui Manuel dos Santos Pereira**

Tese especialmente elaborada para obtenção do grau de doutor em Medicina Dentária, especialidade de Ortodontia

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À Palavra

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Abstract

Objectives: The aims of this investigation were to determine whether nasal morphology differs in Portuguese Caucasians with class I occlusion and class III malocclusion, to objectively quantify the nasal changes produced by the Le Fort 1 maxillary advancement osteotomy in patients with Class III skeletal discrepancies and to determine whether these alterations cause a significant change in the subjective evaluation of frontal and profile, nasal and facial aesthetics according to orthodontists.

Materials and methods: Facial and nasal cephalometric measurements were performed in the frontal and profile photographs and lateral cephalograms of 80 individuals each with class I occlusion and class III malocclusion, equally divided between the genders. The nasal alterations caused by the Le Fort 1 maxillary advancement osteotomy in 32 men and 48 women with class III malocclusion were also measured. The changes in frontal and profile, facial and nasal aesthetics were subjectively evaluated in 19 men and 42 women.

Results and conclusions: The group with Class III occlusion presented larger columella width, frontal nasal length and height, frontal nasal length/morphological width and frontal nasal height/morphological width ratios and smaller alar slope and superior alar angles. In profile, this group displayed greater values for total facial convexity and nasomental angles and nasal height, length and protrusion and smaller ones for facial convexity, nasofacial and supratip break angles. Le Fort 1 maxillary advancement osteotomy significantly increased transverse nasal dimensions and elevated and advanced pronasale and subnasale. Nasal height, length, depth of the supratip break, upper and lower dorsal convexities, nasal, subnasale and nostril projections, nasal protrusion and the nasal prominence, supratip break, nasolabial and nasal tip rotation angles were reduced. Columella depth and the nasal tip, nasal projection and dorsal contour angles increased. Both frontal and profile facial attractiveness and nasal profile aesthetics were significantly improved.

Key words: Le Fort I maxillary advancement osteotomy, nasal morphology, cephalometrics

Resumo

Objetivos: Os objetivos desta investigação foram determinar se a morfologia do nariz, na vista frontal e de perfil, difere em Portugueses caucasianos com oclusão de classe I e maloclusão de classe III, quantificar as alterações produzidas no nariz pela osteotomia Le Fort 1 de avanço maxilar em pacientes com discrepâncias esqueléticas de classe III, e determinar se essas alterações modificam a avaliação subjetiva da estética nasal e facial, da vista frontal e de perfil, de acordo com os ortodontistas.

Materiais e métodos: As medidas cefalométricas esqueléticas e de tecidos moles da face e do nariz foram realizadas nas fotografias frontal e de perfil e telerradiografias de perfil de 80 pessoas em cada grupo com oclusão de classe I ou maloclusão de classe III, igualmente divididos por sexos. A influência do tipo de maloclusão e do género sobre as variáveis nasais foi determinada utilizando uma análise de variância com duas dimensões. A correlação entre as diferentes variáveis morfométricas do nariz foi determinada usando o coeficiente de correlação de Pearson estandardizado. Este método foi ainda utilizado para avaliar a relação entre as variáveis nasais ósseas e dos tecidos moles e os parâmetros faciais esqueléticos e dos tecidos moles.

As alterações causadas pela osteotomia Le Fort 1 de avanço maxilar nas variáveis morfométricas do nariz em 32 homens e 48 mulheres com maloclusão esquelética de classe III também foram mensuradas. O efeito da osteotomia Le Fort 1 de avanço maxilar sobre as medições cefalométricas nasais foi determinado usando um teste t de uma amostra. A influência do género nas alterações cirúrgicas das variáveis nasais foi avaliada usando o teste t de Student para variáveis independentes. A correlação entre as alterações nas medições cefalométricas lineares e angulares do nariz e os movimentos sagitais, verticais e rotacionais da maxila foi determinada com recurso à análise de regressão múltipla, de modo a determinar a contribuição individual de cada uma destas variáveis independentes.

As avaliações por ortodontistas da mudança da estética nasal da vista frontal e de perfil e as alterações nas variáveis morfométricas do nariz após a osteotomia Le Fort 1 de avanço maxilar foram medidas em 19 homens e 42 mulheres com maloclusões de classe III. O efeito da osteotomia sobre as alterações na avaliação estética do nariz foi determinado usando um teste t de uma amostra. A influência do género dos pacientes e dos avaliadores sobre a avaliação estética do nariz foi calculada por meio de uma análise de variância para medições repetidas. O coeficiente de correlação de Pearson foi calculado para determinar a correlação entre as avaliações das fotografias de frente e de perfil e entre as avaliações da face e do nariz. Este procedimento foi realizado para avaliar a diferença resultante do tratamento ortodôntico-cirúrgico. A correlação entre a alteração cirúrgica da avaliação estética nasal e as alterações morfométricas nasais, bem como a magnitude do movimento cirúrgico maxilar, foi determinada usando a análise de regressão múltipla. O nível de significância foi fixado em 5%.

Resultados e conclusões: Nas fotografias frontais, a largura da columela, a altura e o comprimento nasal, os rácios entre o comprimento nasal frontal e a largura morfológica e entre a altura nasal frontal e a largura morfológica foram maiores e os ângulos de inclinação alar e alare superior foram menores no grupo com

maloclusão de classe III. Em perfil, este grupo demonstrou um ângulo de convexidade facial total, ângulo nasomentoniano e altura e protrusão nasais maiores e ângulo de convexidade facial sem o nariz, ângulo nasofacial e ângulo da concavidade inferior do dorso menores. O ângulo da concavidade inferior do dorso foi maior em mulheres com oclusão de Classe I do que nas mulheres com maloclusão de Classe III.

Nas fotografias frontais, a distância endocantal, a largura morfológica e da raiz nasal, base alar e da columela, a altura frontal do nariz e os ângulos alar superior e inferior foram maiores em homens. A largura bilateral do pavimento da narina e a largura da base nasal, as distâncias subnasale frontal-alare e eixo do dorso-alare e a largura diagonais da narina também foram maiores nos homens, no lado esquerdo e direito. Os rácios entre a largura da raiz e a largura morfológica, comprimento frontal do nariz e a largura morfológica, altura frontal do nariz e a largura morfológica e o ângulo alar lateral foram maiores nas mulheres. Em perfil, a altura, comprimento e projeção nasais, as projeções subnasal e da narina e o ângulo da concavidade inferior do dorso foram maiores em homens. A convexidade inferior do dorso e o ângulo da concavidade inferior do dorso foram maiores em homens do que em mulheres com maloclusões de Classe III.

Um ângulo ANB de menor dimensão associou-se ao ângulo nasomentoniano e comprimento frontal do nariz aumentados e um ângulo da concavidade inferior do dorso menor. A altura total e altura ântero-inferior da face aumentadas implicaram aumentos nos valores do ângulo nasomentoniano, comprimento do osso nasal, altura, comprimento, projeção e protrusão nasais e projeção da narina. A inclinação posterior da maxila e da mandibula associaram-se a ângulo nasomentoniano, comprimento do osso nasal, altura, comprimento e protrusão nasais aumentados, rotação posterior da columela e uma concavidade inferior do dorso mais plana. A rotação posterior da maxila associou-se a exposição maior da columela enquanto a rotação posterior da mandíbula implicou um aumento na projeção nasal e no ângulo da saliência nasal. Uma maxila retruída com menor comprimento associou-se a aumentos no ângulo nasomentoniano, comprimento do osso nasal, protrusão nasal e a uma inclinação posterior da columela. Um ângulo SNA menor associou-se a altura, comprimento, projeção, protrusão e ângulo do ápice nasal aumentados. A posição sagital da maxila mais retrusiva tornou a concavidade inferior do dorso mais plano.

A osteotomia Le Fort 1 de avanço maxilar aumentou a largura morfológica e da raiz nasal, base alar e da columela, a largura bilateral do pavimento da narina e a largura da base nasal, as distâncias subnasale frontal-alare, e eixo do dorso-alare e a largura diagonais da narina, o ângulo da inclinação alare e os ângulos alar superior e inferior medidos nas fotografias frontais. Os rácios entre o comprimento frontal e a largura morfológica, altura frontal do nariz e a largura morfológica e o ângulo alar lateral reduziram significativamente.

Em perfil, a altura e o comprimento nasais, a profundidade da concavidade supratip, as convexidades superior e inferior do dorso, as projeções dos pontos pronasale, subnasale e da narina, a protrusão nasal e os ângulos de proeminência nasal, da concavidade inferior do dorso, nasolabial e da rotação do ápice nasal reduziram significativamente. Os pontos pronasale e subnasale elevaram-se e também avançaram e a profundidade da columela e os ângulos da saliência nasal, da projeção nasal e do contorno dorsal aumentaram. O movimento esquelético da maxila não poderia explicar mais do que 10% e 30% da alteração em nenhuma

das variáveis frontais e do perfil, respetivamente. O avanço sagital da maxila medida (ponto A) avançou os pontos pronasale e subnasale em rácios de 0,23:1 e 0,5:1, respetivamente, e elevou os mesmos pontos em rácios de 0,31:1 e 0,19:1, respetivamente. A largura morfológica e a largura da base alar aumentaram com o avanço do ponto A em rácios de 0,60:1 e 0,61:1, respetivamente.

A osteotomia Le Fort 1 de avanço maxilar melhorou significativamente a atratividade da face de vista frontal e de perfil e a estética nasal de perfil e os ortodontistas do sexo feminino foram mais críticos do que os seus colegas do sexo masculino quanto a esta melhoria estética. As alterações causadas pela osteotomia na avaliação estética da face e do nariz, nas vistas frontal e de perfil, foram semelhantes nos pacientes do sexo masculino e feminino. Não se verificou uma correlação significativa entre as avaliações do efeito da osteotomia Le Fort I de avanço maxilar nas vistas frontal e de perfil. A alteração na atratividade da vista frontal do nariz demonstrou uma correlação fraca e significativa com a mudança na atratividade da vista frontal da face. A alteração na atratividade do nariz em perfil não se correlacionou significativamente com a modificação na atratividade do perfil facial. A mudança na largura morfológica, largura da base alar e ângulo alar superior explicaram 19% da variação da alteração da atratividade do nariz na vista frontal. A modificação na altura nasal, a posição vertical do ponto pronasale e o ângulo de concavidade supratip contribuíram em 24% para a variação na alteração da atratividade do nariz em perfil. As alterações na estética do nariz nas vistas frontal e de perfil, avaliadas por ortodontistas, não podem ser previstas baseadas nos movimentos cirúrgicos sagital, vertical e rotacionais da maxila.

Palavras-chave: Osteotomia Le Fort 1 de avanço maxilar, morfologia nasal, cefalometria

List of abbreviations within the text

AC	Alar cinch
ANOVA	Analysis of variance
Fig.	Figure
3D	Three-dimensional
FHP	Frankfurt horizontal plane
ANS	Anterior nasal spine
PNS	Posterior nasal spine
Mm	Millimetres
VAS	Visual analogue scale

I

Introduction

The historical and social importance of beauty has been well documented. The philosopher Pascal claimed that the world would have changed had Cleopatra´s nose been smaller. The poet Christopher Marlowe described Helen of Troy´s face as the one that launched a thousand ships (Naini et al., 2006). Beauty was called "a short tyranny" by Socrates and "the privilege of nature" by Plato (O'Ryan & Lassetter, 2011).

Facial attractiveness affects an individual´s psychological development and plays a tremendous role in interhuman relationships (Adams, 1977; Soncul & Bamber, 2004). The doctrine "what is beautiful is good" is imposed upon us from childhood itself (Dion et al., 1972; Sinko, Tran, et al., 2018). Attractive children receive more attention from teachers, are more successful at exams and develop into happier, more popular and persuasive adults (Clifford & Walster, 1973; Dion et al., 1972; Langlois et al., 2000; Pişiren, et al., 2018). Even their transgressions are more easily forgiven (Dion, 1972). Attractive college students are more likely to display a positive self-concept, socially desirable personalities and resist peer pressure (Adams, 1977).

Adult beauty is synonymous with social power and success (Dion et al., 1972; Giddon, 1995; Matoula & Pancherz, 2006). The most attractive individuals perceive that others find them attractive and possess greater self-esteem (Adams, 1977; Husein et al., 2010). Perhaps this is because they are treated preferentially by others, favoured by their peers in task reviews (Landy & Sigall, 1974; Langlois et al., 2000) and even in legal interactions (Efran, 1974; Sigall & Ostrove, 1975). This social bias leads to confident, friendlier behaviour, which in turn paves the way to greater social success (Al Taki & Guidoum, 2014; Feingold, 1992; Hershon & Giddon, 1980; Murakami et al., 2016; Oluwajana, 2015; Pişiren et al., 2018) Attractive people are perceived as more sociable, intelligent, successful and happy (Dion et al., 1972; Feingold, 1992; Olsen & Inglehart, 2011).

Due to its beneficial influence on psychological health and social behaviour, self-perception of facial appearance and that by others affects educational, employment and romantic opportunities (Berscheid & Gangestad, 1982; Giddon, 1995; Peck & Peck, 1970; Umberson & Hughes, 1987). Attractive people are expected to be more competent spouses and have happier marriages (Dion et al., 1972). In the professional realm, they are considered to be highly employable and of a high socioeconomic level (Sena et al., 2017). This assumption of competence and success leads to career opportunities, actual financial success and enhanced social status (Langlois et al., 2000; Livingston & Pearce, 2009; Springer, Wiltfang, et al., 2012; Watkins & Johnston, 2000). Facial phenotypes even had political repercussions in former times as men with narrow faces were more likely to be powerful in that field (Islam et al., 2017).

Maxwell Maltz wrote that when you change a man's face, you almost invariably change his future while changing his physical image nearly always changes the man (Oluwajana, 2015). Facial beauty depends upon the relative proportion and aesthetic harmony of its components (Begg & Harkness, 1995; Ghorbanyjavadpour & Rakhshan, 2019; Isiekwe et al., 2015; Troncoso Pazos et al., 2008; Uzun & Ozdemir, 2014). Of these, the

nose is especially important as it attracts attention due to its focal location right in the face´s centre (Altman & Oeltjen, 2007; Begg & Harkness, 1995; Isiekwe et al., 2015; Pearson & Adamson, 2004; Uzun & Ozdemir, 2014). It has been considered a more pivotal facial promontory than the chin and malar prominences (Petersen et al., 2018) and has been designated the "corner stone" of facial aesthetics (Begg & Harkness, 1995; Schendel & Carlotti, 1991). Nasolabial form and projection are key factors in facial attractiveness and expression and along with the chin characterize profile aesthetics (Metzler et al., 2014; Mitchell et al., 2007; Troncoso Pazos et al., 2008).

53% of American women of India

Moreover, maxillary surgery affects not only the immediately overlying structures but also features such as the nose that influence overall facial harmony (Engel et al., 1979; Rauso et al., 2011; Vasudavan et al., 2012). Sagittal and vertical maxillary position is one of the key factors in determining nasal morphology (Esenlik et al., 2011; Gulsen et al., 2006). The structures that provide nasal tip support such as the nasal septum, the lower lateral cartilages and their junction with the upper lateral cartilages and the attachment of the medial crura footplates to the septum are in direct contact with the maxilla through the nasal spine and nasal crest (Altman & Oeltjen, 2007; Mommaerts et al., 2000). Hence, maxillary surgery invariably affects nasal tip projection and position (Altman & Oeltjen, 2007). Maxillary repositioning and rhinoplasty are the two procedures that directly modify nasal shape (Begg & Harkness, 1995; Isiekwe et al., 2015; Waite & Matukas, 1991).

Depending on the initial skeletal discrepancy, maxillary orthognathic surgery can involve basic superior, inferior or anterior cardinal movements to correct the specific deformity and restore function (Collins & Epker, 1982; Mitchell et al., 2007). Each of these vectors has the potential to affect the nasolabial region depending on the magnitude of repositioning (Collins & Epker, 1982; Mitchell et al., 2007; Rauso et al., 2011). Vertical excess and sagittal deficiency are the most frequently occurring maxillary anomalies (Rosen, 1988). This is important because maxillary advancement followed by its impaction have the greatest effect on the nose (Altman & Oeltjen, 2007; Collins & Epker, 1982; Mitchell et al., 2007; Rauso et al., 2011). In 1975, Bell stated ´Le Fort 1 osteotomy for anterior or superior repositioning will probably alter nasal aesthetics, favourably or unfavourably, to a lesser or greater degree…..` (Rosen, 1988). An inaesthetic nasal appearance is often considered the most undesirable consequence of the correction of Class II and III malocclusions though maxillary surgery (Coban et al., 2020; Ghorbani et al., 2018). Although 91.7% of Iranian patients reported improved facial appearance, only 48.5% conveyed an improvement in nasal aesthetics and only 25.8% were satisfied with their post-surgical nasal appearance (Ghorbani et al., 2018).

While maxillary osteotomy directly affects nasal morphology, bimaxillary procedures modify the relationship between the rest of the face and the nose (Altman & Oeltjen, 2007; Schendel & Carlotti, 1991). Mandibular osteotomy affects the relative nasal prominence by altering chin and lower lip position (Begg & Harkness, 1995; González-Ulloa & Stevens, 1968; Isiekwe et al., 2015; Schendel & Carlotti, 1991; Wisth, 1975).

As alterations in nasal structure may be beneficial or harmful depending on its pre-existing morphology, a detailed examination will help determine the degree to which each nasal component will be affected (Esenlik et al., 2011; Gassmann et al., 1989). The relative importance of each individual element will vary from patient to patient (Esenlik et al., 2011; O'Ryan & Schendel, 1989b). The objective assessment of nasal form, size and aesthetics aids in making a better diagnosis and treatment plan and in the quantification of nasal and facial changes after midfacial surgery and rhinoplasty (Starck & Epker, 1996). Aesthetic goals should include both subjective and objective criteria (Li et al., 2014). Thus, the evaluation of the nose and its relationship with other facial structures should be an integral part of individual patient assessment prior to orthodontic-orthognathic surgery treatment (Altman & Oeltjen, 2007; Isiekwe et al., 2015; Li et al., 2014; Schendel &

Carlotti, 1991). Along with the overall facial alterations, treatment success will depend upon the post-surgical nasal changes and those in the lateral facial regions that are less affected by the advancement of the semi-circular maxilla (Baik & Kim, 2010; Soncul & Bamber, 2004; Ubaya et al., 2012).

Generally, a multidisciplinary approach wherein surgeons and orthodontists cooperate to develop the best treatment plan ensures optimal outcomes (Altman & Oeltjen, 2007). Both should also counsel patients about potential post-surgical changes in nasal morphology and aesthetics and the need for further corrective surgery to create a more cosmetically pleasing result (Altman & Oeltjen, 2007; Honrado et al., 2006; O'Ryan & Lassetter, 2011; Schendel & Carlotti, 1991).

As such, the quantification of the nasal response to surgical intervention is important as it informs the consent process, improves the accuracy of treatment plans and permits a more correct prediction of postoperative soft tissue changes (Altman & Oeltjen, 2007; Howley et al., 2011). However, the myriad of pre-operative inter-patient differences and the additional confounding factors that affect post-surgical nasal morphology make it difficult to define the exact objective conditions necessary to produce aesthetic noses (Altman & Oeltjen, 2007; Starck & Epker, 1996). This is further compounded by cultural and racial differences in the concept as to what constitutes an aesthetic nose (Gao et al., 2018).

1.1 The concepts of beauty and aesthetics

Orthodontic treatment plans were initially based on Angle´s paradigm wherein a perfect occlusion was considered synonymous with facial attractivity (Ackerman, 1974). However, Angle himself declared that treatment could cause contrasts of beauty or ugliness, harmony or disharmony and perfection or deformity (Abu Arqoub & Al-Khateeb, 2011; Basciftci et al., 2003). Later, other authors paved the way for the soft tissue paradigm where this layer took precedence over dentoskeletal structures (Burstone, 1958; Subtelny, 1961). Today, orthodontic treatment goals encompass the triad of structural equilibrium, functional efficiency and aesthetic harmony (Mantzikos, 1998).

Ancient philosophers opined that beautiful creations respected certain geometric laws (Mantzikos, 1998). Saint Thomas Aquinas wrote the first theoretical description of beauty, differentiating between physical beauty and the beauty of the soul. In ´Summa Contra Gentiles` written between 1261 and 1264, he hypothesized that what offers pleasure to the eyes is beautiful, that beauty is good and that all good things and actions are beautiful. According to him, the pre-requisites for beauty were uniformity and perfection, proportion and harmony and illumination from the Creator (Heppt & Vent, 2015). In the 16th century, the artist Albrecht Dürer explained that, although the perception of beauty is highly subjective, facial proportions can be evaluated in an objective manner. He suggested that well-proportioned features were always acceptable if not beautiful while disproportionate faces were not (Naini et al., 2006).

People take only a fraction of a second to develop a reliable view of attractiveness based on first impressions (Sinko, Tran, et al., 2018; Willis & Todorov, 2006). Thus, rapid, subconscious impressions based on very little information are common in day-to-day life (Sinko, Jagsch, et al., 2018; Sinko, Tran, et al., 2018). Infant visual-inspection times and adult evaluations imply that attractive faces have greater 'positive valence'

i.e. they attract looking (Langlois et al., 1987; Samuels et al., 1994). The capacity for perceiving the attractiveness of objects in evaluative terms is termed 'Aesthetic perceiving` (Samuels et al., 1994). Thus, while beauty requires a combination of qualities that give pleasure to the sensibility or mind, aesthetics involves its study and that of ugliness (Mantzikos, 1998; Naini et al., 2006; Peck & Peck, 1970). In 1750, philosophers Alexander Baumgarten and Ch. Wolff, used the neologism ´aesthetics` based on the Greek word for sensorial perception ´*aesthesis*` (Heppt & Vent, 2015; Naini et al., 2006). Papel (2002) defined the Greek ´aesthesis` as a devotion to what is beautiful. Aesthetics was described as ´the science of beauty in nature and in art` by the Webster´s collegiate dictionary (Mantzikos, 1998). Giddon (1995) termed it the appreciation or satisfaction induced by beauty. Thus, unpleasant or pleasant emotions can be evoked depending on whether an object is aesthetic or not (Heppt & Vent, 2015; Mantzikos, 1998).

Philosopher Immanuel Kant in 1790 stated that beauty is what universally pleases without any specific concept (Naini et al., 2006). Francis Hutcheson, in the 18th century, declared that the origin of the perception of beauty and harmony has to be called a sense because it involves no intellectual element or reflection about causes (Naini et al., 2006).

1.2 The concept of perception

Plato used the aphorism "beholding beauty with the eye of the mind" to highlight the esoteric, complex nature of aesthetics (Hockley et al., 2012). Margarete Wolfe Hungerford coined the phrase "Beauty lies in the eye of the beholder" in the book Molly Bawn in 1878 while the philosopher David Hume stated in 1971 that beauty in objects exists in the mind that contemplates them, both suggesting that perception is subjective and unique to an individual (Naini et al., 2006).

Perception has been defined as a single, unified awareness derived from sensory processes in response to a stimulus (Peck & Peck, 1970). It depends on a variety of physical, psychological, physiological and social factors (Giddon, 1995).

For gestaltists, the response to more complex stimuli and the ability to see either an embedded figure or its background depends on the relative frequency of exposure to stimulation from either physical arrangement. Perception is thus affected by the frequency with which these patterns occur in the environment (Giddon, 1995). Facial perception may depend on "concepts of form", wherein the more often a certain facial type is observed, the greater the likelihood that it will be perceived as "correct" (Peck & Peck, 1970). Selective conditioning leads to presumptive personality traits attributed to individuals with Class II and III malocclusions (Sinko, Jagsch, et al., 2018; Sinko, Tran, et al., 2018). Consistent orthodontic extractions may cause the "dished in" profile to be considered beautiful (Peck & Peck, 1970). Thus, both the observer´s perception and the aesthetic stimulus itself are important in the study of facial aesthetics (Peck & Peck, 1970).

Physical factors that contribute to attractiveness include curved, fine features rather than angular coarse ones and facial symmetry (Samuels et al., 1994). Texture, shape and colour characteristics such as hue, saturation and brightness also affect visual perception (Giddon, 1995). Thus, non-metric factors such as hair colour and facial expression are important (Matoula & Pancherz, 2006; Spyropoulos & Halazonetis, 2001).

Expressiveness and communication skills add to static beauty and affect dynamic attractiveness (Riggio et al., 1991).

Physiological factors that influence perception operate primarily at the level of the nervous system, involving higher order neurons in the cortex, the retina and visual pathways (Giddon, 1995). The perception of loved ones as more beautiful indicates the importance of psychological factors (Giddon, 1995). A resemblance to a mother, another familiar face or even to one's own face increases attractiveness (Samuels et al., 1994). Conversely, anxious and depressed individuals may perceive themselves in a more negative light than normal ones despite both being considered equally attractive by other people (Giddon, 1995).

Some authors suggest that the evaluation of attractiveness is not idiosyncratic but rather biologic and transcendent of cultural differences (O'Ryan & Lassetter, 2011). Langlois et al. (1987) provided evidence for a genetic or innate basis for perception discrediting the notion that standards of attractiveness are learned through exposure to the current cultural concept of beauty and are merely "in the eye of the beholder". Both 2 to 3 and 6 to 8-month-old infants looked longer at attractive female faces when these were paired with unattractive ones (Langlois et al., 1987). A meta-analysis indicated within and cross cultural agreement about facial attractiveness (Langlois et al., 2000). Both Caucasians and Japanese considered composite Japanese female faces more attractive in the presence of features such as bigger eyes, high cheekbones, and narrow jaws and Caucasians preferred similar characteristics in Caucasian women (Perrett et al., 1994). Britishers demonstrated significantly high positive correlations amongst themselves while ranking the ´prettiness` of facial photographs of young women of varying facial types. The top three choices were identical for American evaluators while their other rankings differed only slightly (Peck & Peck, 1970). Studies using art also indicate that aesthetic appreciation transcends education, age, sex and nationality (Peck & Peck, 1970).

Others suggest that the perception of beauty has social and cultural bases (Martin, 1964; Naini et al., 2006). Caucasian and African American men considered Caucasian looking African American women more attractive than their counterparts with more negroid features (Martin, 1964). However, Nigerian men considered Caucasian features attractive less frequently although even though these correlated positively with their rankings due to a possible influence from Nigeria´s Commonwealth status and the English media. Peck and Peck (1970) found that two popular female black celebrities did not exhibit African anthropological characteristics but many Caucasoid-like features. The evaluation of photographs of Caucasian women and multi-racial Miss Universe candidates demonstrated that while African-origin and Eastern beauty contestants possessed ethnically distinct features, they also displayed most of the facial features associated with Caucasian attractiveness (Cunningham, 1986)

Social factors, such as peer pressure, also affect perception (Giddon, 1995). The constant exposure to the various forms of mass communication educates laypeople about cultural norms and reduces the amplitude of what is considered aesthetic (Foster, 1973; Merrifield, 1966). Many people accept the Hollywood standards of attractiveness instead of developing their own concepts of beauty (Merrifield, 1966; Oluwajana, 2015). Moreover, as these popular depictions of attractiveness by the media and the fashion industry face a continuous wave of change, the perception of beauty alters with time and place (de Almeida, Farias, & Bittencourt, 2010;

Giddon, 1995; Hambleton, 1964). Since orthodontists are also exposed to societal and cultural biases, they need to resort to more objective methods of facial assessment (Hambleton, 1964; Peck & Peck, 1970).

Patients, as part of the general population, are also exposed to the media´s influence (Bronfman et al., 2015; Peck & Peck, 1970). Self-image incorporates actual physical morphology in combination with an understanding of the perceptions of others (Giddon, 1995). The unrealistic comparison of their own image to the media chosen images can make patients dissatisfied and develop pathologies such as body dimorphism and eating disorders (Naini et al., 2006; Sarwer et al., 1998).

Thus, an individual's perception of his own profile influences self-esteem more than the actual, objectively determined profile morphology (Giddon, 1995; Maxwell & Kiyak, 1991). This is important as regardless of the existence of actual deviations, self-perception of oral function and appearance may be the best predictor of the patient's decision to undergo orthodontic-surgical correction and of post-treatment satisfaction (Giddon, 1995; Hågensli et al., 2014; Kiyak & Zeitler, 1988; Van Sickels & D'Addario, 2007).

Moreover, treatment success is relative, as what is aesthetically pleasing to some may be displeasing to others (Peck & Peck, 1970). Orthodontists, who are conditioned by their training, need to pay more attention to the layman´s concept of beauty and harmony (Peck & Peck, 1970). They should also not incorporate all patients into a single homogeneous mould (Mantzikos, 1998). Beyond statistical averages, orthodontists should consider the opinion and sensitivities of each individual patient and his loved ones (De Smit & Dermaut, 1984; Foster, 1973; Hockley et al., 2012).

1.3 The history of aesthetics

Aesthetic norms were established very early in the history of mankind (Falkensammer et al., 2014; Springer, Wiltfang, et al., 2012). Palaeolithic cave drawings and stone statues often depicted a female form that may have had religious significance or been used to cast spells for hunters (Papel, 2002). Fear or superstition frequently led to the representation of humans as grotesque or disfigured (Matoula & Pancherz, 2006).

The Austrian stone statue ´Venus of Willendorf` (Fig. 1.1), dated between 25,000 and 20,000 BC, depicted a faceless woman with large breasts and belly and short thick legs. Other European and Asian statues had the same rough proportions (Papel, 2002).

The Egyptians in 5000 BC were possibly the first civilization to give importance to harmonious facial and body proportions (Peck & Peck, 1970). Stone statues such as those of King Mycerinus and Queen Nefertiti (Figure 1.2 and 1.3) exhibited their ideal of beauty and proportion while retaining a vague resemblance to the actual person. The ideal face was broad and rounded with a sloping forehead, weak brow ridge, prominent eyes, uniformly contoured nose, a mild positive chin and in men, a chin beard (Peck & Peck, 1970). The portrait of Prince Ankh-Haf (Figure 1.4) depicted the common bimaxillary dentoalveolar protrusion. Negroid and Asian Caucasoid presence in the population influenced facial aesthetics (Peck & Peck, 1970).

Greek philosophers such as Plato and Aristotle opined that true beauty requires harmonious, geometrical proportions, a notion that has been incorporated in the field of orthodontics which uses objective criteria to evaluate aesthetics (Mantzikos, 1998; Papel, 2002; Peck & Peck, 1970).



Figure 1.1. Venus of Willendorf (Papel, 2002)



Figure 1.2. King Mycerinus, 2580 BC (Peck & Peck, 1970)

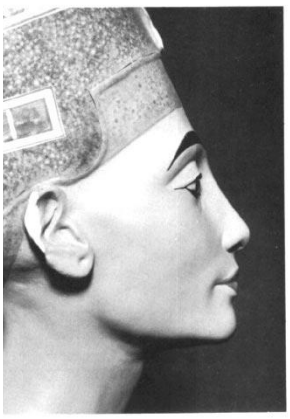


Figure 1.3. Queen Nefertiti 1350 BC (Peck & Peck, 1970)



Figure 1.4. Prince Ankh-Haf 2600 BC (Peck & Peck, 1970)

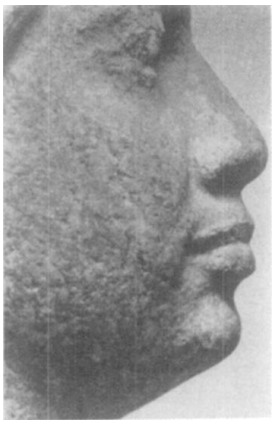




Figure 1.5. Male and female Egyptian statues (Hambleton, 1964)





Figure 1.6. Male and female Greek statues (Hambleton, 1964)

Greek sculptors from the classical era incorporated canons or rules for body proportions, a concept that was later adopted by Leonardo da Vinci (Falkensammer et al., 2014; Lines et al., 1978; Peck & Peck, 1970). Sculptures of Greek gods from the golden age in the 4th and 5th centuries BC depicted perfection of form, character and virtue (Figure 1.7-1.9) Artists such as Phidias and Praxiteles conceived human faces with harmonious classical proportions (Peck & Peck, 1970). Praxiteles (370-330 BC) chose to depict the delicate female form in his sculptures while Polykleitos (5 BC), who initially sculpted only athletes, developed a personal canon where the entire body measured 7.5 times the length of the head with a very stiff appearing torso (Papel, 2002).

Greek sculptures demonstrated an oval face that tapered slightly towards the chin. The profile was orthognathic with a well-proportioned lower face, a straight sweep from the considerably hair hidden, prominent forehead to the tip of the nose, a slightly concave nasal root, a curved upper lip that later served as a model for the Roman cupid's bow, a mild lower lip roll, a well-defined lower labial sulcus and a convex chin

(Peck & Peck, 1970). Angle, for one, considered Apollo Belvedere, an original Roman re-creation of the Hadrianic era (120–140 AC) and the Greek Aphrodite of Melos architypes of facial beauty (Matoula & Pancherz, 2006; Peck & Peck, 1970).



Figure 1.7
Aphrodite of Melos (Venus de Milo)
(Peck & Peck, 1970)



Figure 1.8
Apollo Belvedere



Figure 1.9
Aphrodite by Praxiteles
(Papel, 2002)

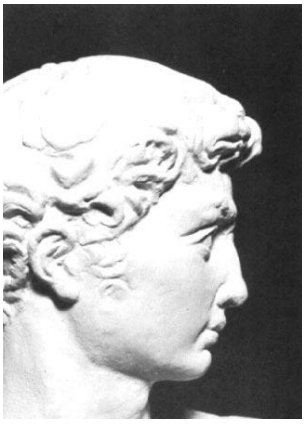


Figure 1.10
David by Michelangelo
(Peck & Peck, 1970)



Figure 1.11 Michelangelo´s satyr´s head
(https://www.artrenewal.org)

After the Golden Age, the Hellenistic period under Alexander the Great preferred more realistic depictions. The Romans followed suit in their sculptures of deities or citizens that were commissioned for political and social reasons (Peck & Peck, 1970).

Religious zeal in the dark ages until the end of the 4th century AD led to the destruction of classical Greek and Roman art which was considered mythical and pagan. Notions of beauty continued to be taboo in the Middle Ages. Medieval descriptions of the lower face include a small discreet mouth, thin red lips and small even teeth (Peck & Peck, 1970).

Influenced by classical Greek and Roman traditions, Michelangelo sculpted "David" with a perfectly proportioned face during the Italian Renaissance in 1504 (Figure 1.10). He also focussed on the facial profile in his famous pictures of satyrs and characteristic men (Figure 1.11) (Heppt & Vent, 2015). The development of the printing press during this period led to written expressions of aesthetics. In the 16th century, an Italian named Firenzoula described his version of the perfect female mouth (Peck & Peck, 1970).

1.4 The historical association between proportion and aesthetics

The theoretical 'Vitruvian man' by Roman architect and engineer Marcus Vitruvius Pollio in 100 BC provided the first version of the ideal human balanced proportions and postulated that the centre of equilibrium and gravity resided in the umbilicus (Heppt & Vent, 2015; Papel, 2002). Renaissance artists subsequently based their work on this concept that, with arms and legs extended, the human body fits into the basic geometric shapes of the circle and the square. Leon Battista Alberti (1404–1472) divided the human length into 600 minutes that were units to aid in drawing to scale. Gerard Audran (c. 1683), based on his observation of a statue of Venus, drew his version of the ideal female proportions (Figure 1.12) (Papel, 2002).



Figure 1.12
Audran´s facial proportions
(Papel, 2002)

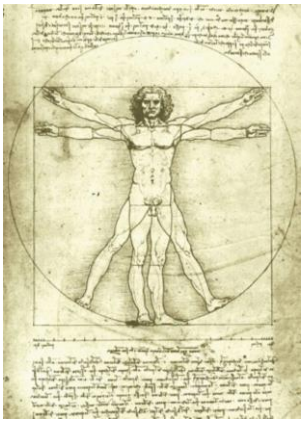


Figure 1.13
Da Vinci´s Vitruvian man
(Heppt & Vent, 2015)



Figure 1.14
Da Vinci's Male head in profile
(Naini et al., 2006)

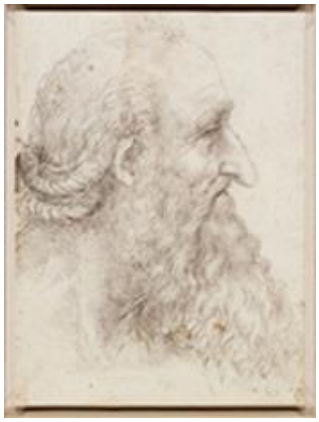


Figure. 1.15
Da Vinci´s Head of an elderly man seen in profile (Birmingham Museums Trust)



Figure 1.16
Da Vinci´s Manuscript A
(Naini, 2012)



Fig. 1.17
Da Vinci´s Portrait of a young woman in profile (www.rct.uk)

Artist and scientist Leonardo da Vinci (1452-1519) changed the position of the legs and arms within a circle and established mathematical rules and 'divine proportions' to define the perfect body and face (Fig. 1.13) (Heppt & Vent, 2015; Papel, 2002). Based on Vitruvian principles, da Vinci used the hairline, eyebrows and nasal base as references to divide his "Male head in Profile" into thirds (Figure 1.14). He divided the lower facial third into an upper third including the upper lip and lower two-thirds (Naini et al., 2006). Da Vinci profile drawings also represented the effects of ageing (Figure 1.15). His "Manuscript A" (Figure 1.16)

appeared to depict Baud´s facial circle method of measuring nasal projection, predating him by nearly 5 centuries (Naini, 2012).

Albrecht Durer (1471–1528) studied Vitruvian principles, wrote four books on human proportions and published 10 drawings of facial proportions (Figures 1.18, 1.19) (Heppt & Vent, 2015; Papel, 2002). He also divided the face into thirds using the same landmarks as Da Vinci and further divided the lower third in halves which encompassed either the lips or the chin (González-Ulloa, 1962). He also criticized the artists of those times for not having learnt geometry (Naini et al., 2006).

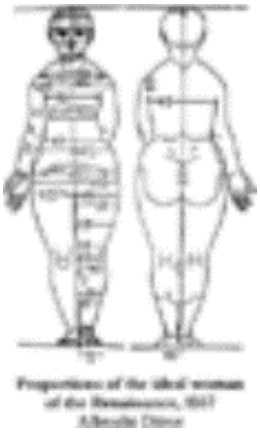


Figure 1.18
Durer´s female proportions
(Papel, 2002)

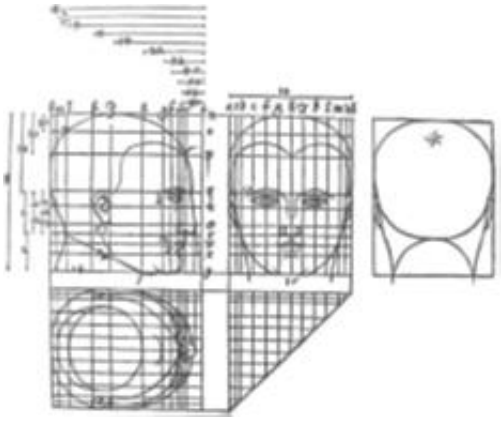


Figure 1.19
Durer´s facial proportion studies
(Heppt & Vent, 2015)

The role of the golden proportion in facial aesthetics

The concept of "golden proportion" has been attributed to both Pythagoras and Plato but was first published by Euclid (ca 325-265 BC) in his treatise *Elements* and book *Element II* (Kiekens, Kuijpers-Jagtman, et al., 2008; Matoula & Pancherz, 2006; Naini et al., 2006). Fibonacci used Phi (ϕ) to describe the proportion in the 12th century, after Greek sculptor Phidias, who incorporated this concept in the Parthenon (Kiekens, Kuijpers-Jagtman, et al., 2008; Naini et al., 2006). Mathematician Luca Pacioli renamed this hypothesis, which could not be rationalised, the "divine proportion" in his 1509 edition of Euclid's *Elements* and in *De Divina Proportione* illustrated by da Vinci (Heppt & Vent, 2015; Naini et al., 2006).

In 1597, Maestlin stated that the longer segment measures 0.618 when a line of length 1 is divided in the golden proportion (ϕ =1.618) (Naini et al., 2006). The ratio of the shorter to the longer section is equal to that of the longer section to the whole line (Kiekens, Kuijpers-Jagtman, et al., 2008; Naini et al., 2006) or (AB = 1.618, BC = 1, AC = 2.618) (Gao et al., 2018). In the 19th century , the term "golden section" was used to describe the point of division (Matoula & Pancherz, 2006; Naini et al., 2006).

The golden proportion has been observed in mathematics, geometry and nature. Filius Bonacci alias Leonardo of Pisa proposed the addition of two consecutive numbers to produce a series of 0, 1, 1, 2, 3, 5, ..144 etc, beyond which and up to infinity, each new addition is precisely I.618 times the previous number (Baker & Woods, 2001; Ricketts, 1982). If two corners of the pentagon which is the base of the five-pointed star are connected by a line which is crossed by another two such lines, each line is divided in a golden section of

1:1.618 and a golden 36, 72, 72° triangle is formed. The three corners of the triangle can be connected in a smooth curve to form the equiangular, logarithmic spiral found in snails, sunflowers, three-leafed clovers, flowers with Fibonacci´s sequence of five, eight or thirteen petals and the arrangement of leaves on a stem (Baker & Woods, 2001; Ricketts, 1982). A golden rectangle with a base of 1.618 and height of 1 has also been described (Ricketts, 1982).

Zeising stated that this proportion made compositions beautiful (Baker & Woods, 2001). It has been associated with harmonious compositions in architecture, sculpture, music and poetry (Kiekens, Kuijpers-Jagtman, et al., 2008; Rossetti et al., 2013). It is even identified in the Great Pyramid of Cheops (Baker & Woods, 2001; Kiekens, Kuijpers-Jagtman, et al., 2008) . The architect Le Corbusier based his Modulor system on this ratio (Baker & Woods, 2001). In Japan and China, the ratio is used in the device sashigane used to contruct buildings and in camera lenses (Mizumoto et al., 2009). The silver ratio of 1:1.414 is present together with the golden ratio in a historical Japanese painting Fuji Sanjuurokkei by Hokusai and the Horyu-ji temple built in 607 AD (Mizumoto et al., 2009). The eyes are placed at a golden distance between forehead and chin in classical and Renaissance art (Rossetti et al., 2013).

The golden ratio was first used in facial plastic surgery in 1964 by Seghers (Gao et al., 2018). Ricketts (1982) also recommended that clinicians use this concept in treatment planning. He found a progressive phi relationship in seven Caucasian, two Oriental, and one African model wherein head width at the temple was ϕ times the exocanthal distance, which in turn was ϕ times mouth width and $\phi 2$ to nasal width. Golden proportions were also revealed between vertical distances measured using trichion, points at the eyebrow; lateral canthus of the eye, superior border of the alar curvature, stomium and menton.

However, facial optical scans of models of both genders did not reveal golden proportions but a wide range of malocclusions and cephalometric values (Moss et al., 1995). Only 4 of 19 facial proportions correlated with the average VAS scores attributed by laypeople to each set of extraoral photographs of 10 to 16 year olds with various types of malocclusion and together, they explained only 16% of the variance (Kiekens, Kuijpers-Jagtman, et al., 2008). Malkoç and Fidancioglu (2015) verified that 19 divine proportions were unrelated to the VAS scores attributed to each triplet of extraoral photographs of 9 to 17-year-olds and could explain only a quarter of orthodontists´ and laypeople´s scores, respectively. Ratios calculated using stereophotogrammetry revealed no relationship with scores attributed to attractive and unattractive Caucasians of both genders although the one between nasal height and nasal base width was one of the three that statistically approached the golden value (Rossetti et al., 2013). Mizumoto et al. (2009) claimed that, in Japanese actresses, unlike models and patients, all ratios obeyed the golden proportion.

Baker and Woods (2001) concluded that clinicians´ and laypeople´s scores for frontal and profile photograph aesthetics did not correlate with the divine proportion in ratios before or after bimaxillary, maxillary or mandibular surgery nor was there a correlation between changes in scores and changes in proportions. Despite improved post-surgical aesthetics in both genders, there was much individual variation and an equal probability of ratios approaching or departing from the golden value.

1.5 The history of nasal aesthetics

Amongst his works collected in the Codex Atlanticus, Leonardo da Vinci described various nasal profiles: straight, bulbous, hollow, prominent above or below the middle, aquiline, regular, flat, round or pointed and various frontal nasal types: equally thick in the middle, thin in the middle, with a thick tip and narrow root or narrow tip and wide root; with wide or narrow, high or low nostrils and the openings wide or hidden by the tip (Heppt & Vent, 2015).

Jacques Joseph, one of the fathers of modern rhinoplasty, used the da Vinci drawing "Portrait of a Young Woman in Profile" (Figure 1.17) to describe the nasofacial or "profile angle`, which he measured using a profilometer (Figure 1.20) (Heppt & Vent, 2015)). In neoclassic times, the German artist von Schadow tried to determine the average nasal measurements by manually measuring these in statues and paintings which, according to him, depicted perfection (Heppt & Vent, 2015). Gaspare Tagliacozzi (1545–1599) who specialized in reconstructing syphilitic and traumatized noses at the University of Bologna provided the first description of nasal reconstruction. In 1816, Ferdinand von Graefe successfully used his 200-year-old description of a forearm flap to reconstruct a German soldier´s nose. Jacques Joseph was responsible for the development of modern plastic surgery when he described a rhinoplasty in 1898 in the Berliner Klinische Wochenschrift (Heppt & Vent, 2015).

The nose has been used to characterize personalities in art, the fairy tale character Pinocchio with his long nose (Figure 1.21), witches with their crooked, parrot-beaked noses and political satire. Daumier created a series of heads with enormous noses at the Parisian Court of Justice to parody famous men in the 19th century (Figure 1.22) (Heppt & Vent, 2015).



Figure 1.20
Jacques Joseph´s Profilometer
(Heppt & Vent, 2015)



Figure 1.21
Carlo Collodi´s Pinocchio (1883)



Figure 1.22
A bust by Daumier
(Heppt & Vent, 2015)

1.6 The social aspects of orthodontic-surgical treatment

Orthognathic surgery is the collective terminology that describes the corrective repositioning of the maxilla, the mandible or both, in an attempt to improve function and aesthetics (Oluwajana, 2015). The average

age of the surgical patient varies between 17 and 35 years (Al Taki & Guidoum, 2014; Siow et al., 2002) and 2/3rds are generally women (Sinko, Tran, et al., 2018; Xu et al., 2008).

Motivation to undergo this type of treatment depends upon objective signs, subjective symptoms and social factors, the relative importance of which vary in each patient (Giddon, 1995). Objective signs include malocclusion indices and cephalometric measurements (Pişiren et al., 2018). The subjective symptoms include the patient's recognition that a problem exists, while social factors involve societal recognition that the malocclusion probably creates a problem for the patient (Giddon, 1995; Prahl-Andersen et al., 1979).

Rustemeyer et al. (2010) concluded that the principal motives for surgical Class III correction were improved mastication in 15.5%, aesthetics in 11.9% and both in 71.4% of patients whilst 2.6% did not declare any specific reason. Garvill et al. (1992) verified that while 60% of patients gave multiple reasons for surgery; 85% mentioned masticatory problems, 74% aesthetics and 59% temporomandibular symptoms.

Aesthetics was the main motivating factor in Indians and one of the main reasons for 97% of Malaysians (Rustemeyer et al., 2010). 71% of patients in another investigation gave it primary importance while 47% and 28% desired functional and temporomandibular joint improvement respectively (Rivera, Hatch, Dolce, et al., 2000). Younger individuals in particular may prioritize aesthetics over function (Asada et al., 2015; Rustemeyer & Gregersen, 2012). More Malaysian men than women desired functional improvement while the converse was true for self-confidence (Siow et al., 2002).

The impaired aesthetics of dentofacial anomalies can interfere with normal social interaction (Giddon et al., 1974; Heldt et al., 1982; Shaw et al., 1980) and even cause psychological harm (de Almeida et al., 2010; Pithon et al., 2014). It affects quality of life more than impaired function (Rustemeyer & Gregersen, 2012). Garvill et al. (1992) verified a blighted personal life in 63% of patients. Folklore and superstition that this is a form of supernatural retribution aggravates the psychological trauma in Japanese patients (Mantzikos, 1998).

Physical attractiveness elicits differential responses from others, which in turn can modify the individual's self-concept (Adams, 1977). Strongly generalized subconscious processes are involved in judging personality based on appearance (Sinko et al., 2012). The ‘zero order acquaintance’ states that evaluators reach a high degree of consensus in assessing strangers based on prior information regarding facial features. As such, in keeping with the ‘what is beautiful is good’ stereotype, people with Class II or III discrepancies are assigned less positive personalities and considered less good-natured, self-confident, and intelligent than those with Class I profiles (Sinko et al., 2012; Sinko, Jagsch, et al., 2018). Laypeople considered women with sagittal mandibular anomalies less intelligent and trustworthy than those with skeletal class I relationships in their right and left profile and smiling frontal photographs and a video demonstrating movement between the three views (Sinko, Tran, et al., 2018). Other panels considered either the exaggerated Class II or III profile modifications of individuals of African origin the least friendly (Sena et al., 2017). Orsini et al. (2006) also observed that Caucasian orthodontists and Caucasian and Japanese American laypeople attributed more positive characteristics to orthognathic profile photographs of both races.

Hence, people with skeletal discrepancies are attributed stereotypical personalities. A dominant chin is usually associated with leadership and aggressiveness, whereas people with a class II ´baby face` are

considered submissive and compliant (Sinko et al., 2012; Sinko, Tran, et al., 2018). Women with Class III discrepancies were considered more intelligent, confident and trustworthy but less mild, flexible and good natured than those with class II relationships in their photographs and videos (Sinko et al., 2012; Sinko, Tran, et al., 2018). However, while aesthetics are assessed in a similar manner in videos and photographs, the former reduce the aggressive /good-natured and brutal /gentle personality traits attributed to the different skeletal classes, although the bias for flexibility still persists (Sinko, Jagsch, et al., 2018; Sinko, Tran, et al., 2018). Thus, the dramatic attribution of personality traits to each skeletal class may not occur to such a great extent in real life (Sinko, Jagsch, et al., 2018; Sinko, Tran, et al., 2018).

However, societal prejudice against their appearance and exposure to images idealized by the media cause self-criticism in surgical patients (Kiyak, 2008; Sinko et al., 2012). Pre-surgical class III patients exhibited lower self-esteem and more social anxiety than the general population (Agırnaslıgıl et al., 2019). They feel less attractive and slightly more insecure about their facial appearance than even Class II patients (Gerzanic et al., 2002). Thus, the surgical patient´s self-perception of oral function and appearance is very important for motivation and post-treatment satisfaction (Giddon, 1995; Hågensli et al., 2014; Kiyak & Zeitler, 1988; Van Sickels & D'Addario, 2007). Moreover, the post-surgical satisfaction of patients with Class III discrepancies depends mainly on improved aesthetics, regardless of the persistence of functional problems (Rustemeyer et al., 2010; Siow et al., 2002). Fortunately, surgery often fulfils the patient´s aesthetic objective as it permits the achievement of visual ideals rapidly and permanently (Cunningham et al., 1996; Sinko et al., 2012; Van Sickels & D'Addario, 2007).

Rustemeyer et al. (2010) demonstrated that 15.6% of individuals with class III malocclusions reported only an aesthetic improvement, 5.1% a functional one, 75.4% both and 4% neither after bimaxillary surgery. All Malaysian patients reported improved aesthetics while 68% noted better mastication (Siow et al., 2002). 89% of British patients referred to an improved smile (Al-Hadi et al., 2019). However, nasal appearance is often the most undesirable aesthetic consequence of surgery (Coban et al., 2020; Ghorbani et al., 2018). Merely 25.8% of Iranian patients with Class II and III discrepancies, of whom 62.9% were women, were satisfied with their post-surgical nasal appearance (Ghorbani et al., 2018).

Orthodontic-surgical treatment improves quality of life (Ghorbani et al., 2018; Rustemeyer & Gregersen, 2012). The improved facial appearance and function confers psychological benefits (Cunningham et al., 1996; Ghorbani et al., 2018; Lazaridou-Terzoudi et al., 2003; Sinko, Jagsch, et al., 2018). These enhance self-confidence and sociability (Asada et al., 2015; Hunt et al., 2001; Oluwajana, 2015; Siow et al., 2002; Sy et al., 2016). Gerzanic et al., (2002) verified that patients with Class III discrepancies self-evaluated themselves as more attractive and self-confident just 6 weeks after surgery while the milder improvement in Class II patients was only significant at 6 post-surgical months. Sinko, Jagsch, et al. (2018) also concluded that surgery improved self-confidence scores less in Class II than in Class III patients who reached the level of Class I controls after surgery. Some investigations suggest that women are more likely to reveal better self-esteem after surgery (Nicodemo et al., 2008; Siow et al., 2002) while others do not find a correlation with gender

(Rustemeyer et al., 2010). However, improved self-confidence appear to be more important for post-surgical satisfaction in women than in men (Siow et al., 2002).

Another factor to be considered is the difficulty that some patients manifest in adapting to their radically altered appearance which increases dissatisfaction one year after surgery (Rustemeyer et al., 2010). 23% of Turkish women reported difficulty in getting used to their new appearance that could persist even after 24 months, even though 90% considered that their image had improved one year after surgery (Türker et al., 2008). Friends and family may also have trouble getting used to this new appearance (Holman et al., 1995; Rustemeyer et al., 2010). While their friend´s support for the decision to undergo surgery influences patient satisfaction in the early postoperative months, their reactions to their postsurgical appearance strongly affect both early and long term satisfaction (Holman et al., 1995).

Thus, post-operative well-being does not depend entirely on treatment results but also on psychological factors. Although most patients report improved self-confidence after surgery, some may be satisfied only temporarily, turning violent and litigious (Barbosa et al., 1993). Orthognathic surgery may not benefit patients who assume that the procedure will solve all their problems (Rustemeyer et al., 2010; Türker et al., 2008). Unrealistic expectations lead to patient dissatisfaction (Finlay et al., 1995; Oluwajana, 2015; Rustemeyer et al., 2010).

Moreover, research demonstrates that people with Class II or III discrepancies continue to be considered to have less positive personalities, self-confidence and intelligence than those with Class I profiles even though surgery improves assigned traits (Sinko et al., 2012; Sinko, Jagsch, et al., 2018). However, in the comparison of profile photographs of women with class III and class II malocclusions, surgical correction eliminated the laypeople´s tendency to consider the former more intelligent and confident and the latter milder, more flexible and good natured (Sinko et al., 2012). Yet in videos, people with Class II discrepancies continued to be considered more flexible than class I cases after surgery, while treatment did not improve this trait for Class III patients (Sinko, Jagsch, et al., 2018).

Orthodontists and surgeons share the responsibility to counsel patients about the anticipated results and advantages and disadvantages of the various treatment options (Finlay et al., 1995; Oluwajana, 2015). An inadequate explanation of surgery may leave patients emotionally unprepared and anxious after the procedure (Rustemeyer et al., 2010; Türker et al., 2008). Written information about possible consequences and recovery and an informed consent are thus essential for postoperative satisfaction (Finlay et al., 1995; Siow et al., 2002). Speaking to other patients who have undergone the procedure may also help (Türker et al., 2008).

1.7 The skeletal components of Class III malocclusions

Ellis & McNamara, (1984) demonstrated that maxillary retrusion occurs in 67% of Caucasian adults with a Class III malocclusion and in 19.5% of cases in an isolated form. Mandibular prognathism accompanied maxillary retrusion in 30.1% of case and occurred alone in 19.2%. 15% demonstrated bimaxillary protrusion relative to a short cranial base and 8% had bimaxillary retrusion. However, a different sample of 66 people revealed isolated maxillary retrusion and mandibular prognathism in 26% and 49% of cases, respectively.

Mandibular prognathism accompanied maxillary retrusion in only 6% of the sample while 14% exhibited no skeletal discrepancies (Jacobson et al., 1974).

Isolated mandibular prognathism was found in 40% of a Korean (Baik et al., 2000) and 38.75% of a Chinese population (Lew & Foong, 1993) with class III malocclusions. In a Chinese sample, 22.5% demonstrated maxillary deficiency alone, 18.75% maxillary deficiency with mandibular excess, 7.5% normally positioned jaws, 11.25% bimaxillary excess and 1.2% bimaxillary deficiency. While most men had isolated mandibular prognathism, most women presented isolated maxillary retrusion (Lew & Foong, 1993). Koreans however did not manifest gender-based dichotomy to such a great extent. Maxillary retrusion occurred in an isolated form in 18% and 25% of Korean men and women, respectively, and co-existed with mandibular prognathism in 37% and 25% of them, respectively (Baik et al., 2000).

Thus, pure mandibular prognathism as the principal cause of the Class III malocclusion occurred twice more frequently in Koreans and in Chinese than in American Caucasians (Baik et al., 2000; Ellis & McNamara, 1984; Lew & Foong, 1993). Maxillary deficiency, alone or in combination with mandibular anomalies, prevailed in 67% of Caucasians, 55% and 50% of Korean men and women respectively and 42.5% of Chinese.

Another important component of the Class III discrepancy is the excessive lower anterior facial height which existed in 87% and 83% of Caucasian men and women, respectively, without a significant gender-based difference. The mandibular plane was rotated posteriorly in 69% of Caucasians (Ellis & McNamara, 1984). Koreans also exhibited a larger gonial angle and increased lower facial height (Baik et al., 2000).

1.8 The demographics of the surgical treatment of Class III malocclusions

Class III malocclusions represented 35% of all surgical cases treated in the University of North Carolina between 1996 and 2000 and 54% between 2006 and 2010 (Proffit et al., 2013). Relative sagittal mandibular position is an important determinant of facial attractivity (Johnston, Hunt, Burden, et al., 2005; Kuroda et al., 2009). Yet, Class III patients are more likely to accept surgery when their primary problem is a maxillary deficiency (Proffit et al., 2013).

The rising frequency of surgery for Class III correction can be attributed, in part, to changing demographics and to its lower social acceptability compared to Class II profiles, which are common in people of European origin (Proffit et al., 2013). Other contributing factors are the psychological and inter-personal problems caused by the Class III facial appearance (Rustemeyer et al., 2010). These individuals are more likely to feel unattractive than Class II patients (Proffit et al., 2013). Moreover, unlike those with Class II skeletal relationships, they cannot posture their jaws anteriorly to disguise their discrepancy (Ghorbani et al., 2018; Proffit et al., 2013). Class III patients are often attributed negative personality traits (Pişiren et al., 2018; Sena et al., 2017). A prominent mandible can be associated with aggressiveness or brutality (Jiang et al., 2018; Oluwajana, 2015; Sinko, Jagsch, et al., 2018). Thus, softening of the facial appearance can be a major motivation for surgery, especially amongst women (Proffit et al., 2013). Conversely, Class II patients prefer non-surgical camouflage treatment more often (Ghorbani et al., 2018; Proffit et al., 2013).

Asymmetry, which affects 42% of Class III and 28% of Class II patients, and functional issues caused by anterior or posterior crossbites, which are common in Class III discrepancies, also influence the surgical decision (Proffit et al., 2013).

Between 1978 and 1985, 50% of American patients with Class III malocclusions were treated with mandibular setback and 15% with maxillary advancement surgery. Between 1985 and 1990, the use of maxillary advancement surgery doubled and bimaxillary surgery benefited 50% of cases. Between 1990 and 1992, maxillary advancement (40%) and bimaxillary surgery (50%) were used far more frequently than mandibular setback surgery (10%) (Bailey et al., 1995). In a Korean sample, maxillary advancement, mandibular setback and bimaxillary surgery were used in 0.7%, 19.7% and 79.6% respectively (Baik et al., 2000). Maxillary advancement surgery is common in some European countries (Verdenik & Ihan Hren, 2014).

Maxillary advancement osteotomy provides a stable occlusion and aesthetic results when the deformity is restricted to this jaw (Verdenik & Ihan Hren, 2014) and even in cases of moderate mandibular excess (Rosen, 2017). It is also considered more stable either alone or as part of bimaxillary surgery than mandibular setback alone (Baik et al., 2000; Bailey et al., 1995). Skeletal expansion improves soft tissue support causing a more defined, fuller and elegant appearance, while skeletal contraction may have the reverse effect causing soft tissues to appear thick and redundant due to their limited adaptive capacity (Rosen, 2017). Mandibular setback can increase the submental tissue and cause a double chin due to inferior tongue displacement in the oral cavity (Baik et al., 2000; Bailey et al., 1995; Ghassemi et al., 2017). Thus, maxillary advancement increases volume and causes a more youthful appearance while mandibular setback can worsen aesthetics (Giddon et al., 1974). An average 4.6 mm maxillary advancement produced better facial aesthetics than an average 7.1 mm mandibular setback in Class III patients even for an SNA angle variation between 80 to 84° (Ghassemi et al., 2017). Moreover, radical mandibular setbacks cause patient dissatisfaction as friends and family manifest difficulty in getting used to their new appearance (Rustemeyer et al., 2010). Rustemeyer et al. (2010) concluded that less satisfied skeletal Class III patients had significantly smaller postsurgical SNB angles, while the SNA and gonial angles were not important.

Additionally, the use of isolated mandibular surgery has inherent constraints, especially when severe sagittal, transverse and vertical discrepancies co-exist in Class III discrepancies (Park et al., 2012; Rosen, 2017). Surgical limitations and the risk of relapse after movements of large magnitude favour the use of bimaxillary surgery to correct severe discrepancies (Chew, Sandham, & Wong, 2008; Ghassemi et al., 2015). Maxillary or bimaxillary surgery offer better long-term stability than mandibular setback osteotomy (Bailey et al., 1996; Ghassemi et al., 2017; Jakobsone et al., 2012, 2011; Park et al., 2012; Proffit et al., 2013). Bimaxillary surgery also permits clockwise occlusal plane rotation for stable and aesthetic results (Bailey et al., 1996; Oh et al., 2013; Park et al., 2012; Reyneke & Evans, 1990; Verdenik & Ihan Hren, 2014). It improves the Asian facial profile by permitting the correction of a greater skeletal discrepancy, reducing lower facial height and leading to clockwise occlusal plane rotation, causing upper incisor retroclination and a reduction in the nasolabial angle (Asada et al., 2015). Laypeople´s limited capacity to detect change also makes them more critical of the results of unimaxillary surgery (Fabré et al., 2010).

Facial aesthetics is therefore one of the main reasons why clinicians increasingly opt for bimaxillary surgery (Bailey et al., 1995; Hemmatpour et al., 2016; Oh et al., 2013; Park et al., 2012; Rosen, 2017; Verdenik & Ihan Hren, 2014). Patients treated in this manner were more satisfied with the appearance of their mouth, smile and treatment outcome than a mandibular setback group (Asada et al., 2015). They also had the most benefits in terms of health-related quality of life (Sun et al., 2018).

However, some authors suggest that, due to anterior nasal spine recontouring and surgical closure of the soft tissue incision, maxillary surgery produces more variable results than mandibular osteotomy (Chew, Sandham, et al., 2008; Jensen et al., 1992). Others suggest that soft tissue outcomes are more complex after bimaxillary surgery (Altug-Atac et al., 2008; Hemmatpour et al., 2016). Pospisil (1987) observed that while 33% of inaccurate prediction tracings were caused by surgical errors, planning inaccuracies occurred more frequently in bimaxillary (83%) than unimaxillary procedures (40%) due to the larger soft and hard tissue movement involved.

1.9 Nasal anatomy

1.9.1 The evaluation of the nose as a facial subunit

The nose is one of the major subunits of the face (Papel, 2002). Together with the upper lip, it composes the nasolabial region overlying the maxilla (Mitchell et al., 2007). This three-dimensional structure should be in harmony with the face (Schendel & Carlotti, 1991). Any clinical examination should assess general facial proportion and symmetry prior to a nasal evaluation (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

From the frontal view, a vertical line between the soft tissue glabella and menton should bisect the nose in two halves. Bilaterally, the nose should be at the level of the ear (Milgrim et al., 1996). The glabella to subnasale distance should be approximately one third of the facial height from trichion to menton (Altman & Oeltjen, 2007). The nose should occupy the central part when the face is divided into five vertical segments at this level (Altman & Oeltjen, 2007). In keeping with the facial canons, the interalar width should equal the inner intercantal distance (Altman & Oeltjen, 2007) and the width of the palpebral fissure (Papel, 2002).

Canons

The classical canons formulated by Renaissance artists and scholars often serve as guides for modern plastic surgeons (Gao et al., 2018; Husein et al., 2010). According to these, the points trichion, nasion, subnasale and gnathion divide the face into equal thirds. Ear length is equal to the nasal length in the naso-aural canon and the long axis of its atrium is parallel to the slope of the nasal dorsum (Gao et al., 2018). Horizontally, the intercanthal distance is equal to the interalar distance (Altman & Oeltjen, 2007; Gao et al., 2018) and the width of the mouth is one and a half times nasal width (Gao et al., 2018). The nasofacial canon states that nasal width should be a quarter of the interzygomatic width (Farkas et al., 2000). Yet, the reliability of the canons has been questioned (Farkas et al., 2000). For instance, Asians possess a wider intercantal distance, a narrower eye fissure, a much wider nose within a wider face and a smaller mouth (Le et al., 2002).

The nose formed the smallest vertical segment and invalidated the vertical facial third canon in African Americans, Caucasians (Farkas et al., 2000), Chinese and Vietnamese (Le et al., 2002), although it was almost confirmed in Indian women (Husein et al., 2010). The lower third was longer than the nose in Spaniards (Fernández-Riveiro et al., 2003) and in Turks (Malkoc et al., 2009). In another investigation, the nose was shorter than the lower third in 78-81% and longer in 10-11% of Turks and was either shorter or longer than the forehead (Borman et al., 1999). Iranian women also had a shorter forehead (Amini et al., 2014).

A predominately longer ear caused the naso-aural canon to be valid only in 1% of African Americans, 4.9% of Caucasians (Farkas et al., 2000), 21.7% of Asians (Le et al., 2002) and invalid in Iranian women (Amini et al., 2014). The greater nasal bridge inclination in over 90% of African Americans and Caucasians (Farkas et al., 2000) and almost 90% of Turks (Borman et al., 1999) resulted in the naso-aural inclination canon being valid in 3% of African Americans and Turks and 8.9% of Caucasians.

The orbito-nasal canon was confirmed in Iranian women with normal occlusions (Amini et al., 2014) but in only 40.8% of Caucasians (Farkas et al., 2000), 19 to 20% of Turks (Borman et al., 1999), 9% of Indian women (Husein et al., 2010) and 3% of African Americans (Farkas et al., 2000). The nose was disproportionately wider in 94% of African Americans (Farkas et al., 2000), 86% of Indian women (Husein et al., 2010), 77.27% of Han Chinese (Zhang et al., 1990), 76.7% of Thai and Vietnamese (Le et al., 2002), 65-68% of Turks (Borman et al., 1999) and 37.9% of Caucasians (Farkas et al., 2000).

The naso-oral canon was valid in 22% of Indian women (Husein et al., 2010), 20.4% of Caucasians (Farkas et al., 2000), 5 to 6% of Turks (Borman et al., 1999) and only 1% of African Americans (Farkas et al., 2000) and of Chinese, Thai and Vietnamese (Le et al., 2002). The nose was wider in other Indian women (Husein et al., 2010), 96.7 to 100% of Eastern individuals (Le et al., 2002), 94% of African Americans and 9.4% of Caucasians (Farkas et al., 2000).

Nasal width was about a quarter of the interzygomatic width in Iranian women with normal occlusions (Amini et al., 2014). Yet, only 36.9%.of Caucasians (Farkas et al., 2000), 10.91 and 26.36% of Han Chinese men and women respectively (Zhang et al., 1990), 9.4% of Chinese, Thai and Vietnamese (Le et al., 2002), 6% of Indians (Husein et al., 2010) and 3 to 4% of Turks (Borman et al., 1999) presented a valid nasofacial canon. The nose was wider in all African Americans (Farkas et al., 2000), most Indian women (Husein et al., 2010), 83.3 to 90% of Eastern individuals (Le et al., 2002), 86.36 and 41.82% of Han Chinese men and women respectively (Zhang et al., 1990), 30-39% of Turks (Borman et al., 1999) and 24.3% of Caucasians (Farkas et al., 2000).

Norms proposed for nasal tip position relative to the face

Several norms have been established in the measurement of nasal projection. Jacques Joseph suggested a normal range of 30-40° for the "profile angle" between the nasal dorsum and the soft tissue glabella-pogonion plane (Papel, 2002). Others proposed a value of 30-35° (O'Ryan & Schendel, 1989a).

While Baum´s method proposes a 2:1 ratio between the length of the vertical line between the vertices of the nasofrontal and nasolabial angles till the point where a perpendicular from the nasal tip intercepts this

line and the length of the perpendicular itself, rhinoplasty surgeons subjectively preferred a 2.55:1 ratio (Crumley & Lanser, 1988). Laypeople also preferred a slightly lower tip projection represented by the 2.28:1 ratio in composite profile photographs of attractive 18-25 year old women (Devcic et al., 2011).

While Powell and Humphreys suggested that the ratio between the length of the entire line between the aforementioned vertices and that of the perpendicular from the nasal tip should be 2.8:1, rhinoplasty surgeons (Crumley & Lanser, 1988) and laypeople (Devcic et al., 2011) preferred ratios of 3.02:1 and 2.94:1, respectively and thus, smaller nasal projection. Simon proposed a 1:1 ratio between nasal protrusion and the total upper lip length while plastic surgeons and laypeople preferred ratios of 1.58:1 and 1.70:1 respectively (Crumley & Lanser, 1988; Devcic et al., 2011).

Crumley and Lanser (1988) suggested that the length of a vertical line from the nasofrontal angle vertex up to the mucocutaneous junction of the upper lip should be 3.53 times the perpendicular distance from this line to the nasal tip. They also concluded that the length of the vertical line from the nasofrontal angle vertex to soft tissue menton should be 4.23 times that of the perpendicular from the nasal tip. The two ratios were similar and measured 3.5:1 and 4.2:1, respectively in composite photographs of attractive women (Devcic et al., 2011).

Goode´s 3-4-5 triangle suggests that with a 30-36° nasofrontal angle, the length of the perpendicular from the nasal tip to the glabella-alar sulcus line should be 0.55-0.60 of the nasal length or the hypotenuse of the triangle. Rhinoplasty surgeons and laypeople chose aesthetic ratios of 0.60 and 0.61 respectively (Crumley & Lanser, 1988; Devcic et al., 2011). Larger ratios indicate greater nasal tip projection (Papel, 2002).

In 1968, Baud developed his “facial circle” method, according to which trichion, pronasale and soft issue pogonion should be located on a semicircle which has as its centre the midpoint of the external auditory canal or in the Behrbohm modification, a notch on the superior border of the tragus (Heppt & Vent, 2015; Naini, 2012). Assuming normal forehead and chin position, the nasal tip is considered protrusive if it falls outside this circle.

The “quantitative principle" indicates that the alar sulcus, the vermilion border of both lips and soft tissue pogonion should approach the perpendicular to the Frankfort plane through soft tissue nasion (González-Ulloa, 1962). The correction of facial disharmony according to this principle is called profileplasty.

1.9.2 External nasal morphology

The evaluation of the nasal anatomy itself should begin with the identification of external anatomical landmarks that serve as a reference for internal nasal structures (Schendel & Carlotti, 1991). From the frontal view, the nasal root or ´radix` should present a smooth, uninterrupted curve along the lateral nasal contour until the eyebrow and may be demarcated superiorly by a transverse skin fold perpendicular to the procerus (O’Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).The dorsum connects the radix with the nasal lobule and the projections of the crura of the alar cartilages and demonstrates two smooth concave lines that extend from the supercilliary ridges (Mitchell et al., 2007; O’Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). In women, this curve should be wider at the root and tip and narrower in the middle third, producing a subtle

and continuous hourglass shape (Gao et al., 2018). Dorsal width is determined by the nasal bones and upper lateral cartilages and should be in harmony with the nasal tip and facial width (Schendel & Carlotti, 1991). It averages 8 to 10 mm in men and 6 to 8 mm in women (Furtado, 2016). Dorsal axis deviation from the midline should be observed (Furtado, 2016). The alae represent the lateral extensions of the lobule that extend to the cheek and cover the nostrils (Mitchell et al., 2007).

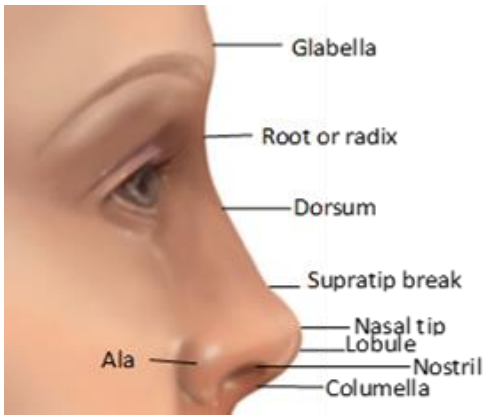


Figure 1.23
External nasal morphology

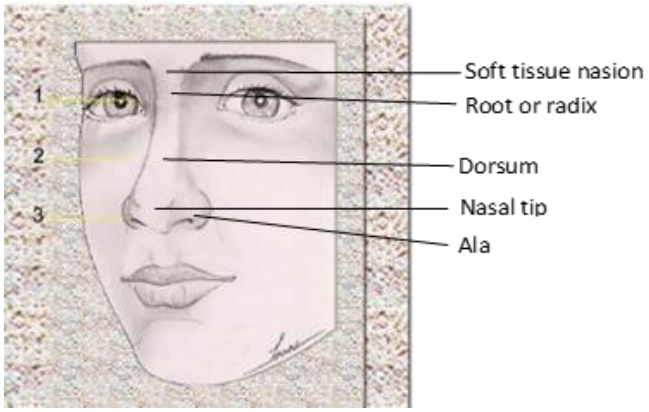


Figure 1.24
Joseph zones 1. Bony part; 2. Middle third 3. Lower third or lobe (Furtado, 2016)

Ideally, the nasal tip, in the frontal view, should demonstrate an equilateral triangle whose base is created by two light reflexes at the lateral domes of the alar cartilages and apex by a highlight at the columellar-lobule junction. The shadowed supratip concavity above the triangle demarcates the dorsum from the tip (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The width of the tip is determined by the width of the alar cartilages and by the interalar angle of divergence (Schendel & Carlotti, 1991).

The columella, in the frontal view, should project slightly below a horizontal line drawn through the nasal base resulting in a characteristic ´gull wing` or ''gull in flight'' appearance (Altman & Oeltjen, 2007; Mitchell et al., 2007; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

The nasal base is composed of the tip lobule, the columella, the alae and the nostrils (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). It should be triangular in the basal view with the nostrils constituting two thirds of its height and the tip lobule forming the other third (Altman & Oeltjen, 2007; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). While the columella should flare at its base and at its junction with the tip lobule, the nostrils should be symmetrical, elliptical and converge towards the tip (Altman & Oeltjen, 2007; Schendel & Carlotti, 1991). The convex alar-facial groove demarcates the lateral junction of the alar base with the face (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

Altman and Oeltjen (2007) stated that, in profile, nasal projection should ideally be approximately 60% of the nasal length or 75% of the nasal height. The nasolabial angle should always be evaluated with the lips and mandible at rest (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). An arbitrary wide range of 90-120° has been considered normal due to different manners of defining this angle (Gao et al., 2018).

The presence of the *hump* or upper dorsal convexity should be recorded (Furtado, 2016; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The supratip concavity should be slight and the nasal tip should be the highest point on the nasal profile (Schendel & Carlotti, 1991). The supratip break is not obvious in straight or convex nasal profiles (González-Ulloa, 1962).

The columellar base should bend superiorly at the columella-lobule junction. The columella in the lateral view should be several millimetres below and parallel to the alar rims themselves (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). A 2 mm columella depth is considered ideal (Altman & Oeltjen, 2007) .

The location of soft tissue nasion

While the nasofrontal groove in adult autopsies was located an average 5.8 mm above the intercanthal line, this distance ranged from 6-14 mm and averaged 10 mm in 67.7% of in young attractive adult Caucasian women (Farkas et al., 1986). Farkas et al. (1986) stated that the nasion is always located at a higher level than the eye fissures and in the absence of orbital anomalies, could be marked in the midline of the root on the line connecting the highest points of the superior palpebral sulci. Furtado (2016) also supported a position at the level of the upper eyelid crease 4 to 6 mm below the glabella and close to the upper eyelid projection. Ahmed et al. (2014) suggested an ideal position between the supratarsal fold and upper eyelash line.

Gao et al. (2018) suggested the nasion should coincide with the interpupillary line in Eastern women and the supratarsal fold in Caucasian women. Mowlavi et al. (2003) concluded that the most aesthetic soft tissue nasion position in scaled, sketched Caucasian images was at the level of the supratarsal fold, upper ciliary margin or midpupil in men and at the upper ciliary margin or midpupil in women.

1.9.3 Internal nasal anatomy

The skeletal nose is covered by skin, subcutaneous tissue and a superficial musculoaponevrotic layer. The skin is thickest over the tip and the thinnest over rhinion or the junction of the nasal bones and upper lateral cartilages (Altman & Oeltjen, 2007).

In the centre of the maxilla, the piriform aperture helps to determine nasal width (Figure 1.25) (Mitchell et al., 2007; O'Ryan & Schendel, 1989a). The anterior nasal spine in its lower central part supports nasal tip projection (Mitchell et al., 2007). Skeletal elements including the nasal bones, the anterior nasal spine, the vomer and the perpendicular plate of the ethmoid, together with cartilaginous components, provide midline support to the nasal septum (Figure 1.26) (Mitchell et al., 2007).

Altman and Oeltjen (2007) divided the nose into the subunits of the bony pyramid, the dorsum, the side walls and the tip. The bony pyramid consists of the nasal bones, the frontal processes of the maxilla and the bony septum. The dorsum consists of the junction of the nasal bones and the bony septum superiorly and the upper lateral cartilages and cartilaginous septum inferiorly. The side walls or cartilaginous pyramid are constituted by the upper lateral cartilages and the cartilaginous septum. The lower lateral or alar cartilages and caudal septum comprise the nasal tip (Altman & Oeltjen, 2007). The Joseph zones created by Jacques Joseph

demarcated an upper third consisting of the bony part of the nasal dorsum, the middle third of the triangular cartilages and the movable lower third or lobe including the tip (Figure 1.24) (Furtado, 2016) The concave or convex nasal subunits are separated by low ridges or shallow valleys, giving rise to an interplay of light and shadows that are of the utmost importance in nasal aesthetics (O'Ryan & Schendel, 1989a).

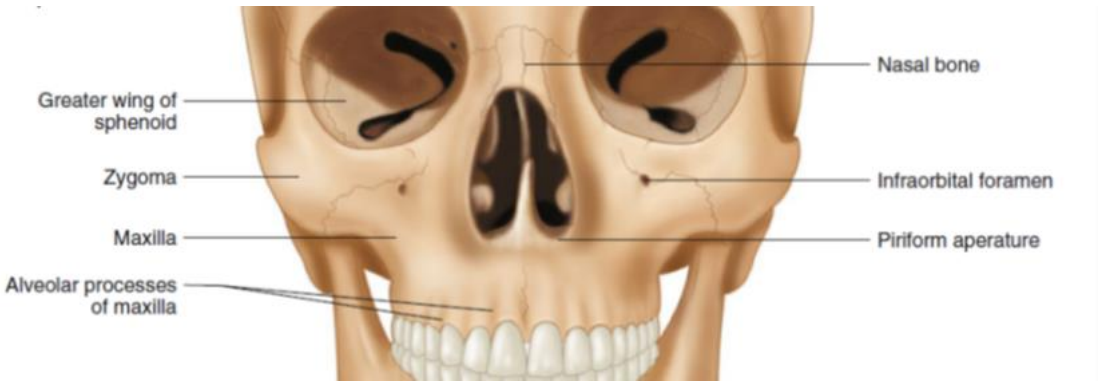


Figure 1.25 Skeletal anatomy

(Taub et al., 2015)

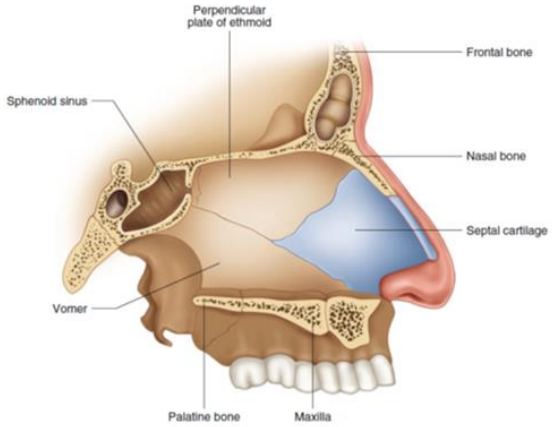


Figure1.26 Nasal septum

(Taub et al., 2015)

Various skeletal, cartilaginous, muscular and fascial components contribute to the internal nasal anatomy. The paired nasal bones, of an average 25 mm in length, articulate with the frontal bone at the frontonasal suture, and together with the frontal process of the maxilla determine the width of the nasal dorsum (Figure 1.25) (Mitchell et al., 2007; Schendel & Carlotti, 1991). Inferiorly, the nose is limited by the anterior nasal spine with its muscular and fascial attachments and posteriorly by the vomer and perpendicular plate of the ethmoid (Figure 1.26) (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

The cartilaginous portion of the external nose is situated anterior to the piriform aperture. In the upper part, the cephalic portion of the bilateral superior lateral or triangular cartilages, which are really quadrangular in shape, is overlapped by the caudal portion of the nasal bones in an area that is approximately 9 mm in the midline and 4 mm laterally. This osseocartilaginous junction, termed the *rhinion* or *keystone* area, is firmly joined by fibrous connective tissue. The upper two thirds of the upper lateral cartilages are fused along the

dorsal border of the nose to each other and also to the septum which projects between the inferior third of the separated cartilages (Figure 1.27) (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

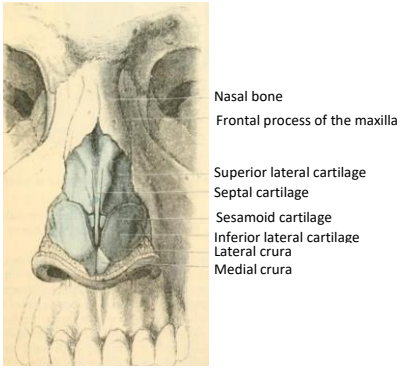


Figure 1.27 Frontal view of nasal cartilages

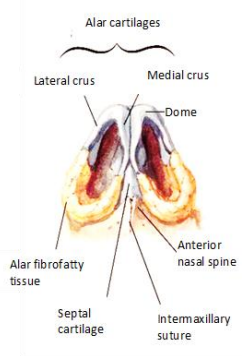


Figure 1.28 Basal view of nasal cartilages

The lower lateral or alar cartilages are situated below the upper lateral cartilages and are responsible for tip and lobule structure and support (Figure 1.27) (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). Some authors divide the alar cartilages into medial and lateral crus separated by a middle crus or domal segment (Altman & Oeltjen, 2007; O'Ryan & Schendel, 1989a). Others suggest the existence of only two components, the medial and lateral crus, joined at the dome of the alar cartilage which is the highest point of the nose (Figure 1.28) (Mitchell et al., 2007; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The domes should be symmetric and equidistant from the midline (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The soft-tissue triangle beneath the alar dome is devoid of cartilage and consists of the juxtaposed vestibular lining and the skin of the nasal tip. The medial crura extend parallel to each other in the midline along the columella, joined by fibrous tissue and curve laterally at their base near the anterior nasal spine (Figure 1.28) (Mitchell et al., 2007; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The lateral crus extend parallel to the nasal rim for approximately one half of their length, their cephalic aspect overlapping the caudal part of the upper lateral cartilages, after which they turn in a posterosuperior direction (Mitchell et al., 2007; O'Ryan & Schendel, 1989a). Thus, the nasal alae and the alar-facial groove do not contain cartilage but are composed principally of fibro-areolar tissue (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

Vestigial sesamoid cartilages persist between the upper and lower lateral cartilages and have a firm fibrous connection to the lateral crura (Figure 1.27) (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The first accessory cartilage lies beneath the alar crease. A second one is attached to the piriform aperture through the deep division of the alar portion of the nasalis muscle from the under-surface of the maxilla. The third one has a fibrinous attachment to the anterior nasal spine and forms the internal nostril fold on the floor of the nasal vestibule. These accessory cartilages, together with the septal cartilage resting on the nasal spine, the fibrous tissue between the medial and lateral crura and the nasal floor form a continuous ring of nasal support (Mitchell et al., 2007; O'Ryan & Schendel, 1989a).

The cartilaginous portion of the nasal septum has a quadrangular shape and is bound posteriorly to the vomer and inferiorly to the nasal crest of the maxilla and the anterior nasal spine. The septal perichondrium is

continuous with the periosteum of the vomer and the mucosa of the nasal floor. The free caudal margin of the cartilaginous septum is separated from the columella by the juxtaposition of two mucocutaneous flaps known as the membranous septum. The layers of the membranous septum extend forward and join the cutaneous covering of the medial crura. The narrowest part of the nasal airway, the internal nasal valve, is located at the junction of the septum and the upper lateral cartilages (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). During inspiration, the alar cartilages flare and the caudal aspect of the upper lateral cartilages moves inward, narrowing the nasal valve while during expiration, its lateral movement widens it (O'Ryan & Schendel, 1989a).

Many muscles jointly contribute to the position and form of the lateral nasal and lip regions (Figure 1.29) (Mitchell et al., 2007; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The procerus, responsible for drawing the skin forward and causing wrinkles at the nasal root, arises from the nasal bones and the upper aspect of the upper lateral cartilages and inserts into the skin of the radix. The nasalis muscle consists of two components and originates along the nasal dorsum in the midline and spreads laterally over the outer part of the upper lateral cartilages, where it intermingles with the fibres of the levator labii superioris alaeque nasi and the levator labii superioris. The alar portion of the nasalis muscle reflects inward and helps in the formation of the anterior nasal floor. One part of the transverse portion of the muscle blends into the skin of the nasolabial groove where it intermingles with the fibres of the levator labii superioris alaeque nasi and the oblique fibres of the orbicularis oris to form a lateral nasal modiolus (Mitchell et al., 2007; O'Ryan & Schendel, 1989a). A deeper portion curves around the lower lateral cartilages and inserts into the pyriform rim all the way to the anterior nasal spine and the incisal crest and contacts with the depressor septi (O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). This muscle is important in determining the lateral alar shape and the transverse nasal width (Schendel & Carlotti, 1991).

The levator labii superioris arises from the infraorbital maxillary margin just below the orbicularis oculi muscle and extends downward and medially to insert along the nasal floor and the skin of the lateral half of the upper lip, apart from interdigitating with the orbicularis oris. The levator labii superioris alaeque nasi arises from the frontal process of the maxilla alongside the nose and divides into two segments. One segment inserts into the lateral crura of the alar cartilage and nasal skin, whereas the other deeper segment travels down to the nasal vestibule where it blends with fibres of the nasalis, depressor septi and oblique bands of the orbicularis oris. The dilator naris, which helps dilate the nostrils, passes over and inserts into the lateral edge of the lateral crura of the alar cartilages.

The depressor septi, which arises from the incisive fossa and ascends superiorly to insert into the anterior nasal spine and posterior half of the medial crura, causes downward movement of the nasal septum. The levator angularis oris, which lies deep to the levator labii superioris and zygomaticus major, arises from the canine fossa, extends down to interdigitate with the orbicularis oris and is responsible for elevation of the corner of the mouth (Mitchell et al., 2007; O'Ryan & Schendel, 1989a). The orbicularis oris muscle surrounds the mouth and is composed of three parts. Horizontal fibres extend from one commissure to the other beneath the philtrum. The oblique part extends from the commissures to the anteroinferior aspect of the nasal septal cartilage, anterior nasal spine, pyriform rim and nasal floor. Incisal bands extend from the commissures to

insert onto the incisive fossa of the maxilla (Mitchell et al., 2007; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991).

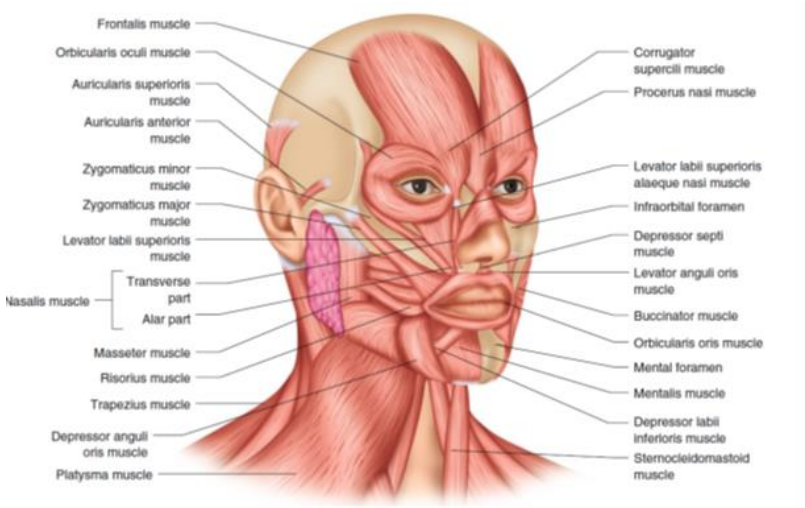


Figure 1.29 Facial musculature

(Taub et al., 2015)

1.10 The importance of averageness, symmetry, familiarity and sexual dimorphism in facial attractiveness

Averageness, symmetry, and sexual dimorphism are important in the perception of beauty and optimal mate selection (O'Ryan & Lassetter, 2011; Rhodes, 2006; Valentine et al., 2004). The good genes account states that average, symmetrical faces imply good health while the perceptual bias theory suggest that facial perceptual systems respond strongly to attractive traits (Rhodes, 2006; Valentine et al., 2004). Symmetry may indicate stress-free growth ,while averageness may signify genetic diversity that boosts immunity (O'Ryan & Lassetter, 2011). Facial 'archetypes' caused by optimal growth without stressful deformation may be preferred (Samuels et al., 1994).

Rhodes et al. (2001) noted that while facial symmetry and averageness enhanced perceived health, only distinctiveness, but not asymmetry, caused the perception of poor male childhood and female current health in 17-year-olds. However, the perception of attractive adolescents as healthier than their peers was not supported by their actual and future health data until late adulthood (Kalick et al., 1998). Thus, evidence appears to favour the perceptual bias account for average and symmetrical faces (Valentine et al., 2004).

The evolutionary theory supports an innate preference for attractive faces, while the cognitive theory suggests an acquisition early in life through exposure to category examples (Langlois & Roggman, 1990). Evolution may favour characteristics that are close to the population mean and cognitive processes may support prototypes which are the central representation of a category and possess the average value of its attributes (Langlois & Roggman, 1990). Thus, a prototype produced by averaging multiple faces together is attractive, even to infants, as it resembles the population mean (Langlois & Roggman, 1990; Langlois et al., 1994).

An interplay of averageness, symmetry and uniform skin texture may make composite faces attractive (Alley & Cunningham, 1991; Valentine et al., 2004). Sir Francis Galton´s photographic composites of criminals and tuberculosis patients amongst others and Stoddard´s composites of highly educated adults were considered better looking than their individual components and, in Galton´s case, eliminated "the special villainous irregularities" (Langlois & Roggman, 1990; Naini et al., 2006; O'Ryan & Lassetter, 2011). Caucasian, Hispanic and Asian digital composites were more attractive than almost all individual faces and became more so as more faces were entered (Langlois & Roggman, 1990). Attractiveness increased with the level of averageness when individual photographs mathematically warped towards distinctiveness or averageness, composites and their blended chimeras were compared (Rhodes et al., 1999). Even in the Japanese and Chinese, warping individual faces towards a composite of the same race and sex made them more attractive while caricaturing decreased attractiveness (Rhodes et al., 2001).

Yet, averageness is attractive even when skin texture isn´t a factor. Modification of individual photographs towards composites were favoured and the original face was preferred over its caricature with or without skin blending especially in the frontal view where both averageness and symmetry played a role (Valentine et al., 2004). Even frontal facial line drawings are more attractive when modified towards the norm and less so when caricatured (Rhodes & Tremewan, 1996). Moreover, attractiveness increases when multiple faces of different individuals rather than multiple images of the same face are averaged (Langlois et al., 1994).

However, the logic of evolutionary mate selection suggests that atypical faces should be preferred (Alley & Cunningham, 1991). Men should prefer youthful female faces that denote reproductive capacity while women should prefer extreme male features which, together with strong muscles, reflect health and the ability to provide (Alley & Cunningham, 1991; Grammer & Thornhill, 1994). While women´s composites were considered more attractive, sexier and less dominant than individual photographs with no difference in health, individual male faces were perceived as healthier, sexier and more dominant than their composites (Grammer & Thornhill, 1994). The composite line drawings of attractive faces of both genders were preferred to those of the original samples of Caucasian faces from which they were selected wherein the averageness hypothesis suggests that they should not differ (Perrett et al., 1994) Also, 50% caricaturing made the attractive female composite even more attractive, but not the male one. Thus, faces with an average shape are attractive but might not be optimally attractive (Naini et al., 2006). Also, highly attractive faces are not necessarily average (Alley & Cunningham, 1991). Moreover, while an averaged face is attractive, it reveals nothing about isolated features such as the nose (Langlois et al., 1994). Peck and Peck (1970) emphasized the importance of distinguishing between population norms and those for attractive individuals when they detected a relatively protrusive dentofacial pattern in very attractive women.

Symmetry

Symmetry is considered an important biological indicator of good genes, health and mate quality (O'Ryan & Lassetter, 2011). Fluctuating, unilateral, static craniofacial skeletal asymmetries caused by environmental stress such as malnourishment may indicate instability and/or a reduced ability to fine tune

between-side variability during development (Graves & Landis, 1990; Kowner, 1996). However, directional unilateral asymmetries are more prominent during function. The right side of the mouth moves more during speech due to linguistic control in the left brain (Graves & Landis, 1990; Kowner, 1996; Perrett et al., 1999). Greater right cerebral hemisphere activity moves the left face more in emotional expression (Graves & Landis, 1990; Perrett et al., 1999).

Investigative results depend on the method in which symmetry is produced. Asymmetry in the location of the eyes or midline features, such as the nose, make chimeras obtained by reflecting each hemiface about the midline less attractive (O'Ryan & Lassetter, 2011; Perrett et al., 1999; Rhodes et al., 1999). Although two chimeric female faces were considered more symmetrical than thirty-two female faces and their composites, symmetry did not affect attractiveness as even the original photographs were perceived as more attractive than the chimeras (Langlois et al., 1994). Symmetry of frontal photographs of children, young and old adults and their chimeras also did not linearly affect attractiveness (Kowner, 1996). Original smiling Caucasian and Japanese portraits were preferred to their chimeras for attractiveness and ´genuineness of the smile` (Kowner, 1996). Samuels et al. (1994) concluded that making unattractive Caucasian female faces symmetrical did not render them more attractive, whereas attractive faces became less so as chimeras.

However, the absence of midline distortions makes symmetrical images produced by blending original and mirror-reversed photographs or mapping onto a mathematical averaged face more attractive (O'Ryan & Lassetter, 2011; Perrett et al., 1999). Symmetrical Caucasian faces produced by mathematically averaging the distance of corresponding bilateral features from a facial midline were preferred to the original photographs whether the skin was blended or not, although this decision was attributed to factors such as kind eyes and grumpy expression and only one judge commented on symmetry (Perrett et al., 1999). Japanese evaluators also preferred blended symmetric versions to the original faces (Rhodes et al., 2001).

Attractiveness increased with averageness and symmetry, with no interaction between the two, when judges evaluated mathematically averaged, high-averaged and high-distinctive composites, the original photographs of young adults and their blended symmetric counterparts (Rhodes et al., 1999). Yet, symmetry contributes to averageness as symmetrical faces tend to have more average dimensions (Valentine et al., 2004).

Men find symmetrical female faces more attractive (Baudouin & Tiberghien, 2004). Facial fluctuating asymmetry of young Spanish women affected both self-perceived and male-rated attractiveness (Muñoz-Reyes et al., 2015). Asymmetry contributed significantly to make pairs of adult frontal and profile images less attractive (Hatch et al., 2017). Facial asymmetry, measured in optical sensor images before and after orthognathic surgery, correlated with the subjective evaluation of symmetry and attractiveness (Ostwald et al., 2015). Surgery increased measured and evaluated symmetry and attractiveness. However, asymmetry was not important for Czechs of both genders, whose attractiveness increased with averageness and greater femininity (Kočnar, Saribay, & Kleisner, 2019).

Wrinkles, fat deposits, skin blemishes and hair distribution patterns contribute to asymmetry, making these faces appear older (Kowner, 1996; O'Ryan & Lassetter, 2011). Chimeric composites of elderly Japanese were considered ´youthful` more frequently that their original photographs (Kowner, 1996).

Facial images of young adults before orthodontic treatment revealed minor asymmetry, mostly found in the chin and cheeks, that did not affect perceived attractiveness by laypeople (Kaipainen et al., 2016). A mild assymetry is generally considered normal and may not be evident (Peck & Peck, 1970; Sutton, 1968). Its commonness makes it more familiar than perfect symmetry and hence, more attractive (Kowner, 1996). Chimeric composites of beautiful women made asymmetry more obvious (Peck & Peck, 1970). Asymmetry in the distance of midline landmarks from the tragus was very common in young Caucasians although average absolute and relative differences between right and left measurements were less than 3mm or 3% respectively (Farkas & Cheung, 1981). Subnasale moved laterally with age in a longitudinal investigation in Caucasian Australians and Polynesians from age 3 to over 40 years (Sutton, 1968).

Unilaterally cast shadows and asymmetrical haircuts usually distract from the perception of asymmetry (Kowner, 1996). Facial expressions and speech movements are also asymmetrical (Graves & Landis, 1990). Moreover, whereas a mild asymmetry needs frontal assessment, people avoid looking directly at others more than briefly and find it difficult to maintain their head straight without the aid of a mirror (Kowner, 1996).

Springer et al. (2007) verified that asymmetry near the midline was more important. However, although a nevus close to the midline was less attractive than a more lateral one, a bilaterally symmetrical pair received the worst scores, indicating that under certain conditions symmetry can be quite unattractive.

Familiarity

Repeated exposure enhances one's attitude towards a stimulus and improved scores for attractive and unattractive Caucasian and Black photographs without a convergence between the two (Hamm, Baum, & Nikels, 1975). Composites´ averageness can also make them more familiar and attractive (Alley & Cunningham, 1991; Langlois et al., 1994). After viewing systematic variations in facial features, when asked to evaluate some of the original and new faces and a prototype with most of the original features, subjects confidently misidentified the prototype as a formerly seen face (Solso & McCarthy, 1981). Thus, a resemblance to a prototype, mother, self or even frequently seen people increases attractiveness (Bruce et al., 1994; Koehler et al., 2004; Samuels et al., 1994).

Mild facial asymmetry is more common and thus, more attractive than perfect symmetry (Kowner, 1996; Rhodes et al., 2009). Symmetrical faces were perceived as such when evaluators viewed a continuum that included contraction and expansion distortions and the original symmetric frontal photograph of adult faces. Yet, after repeatedly viewing unilaterally distorted faces and a randomly selected asymmetrical face before each test image, evaluators biased their choices toward asymmetry in a second evaluation. Adaptation occurred for all grades of asymmetry with larger perceptual shifts for more extreme ones (Rhodes et al., 2009)

Distinctive famous faces are recognized as familiar more quickly than more typical ones. When photographs were rated for distinctiveness initially and shortly later after being incorporated into a larger sample of faces, evaluators more easily remembered having seen distinctive target faces and not having seen previously unseen distinctive distractor faces (Bruce et al., 1994).

Sexual Dimorphism

At male puberty, testosterone stimulates the development of a prominent frontal bone and brow ridges, a wider mandible, thinner lips and facial hair. In girls, oestrogen inhibits these features and may increase lip size (Rhodes, 2006; Valentine et al., 2004). Larger male nasal and oral apertures rapidly transport oxygen to the lungs with increased vital capacity that support the higher metabolism and haemoglobin level required by the increased muscle mass. Bushy eyebrows and protruding brow ridges protect the male hunter´s eyes from sweat and the sun (Johnston et al., 2001).

Prominent jaws and cheekbones advertise immunocompetence and make men attractive as only healthy organisms can support the levels of testosterone necessary for these changes (Grammer & Thornhill, 1994; Perrett et al., 1998; Rhodes, 2006). This is also true for feminine traits in women as high levels of female hormones stress the immune system (Rhodes, 2006). Hence, makeup is used to enhance cheekbones and lips that advertise immunocompetence and fertility and reduce chin and nose size (Grammer & Thornhill, 1994).

Female faces

Subjective masculinity made women´s frontal and profile photographs less attractive (Bruce et al., 1994). It also decreased perceived warmth, emotionality, honesty and cooperativeness in Japanese and Caucasian women (Perrett et al., 1998).

Women considered a more feminine face the most attractive when viewing the transformation between the extremely masculine and feminine versions of a female composite (Johnston et al., 2001). Moreover, although significantly feminized Caucasian and Japanese images were preferred to composite photographs and their masculinized versions, evaluators preferred a greater degree of feminization in their own race, indicating that race specific gender variations and attractiveness cues may be learned (Perrett et al., 1998).

Attractive women, whether Caucasian or Japanese, possess feminine features such as larger eyes, high cheekbones, a smaller mandible and fuller lips (Johnston et al., 2001; Perrett et al., 1994). Large neotenous eyes and thin eyebrows increased attractiveness in female Identi-Kit composites but, unexpectedly, thin lips were perceived as more attractive than thick ones (Keating, 1985).

Men find women with thin eyebrows, large eyes, prominent cheekbones, thick lips, and a small nose and chin more attractive (Baudouin & Tiberghien, 2004). Also, photographs of Caucasian college seniors and multiracial Miss Universe candidates were considered more attractive in the presence of neonate features, such as larger more separated eyes and a smaller chin and nose, mature features of wide cheekbones and narrow cheeks and the expressive features of highly set eyebrows, wide pupils and a large smile. Eye height, nose area and cheek and smile widths explained 52.5% of the variance in the mean attractiveness rating (Cunningham, 1986).

However, surprisingly, Grammar and Thornhill (1994) concluded that men considered larger eyes in female composites and individual faces less attractive although prominent cheekbones were found ´sexy`

Male faces

Women considered more pronounced brow ridges, lower positioned eyebrows, wider nostrils, cheekbones and jaws, larger chins and longer lower faces more masculine in male faces (Johnston et al., 2001;

Koehler et al., 2004). They deemed a large nose and a wide mouth healthy and faces with a higher breadth/length ratio attractive, sexy, healthy, and dominant in male composites and individual faces (Grammer & Thornhill, 1994). Men themselves also considered larger eyebrows and cheekbones more attractive in male composites but also selected larger eyes and smaller facial width to lower facial height ratios (Penton-Voak et al., 2001).

The effect of masculinity on male attractiveness is more ambiguous (Valentine et al., 2004). Bruce et al., (1994) verified that it did not affect the attractiveness of male frontal and profile photographs. Johnston et al., (2001) concluded that increased masculinity caused composites to be considered more volatile, threatening, controlling, selfish, dominant and impulsive and less friendly. Increasing masculinity by 50% in averaged Caucasian and Japanese male faces increased perceived dominance and age but decreased perceived warmth, emotionality, honesty, cooperativeness and parent quality (Perrett et al., 1998).

Feminization 'softens' male features associated with negative personality traits (Perrett et al., 1998). It can even make them "pretty" (Bruce et al., 1994). Caucasians and Japanese preferred a neotenous feminized appearance to masculinized or composite male faces (Perrett et al., 1998). Cunningham et al., (1990) verified that neotenous large eyes, mature prominent cheekbones and a large chin, an expressive big smile and high-status clothing made men more attractive. However, both genders and specially women preferred mature features, such as thinner lips and square jaws, in male Identi-Kit composites and did not pay attention to the brows and eyes (Keating, 1985). Thus, while averageness and masculinity contribute independently to male attractiveness, moderate rather than extreme masculinity is preferred (Rhodes, 2006). The most attractive male faces may possess some degree of femininity indicating openness and the ability to cooperate (Valentine et al., 2004)

II

Comparative study of nasal morphology in people with Class I and Class III skeletal malocclusions using lateral cephalograms and facial photographs

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2.1 Introduction

Facial characteristics diverge across the different races (Anić-Milošević et al., 2008; Arshad et al., 2013; Bergman, 1999; Gulsen et al., 2006). The uniformity of the soft tissue layer is also different (Zhang et al., 2007). Nasal form, which has been extensively studied in anthropometric investigations, also exhibits great racial variation (Choe et al., 2006; Farkas et al., 1983, 2005, 1986; Leong & White, 2004, 2006; Troncoso Pazos et al., 2008) (Appendix 1, annex 1).

Nasal function as a respiratory organ contributes to its morphological variation. Noses are comparatively longer and narrower in cold and dry climates and shorter and wider in hot and humid ones (Davies, 1932; Jovanović et al., 2014). The generally leptorrhine or long, narrow Caucasian nose is covered by thinner skin and is more projected and pointed with more vertical nostrils and a larger nostril /infralobule ratio than the African shorter and wider platyrrhine one, while the Asian mesorrhine nose exhibits intermediate characteristics (Baker, 1989; Li et al., 2014). The Caucasian nose has a long nasal bone, more convex dorsum and a supratip break located at three quarters of its length, close to the apex (Milgrim et al., 1996). The greater dorsal depth and at soft tissue nasion make Caucasian eyes appear deeper set (Choe et al., 2006; Leong & White, 2004; Wang et al., 2009). Milgrim et al. (1996) concluded that 69% of Caucasian women exhibit a larger dorsal convexity.

Africans reveal thicker skin, greater alar flaring, a wider alar base, more horizontal nostrils, shorter columella, a smaller nasolabial angle and a shorter and wider, upper and lower dorsum making it appear flattened compared to the Caucasian one (Baker, 1989; Flynn et al., 1989). The angle of divergence between the medial and lateral crus is often obtuse (Furtado, 2016). The thick skin, prominent, subcutaneous fibro-fatty cushion and lack of bony and cartilaginous support contribute to a poorly projected and fuller, amorphous tip that lacks in definition (Furtado, 2016; Isiekwe et al., 2015; Jovanović et al., 2014). However, racial admixture makes nasal morphology vary widely in African Americans (Baker, 1989). While a slightly rounded tip, horizontal nostrils, moderate basal width, a well-proportioned upper and lower dorsum of adequate height and a nasolabial angle of approximately 95° are more common, others show the typically negroid nose with a nasolabial angle of only 65°. Yet others have a more Caucasian appearance and a few, the excessive *hump* that is more characteristic of the Middle east.

Nasal features also vary within different segments of the Chinese population and amongst Asians (Dong et al., 2010). Leong and White (2004) observed a larger alar width and width/length ratio in Eastern populations from Malaysia, Singapore and Hong Kong than in British Caucasians. Eastern women in this study, but not

men, demonstrated a greater tip elevation and nostril display. However, Korean women exhibit a less upwardly rotated tip although a flatter, less inclined dorsum causes a more obtuse nasal tip angle compared to Caucasians (Choe et al., 2006; Hwang et al., 2002). An even flatter nasal base allows Korean men to have a nasal tip angle similar to Caucasians (Hwang et al., 2002). Korean women present a shorter dorsum, more divergent alae and alar base with a more horizontal, ellipsoidal basal appearance and a shorter and wider columella than Caucasians (Choe et al., 2006). The lower upper origin, wider upper two-thirds, flatter dorsum and fuller, less elevated tip contribute to the flat Korean nasal appearance (Choe et al., 2006). The smaller nasal projection in Korean women reinforces the Asian "flat nose" concept while the larger nasofacial angle and similar nasal protrusion do not. Eastern populations from Malaysia, Singapore and Hong Kong also exhibited a smaller nasal projection than Caucasians (Leong & White, 2004).

The South American female nose is wider and less projected than in Caucasians and narrower than in African Americans but exhibits ethnic variability (Milgrim et al., 1996). Interracially mixed Caribbean women from Puerto Rico and the Dominican Republic differ the most from Caucasians due to their thick-skinned ´chata` noses which are shorter and less protrusive than both African and Caucasian ones. They have a short and wide nasal bone, a short, broad, flat dorsum and a wide, low-lying alar cartilage. 95% of them present bulbous tips. Central American noses present broad roots and bases and bulbous tips to a smaller extent. The South American nose has a narrower root, broader base, fuller tip and larger dorsal convexity than Caucasian ones. Bulbous tips were present in 34% and 54% of Central and South American women, respectively. The supratip break is situated in the mid-dorsum in Caribbean women and at approximately two thirds of dorsal length in Central and South American women

Indian women have a smaller nasal length, height, projection, columella thickness and nasolabial angle and a more rounded nasal tip than Caucasians. As in Koreans, diverging alar cartilages and a wider base cause a larger width/length ratio and a more horizontal ellipsoidal basal appearance in comparison with the more triangular Caucasian architecture (Patil et al., 2011).

A dorsal *hump* was found in 49, 63 and 68% of Caribbean, Central and South American women respectively (Milgrim et al., 1996). Straight, concave and convex dorsums were discerned in 70, 25 and 5% of Indian women, respectively (Patil et al., 2011).

2.1.1 Nasal growth

Anterior-inferior soft tissue nasal growth accompanies that of the maxilla and increases its prominence in the facial profile (Chaconas, 1969; Subtelny, 1961). Incremental nasal growth and relative size are generally greater in men, except at the female growth spurt (Chaconas, 1969; Ferrario et al., 1997; Posen, 1967; Sforza et al., 2011). The greatest nasal growth velocity occurs at 11±0.9 years in girls and 12.6±0.3 years in boys and coincides with the phase of maximal increase in body height. 98% of girls and boys achieve nasal maturity at 15.8 and 16.9 years, respectively (van Der Heijden et al., 2008).

Nasal hard and soft tissues are significantly intercorrelated as they have the same genetic background and are exposed to the same environmental factors (Ferrario et al., 1997; Robison, Rinchuse, & Zullo, 1986).

However, it is soft tissue growth that is responsible for gender-based size differences (Prahl-Andersen et al., 1995). The nose continues to grow and change throughout life even after attaining skeletal maturity (Ferrario et al., 1997, 1999; Genecov et al., 1990; Posen, 1967; Prahl-Andersen et al., 1995; Sforza et al., 2011). Continuous growth, although manifested at a slower rate after the age of 20, results in the elderly exhibiting bigger noses than youth of the same gender and ethnicity (Ferrario et al., 1997; van Der Heijden et al., 2008; West & McNamara, 1999; Zankl et al., 2002).

The nose, lips and chin descend without altering the nasolabial angle in both genders between the ages 17 to 40 years (West & McNamara, 1999). Continual nose and chin advancement, which is greater in men, cause lip recession relative to Ricketts aesthetic line (Blanchette et al., 1996; Chaconas & Bartroff, 1975; Foley & Duncan, 1997; Nanda et al., 1990; Subtelny, 1961; West & McNamara, 1999). The observed reduction in the total soft tissue convexity angle between the ages 5 and 45 years was attributed to nasal tip advancement, although during the latter half of this period, more vertical nasal tip growth or greater soft tissue pogonion advancement increased the angle by an average 2.1 and 1.3°, in men and women respectively (Anić-Milošević et al., 2008; Bishara et al., 1998). However, Subtelny (1961) suggested that the continual forward nasal growth in relation to other soft tissue components of the facial profile should cause a progressive age-related decrease in this angle.

The one-year old nose appears wide as its width, protrusion and height represent approximately 79.5, 51 and 59% of their 18-year-old dimensions, respectively. Subsequent growth, which is largest in the vertical dimension and smallest in width, corrects this imbalance (Farkas et al., 1992; Ferrario et al., 1997; Subtelny, 1961). Thus, width represents 65% of height at maturity in Caucasians (Farkas et al., 1992). A cross-sectional study verified that nasal height increased more than length while width grew the least in a sample of 3 to 80 year old people but no consistent changes in the width/height ratios (Sforza et al., 2011). The change in height /width proportion was confirmed in a longitudinal study performed in childhood, adolescence and between 19 and 32 years of age (Ferrario et al., 1997).

Thus, the nasal length, height, protrusion, morphological, nasal base and nostril width and height increase until old age (Özkoçak & Özdemir, 2018; Sforza et al., 2011). 51 to 64 year old Italian men and 65 to 80 year old women presented nasal volumes that were 129 and 118% of the mean 18 to 30 year old values, respectively (Sforza et al., 2011). 65 to 80 year old men and 51 to 64 year old women exhibited morphological widths that were 15 and 22% larger than the 18 to 30 year old values, respectively (Sforza et al., 2011). 20 to 40-year-old male Turks also demonstrated a smaller width than 40 to 60 and 60 to 80 year-olds. The alar base and nasal root widths also increased progressively between the three age groups (Özkoçak & Özdemir, 2018).

Italians revealed little change in nasal height and length after 30 years of age, with the oldest Italians exhibiting a height that was only 5% more than the 18-30 year old value (Sforza et al., 2011). 20 to 40 year old Turkish men did not exhibit a different nasal height but a smaller nasal length than older ages groups (Özkoçak & Özdemir, 2018).

Nasal protrusion in 51 to 64 year old men and 65 to 80 year old women reached 121% and 126% of the mean 18 to 30 year old value, respectively (Sforza et al., 2011). It increased progressively with age in Turkish

men (Özkoçak & Özdemir, 2018). Thus, sagittal nasal tip growth has to be considered in orthodontic treatment plans (Foley & Duncan, 1997).

Cephalograms obtained at approximately 17 years and also in men and women in their late 30s and 40s demonstrated that the nasolabial angle did not significantly change over time (West & McNamara, 1999). Yet, 20 to 40 year old Turkish men revealed a larger angle than older ones (Özkoçak & Özdemir, 2018).

Nasal shape itself changes little during growth although the nasal tip angle becomes more acute (Subtelny, 1961). It was 1-2% smaller in 65-80 year old Italians than in young adults (Sforza et al., 2011) but did not reveal age related changes in Turkish men (Özkoçak & Özdemir, 2018). Another investigation found an almost constant value in different Italians belonging to the ages groups of 6-12 and 11-14 years with an additional record between 19 and 32 years of age (Ferrario et al., 1997). The nasal prominence angle also did not change significantly between the ages of 3 and 80 years in Italians (Sforza et al., 2011).

2.1.2 Variability in published nasal measurements

Apart from racial variation, inconsistencies in the values reported by different authors for different variables can be related to factors such as methodology, age of the sample population and the use of individuals belonging to all skeletal classes or only those with Class I occlusion and/or harmonious profiles (Amini et al., 2014; Anić-Milošević et al., 2008; Nguyen & Turley, 1998). Many authors require the presence of ideal occlusions in their sample (Amini et al., 2014; Flynn et al., 1989; Malkoc et al., 2009). However, most direct anthropometric studies do not use the type of malocclusion as an inclusion criterion (Farkas et al., 2005, 2007). Other authors use a harmonious profile as the defining factor in sample selection (Burstone, 1967; Fitzgerald et al., 1992). Still other authors use both ideal occlusion and pleasant profiles as a pre-requisite for inclusion (Hwang et al., 2002; Malkoc et al., 2009). Differences in the soft tissue layer resulting in a Class II soft tissue profile accompanying a Class I occlusion can cause further variation amongst study populations (Nguyen & Turley, 1998). Fernandez-Riveiro et al., (2003) cited this soft tissue divergence from the underlying dentoskeletal profile to justify their inclusion of all skeletal classes. Farkas et al., (2005) measured a few nasal variables in a limited sample of 15 Portuguese of each gender and of all malocclusion types.

Moreover, different methods such as direct anthropometry (Borman et al., 1999; Uzun & Ozdemir, 2014), lateral cephalograms (Begg & Harkness, 1995; Flynn et al., 1989), photographs (Al-Qattan et al., 2012; Anić-Milošević et al., 2008; Troncoso Pazos et al., 2008), facial plaster models (Mishima et al., 2001) and three dimensional registration (Aung et al., 2000; Dong et al., 2010) have been used to study the nose. Three-dimensional tools can produce results different from two-dimensional methods (Sforza et al., 2004).

Indirect measurements in nose models incorporate errors induced by dimensional changes in impression materials and models, in addition to the possible soft tissue compression caused by the impression (Vasudavan et al., 2012). Direct anthropometric measurement, which besides photography, is the most commonly used tool to study nasal morphology, may not be accurate due to lack of nasal bone support and the resultant skin compression by callipers and contact scanners (Burke & Hughes-Lawson, 1989; Sforza et al., 2004). Reference points are difficult to identify and there is inter and intra-observer variation in calliper positioning and reading

(Sforza et al., 2004). Sforza et al. (2004) stated that, although a digital electromagnetic digitizer yielded significantly higher measurements of nasal length and protrusion than conventional callipers, with mean differences of 1.3±0.5 mm and 1.4±0.3, respectively, this difference was not clinically significant. However, even a millimetre difference can cause a considerable difference in nasal appearance (Foley & Duncan, 1997; Rosen, 1988).

Three-dimensional digital techniques include stereophotogrammetry, 3D computed tomography and laser scanning (Baik & Kim, 2010). These permit a quantification of nasal morphology in area and volume but with the disadvantage of a high cost (Chung et al., 2008; Nkenke et al., 2008). They are also not always available (Hemmatpour et al., 2016) and may often involve a lengthy imaging acquisition procedure (Nkenke et al., 2008). Moreover, there are no standardized methods of assessment in the 3D reconstruction software as there are for cephalometric analysis of radiographs and thus, the interpretation of results can vary (Moroi et al., 2014). The wide, curved nature of tissues also makes landmark identification difficult with three-dimensional imaging (Betts et al., 1993; Ryckman et al., 2010). The use of conventional three-dimensional tomography for serial measurements is limited due to the potential radiation risk (Marşan et al., 2009; Park et al., 2012) and worse resolution than conventional photography (Marşan et al., 2009). Cone-beam computed tomography enables visualization of the bone and soft tissue (Hellak et al., 2015; Park et al., 2012; Ryckman et al., 2010). However, the nasal tip cannot always be visualized with geometric precision, as the limited detector size causes truncated view artefacts in the areas located near the edge of the field of view in the nasal region (Liebregts et al., 2015). Due to the risk of radiation exposure (Hellak et al., 2015; Hemmatpour et al., 2016; Verdenik & Ihan Hren, 2014), authors suggest it´s use to evaluate nasal structures only when already recommended for other purposes (Hellak et al., 2015; Hemmatpour et al., 2016). Hellak et al. (2015) stated that there is no indication for its use in soft tissue evaluation.

Optical laser scanning is minimally invasive, easy to use, economical and of high resolution (Soncul & Bamber, 2004). It generates results that are independent of spatial orientation of the profile (McCance et al., 1992; Moss et al., 1994). However, it does not provide osseous information (Oh et al., 2013; Verdenik & Ihan Hren, 2014). The lack of stable references prevents standardization of image registration (Oh et al., 2013) and can lead to image superimposition errors (Park et al., 2012). The evaluation criteria for the numerical comparison between two images have also not been established (McCance et al., 1992; Moss et al., 1994). Additionally, posture, movement, breathing and facial expression also contribute to error (Baik et al., 2007; Baik & Kim, 2010). While some authors opine that resolution and accuracy are adequate (Soncul & Bamber, 2004; Yamada et al., 2010), others infer that laser scanning does not provide adequate resolution for soft tissue assessment, unlike photography (Choi et al., 2014). Three-dimensional photography does not allow accurate image standardization due to lack of stable references (Oh et al., 2013). As a conventional light-based method, it does not provide information about the structures underlying the skin and the presence of shadows may make it impossible to evaluate some areas (Hellak et al., 2015). As in conventional photography, different facial expressions may also bias research results (Metzler et al., 2014).

While lateral cephalograms have been used to evaluate the nose, they only permit measurements in the midsagittal plane (Honrado et al., 2006). Moreover, their analysis is limited to a small constellation of nasal points and variables (Gassmann et al., 1989; McCance et al., 1992; Moss et al., 1994). The more complex, traditional nasal evaluation essentially requires photographs (Gassmann et al., 1989; Guyuron, 1988). Profile photographs permit the identification of both midsagittal landmarks and laterally located ones, such as the alar base curvature (Farkas & Deutsch, 1996; Nguyen & Turley, 1998; Ritto et al., 2011) Frontal photographs depict frontal nasal morphology, which is more important to the patient and make transverse measurements possible (Hemmatpour et al., 2016; Phillips et al., 1984).

2.1.3 Errors in cephalometric measurements

Random errors are caused by non-standardized lateral cephalograms and incorrect patient positioning (Battagel, 1993; Houston, 1983). The head holder and film positions must be fixed and the metal markers in the ear rods aligned. Poor head placement within the cephalostat or anatomical variation in the external auditory meatus prevent the patient´s mid-sagittal plane from being parallel to the film (Houston, 1983).

Projection errors occur since lateral cephalograms are two-dimensional images of three-dimensional objects (Baumrind & Frantz, 1971a). As the x rays originate from a small source and are not parallel to each other, magnification depends on the plane where the cephalometric point is located. Distortion occurs due to shortening of distances between points situated in different planes or the radial displacement of all points not located on the principal axis (Baumrind & Frantz, 1971a). A metallic ruler in the midsagittal plane eliminates the systematic error caused by comparing lateral cephalograms with different magnifications (Houston, 1983). Although angular measurements are inherently less affected by magnification and by projection errors that linear ones, linear measurements along the midsagittal plane possess similar magnification due to the constant distance from the film and x-ray source (Baumrind & Frantz, 1971b).

The greatest random errors are caused by the incorrect identification of cephalometric points (Baumrind & Frantz, 1971a; Houston et al., 1986). Evaluators should be calibrated in the identification of well-defined points to avoid systematic errors (Baumrind & Frantz, 1971a; Houston, 1983). Otherwise points should be marked by the same experienced individual (Battagel, 1993) using adequate ambient light (Baumrind & Frantz, 1971a; Houston, 1983). Points located along curves, such as pogonion, generate greater errors than those on sharp borders, such as the incisal edge or the centre of an anatomical structure, such as sella (Baumrind & Frantz, 1971a). Projected points, such as an incisor apex, involve a conceptual decision based on anatomical knowledge. Adjacent and overlapping structures make internal points difficult to identify. A prospective estimation of measurement error indicates the reliability of each point and helps in choosing variables for the investigation (Battagel, 1993; Houston, 1983).

Measurement error contributes more to the total linear or angular measurement as the distance between two reference points decreases (Baumrind & Frantz, 1971b). The random error in locating a point common to two linear or angular measurements contributes to the value of the two measurements inflating the apparent

correlation between them and escapes detection by simple statistical tests. These correlations are avoided by measuring the two variables separately or by tracing each structure separately.

Errors in the superimposition of lateral cephalograms should also be assessed (Baumrind & Frantz, 1971a). Errors in locating reference points caused by superimposition errors are for geometric reasons smaller than the superimposition errors themselves.

Systematic and random errors in cephalometric point location must be assessed separately (Houston, 1983). The replication of an insufficient number of cases increases the risk of systematic errors escaping undetected. Systematic bias can be reduced by randomizing the sequence of tracings from different groups without the investigator knowing which group the record belongs to, although this procedure increases the random error (Houston, 1983; Phillips et al., 1984). All serial cephalometric tracings of an individual are performed at the same time to minimize the variance of error, although the risk of bias increases (Houston, 1983)

The variance from random error can increase the total variance so that a result that would be significant in the absence of error becomes non-significant. Ideally, the error variance should not exceed 3% of the total and beyond 10% indicates an inappropriate measurement method (Midtgard et al., 1974). Houston (1983) stated that this goal might not always be achieved, especially in serial studies, even with a very small random error. In these studies, the error in measuring each record contributes to the error variance and the reliability coefficient of interest is the serial change and not individual records, as in cross-sectional studies (Houston, 1983). Increasing the number of cases by 10% can be as effective in reducing the standard error of the difference between means as eliminating 10% of the variance error.

Lack of statistical significance can be due to measurement errors or an insufficient number of cases Also, statistical significance may not have clinical meaning and vice versa (Battagel, 1993). The inclusion of an excessively large number of cases may cause a very small difference between groups to be demonstrated as statistically significant even though it is of no clinical importance (Houston, 1983).

2.1.4 Errors in photography

A standardized photographic technique favours reproducible and reliable measurements (Gomes et al., 2013; Zhang et al., 2007). Zhang et al., (2007) demonstrated excellent reliability with intraclass correlation coefficients greater than 0.90 for angular and linear, sagittal and vertical measurements in profile photographs. However, a non-standardized photographic technique may not show a clinical improvement that actually occurred or may even aggravate unwanted features (Claman et al., 1990; Nechala et al., 1999). Head rotation or tilting can make landmark identification difficult (Betts et al., 1993; Hemmatpour et al., 2016; Park et al., 2012).

Unlike lateral cephalograms, where reference points are either in the mid-sagittal plane or, in the case of bilateral structures, projected onto this plane, structures closer to the camera are magnified in photographs (Bishara, Cummins, et al., 1995; Gavan et al., 1952; Gomes et al., 2013). The nasal tip appears larger in a frontal photograph while the lateral part of the nose is magnified in a profile one. This error does not affect

structures located on the midsagittal plane in profile photographs which are at the same distance from the lens (Bishara, Cummins, et al., 1995; Gomes et al., 2013). The object-lens distance should be at least ten times the facial width to reduce photographic error to less than 1% (Gavan et al., 1952; Muradin et al., 2007).

Optimized lighting that produces a sharp transition between the profile and the background helps in landmark identification. Differences in the intensity and direction of lighting can affect facial features (Bishara, Cummins, et al., 1995; Gavan et al., 1952).

Linear measurements are more reliable than angular measurements (Bishara, Cummins, et al., 1995). As in cephalometry, the reliability of angular and linear measurements is affected by the error associated with locating each pair or triad of points incorporated in the measurement (Phillips et al., 1984). Researchers have to be provided with a detailed definition of each reference point and trained in its identification in a calibration phase (Bishara, Cummins, et al., 1995; Bishara, Jorgensen, & Jakobsen, 1995; Phillips et al., 1984). Frontal photographs allow more reliable measurements than profile photographs, as they have more distinctive reference points (Bishara, Cummins, et al., 1995). Measurements that include points located on curves, such as subnasale or pogonion, tend to be less reliable (Bishara, Cummins, et al., 1995; Phillips et al., 1984). Phillips et al. (1984) concluded that pronasale and the most anterior point of the nostril were the most reliable points while gonion and the malar prominence were the least reliable in profile photographs.

Landmarks situated at the junction of two soft tissue curvatures, such as subalare, are more difficult to identify than those on the edge of a soft tissue structure such as alare (Betts et al., 1993). A double chin can make it difficult to identify soft tissue menton in frontal photographs (Bishara, Cummins, et al., 1995). Mandibular opening, shadows at the corners of the mouth and lip tension, all contribute to error (Bishara, Cummins, et al., 1995; Gomes et al., 2013). Photographs must have sufficient sharpness to permit the correction identification of points such as alare (Aksu et al., 2010).

The superimposition of coordinated lateral cephalograms and photographs allows assessing the relationship between soft and hard tissues (Phillips et al., 1984). For this, the magnification factor in both has to be corrected (Nguyen & Turley, 1998; Zhang et al., 2007). Angular variables overcome problems caused by magnification (Gomes et al., 2013). The operator must also be careful to avoid linear, angular and shape distortions during digital photo superimposition (Park et al., 2012).

2.2 Justification for the investigation

Many researchers have highlighted the importance of evaluating both the internal structure and external anatomy of the nose (Mitchell et al., 2007; Schendel & Carlotti, 1991). The nose is overshadowed in the presence of a smile (Godinho et al., 2020). However, in its absence, nasal length, width, projection, rotation and shape affect facial aesthetics (de Assis et al., 1996a; Starck & Epker, 1996). This is due to its central position within the face in both the vertical and horizontal dimensions, which makes it a difficult feature to ignore (Altman & Oeltjen, 2007; Begg & Harkness, 1995; Isiekwe et al., 2015; Pearson & Adamson, 2004; Uzun & Ozdemir, 2014). Moreover, nasal shape is directly or indirectly affected by orthodontic treatment (Begg & Harkness, 1995; Isiekwe et al., 2015; Khan et al., 2019). Nose projection is an important part of the

orthodontic extraction decision (Isiekwe et al., 2015; Khan et al., 2019; Konstantonis et al., 2018; Naeem et al., 2015).

The magnitude and direction of surgical maxillary movement is decided based on the anatomical characteristics of the deformity and should aim to produce optimal aesthetic and functional results (Ghassemi et al., 2015). The surgery´s effect on the nasolabial region depends upon the pre-existing nasal form and on maxillary position in relation to the upper lip (Conley & Boyd, 2007; Soncul & Bamber, 2004). Changes can be beneficial or unsightly depending on the pre-surgical nasal shape and dimensions (Hemmatpour et al., 2016; Schendel & Carlotti, 1991). Moreover, the pre-surgical nasal morphology actually affects the susceptibility to these changes (Betts et al., 1993; Chung et al., 2008; McFarlane et al., 1995).

Hence, surgery and soft tissue manipulation must be modified to either correct previous nasal deformities or to minimize or avoid unfavourable changes in an attractive nose (Hemmatpour et al., 2016; Mitchell et al., 2007). Any expected deterioration in nasal aesthetics and the need for secondary corrective surgery must be communicated to the patient prior to surgery and be part of the informed consent (Altman & Oeltjen, 2007; Chung et al., 2008; Howley et al., 2011). Thus, nasal morphology has to be evaluated and quantified before investigating the influence that maxillary and soft tissue surgical manipulation will have on the nasolabial aesthetics (Mitchell et al., 2007). A detailed evaluation of each patient's nose helps in determining the magnitude by which each of its components will be affected by maxillary surgery (Gassmann et al., 1989; Starck & Epker, 1996). An in-depth knowledge of nasal morphology and anatomy, of its close relationship with the maxilla and of the factors that enhance nasal and facial harmony enable the clinician to achieve optimal results for each individual (Altman & Oeltjen, 2007).

Authors have emphasized the importance of racial differences in nasal morphology and the influence that they have on surgical results. Thus, the surgical procedure has to be modified according to the nasal characteristics that epitomize the patient's ethnicity (Schendel & Williamson, 1983; Worasakwutiphong et al., 2015). Post-surgical changes are of special importance in Asians due to the wider, blunt presurgical nose with greater nostril exposure (Baik et al., 2000; Chung et al., 2008). Clemente-Panichella et al. (2000) highlighted the differences in nasolabial characteristics between the Caucasian and Hispanic surgical population and their response to maxillary surgery. Esenlik et al. (2011) concluded that the results of their investigation could probably only be applied to Turkish noses. Many authors have reiterated the need to have different ratios of soft tissue /hard tissue movement for people of different racial origin (Clemente-Panichella et al., 2000; Lew, 1990).

Studies suggest that an average face with anatomical dimensions within the norm may be considered more attractive (Alley & Cunningham, 1991; Rhodes & Tremewan, 1996; Valentine et al., 2004). Faces that least deviate from the cultural norm are considered the paradigm of facial beauty (Heppt & Vent, 2015). As the concept of beauty is highly subjective, the results of research in one race cannot be applied to individuals from other races (Sushner, 1977). Specifically, what is considered attractive in one culture at a particular time may be unacceptable in another culture at the same time or at a different time point (Oluwajana, 2015; Sinko et al., 2012). Hence, before investigating the objective and aesthetic nasal effects of maxillary surgery in

individuals with class III malocclusions, it is essential to know whether their pre-surgical nose differs from the one seen in class I individuals. Studying the average nose morphology could also help to formulate treatment plans as it may differ from the guidelines generally suggested and used by rhinoplasty surgeons (Leong & White, 2006). Hence, this investigation aims to evaluate nasal morphology in individuals with class I occlusions and class III skeletal and dental malocclusions.

2.3 Aims of the investigation

The objectives of the investigation were as follows:

1) To study the nasal morphology of adults with Class III malocclusions, in comparison with individuals with Class I skeletal malocclusions according to the following null hypothesis:

H0: There are no significant differences in the cephalometric measurements of the nasolabial region between individuals with Class I and Class III skeletal and dental malocclusions.

H1: There are significant differences in the cephalometric measurements of the nasolabial region between individuals with Class I and Class III skeletal and dental malocclusions.

2) To compare nasal morphology between men and women.

H0: Nasal form and dimensions do not exhibit sexual dimorphism.

H1: Nasal form and dimensions exhibit sexual dimorphism

3) To evaluate the correlation between the various linear and angular measurements of the nose.

H0: There are no significant correlations between the various linear and angular measurements of the nose.

H1: There are significant correlations between the various linear and angular measurements of the nose.

4) To correlate the various linear and angular measurements of the nose with the cephalometric variables of the maxilla and face.

H0: The cephalometric measurements of the nasal region do not correlate significantly with the cephalometric measurements of the maxilla and face.

H1: The cephalometric measurements of the nasal region correlate significantly with the cephalometric measurements of the maxilla and face.

2.4 Materials and methods

The patients participating in this study were chosen from pre-existing records from the Department of Orthodontics of the College of Dental Medicine of the University of Lisbon and the private clinics of various specialists in Orthodontics who form part of its faculty. The initial contact to explain the nature of the investigation to the patients was established either by telephone or in a routine consultation for the control of retention appliances, either by the investigator, one of the collaborating specialists or the dental hygienist from the Department of Orthodontics. The subject of the study and the necessity of the lateral cephalograms and photographs were explained to the patients in person. Patients who agreed to participate in the study signed an

informed consent. The investigation and consent form were approved by the Ethics committee of the College of Dental Medicine of the University of Lisbon.

2.4.1 Inclusion and exclusion criteria

The general inclusion criteria were

- Adult non-growing patients between 18 and 30 years of age.
- Caucasian ancestry.
- Lips supported by a natural dentition.

The inclusion criteria for individuals in the sample with Class I malocclusion were:

- Skeletal basal Class I relationship with an ANB angle that varied between > 0° and 4°
- Class I molar and canine relationship.
- Overjet and overbite between 1 and 3 mm.
- A profile considered harmonious by 3 specialists in orthodontics.

The inclusion criteria for individuals in the sample with Class III malocclusion were:

- Skeletal basal Class III relationship with an ANB angle < 0°,
- Class III molar and canine relationship.
- Ovejet ≤ 0 mm.

The criteria for exclusion of individuals from the sample were:

- Extensive restorations of anterior teeth.
- History of previous orthodontic treatment.
- History of previous osteotomies or other facial or nasal surgeries.
- Cleft lip and/or palate or other congenital anomalies.
- Marked facial asymmetry or *canting* of the lips.
- History of maxillo-facial trauma.

2.4.2 Diagnostic tools used in the investigation

Photographs

This investigation used profile and frontal photographs that are routinely performed prior to orthodontic treatment. For consistency, semi-standardized photographs were provided by specialists who used the photographic method routinely employed in the Department of Orthodontics of the University of Lisbon.

Each patient stood in front of a homogeneous white background in a relaxed upright position with his arms resting at his side. The patient was asked to keep his lips relaxed and his eyes fully open and look at a distant point at eye level. The height of the camera was adjusted to the height of the subject to be photographed. Patients taller than the photographer sat on a rotating chair. Spectacles and jewellery were removed and the patient´s forehead, neck and ears were clearly visible during photography.

A Nikon D80 camera with a 105-mm Sigma DG Macro lens and a Sigma EM-140 DG ring flash was used. Depth of field and shutter speed were kept constant at F10 and 60, respectively.

The direction of illumination from the flash was adjusted so that light was directed downward from above, in the frontal photograph, and from the front towards the back in the profile photograph. As such, the shadows were directed toward the zone of the chin and mandibular angle in the frontal photograph and toward the back of the head in the profile photograph.

The profile and frontal photographs were superimposed on the lateral cephalogram using the Nemoceph® program (Nemotec, Madrid, Spain). Soft tissue nasion was marked in the midline at the level of the highest points of the superior palpebral sulci in the frontal photographs using the Adobe Photoshop CS5 program® (Adobe Inc. San José, California) (Farkas et al., 1986; Furtado, 2016). A line was then traced passing through soft tissue nasion, menton and the midline of the philtrum. The photograph was then calibrated using the ruler in the lateral cephalogram and the homologous distance between soft tissue nasion at the level of the frontonasal suture and menton in the profile photographs.

Lateral cephalograms

This investigation used lateral cephalograms obtained with the aid of a cephalostat and with the Frankfurt horizontal plane parallel to the floor. The images had to be of adequate quality with highly visible skeletal structures and soft tissue contours and obtained in centric occlusion with the lips in a resting position. Radiographic films were scanned using an Epson Perfection V700 PHOTO scanner.

The horizontal reference plane (x) was constructed 7° below the Sella-Nasion line with its origin at Sella using the Adobe Photoshop CS5 program™ (Adobe Inc. San José, California), in an adaptation of the method used by Legan and Burstone (Legan & Burstone, 1980). A line perpendicular to the horizontal plane through Sella was used as the vertical reference plane (y). The profile and frontal photographs were superimposed over the lateral cephalogram using the Nemoceph program®. All cephalometric variables were measured using the same program under the same conditions of lighting (Baumrind & Frantz, 1971a; Houston, 1983). Calibration was achieved using the ruler visible in each lateral cephalogram.

The cephalometric analysis also used the palatal plane (PP) that unites the points anterior nasal spine and posterior nasal spine and the mandibular plane (MP) defined as the tangent to the lower border of the mandible that passed through hard tissue menton. The pterygomaxillary plane (PtmP) was defined as the plane tangent to the anterior border of the pterygomaxilary fissure that passed through the pterygomaxillary point.

2.4.3 Cephalometric points

Hard tissue cephalometric points (Figure 2.2)

Nasion (N)	The most anterior point of the frontonasal suture in the midsagittal plane.
Sela (S)	The point situated in the radiographic centre of the skeletal concavity of the sella turcica.
Nasion 1 (N1)	The most concave point of the nasal bone in the midsagittal plane.
Nasion 2 (N2)	The most convex point of the nasal bone in the midsagittal plane.

Rhinion (Rh)	The most anterior-inferior point at the extremity of the nasal bone in the midsagittal plane.
Anterior nasal spine (ANS)	The point at the anterior extremity of the nasal spine.
Posterior nasal spine (PNS)	The point at the posterior extremity of the hard palate.
A point (A)	The deepest point on the anterior contour of the maxillary alveolar bone.
B point (B)	The deepest point on the anterior contour of the mandibular alveolar bone.
Menton (Me)	The most inferior point on the contour of the mandibular symphysis.
Pterygomaxillary point (Ptm)	The projected intersection of the inferior margin of the pterygomaxillary fissure with the hard palate.

Soft tissue cephalometric points

Frontal analysis (Figure 2.1)

Soft tissue Nasion (N´)	Lateral cephalograms: The soft tissue point that corresponds to the most anterior point on the frontonasal suture in the midsagittal plane. Frontal photographs: The centre of the horizontal line connecting the highest points of the bilateral superior palpebral sulci.
Endocanthium (En)	The most medial point on each eye fissure.
Nasal root (R)	The most lateral point on the narrowest part of the nasal root in the frontal view.
Mid-dorsum (Mn)	The midpoint of the nasal length (N´-Prn) that separates the upper dorsum from the lower dorsum.
Pronasale (Prn)	The most protrusive point of the nasal tip.
Frontal subnasale (Snf)	The most inferior point of the columella seen in the frontal view.
Alare (Al)	The most lateral point on the outer contour of each nasal wing.
Alar curvature (Ac)	The most lateral point on the basal curvature of each alar cartilage corresponding to the facial insertion of the base of the nasal wing.
Subalare (Sbal)	The point on the inferior limit of each alar base at its junction with the upper lip in the frontal view.
Lateral Nostril (NrL)	The most superior and lateral point of each nostril in the frontal view.
Frontal Columella (Cmf)	The most posterior-inferior and lateral point of the columella in the frontal view.

Profile analysis (Figure 2.2)

Soft tissue Glabela (G´)	The soft tissue point that corresponds to the most anterior point on the frontal bone in the midsagittal plane.
Soft tissue Nasion (N´)	The midsagittal soft tissue profile intersection of a plane that passed through nasion and was parallel to the horizontal plane x.
Nasal dorsum (Nd)	The most prominent point on the upper part of the nasal dorsum in the mid-sagittal plane.
Mid-dorsum (Mn)	The midpoint of the nasal length (N´-Prn) that separates the upper dorsum from the lower dorsum.

Supratip concavity (Stp)	The deepest point in the inferior third of the nasal dorsum in the midsagittal plane situated between the points mid-dorsum and inferior dorsum.
Inferior dorsum (Id)	The point of greatest convexity on the lower part of the nasal dorsum in the midsagittal plane.
Pronasale (Prn)	The most protrusive point of the nasal tip.
Columella (Cm)	The most anterior-inferior point of the nasal columella in the midsagittal plane.
Subnasale (Sn)	The point of intersection between the columella and the labial philtrum in the profile view.
Alar curvature (Ac)	The most lateral point on the basal curvature of each alar cartilage corresponding to the facial insertion of the base of the nasal wing.
Anterior Nostril (NrA)	The most anterior-inferior point of the nostril in the sagittal plane.
Superior Nostril (NrS)	The most superior point of the nostril identified in the profile view.
Upper lip (Ls)	The point situated on the mucocutaneous junction of the upper lip in the midsagittal plane.
Soft issue Pogonion (Pg´)	The most anterior point on the soft tissue contour of the chin in the midsagittal plane.
Soft tissue Menton (Me´)	The most inferior point on the soft tissue contour of the chin in the midsagittal plane.

Figure 2.1 Soft tissue cephalometric points in the frontal view

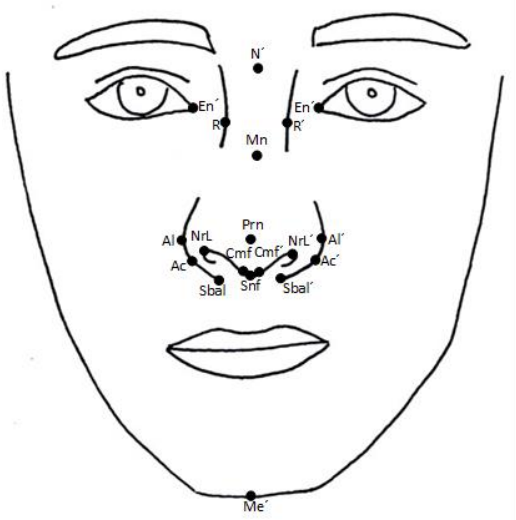


Figure 2.2 Hard and soft tissue cephalometric points in the profile view, horizontal (*x*) and vertical (*y*) reference planes

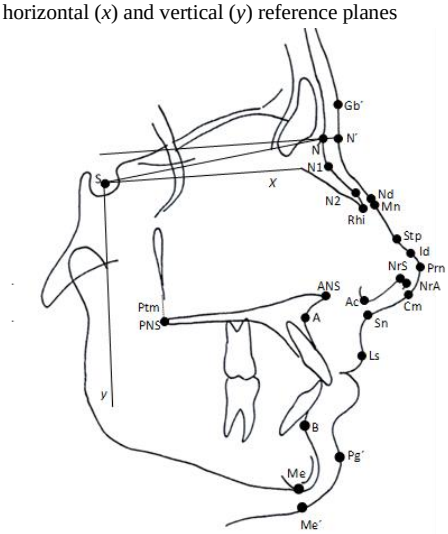


Figure 2.3 Skeletal facial and nasal measurements

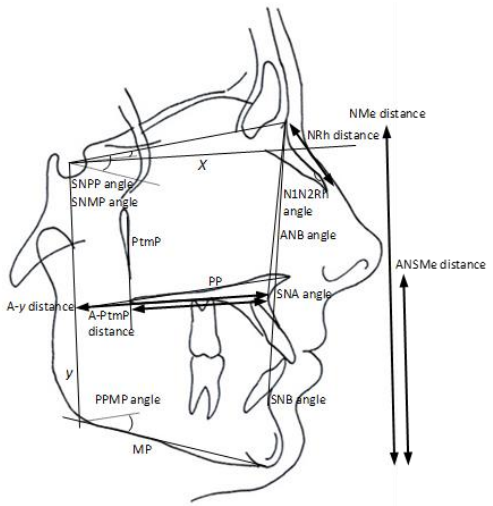


Figure 2.4 Direct linear frontal soft tissue measurements

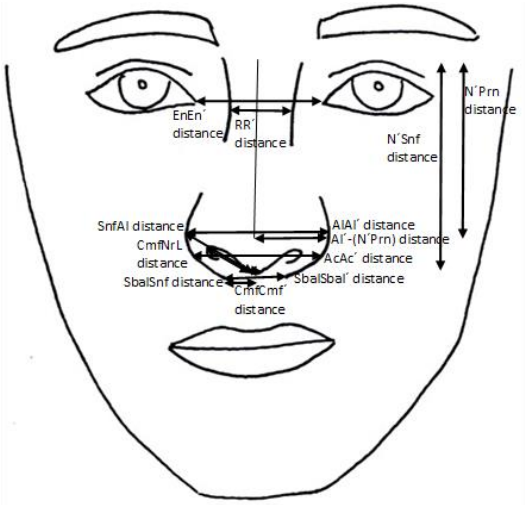


Figure 2.5 Angular frontal nasal measurements

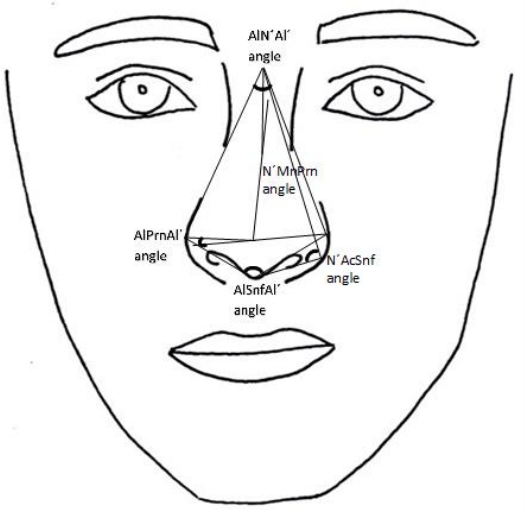


Figure 2.6 Soft tissue angular facial measurements

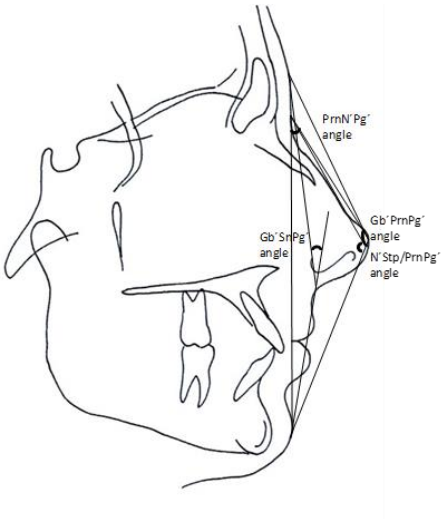


Figure 2.7 Direct linear profile nasal measurements

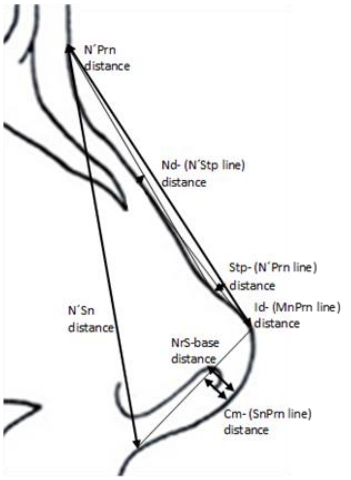


Figure 2.8 Linear measurements performed parallel to the horizontal reference line *x*

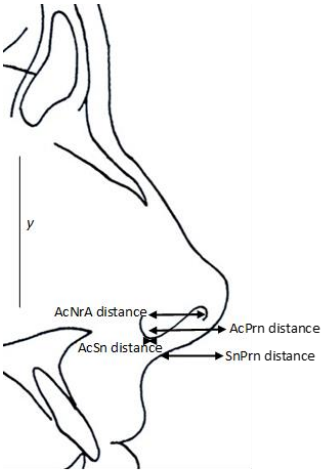


Figure 2.9 Angles of nasal form and nasal projection

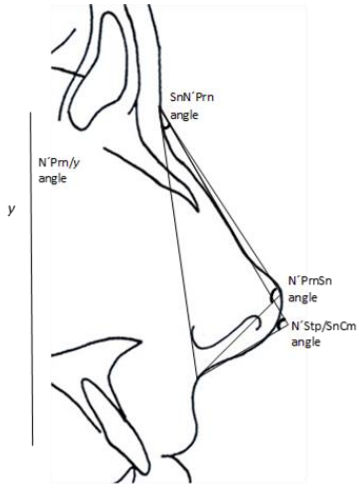
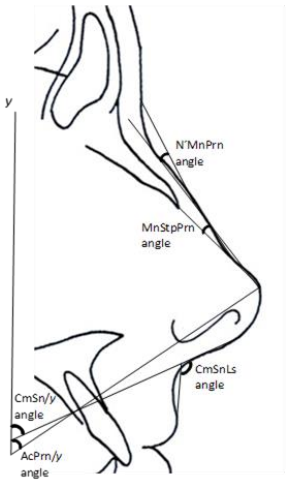


Figure 2.10 Angles of dorsal form and nasal rotation



2.4.4 Cephalometric measurements

All linear and angular measurements were measured in units of millimetres and degrees, respectively.

1. Skeletal facial measurements

Linear vertical measurements (Figure 2.3)

1	Total facial height TFH (N-Me)	Distance between the points nasion (N) and menton (Me).
2	Lower facial height LFH (ANS-Me)	Distance between the points anterior nasal spine (ANS) and menton (Me).
3	Lower facial height LFH (ANS-Me): Total facial height TFH (N-Me) ratio	Ratio between the anterior nasal spine-menton distance and the nasion-menton distance.

Linear measurements performed parallel to the horizontal reference line *x* (Figure 2.3)

4	Sagittal maxillary position (A-*y*)	Distance between the A point and the vertical reference line *y*.
5	Maxillary length (A- PtmP)	Distance between the A point and the Pterygomaxillary plane (PtmP).

Angular measurements (Figure 2.3)

6	SNA angle (SNA)	Angle between the sela-nasion line (SN line) and the nasion-A point line (NA line).
7	SNB angle (SNB)	Angle between the sela-nasion line (SN line) and the nasion-B point line (NB line).
8	ANB angle (ANB)	Angle between the nasion-A point line (NA line) and the nasion-B point line (NB line).
9	Maxillary inclination (SN-PP)	Angle between the sela-nasion line (SN line) and the palatal plane (PP).
10	Mandibular plane inclination (SN-MP)	Angle between the sela-nasion line (SN line) and the mandibular plane (MP).
11	Vertical intermaxillary angle (PP-MP)	Angle between the palatal plane (PP) and the mandibular plane (MP).

II. Soft tissue measurements in frontal photographs

Direct transverse linear measurements (Figure 2.4)

1	Inner endocanthal distance (En-En´)	Distance between the right endocanthium point (En) on the right eye fissure and the corresponding point on the left eye fissure (En´).
2	Nasal root width (R-R´)	Distance between the nasal root point (R) on the right nasal contour and the corresponding point on the left side (R´).
3	Morphological width (Al-Al´)	Distance between the alare point (Al) located on the right nasal contour and the corresponding point on the left side (Al´).
4	Alar base width (Ac-Ac´)	Distance between the alar curvature point (Ac) located on the right nasal contour and the corresponding point on the left side (Ac´).
5	Columella width (Cmf-Cmf´)	Distance between the frontal columella point (Cmf) located on the right margin of the columella and the corresponding point on the left side (Cmf´).
6	Bilateral width of the nostril floor (Sbal-Sbal´)	Distance between the subalare point (Sbal) located on the lower limit of the right alar base and the corresponding point located on the left side (Sbal´).
7	Right nasal base width (SnfSbal)	Distance between the points frontal subnasale (Snf) and subalare (Sbal) located on the right side of the nose.
8	Left nasal base width (SnfSbal´)	Distance between the points frontal subnasale (Snf) and subalare (Sbal´) located on the left side of the nose.

9	Right frontal subnasal-alare distance (SnfAl)	Distance between the points frontal subnasale (Snf) and alare (Al) located on the right side of the nose.
10	Left frontal subnasal-alare distance (SnfAl´)	Distance between the points frontal subnasale (Snf) and alare (Al´) located on the left side of the nose.
11	Right diagonal nostril width (CmfNrL)	Distance between the points frontal columella (Cmf) and lateral nostril (NrL) located on the right side of the nose.
12	Left diagonal nostril width (Cmf´NrL´)	Distance between the points frontal columella (Cmf´) and lateral nostril (NrL´) located the left side of the nose.
13	Right dorsal axis-alare distance (Al-N´Prn line)	Distance between the soft tissue nasion-pronasale line (N´Prn line) and the point (Al) located on the right nasal contour.
14	Left dorsal axis-alare distance (Al´-N´Prn line)	Distance between the soft tissue nasion-pronasale line (N´Prn line) and the point (Al´) located on the left nasal contour.

Direct vertical linear measurements (Figure 2.4)

15	Frontal nasal length (N´Prn)	Distance between the points soft tissue nasion (N´) and pronasale (Prn).
16	Frontal nasal height (N´Snf)	Distance between the points soft tissue nasion (N´) and frontal subnasale (Snf).

Ratios between linear frontal measurements in frontal photographs

17	Root width:Morphological width ratio (RR´:AlAl´ ratio)	Ratio between the nasal root width (RR´) and the morphological width (AlAl´).
18	Frontal nasal length:Morphological width ratio (N´Prn:AlAl´ ratio)	Ratio between the nasal length (N´Prn) and the morphological width (AlAl´).
19	Frontal nasal height:Morphological width ratio (N´Snf:AlAl´ ratio)	Ratio between the nasal height (N´Snf) and the morphological width (AlAl´).

Angular measurements in frontal photographs (Figure 2.5)

20	Dorsal angle (N´MnPrn angle)	Angle formed by the intersection of the soft tissue nasion-mid-dorsum line (N´Mn line) with the mid-dorsum-pronasale line (MnPrn line) in the frontal view.
21	Alar slope angle (AlPrnAl´ angle)	Angle between the right alare-pronasale line (AlPrn line) and the corresponding line on the left side.
22	Superior nasal angle (AlN´Al´ angle)	Angle between the right alare-soft tissue nasion line (AlN´ line) and the corresponding line on the left side.
23	Right lateral alar angle (N´AcSnf)	Angle between the right soft tissue nasion-alar curvature line (N´Ac line) and the right alar curvature-frontal subnasale line (Ac-Sn line).
24	Inferior nasal angle (AlSnfAl´ angle)	Angle between the right alare-frontal subnasale line (AlSnf line) and the corresponding line on the left side.

III. Soft tissue facial measurements in profile photographs

Angular facial measurements (Figure 2.6)

1	Total facial convexity angle (G´PrnPg´)	Angle formed by the intersection of the soft tissue glabela-pronasale line (G´Prn line) with the pronasale-soft tissue pogonion line (PrnPg´ line).
2	Facial convexity angle (G´SnPg´)	Angle formed by the intersection of the soft tissue glabela-subnasale line (G´Sn line) with the subnasale-soft tissue pogonion line (SnPg´ line).

3	Nasomental angle (N´Stp/PrnPg´)	Angle formed by the intersection of the soft tissue nasion-supratip concavity line (N´Stp line) with the pronasale-soft tissue pogonion line (PrnPg´ line).
4	Nasofacial angle (PrnN´Pg´)	Angle formed by the intersection of the soft tissue nasion-pronasale line(N´Prn line) with the soft tissue nasion-soft tissue pogonion line (N´Pg´).

IV. Skeletal nasal measurements measured in the lateral cephalograms (Figure 2.3)

1	Nasal bone angle (N1N2Rh)	Angle formed by the intersection of the nasion 1-nasion 2 line (N1N2 line) with the nasion 2-rhinion line (N2Rh line).
2	Nasal bone length (N-Rh)	Linear distance between the points nasion (N) and rhinion (Rh).

V. Soft tissue nasal measurements in profile photographs

Linear measurements in profile photographs (Figure 2.7)

Direct linear measurements

1	Nasal height (N´-Sn)	Distance between the points soft tissue nasion (N´) and subnasale (Sn).
2	Nasal length (N´-Prn)	Distance between the points soft tissue nasion (N´) and pronasale (Prn).
3	Upper dorsal convexity (Nd- N´Stp line)	Perpendicular distance between the nasal dorsum point (Nd) and the soft tissue nasion-supratip concavity line (N´Stp line).
4	Depth of the supratip break (Stp- N´Prn line)	Perpendicular distance between the supratip concavity point (Stp) and the soft tissue nasion-pronasale line (N´Prn line).
5	Lower dorsal convexity (Id- MnPrn line)	Perpendicular distance between the inferior dorsum point (Id) and the mid-dorsum-pronasale line (MnPrn line).
6	Columella depth (Cm- PrnSn line)	Perpendicular distance between the columella point (Cm) and the pronasale-subnasale line (PrnSn line).
7	Columella exposure (NrS- columella base)	The shortest distance between the superior nostril point (NrS) and the columella base.

Linear measurements performed parallel to the horizontal reference line *x* (Figure 2.8)

8	Nasal projection (Ac-Prn)	Distance between the points alar curvature (Ac) and pronasale (Prn).
9	Nostril projection (Ac-NrA)	Distance between the points alar curvature (Ac) and anterior nostril (NrA).
10	Subnasale projection (Ac-Sn)	Distance between the points alar curvature (Ac) and subnasale (Sn).
11	Nasal protrusion (Sn-Prn)	Distance between the points subnasale (Sn) and pronasale (Prn).

Angular measurements

Angles of nasal form (Figure 2.9)

12	Nasal prominence angle (SnN´Prn)	Angle formed by the intersection of the subnasale-soft tissue nasion line (SnN´ line) with the soft tissue nasion-pronasale line (N´Prn line).
13	Apical nasal angle (N´-Stp/Sn-Cm)	Angle formed by the intersection of the soft tissue nasion-supratip concavity line (N´Stp line) with the subnasale-columella line (SnCm line).

14 Nasal tip angle (N´PrnSn) — Angle formed by the intersection of the soft tissue nasion -pronasale line (N´Prn line) with the pronasale-subnasale line (PrnSn line).

Angles of nasal projection (Figure 2.9)

15 Nasal projection angle (N´Prn/ *y*) — Angle formed by the intersection of the soft tissue nasion-pronasale line (N´Prn line) with the vertical reference line *y*.

Angles of dorsal form (Figure 2.10)

16 Dorsal contour angle (N´MnPrn) — Angle formed by the intersection of the soft tissue nasion-mid-dorsum line (N´Mn line) with the mid-dorsum -pronasale line (MnPrn line).

17 Supratip break angle (MnStpPrn) — Angle formed by the intersection of the mid-dorsum-supratip concavity line (MnStp line) with the supratip concavity-pronasale line (StpPrn line).

Angles of nasal rotation (Figure 2.10)

18 Nasolabial angle (CmSnLs) — Angle formed by the intersection of the columella-subnasale line (CmSn line) with the subnasale-upper lip line (SnLs line).

19 Columella rotation angle (CmSn/ *y*) — Angle between the columella-subnasale line (CmSn line) and the vertical plane *y*.

20 Nasal tip rotation (AcPrn/ *y*) — Angle between the alar curvature-pronasale line (AcPrn line) and the vertical plane *y*.

2.4.5 Method error

Table 2.1: Systematic error according to the paired sample t test and random error according to the intraclass coefficient for the frontal soft tissue variables

Cephalometric variable	1st evaluation Mean ± SD	2nd evaluation Mean ± SD	Paired sample t test *P*-Value	Intraclass correlation	
				Single measures	Cronbach´s Alpha
Inner endocanthal distance	34.13 ± 4.25	34.29 ± 4.13	0.258	0.99	0.99
Nasal root width	15.87 ± 1.68	15.91 ± 1.85	0.892	0.87	0.92
Morphological width of nose	36.88 ± 3.64	36.81 ± 3.74	0.659	0.99	0.99
Alar base width	32.99 ±3.40	33.13 ± 3.68	0.485	0.98	0.99
Columella width	6.38 ± 1.42	6.49 ± 1.52	0.354	1.00	1.00
Bilateral width of the nostril floor	19.49 ±3.16	19.30 ± 3.25	0.36	0.97	0.98
Right nasal base width	10.47 ± 1.76	10.55 ± 1.82	0.704	0.88	0.93
Left nasal base width	9.45 ± 2.05	9.19 ± 1.85	0.139	0.97	0.97
Right frontal subnasale-alare distance	20.69± 2.11	20.67 ± 2.15	0.925	0.97	0.98
Left frontal subnasale-alare distance	19.78 ±1.61	19.55± 1.59	0.078	0.94	0.97
Right diagonal nostril width	10.15 ± 1.96	10.05 ± 1.82	0.505	0.96	0.98
Left diagonal nostril width	9.45 ± 1.03	9.45 ± 1.08	0.998	0.87	0.92
Right dorsal axis-alare distance	19.09 ± 2.02	18.97 ± 2.09	0.441	0.96	0.97
Left dorsal axis-alare distance	17.78 ± 1.88	17.82 ± 2.01	0.754	0.97	0.98
Frontal nasal length	43.77± 3.38	44.14 ± 3.24	0.117	0.96	0.98
Frontal nasal height	54.17 ± 4.35	54.19 ± 3.87	0.922	0.98	0.99
Root width/morphological width ratio	0.43 ± 0.05	0.43 ± 0.06	0.582	0.99	0.99
Frontal nasal length/morphological width ratio	1.21 ± 0.21	1.19 ± 0.22	0.164	0.98	0.99
Frontal nasal height/morphological width ratio	1.9 ± 1.48	1.84 ± 1.49	0.641	0.99	0.98
Dorsal angle	3.70 ± 1.95	3.82 ± 2.12	0.755	0.76	0.85
Alar slope angle	11.97 ± 8.65	13.19 ± 9.74	0.311	0.88	0.94
Superior alar angle	44.07 ± 4.64	43.78 ± 4.58	0.067	0.99	0.99
Right lateral alar angle	80.76 ± 9.14	80.97 ± 9.37	0.439	0.99	0.99
Inferior alar angle	132.25 ± 10.57	133.45± 11.02	0.230	0.94	0.97

The frontal and profile cephalometric analyses were performed in 15 randomly selected cases in which both class I occlusion and class III malocclusion were represented. The analyses were repeated after a month. The two measured values for each variable were compared. A paired sample t test did not detect systematic error for any of the variables (Tables 2.1, 2.2). The intraclass coefficient revealed a random error in the measurement of the frontal soft tissue variable dorsal angle (Table 2.1).

Table 2.2: Systematic error according to the paired sample t test and random error according to the intraclass coefficient for the facial and nasal profile variables

Cephalometric variable	1st evaluation Mean ± SD	2nd evaluation Mean ± SD	Paired sample t test *P*-Value	Intraclass correlation	
				Single measures	Cronbach´s Alpha
Total facial height	124.92 ± 10.79	125.01 ± 10.75	0.178	1.00	1.00
Inferior facial height	72.66 ± 8.45	72.65 ± 8.32	0.948	0.99	0.99
Inferior facial height: Total facial height ratio	0.59 ± 0.03	0.59 ± 0.03	1.000	1.00	1.00
Sagittal maxillary position	61.42 ±5.51	61.49 ± 5.50	0.199	0.99	0.99
Maxillary length	41.76 ± 4.08	41.84 ± 4.07	0.442	0.99	0.99
SNA angle	77.80 ± 3.95	77.67 ± 4.06	0.164	0.99	0.99
SNB angle	80.20 ± 4.24	80.20 ± 4.26	0.999	0.99	0.99
ANB angle	-2.40 ± 1.99	-2.53 ± 1.96	0.334	0.96	0.98
Maxillary inclination	9.40 ± 3.46	9.60 ± 3.72	0.458	0.96	0.98
Mandibular inclination	40.66 ± 6.62	40.46 ± 6.43	0.384	0.99	0.99
Vertical intermaxillary angle	31.27± 6.35	30.87 ± 5.89	0.164	0.98	0.99
Total facial convexity angle	143.07± 5.62	143.53 ± 5.54	0.187	0.97	0.98
Facial convexity angle	7.20 ± 5.17	7.00 ± 4.33	0.629	0.95	0.97
Nasomental angle	137.40 ± 5.74	137.33 ± 5.21	0.806	0.98	0.99
Nasofacial angle	24.07±2.58	24.03 ± 2.63	0.989	0.96	0.98
Nasal bone angle	164.99 ± 3.90	164.97 ± 3.78	0.751	0.81	0.89
Nasal bone length	15.20 ± 4.31	14.67 ± 4.35	0.461	0.98	0.99
Nasal height	59.21 ± 4.99	59.24 ± 4.88	0.742	0.99	0.99
Nasal length	55.06± 4.60	55.05 ± 4.30	0.949	0.99	0.99
Upper dorsal convexity	-1.97 ± 0.76	-2.04 ± 0.77	0.246	0.95	0.97
Depth of the supratip break	0.22 ± 0.78	0.18 ± 0.80	0.521	0.96	0.98
Lower dorsal convexity	1.71 ± 0.42	1.77 ± 0.39	0.465	0.81	0.87
Columella depth	2.57± 0.84	2.55 ± 0.85	0.790	0.95	0.97
Columella exposure	4.17 ± 1.69	4.19 ± 1.70	0.469	0.99	0.99
Nasal projection	28.45 ± 3.28	28.43 ± 3.14	0.871	0.99	0.99
Nostril projection	18.94 ± 2.65	19.01 ± 2.78	0.461	0.99	0.99
Subnasale projection	11.38 ± 3.01	11.37 ± 2.85	0.891	0.99	0.99
Nasal protrusion	17.07 ± 1.73	17.05 ± 1.78	0.886	0.96	0.97
Nasal prominence angle	19.67± 1.80	19.60 ± 1.64	0.670	0.94	0.96
Apical nasal angle	78.87 ± 7.44	79.87 ±7.72	0.140	0.94	0.97
Nasal tip angle	96.20 ± 2.93	96.87 ± 3.60	0.126	0.87	0.94
Nasal projection angle	24.00 ± 5.57	24.13 ± 5.87	0.334	0.99	0.99
Dorsal contour angle	5.53 ± 4.72	5.80 ± 4.59	0.623	0.90	0.94
Supratip break angle	7.60 ± 3.74	7.87 ± 3.89	0.628	0.86	0.91
Nasolabial angle	105.33 ± 11.87	106.60 ± 11.31	0.147	0.95	0.98
Columella rotation angle	77.13 ± 9.58	75.93 ± 10.00	0.057	0.96	0.99
Nasal tip rotation angle	73.20 ± 6.47	72.73 ± 6.50	0.301	0.96	0.98
Columella-lobule angle	15.73 ± 7.80	15.60 ± 8.10	0.792	0.97	0.98

2.4.6 Description of the sample

Each group with class I occlusion or class III malocclusion consisted of 80 Caucasian individuals, equally divided between the genders. In a pilot investigation, nasal protrusion averaged 15.75±1.33 mm in 8 men and 7 women with class I occlusion and 16.95±1.74 mm, in a similarly composed sample with class III malocclusion. Thus, based on the standard deviation of 1.74 mm, 49 patients were required in each group to provide an 80% probability of detecting an inter-group difference of 1 mm at a two-sided 0.05 significance level.

The average ages of the class I and class III samples were 22.6 years and 21.3 years respectively. The restriction of the selection criteria to young adults of 18-30 years avoided the confounding effect of nasal growth (Porter & Olson, 2003). Most anthropometric studies of the nose also use this age group to represent young adults (Appendix I, annex 1).

2.4.7 Statistical analysis

The Kolmogorov-Smirnov test was used to test the null hypothesis that the sample was derived from a population with normal distribution. In the absence of a normal distribution, non-parametric tests were used. The skeletal and soft tissue nasal cephalometric variables were used as dependent variables. The skeletal class, gender and the skeletal cephalometric variables of the maxilla and the face were used as independent variables. Descriptive statistics were calculated for each variable.

The influence of the skeletal class and gender on nasal variables was determined using a 2-way ANOVA.

The correlation between the different nasal variables was determined using Pearson´s correlation coefficient. This method was also used to evaluate the relationship between the different nasal variables and skeletal and soft tissue facial variables. The level of significance was fixed at 5%. Statistical analyses were performed with SPSS® version 25.0 for Windows (IBM Company, Armonk, NY, USA).

2.5 Results

2.7.1 Skeletal facial variables

The normality of the sample distribution was calculated according to the Kolmogorov-Smirnov test. Descriptive statistics included the mean, standard deviation, standard error of the mean and the maximum and minimum values for each skeletal facial cephalometric variable in the groups with Class I and Class III malocclusion, stratified by gender. Results are presented in Tables 1-6 of Appendix 1, annex 2. The ANB angle was not normally distributed in men with Class III malocclusion (P=0.007) at a 1% level of significance.

Whites test confirmed the homocedasticity of the profile facial and nasal variables (P >0.05). Results of the 2-way ANOVA, verifying the influence of the type of malocclusion and gender on the skeletal facial profile variables are reported in Table 2.3 and Figure 2.11. The type of malocclusion influenced the variables total facial height, lower facial height, SNB angle (P<0.001), maxillary inclination angle (P<0.05), mandibular plane inclination and vertical intermaxillary angle (P<0.001), which were larger in the group with Class III

malocclusion. The variables sagittal maxillary position, maxillary length and SNA angle (P<0.001) were greater in the group with Class I occlusion.

Gender influenced total facial height, lower facial height, sagittal maxillary position and maxillary length (P<0.001), which were larger in men than in women, and mandibular plane inclination (P<0.01), which was greater in women. The variable lower facial height/total facial height ratio was also larger in men than in women (P<0.01).

Table 2.3: Results of the 2-way ANOVA used to verify the influence of occlusion type (Class I or class III malocclusion) and gender on the skeletal facial variables measured in lateral cephalograms

Variable	G	Class I Mean (SD)	Class III Mean (SD)	Source	Sum of Squares	Mean Square	F value	Power	*P*-value
Total facial height		118.14 (7.23)	123.70 (8.49)	Class	1234.88	1234.88	29.99	1.00	0.000***
	M	121.45 (6.59)	129.32 (7.27)	Gender	3183.55	3183.55	77.32	1.00	0.000***
	F	114.84 (6.33)	118.09 (5.32)						
				Class * Gender	213.21	213.21	5.18	0.62	0.024*
Lower facial height		68.63 (5.76)	72.15 (6.93)	Class	495.62	495.62	16.89	0.98	0.000***
	M	70.77 (5.11)	76.42 (5.98)	Gender	1649.94	1649.94	56.21	1.00	0.000***
	F	66.48 (5.63)	67.87 (4.89)						
				Class * Gender	181.90	181.90	6.20	0.70	0.014*
Lower facial height/Total facial height ratio		0.58 (0.02)	0.58 (0.02)	Class	0.00	0.00	0.31	0.09	0.577
	M	0.58 (0.02)	0.59 (0.02)	Gender	0.00	0.00	7.75	0.79	0.006**
	F	0.58 (0.03)	0.57 (0.02)						
				Class * Gender	0.00	0.00	2.78	0.38	0.097
Sagittal maxillary position		65.57 (5.41)	62.16 (5.30)	Class	465.47	465.47	21.38	1.00	0.000***
	M	68.54 (4.55	64.47 (4.71)	Gender	1116.72	1116.72	51.30	1.00	0.000***
	F	62.60 (4.51	59.85 (4.88)						
				Class * Gender	17.62	17.62	0.81	0.15	0.370
Maxillary length		44.47 (4.02)	42.11 (4.10)	Class	223.26	223.26	17.29	0.99	0.000***
	M	46.78 (3.19)	43.52 (3.84)	Gender	553.54	553.54	42.87	1.00	0.000***
	F	42.16 (3.40)	40.70 (3.89)						
				Class * Gender	32.40	32.40	2.51	0.35	0.115
SNA angle		80.33 (3.41)	78.15 (3.80)	Class	190.31	190.31	14.80	0.97	0.000***
	M	81.11 (3.48)	78.47 (4.08)	Gender	48.51	48.51	3.77	0.49	0.054
	F	79.55 (3.20)	77.83(3.53)						
				Class * Gender	8.42	8.42	0.65	0.13	0.420
SNB angle		78.21 (3.44)	81.02 (4.08)	Class	316.41	316.41	22.49	1.00	0.000***
	M	78.94 (3.32)	81.45 (4.30)	Gender	53.36	53.36	3.79	0.49	0.053
	F	77.48 (3.46)	80.59 (3.85)						
				Class * Gender	3.66	3.67	0.26	0.08	0.611
Maxillary inclination angle		7.85 (3.57)	9.13 (3.18)	Class	65.79	65.79	5.96	0.68	0.016*
	M	7.90 (3.18)	8.10 (2.83)	Gender	38.42	38.42	3.48	0.46	0.064
	F	7.80 (3.97)	10.16 (3.21)						
				Class * Gender	46.87	46.87	4.25	0.54	0.041*
Mandibular plane inclination		33.78 (6.95)	39.62 (6.03)	Class	1366.56	1366.56	33.82	1.00	0.000***
	M	31.65 (6.65)	39.11 (6.55)	Gender	278.26	278.26	6.89	0.74	0.010*
	F	35.91 (6.66)	40.13 (5.50)						
				Class * Gender	105.30	105.30	2.61	0.36	0.108
Vertical intermaxillary angle		25.93 (6.67)	30.49 (6.00)	Class	832.66	832.66	21.80	1.00	0.000***
	M	23.75 (5.76)	31.01 (6.60)	Gender	109.89	109.89	2.88	0.39	0.092
	F	28.11 (6.88)	29.97 (5.37)						
				Class * Gender	292.68	292.68	7.66	0.79	0.006**

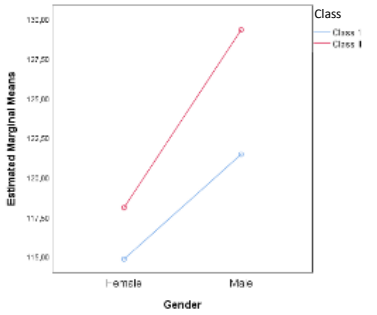
G: Gender, M: Male, F: Female, SD: Standard deviation, *P<0.05, **P<0.01, ***P<0.001

An interaction between the occlusion type and gender factors was detected for the variables total facial height, lower facial height, maxillary inclination angle (P<0.05) and vertical intermaxillary angle (P<0.01).

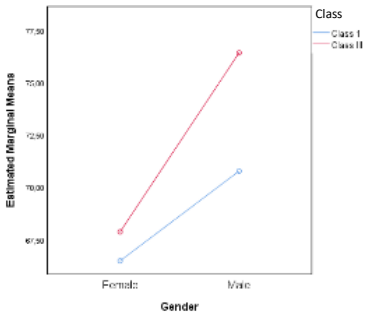
Class

This indicated that the differences of the statistical means of these variables can vary among the men and women in the groups with class I occlusion and class III malocclusion and vice versa.

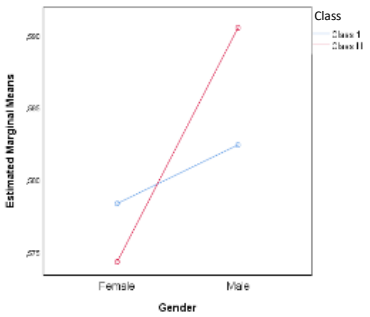
Figure 2.11: Results of the 2-way ANOVA to determine the influence of the occlusion type (Class I or class III malocclusion) and gender for the skeletal facial variables measured in lateral cephalograms



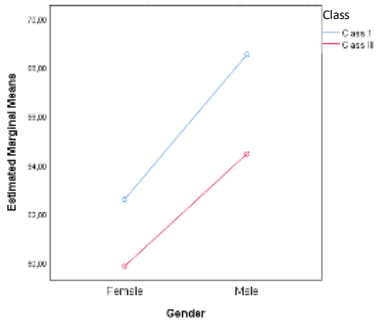
Total facial height



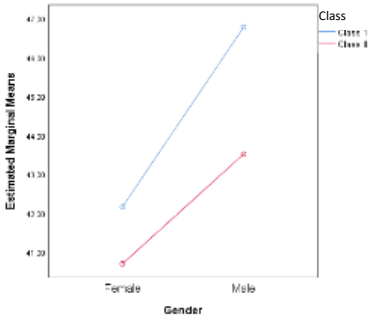
Lower facial height



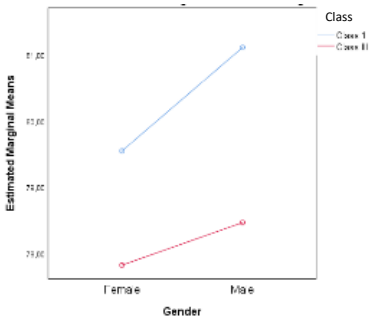
Lower facial height/Total facial height ratio



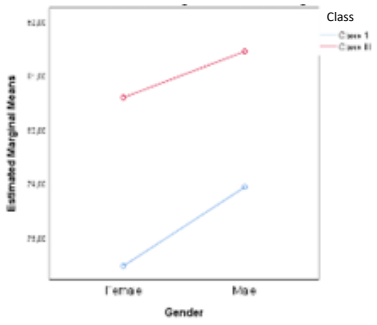
Sagittal maxillary position



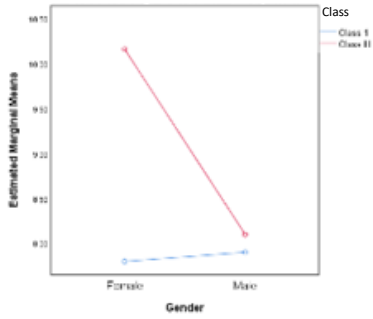
Maxillary length



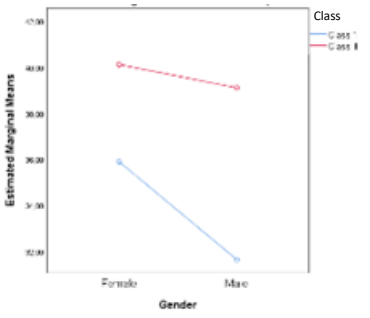
SNA angle



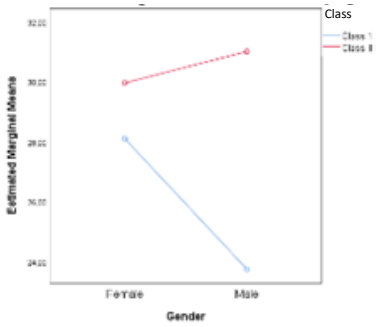
SNB angle



Maxillary inclination angle



Mandibular plane inclination



Vertical intermaxillary angle

Amongst the variables that demonstrated an interaction between occlusion type and gender in the 2-way ANOVA, an independent t-test verified that men with Class III malocclusion demonstrated a significantly greater total facial height, lower facial height and vertical intermaxillary angle (P<0.001) than those with Class

I occlusion (Table 2.4). Total facial height (P<0.05) and maxillary inclination angle (*P*<0.01) were larger in women with Class III malocclusion than those with Class I occlusion (Table 2.4).

Total facial height (*P*<0.001) and lower facial height (*P*<0.01) were larger in men than in women with Class I occlusion. They were also greater in men than in women in the group with class III malocclusion (*P*<0.001). Vertical intermaxillary angle measured more in women than in men in the group with class I occlusion (*P*<0.01). Maxillary inclination angle was larger in women than in men in the group with class III malocclusion *(P*<0.01) (Table 2.5).

Table 2.4: Results of the independent t test to compare men with Class I occlusion and Class III malocclusion and women with Class I occlusion and Class III malocclusion for the variables that demonstrated an interaction between the occlusion type and gender factors in the 2-way ANOVA

Cephalometric variable	Class I men (n=40)		Class III men (n=40)		t-test		
					95% CI		*P*-value
	Mean	SD	Mean	SD	Lower	Upper	
Total facial height	121.45	6.59	129.32	7.27	-10.95	-4.78	0.000***
Lower facial height	70.77	5.11	76.42	5.98	-8.13	-3.18	0.000***
Maxillary inclination angle	7.90	3.18	8.10	2.83	-1.54	1.14	0.767
Vertical intermaxillary angle	23.75	5.76	31.01	6.60	-10.02	-4.51	0.000***
	Class I women (n=40)		Class III women (n=40)				
Total facial height	114.84	6.33	118.09	5.32	-5.851	-0.644	0.015*
Lower facial height	66.48	5.63	67.87	4.89	-3.735	0.960	0.243
Maxillary inclination angle	7.80	3.97	10.16	3.21	-3.970	-0.760	0.004**
Vertical intermaxillary angle	28.11	6.88	29.97	5.37	-4.604	0.889	0.182

**P*<0.05, ***P*<0.01, ****P*<0.001, SD: Standard deviation, CI: Confidence interval of the difference

Table 2.5: Results of the independent t test to compare men and women within the groups of Class I occlusion and Class III malocclusion for the variables that demonstrated an interaction between the occlusion type and gender factors in the 2-way ANOVA

Cephalometric variable	Class I men (n=40)		Class I women (n=40)		t teste		
					95% CI		*P*-value
	Mean	SD	Mean	SD	Lower	Upper	
Total facial height	121.45	6.59	114.84	6.33	-9.49	-3.74	0.000***
Lower facial height	70.77	5.11	66.48	5.63	-6.68	-1.90	0.001**
Maxillary inclination angle	7.90	3.18	7.80	3.97	-1.70	1.50	0.899
Vertical intermaxillary angle	23.75	5.76	28.11	6.88	1.54	7.19	0.003**
	Class III men (n=40)		Class III women (n=40)				
Total facial height	129.32	7.27	118.09	5.32	-14.07	-8.39	0.000***
Lower facial height	76.42	5.98	67.87	4.89	-10.99	-6.12	0.000***
Maxillary inclination angle	8.10	2.83	10.16	3.21	0.72	3.41	0.003**
Vertical intermaxillary angle	31.01	6.60	29.97	5.37	-3.73	1.63	0.439

***P*<0.01, ****P*<0.001, SD: Standard deviation, CI: Confidence interval of the difference

The non-normal distribution of the ANB angle in men with Class III malocclusion did not permit the use of the 2-way ANOVA. Independent t tests were used to compare this variable between the groups with Class I occlusion and Class III malocclusion (Table 2.6), women with Class I occlusion and Class III malocclusion (Table 2.7) and men and women with class I occlusion (Table 2.9). The ANB angle was significantly larger in the group with Class I occlusion than the group with Class III malocclusion (*P*<0.001) (Table 2.6). Women with Class I occlusion also had greater values than those with class III malocclusion (*P*<0.001) (Table 2.7).

Mann Whitney tests were used to compare the ANB angle between men with class I occlusion and class III malocclusion (Table 2.8) and between men and women with class III malocclusion (Table 2.10). The ANB angle was significantly larger in men with class I occlusion than in those with class III occlusion (P<0.001) (Table 2.8). No gender-based difference was verified within the groups (Table 2.9 and 2.10).

Table 2.6: Results of the independent t test for the comparison of the ANB angle between the groups with Class I occlusion and Class III malocclusion

Cephalometric variable	Class I (n=80)		Class III (n=80)		t test		
					95% CI		*P*-value
	Mean	SD	Mean	SD	Lower	Upper	
ANB angle	2.12	1.08	-2.87	2.43	4.41	5.58	0.000***

SD: Standard deviation, CI: Confidence Interval of the Difference, ***P<0.001

Table 2.7: Results of the independent t test for the comparison of the ANB angle between women with Class I occlusion and Class III malocclusion

Cephalometric variable	Class I women (n=40)		Class III women (n=40)		t teste		
					95% CI		*P*-value
	Mean	SD	Mean	SD	Lower	Upper	
ANB angle	2.07	0.99	-2.77	2.09	4.111	5.564	0.000***

SD: Standard deviation, CI: Confidence Interval of the Difference, ***P<0.001

Table 2.8 Results of the Mann Whitney test to compare the means of the ANB angle between men with class I occlusion and class III malocclusion

Cephalometric variable	Class I men (n=40)		Class III men (n=40)		Mann Whitney test *P*-value
	Mean	SD	Mean	SD	
ANB angle	2.17	1.18	-2.98	2.76	0.000***

SD: Standard deviation, ***P<0.001

Table 2.9: Results of the independent t test for the comparison of the ANB angle between men and women with Class I occlusion

Cephalometric variable	Class I men (n=40)		Class I women (n=40)		t test		
					95% CI		*P*-value
	Mean	SD	Mean	SD	Lower	Upper	
ANB angle	2.17	1.18	2.07	0.99	-0.59	0.38	0.675

SD: Standard deviation, CI: Confidence Interval of the Difference

Table 2.10: Results of the Mann Whitney test to compare the means of the ANB angle between men and women with class III malocclusion

Cephalometric variable	Class III men (n=40)		Class III women (n=40)		Mann Whitney test *P*-value
	Mean	SD	Mean	SD	
ANB angle	-2.98	2.76	-2.77	2.09	0.795

2.7.2 Frontal soft tissue variables

The normality according to the Kolmogorov-Smirnov test and descriptive statistics including the mean, standard deviation, standard error of the mean and the maximum and minimum values for each cephalometric variable measured in the frontal photograph in the groups with class I occlusion and Class III malocclusion and in the men and women in each group are represented in the Tables 7-12 in Appendix 1, annex 2. All the variables were normally distributed at a 1% level of significance (α) when the whole groups were considered. However, the variables alar base width in men with Class III malocclusion (P=0.006) and superior nasal angle (P=0.006) in women with Class I occlusion were not normally distributed (P<0.01).

Whites test was performed to determine the homoscedascity of the frontal nasal variables. A 2-way ANOVA was then used to verify the influence of type of malocclusion as well as gender on the variables that presented a normal distribution (Table 2.11, Figure 2.12). An interaction between the type of malocclusion and gender was not verified for any of the variables.

Columella width (P<0.01), frontal nasal length (P<0.001), frontal nasal height, frontal nasal length/morphological width ratio (P<0.01) and frontal nasal height/morphological width ratio (P<0.05) were larger in the group with Class III occlusion. The alar slope angle (P<0.01) was greater in the group with Class I occlusion. Morphological width and left frontal subnasale-alare distance demonstrated an identical average value in the two groups and similar standard deviations and generated only single lines in the graph. These values were reconfirmed.

The variables nasal root width, inner endocanthal distance (P<0.01), morphological width (P<0.001), columella width (P<0.01), bilateral width of the nostril floor, right nasal base width, left nasal base width, right frontal subnasale-alare distance, left frontal subnasale-alare distance, right diagonal nostril width, left diagonal nostril width, right dorsal axis-alare distance, left dorsal axis-alare distance (P<0.001) and frontal nasal height (P<0.05) were larger in men. Root width/morphological width (P<0.05), frontal nasal length/morphological width and frontal nasal height/morphological width ratios (P<0.001) were greater in women. Inferior alar angle (P<0.05) was larger in men and lateral alar angle (P<0.01) had a higher value in women.

Table 2.11 Results of the 2-way ANOVA to determine the influence to verify the influence of occlusion type (Class I or class III malocclusion) and gender on the soft tissue variables measured in frontal photographs

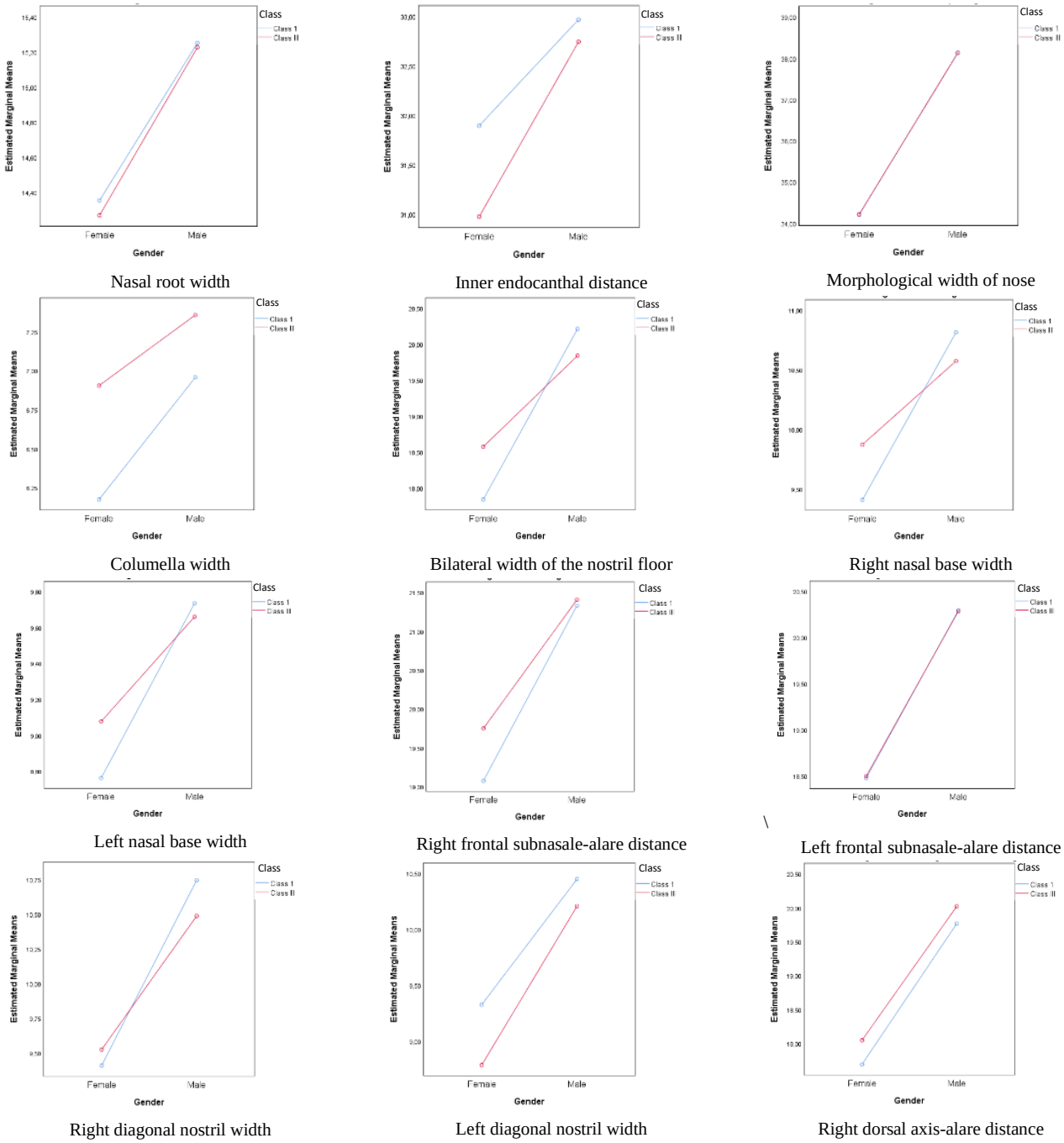
Variable	G	Class I Mean (SD)	Class III Mean (SD)	Source	Sum of Squares	Mean Square	F value	Power	*P*-value
Nasal root width		14.80 (2.17)	14.75 (2.31)	Class	0.12	0.12	0.03	0.05	0.875
	M	15.25 (2.01)	15.23 (2.20)	Gender	34.41	34.41	7.05	0.75	0.009**
	F	14.36 (2.26)	14.27 (2.35)						
				Class * Gender	0.04	0.04	0.01	0.05	0.932
Inner endocanthal distance		32.43 (2.81)	31.86 (2.78)	Class	13.11	13.11	1.78	0.26	0.184
	M	32.97 (2.99)	32.75 (2.63)	Gender	80.94	80.94	10.99	0.91	0.001**
	F	31.90 (2.55)	30.98 (2.66)						
				Class * Gender	4.83	4.83	0.66	0.13	0.419
Morphological width		36.17 (3.15)	36.17 (3.76)	Class	0.00	0.00	0.00	0.05	1.000
	M	38.14 (2.22)	38.13 (3.28)	Gender	614.66	614.66	74.40	1.00	0.000***
	F	34.21 (2.70)	34.22 (3.17)						
				Class * Gender	0.00	0.00	0.00	0.05	0.987
Columella width		6.57 (1.34)	7.13 (1.33)	Class	12.77	12.77	7.55	0.78	0.007**
	M	6.96 (1.52)	7.36 (1.27)	Gender	15.25	15.25	9.01	0.85	0.003**
	F	6.18 (1.00)	6.91 (1.36)						
				Class * Gender	1.09	1.09	0.64	0.13	0.424
Bilateral width of the nostril floor		19.03 (2.69)	19.21 (2.53)	Class	1.31	1.31	0.22	0.08	0.639
	M	20.22 (2.47)	19.84 (2.53)	Gender	132.68	132.68	22.29	1.00	0.000***
	F	17.84 (2.37)	18.58 (2.39)						
				Class * Gender	12.27	12.27	2.06	0.30	0.153
Right nasal base width		10.11 (1.59)	10.23 (1.58)	Class	0.50	0.50	0.22	0.08	0.638
	M	10.82 (1.42)	10.58 (1.51)	Gender	44.21	44.21	19.80	0.99	0.000***
	F	9.41 (1.45)	9.88 (1.59)						
				Class * Gender	4.94	4.94	2.21	0.32	0.139

Left nasal base width		9.25 (1.66)	9.37 (1.55)	Class	0.58	0.58	0.24	0.08	0.628
	M	9.74 (1.58)	9.66 (1.71)	Gender	24.18	24.18	9.88	0.88	0.000***
	F	8.76 (1.61)	9.08 (1.33)						
				Class * Gender	1.52	1.52	0.62	0.12	0.432
Right frontal subnasale-alare distance		20.20 (2.05)	20.58 (2.21)	Class	5.66	5.66	1.58	0.24	0.211
	M	21.33 (1.69)	21.41 (2.13)	Gender	153.08	153.08	42.69	1.00	0.000***
	F	19.08 (1.75)	19.75 (1.98)						
				Class * Gender	3.57	3.57	1.00	0.17	0.320
Left frontal subnasale-alare distance		19.39 (1.76)	19.39 (1.89)	Class	0.00	0.00	0.00	0.05	0.980
	M	20.30 (1.38)	20.29 (1.85)	Gender	130.14	130.14	51.16	1.00	0.000***
	F	18.48 (1.64)	18.50 (1.47)						
				Class * Gender	0.01	0.01	0.00	0.05	0.949
Right diagonal nostril width		10.08 (1.72)	10.01 (1.76)	Class	0.20	0.20	0.08	0.06	0.785
	M	10.75 (1.48)	10.49 (1.62)	Gender	52.79	52.79	19.42	0.99	0.000***
	F	9.41 (1.69)	9.53 (1.79)						
				Class * Gender	1.39	1.39	0.51	0.11	0.476
Left diagonal nostril width		9.89 (1.51)	9.50 (1.87)	Class	6.12	6.12	2.45	0.34	0.120
	M	10.45 (1.28)	10.21 (2.05)	Gender	64.64	64.64	25.86	1.00	0.000***
	F	9.33 (1.52)	8.79 (1.36)						
				Class * Gender	0.89	0.89	0.35	0.09	0.553
Right dorsal axis-alare distance		18.73 (1.95)	19.04 (2.27)	Class	3.72	3.72	1.07	0.18	0.302
	M	19.77 (1.62)	20.02 (2.06)	Gender	164.03	164.03	47.22	1.00	0.000***
	F	17.69 (1.69)	18.05 (2.04)						
				Class * Gender	0.10	0.10	0.03	0.05	0.865
Left dorsal axis-alare distance		17.42 (1.74)	17.12 (1.92)	Class	3.69	3.69	1.49	0.23	0.225
	M	18.35 (1.31)	18.09 (1.77)	Gender	143.45	143.45	57.78	1.00	0.000***
	F	16.50 (1.64)	16.15 (1.54)						
				Class * Gender	0.10	0.10	0.04	0.05	0.845
Frontal nasal length		43.98 (4.27)	46.52 (4.56)	Class	258.06	258.06	13.39	0.95	0.000***
	M	44.84 (4.16)	46.95 (4.86)	Gender	66.82	66.82	3.47	0.46	0.065
	F	43.12 (4.26)	46.09 (4.25)						
				Class * Gender	7.40	7.40	0.38	0.09	0.537
Frontal nasal height		55.05 (4.22)	57.16 (4.61)	Class	177.66	177.66	9.33	0.86	0.003**
	M	56.04 (3.99)	57.77 (4.99)	Gender	103.04	103.04	5.41	0.64	0.021*
	F	54.06 (4.26)	56.54 (4.16)						
				Class * Gender	5.48	5.48	0.29	0.08	0.593
Root width / morphological width ratio		0.41 (0.06)	0.41 (0.05)	Class	0.00	0.00	0.08	0.06	0.783
	M	0.40 (0.06)	0.40 (0.05)	Gender	0.01	0.01	4.23	0.53	0.041*
	F	0.42(0.07)	0.42 (0.06)						
				Class * Gender	0.00	0.00	0.02	0.05	0.903
Frontal nasal length / morphological width ratio		1.22 (0.14)	1.30 (0.18)	Class	0.23	0.23	9.59	0.87	0.002**
	M	1.18 (0.12)	1.24 (0.16)	Gender	0.43	0.43	17.77	0.99	0.000***
	F	1.27 (0.15)	1.36 (0.18)						
				Class * Gender	0.01	0.01	0.43	0.10	0.511
Frontal nasal height / morphological width ratio		1.53 (0.15)	1.60 (0.20)	Class	0.17	0.17	6.26	0.70	0.013*
	M	1.47 (0.13)	1.52 (0.17)	Gender	0.66	0.66	24.61	1.00	0.000***
	F	1.59 (0.15)	1.67 (0.20)						
				Class * Gender	0.01	0.01	0.31	0.09	0.580
Alar slope angle		20.23 (11.33)	14.71 (12.12)	Class	1219.92	1219.92	8.88	0.84	0.003**
	M	18.35 (11.12)	15.39 (12.37)	Gender	57.84	57.84	0.42	0.10	0.517
	F	22.12 (11.36)	14.03 (11.98)						
				Class * Gender	263.17	263.17	1.92	0.28	0.168

Inferior alar angle		133.19 (9.61)	130.76 (11.14)	Class	236.20	236.20	2.24	0.32	0.137
	M	134.09 (10.30)	133.38 (9.87)	Gender	496.32	496.32	4.70	0.58	0.032*
	F	132.29 (8.91)	128.14 (11.83)						
				Class * Gender	118.34	118.34	1.12	0.18	0.292
Right lateral alar angle		81.93 (6.53)	83.44 (7.97)	Class	91.20	91.20	1.82	0.27	0.179
	M	80.50 (5.99)	81.23 (6.97)	Gender	533.63	533.63	10.64	0.90	0.001**
	F	83.37 (6.80)	85.66 (8.36)						
				Class * Gender	24.34	24.34	0.49	0.11	0.487

M: Male, F: Female, SD: Standard deviation, *P<0.05, **P<0.01, ***P<0.001

Figure 2.12 Results of the 2-way ANOVA to determine the influence of occlusion type (Class I or class III malocclusion) and gender on the soft tissue variables measured in frontal photographs

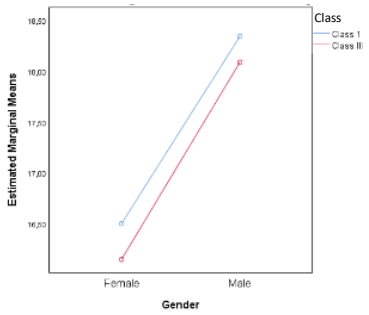


Nasal root width | Inner endocanthal distance | Morphological width of nose

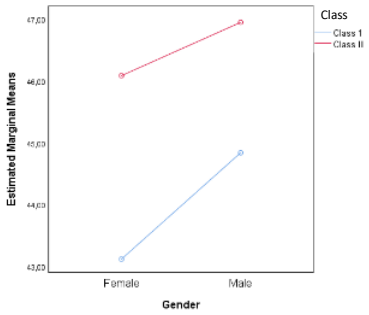
Columella width | Bilateral width of the nostril floor | Right nasal base width

Left nasal base width | Right frontal subnasale-alare distance | Left frontal subnasale-alare distance

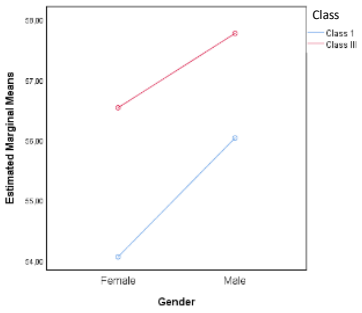
Right diagonal nostril width | Left diagonal nostril width | Right dorsal axis-alare distance



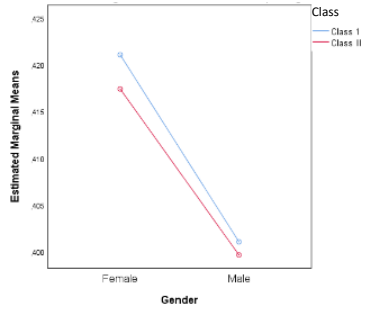
Left dorsal axis-alare distance



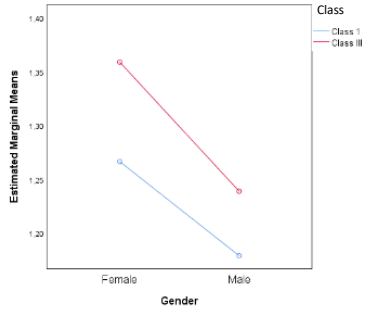
Frontal nasal length



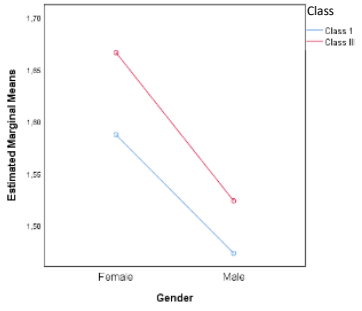
Frontal nasal height



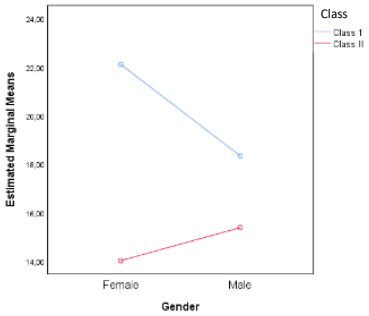
Root width/morphological width ratio



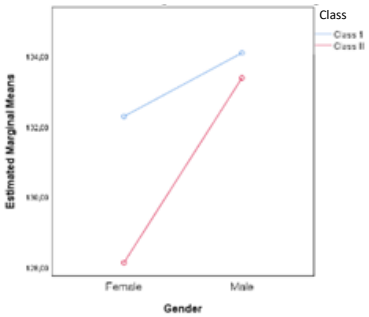
Frontal nasal length/morphological width ratio



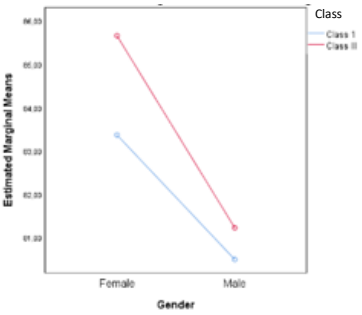
Frontal nasal height/morphological width ratio



Alar slope angle



Inferior alar angle



Right lateral alar angle

The 2-way ANOVA could not be performed for alar base width and superior nasal angle which were not normally distributed in men with Class III malocclusion and in women with Class I occlusion, respectively. Hence, an independent t test was used to compare the two variables between the groups with class I occlusion and class III malocclusion (Table 2.12), alar base width between women with Class I occlusion and Class III malocclusion (Table 2.13) and between men and women with Class I occlusion (Table 2.15) and superior alar angle between men with Class I occlusion and Class III malocclusion (Table 2.13) and between men and women with Class III malocclusion (Table 2.15). Mann Whitney tests were used to compare alar base width between men with class I occlusion and class III malocclusion (Table 2.14) and between men and women with Class III malocclusion (Table 2.16) and superior alar angle between women with class I occlusion and class III malocclusion (Table 2.14) and between men and women with Class I malocclusion (Table 2.16).

The independent t test demonstrated that superior alar angle was larger in the group with Class I occlusion than in the group with class III malocclusion ($P<0.05$) (Table 2.12) and in men with class III malocclusion than in women ($P<0.01$) (Table 2.15). The alar base width had a superior value in men with class I occlusion than in women ($P<0.001$) (Table 2.15).

Table 2.12: Results of the independent t test for the comparison of alar base width and superior nasal angle between the groups with Class I occlusion and Class III malocclusion

Cephalometric variable	Class I (n=80)		Class III (n=80)		t teste 95% CI		*P*-value
	Mean	SD	Mean	SD	Lower	Upper	
Alar base width	33.18	3.05	33.12	3.55	-0.98	1.09	0.916
Superior alar angle	42.03	4.06	40.70	4.40	0.01	2.65	0.048*

SD: Standard deviation, CI: Confidence Interval of the Difference, *P<0.05

Table 2.13: Results of the independent t test for the comparison of alar base width between women with Class I occlusion and Class III malocclusion and superior alar angle between men with Class I occlusion and Class III malocclusion

Cephalometric variable	Gender	Class I (n=40)		Class III (n=40)		t teste 95% CI		*P*-value
		Mean	SD	Mean	SD	Lower	Upper	
Alar base width	Female	31.35	2.73	31.48	2.91	-1.39	1.13	0.837
Superior alar angle	Male	43.53	3.80	42.26	4.25	-0.52	3.06	0.163

SD: Standard deviation

Table 2.14: Results of the Mann Whitney test for the comparison of alar base width between men with Class I occlusion and Class III malocclusion and superior alar angle between women with Class I occlusion and Class III malocclusion

Cephalometric variable	Gender	Class I (n=40)		Class III (n=40)		Mann Whitney test *P*-value
		Mean	SD	Mean	SD	
Alar base width	Male	35.00	2.16	34.76	3.40	0.392
Superior alar angle	Female	40.54	3.78	39.14	4.02	0.204

SD: Standard deviation

Table 2.15: Results of the independent t test for the comparison of alar base width between men and women with Class I occlusion and superior alar angle between men and women with Class III malocclusion

Cephalometric variable	Group	Men (n=40)		Women (n=40)		t teste 95% CI		*P*-value
		Mean	SD	Mean	SD	Lower	Upper	
Alar base width	Class I	35.00	2.16	31.35	2.73	-4.74	-2.55	0.000***
Superior alar angle	Class III	42.26	4.25	39.14	4.02	-4.96	-1.28	0.001**

SD: Standard deviation, CI: Confidence Interval of the difference, **P<0.01, ***P<0.001

Table 2.16 Results of the Mann Whitney test for the comparison of alar base width between men and women with Class III malocclusion and superior alar angle between men and women with Class I occlusion

Cephalometric variable	Class	Men (n=40)		Women (n=40)		Mann Whitney test *P*-value
		Mean	SD	Mean	SD	
Alar base width	Class III	34.76	3.40	31.48	2.91	0.000***
Superior alar angle	Class I	43.53	3.80	40.54	3.78	0.000***

SD: Standard deviation, ***P<0.001

According to the Mann Whitney test, the alar base width was greater in men than in women in the group with class III malocclusion (P<0.001) (Table 2.16). Superior alar angle was larger in men than in women in the group with class I malocclusion (P<0.001) (Table 2.16).

2.7.3 Facial soft tissue and nasal profile variables

The normality according to the Kolmogorov-Smirnov test and descriptive statistics including the mean, standard deviation, standard error of the mean and the maximum and minimum values of each soft tissue facial

and soft tissue and skeletal nasal cephalometric variable measured in the groups with class I occlusion and Class III malocclusion and the men and women within these groups are presented in Tables 13 to 18 in Appendix 1, annex 2. After the use of White´s test to confirm homoscedascity, a 2-way ANOVA, used to verify the influence of type of malocclusion and gender on these variables, indicated that total facial convexity angle, nasomental angle (P<0.001), nasal height (P<0.01), nasal length and nasal protrusion (P<0.05) were larger in the group with class III malocclusion. Facial convexity angle, nasofacial angle (P<0.001) and supratip break angle (P<0.05) were greater in the group with Class I occlusion (Table 2.17, Figure 2.13).

Nasal height, nasal length, nasal projection, nostril projection and subnasale projection (P<0.001) and the supratip break angle (P<0.05) were greater in men.

Table 2.17: Results of the 2-way ANOVA used to verify the influence of occlusion type (Class I or class III malocclusion) and gender on the facial soft tissue and nasal profile variables

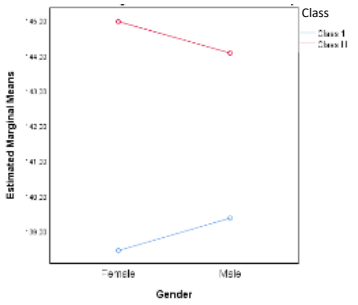
Variable	G	Class I Mean (SD)	Class III Mean (SD)	Source	Sum of squares	Mean Square	F Value	Power	*P*-value
Total facial convexity angle		138.91 (4.37)	144.52 (5.73)	Group	1260.01	1260.01	48.30	1.00	0.000***
	M	139.37 (4.13)	144.07 (5.89)	Gender	0.01	0.01	0.00	0.05	0.985
	F	138.45 (4.60)	144.97 (5.61)						
				Group * Gender	33.12	33.12	1.27	0.20	0.262
Facial convexity angle		13.67 (4.39)	7.25 (5.52)	Group	1648.66	1648.66	67.24	1.00	0.000***
	M	13.39 (5.11)	8.35 (5.85)	Gender	26.90	26.90	1.10	0.18	0.297
	F	13.95 (3.57)	6.15 (5.00)						
				Group * Gender	76.45	76.45	3.12	0.42	0.079
Nasomental angle		132.04 (5.26)	138.25 (5.91)	Group	1541.94	1541.94	48.94	1.00	0.000***
	M	132.32 (5.16)	137.68 (5.74)	Gender	3.28	3.28	0.10	0.06	0.747
	F	131.76 (5.40)	138.81 (6.11)						
				Group * Gender	28.48	28.48	0.90	0.16	0.343
Nasofacial angle		27.82 (2.77)	24.41 (3.30)	Group	465.47	465.47	49.72	1.00	0.000***
	M	27.72(2.36)	24.72 (3.50)	Gender	1.91	1.91	0.20	0.07	0.652
	F	27.92 (3.16)	24.09 (3.10)						
				Group * Gender	6.93	6.93	0.74	0.14	0.391
Nasal bone angle		167.24 (6.67)	166.02 (6.61)	Group	58.93	58.93	1.37	0.21	0.244
	M	167.09 (6.83)	164.26 (7.06)	Gender	145.73	145.73	3.39	0.45	0.068
	F	167.38 (6.59)	167.79 (5.69)						
				Group * Gender	105.14	105.14	2.44	0.34	0.120
Nasal bone length		23.18 (3.47)	24.28 (3.26)	Group	48.40	48.40	4.26	0.54	0.041
	M	23.45 (3.49)	24.66 (3.71)	Gender	17.69	17.69	1.56	0.24	0.214
	F	22.90 (3.48)	23.89 (2.72)						
				Group * Gender	0.48	0.48	0.04	0.06	0.837
Nasal height		56.28 (3.95)	58.04 (3.95)	Group	123.90	123.90	8.99	0.85	0.003**
	M	57.48 (3.68)	59.62 (3.94)	Gender	309.14	309.14	22.43	1.00	0.000***
	F	55.08 (3.88)	56.46 (3.32)						
				Group * Gender	5.85	5.85	0.43	0.10	0.516
Nasal length		49.78 (3.71)	51.26 (4.11)	Group	87.17	87.17	6.54	0.72	0.011*
	M	50.94 (3.66)	52.98 (4.01)	Gender	330.91	330.91	24.84	1.00	0.000***
	F	48.62 (3.43)	49.54 (3.47)						
				Group * Gender	12.49	12.49	0.94	0.16	0.334
Depth of the supratip break		0.14 (1.11)	-0.20 (1.11)	Group	4.73	4.73	3.92	0.50	0.050
	M	0.14 (1.28)	0.09 (1.04)	Gender	3.34	3.34	2.76	0.38	0.098
	F	0.14 (0.93)	-0.49 (1.12)						
				Group * Gender	3.28	3.28	2.72	0.37	0.101
Columella depth		2.50 (0.75	2.59 (0.72)	Group	0.32	0.32	0.59	0.12	0.443
	M	2.52 (0.80	2.63 (0.78)	Gender	0.13	0.13	0.24	0.08	0.624
	F	2.48 (0.71	2.55 (0.67)						
				Group * Gender	0.02	0.02	0.03	0.05	0.864

Columella exposure		4.79 (1.43)	4.72 (1.43)	Group	0.20	0.20	0.10	0.06	0.754
	M	4.86 (1.62)	4.70 (1.16)	Gender	0.11	0.11	0.05	0.06	0.822
	F	4.72 (1.22)	4.74 (1.67)						
				Group * Gender	0.30	0.30	0.14	0.07	0.705
Nasal projection		27.23 (2.23)	27.90 (3.17)	Group	18.16	18.16	2.77	0.38	0.098
	M	27.87 (2.06)	29.20 (2.81)	Gender	149.96	149.96	22.89	1.00	0.000***
	F	26.59 (2.24)	26.61 (3.00)						
				Group * Gender	17.10	17.10	2.61	0.36	0.108
Nostril projection		18.88 (2.26)	18.71 (2.55)	Group	1.21	1.21	0.23	0.08	0.634
	M	19.37 (2.19)	19.66 (2.29)	Gender	83.09	83.09	15.67	0.98	0.000***
	F	18.39 (2.26)	17.75 (2.46)						
				Group * Gender	8.70	8.70	1.64	0.25	0.202
Subnasale projection		11.47 (1.55)	11.53 (2.23)	Group	0.12	0.12	0.04	0.05	0.844
	M	12.02 (1.61)	12.49 (1.99)	Gender	90.90	90.90	29.22	1.00	0.000***
	F	10.92 (1.29)	10.57 (2.05)						
				Group * Gender	6.72	6.72	2.16	0.31	0.144
Nasal protrusion		15.75 (1.83)	16.38 (2.19)	Group	16.07	16.07	3.96	0.51	0.048*
	M	15.84 (1.82)	16.72 (2.20)	Gender	7.53	7.53	1.85	0.27	0.175
	F	15.65 (1.85)	16.04 (2.16)						
				Group * Gender	2.38	2.38	0.59	0.12	0.446
Nasal prominence angle		19.88 (2.18)	19.82 (1.88)	Group	0.14	0.14	0.04	0.05	0.853
	M	19.73 (1.98)	19.73 (2.06)	Gender	2.50	2.50	0.60	0.12	0.440
	F	20.04 (2.37)	19.92 (1.69)						
				Group * Gender	0.12	0.12	0.03	0.05	0.865
Apical nasal angle		82.13 (8.00)	82.07 (8.29)	Group	0.14	0.14	0.00	0.05	0.963
	M	82.16 (7.54)	80.89 (9.10)	Gender	53.59	53.59	0.81	0.15	0.371
	F	82.11 (8.53)	83.26 (7.32)						
				Group * Gender	58.08	58.08	0.87	0.15	0.351
Nasal tip angle		99.33 (5.09)	99.78 (5.65)	Group	8.24	8.24	0.28	0.08	0.595
	M	99.23 (5.05)	99.05 (6.34)	Gender	28.14	28.14	0.97	0.17	0.326
	F	99.43 (5.20)	100.52 (4.83)						
				Group * Gender	16.32	16.32	0.56	0.12	0.454
Nasal projection angle		26.15 (4.48)	25.07 (4.67)	Group	46.98	46.98	2.26	0.32	0.135
	M	26.93 (4.26)	25.54 (5.51)	Gender	62.13	62.13	2.99	0.41	0.086
	F	25.38 (4.60)	24.60 (3.66)						
				Group * Gender	3.69	3.69	0.18	0.07	0.674
Dorsal contour angle		5.82 (7.14)	6.55 (6.22)	Group	21.32	21.32	0.48	0.11	0.492
	M	5.68 (7.55)	5.56 (6.05)	Gender	51.53	51.53	1.15	0.19	0.286
	F	5.97 (6.80)	7.55 (6.30)						
				Group * Gender	28.73	28.73	0.64	0.13	0.425
Supratip break angle		7.64 (5.09)	5.62 (5.64)	Group	161.81	161.81	5.93	0.68	0.016*
	M	7.69 (5.06)	7.56 (4.74)	Gender	157.41	157.41	5.77	0.67	0.017*
	F	7.59 (5.18)	3.69 (5.85)						
				Group * Gender	141.94	141.94	5.20	0.62	0.024*
Nasal tip rotation angle		70.57 (4.61)	70.66 (5.74)	Group	0.29	0.29	0.01	0.05	0.918
	M	70.52 (4.06)	70.88 (5.57)	Gender	1.23	1.23	0.05	0.06	0.833
	F	70.62 (5.15)	70.43(5.97)						
				Group * Gender	2.92	2.92	0.11	0.06	0.745
Columella-lobule angle		13.00 (7.55)	13.00 (7.30)	Group	0.00	0.00	0.00	0.05	0.999
	M	12.31 (7.09)	12.80 (7.74)	Gender	31.95	31.95	0.58	0.12	0.450
	F	13.69 (8.03)	13.21 (6.91)						
				Group * Gender	9.46	9.46	0.17	0.07	0.681

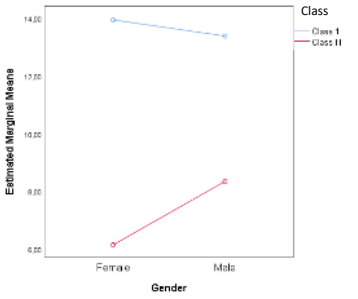
G: Gender, M: Male, F: Female, SD: Standard deviation, *P<0.05, **P<0.01, ***P<0.001

The 2-way ANOVA indicated an interaction between occlusion type and gender for the supratip break angle (P<0.05). This indicated that the differences of the statistical means of these variables can vary among the men and women in the groups with class I occlusion and class III malocclusion and vice versa.

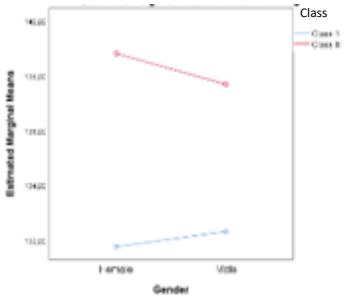
Figure 2.13: Results of the 2-way ANOVA used to verify the influence of occlusion type (Class I or class III malocclusion) and gender on the facial soft tissue and nasal profile variables



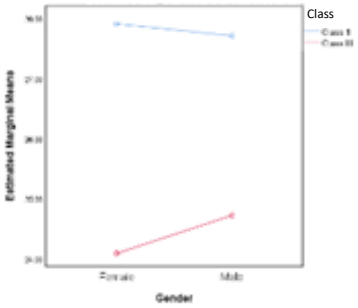
Total facial convexity angle



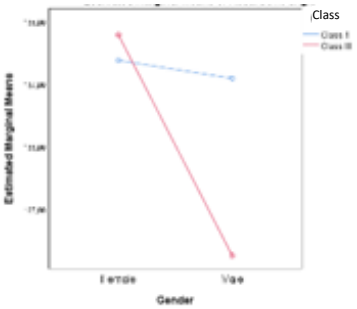
Facial convexity angle



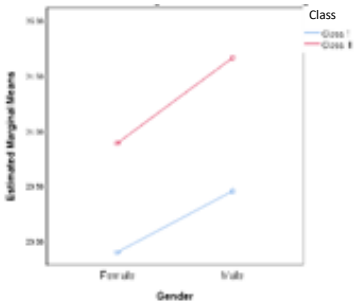
Nasomental angle



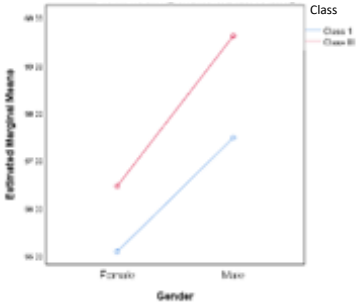
Nasofacial angle



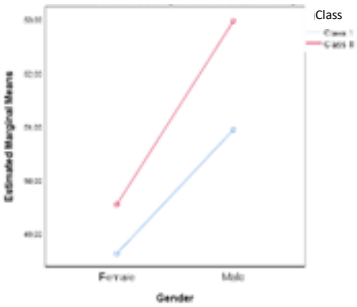
Nasal bone angle



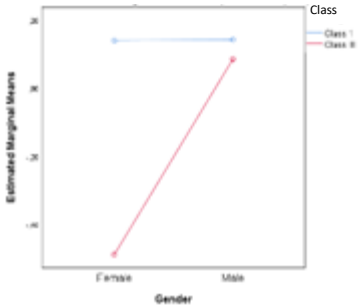
Nasal bone length



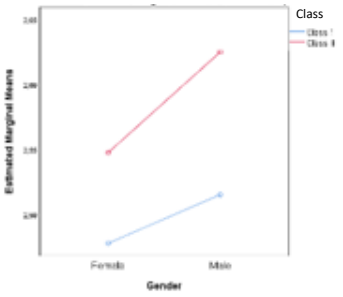
Nasal height



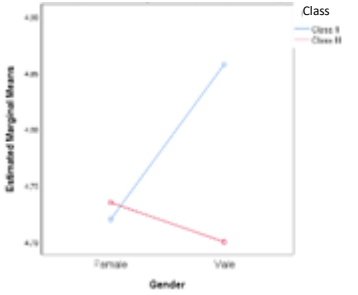
Nasal length



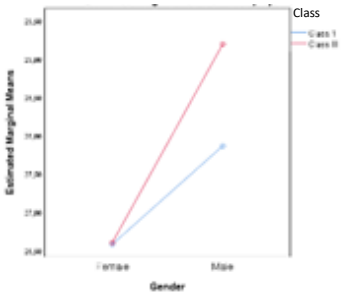
Depth of the supratip break



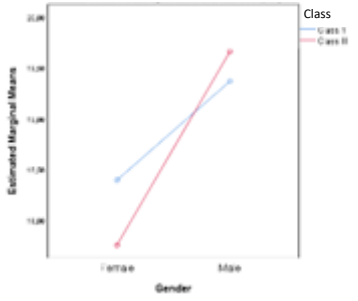
Columella depth



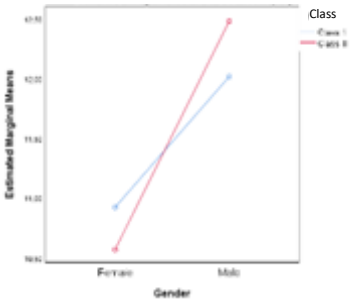
Columella exposure



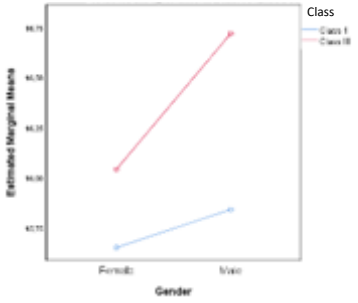
Nasal projection



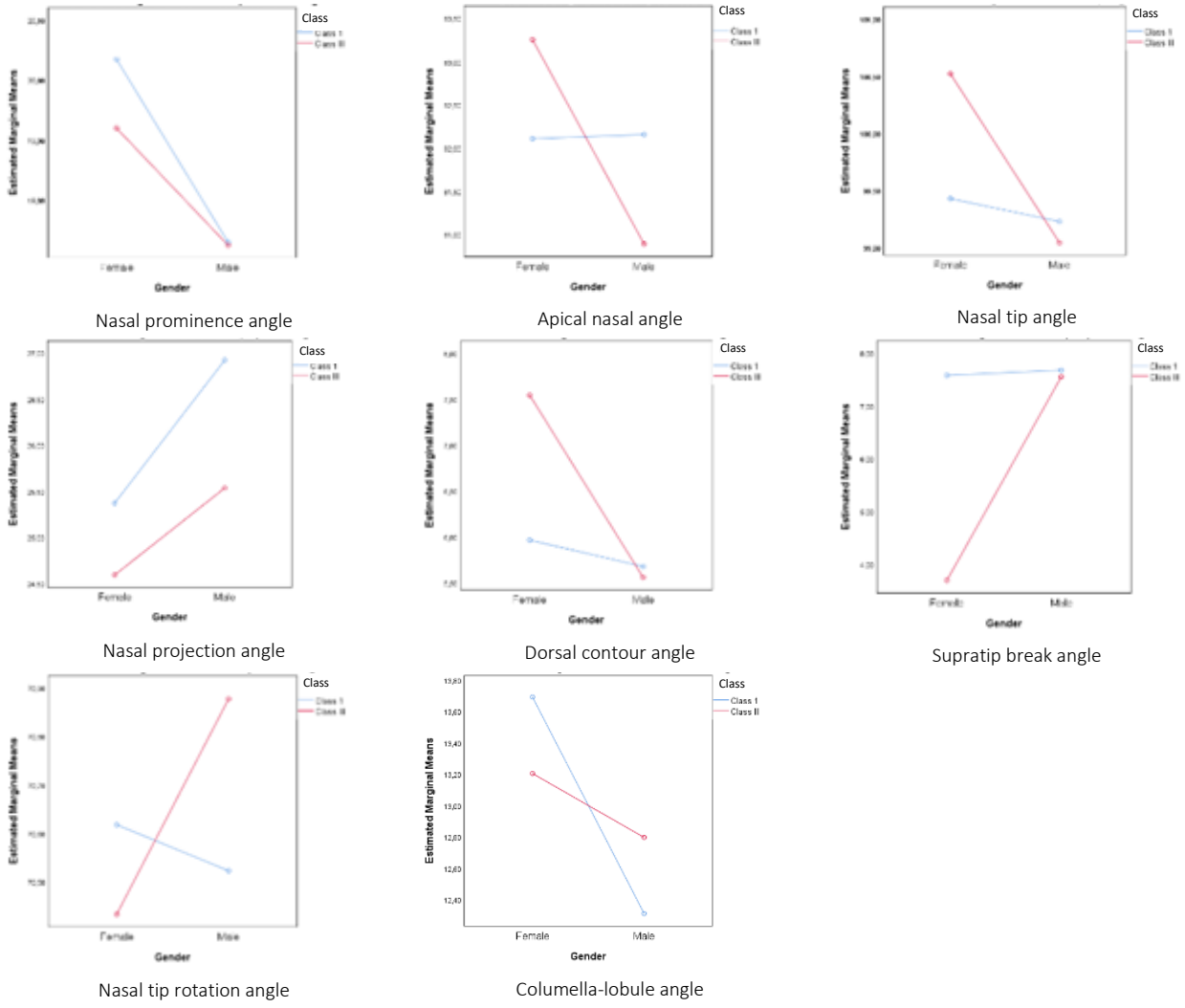
Nostril projection



Subnasale projection



Nasal protrusion



Nasal prominence angle | Apical nasal angle | Nasal tip angle

Nasal projection angle | Dorsal contour angle | Supratip break angle

Nasal tip rotation angle | Columella-lobule angle

Table 2.18: Results of the independent t test to compare the supratip break angle between men with Class I occlusion and Class III malocclusion and women with Class I occlusion and Class III malocclusion.

Cephalometric variable	Gender	Class I (n=40)		Class III (n=40)		t teste 95% CI		*P*-value
		Mean	SD	Mean	SD	Lower	Upper	
Supratip break angle	Male	7.69	5.06	7.56	4.74	-2.060	2.310	0.908
	Female	7.59	5.18	3.69	5.85	1.435	6.355	0.002**

SD: Standard deviation, CI: Confidence Interval of the difference, ****P*<0.001

Table 2.19: Results of the independent t test to compare the supratip break angle between men and women within the groups with Class I occlusion and Class III malocclusion

Cephalometric variable	Class	Men (n=40)		Women (n=40)		t teste 95% CI		*P*-value
		Mean	SD	Mean	SD	Lower	Upper	
Supratip break angle	Class I	7.69	5.06	7.59	5.18	-2.38	2.18	0.931
	Class III	7.56	4.74	3.69	5.85	-6.24	-1.50	0.002**

SD: Standard deviation, CI: Confidence Interval of the difference, **P*<0.05, ***P*<0.01

As the 2-way ANOVA demonstrated an interaction between occlusion type and gender for the supratip break angle, an independent t test was performed to determine the effect of gender on this variable in the groups with Class I occlusion and Class III malocclusion. It indicated that the angle measured significantly more in

women with Class I occlusion than in women with Class III malocclusion (P<0.01) (Table 2.18) and in men with class III malocclusion than in women (P<0.01) (Table 2.19).

At a 1% level of significance (α), the variables upper dorsal convexity (P=0.002) and lower dorsal convexity (P=0.001) in the group with Class I occlusion and columella rotation angle (P=0.008) in the group with Class III malocclusion were not normally distributed. A Mann Whitney test did not detect significant differences between the groups for these variables (Table 2.20).

Table 2.20 Results of the Mann Whitney test to compare the means of the soft tissue facial and nasal profile variables that were not normally distributed between the groups with class I occlusion and class III occlusion

Cephalometric variable	Class I (n=80)		Class III (n=80)		Mann Whitney test *P*-value
	Mean	SD	Mean	SD	
Upper dorsal convexity	-1.97	1.20	-1.83	1.18	0.607
Lower dorsal convexity	1.42	0.37	1.41	0.46	0.793
Columella rotation angle	71.50	6.80	73.26	8.57	0.140

SD: Standard deviation

Table 2.21: Results of the independent t test for the comparison of the nasolabial angle between the groups with Class I occlusion and Class III malocclusion

Cephalometric variable	Class I (n=80)		Class III (n=80)		t teste		*P*-value
					95% CI		
	Mean	SD	Mean	SD	Lower	Upper	
Nasolabial angle	109.24	9.44	106.74	12.48	-0.95	5.96	0.154

SD: Standard deviation

Table 2.22: Results of the independent t test to compare the variables that did not permit the use of the 2-way ANOVA between men with Class I occlusion and Class III malocclusion and women with Class I occlusion and Class III malocclusion.

Cephalometric variable	Gender	Class I (n=40)		Class III (n=40)		t teste		
						95% CI		*P*-value
		Mean	SD	Mean	SD	Lower	Upper	
Upper dorsal convexity	Male	-2.06	1.27	-1.93	1.28	-0.700	0.430	0.643
Lower dorsal convexity		1.46	0.32	1.54	0.43	-0.250	0.090	0.334
Columella rotation angle		70.67	5.97	73.53	9.41	-6.370	0.640	0.108
Upper dorsal convexity	Female	-1.89	1.15	-1.74	1.07	-0.649	0.339	0.534
Nasolabial angle		109.44	9.24	106.69	13.77	-2.473	7.968	0.298

SD: Standard deviation, CI: Confidence Interval of the difference, ***P<0.001

Nasolabial angle (P=0.009) in men and lower dorsal convexity (P=0.009) in women with class I occlusion and columella rotation angle (P=0.002) in women with Class III malocclusion were not normally distributed (P< 0.01). An independent t test did not detect significant differences in the nasolabial angle between the groups with class I occlusion and class III occlusion (Table 2.21).

Table 2.23 Results of the Mann Whitney test to compare the means of the non-normally distributed soft tissue facial and nasal profile variables between men with class I occlusion and class III malocclusion and between women with class I occlusion and class III malocclusion

Cephalometric variable	Gender	Class I (n=40)		Class III (n=40)		Mann Whitney test *P*-value
		Mean	SD	Mean	SD	
Nasolabial angle	Male	109.05	9.74	106.79	11.22	0.281
Lower dorsal convexity	Female	1.39	0.42	1.28	0.46	0.184
Columella rotation angle		72.34	7.52	73.00	7.75	0.620

SD: Standard deviation

Independent t test (Tables 2.22, 2.24) and Mann Whitney tests (Tables 2.23, 2.25) were used to compute differences between the other subgroups or groups. The independent t-test demonstrated that lower dorsal convexity was greater in men than in women in the group with Class III malocclusion (P<0.05) (Table 2.24).

Table 2.24: Results of the independent t test to compare the variables that did not permit the use of the 2-way ANOVA between men and women within the groups with Class I occlusion and Class III malocclusion

Cephalometric variable	Class	Men (n=40)		Women (n=40)		t teste 95% CI		*P*-value
		Mean	SD	Mean	SD	Lower	Upper	
Upper dorsal convexity	Class I	-2.06	1.27	-1.89	1.15	-0.37	0.71	0.538
Columella rotation angle		70.67	5.97	72.34	7.52	-1.35	4.70	0.274
Upper dorsal convexity		-1.93	1.28	-1.74	1.07	-0.34	0.72	0.474
Lower dorsal convexity	Class III	1.54	0.43	1.28	0.46	-0.46	-0.07	0.010*
Nasolabial angle		106.79	11.22	106.69	13.77	-5.69	5.50	0.973

SD: Standard deviation, CI: Confidence Interval of the difference, *P<0.05, **P<0.01

Table 2.25: Results of the Mann Whitney test to compare the means of the soft tissue facial and nasal profile variables that were not normally distributed between men and women within the groups with Class I occlusion and Class III malocclusion

Cephalometric variable	Class	Men (n=40)		Women (n=40)		Mann Whitney test *P*-value
		Mean	SD	Mean	SD	
Lower dorsal convexity	Class I	1.46	0.32	1.39	0.42	0.294
Nasolabial angle		109.05	9.74	109.44	9.24	0.774
Columella rotation angle	Class III	73.53	9.41	73.00	7.75	0.711

SD: Standard deviation

2.7.4 Correlations between frontal nasal variables

Pearson´s correlation coefficient was calculated for different frontal nasal variables (Table 2.26). Morphological width demonstrated positive correlations that were weak with frontal nasal height (P<0.05) and inferior alar angle (P<0.001), moderate with right and left diagonal nostril widths (P<0.001) and strong with alar base width and superior alar angle (P<0.001). Furthermore, alar base width revealed a weak, positive correlation with frontal nasal height and inferior alar angle (P<0.01) and a moderate, positive correlation with right and left diagonal nostril widths and superior alar angle (P<0.001). Right diagonal nostril width additionally exhibited a weak, positive correlation with frontal nasal length, a moderate, positive correlation with left diagonal nostril width, frontal nasal height and superior alar angle (P<0.001), a weak, negative correlation with inferior alar angle (P<0.05) and a moderate, negative correlation with alar slope angle (P<0.001). Left diagonal nostril width also demonstrated positive correlations that were weak with frontal nasal height (P<0.01) and moderate, with the superior alar angle (P<0.001). Frontal nasal length revealed a strong, positive correlation with frontal nasal height (P<0.001) and both these variables had moderate, negative correlations with the alar slope angle, superior alar angle and inferior alar angle (P<0.001). Alar slope angle and superior alar angle also demonstrated strong and moderate, positive correlations with inferior alar angle, respectively (P<0.001).

Table 2.26: Pearson´s correlations between linear and angular nasal variables measured in frontal photographs. Table demonstrate the Pearson´s correlation coefficient followed by the *P*-value

Variable	Alar base width	Diagonal nostril width		Frontal nasal length	Frontal nasal height	Angles		
		Right	Left			Alar slope	Superior alar	Inferior alar
Morphological width	.957 .000***	.579 .000***	.576 .000***	.105 .186	.192 .015*	-.045 .573	.723 .000***	.277 .000***
Alar base width		.608 .000***	.582 .000***	.124 .117	.220 .005**	-.076 .339	.681 .000***	.207 .009**
Right diagonal nostril width			.661 .000***	.280 .000***	.359 .000***	-.319 .000***	.335 .000***	-.189 .017*
Left diagonal nostril width				.132 .096	.206 .009**	-.131 .097	.395 .000***	.009 .913
Frontal nasal length					.963 .000***	-.634 .000***	-.542 .000***	-.459 .000***
Frontal nasal height						-.554 .000***	-.471 .000***	-.502 .000***
Alar slope angle							.136 .087	.771 .000***
Superior alar angle								.328 .000***

*P<0.05, **P<0.01, ***P<0.001

2.7.5 Correlations between facial soft tissue and nasal profile variables

Pearson´s correlation coefficient was calculated for the facial soft tissue and nasal profile variables (Table 2.27). Facial convexity angle revealed a strong, negative correlation with nasomental angle (P<0.001) and weak, positive correlations with nasal projection (P<0.05), nostril projection and supratip break angle (P<0.01). Nasomental angle also demonstrated a moderate, positive correlation with nasal tip angle (P<0.001), a weak, negative correlation with columella exposure (P<0.05), upper dorsal convexity and nasal protrusion (P<0.01) and a moderate, negative correlation with nasal projection, nostril projection and supratip break angle *(*P<0.001). Nasal bone length exhibited positive correlations that were weak with nasal projection (P<0.05), nasal protrusion and columella rotation angle (P<0.01) and moderate with nasal length and nasal height (P<0.001). Nasal bone angle did not exhibit significant correlations with other nasal variables.

Nasal length additionally demonstrated positive correlations that were weak with columella exposure (P<0.05) and upper dorsal convexity (P<0.01), moderate with nasal projection, nostril projection, nasal protrusion and columella rotation angle (P<0.001), a strong positive correlation with nasal height (P<0.001) and a weak, negative correlation with nasal tip angle (P<0.01). Nasal height showed weak, positive correlations with columella rotation angle (P<0.05) and nostril projection (P<0.001) and moderate positive correlations with columella exposure, nasal projection and nasal protrusion (P<0.001). Upper dorsal convexity demonstrated weak, positive correlations with nasal projection (P<0.05), nasal protrusion *(*P<0.01) and the columella rotation angle (P<0.001) and moderate, negative correlations with nasal tip angle and supratip break angle (P<0.001). Columella exposure revealed weak, positive correlations with nasal projection and nasal protrusion (P<0.001) and a moderate positive correlation with nostril projection (P<0.001). Nasal projection also established positive correlations that were weak with columella rotation angle (P<0.01) and strong with nostril projection and nasal protrusion and a moderate, negative correlation with nasal tip angle (P<0.001). Nostril projection additionally demonstrated a weak, positive correlation with supratip break angle (P<0.01),

a moderate positive correlation with nasal protrusion and a moderate negative correlation with nasal tip angle (P<0.001). Nasal protrusion additionally exhibited a moderate, negative correlation with nasal tip angle and a positive one with the columella rotation angle (P<0.001). The nasal tip angle also demonstrated a moderate negative correlation with columella rotation angle (P<0.001).

Table 2.27: Pearson´s correlations between facial soft tissue and nasal profile variables measured in the profile photographs. Tables demonstrate the Pearson´s correlation coefficient followed by the *P*-value

	Nasomental. angle	NBL	NBA	Nasal length	Nasal height	U dorsal convexity	Col. exp	Nasal projection	Nostril projection	Nasal protrusion	Nasal tip angle	Col. rot angle	Supratip angle
Facial convexity angle	-.766 .000**	-.023 .773	-.032 .690	.103 .194	.029 .715	.123 .122	.041 .607	.163 .040*	.236 .003**	-.053 .504	-.147 .064	-.051 .521	.207 .009**
Nasomental angle		.151 .056	.02 .798	-.042 .600	.107 .178	-.264 .001**	-.171 .030*	-.328 .000***	-.462 .000***	-.248 .002**	.526 .000***	-.056 .481	-.345 .000***
Nasal bone length			-.136 .086	.650 .000***	.680 .000***	.145 .067	.066 .410	.165 .037*	.01 .896	.268 .001**	.107 .177	.266 .001**	-.146 .066
Nasal bone angle				-.031 .700	-.006 .935	-.152 .054	.092 .248	-.029 .711	.014 .859	.084 .291	.031 .700	.023 .770	-.040 .616
Nasal length					.911 .000***	.230 .003**	.177 .025*	.526 .000***	.334 .000***	.538 .000***	-.232 .003**	.445 . 000***	-.03 .708
Nasal height						.127 .109	.312 .000***	.486 .000***	.299 .000***	.485 .000***	.130 .102	.195 .014*	-.09 .255
Upper dorsal convexity							.022 .784	.190 .016*	.091 .252	.269 .001**	-.322 .000***	.292 . 000***	-.310 .000***
Columella exposure								.267 .001**	.371 .000***	.251 .001**	.127 .109	-.064 .420	.086 .280
Nasal projection									.839 .000***	.721 .000***	-.402 .000***	.271 .001**	.065 .412
Nostril projection										.541 .000***	-.367 .000***	.111 .163	.227 .004**
Nasal protrusion											-.515 .000***	.491 . 000***	-.066 .403
Nasal tip angle												-.564 . 000***	-.123 .121
Columella rotation angle													-.115 .147

*P<0.05, **P<0.01, ***P<0.001, NBL: Nasal bone length, NBA: Nasal bone angle, U dorsal convexity: Upper dorsal convexity, Col. exp: Columella exposure, Col. rot angle: Columella rotation angle, Supratip angle: Supratip break angle

2.7.6 Correlation between skeletal facial profile variables and frontal soft tissue nasal variables

Pearson´s correlation coefficients were calculated to determine the relationship between the different skeletal facial profile variables and soft tissue nasal variables measured in the frontal photographs (Table 2.29).

The ANB angle did not exhibit a normal distribution at the 1% level using the Kolmogorov-Smirnov test. Spearman´s coefficient revealed a weak negative correlation with the frontal nasal length (P<0.05) (Table 2.28).

Table 2.28: Spearman´s correlations between the ANB angle and the soft tissue nasal variables measured in frontal photographs. Tables demonstrate the Pearson´s correlation coefficient followed by the *P*-value

Variable	Morphological width	Alar base width	Diagonal nostril width		Frontal nasal length	Frontal nasal height	Angles		
			Right	Left			Alar slope	Superior alar	Inferior alar
ANB angle	-0.006 .943	.022 .781	.005 .953	.085 .284	-.164 .038*	-.143 .072	.13 .102	.095 .230	.024 .764

*P<0.05

Left diagonal nostril width demonstrated a weak negative correlation with maxillary inclination (P<0.05). Frontal nasal height demonstrated a weak, positive correlation with maxillary length (P<0.05). The other frontal nasal variables did not demonstrate correlations with the skeletal facial variables (Table 2.29).

Table 2.29: Pearson´s correlations between skeletal facial variables and soft tissue nasal variables measured in frontal photographs. Tables demonstrate the Pearson´s correlation coefficient followed by the *P* value

Variable	Morphological width	Alar base width	Diagonal nostril width		Frontal nasal length	Frontal nasal height	Angles		
			Right	Left			Alar slope	Superior alar	Inferior alar
Total facial height	.028	.026	-.038	-.032	.06	.04	.003	-.04	.075
	.728	.749	.635	.683	.450	.618	.971	.619	.344
Lower facial height	.04	.04	-.028	-.033	-.004	-.033	-.004	.029	.091
	.619	.615	.723	.682	.964	.679	.961	.712	.253
Sagittal maxillary position	.089	.1	.049	.103	.077	.116	-.025	.012	-.058
	.263	.210	.537	.193	.332	.145	.757	.878	.466
Maxillary length	.071	.073	.054	.13	.138	.165	-.094	-.025	-.107
	.372	.360	.497	.100	.082	.037*	.236	.75	.178
SNA angle	.002	-.011	.02	.094	.073	.09	-.062	-.03	-.1
	.976	.895	.804	.239	.362	.256	.44	.706	.208
Maxillary inclination	-.021	-.026	-.052	-.158	.076	.09	.056	-.102	.013
	.788	.742	.518	.046*	.341	.255	.480	.199	.871
Mandibular plane inclination	.027	.04	-.076	-.134	.004	-.028	.022	-.004	.105
	.737	.611	.341	.092	.961	.727	.785	.964	.187

*P<0.05, **P<0.01, ***P<0.001

2.7.7 Correlation between skeletal facial profile and skeletal and soft tissue nasal profile variables

Pearson´s correlation coefficients were calculated to determine the relationship between the different skeletal facial profile variables and skeletal and soft tissue nasal profile variables (Table 2.30). Nasomental angle demonstrated a weak, positive correlation with total facial height (P<0.01), lower facial height, maxillary inclination (P<0.05) and mandibular plane inclination (P<0.01) and a weak, negative one with sagittal maxillary position (P<0.05), maxillary length and SNA angle (P<0.01).

Table 2.30: Pearson´s correlations between skeletal facial variables and nasal profile variables. Tables demonstrate the Pearson´s correlation coefficient followed by the *P*-value

Variable	Nasomen. angle	NBL	NBA	Nasal length	Nasal height	U dorsal convexity	Col. exposure	Nasal projection	Nostril projection	Nasal protrusion	Nasal tip angle	Col. rot angle	Supratip angle
Total facial height	.254	.426	-.136	.650	.749	.035	.088	.483	.283	.349	.152	.068	-.024
	.001**	.000***	.087	.000***	.000***	.662	.270	.000***	.000***	.000***	.055	.394	.763
Lower facial height	.182	.191	-.160	.401	.498	.052	.004	.400	.223	.256	.135	-0.023	.02
	.021*	.015*	.044*	.000***	.000***	.511	.962	.000***	.005**	0.001**	.088	.776	.806
Sagittal maxillary position	-.192	-.226	-.065	-.035	-.079	-.096	-.067	.005	.117	-.240	-.104	-.296	.173
	.015*	0.004**	.413	.657	.322	.226	.397	.951	.140	0.002**	.189	.000***	.028*
Maxillary length	-.207	-.240	-.054	-.075	-.124	-.053	-.061	.035	.155	-.213	-.142	-.279	.154
	.009**	0.002**	0.501	.343	.119	.503	.444	.658	.050	0.007**	.074	.000***	.052
SNA angle	-257	-.281	-.085	-.259	-.353	-.096	-.071	-.217	-.033	-.388	-.199	-.354	.136
	.001**	.000***	.287	.001**	.000***	.230	.372	.006**	.675	.000***	.012*	0.000***	.087
Maxillary inclination	.174	.412	.071	.402	.402	-.02	.267	.078	-.007	.262	.046	.411	-.220
	.027*	.000***	.370	.000***	.000***	.802	.001**	.324	.928	0.001**	.562	.000***	.005**
Mandibular plane inclination	.239	.368	-.024	.309**	.394	.113	-.006	.180	-.008	.274	.194	.244	-.214
	.002**	.000***	.764	.000***	.000***	.154	.940	.023*	.923	.000***	.014*	.002**	.006**

*P<0.05, **P<0.01, ***P<0.001, Nasomen. Angle: Nasomental angle, NBL: Nasal bone length, NBA: Nasal bone angle, U dorsal convexity: Upper dorsal convexity, Col. exposure: Columella exposure, Col. rot angle: columella rotation angle, Supratip angle: supratip break angle

Nasal bone length exhibited a weak, positive correlation with lower facial height (P<0.05), moderate, positive ones with total facial height, maxillary inclination and mandibular plane inclination (P<0.001) and weak, negative ones with sagittal maxillary position, maxillary length (P<0.01) and the SNA angle (P<0.001). The nasal bone angle demonstrated a weak, negative correlation with the lower facial height (P<0.05).

Nasal length showed moderate, positive correlations with total facial height, lower facial height, maxillary inclination and mandibular plane inclination (P<0.001) and a weak, negative correlation with SNA angle (P<0.01). Nasal height demonstrated moderate positive correlations with lower facial height, maxillary inclination and mandibular plane inclination (P<0.001), a strong, positive correlation with total facial height (P<0.001) and a moderate, negative correlation with SNA angle (P<0.001). Upper dorsal convexity did not reveal significant correlations with skeletal facial variables. Columella exposure revealed a weak, positive correlation with maxillary inclination (P<0.01). Nasal projection demonstrated positive correlations that were weak with mandibular plane inclination (P<0.05) and moderate with total facial height and lower facial height (P<0.001) and a weak, negative correlation with SNA angle (P<0.01). Nostril projection indicated a weak, positive correlation with total facial height (P<0.001) and lower facial height (P<0.01). Nasal protrusion revealed positive correlations that were weak with lower facial height, maxillary plane inclination (P<0.01) and mandibular plane inclination (P<0.001) and moderate with total facial height *(*P<0.001) and negative correlations that were weak with sagittal maxillary position and maxillary length (P<0.01) and moderate with SNA angle *(*P<0.001). Nasal tip angle demonstrated a weak, positive correlation with mandibular plane inclination and a weak, negative correlation with SNA angle (P<0.05). Columella rotation angle revealed positive correlations that were weak with mandibular plane inclination (P<0.01) and moderate with maxillary inclination (P<0.001) and negative ones that were weak with sagittal maxillary position and maxillary length and moderate with the SNA angle (P<0.001). Supratip break angle demonstrated a weak, positive correlation with sagittal maxillary position (P<0.05) and a weak, negative correlation with maxillary inclination and mandibular plane inclination (P<0.01).

The ANB angle did not exhibit a normal distribution at the 1% level using the Kolmogorov-Smirnov test. Spearman´s correlation revealed that the ANB angle had a moderate negative correlation with the nasomental angle (P<0.001) and a weak positive one with the supratip break angle (P<0.05) (Table 2.31).

Table 2.31: Spearman´s correlations between the ANB angle and nasal profile variables. Tables demonstrate the Pearson´s correlation coefficient followed by the *P*-value

Variable	Nasomen. angle	NBL	NBA	Nasal length	Nasal height	U dorsal convexity	Columella exposure	Nasal projection	Nostril projection	Nasal protrusion	Nasal tip angle	Columella rot angle	Supratip break angle
ANB angle	-.601	-.047	.052	-.051	-.099	-.009	.036	-.044	.058	-.056	-.087	-.067	.179
	.000***	.558	.516	.520	.215	.906	.654	.577	.467	.481	.275	.401	.024*

Nasomen. angle: Nasomental angle, NBL: Nasal bone length, NBA: Nasal bone angle, U dorsal convexity: Upper dorsal convexity, Columella rot angle: columella rotation angle

2.8 Discussion

Lateral cephalometry and clinical photography are the most commonly used tools for studying facial morphology (Hellak et al., 2015; Nkenke et al., 2008). Each of these bidimensional methods has the inherent disadvantage of not being able to describe facial depth and width simultaneously (Honrado et al., 2006;

Verdenik & Ihan Hren, 2014). However, two projections that are perpendicular to each other can adequately describe the three-dimensional nose (Betts et al., 1993; Bottini et al., 2013).

Lateral cephalograms permit the analysis of the patient's facial and nasal morphology and the quantification of its deviation from the norm (Baumrind & Frantz, 1971a, 1971b; Phillips et al., 1984). However, they allow measurements only in the midsagittal plane and do not optimally present the soft tissue layer, making the use of photographs necessary (Betts et al., 1993; Donatsky et al., 2009; Hemmatpour et al., 2016; Honrado et al., 2006). Both are more easily interpreted than three-dimensional images (Hellak et al., 2015; Nkenke et al., 2008).

Photographs are routinely used in clinical practice for diagnosis, monitoring clinical progress and the evaluation and demonstration of treatment results (Claman et al., 1990; Edler et al., 2011; Zhang et al., 2007). They permit reproducible, linear and angular measurements (Gomes et al., 2013; Zhang et al., 2007) and are the easiest and most reliable method for measuring nasal variables (Naeem et al., 2015; Prinsley, 1992).

The semi-standardized photographs used in this investigation were always obtained using the same procedure. They were taken with the camera mode set to manual to obtain consistent exposure (Becker & Tardy, 1999; Khavkin & Ellis, 2011). A macro lens with the same focal length in obtaining all images also ensured consistency (Khavkin & Ellis, 2011). A 105 mm focal length that is recommended with DSLR cameras was used to minimize facial distortion and provide a comfortable distance from the patient and the largest depth of field to ensure that the whole face was in focus (Becker & Tardy, 1999; Khavkin & Ellis, 2011; Swamy & Most, 2010). The aperture f-stop setting of F10 ensured that all facial features were sharply focussed (Khavkin & Ellis, 2011). The 1/60 second shutter speed controlled the time of light exposure (Becker & Tardy, 1999; Khavkin & Ellis, 2011). An even, monochromatic, non-reflective, white background eliminated distractions and provided sufficient contrast for patient-background separation, allowing full focus on the patient (Khavkin & Ellis, 2011; Persichetti et al., 2007; Swamy & Most, 2010).

Adequate lighting eliminated shadows and ensured the greatest possible depth of field (Becker & Tardy, 1999). The use of an annular flash created even lighting (Becker & Tardy, 1999; Khavkin & Ellis, 2011). The flash, which is characterized by a low flash-to-subject distance using the macro function, was placed on top to provide standardized illumination for frontal images of vertical subjects and on the same side as the profile line for lateral images to avoid shadows from the forehead, nose and lip (Persichetti et al., 2007).

The best way to standardize facial portraits is to keep the focal length constant at 105 mm and mount the camera on a tripod at a fixed distance (Claman et al., 1990; Nechala et al., 1999). Although the semi-standardized photographs used in this investigation were obtained without the use of a tripod, floor markings ensured uniformity in the operators and patient´s position (Khavkin & Ellis, 2011; Persichetti et al., 2007; Swamy & Most, 2010). The clinician and thus, camera stood at a fixed 1.5 meter distance from the patient to ensure uniform magnification and consistent perspective and reproduction ratios for all patients (Claman et al., 1990; Khavkin & Ellis, 2011). This distance was greater than the recommended minimum of 10 times the “breadth of the subject” for photographic distortion to be less than 1% (Gavan et al., 1952; Muradin et al., 2007).

The liquid crystal display (LCD) screen with a grid of the Nikon D80 camera helped to review the image and ensure whether the patient´s position or the horizontal plane needed to be adjusted (Becker & Tardy, 1999; Khavkin & Ellis, 2011; Swamy & Most, 2010). The face was positioned in the centre of the frontal photograph with both ears, the crown of the head and the clavicle clearly visible (Claman et al., 1990; Nechala et al., 1999). Profile photographs allowed clear visualization of the nose, the inner and outer contours of one eye but not of the contralateral facial structures including the eyebrow (Claman et al., 1990; Persichetti et al., 2007). The superimposition of the eyelashes and eyebrows was thus an alignment safeguard for profile photographs (Khavkin & Ellis, 2011; Swamy & Most, 2010).

Patient head position is very important during photography (Gomes et al., 2013; Persichetti et al., 2007; Sommer & Mendelsohn, 2004). The photographs used in this investigation were taken using the highly reproducible, natural head position, generally recommended for clinical photography (Fabré et al., 2010; Leitao & Nanda, 2000; Lundström & Lundström, 1992; Solow & Tallgren, 1971). Patients taller than the photographer were asked to sit in in a rotating chair with their feet flat on the floor (Becker & Tardy, 1999; Swamy & Most, 2010). Bjerin (1957) demonstrated a standard deviation of only 1.62° for the natural head position in the sitting position, justifying its use.

Natural head orientation was used when the clinician perceived that the patient´s head position was 'unnatural' (Arnett et al., 1999; Lundström & Lundström, 1995). Researchers demonstrated a high correlation in estimating the natural head position in profile photographs cut in a circular shape and a good correlation with head orientation repeated after a 3-week interval indicating that clinicians can critically evaluate the patient's natural head position and correct head orientation to ensure standardization (Lundström & Lundström, 1995).

2.8.1 Differences between the groups with Class I and Class III malocclusions

Soft tissue facial angles must be measured as variations in thickness may cause a divergence from the underlying dentoskeletal discrepancy (Burstone, 1959, Maurya et al., 2014). Surgical treatment plans should aim to bring these angles closer to more harmonious Class I values. In this study, the shorter, more retrusive maxilla, the prognathic mandible and a greater vertical dimension, associated with greater posterior mandibular inclination, contributed to reduce the facial convexity angle in the group with Class III malocclusion (Arnett & Bergman, 1993, Gulsen et al., 2006). Investigations in Pakistanis (Arshad et al., 2013), Turks (Gulsen et al., 2006) and Caucasians (Bergman, 1999) confirm that individuals with class III malocclusions tend to have reduced convexity angles. The average values in the groups with Class I (13.67±4.39°) and Class III malocclusions (7.25±5.52°) in this investigation were close to the upper and lower limits of the North American 7° to 15° Class I range, indicating that class III individuals had a relatively straight profile (Bergman, 1999). Adult Caucasian norms of 12±4° (Legan & Burstone, 1980) and 5°-15° (Arnett and Bergman,1993b) have also been proposed. Burstone (1959) measured an angle of 11.3±4° in 16.5 to 36.3-year-old Caucasians with good or excellent facial profiles.

Besides a greater total facial convexity angle, the greater vertical dimension and mandibular protrusion also led to a larger nasomental angle in the group with class III malocclusion, in conformity with the results of studies on Pakistanis and Turks (Arshad et al., 2013; Gulsen et al., 2006). Other authors have indicated a relationship between the nasomental angle and malocclusion type although their samples did not include class III cases (Maurya et al., 2014; Naeem et al., 2015). The class I values of the total facial convexity angle were comparable to those measured in a previous study on Caucasians (Bishara et al., 1984).

Smaller nasal tip prominence relative to the more protrusive chin caused a smaller nasofacial angle in the group with class III malocclusion. A superior soft tissue nasion position may also be a contributing factor (Lines et al., 1978; Naini, 2012). Robison et al. (1986) also observed that mandibular protrusion contributed to a smaller dorsal axis/soft tissue glabella-pogonion line angle in young Caucasian girls with class III malocclusions. In this study, the value in the group with Class I occlusions was close to 30° and within the Jacques Joseph´s ideal 23° to 37° range, which was based on the paintings of artists such as Leonardo da Vinci and Thomas Gainsborough (Naini, 2012). Mandibular setback surgery and nasal tip advancement caused by maxillary advancement to correct class III discrepancies should increase this angle to Class I values.

Several authors have suggested that, due to the great variability in nasal form and profile, different skeletal classes can exhibit a variety of nasal characteristics (Gulsen et al., 2006; Wisth, 1975, Nahidh, 2009). Nahidh (2009) proposed that this is due to variations in size, shape and spatial relationship between the bony and cartilaginous nasal components and the overlying muscles and integumental tissue. This investigation detected only a few differences between Caucasians with class I occlusion and class III malocclusion.

Robison et al. (1986) did not detect a correlation between morphological width and sagittal skeletal facial dimensions in 11 to 26 year-old girls although a smaller width tended to be associated with a smaller dorsal plane/glabella-pogonion line angle and thus, mandibular prognathism. Other authors have not considered frontal nasal morphology. While the larger average 0.56 mm columella width was unlikely to be clinically significant, the larger nasal length and height in both the frontal and profile photographs and ratios calculated using the similar morphological width confirmed that the group with class III malocclusion presented a greater vertical nasal dimension. The smaller alar slope angle in this group also reflected the longer dorsum and lower nasal tip position relative to the alae. The smaller superior alar angle indicated that a higher soft tissue nasion position also contributed to the longer length and height.

The discrepancy between the values of nasal height and length measured in frontal and profile photographs was caused by the different definition of soft tissue nasion, pronasale and the columella overhang in the frontal view. Pronasale was identified as the centre of a triangle of light on the nasal tip (O'Ryan & Schendel, 1989; Schendel & Carlotti, 1991). While other authors did not measure nasal height, Wisth (1975) demonstrated a longer nose in adult men with Class II and III malocclusions compared to those with Class I occlusion. Chaconas (1969) observed a longer nose in his small sample of 4 individuals with Class III malocclusions than in other skeletal classes. However, nasal length did not differ between Turks and Pakistanis with different types of malocclusion, indicating racial variation, although the latter study included only 8

individuals with class III discrepancies and both studies did not indicate whether anomalies in maxillary or mandibular position or both contributed to the negative ANB angle (Arshad et al., 2013; Gulsen et al., 2006).

Maxillary advancement surgery for the correction of Class III occlusion elevates both pronasale and subnasale (Mitchell et al., 2007, McCollum et al., 2009). However, while nasal height and length are favourably reduced, the larger post-surgical width (DeSesa et al., 2016; Metzler et al., 2014) is likely to deviate further from that of the Class I nose.

Nasal bone parameters did not differ significantly between the groups, supporting the conclusions of studies on Pakistanis and Turks (Arshad et al., 2013; Gulsen et al., 2006). Its length did not differ between 10 to 16 year-old children with different types of malocclusions (Chaconas, 1969). Wisth (1975) found that nasal bones were an average 3.4 mm longer in men with class III malocclusion than those with class I occlusion. However, the average 82±4.0° SNA angle in their class III sample indicated varying degrees of maxillary prognathism.

The group with Class III malocclusion also had slightly larger nasal protrusion, but similar nasal and subnasale projection, when compared to the group with class I occlusion. While other authors did not measure nasal protrusion, they confirmed the similar nasal projection using other variables. The alare-pronasale and pronasale/soft tissue nasion-subnasale line distances did not differ between Pakistanis (Arshad et al., 2013) and Turks (Gulsen et al., 2006) of different skeletal types. Nahidh (2009) did not find a correlation between these variables and sagittal jaw parameters in Iraqis with class I and II malocclusions. The sella-nasion-pronasale angle did not differ between men of different skeletal classes (Wisth 1975). Robison et al. (1986) did not find a correlation between sagittal skeletal facial parameters and sagittal pronasale-soft tissue nasion and pronasale-anterior nasal spine distances in young Caucasian girls. However, Chaconas (1969) demonstrated greater nasal tip/nasion-A point line distance in a limited sample of 4 individuals with Class III malocclusions than in other skeletal classes, although this variable may have reflected maxillary retrusion. Maxillary advancement surgery reduces nasal protrusion (Betts et al., 1993; Chung et al., 2008) and nasal tip projection (Almukhtar et al., 2016; Metzler et al., 2014) as subnasale and the alar curvature advance more than the nasal tip and can result in a flatter appearing nose.

Among the variables defining dorsal form, the supratip break angle indicated a flatter contour in the group with Class III malocclusion, especially in the women in this group. The linear measurement also indicated a non-significant tendency for flattening. Columella depth and upper and lower dorsal convexity did not differ between the groups. Studies on Pakistanis and Turks confirm the similarity in columella depth and upper dorsal convexity (Arshad et al., 2013; Gulsen et al., 2006). Chaconas (1969) concluded that 4 individuals with Class III malocclusion had a more concave upper dorsum. Robison et al. (1986) also observed that the upper dorsal contour was concave in 89.10% of young girls with a skeletal Class III discrepancy based on the Sassouni analysis and straight in 75% of those with a class I relationship. However, both authors used subjective classifications rather than actual measurements. Authors associate greater dorsal convexity with class II malocclusions (Chaconas, 1969; Genecov et al., 1990). While Turks also did not demonstrate a difference for the lower dorsal convexity (Gulsen et al., 2006), it was flatter in eight Pakistanis with class III malocclusions

(1.62±0.74 mm) than in those with class I occlusions (2.35±0.67 mm), indicating racial variation (Arshad et al., 2013). While maxillary advancement surgery may not directly affect the *hump*, nasal tip elevation and advancement can affect its relative size (Esenlik et al., 2011; Mitchell et al., 2007; Schendel & Carlotti, 1991). Thus, the nasal dorsum, which has a similar shape to the one seen in Class I occlusions, may appear concave after surgery. Conversely, the supratip break depth will appear deeper relative to the soft tissue nasion-pronasale line (Esenlik et al., 2011, Choi et al., 2014)

The nasolabial angle tended to be smaller in the class III group (106.74±12.48°) than in the Class I group (109.24±9.44°) in this study, although with a large standard deviation. A similar non-significant tendency was seen in Turks with angles of 103.57±15.04° and 106.77±11.81°, respectively (Gulsen et al., 2006) and in Pakistanis with values of 92.25±15.35° and 99.23±13.99°, respectively (Arshad et al., 2013). Smaller nasolabial angles were associated with mandibular prognathism in young Caucasian girls (Robison et al., 1986). This tendency is possibly caused by the severely negative overjet, deep overbite and the dead space behind the upper lip, whose support is provided by the lower lip and incisors (Soncul & Bamber, 2004; Stella et al., 1989). In the absence of a dead space, upper incisor compensation may also contribute to lower this angle. The patient´s age and closed vs relaxed lip positions cause further variation (Arnett & Bergman, 1993). Although authors recommend that this angle should be interpreted with caution due to its large variability (Fernández-Riveiro et al., 2003; Malkoc et al., 2009; Scheideman et al., 1980), it influences the orthodontic-surgical treatment plan (Anić-Milošević et al., 2008; Bergman, 1999; Legan & Burstone, 1980). Some authors observed that maxillary advancement surgery reduced this angle due to anterior upper lip inclination (Carlotti et al., 1986, Rosen, 1988) while others identified an increase due to upward columella rotation (Esenlik et al., 2011, Khamashta-Ledezma & Naini, 2015) or even no change (Metzler et al., 2014; Misir et al., 2011). However, the pre-surgical value after upper incisor decompensation is more important than the initial one in treatment planning.

2.8.2 Differences between men and women

The male face is larger than the female face (Ferrario et al., 1994; Maurya et al., 2014; Starck & Epker, 1996). Accordingly, men have bigger noses (Ferrario et al., 1994; Li et al., 2014; Park et al., 2014). with larger volume and external area (Sforza et al., 2011) to permit the rapid transport of oxygen to their lungs with larger vital capacity (Burke & Hughes-Lawson, 1989; Johnston et al., 2001).

In this study, the greater nasal root, morphological, alar base, columella, nasal base and diagonal nostril widths, bilateral width of the nostril floor, inner endocanthal, frontal subnasale-alare and dorsal axis-alare distances and superior and inferior alar angles and smaller lateral alar angle reflected the wider male nose. Frontal nasal height, nasal height, nasal length and nasal tip, subnasale and nostril projections were also larger in men while frontal nasal length tended to be so. The calculated ratios were larger in women despite their tendency to have shorter noses and narrower roots indicating a much smaller, relative morphological width.

Measurements in most races confirm that men have larger nasal dimensions (Appendix 1, annex 1). In accord with this research, men revealed a larger morphological width than women in Caucasians (Ferrario et

al., 1993; Jovanović et al., 2014; Sforza et al., 2011), Iranians with normal occlusions (Amini et al., 2014; Fariaby et al., 2006), Turks (Borman et al., 1999; Ozdemir & Uzun, 2015) and Chileans (Troncoso Pazos et al., 2008). Studies on Caucasians (Sforza et al., 2011), Iranians with class I occlusion (Moshkelgosha et al., 2015) and Han Chinese (Li et al., 2014) confirm the larger male alar base width. Saudi Arabian (Al-Qattan et al., 2012) and Turkish (Ozdemir & Uzun, 2015) women presented a larger alar base width than men, despite their smaller morphological width. While columella width was larger in men in this study, it did not demonstrate sexual dimorphism in Turks (Ozdemir & Uzun, 2015) and together with morphological width, in Han Chinese (Li et al., 2014).

Caucasians from New Zealand (Begg & Harkness, 1995), Italian Caucasians with less than 5 mm overjet (Sforza et al., 2004), Turks (Ozdemir & Uzun, 2015) and Saudi Arabians (Al-Qattan et al., 2012) also revealed larger nasal heights and lengths in men than in women. Men presented larger nasal heights in studies on Turks (Borman et al., 1999), Serbians (Jovanović et al., 2014) and Italians with a class I occlusion (Ferrario et al., 1993). Caucasians with Class I occlusion (Starck & Epker, 1996), Indians (Prasad et al., 2014), Turks (Gulsen et al., 2006), Chileans (Troncoso Pazos et al., 2008) and Pakistanis (Arshad et al., 2013) and Iranians with class I occlusions (Fariaby et al., 2006) also displayed larger nasal lengths in men. Yet, Scheideman et al. (1980) found a similar nasal height in Caucasians of both genders with class I occlusion. In addition, nasal height and length did not differ between Han Chinese men and women (Li et al., 2014).

Nasal bone length did not reveal significant gender based differences in this investigation and in Turks (Gulsen et al., 2006). The nasal bone was longer in men in studies on Pakistanis (Arshad et al., 2013), and Koreans (Kim et al., 2015).

Nasal projection was larger in Han Chinese (Li et al., 2014) and in Chilean men than in women (Troncoso Pazos et al., 2008) in agreement with this study, but larger in Turkish women (Ozdemir & Uzun, 2015). Pronasale/soft tissue nasion-subnasale line distance was larger in Turkish (Gulsen et al., 2006), Pakistani (Arshad et al., 2013) and Indian (Prasad et al., 2014) men than in women. Ferrario et al. (1994) suggested that a greater nasal tip projection represented a larger male nostril size. Men generally have more flared, divergent nostrils (Ferrario et al., 1994; Gulsen et al., 2006). In this study, both diagonal nostril width and nostril projection were larger in men. Nostril width and height were larger in Italian men than in women (Sforza et al., 2011).

As both subnasale and nasal tip projections were larger in men in this study, nasal protrusion did not exhibit a gender-based difference in agreement with another study on Caucasians (Fernández-Riveiro et al., 2002). Begg and Harkness (1995) also found larger subnasale-vertical reference plane distances in men than in women. Nasal protrusion did not reveal sexual dimorphism in a multinational sample (Kim et al., 2015), Koreans (Kim et al., 2015; Park et al., 2014) and Han Chinese (Li et al., 2014). However, studies demonstrated more protrusive noses in Italian (Sforza et al., 2011) and Turkish (Ozdemir & Uzun, 2015) men while Saudi Arabians revealed opposite results (Al-Qattan et al., 2012).

Among the variables of dorsal form, the supratip break angle was greater in men when both groups were considered and both the supratip break angle and the lower dorsal convexity were larger in men with class III

malocclusion, while women presented a flatter lower dorsal profile. However, the supratip contour was flatter in Caucasian men from New Zealand than in women, albeit with a larger variation (Begg & Harkness, 1995). Starck and Epker (1996) concluded that a supratip break and other dorsal profile variations occurred with equal probability in both genders in cases of class I occlusion. The lower dorsal convexity did not exhibit sexual dimorphism in studies on Pakistanis (Arshad et al., 2013) and Turks (Gulsen et al., 2006). However, these studies did not attempt to detect gender-based differences within each occlusion type.

The lack of sexual dimorphism in upper dorsal convexity was in agreement with a study on Indians (Prasad et al., 2014). Studies in Caucasians indicate that a larger *hump* can occur with equal frequency in both genders (Springer et al., 2008; Starck & Epker, 1996). This feature was larger in Pakistani (Arshad et al., 2013) and Turkish (Gulsen et al., 2006) male samples. However, Uzun et al. (2006) observed an average, straight dorsal shape in Turkish men.

Turks also did not demonstrate sexual dimorphism for columella depth (Gulsen et al., 2006). It was, however, larger in Pakistani (Arshad et al., 2013) and Indian (Prasad et al., 2014) men than in women, indicating racial variation.

All angular measurements indicated that the profile nasal form did not show sexual dimorphism, in agreement with a study in Caucasians with Class I occlusions (Starck and Epker 1996). The nasal prominence angle did not exhibit gender based differences in African Americans with ideal occlusions (Flynn et al., 1989) and in Caucasians (Sforza et al., 2011). The nasal tip angle was similar in men and women in studies on Caucasians with class I occlusions (Hwang et al., 2002; Sforza et al., 2011), but larger in men in a study on Turks (Uzun & Ozdemir, 2014) and greater in women in studies on Saudi Arabians (Al-Qattan et al., 2012) and Turks (Kale-Varnk, 2008) and Koreans (Hwang et al., 2002) with class I occlusions. Turks with Class I occlusion also did not exhibit gender-based differences in the dorsal contour angle (Malkoc et al., 2009). Yet, studies on Galicians (Fernández-Riveiro et al., 2003) and Iranians with class I occlusions (Moshkelgosha et al., 2015) revealed larger angles in men.

The nasal projection, nasolabial, columella rotation and nasal tip rotation angles also did not show sexual dimorphism. The nasal projection angle did not demonstrate sexual dimorphism in Koreans (Hwang et al., 2002) and North Americans with class I occlusions (Hwang et al., 2002; Starck & Epker, 1996) when calculated using the perpendicular to the FHP and in Turks with class I occlusion (Malkoc et al., 2009) using the true vertical line. The latter angle was, however, larger in Galician men than in women (Fernández-Riveiro et al., 2003).

The nasolabial angle has also generated conflicting results in different studies, possibly due to its dependence on lip posture. It did not show sexual dimorphism in Chinese (Dong et al., 2010), Caucasians with class I occlusions (Scheideman et al., 1980) or of all skeletal types (Begg & Harkness, 1995; Fernández-Riveiro et al., 2003), Iranians with class I occlusions (Amini et al., 2014; Fariaby et al., 2006), Pakistanis (Arshad et al., 2013), Indians (Prasad et al., 2014), Turks (Gulsen et al., 2006; Uzun & Ozdemir, 2014) and Saudi Arabians (Al-Qattan et al., 2012). However, studies on Croatians (Anić-Milošević et al., 2008), Turks (Borman et al., 1999; Kale-Varnk, 2008; Malkoc et al., 2009) and Chileans (Troncoso Pazos et al., 2008) revealed larger

angles in women while others in Caucasians (Hwang et al., 2002; Starck & Epker, 1996) and African Americans (Flynn et al., 1989) with class I occlusion and Han Chinese (Li et al., 2014) demonstrated a smaller angle, possibly due to greater lip protrusion (Starck & Epker, 1996).

The columella/perpendicular to the FHP angle did not differ between Caucasian men and women with class I malocclusions (Starck & Epker, 1996) or balanced profiles (Fitzgerald et al., 1992). However, women showed a greater upward columella rotation in relation to this plane in a multiracial sample (Kim & Egan, 2006).

In this study, women displayed a shorter, more retrusive maxilla and smaller total and lower facial heights and lower facial height/total facial height ratio than men. The more posterior mandibular inclination also indicated a shorter relative posterior facial height. Yet, gender-based differences were not detected in facial soft tissue profile. The total facial convexity angle did not reveal sexual dimorphism in Caucasians with pleasant profiles (Fortes et al., 2014) and of all skeletal classes (Fernández-Riveiro et al., 2003) and in Turks (Malkoc et al., 2009) and Iranians (Moshkelgosha et al., 2015) with class I occlusion. The facial convexity angle did not show gender-based differences in Caucasians with pleasant profiles (Fortes et al., 2014) and those belonging to all skeletal classes (Anić-Milošević et al., 2008; Fernández-Riveiro et al., 2003), Iranians (Moshkelgosha et al., 2015) and Turks (Kale-Varnk, 2008; Malkoc et al., 2009) with Class I malocclusions and Pakistanis (Arshad et al., 2013). The nasomental angle did not reveal gender-based differences in Pakistanis (Arshad et al., 2013), Turks (Gulsen et al., 2006) and Caucasians (Begg & Harkness, 1995). The nasofacial angle did not demonstrate sexual dimorphism in Caucasians (Anić-Milošević et al., 2008) and Iranians (Fariaby et al., 2006) with Class I occlusion. However, the facial convexity angle was larger in Turkish men than in women (Gulsen et al., 2006). Both the facial convexity and the nasomental angle were larger in North Indian women with Class I occlusion than in men who presented a thicker soft tissue layer at the chin (Maurya et al., 2014). Saudi Arabian men demonstrated a larger nasofacial angle than women (Al-Qattan et al., 2012).

2.8.3 Correlation between soft tissue nasal variables measured in frontal photographs

The nose presented significant correlations in the frontal view. Morphological and alar base width were positively correlated with diagonal nostril widths and superior and inferior alar angles.

Increased height was also associated with wider nostrils. Larger length and height also implied smaller superior and inferior alar angles due to the vertical position of soft tissue nasion, pronasale and subnasale relative to the alae, despite the weak, positive correlation between frontal nasal height and morphological width. Increased vertical dimension was also associated with a smaller alar slope angle, due to lower pronasale position and nasal widening. The influence of the vertical nasal dimension also resulted in a positive correlation between alar slope angle and the inferior alar angle.

2.8.4 Correlation between soft tissue facial and nasal profile variables

The influence of chin position made a smaller facial convexity angle occur in association with a larger nasomental angle, in conformity with previous results in Turks (Gulsen et al., 2006). More concave profile implied smaller tip and nostril projections and a flatter supratip break in this study. Larger nasomental angles also denoted less protrusive noses with blunter tips, reduced columella exposure and smaller *humps*. Gulsen et al. (2006) observed an association with smaller *humps* and pronasale-alare and pronasale/soft tissue nasion-subnasale line distances even though he did not measure the other variables.

The nose presented size correlations in the vertical and sagittal planes. Longer noses with larger heights and longer nasal bones also displayed greater tip and nostril projections. Chaconas (1969) also observed positive correlations between nasal length, nasal bone length and pronasale/ nasion-A point line distance in 10 to 16-year-old Caucasians. Length in Turks correlated positively with pronasale-alare distance, while both longer noses and nasal bones were associated with a larger pronasale/soft tissue nasion-subnasale line distance (Gulsen et al., 2006). Indians and South Indians also revealed positive correlations between nasal length and the latter distance (Nehra & Sharma, 2009; Prasad et al., 2014).

Longer, more protrusive noses with greater tip projection implied larger *humps*, more pointed tips and, together with larger heights, denoted posterior columella rotation and larger columella exposure. A longer nasal bone was also associated with clockwise columella rotation. Longer noses with larger depth implied a smaller dorsal axis/columella tangent angle in Indians (Nehra & Sharma, 2009) and a smaller soft tissue nasion-pronasale-columella angle in South Indians (Prasad et al., 2014). Length and projection measured using the pronasale-alare and pronasale/soft tissue nasion-subnasale line distances also correlated positively with upper dorsal convexity in Turks and South Indians (Gulsen et al., 2006; Prasad et al., 2014). A convex dorsum was associated with a larger nasal tip-skeletal nasion distance measured parallel to the FHP in young Caucasian girls (Robison et al., 1986). Length and projection correlated positively with posterior long nostril axis rotation relative to the soft tissue glabella-subnasale line in Turks (Gulsen et al., 2006) and clockwise columella rotation relative to the FHP in Indians (Nehra & Sharma, 2009).

The nose also exhibited correlations in form. Larger nostril projection implied larger vertical nostril exposure. The *hump* seen in larger noses was associated with a posteriorly rotated columella, a pointed nasal tip and a flatter supratip contour. In Turks, a larger *hump* accompanied posterior long nostril axis rotation, but the other variables were not measured (Gulsen et al., 2006).

This investigation did not confirm the weak positive correlation between the upper dorsal convexity and nasal bone length observed in Turks. However, Chaconas (1969) suggested that larger *humps* were caused by a larger sella-nasion-rhinion angle and hence, an anteriorly positioned skeletal rhinion and were unrelated to nasal bone length. In his study on 10 to 16-year-old children, nasal bone length was not correlated with the sella-nasion-rhinion or sella-nasion-pronasale angles. In 7 of the 46 children studied, a greater dorsal convexity was noted when skeletal rhinion advancement during growth caused the former angle to surpass the latter (Chaconas, 1969).

Greater nostril projection also implied a more pointed tip and deeper supratip break, all features of more convex profiles.

2.8.5 Correlations between the skeletal facial profile variables and frontal nasal variables

Only weak correlations were found between nasal variables measured in frontal photographs and skeletal profile variables. Posterior-anterior radiographs were not available in this retrospective study. Smaller ANB angles implied longer noses while shorter maxillae implied smaller nasal height. While posterior maxillary inclination weakly implied a smaller left diagonal nostril width, the lack of association with the contralateral variable suggests that this finding should be considered with caution. Robison et al. (1986) also did not reveal correlations between nasal width and sagittal or vertical skeletal parameters in 11 to 26 year-old Caucasian girls, although part of that sample had as yet not achieved nasal maturity.

2.8.6 Correlations between the skeletal facial and profile facial and nasal variables

Ellis & McNamara (1984) demonstrated that maxillary retrusion, excessive lower anterior facial height and posterior mandibular rotation are important components of the Caucasian Class III discrepancy. In this study, the group with class III occlusion had a shorter, more retrusive maxilla, more protrusive mandible, larger total and lower facial heights and bimaxillary clockwise rotation than the group with class I occlusion. Within the Class III sample, women exhibited greater posterior maxillary rotation than men. Moreover, facial skeletal dimensions influenced the Caucasian nasal morphology.

The nasomental angle is an important variable because it includes both nasal and chin landmarks. Larger angles were associated with hyperdivergent, mesial sagittal discrepancies, shorter, retrusive maxillae and larger total and lower facial heights, although only the correlation with the ANB angle was moderate, indicating the importance of sagittal mandibular position. Turks also revealed larger values in the presence of maxillary retrusion and smaller ANB angles, in weak and moderate correlations, respectively, but no association with vertical parameters (Gulsen et al., 2006). These authors did not publish descriptive statistics for their skeletal variables, but the average 124.4±6.7° and 128.3±6.8° for this angle in Class I and Class III cases, respectively, compared to the 132.0 ±5.3° and 138.3±5.9° measured in this study suggests a very different sample.

In the vertical plane, greater nasal and nasal bone length and nasal height were in harmony with larger total and lower facial heights with posterior jaw inclination. Nasal bone length revealed similar correlations in Turks (Gulsen et al., 2006), was associated with posterior maxillary rotation in Indians with Class I malocclusions (Bhushan et al., 2015) and with a greater nasion-sella-gnathion angle and thus, vertical dimension in another Caucasian sample (Chaconas, 1969).

As in this study, nasal length correlated positively with total anterior facial height in Turks (Gulsen et al., 2006), Indians (Nehra & Sharma, 2009) and Iraqis (Nahidh, 2009) and with maxillary inclination in Indians (Nehra & Sharma., 2009) and South Indians (Prasad et al., 2014). However, it was not correlated with lower facial height measured parallel to the FHP and the gonial angle in Iraquis (Nahidh 2009), with unpublished

values of jaw inclination in Turks (Gulsen et al., 2006) or with mandibular inclination in Indians which averaged 30.3±6.9° and hence, was smaller than the value in both the Class I and Class III samples in this study (Nehra & Sharma, 2009). Bhushan et al. (2015) concluded that nasal height, but not length, increased in association with clockwise maxillary inclination using the N-ANS-PNS angle, but used a sample restricted to 45 Indian men with Class I malocclusions.

In this investigation, posterior mandibular and especially maxillary inclination implied posterior columella rotation. Thus, clockwise maxillary rotation denoted larger columella exposure, a variable that was not studied by other authors. In Indians, clockwise palatal plane inclination denoted posterior columella rotation relative the FHP (Nehra & Sharma, 2009). In Turks, posterior jaw inclination implied posterior long nostril axis rotation relative to the soft tissue glabella-subnasale line (Gulsen et al., 2006). Fitzgerald et al. (1992) did not find a correlation between the columella-FHP angle and mandibular rotation relative to the FHP or the nasion-sella-gnathion angle in Caucasians in a sample with balanced profiles that did not include Class III cases.

Sagittal nasal dimensions were harmonious with vertical facial size. Larger total and lower facial heights implied greater nasal and nostril projection, and along with clockwise jaw rotation, denoted larger nasal protrusion, indicating a greater association with nasal tip position than that of subnasale. Posterior mandibular rotation denoted more projected tips, in conformity with previous results in Pakistanis (Arshad et al., 2013). As in this study, maxillary rotation did not affect nasal projection in Indians (Bhushan et al., 2015). In Turks, pronasale-alare and pronasale/soft tissue nasion-subnasale line distances correlated positively with anterior total facial height but were not influenced by jaw inclination (Gulsen et al., 2006). Nasal projection relative to the same line was not correlated with facial heights measured parallel to the FHP and the gonial angle in Iraqis (Nahidh, 2009) but correlated with total facial height and only the palatal plane inclination in an Indian sample with a smaller average mandibular plane inclination (Nehra & Sharma, 2009). Pronasale-anterior nasal spine distance measured parallel to the FHP did not correlate with sagittal or vertical skeletal patterns in 11 to 26 year old Caucasian girls (Robison et al., 1986).

Only larger lower facial height was associated with a more acute nasal bone angle. Gulsen et al. (2006) did not find an association with total facial height and suggested that more acute angles should accompany anterior mandibular inclination, but only in individuals with class I skeletal patterns.

Maxillary retrusion also implied larger vertical and sagittal nasal dimensions. A smaller SNA angle was associated with larger nasal length and height. Shorter, more retrusive maxillae denoted a longer nasal bone and clockwise columella rotation. In Turks, longer noses accompanied maxillary retrusion represented by smaller SNA angles and A point-vertical reference line distances but also, longer A point-condylion distances that do not really represent maxillary base length. Maxillary retrusion also implied longer nasal bones (Gulsen et al., 2006). South Indians, unlike Turks and this study, demonstrated a non-significant tendency for a positive correlation between nasal length and sagittal maxillary position, indicating racial variation (Prasad et al., 2014). Iraqis did not reveal a significant correlation with sagittal jaw parameters (Nahidh 2009). These authors did

not study nasal height. The columella-FHP angle also did not correlate with the ANB angle in a study that only included Caucasians with balanced profiles (Fitzgerald et al., 1992).

Shorter, more retrusive maxillae were associated with greater nasal protrusion. A smaller SNA angle implied larger tip projection. In Turks also, maxillary retrusion denoted a larger pronasale-alare distance. However, pronasale/soft tissue nasion-subnasale line distance demonstrated a weak positive correlation with A point-condylion distance in Turks (Gulsen et al., 2006), only with maxillary length but not position in South Indians (Prasad et al., 2014) and did not correlate with sagittal jaw parameters in Iraqis (Nahidh, 2009), indicating racial variation.

Among the variables that defined nasal shape, a smaller SNA angle and posterior mandibular rotation implied a blunter tip. Larger soft tissue nasion-pronasale-columella angles were associated with shorter PNS-A point distances in South Indians (Prasad et al., 2014) but were unaffected by skeletal parameters in Indians (Nehra & Sharma, 2009). In Indians, the dorsal axis-columella tangent angle was larger in the group with posterior maxillary rotation measured by the N-ANS-PNS angle than in the groups with normal or decreased rotation, although these authors considered only a single value as normal, without taking the standard deviation into consideration (Bhushan et al., 2015).

The mesial intermaxillary discrepancy was only associated with the supratip break and together with maxillary retrusion and posterior jaw rotation, flattened this feature. The supratip break variable was not studied by other authors.

Upper dorsal convexity did not correlate significantly with skeletal facial variables. South Indians did not present an association with maxillary parameters (Prasad et al., 2014). A Turkish study that included cases of class II malocclusion revealed weak positive correlations with anterior maxillary position and total facial height but none with jaw inclination and the ANB angle (Gulsen et al., 2006).

2.9 Clinical considerations

Nasal morphology should be harmonious with general facial proportions (O'Ryan & Schendel, 1989; Schendel & Carlotti, 1991). This study demonstrated that definite patterns exist in Caucasian nasal morphology and that these, in turn, are influenced by facial dimensions.

Maxillary retrusion increases all the major vertical and sagittal nasal dimensions, reduces the supratip break and rotates the columella inferiorly, causing a sharper tip. Yet, these were the nasal features associated with a larger dorsal convexity, a parameter that did not differ between the groups with Class III malocclusion and Class I occlusion. Larger total and lower anterior facial heights accompany the majority of class III skeletal discrepancies (Baik et al., 2000; Ellis & McNamara, 1984). They also contribute to increase the overall vertical and sagittal nasal size. However, the larger nasomental angle seen in the class III sample was associated with a blunter tip, smaller sagittal dimensions, flatter upper and lower dorsum and smaller columella exposure indicating the importance of sagittal chin position. Individual variations are also inevitable.

Also, while the nose shows patterns of correlation, it does not mean that these patterns enhance aesthetics. For example, a shorter Class I nose is not necessarily the most attractive in a concave,

dolichocephalic profile. Smaller noses are generally considered more appealing. However, reducing nasal dimensions through rhinoplasty may result in a nose that appears excessively small and under projected in the longer pre-surgical Class III face. Surgery to introduce a supratip break or to reduce the columella exposure in a long nose with increased height may also not have aesthetic benefits.

Nasal height, length and protrusion were larger in the group with class III malocclusion. Women with Class III malocclusion have a flattened supratip contour. Maxillary advancement surgery advances and elevates subnasale and the nasal tip and can have a beneficial effect on all these features. However, as longer, more prominent noses with increased height exist in harmony with longer facial dimension, the nasal change must be harmonious with the surgical reduction in the larger total and lower anterior facial heights that characterize most class III skeletal discrepancies (Baik et al., 2000; Ellis & McNamara, 1984). Surgery also increases morphological width, a parameter that did differ between the groups and may lead to poor aesthetics. Since the Class III group showed similar upper dorsal convexity when compared with the class I sample, surgical nasal tip elevation and projection may even cause the upper dorsum to appear excessively straight. This is important in Asians who may desire a more prominent nasal *hump* although this investigation was conducted on Caucasian individuals (Springer et al., 2008).

2.10 Conclusions

1) In frontal photographs, the variables columella width, frontal nasal length, frontal nasal height, frontal nasal length/morphological width ratio and frontal nasal height/morphological width ratio were larger in the group with Class III malocclusion. The alar slope and superior alar angles were reduced in the group with Class III malocclusion.
2) The profile variables of total facial convexity and nasomental angles and nasal height, length and protrusion were larger in the group with class III malocclusion. Facial convexity, nasofacial and supratip break angles had a smaller value in the group with Class III malocclusion. The supratip break angle was larger in women with Class I occlusion than in women with Class III malocclusion.
3) The inner endocanthal distance, nasal root, morphological, alar base and columella widths, bilateral width of the nostril floor, right and left nasal base widths, frontal subnasale-alare distances, diagonal nostril widths and dorsal axis-alare distances, frontal nasal height, superior alar and inferior alar angles were larger in men. The root width/morphological width, frontal nasal length/morphological width, frontal nasal height/morphological width ratios and lateral alar angle were greater in women.
4) Nasal height, length, projection, nostril and subnasale projections and the supratip break angle were greater in male profiles. The lower dorsal convexity and supratip break angle were larger in men than in women in the group with Class III malocclusion.
5) Correlating patterns were observed in both the frontal and profile nasal morphology: a smaller ANB angle, a shorter, more retrusive maxilla, larger total and lower anterior facial heights and bimaxillary posterior inclination were associated with a larger nasomental angle. A smaller ANB angle implied larger frontal nasal length and a flatter supratip break. A shorter, more retrusive maxilla was associated with a larger

nasal bone length, nasal protrusion and inferior columella inclination. A smaller SNA angle was associated with larger nasal length, height, projection, protrusion and nasal tip angle. A more retrusive sagittal maxillary position implied a flatter supratip break. Larger total and lower anterior facial heights were associated with a larger nasal bone length, nasal length, height, projection and protrusion and nostril projection. Posterior maxillary and mandibular inclination implied a larger nasal bone length, nasal length, height, protrusion and clockwise columella rotation, but a flatter supratip concavity. Additionally, clockwise maxillary rotation was associated with greater columella exposure, while clockwise mandibular inclination implied a larger nasal projection and nasal tip angle.

III

Influence of Le Fort 1 maxillary advancement osteotomy on nasal morphology in people with Class III skeletal malocclusions

3.1 Introduction

The maxilla can be surgically repositioned in the anterior, superior and inferior directions or in a combination thereof, depending on the deformity present. Each of these vectors can potentially affect nasal subunits, depending on the magnitude of movement (Collins & Epker, 1982; Mitchell et al., 2007; Rauso et al., 2011).

Inferior maxillary repositioning widens and lowers the alar base and may cause or worsen the pre-surgical appearance of a retracted columella and accentuated nasolabial sulcus (Mitchell et al., 2007; Schendel & Carlotti, 1991). Nasal tip lowering causes a "parrot beak" deformity with a broad, curved dorsum and a break in the columella-lobule junction and loss of the supratip depression (Altman & Oeltjen, 2007; Mitchell et al., 2007; Schendel & Carlotti, 1991). Maxillary impaction can widen the alar base and elevate the nasal tip, accentuating the supratip depression (Altman & Oeltjen, 2007; Mitchell et al., 2007; Schendel & Carlotti, 1991). It can also accentuate the nasolabial sulcus and cause an aged appearance (Mitchell et al., 2007).

However, it is the Le Fort 1 maxillary advancement osteotomy that has the most profound effect on the nasolabial region (Mitchell et al., 2007; Rauso et al., 2011). Facial and nasal aesthetics can change significantly due to the close relationship between the maxilla and the overlying soft tissue (Baik et al., 2000; Bell, 1975; Metzler et al., 2014). This procedure advances and widens the alar bases, lowers the columella, elevates the nasal tip, deepens the supratip break and can reduce the nasolabial angle (Altman & Oeltjen, 2007; Dann, Fonseca, & Bell, 1976; Mommaerts et al., 1997; Rauso et al., 2011; Tartaro et al., 2008).

3.1.1 Le Fort I Maxillary Osteotomy

In 1901, Rene Le Fort published his classic description of the natural Le Fort I, Le Fort II and Le Fort III fracture planes. Wassmund used the Le Fort 1 midfacial fracture plane for orthognathic-surgical correction for the first time in 1927, although he maintained the pterygomaxillary junction intact and used elastic forces to gradually bring the midface forward. Schuchardt, in 1942, recommended complete separation of the pterygomaxillary junction for anterior maxillary repositioning. Midfacial advancement was initially troubled by limited visualization, significant blood loss and mobilization that was insufficient for a stable long-term outcome. Obwegeser perfected the surgical technique to allow total maxillary mobilization in the 1960s, to overcome tissue resistance and to enable the use of bone grafts between the pterygoid plate and the maxillary tuberosity. However, it was Bell and his colleagues who enabled the widespread use of this procedure after their research on the vascular supply of the maxilla during and after downfracture surgery. Until then, many

of the deformities that required maxillary advancement were aesthetically and functionally compromised due to the use of mandibular setback surgery (Reyneke 2010, Taub et al., 2015).

The surgical procedure

A horizontal circumvestibular mucosal incision is made well above the attached gingiva from the bicuspid to the bicuspid region, leaving an adequate mucosal edge of a minimum of 5–8 mm from the gingiva to facilitate final closure and avoid exposure in the patient´s smile line. This incision should increase to approximately 10 mm at the buttress area (Reyneke 2010, Taub et al., 2015).

Subperiosteal buccal dissection proceeds from the anterior to the posterior direction around the tuberosity. The lateral nasal wall, anterior nasal spine, nasal piriform aperture and the intranasal cavity must then be exposed, avoiding periosteal perforations and the subsequent herniation of the buccal fat pad. Anterior nasal spine resection can facilitate the dissection of the nasal mucosa from the septum and floor. The exposure continues intranasally from anterior to posterior up to the junction of the hard and soft palate. The superior-lateral subperiosteal dissection exposes the nasomaxillary buttress and the anterior maxillary wall, identifying the inferior orbital foramen and exposing the lateral zygomatic-maxillary buttress, the body of the zygoma, and the anterior portion of the zygomatic arch. The posterior dissection continues to the pterygopalatine region (Reyneke 2010, Taub et al., 2015).

With skeletal exposure complete, the planned osteotomy is performed at least 5 mm above the canine root apex, proceeding from the lateral nasal wall across the anterior maxillary wall and through the posterior-lateral maxillary wall in a straight line or with a vertical step. Next the pterygoid plate is separated from the maxillary tuberosity. The osteotomy of the posterior maxilla is completed, while protecting the contents of the pterygopalatine fossa (Reyneke 2010, Taub et al., 2015).

The maxilla is then downfractured with digital pressure alone by placing the thumbs at the base of the pyriform aperture. Adherent nasal floor mucosa is elevated simultaneously until the junction of the hard and soft palate. Then under direct visualization, the perpendicular process of the palatine bone and the pterygoid plates are completely separated from the maxilla. The maxilla is rotationally mobilized from side to side and then anteriorly. All bony interferences are removed to facilitate accurate maxillary repositioning.

A prefabricated occlusal surgical splint is ligated to the maxillary arch wire and the maxilla and mandible are fixed in occlusion. The maxillomandibular complex is rotated closed and the reference marks are checked to place the maxilla in its planned position, while both mandibular condyles are in an ideal relationship within the glenoid fossa. When the maxillary-mandibular fixation is released, the mandible, with the condyle seated, should close passively into the splint. If the occlusion is stable, no occlusal splint is required.

Additionally, bone is removed along the vomer and the nasal cartilage base is resected to prevent septal buckling. A trough is created on the nasal floor to hold the nasal septum after maxillary repositioning, thus avoiding a deviated septum and an asymmetric columella. The nasal septum may be secured in position by placing a suture through it and through the horizontal hole in the base of the nasal spine after maxillary fixation. Once semirigid maxillary fixation is achieved using bilateral titanium bone plates, the anterior nasal spine and

the piriform rim can be contoured to accommodate the nasal tissue. An alar cinch suture is placed to control the width of the alar base. The vestibular mucosal incision is then closed using a V-Y advancement (Reyneke 2010, Taub et al., 2015).

Nasolabial reconstruction

During the Le Fort 1 osteotomy, most muscle insertions in the nasal area, the pyriform aperture, the anterior nasal spine and the lateral maxillary surface are detached, depending on the level of subperiosteal dissection and periosteal elevation (Rauso et al., 2010; Ritto et al., 2011; Schendel & Williamson, 1983; Shoji et al., 2012; Ubaya et al., 2012; Worasakwutiphong et al., 2015). The affected muscles include the transverse nasalis, depressor alae nasi, zygomaticus major, the levator labii superioris, levator levator labii superioris alaeque nasi and oblique fibres of the orbicularis oris (Schendel & Williamson, 1983; Verzé et al., 2014; Yamada et al., 2010). These muscles, with their insertions or origins removed, eventually reinsert with a reduced length. Thus, muscle shortening and lateral retraction, especially when the insertion is detached and the origin is unaffected, moves the oronasal soft tissue laterally away from the midline (Schendel & Carlotti, 1991; Schendel & Williamson, 1983).

Besides a wider alar base, decreased midline tissue also manifests as a thinner, rolled in upper lip with less visible vermilion (Carlotti et al., 1986; Schendel & Williamson, 1983). Soft tissue stretching during maxillary advancement magnify these effects, potentially leading to poor hard to soft tissue ratios (Carlotti et al., 1986). Excessive alar base widening and superior retraction can also cause alar asymmetry and deepen the alar-facial sulcus, leading to an aged appearance (Ritto et al., 2011). The detachment of the levator muscles allows the unopposed action of the depressor muscles to pull the labial commissures inferiorly (Schendel & Williamson, 1983). Other muscles, such as the buccinator, which are unaffected by the subperiosteal dissection enhance the lateral traction exerted by the dissected muscles and amplify alar base widening (Ritto et al., 2011; Schendel & Williamson, 1983; Verzé et al., 2014; Yamada et al., 2010).

Hence, control of the muscular insertion and orientation is the key to maintain lip thickness, alar base width and soft tissue morphology (Liebregts et al., 2016; Moroi et al., 2014; Ritto et al., 2011; Ryckman et al., 2010; Stewart & Edler, 2011; Ubaya et al., 2012; Yamada et al., 2010). Nasal widening may, however, be beneficial in patients with a narrow alar base and prominent dorsum (Honrado et al., 2006; Ritto et al., 2011; Stewart & Edler, 2011; Ubaya et al., 2012).

Nasolabial reconstruction was advocated to prevent undesirable soft tissue effects (Schendel & Williamson, 1983). It aids in controlling transverse nasal form and width by repositioning the detached tissues back at the anterior nasal spine and restoring alar cartilage support from the transverse nasalis through the placement of a permanent alar cinch suture (AC) in the muscle fascia at the alar base through the intraoral incision. The VY closure of the upper vestibular incision advances the mucosa, muscle and periosteum in the midline, reinforces against the lateral traction exerted by the unaffected facial muscles and helps maintain lip length (Schendel & Williamson, 1983; Stewart & Edler, 2011). The AC-VY closure also minimizes the loss of lip thickness, length and vermillion (Guymon et al., 1988; Rosen, 1988).

This concept is based on work by other authors. Millard (1980) invented the alar cinch suture to control alar widening after osteotomies in cases of cleft lip and palate. In this procedure, dermal-subcutaneous flaps denuded of epithelium on each side of the alar base were advanced into a tunnel dissected across the upper lip just in front of the bilateral nasal sills and were subsequently attached to each other and to the base of the septum with the help of one or more sutures. Collins and Epker (1982) applied extraoral pressure to identify the bilateral fibroareolar connective tissue of the alar base, which was then sutured through the circumvestibular incision to control width, increase the subnasal volume, elevate the nasal tip and lengthen the upper lip.

The VY closure and anterior nasal spine or piriform aperture recontouring increase the efficiency of the AC suture (Shoji et al., 2012). Other authors suggest the concomitant use of an external fixator or a subspinal osteotomy (Verzé et al., 2014; Yamada et al., 2010).

The AC suture thus avoids the inconvenience and expense of secondary corrective surgery for alar expansion and the irreversible loss of vermillion (Guymon et al., 1988, Wolford 1988). Chung et al. (2008) specially recommended its use during bimaxillary surgery for Class III correction in Asian women with narrow noses who are more susceptible to nasal changes. However, Rosen (1988) stated that nasolabial reconstruction for the transverse nasalis muscle was inaccurate and unpredictable especially with nasal intubation and that the associated soft tissue changes such as lip lengthening could actually be undesirable. He suggested the use of the suture in a secondary procedure at least six months after surgery when final soft tissue position had been achieved. Other authors also commented on a possible unattractive result due to the unpredictability of the eventual position of the alar cartilages (Bottini et al., 2013). Surgeons may also need to allow widening of a narrow pre-surgical alar base (Hackney et al., 1988; Mommaerts et al., 1997; Ryckman et al., 2010). Ubaya et al. (2012) used the suture only when the alar base widened more than 3 mm during the maxillary advancement surgery.

Several authors have proved the effectiveness of the AC suture at the alar base. Schendel and Williamson (1983) did not register changes in the morphological and alar base width after 6.3±0.7 mm maxillary impaction with AC-VY closure. Vasudavan et al. (2012) concluded that Le Fort 1 advancement osteotomy, with or without vertical movement, did not change the alar base width which surgeons were careful to narrow by 2 to 3 mm by suturing the alar base to the anterior nasal spine in all patients including those with cleft lip and/or palate. In another investigation, maxillary advancement and/or impaction surgery increased alar base width 2.89±4.17% in patients submitted to the AC suture and 10.75±7.30% in cases without the suture (Guymon et al., 1988). A greater alar base widening of 2.3±1.3mm or 6.9% was observed without the AC suture than the 1.6±1.2mm or 4.6% with the suture after maxillary advancement and impaction accompanied by anterior nasal spine resection although no difference was observed in cases treated with isolated advancement or impaction (Westermark et al., 1991). Even the VY closure had an advantage over the simple continuous suture in terms of alar base widening after Le Fort 1 advancement and impaction osteotomy (Chandra et al., 2013).

Other authors suggest that if the AC suture limits alar base widening, it does so to a degree that is not clinically significant (Howley et al., 2011; Khamashta-Ledezma & Naini, 2015). Betts et al. (1993) found that

the alar base actually widened more as the placement of the AC suture prior to closure of the soft tissue incision hindered the relocation of the periosteum and muscles to their anatomically correct midline positions leaving them in a more superior-lateral position.

Several researchers concluded that the morphological width (Dantas et al., 2015; Hemmatpour et al., 2016; Khamashta-Ledezma & Naini, 2015; Liebregts et al., 2016) and alar base width (Honrado et al., 2006; Khamashta-Ledezma & Naini, 2015; Park et al., 2012; Ubaya et al., 2012) increased, despite the use of the AC-VY closure. Photographs indicated that VY closure alone was insufficient to prevent interalar and alar base widening after maxillary impaction with slight advancement (Phillips et al., 1986). AC-VY closure did not prevent nasal widening after maxillary advancement and/or impaction surgery in Class II or III malocclusions (Dantas et al., 2015). Cone beam computerized tomography also demonstrated alar base widening in patients subjected to bimaxillary surgery including maxillary advancement and impaction with AC-VY closure to treat class III malocclusions (Park et al., 2012). Hemmatpour et al. (2016) also noted that the alar base widened after maxillary advancement and mandibular setback surgery with AC-VY closure. Morphologic, alar base and nostril widths increased after maxillary advancement and posterior impaction and mandibular setback surgery with the AC suture in Koreans, especially in women with a narrow pre-surgical interalar width (Chung et al., 2008). No significant difference was found with or without the suture after maxillary advancement and posterior impaction surgery, although AC-VY closure explained 11% of changes in morphological width (Khamashta-Ledezma & Naini, 2015). Maxillary advancement performed as part of a bimaxillary advancement procedure with AC-VY closure also caused interalar widening (Ryckman et al., 2010) Another study revealed that the interalar distance increased irrespective of the use of simple, continuous, AC-VY or AC-double VY-closure because the surgeon allowed widening when he found the alar base too narrow (Hackney et al., 1988).

Published ratios between the amount of widening and magnitude of maxillary advancement vary widely. Hellak et al. (2015) revealed that, even with the AC suture, nasal widening was approximately 50% of the maxillary advancement in more than 80% of cases. A 0.05 to 0.08 mm interalar widening was observed for each millimetre of maxillary advancement between 3 and 7 mm after bimaxillary surgery with AC-VY closure to treat Class III malocclusions (Rauso et al., 2011). Liebregts et al. (2016) determined that the AC, VY or ACVY closure did not influence interalar widening that was 0.24 mm for each millimetre of advancement with and without vertical rotation, in a weak to moderate correlation.

Howley et al. (2011) also demonstrated an average alar base widening of 2.2 and 2.6 mm, respectively with and without the AC suture at one month after maxillary advancement surgery with or without impaction and 1.9 and 2.7 mm respectively after the resolution of oedema at six months. CBCT revealed that the remodelling and relocation of the dissected perioral muscles at 6 months reduced the alar base widening measured at 2 months after posterior maxillary impaction and mandibular setback surgery with AC-VY closure in skeletal Class III cases (Oh et al., 2013). However, the interalar and alar base width did not differ between 3 and 6 months after maxillary advancement and posterior impaction surgery when the ACVY reconstruction

and anterior nasal spine recontouring was not always used (Khamashta-Ledezma & Naini, 2015). Shoji et al. (2012) found the alar base width to be stable one year after bimaxillary surgery with the AC suture.

Control of alar base width is dictated by the amount of tension placed on the aponeurotic suture (O'Ryan & Carlotti, 1989). Nasal widening after the AC-VY closure may be due to an insufficient number of sutures with tensile strength of short duration placed with nasal intubation (Yamada et al., 2010). Shoji et al. (2011) advocated substituting the nasotracheal tube by an oro-endotracheal one prior to suture placement as the former distorts the nostrils, makes it difficult to measure the alar base and prevents adequate suture tightening. Others even proposed disintubating the patient before tightening the sutures (Collins & Epker, 1982). However, the passage of the suture through the fibrous adipose tissue of the nasal base in a figure of eight may control width even with nasal intubation (Wolford 1988). Thus, different methodology and surgical techniques generate contradictory results making it difficult to compare the results of different investigations using the AC suture (Howley et al., 2011).

Guymon et al. (1988) suggested the use of a slightly lax suture even when alar base widening is desired to prevent it from becoming excessive. Other authors recommend slight overcorrection to counterbalance the minor relapse caused by suture loosening or fibroareolar tissue stretching in the immediate postoperative period (O'Ryan & Carlotti, 1989; Schendel & Williamson, 1983; Shams & Motamedi, 2002). Resolution of oedema, tissue laxity or muscular movement contribute to cinch relapse (Shams & Motamedi, 2002). Authors suggest that this postoperative expansion made it improbable that post-surgical alar base width would be narrower than its pre-surgical size even with overcorrection (Schendel & Williamson, 1983). This is especially true for a wide initial alar width where correction would probably be insufficient (O'Ryan & Carlotti, 1989). Ritto et al. (2011), however, observed a smaller post-surgical alar width after the suture.

Modified techniques may generate better results. At six months after bimaxillary surgery, the classic intraoral technique anchoring fibroareolar tissue to the anterior nasal spine prevented widening in 3 of 20 patients with Class III malocclusions, while this number rose to 14 using a technique with extraoral access that also passed through the anterior nasal spine (Rauso et al., 2010). The modified technique anchored a larger amount of soft tissue due to the use of a straight rather than curved needle that was partly retracted without leaving the point of access in the nasofacial sulcus at the alar base and then reinserted into the oral cavity in a medial position. At 3 months after maxillary advancement and/or impaction surgery, the extraoral technique was found to be more effective in controlling alar and alar base widening than the classic intraoral one, although both could not entirely prevent it (Ritto et al., 2011).

Some authors suggested that the suture has a greater effect at the alar base. In an investigation that used submental intubation to avoid the nasal expansion caused by the endotracheal tube, maxillary advancement and mandibular setback osteotomy immediately caused a 10.7 and 8.7% alar base and interalar widening, respectively, which were subsequently reduced 58.3 and 53.3% respectively by AC-VY closure. The greater effect of both osteotomy and closure at the alar base was demonstrated by the surgical nasolabial sulcus obliteration and its subsequent recreation after suturing (Stewart & Edler, 2011). Cone beam computerized tomography revealed that the AC suture restricted the alar base width but could not prevent interalar and nostril

widening after maxillary advancement and impaction with anterior nasal spine recontouring (Almukhtar et al., 2016). 3D photogrammetry demonstrated that bimaxillary surgery involving maxillary advancement with or without posterior impaction with the AC suture increased only the interalar but not the alar base width (Worasakwutiphong et al., 2015). Computerized tomography and cephalometry performed one year after bimaxillary surgery demonstrated that the AC suture controlled both alar and alar base width in symmetrical Japanese Class III patients but only the latter in asymmetrical cases that required a larger magnitude of surgical movement (Moroi et al., 2014).

The AC-VY reconstruction grasps the paranasal sling causing a greater capacity for contraction of the muscles used in horizontal alare motion, while with simple continuous sutures of the vestibular incision, the muscles remain shortened and contract less (Muradin et al., 2012). As a result, while both the simple continuous suture and AC-VY closure increased lateral alar excursion, only the latter procedure increased lateral cheilion movement and the amplitude of both in the closed smile position to that of a control group in frontal photographs. The AC-VY closure also has a beneficial effect in maintaining post-surgical upper lip thickness (Peled et al., 2004; Talebzadeh & Pogrel, 2000). However, sutures placed in a deeper position under excessive tension without alar base involvement can cause excessive upper lip thickening (Guymon et al., 1988).

Influence of the AC suture on the nasolabial profile

The AC suture can magnify the nasolabial angle as it acts as a filler graft and produces soft tissue compression while transversely crossing the midline (Honrado et al., 2006; Shoji et al., 2012; Westermark et al., 1991). Septal support and the re-approximation of the nasalis muscle push the lateral crura under the nasal tip for support, causing its anterior-superior movement (Carlotti et al., 1986; Muradin et al., 2011).

Khamashta-Ledzema and Naini (2015) concluded that the AC suture increased the nasolabial angle and explained 45% of the variability after maxillary advancement surgery with posterior impaction and with or without anterior nasal spine recontouring. Westermark et al. (1991) verified larger increases in the angle with the AC suture than without it after maxillary advancement and impaction surgery with anterior nasal spine recontouring although this was true only for impactions and advancements greater than 4 mm and posterior impactions. Honrado et al. (2006) also attributed nasolabial angle increases to the AC suture. However, while the angle showed a nonsignificant tendency to increase after impaction, in cases of advancement, it demonstrated great variation when rotation was not performed, a nonsignificant tendency to decrease after inferior rotation and a significant decrease after superior rotation, even with the suture indicating that the direction of maxillary movement was far more important than the use of the suture.

Both pronasale and subnasale advancement and the increased nasolabial angle after bimaxillary surgery with maxillary advancement or rotation in Japanese with Class III malocclusions were attributed to the AC suture (Shoji et al., 2012). Rosenberg et al. (2002) recommended that the AC suture should not accompany maxillary advancement or dorsal impaction surgery when larger nasolabial angles and nasal tip elevation and projection were unwanted, or when used, anterior nasal spine resection should be performed. Yet, Westermark

et al., (1991) noted nasal tip elevation and projection with and without the suture after maxillary impaction and advancement surgery and anterior nasal spine recontouring, indicating that these were caused by the surgery itself rather than the suture.

Authors suggest that the suture´s effect on the nasolabial angle, which can exceed its effect on nasal width, can be reduced by suturing the alar base to the ipsilateral bony edge of the piriform aperture thus avoiding the midline (Shoji et al., 2012; Westermark et al., 1991). Muradin et al. (2011) suggested that a modified AC suture that passed through the levator and nasalis muscles, the periosteum and the nasal septum 10 mm posterior to the anterior nasal spine should accompany the VY closure. They observed that, although the nasal tip still advanced and elevated significantly, the amount of elevation did not differ significantly from a sample subjected to a simple continuous suture, indicating that excessive lifting had been prevented. The VY closure alone does not affect nasal tip projection, columella inclination or the supratip break angle (Gassmann et al., 1989).

The surgical management of the anterior nasal spine

The anterior nasal spine may remain intact or be recontoured partially or totally during maxillary surgery (Esenlik et al., 2011; Gassmann et al., 1989). The recontouring, along with factors such as the magnitude of maxillary advancement and the pre-existing nasolabial morphology, can influence subnasale and nasal tip movement (Khamashta-Ledezma & Naini, 2015; Louis et al., 2001; Mansour et al., 1983; Marşan et al., 2015; Metzler et al., 2014; Rosen, 1988; Westermark et al., 1991). The amount of this resection, together with the type of surgical closure of the soft tissue incision, make the results of maxillary surgery more variable than those of mandibular surgery (Altug-Atac et al., 2008; Chew, 2005; Chew, Sandham, et al., 2008).

The anterior nasal spine provides support for nasal soft tissues which reinsert even after their complete surgical dissection (Freihofer, 1977). It supports the feet of the medial crura, which offers varying degrees of support to the nasal tip depending on the individual nasal anatomy (Gassmann et al., 1989; Stewart & Edler, 2011). Therefore, its resection reduces tip support and may cause simultaneous nasal widening. However, it is only one of many contributing factors, as the alar width increases even after subspinal osteotomy (Stewart & Edler, 2011).

An intact anterior nasal spine magnifies nasal tip projection and elevation produced by maxillary advancement surgery (Becker et al., 2014; Esenlik et al., 2011; Gassmann et al., 1989). Thus, it is almost always removed with maxillary advancement but not necessarily with other vectors of movement (Gassmann et al., 1989; Ubaya et al., 2012). Its removal is especially important in cases of advancement with AC-VY reconstruction (Rosenberg et al., 2002). The recontouring of this structure and the paranasal area has also been found to prevent dorsal maxillary impaction from excessively elevating the nasal tip (Rosenberg et al., 2002). Yet, while insufficient resection risks causing caudal septal deflection and deviation, excessive resection can deteriorate a retracted columella and cause a loss of tip projection, both of which can jeopardize optimal nasal morphology and aesthetics (Metzler et al., 2014; Mitchell et al., 2007).

Mitchell et al. (2007) suggested that the anterior nasal spine should be recontoured only when very prominent and in the presence of unfavourable pre-surgical nasolabial morphology. However, Metzler et al. (2014) recommended additional ostectomy within the lateral piriform aperture, especially in larger maxillary Le Fort I advancements, to reduce or smoothen the step between the upper portion of the bilateral nasal buttresses and the lower portion of the advanced segment and decrease post-surgical alar base projection and widening. Nasal crest levelling for the correction of the septal interface with the anterior nasal spine and removing any septal-maxillary interference also helps to maintain the midsagittal septal position (Metzler et al., 2014).

Many authors use the surgical treatment of the anterior nasal spine to rationalize surgical outcomes. Almukhtar et al. (2016) attributed the smaller nasal tip advancement, in comparison with the columella and alae, after maxillary advancement and impaction surgery with the alar cinch suture to anterior nasal spine recontouring. Becker et al. (2014) considered its removal responsible for the smaller nasal tip advancement after bimaxillary surgery involving maxillary advancement with less than 3 mm vertical movement.

Altug-Atac et al. (2008) suggested that the nasal base response to maxillary osteotomy could also be related to spinal resection. The restriction of subnasale movement, generating weak ratios with upper incisor advancement, after Le Fort 1 maxillary advancement surgery with ACVY reconstruction was attributed to its recontouring (Carlotti et al., 1986). Lin and Kerr (1998) ascribed the weak correlation between subnasale and bone movement after maxillary advancement and mandibular setback surgery to anterior nasal spine recontouring and the firm union of soft tissue in this region to the nasal base. Dantas et al. (2015) attributed the nasal changes after maxillary advancement and/or impaction surgery with ACVY reconstruction to treat skeletal Class II or Class III malocclusions to anterior nasal spine modification and soft tissue dissection.

However, Freihofer (1977) demonstrated that although maintaining the anterior nasal spine intact during maxillary advancement surgery caused greater pronasale and subnasale advancement and anterior-superior columella inclination, these results varied greatly. The nasal tip remained unchanged in some individuals even with upward maxillary displacement and an intact anterior nasal spine but significantly advanced and elevated in others, after resection and downward maxillary inclination. Moreover, Esenlik et al. (2011) could not detect a correlation between the magnitude of anterior nasal spine resection and soft tissue response after maxillary advancement osteotomy, with or without impaction. Another study concluded that anterior nasal spine management did not influence post-surgical changes in the nasal tip projection, columella tilt and the supratip break (Gassmann et al., 1989).

Additionally, multiple elements contribute to nasal tip support besides the medial crura which rest on the anterior nasal spine (Gassmann et al., 1989). Mommaerts et al. (2000) concluded that nasal tip advancement and elevation did not differ between patients subjected to subspinal advancement and impaction osteotomy or conventional osteotomy with AC-VY reconstruction, even though in the latter group, the anterior nasal spine was recontoured, the caudal border of the cartilaginous septum was trimmed and the attachments between the footplates and the septum were partially ruptured. The authors suggested that the advancing pyriform aperture pushing upon the alae, rather than the anterior nasal spine, increased tip projection. Betts et al. (1993) agreed

that changes in the lateral region of the pyriform aperture affect the nasal base soft tissues, which in turn influence the tip and nasolabial angle.

Moreover, it is extremely difficult to quantify the degree of anterior nasal spine resection (Esenlik et al., 2011; Gassmann et al., 1989). The quantification of its sagittal movement has an extremely low coefficient of reliability (McCollum et al., 2009).

Subspinal Le Fort 1 osteotomy

Beceli et al. (1996) described the subspinal osteotomy that modifies the vestibular incision to preserve the insertion of the transverse nasalis, depressor septi and myrtiformis muscles and leaves the mucomusculoperiosteal flap attached to the nasal septum. Mommaerts et al. (2000) also maintained soft tissue attachment at the anterior nasal spine which was separated from the maxilla and left attached to the anterior nasal septum, footplates and muscle insertion during the osteotomy.

Opponents of this procedure state that it jeopardizes the dentition and does not prevent adverse soft tissue effects (Metzler et al., 2014). Yet, Beceli et al. (1996) concluded that it avoided alar base widening and caused less nasal tip elevation than the conventional Le Fort 1 impaction osteotomy with anterior nasal spine resection and the AC suture. Mommaerts et al. (1997) also demonstrated less alar base widening than conventional osteotomy of a similar magnitude with AC-VY closure and anterior nasal spine recontouring. Even though the AC-VY closure reduced morphological width by 50% in the conventional sample, immediately after surgery the width was similar in both groups because extubation caused a greater reduction in the subspinal group. During the six months after surgery, alar width increased due to the resorbable AC sutures used in the conventional group but decreased in the subspinal osteotomy group, although this difference was smaller at 20 months post-surgery. The authors suggested the use of subspinal osteotomy with the AC suture in patients with lateral-caudal origins of nasolabial muscles (Mommaerts et al., 1997). Alar base width, nasal tip protrusion and nasal length did not change significantly after subspinal maxillary advancement osteotomy with AC-VY reconstruction (Fernández Sanromán et al., 2014). Yet, Mommaerts et al. (2000) observed that both the Le Fort 1 subspinal and the conventional Le Fort 1 advancement or impaction osteotomy with anterior nasal spine recontouring and AC-VY reconstruction caused similar nasal tip advancement and elevation and nasolabial angle maintenance, albeit with a large individual variation, suggesting that it was the advancing pyriform opening pushing upon the alar cartilages that advanced the nasal tip. Mommaerts et al. (1997) attributed possible interalar widening after this procedure to the confounding factor of the surgeon permitting it if he considered the pre-surgical nose too narrow.

3.1.2 Confounding factors associated with the investigation of the soft tissue changes produced by maxillary osteotomy

Few authors have conducted an in-depth analysis of the nasal changes caused by maxillary osteotomy. The published ratios between hard and soft tissue change vary widely (de Assis et al., 1996b; Esenlik et al.,

2011; Gassmann et al., 1989; Lin & Kerr, 1998; McFarlane et al., 1995; Rosen, 1988). Moreover, lower facial soft tissue landmarks such as pogonion demonstrate a more predictable response to orthognathic surgery than the nose and lips (Bailey et al., 1996; Esenlik et al., 2011). The post-surgical nasal tip, subnasale and upper lip positions generally register the biggest discrepancies from their pre-surgical predictions (Arnett & Bergman, 1993b; Eales et al., 1994; Esenlik et al., 2011; Legan & Burstone, 1980). Of primordial importance is the general consensus that exists regarding the difficulty in predicting nasal changes following a Le Fort 1 osteotomy (Eales et al., 1994; Esenlik et al., 2011).

Thus, the problems in identifying specific changes in nasal parameters caused by different vectors of surgical movement has led authors to suggest that the algorithms used to predict the final nasal profile have to be reviewed (Eales et al., 1994; Esenlik et al., 2011). Most researchers have focussed on sagittal changes but ignored vertical and transverse ones (Almukhtar et al., 2016). Moreover, authors often use linear ratios to interrelate soft and hard tissue movement assuming that soft tissue response occurs as a fixed percentage of the magnitude of bone movement and ignore other factors such as the vector of skeletal repositioning and individual variability (Chew, Sandham, et al., 2008).

Also, the inconsistent soft tissue changes registered by different authors after maxillary advancement surgery make it difficult to obtain reliable hard /soft tissue ratios (Eales et al., 1994; Esenlik et al., 2011). Published results about nasal tip projection and the nasolabial angle are especially contradictory (Worasakwutiphong et al., 2015). Methodological differences and sample heterogeneity make the comparison of the effect of different vectors of maxillary movement very complex (Chew, Sandham, et al., 2008; Esenlik et al., 2011; Worasakwutiphong et al., 2015). Variations in methodology may include sample selection (Becker et al., 2014; Joss et al., 2010; McCollum et al., 2009), the inclusion of patients with cleft lip and palate (Freihofer, 1977; McCollum et al., 2009), lateral cephalograms and photographs obtained without the relaxed lip position or prior to the resolution of oedema (McCollum et al., 2009), the cephalometric analysis (Altman & Oeltjen, 2007; Joss et al., 2010; McCollum et al., 2009), errors in landmark location (Radney & Jacobs, 1981) and the statistical method used (Becker et al., 2014; Joss et al., 2010).

Factors such as gender (Hui et al., 1994; Khamashta-Ledezma & Naini, 2015), ethnicity (Becker et al., 2014; Chung et al., 2008; Clemente-Panichella et al., 2000; Joss et al., 2010; Khamashta-Ledezma & Naini, 2015), age (Baik et al., 2000; Khamashta-Ledezma & Naini, 2015; McCollum et al., 2009; Moroi et al., 2014), weight (Baik et al., 2000; Moroi et al., 2014; Verdenik & Ihan Hren, 2014), posture, movement, facial expression (Oh et al., 2013) and long term morphological changes and ageing (Verdenik & Ihan Hren, 2014) enhance individual variation. Nutrition, use and age modify muscle, adipose tissue and fascia depending upon individual characteristics (Aydil et al., 2013; Kim et al., 2011). Bailey et al., (1996) attributed the slight lip and mandibular soft tissue changes observed one year and between 3 and 5 years after orthognathic surgery to the normal ageing process. The unpredictability of weight and age-related changes make long-term cephalometric predictions difficult (Becker et al., 2014).

Pre-surgical factors that may influence soft tissue/hard tissue ratios are the presence of syndromes such as hemifacial microsomia or cleft lip and palate, nasal deformities or previous maxillofacial trauma or surgery

(Louis et al., 2001). Soft tissue scarring and contraction after corrective procedures for syndromic deformities can limit correct maxillary repositioning (Bell & Dann, 1973; Hui et al., 1994; Louis et al., 2001). Soft tissue tonicity and thickness as well as its response to bone movement is altered (Louis et al., 2001; Verzé et al., 2014). The stronger scar tissue at the nasal base generates higher ratios as it suffers less lateral displacement and responds better to the forces transmitted from maxillary advancement, resulting in more consistent and predictable movement, (Freihofer, 1977; Hui et al., 1994). Scar tissue contracture can also lead to residual nasal tip defects (Verzé et al., 2014).

Initial nasal morphology (Betts et al., 1993; Chung et al., 2008; Moss et al., 1994; Radney & Jacobs, 1981; Rauso et al., 2010) and soft tissue thickness, length and tonicity (Abeltins & Jakobsone, 2011; Altman & Oeltjen, 2007; Baik & Kim, 2010; Becker et al., 2014; Eales et al., 1994; Kim et al., 2011; Louis et al., 2001; McCollum et al., 2009; Moroi et al., 2014; Radney & Jacobs, 1981; Rauso et al., 2010, 2011; Stella et al., 1989) are also influencing factors. A thicker soft tissue layer has a greater capacity to absorb the hard tissue movement and reflects this movement to a lesser and less-predictable extent (Bailey et al., 1996; Becker et al., 2014; Burstone, 1958; Kim et al., 2011; Louis et al., 2001; Mansour et al., 1983; Stella et al., 1989). The preoperative upper lip volume can influence the alteration in the nasolabial angle (Mansour et al., 1983; Westermark et al., 1991). The volume of adipose tissue (Rauso et al., 2011), the musculature (Altman & Oeltjen, 2007; Becker et al., 2014; Moroi et al., 2014; Oh et al., 2013; Rauso et al., 2011), variable nasal tip support (Altman & Oeltjen, 2007) and lip competence (Rauso et al., 2011) are also important variables. Firm union of soft tissue at the nasal base can prevent subnasale from responding proportionally to sagittal and vertical maxillary movement and thus, lower ratios (Altug-Atac et al., 2008; Lin & Kerr, 1998).

Other factors include the pre-surgical overbite and overjet (Rauso et al., 2010, 2011) and partial upper lip support from the lower incisors (Altug-Atac et al., 2008; Freihofer, 1976). A dead space between the upper dentoalveolar structures and lip usually accompanies severe maxillary retrusion (Louis et al., 2001). Hence, soft tissue movement only occurs when the magnitude of maxillary advancement is sufficient to permit contact (Altug-Atac et al., 2008; Chew, 2005; Louis et al., 2001; Stella et al., 1989). In the absence of a dead space, advancements of great magnitude cause soft tissue tension and less movement (Carlotti et al., 1986; Chew, 2005).

The knowledge of pre-surgical nasal anatomy is crucial to enable prediction of the nasal tip position after the Le Fort 1osteotomy (McFarlane et al., 1995; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The highly variable nasal morphology and skeleto-cartilaginous composition cause a complex relationship between soft and hard tissues (Esenlik et al., 2011; Gassmann et al., 1989). There are at least six elements that contribute to nasal tip support, the importance of which can vary significantly between patients (Gassmann et al., 1989). Betts et al. (1993) suggested that narrow alar bases showed a slight tendency to widen more than broader ones after maxillary advancement and/ or vertical repositioning without the AC. Korean women with a narrow pre-surgical alar width revealed the most widening after the use of AC suture (Chung et al., 2008). The Deflection Resistance Index subjectively appraises whether the nasal tip tissue anterior to the nostril is slightly greater, slightly less or markedly less than one-third of the sagittal nasal size wherein the first situation

indicates a high degree of susceptibility to nasal tip deflection after maxillary advancement and impaction surgery (McFarlane et al., 1995). Starck and Epker (1996) classified noses into three types depending on tip rotation and the size of the upper dorsal convexity and supratip break. Surgical influence on the various types of noses is essentially different (McFarlane et al., 1995; Schendel & Carlotti, 1991).

Other confounding variables are related to the treatment itself. These variables include orthodontic tooth movement (Becker et al., 2014; Joss et al., 2010; Khamashta-Ledezma & Naini, 2015; Moroi et al., 2014; Radney & Jacobs, 1981; Rauso et al., 2010), the number and skill of surgeons (Khamashta-Ledezma & Naini, 2015), the level of the vestibular incision (McCollum et al., 2009; Shoji et al., 2012; Tomlak et al., 1984), the degree of soft tissue dissection and deflection (Becker et al., 2014; Louis et al., 2001; Shoji et al., 2012), including the degloving of the lower lateral cartilages and the separation of the nasal septum (Gassmann et al., 1989), the type, direction and magnitude of surgical movement (Altug-Atac et al., 2008; Becker et al., 2014; Joss et al., 2010; Khamashta-Ledezma & Naini, 2015; Louis et al., 2001; Moroi et al., 2014; Oh et al., 2013; Radney & Jacobs, 1981; Rauso et al., 2010, 2011; Stella et al., 1989), occlusal plane rotation (DeSesa et al., 2016; Mansour et al., 1983; McCollum et al., 2009), the type of fixation (Becker et al., 2014; Joss et al., 2010), the method of soft tissue incision closure (Becker et al., 2014; Gassmann et al., 1989; Guymon et al., 1988; Khamashta-Ledezma & Naini, 2015; Louis et al., 2001; McCollum et al., 2009; Radney & Jacobs, 1981; Rauso et al., 2011; Shoji et al., 2012) and the insertion of facial implants as fillers (Louis et al., 2001). Several authors conclude that soft tissue changes are influenced more by the position and method of closure of the soft tissue incision than by surgical bone movement (Betts et al., 1993; Phillips et al., 1986).

The post-surgical variables that may influence results are oedema (Baik & Kim, 2010; Becker et al., 2014; Louis et al., 2001; Moroi et al., 2014; Rauso et al., 2011), haematomas, infection, bone resorption, surgical stability (Becker et al., 2014; Louis et al., 2001) soft tissue scarring (Altug-Atac et al., 2008; Becker et al., 2014; Gassmann et al., 1989; Louis et al., 2001; Moroi et al., 2014) and contraction (Becker et al., 2014; Louis et al., 2001) and the postoperative orthodontics required to optimize occlusal harmony and dental aesthetics (Louis et al., 2001).

Race as a confounding factor

Asians have a greater prevalence of Class III skeletal discrepancies that are also more pronounced (Chew, 2005; Chung et al., 2008; Lew & Foong, 1993). Hence, most studies on the soft tissue response to maxillary surgery have been performed in populations of Asian origin (Altman & Oeltjen, 2007; Hellak et al., 2015; Park et al., 2012). However, nasal morphology exhibits great racial variation (Choe et al., 2006; Clemente-Panichella et al., 2000; Farkas et al., 2005, 1986; Leong & White, 2004, 2006; Troncoso Pazos et al., 2008). Therefore, due to ethnic differences, the results of research conducted in other populations and races cannot be extrapolated to Caucasian faces and noses (Esenlik et al., 2011; Farkas et al., 2005; Hellak et al., 2015). Each patient is unique and the therapeutic approach has to be adjusted based on gender, ethnicity and treatment goals (Metzler et al., 2014).

Nasal widening caused by maxillary surgery is detrimental to Asian facial aesthetics due to their wider, flatter nose with a shorter columella compared to European Caucasians (Choe et al., 2006; Chung et al., 2008; Farkas et al., 2005; Hemmatpour et al., 2016; Park et al., 2012; Schendel & Williamson, 1983; Shoji et al., 2012). The average Asian nose is 4-6 mm broader than the North American Caucasian one (Worasakwutiphong et al., 2015). While surgical consequences like nasal tip elevation and enhanced nostril exposure may actually be positive in the rather long and narrow Caucasian nose with little nostril exposure, they are undesirable in Asians (Worasakwutiphong et al., 2015). Thus, as in Caucasians, the individual Asian patient´s nose should be evaluated prior to surgical planning (Chung et al., 2008). Susceptibility to nasal widening and the possible need for corrective rhinoplasty should be part of the informed consent (Chung et al., 2008).

The AC suture and anterior nasal spine resection are often used in Asians to prevent nasal enlargement during surgery (Chung et al., 2008; Schendel & Williamson, 1983; Shoji et al., 2012). AC sutures after bimaxillary surgery controlled alar base width and increased the nasolabial angle and nasal tip projection and thus, produced desirable aesthetics in Japanese noses (Shoji et al., 2012). However, Baik et al. (2000) stated that the excessively large alar base width existent prior to surgery prevents the AC suture from being effective in Koreans.

Isolated mandibular prognathism causes Class III malocclusion twice as frequently in Koreans and Chinese than in American Caucasians (Baik et al., 2000; Ellis & McNamara, 1984; Lew & Foong, 1993). However, bimaxillary surgery with posterior maxillary impaction is generally preferred to mandibular setback alone in Korean patients to improve facial aesthetics and increase surgical stability (Baik et al., 2000; Chung et al., 2008). This procedure may produce better facial aesthetics than maxillary advancement in the presence of a larger lower facial height and flatter occlusal plane (Baik & Kim, 2010; Choi et al., 2014). Yet, maxillary rotation in posterior impaction and advancement osteotomy may enhance nasal enlargement because the nasal base advances more than the dentition. Therefore, some authors advocate isolated mandibular setback in Asians to avoid negative nasal morphological changes (Baik et al., 2000; Chung et al., 2008).

Lew et al. (1990) reiterated the need to have race specific ratios after verifying distinct profile changes in Chinese and European Americans caused by differences in soft tissue thickness. Clemente-Panchiella et al. (2000) stated that as Hispanics revealed higher 0.58:1 and 1.1 ratios, respectively for vertical and sagittal subnasale movement relative to upper incisor movement after a variety of maxillary or bimaxillary surgeries than those found by other authors in Caucasian Americans, they required a smaller magnitude of maxillary advancement to achieve the same soft tissue results. The authors suggested that this was due to racial differences in soft tissue tonicity and thickness, incisor position and inclination and maxillary position and vertical dimension.

3.1.3 The use of ratios and multivariate equations to predict changes in nasal morphology

Ratios between soft and hard tissue movement have the advantage of eliminating gender-based size differences (Becker et al., 2014). However, they must be approached with caution. While useful as guides,

they do not guarantee the final treatment outcome, which depends on the specific magnitude and vector of maxillary movement necessary for correction and the individual variability in the soft tissue response (Rosenberg et al., 2002). Ratios are based on the average values of soft tissue response to hard tissue movement and do not consider extreme variations (McCollum et al., 2009). Hence, they merely simplify a complex set of interactions between soft and hard tissues and ignore many important contributing factors (Carlotti et al., 1986; Radney & Jacobs, 1981). Differences in individual skeletal patterns, orthodontic and surgical movement or the type of closure contribute to variations in prediction models (Betts et al., 1993; Brooks et al., 2001). Thus, it is unlikely that the correlation of only one variable with another variable can correctly predict soft tissue changes (Engel et al., 1979).

Rosen (1988) stated that the use of quantitative ratios to predict nasal changes was fraught with inaccuracy. These errors are especially critical when nasal changes range from 1 to 2 mm (Mansour et al., 1983). While a 1 mm increase in tip projection may noticeably alter the nasal appearance, this value is within the range of statistical error for serial cephalometric tracings (Altman & Oeltjen, 2007; Rosen, 1988). This error can also cause the prediction to deviate markedly from the final soft tissue profile, despite careful planning (Betts et al., 1993; Brooks et al., 2001). Thus, planning based on the incorrect prediction of soft tissue changes leads to less than optimal surgical outcomes (Rosen, 1988). A systematic review verified that although the difference between prediction and actual measurement for various profile variables was less than 2mm, the addition of these minimal errors could have clinical implications (Kaipatur & Flores-Mir, 2009). Thus, ratios are at best an estimate of what the final result will look like (Betts et al., 1993; Rosenberg et al., 2002).

Also, the lower correlation coefficients of vertical soft and hard tissue movement make it more difficult to predict changes in this plane than in the sagittal one (Chew, Sandham, et al., 2008; Lin & Kerr, 1998). As a result, predictive programs are less accurate in the vertical dimension (Chew, Sandham, et al., 2008). Therefore, further studies are needed to assess the influence of pre, peri and postoperative factors on soft tissue response to construct a more accurate prediction database (Chew, Sandham, et al., 2008).

Due to the complex soft tissue changes, a prediction method based on multiple variables, rather than simple ratios, could possess greater value and accuracy in defining the relationship between the movement of reference points (Engel et al., 1979; McCollum et al., 2009). Regression equations, by taking into account the interaction of several factors, make the description of soft tissue changes after three-dimensional skeletal movement more realistic (Radney & Jacobs, 1981).

Betts et al. (1993) considered stepwise multiple regression equations useful predictive tools, especially when the maxillary movement was divided by vectors, although they emphasized that soft tissue may be influenced more by the position and method of closure of the incision than by osseous movement. Yet, Mansour et al. (1983) verified that although progressive regression equations were better than ratios in predicting soft tissue changes when the principal movement was impaction rather than advancement, pronasale and subnasale advancement remained unpredictable.

Stepwise regression equations may not be able to correctly predict the nasolabial response to maxillary surgery due to the use of inadequate soft tissue morphological variables and the lack of inclusion of all the

skeletal variables that affect the soft tissue layer (Betts et al., 1993; Dann et al., 1976; Mansour et al., 1983; Phillips et al., 1986; Radney & Jacobs, 1981). Post-surgical orthodontic treatment may also contribute to the inability of regression equations using skeletal variables to explain all observed soft tissue changes (Betts et al., 1993).

Phillips et al. (1986) concluded that the regression equation using hard tissue variables explained only 35% of the variability in alar base widening caused by maxillary impaction. Engel et al. (1979) stated that even the multivariate method was inaccurate in predicting the very small sagittal or vertical nasal tip movement caused by surgery. Factors such as cephalometric tracing and superimposition errors, oedema and different surgical techniques also introduce errors in multivariate predictions

Yet, Mansour et al (1983) observed that the range of error was 22% and almost identical for ratios and regression equations. Radney and Jacobs (1981) also demonstrated that the predictive difference between ratios and multiple regression equations did not exceed 1.5 mm in both the sagittal and vertical dimensions. Moreover, orthodontists and surgeons may find it easier to use ratios for soft tissue assessment during surgical planning (Mansour et al., 1983).

3.1.4 Simultaneous correction of nasal anomalies

Some authors have opined that *humps*, bulbous nasal tips, septal deviation and a nasal valve obstruction can be corrected simultaneously with the osteotomy (Altman & Oeltjen, 2007; Schendel & Carlotti, 1991). Others concluded that all pre-existing nasal defects including the dorsal *hump*, nasal base width discrepancies, nasal pyramid deviation and changes caused by the orthognathic surgery itself should be corrected only during a secondary procedure 6 to 12 months later, to allow the resolution of oedema and stabilization of bone and soft tissues, as before this period, soft tissue reorganization makes nasal form and aesthetics unpredictable (Bottini et al., 2013; Marşan et al., 2015; Rosenberg et al., 2002). This is especially true for tip malposition and lateral crura and alar base malformations which are greatly affected by maxillary surgery, making it difficult to predict their final positions (Altman & Oeltjen, 2007). Simultaneous rhinoplasty is additionally complex because the endotracheal tube must be replaced by oral intubation (Altman & Oeltjen, 2007; Rosenberg et al., 2002; Schendel & Carlotti, 1991).

3.2 Justification for the study

The principal reasons that lead patients to seek orthodontic-surgical treatment are the improvement of facial aesthetics and the correction of function (Garvill et al., 1992; Laufer et al., 1976). Thus, the nose assumes importance due to its location in the middle of the face. Nasolabial shape, symmetry and projection play a key role in facial aesthetics and expression (Altman & Oeltjen, 2007; Liebregts et al., 2016; Metzler et al., 2014; Mitchell et al., 2007).

The most frequent maxillary anomalies are vertical excess and sagittal deficiency (Rosen, 1988). Advancement to correct a sagittal discrepancy affects the nasolabial region more profoundly than all other

vectors of maxillary movement (Mitchell et al., 2007; O'Ryan & Schendel, 1989b; Rauso et al., 2011). Changes are immediate and may be caused only by pressure on soft tissue even without muscle influence and are observed even in recently deceased corpses (Altman & Oeltjen, 2007; O'Ryan & Schendel, 1989b). Moreover, these changes in the nasal structure can be beneficial or harmful depending on the pre-existing nasal anatomy (McFarlane et al., 1995; O'Ryan & Schendel, 1989b; Schendel & Carlotti, 1991).

Asian populations are more prone to Class III skeletal malocclusions which are generally more accentuated (Chung et al., 2008; Lew & Foong, 1993). For this reason, most research on the soft tissue response to maxillary surgery have been carried out in populations of Asian descent (Hellak et al., 2015; Park et al., 2012). However, due to ethnic differences in facial and nasal morphology (Farkas et al., 2005; Schendel & Williamson, 1983), these results cannot be extrapolated to Caucasians (Hellak et al., 2015). The most frequently used vectors of movement and methods of surgical closure also vary between the different populations studied due to basic differences in the most commonly prevalent skeletal discrepancy (Baik et al., 2000; Bailey et al., 1995; Ellis & McNamara, 1984) and divergent aesthetic preferences (Lee et al., 2011; Worasakwutiphong et al., 2015). Moreover, each patient is unique and the therapeutic approach needs to be adjusted based on gender, ethnicity and individual treatment objectives (Metzler et al., 2014).

Soft tissue thickness also varies between different ethnicities (Clemente-Panichella et al., 2000; Lew, 1990) and can influence surgical results (Abeltins & Jakobsone, 2011; Kim et al., 2011; Stella et al., 1989). It also exhibits gender-based differences and is generally thicker in men compared to women (Abeltins & Jakobsone, 2011; Hu et al., 1999). Moreover, ageing makes the skin even thinner in women (Kim et al., 2011; Louis et al., 2001). Thus, the soft tissue response to skeletal movement can differ between the genders (Abeltins & Jakobsone, 2011). Ubaya et al. (2012) discovered that only women differed post-surgically from a gender-specific reference group with harmonious profiles despite both genders undergoing an equal magnitude of advancement.

The quantification of the soft tissue response to the surgical intervention is important because it informs the consent process, improves the accuracy in predicting possible postoperative soft tissue changes and helps surgical planning (Howley et al., 2011). The knowledge of possible changes allows orthodontists and surgeons to modify the surgical plan to avoid undesirable changes in an already harmonious nose or to improve unpleasant pre-surgical nasal characteristics (Altman & Oeltjen, 2007; Schendel & Carlotti, 1991). The patient must be informed of possible changes and also be made aware that additional surgery may be necessary in the future to create a cosmetically pleasing result (Altman & Oeltjen, 2007; Schendel & Carlotti, 1991).

Several authors have emphasized the importance of studying only one vector of maxillary movement (Betts et al., 1993; Khamashta-Ledezma & Naini, 2015, Wolford 1988). The few two-dimensional studies that assessed the changes in the nose caused by maxillary advancement, as part of a bimaxillary surgery in Class III malocclusions, were performed mainly in Turks or Asians and used limited variables, focussing mainly on sagittal and vertical pronasale and subnasale movements and occasionally on the changes in the morphological and alar base widths, although lateral cephalograms and frontal and profile facial photographs are routinely obtained in the pre-treatment, pre-surgical and post-treatment phases. This study aimed to conduct a more

detailed investigation of the change caused in Caucasian nasal morphology by maxillary advancement surgery for the correction of the Class III discrepancy in order to help orthodontic-surgical planning and facilitate clinician-patient communication about expected outcomes in a manner that satisfies both groups.

3.3 Aims of the investigation

The objectives of this investigation are as follows:

1) To evaluate the alterations produced by the Le Fort 1 maxillary advancement osteotomy on nasal shape and dimension in lateral cephalograms and in frontal and profile photographs, according to the following null hypotheses:

H0: Le Fort 1 maxillary advancement osteotomy does not significantly change nasal shape and dimension.

H1: Le Fort 1 maxillary advancement osteotomy significantly changes nasal shape and dimension.

2) To compare the changes produced by the Le Fort 1 osteotomy in cephalometric measurements of the nose between men and women.

H0: The changes produced by the Le Fort 1 osteotomy in women are not significantly different from the changes in men.

H1: The changes produced by the Le Fort 1 osteotomy in women are significantly different from the changes in men.

3) To evaluate the correlation between the magnitudes of each of the sagittal, vertical and rotational maxillary movements and the change in nasal shape and dimensions.

H0: The magnitude of each of the sagittal, vertical and rotational maxillary movements do not correlate significantly with the changes in nasal shape and dimensions.

H1: The magnitudes of each of the sagittal, vertical and rotational maxillary movements correlate significantly with the changes in nasal shape and dimensions.

3.4 Material and methods

The patients participating in this study were chosen from pre-existing records from the Department of Orthodontics of the Faculty of Dental Medicine of the University of Lisbon and the private clinics of various specialists in Orthodontics who are members of this department. Initial contact with all patients, explaining the nature of the study, was established either by telephone or in a routine consultation for the control of retention appliances, either by the investigator, one of the collaborating specialists or the dental hygienist from the Department of Orthodontics. The subject of the investigation and the use of lateral cephalograms and photographs were explained to the patients in person. Patients who agreed to participate in the study signed an informed consent. The investigation and the consent form were approved by the Ethics committee of the Faculty of Dental Medicine of the University of Lisbon.

This investigation used lateral cephalograms obtained with the aid of a cephalostat and with the Frankfurt horizontal plane parallel to the floor. These lateral cephalograms, obtained in centric occlusion and with the lips in a resting position, had to be of adequate quality with highly visible skeletal structures and soft tissue contours. Radiographic films were scanned using an Epson Perfection V700 PHOTO scanner.

The lateral cephalograms of the adult non-growing patients obtained prior to surgery (T2) and after surgery and the removal of fixed orthodontic appliances (T3) were superimposed and traced by the principal investigator, using the Adobe Photoshop CS5™ software (Adobe Systems Incorporated®, San José, CA, USA) and the Bjork structural method, which is based on de Coster's observation of a stable basicranial line from the inner contour of the frontal bone to the anterior aspect of the sella turcica (Björk, 1968; Björk & Skieller, 1983; Ghafari et al., 1987). The structures used for superimposition, including the contours and especially, the inner margin of the anterior wall of the sella turcica and its intersection with the anterior clenoid processes, the anterior contours of the middle cranial fossae and the contours of the cribriform plate, bilateral frontoethmoidal crests, the cerebral surfaces of the orbital roofs and the cortical layers of the frontal bone, were traced on the final lateral cephalograms. Trabecular details, the ptrerygomaxillary fissure and structures in the posterior cranial fossa were also traced and helped in the superimposition. This is the most commonly used method in investigations into the alterations caused by maxillary and bimaxillary surgery (Abeltins & Jakobsone, 2011; Aydil et al., 2013; Clemente-Panichella et al., 2000; Conley & Boyd, 2007; Gassmann et al., 1989; Jakobsone et al., 2012; Kim et al., 2011; Mansour et al., 1983; McCollum et al., 2009; Misir et al., 2011; Mommaerts et al., 2000; Stella et al., 1989).

The horizontal reference plane (x) was constructed 7° below the Sella-Nasion line with its origin at Sella using the Adobe Photoshop CS5 program™ in an adaptation of the method used by Legan and Burstone (1980). A perpendicular to the horizontal plane at Sella was used as the vertical reference plane (*y*) (Figure 3.2). The palatal plane (PP) that unites the points anterior nasal spine and posterior nasal spine was also used in the analysis

All cephalometric variables were measured using the cephalometric program Nemoceph® (Nemotec, Madrid, Spain). Calibration was performed using the ruler that exists in each lateral cephalogram prior to the identification of cephalometric reference points. The profile and frontal photographs were superimposed on the lateral cephalogram using the Nemoceph program®. Soft tissue nasion was marked in the midline on the line connecting the highest points of the superior palpebral sulci in the frontal photographs using the Adobe Photoshop CS5 program (Farkas et al., 1986; Furtado, 2016). A line was then designed passing through soft tissue nasion, and the midline of the philtrum till the level of menton. The homologous distance between soft tissue nasion at the level of the frontonasal suture and menton in the patient´s profile photograph superimposed on the lateral cephalogram with its incorporated ruler was then used to calibrate the frontal photograph. The intercanthal distance was also used as a reference to ensure that both the pre-surgical and post-treatment frontal photographs were the same size (Guymon et al., 1988; Phillips et al., 1986).

3.4.1 Inclusion and exclusion criteria

The criteria for the inclusion of individuals in the sample were:

- Le Fort 1 maxillary advancement osteotomy with rigid fixation.
- The use of the alar cinch and VY sutures
- Non-growing patients between 18 and 30 years of age.
- Caucasian race.
- Skeletal Class III malocclusion with a maxillary sagittal deficiency
- Class III molar and canine relationship prior to treatment
- Negative overjet in the pre-surgical phase
- A stable Class I canine position after orthodontic-surgical treatment.
- Lips supported by a natural dentition.
- Fixed orthodontic appliances present in the pre-surgical phase and the removal of these appliances before final photographs and lateral cephalograms.
- Incisor decompensation and arch coordination and stabilization performed before surgery to minimize incisor movement in the post-surgical treatment phase.
- Pre-surgical frontal and profile extra-oral photographs and lateral cephalograms obtained after the termination of the pre-surgical orthodontic treatment and within 4 weeks before surgery (T2) and post-treatment records acquired at least 6 months after surgery (T3).

The criteria for exclusion of individuals from the sample were:

- Extensive restoration of anterior teeth before or after surgery.
- Nasal surgery including rhinoplasty.
- History of previous facial surgeries or osteotomies.
- Cleft lip and/or palate and other congenital craniofacial anomalies.
- Marked facial asymmetry, anterior open bite and canting of the lips.
- History of maxillo-facial trauma.
- Severe weight changes during treatment that were obvious in the face
- Segmental surgery and/or bone grafts.

3.4.2 Cephalometric points

Hard tissue cephalometric points (Figure 3.2)

Nasion (N)	The most anterior point of the frontonasal suture in the midsagittal plane.
Sela (S)	The point situated in the radiographic centre of the skeletal concavity of the sella turcica.
Rhinion (Rh)	The most anterior-inferior point at the extremity of the nasal bone in the midsagittal plane.
Anterior nasal spine (ANS)	The point at the anterior extremity of the nasal spine.
Posterior nasal spine (PNS)	The point at the posterior extremity of the hard palate.

A point (A)	The deepest point on the anterior contour of the upper alveolar bone.
Prosthion (Pr)	The most anterior-inferior point of the upper alveolar bone between the upper central incisors.
B point (B)	The deepest point on the anterior contour of the lower alveolar bone.

Soft tissue cephalometric points

Frontal analysis (Figure 3.1)

Soft tissue Nasion (N´)	Lateral cephalograms: The soft tissue point that corresponds to the most anterior point on the frontonasal suture in the midsagittal plane. Frontal photographs: The centre of the horizontal line connecting the highest points of the bilateral superior palpebral sulci.
Nasal root (R)	The most lateral point on the narrowest part of the nasal root in the frontal view.
Mid-dorsum (Mn)	The midpoint of the nasal length (N´-Prn) that separates the upper dorsum from the lower dorsum.
Lateral dorsum (D)	The most lateral point on the lower nasal dorsum in frontal photographs.
Pronasale (Prn)	The most protrusive point of the nasal tip.
Frontal subnasale (Snf)	The most inferior point of the columella seen in the frontal view.
Alare (Al)	The most lateral point on the outer contour of each nasal wing.
Alar curvature (Ac)	The most lateral point on the basal curvature of each alar cartilage corresponding to the facial insertion of the base of the nasal wing.
Subalare (Sbal)	The point on the inferior limit of each alar base at its junction with the upper lip in the frontal view.
Lateral Nostril (NrL)	The most superior and lateral point of each nostril in the frontal view.
Frontal Columella (Cmf)	The most posterior-inferior and lateral point of the columella in the frontal view.

Profile analysis (Figure 3.2)

Soft tissue Nasion (N´)	The midsagittal soft tissue profile intersection of a plane that passed through Nasion and was parallel to the horizontal plane *x*.
Soft tissue Rhinion (Rh´)	The soft tissue point corresponding to the most anterior-inferior point on the extremity of the nasal bone in the mid-sagittal plane.
Nasal dorsum (Nd)	The most prominent point on the upper part of the nasal dorsum in the mid-sagittal plane.
Mid-dorsum (Mn)	The midpoint of the nasal length (N´-Prn) that separates the upper dorsum from the lower dorsum.
Supratip concavity (Stp)	The deepest point in the inferior third of the nasal dorsum in the midsagittal plane situated between the points mid-dorsum and inferior dorsum.
Inferior dorsum (Id)	The point of greatest convexity on the lower part of the nasal dorsum in the midsagittal plane.
Pronasale (Prn)	The most protrusive point of the nasal tip.
Infralobule (In)	The most anterior-inferior point of the nasal tip identified in the lateral view.
Columella (Cm)	The most anterior-inferior point of the nasal columella in the midsagittal plane.
Subnasale (Sn)	The point of intersection between the columella and the labial philtrum in the profile view.

Alar curvature (Ac)	The most lateral point on the basal curvature of each alar cartilage corresponding to the facial insertion of the base of the nasal wing.
Anterior Nostril (NrA)	The most anterior-inferior point of the nostril in the sagittal plane.
Superior Nostril (NrS)	The most superior point of the nostril identified in the profile view.
Upper lip (Ls)	The point situated on the mucocutaneous junction of the upper lip in the midsagittal plane.

Figure 3.1 Soft tissue cephalometric points in the frontal view

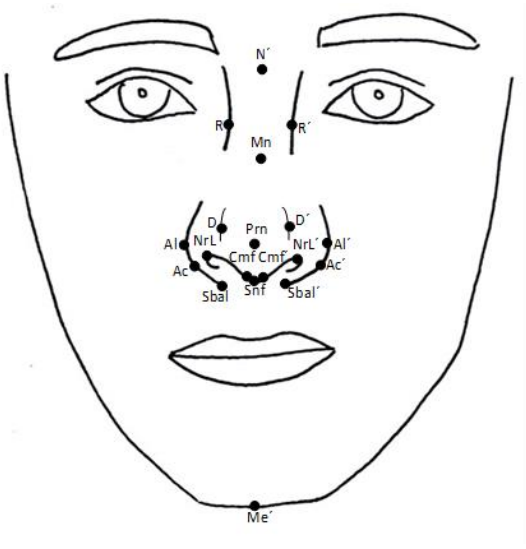


Figure 3.2 Hard and soft tissue cephalometric points in the profile view, horizontal (*x*) and vertical (*y*) reference planes

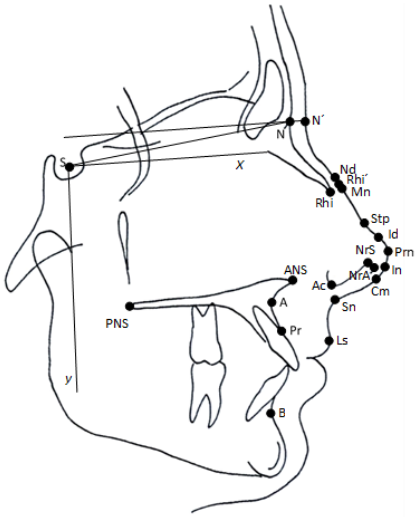


Figure 3.3 Skeletal facial measurements

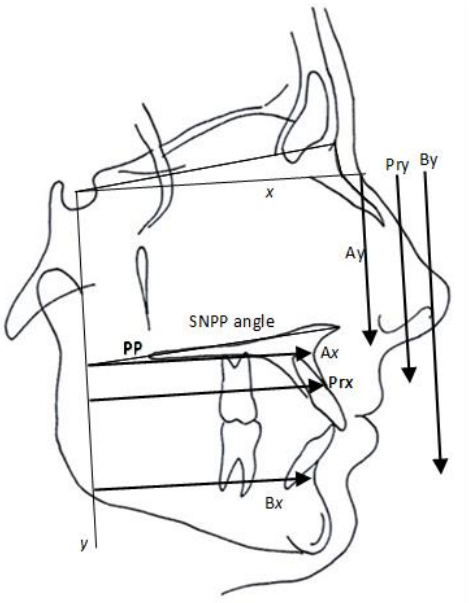
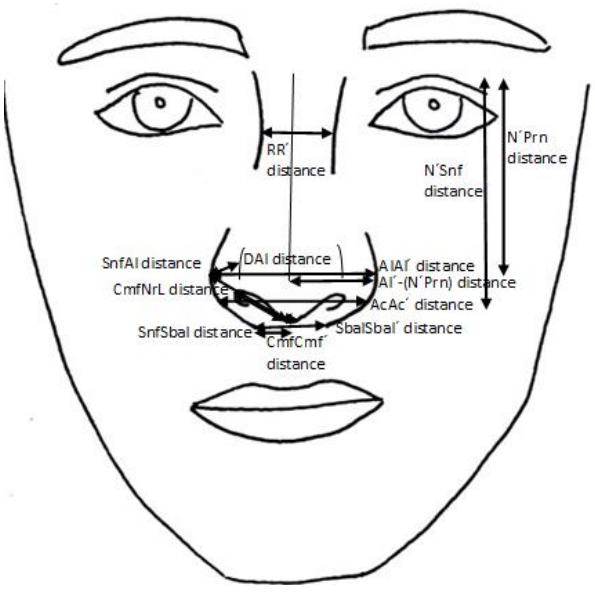


Figure 3.4 Direct frontal linear measurements



3.4.3 Cephalometric measurements

All linear and angular measurements were measured in units of millimetres and degrees, respectively.

The difference between the measurements at T3 and T2 (Value at T3-Value at T2) were calculated for the following cephalometric variables:

1. Skeletal facial measurements

Sagittal measurements (Figure 3.3)

1	Sagittal maxillary advancement (A point) (A*x*)	Distance between the point A and the vertical plane *y*.
2	Sagittal maxillary advancement (prosthion) (Pr*x*)	Distance between the point prosthion (Pr) and the vertical plane *y*
3	Sagittal mandibular change (B*x*)	Distance between the point B and the vertical plane *y*.

Vertical measurements (Figure 3.3)

4	Vertical maxillary change (A point) (A*y*)	Distance between the point A and the horizontal plane *x*.
5	Vertical maxillary change (prosthion) (Pr*y*)	Distance between the point prosthion (Pr) and the horizontal plane *x*.
6	Vertical mandibular change (B*y*)	Distance between the point B and the horizontal plane *x*.

Rotational measurements (Figure 3.3)

7	Maxillary inclination change (SN-PP)	Angle between the sella-nasion line (SN line) and the palatal plane (PP).

II. Soft tissue nasal measurements in frontal photographs

Direct transverse linear measurements (Figure 3.4)

1	Nasal root width (R-R´)	Distance between the nasal root point (R) on the right nasal contour and the corresponding point on the left side (R´).
2	Morphological width (Al-Al´)	Distance between the alare point (Al) located on the right nasal contour and the corresponding point on the left side (Al´).
3	Alar base width (Ac-Ac´)	Distance between the alar curvature point (Ac) located on the right nasal contour and the corresponding point on the left side (Ac´).
4	Columella width (Cmf-Cmf´)	Distance between the frontal columella point (Cmf) located on the right margin of the columella and the corresponding point on the left side (Cmf´).
5	Bilateral width of the nostril floor (Sbal-Sbal´)	Distance between the subalare point (Sbal) located on the lower limit of the right alar base and the corresponding point located on the left side (Sbal´).
6	Right nasal base width (SnfSbal)	Distance between the points frontal subnasale (Snf) and subalare (Sbal) located on the right side of the nose
7	Left nasal base width (SnfSbal´)	Distance between the points frontal subnasale (Snf) and subalare (Sbal´) located on the left side of the nose.
8	Right frontal subnasal-alare distance (SnfAl)	Distance between the points frontal subnasale (Snf) and alare (Al) located on the right side of the nose.
9	Left frontal subnasal-alare distance (SnfAl´)	Distance between the points subnasale (Sn) and alare (Al´) located on the left side of the nose.
10	Right diagonal nostril width (CmfNrL)	Distance between the points frontal columella (Cmf) and lateral nostril (NrL) located on the right side of the nose.

11	Left diagonal nostril width (Cmf´NrL´)	Distance between the points frontal columella (Cmf´) and lateral nostril (NrL´) located on the left side of the nose.
12	Right dorsal axis-alare distance (Al-N´Prn line)	Distance between the N´Prn line and the point alare (Al) located on the right nasal contour
13	Left dorsal axis-alare distance (Al´-N´Prn line)	Distance between the N´Prn line and the point alare (Al´) located on the left nasal contour.
14	Right dorsum-alare distance (D-Al)	Distance between the most lateral point on the nasal dorsum (D) and the point alare (Al) located on the right side of the nose.
15	Left dorsum-alare distance (D´-Al´)	Distance between the most lateral point on the nasal dorsum (D´) and the point alare (Al´) located on the left side of the nose.

Direct vertical linear measurements (Figure 3.4)

16	Frontal nasal length (N´Prn)	Distance between the points soft tissue nasion (N´) and pronasale (Prn).
17	Frontal nasal height (N´Snf)	Distance between the points soft tissue nasion (N´) and frontal subnasale (Snf).

Figure 3.5 Frontal angular measurements

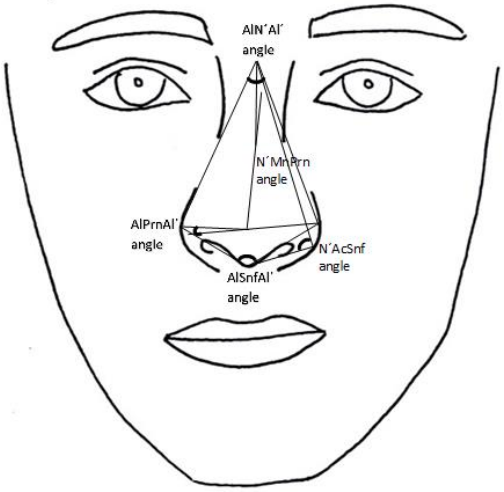
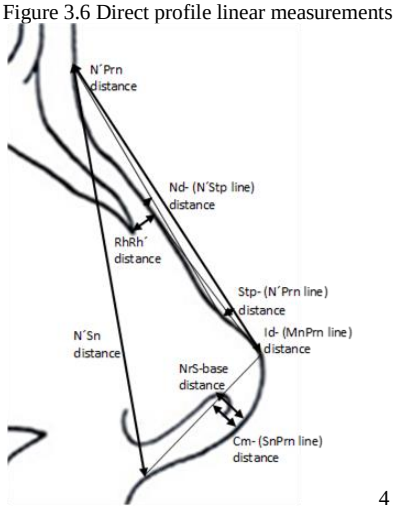


Figure 3.6 Direct profile linear measurements



4

Figure 3.7 Linear profile measurements performed parallel to *x* or *y*

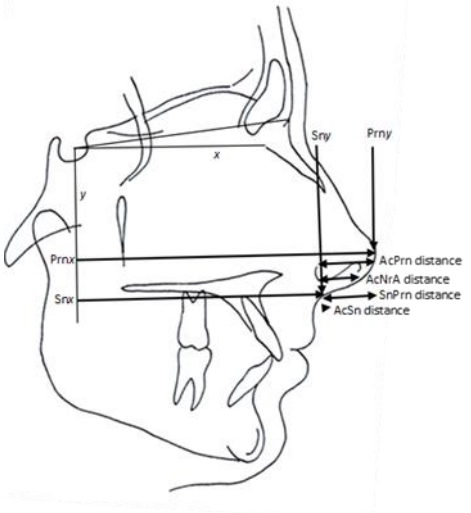


Figure 3.8 Angles of nasal form and projection

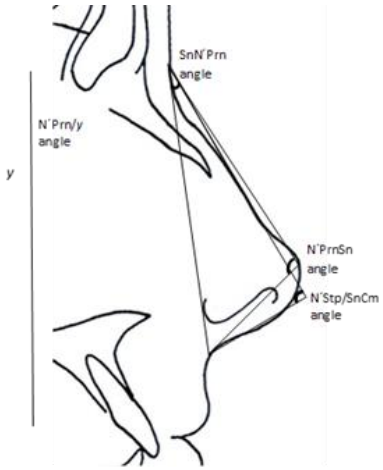
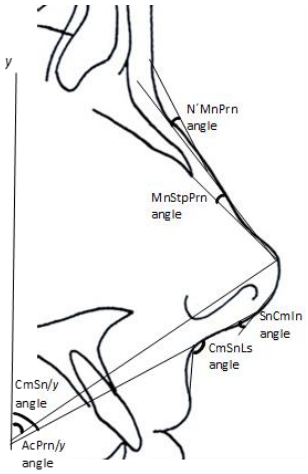


Figure 3.9 Angles of dorsal form and nasal rotation



Ratios between linear frontal measurements in frontal photographs

18	Root width: Morphological width ratio (RR´:AlAl´ ratio)	Ratio between the nasal root width (RR´) and the morphological width (AlAl´).
19	Frontal nasal length:Morphological width ratio (N´Prn:AlAl´ ratio)	Ratio between the nasal length (N´Prn) and the morphological width (AlAl´).
20	Frontal nasal height:Morphological width ratio (N´Snf:AlAl´ ratio)	Ratio between the nasal height (N´Sn) and the morphological width (AlAl´).

Angular measurements (Figure 3.5)

21	Dorsal angle (N´MnPrn angle)	Angle formed by the intersection of the soft tissue nasion-mid-dorsum line (N´Mn line) with the mid-dorsum-pronasale line (MnPrn line) in the frontal view.
22	Alar slope angle (AlPrnAl´ angle)	Angle between the right alare-pronasale line (AlPrn line) and the corresponding line on the left side.
23	Superior nasal angle (AlN´Al´ angle)	Angle between the right alare-soft tissue nasion line (AlN´ line) and the corresponding line on the left side.
24	Right lateral alar angle (N´AcSnf angle)	Angle between the right soft tissue nasion -alar curvatures line (N´Ac line) and the right alar curvature-frontal subnasale line (Ac-Sn line).
25	Inferior nasal angle (AlSnfAl´ angle)	Angle between the right alare-frontal subnasale line (AlSnf line) and the corresponding line on the left side.

III. Soft tissue nasal variables measured in profile photographs and lateral cephalograms

Direct linear measurements (Figure 3.6)

1	Nasal height (N´-Sn)	Distance between the points soft tissue nasion (N´) and subnasale (Sn).
2	Nasal length (N´-Prn)	Distance between the points soft tissue nasion (N´) and pronasale (Prn).
3	Soft tissue thickness at rhinion (Rh-Rh´)	Distance between the points rhinion (Rh) and soft tissue rhinion (Rh´).
4	Upper dorsal convexity (Nd- N´Stp line)	Perpendicular distance between the nasal dorsum point (Nd) and the soft tissue nasion-supratip concavity line (N´Stp line).
5	Depth of the supratip break (Stp- N´Prn line)	Perpendicular distance between the supratip concavity point (Stp) and the soft tissue nasion--pronasale line (N´Prn line).
6	Lower dorsal convexity (Id- MnPrn line)	Perpendicular distance between the inferior dorsum point (Id) and the mid-dorsum-pronasale line (MnPrn line).
7	Columella depth (Cm- PrnSn line)	Perpendicular distance between the columella point (Cm) and the pronasale-subnasale line (PrnSn line).
8	Columella exposure (NrS- columella base)	The shortest distance between the superior nostril point (NrS) and the columella base.

Linear measurements performed parallel to the horizontal reference line *x* (Figure 3.7)

9	Sagittal position of point pronasale (Prn*x*)	Distance between the point pronasale (Prn) and the vertical plane *y*.

10 Sagittal position of point subnasale (Sn*x*)	Distance between the point subnasale (Sn) and the vertical plane *y*.
11 Nasal projection (Ac-Prn)	Distance between the points alar curvature (Ac) and pronasale (Prn).
12 Nostril projection (Ac-NrA)	Distance between the points alar curvature (Ac) and anterior nostril (NrA).
13 Subnasale projection (Ac-Sn)	Distance between the points alar curvature (Ac) and subnasale (Sn).
14 Nasal protrusion (Sn-Prn)	Distance between the points subnasale (Sn) and pronasale (Prn).

Linear measurements performed parallel to the horizontal reference line *y* (Figure 3.7)

15 Vertical position of point pronasale (Prn*y*)	Distance between the point pronasale (Prn) and the horizontal plane *x*.
16 Vertical position of point subanasale (Sn*y*)	Distance between the point subnasale (Sn) and the horizontal plane *x*.

Angular measurements

Angles of nasal form (Figure 3.8)

17 Nasal prominence angle (SnN´Prn)	Angle formed by the intersection of the subnasale-soft tissue nasion line (SnN´ line) with the soft tissue nasion-pronasale line (N´Prn line).
18 Apical nasal angle (N´-Stp/Sn-Cm)	Angle formed by the intersection of the soft tissue nasion-supratip concavity line (N´Stp line) with the subnasale-columella line (SnCm line).
19 Nasal tip angle (N´PrnSn)	Angle formed by the intersection of the soft tissue nasion-pronasale line (N´Prn line) with the pronasale-subnasale line (PrnSn line).

Angles of nasal projection (Figure 3.8)

20 Nasal projection angle (N´Prn/y)	Angle formed by the intersection of the soft tissue nasion-pronasale line (N´Prn line) with the vertical reference line *y*.

Angles of dorsal form (Figure 3.9)

21 Dorsal contour angle (N´MnPrn)	Angle formed by the intersection of the soft tissue nasion-mid-dorsum line (N´Mn line) with the mid-dorsum-pronasale line (MnPrn line).
22 Supratip break angle (MnStpPrn)	Angle formed by the intersection of the mid-dorsum-supratip concavity line (MnStp line) with the supratip concavity-pronasale line (StpPrn line).

Angles of nasal rotation (Figure 3.9)

23 Nasolabial angle (CmSnLs)	Angle formed by the intersection of the columella-subnasale line (CmSn line) with the subnasale-upper lip line (SnLs line).
24 Columella rotation angle (CmSn/ y)	Angle between the columella-subnasale line (CmSn line) and the vertical plane *y*.
25 Nasal tip rotation (AcPrn/ y)	Angle between the alar curvature-pronasale line (AcPrn line) and the vertical plane *y*.
26 Columella-lobule angle (SnCmIn)	Angle between the subnasale-columella line (CmSn line) and the columella-infralobule line (CmIn line).

3.4.4 Method error

The cranial structures used for superimposition were traced and post-treatment lateral cephalograms of 15 randomly selected cases were superimposed on the corresponding pre-surgical radiographs. Frontal and profile cephalometric analyses were performed to determine the surgical change (T3-T2) in each of the variables. The entire process including the tracing, superimposition and analyses was repeated after a month. A paired sample t test detected a systematic error in the frontal nasal variable Dorsal angle ($P<0.05$) (Table 3.1). The intraclass coefficient revealed a random error in the measurement of the frontal nasal variables dorsal angle and left dorsum-alare distance (Table 3.1).

Table 3.1: Systematic error according to the paired sample t test and random error according to the intraclass coefficient for the frontal nasal variables

Cephalometric variable	1st evaluation Mean ± SD	2nd evaluation Mean ± SD	Paired sample t test *P*-Value	Intraclass correlation	
				Single measures	Cronbach´s Alpha
Nasal root width	0.41 ± 0.59	0.25 ± 0.83	0.174	0.81	0.90
Morphological width of nose	2.41 ± 1.31	2.19 ± 1.29	0.661	0.94	0.98
Alar base width	2.14 ± 1.46	2.07 ± 1.55	0.668	0.93	0.96
Columella width	0.52± 1.10	0.76 ±1.25	0.065	1.00	1.00
Bilateral width of the nostril floor	1.91 ± 1.14	1.58 ± 1.43	0.112	0.81	0.90
Right nasal base width	0.71 ± 1.21	0.64 ± 1.23	0.722	0.84	0.91
Left nasal base width	0.72 ± 1.06	0.60 ± 1.08	0.290	0.83	0.91
Right frontal subnasale-alare distance	1.57 ± 1.10	1.37 ± 1.08	0.291	0.80	0.89
Left frontal subnasale-alare distance	1.11 ± 0.94	1.25 ± 1.32	0.401	0.85	0.92
Right diagonal nostril width	0.79 ± 0.65	0.81 ± 0.80	0.871	0.81	0.89
Left diagonal nostril width	0.53± 1.23	0.44 ± 1.46	0.701	0.81	0.89
Right dorsal axis-alare distance	1.11 ±1.02	1.07 ± 0.85	0.751	0.83	0.90
Left dorsal axis-alare distance	1.33 ± 0.92	1.18 ± 1.25	0.317	0.86	0.93
Right dorsum-alare distance	-0.06 ± 0.09	-0.05 ± 0.11	0.334	0.88	0.94
Left dorsum-alare distance	-0.02 ± 0.04	-0.03 ± 0.06	0.670	0.34	0.49
Frontal nasal length	0.54 ± 3.14	0.69 ± 3.45	0.461	0.97	0.98
Frontal nasal height	1.40 ± 3.33	1.17 ± 3.57	0.161	0.98	0.99
Root width/morphological width ratio	-0.02 ± 0.04	-0.02 ± 0.06	0.928	0.36	0.51
Frontal nasal length/ morphological width ratio	-0.04 ± 0.11	-0.04 ± 0.10	0.988	0.88	0.93
Frontal nasal height/ morphological width ratio	-0.06 ± 0.10	-0.05 ± 0.11	0.334	0.88	0.94
Dorsal angle	0.85 ± 6.71	-2.63 ± 7.86	0.037	0.62	0.81
Alar slope angle	0.60 ± 4.39	-1.36 ± 4.22	0.230	0.81	0.89
Superior alar angle	1.89 ± 2.57	2.02 ± 2.49	0.636	0.92	0.96
Right lateral alar angle	0.03 ± 4.94	-0.65 ± 4.77	0.158	0.93	0.97
Inferior alar angle	0.46 ± 6.05	-0.59 ± 6.62	0.291	0.83	0.91

Table 3.2: Systematic error according to the paired sample t test and random error according to the intraclass coefficient for the facial and nasal profile variables

Cephalometric variable	1st evaluation Mean ± SD	2nd evaluation Mean ± SD	Paired sample t test *P*-Value	Intraclass correlation	
				Single measures	Cronbach´s Alpha
Sagittal maxillary advancement (A point)	2.60 ± 1.59	2.54 ± 1.44	0.548	0.84	0.98
Sagittal maxillary advancement (prosthion)	3.40 ± 1.73	3.43 ± 1.78	0.867	0.94	0.96
Sagittal mandibular change (B point)	-2.57 ± 3.04	-2.61± 2.95	0.776	0.99	0.99
Vertical maxillary change (A point)	-0.33 ± 1.77	-0.37± 1.77	0.718	0.96	0.98
Vertical maxillary change (prosthion)	0.17 ± 1.39	0.09± 1.39	0.370	0.96	0.98
Vertical mandibular change (B point)	-1.96 ± 2.46	-1.76 ± 2.20	0.386	0.93	0.96

Maxillary inclination change	0.47 ± 1.51	0.53 ± 1.36	0.719	0.87	0.93
Nasal height	-0.02 ± 1.18	0.17 ± 1.10	0.285	0.84	0.91
Nasal length	-0.03 ± 1.12	0.03 ± 1.03	0.696	0.86	0.92
Soft tissue thickness at Rhinion	0.11 ± 0.66	0.12 ± 0.72	0.845	0.93	0.96
Upper dorsal convexity	0.10 ± 0.44	0.03± 0.45	0.350	0.84	0.91
Depth of the supratip break	-0.23 ± 0.43	-0.24 ± 0.41	0.843	0.83	0.90
Lower dorsal convexity	0.03 ± 0.38	0.01 ± 0.29	0.830	0.81	0.90
Columella depth	-0.06 ±0.44	-0.07 ± 0.58	0.931	0.85	0.91
Columella exposure	0.32 ± 0.89	0.37 ± 0.81	0.487	0.96	0.98
Sagittal position of point pronasale	0.79 ± 1.70	0.71 ± 1.49	0.573	0.96	0.98
Sagittal position of point subnasale	1.48 ± 2.15	1.33± 2.06	0.183	0.98	0.99
Nasal projection	-1.03 ± 2.03	-0.89± 1.96	0.331	0.96	0.98
Subnasale projection	-0.23 ± 1.90	-0.30 ± 1.55	0.666	0.95	0.97
Nostril projection	-0.71 ± 1.56	-0.61 ± 1.47	0.455	0.95	0.97
Nasal protrusion	-0.77 ± 1.04	-0.63 ± 1.03	0.273	0.90	0.95
Vertical position of point pronasale	-0.57 ± 1.13	-0.41 ± 1.22	0.172	0.94	0.97
Vertical position of point subnasale	-0.28 ± 1.09	-0.09 ± 1.21	0.248	0.86	0.93
Nasal prominence angle	-0.67 ± 1.18	-0.60 ± 1.12	0.719	0.82	0.99
Apical nasal angle	-0.67 ± 2.89	-0.07 ± 3.28	0.246	0.80	0.89
Nasal tip angle	0.40 ± 1.59	0.13 ± 1.55	0.262	0.84	0.91
Nasal projection angle	1.24 ± 1.20	1.49 ± 1.14	0.139	0.85	0.93
Dorsal contour angle	0.40 ± 2.16	0.00 ± 2.07	0.253	0.81	0.90
Supratip break angle	-0.67 ± 1.88	-0.27 ± 2.58	0.271	0.82	0.90
Nasolabial angle	0.04 ± 5.46	0.20± 4.79	0.637	0.80	0.89
Columella rotation angle	-0.20 ± 3.08	-0.67 ± 3.62	0.388	0.82	0.90
Nasal tip rotation angle	-3.07 ± 3.13	-2.80 ± 2.73	0.573	0.80	0.90
Columella-lobule angle	-1.17 ± 3.27	-0.67 ± 3.06	0.152	0.78	0.88

3.4.5 Statistical analysis and sample size determination

Based on the 1.31 mm standard deviation detected in the pilot study, a sample size of 29 patients was required to provide 80% power to detect a treatment induced difference of 1 mm in morphological width at a two-sided 0.05 significance level (http://hedwig.mgh.harvard.edu/sample_size). A total of 19 patients was required to provide an 80% probability of detecting a 1 mm difference in nasal tip protrusion caused by treatment at a two-sided 0.05 significance level, based on the 1.03 mm standard deviation verified in the pilot study. 80 patients were included in the sample.

The Kolmogorov-Smirnov test was used to test the null hypothesis that the sample was derived from a normally distributed population. Non-parametric tests were used for non-normally distributed variables. The changes in the cephalometric measurements of the nose were used as dependent variables. The Le Fort I osteotomy, gender and the alterations in the skeletal variables were used as independent variables. Descriptive statistics including the mean, standard deviation, standard error of the mean and the minimum and maximum values were calculated for each dependent variable.

The effect of the Le Fort 1 maxillary advancement osteotomy on the nasal cephalometric variables was determined using a one sample t test. The influence of gender on the surgical change in the nasal variables was evaluated using Student´s t test for independent variables.

The correlation between the changes in the linear and angular nasal morphometric measurements and the sagittal, vertical and rotational maxillary movement was determined using a backward multiple regression analysis in order to determine the individual contribution of each of these independent variables.

The level of statistical significance was fixed at 5%. The statistical program SPSS® version 25 for Windows (IBM Company, Armonk, NY, USA) was used.

3.5 Results

3.5.1 Alterations produced by the Le Fort 1 maxillary advancement osteotomy in skeletal maxillary and mandibular variables

Descriptive statistics for the alteration caused by maxillary advancement surgery in each skeletal variable (T3-T2) are presented in Tables 3.3 and 3.4. The Kolmogorov-Smirnov test demonstrated that the variable sagittal maxillary advancement (A point) was not normally distributed at a 1% level of significance (P =0.000).

Results of the one sample t test used to determine the effect of the Le Fort maxillary advancement osteotomy on the normally distributed skeletal maxillary and mandibular variables are reported in Table 3.3. Sagittal maxillary advancement (Prosthion) (P<0.001) significantly increased and sagittal mandibular change (P<0.001), vertical maxillary change (A point) (P<0.05), vertical maxillary change (Prosthion) (P<0.01) and vertical mandibular change (P<0.001) significantly decreased. The Wilcoxon signed ranked test revealed that the non-normally distributed variable sagittal maxillary advancement (A point) increased significantly (P<0.001) (Table 3.4).

Table 3.3: Descriptive statistics and results of the one sample t-test to evaluate the effect of Le Fort 1 maxillary advancement surgery on maxillary and mandibular skeletal variables measured in the lateral cephalograms of 80 patients (T3-T2)

Cephalometric variable	Descriptive statistics					One sample t test		
	Mean	Standard deviation	Standard error	Min. value	Max. value	95% CI of the Difference		*P*-Value
						Lower	Upper	
Sagittal maxillary advancement (Prosthion)	4.09	2.71	0.30	0.1	13.6	3.49	4.69	0.000***
Sagittal mandibular change (B point)	-1.67	3.86	0.43	-12.3	9.2	-2.53	-0.81	0.000***
Vertical maxillary change (A point)	-0.59	2.07	0.23	-5.3	4.5	-1.05	-0.13	0.012*
Vertical maxillary change (Prosthion)	-0.63	2.11	0.24	-6.4	4.2	-1.10	-0.16	0.009**
Vertical mandibular change (B point)	-2.68	3.65	0.41	-11.7	6.6	-3.49	-1.86	0.000***
Maxillary inclination change	0.31	2.39	0.27	-5.3	5.2	-0.22	0.84	0.247

P<0.05*, *P*<0.01**, *P*<0.001***, Min. value: Minimum value, Max. value: Maximum value, CI of the Difference; Confidence Interval of the difference

Table 3.4: Descriptive statistics and results of the Wilcoxon signed ranked test to evaluate the effect of Le Fort 1 maxillary advancement surgery on the non-normally distributed skeletal variable sagittal maxillary advancement (A point) in 80 patients (T3-T2)

Cephalometric variable	Descriptive statistics					Wilcoxon signed ranked test
	Mean	Standard deviation	Standard error	Minimum value	Maximum value	*P*-value
Sagittal maxillary advancement (A point)	3.78	2.48	0.28	0.3	12.6	0.000***

P<0.001***

3.5.2 Changes produced by the Le Fort 1 maxillary advancement osteotomy in variables measured in frontal photographs

Descriptive statistics for the changes caused by maxillary advancement surgery in each cephalometric variable (T3-T2) measured in frontal photographs were calculated (Tables 3.5 and 3.6). According to the Kolmogorov-Smirnov test, the variables nasal root width (P =0.007), columella width and frontal nasal length (P =0.000) were not normally distributed at a 1% level of significance (α).

Results of the one sample t test used to determine the effect of the Le Fort maxillary advancement osteotomy on the normally distributed soft tissue nasal variables measured in frontal photographs are reported in Table 3.5. Mean values of morphological width, alar base width, bilateral width of the nostril floor, right nasal base width, left nasal base width, right frontal subnasale-alare distance, left frontal subnasale-alare distance, right diagonal nostril width, left diagonal nostril width, right dorsal axis-alare distance, left dorsal axis-alare distance, alar slope angle, superior alar angle (P<0.001) and inferior alar angle (P<0.05) increased significantly. The frontal nasal length/morphological width ratio, frontal nasal height/morphological ratio (P<0.001) and lateral alar angle (P<0.01) decreased significantly.

Table 3.5: Descriptive statistics and results of the one sample t test to determine the effect of Le Fort 1 maxillary advancement surgery on nasal morphometric variables measured in frontal photographs of 80 individuals (T3-T2)

Cephalometric variable	Descriptive statistics					One sample t test		
	Mean	SD	SE	Min. value	Max. value	95% CI of the Difference Lower	Upper	*P*-Value
Morphological width	2.29	1.47	0.16	-0.7	6.7	1.97	2.62	0.000***
Alar base width	2.32	1.52	0.17	-1.0	6.7	1.98	2.66	0.000***
Bilateral width of the nostril floor	1.46	1.15	0.13	-0.8	4.3	1.21	1.72	0.000***
Right nasal base width	0.71	1.22	0.14	-2.4	4.4	0.44	0.99	0.000***
Left nasal base width	0.65	1.26	0.14	-3.6	3.2	0.37	0.93	0.000***
Right frontal subnasale-alare distance	1.08	1.33	0.15	-2.1	4.6	0.78	1.37	0.000***
Left frontal subnasale-alare distance	1.15	1.31	0.15	-2.2	4.6	0.86	1.45	0.000***
Right diagonal nostril width	0.80	1.17	0.13	-1.4	4.8	0.54	1.06	0.000***
Left diagonal nostril width	0.74	1.18	0.13	-1.7	4.7	0.47	1.00	0.000***
Right dorsal axis-alare distance	1.04	1.30	0.15	-1.8	4.2	0.75	1.33	0.000***
Left dorsal axis-alare distance	1.24	1.17	0.13	-1.7	4.5	0.97	1.50	0.000***
Frontal nasal height	0.43	2.66	0.30	-5.7	4.7	-0.16	1.02	0.149
Frontal nasal length/morphological width ratio	-0.12	0.08	0.01	-0.3	0	-0.13	-0.10	0.000***
Frontal nasal height/morphological width ratio	-0.09	0.11	0.01	-0.5	0.2	-0.11	-0.07	0.000***
Alar slope angle	8.36	8.31	0.93	-11.3	29.9	6.51	10.21	0.000***
Superior alar angle	2.14	2.13	0.24	-2.8	7.9	1.67	2.62	0.000***
Inferior alar angle	1.59	6.75	0.76	-13.8	17.2	0.08	3.09	0.039*
Right lateral alar angle	-1.20	3.92	0.44	-8.7	7.6	-2.08	-0.33	0.007**

P<0.05*, *P*<0.01**, *P*<0.001***, SD: Standard deviation, SE: Standard error, Min. value: Minimum value, Max. value: Maximum value, CI of the Difference: Confidence interval of the Difference

Table 3.6: Descriptive statistics and the results of the Wilcoxon signed ranked test to determine the effect of Le Fort 1 maxillary advancement surgery on the non-normally distributed soft tissue variables measured in the frontal photographs of 80 individuals (T3-T2)

Cephalometric variable	Descriptive statistics					Wilcoxon signed ranked test
	Mean	Standard deviation	Standard error	Minimum value	Maximum value	*P*-value
Nasal root width	0.04	0.17	0.17	-0.5	0.5	0.026*
Columella width	0.33	0.39	0.39	-0.2	1.2	0.000***
Frontal nasal length	-1.41	1.19	0.13	-4.2	0.2	0.000***

P<0.05*, *P*<0.001***

Amongst the non-normally distributed variables, the Wilcoxon signed ranked test showed that Le Fort 1 maxillary advancement surgery significantly increased nasal root width (P<0.05) and columella width (P<0.001) and reduced frontal nasal length (P<0.001) (Table 3.6).

3.5.3 Changes produced by the Le Fort 1 maxillary advancement osteotomy in nasal variables measured in profile photographs and lateral cephalograms

Tables 3.7 and 3.8 present descriptive statistics for the changes caused by maxillary advancement surgery in each nasal cephalometric variable (T3-T2) measured in lateral cephalograms and profile photographs. According to the Kolmogorov-Smirnov test, only the variables upper dorsal convexity (P =0.001) and subnasale projection (P =0.008) were not normally distributed at a 1% level of significance.

Table 3.7: Descriptive statistics and results of the one sample t test to the effect of Le Fort 1 maxillary advancement surgery on nasal morphometric variables measured in lateral cephalograms and profile photographs of 80 individuals (T3-T2)

Cephalometric variable	Descriptive statistics					One sample *t* test		
	Mean	Standard deviation	Standard error	Min. value	Max. value	95% CI of the Difference Lower	Upper	*P*-Value
Nasal height	-0.49	1.07	0.12	-3.7	2.3	-0.73	-0.25	0.000***
Nasal length	-0.63	1.15	0.13	-4.0	1.7	-0.88	-0.37	0.000***
Soft tissue thickness at rhinion	-0.01	0.68	0.08	-1.5	1.6	-0.16	0.14	0.871
Depth of the supratip break	-0.62	0.70	0.08	-2.4	0.7	-0.77	-0.46	0.000***
Lower dorsal convexity	-0.24	0.47	0.05	-1.4	0.9	-0.35	-0.14	0.000***
Columella depth	0.13	0.52	0.06	-1.0	1.3	0.01	0.25	0.029*
Columella exposure	0.09	0.73	0.08	-1.7	2.3	-0.08	0.25	0.291
Sagittal position of point pronasale	0.87	1.13	0.13	-1.3	4.3	0.62	1.12	0.000***
Sagittal position of point subnasale	1.89	1.48	0.17	-0.3	7.2	1.56	2.22	0.000***
Nasal projection	-2.16	1.89	0.21	-6.0	2.1	-2.58	-1.74	0.000***
Nostril projection	-1.86	1.69	0.19	-5.8	1.6	-2.24	-1.48	0.000***
Nasal protrusion	-1.01	0.97	0.11	-3.5	1.6	-1.22	-0.79	0.000***
Vertical position of point pronasale	-1.18	1.26	0.14	-4.5	1.3	-1.46	-0.90	0.000***
Vertical position of point subnasale	-0.72	1.00	0.11	-3.1	1.9	-0.95	-0.50	0.000***
Nasal prominence angle	-0.48	0.99	0.11	-3.4	1.6	-0.70	-0.26	0.000***
Apical nasal angle	-0.24	4.92	0.55	-12.7	12.3	-1.33	0.86	0.667
Nasal tip angle	1.19	2.84	0.32	-5.4	8.2	0.56	1.82	0.000***
Nasal projection angle	1.50	1.58	0.18	-1.3	5.3	1.14	1.85	0.000***
Dorsal contour angle	2.48	3.22	0.36	-5.0	11.1	1.76	3.20	0.000***
Supratip break angle	-2.75	3.93	0.44	-14.9	6.1	-3.62	-1.87	0.000***
Nasolabial angle	-2.57	9.89	1.11	-41.1	18.6	-4.77	-0.37	0.023*
Columella rotation angle	-0.32	4.86	0.54	-9.1	11.1	-1.40	0.77	0.564
Nasal tip rotation angle	-3.54	3.28	0.37	-12.2	5.5	-4.26	-2.81	0.000***
Columella-lobule angle	1.46	7.19	0.80	-14.0	18.2	-0.14	3.06	0.073

P<0.05*, P<0.01**, P<0.001***, Min. value: Minimum value, Max. value: Maximum value, CI of the Difference: Confidence interval of the Difference

A one sample t test was used to determine the effect of Le Fort maxillary advancement osteotomy on the normally distributed soft tissue profile variables (Table 3.7). Nasal height, nasal length, depth of the supratip break, lower dorsal convexity, nasal projection, nostril projection, nasal protrusion, vertical position of point pronasale, vertical position of point subnasale, nasal prominence angle, supratip break angle (P<0.001), nasolabial angle (P<0.05) and nasal tip rotation angle (P<0.001) decreased significantly. Columella depth (P<0.05), sagittal position of point pronasale, sagittal position of point subnasale, nasal tip angle, nasal

projection angle and dorsal contour angle (P<0.001) significantly increased. The Wilcoxon signed ranked test demonstrated significant reductions in the non-normally distributed upper dorsal convexity (P<0.05) and subnasale projection (P<0.001) (Table 3.8).

Table 3.8: Descriptive statistics and the results of the Wilcoxon signed ranked test to determine the effect of Le Fort 1 maxillary advancement surgery on the non-normally distributed variables in the profile photographs of 80 individuals (T3-T2)

Cephalometric variable	Descriptive statistics					Wilcoxon signed ranked test
	Mean	Standard deviation	Standard error	Minimum value	Maximum value	*P*-value
Upper dorsal convexity	-0.24	1.12	0.13	-6.6	4.3	0.016*
Subnasale projection	-1.15	1.86	0.21	-5.5	3.2	0.000***

P<0.05*, *P*<0.001***

3.5.4 Differences between the changes produced by the Le Fort 1 maxillary advancement osteotomy in men and women

3.5.4.1 Skeletal maxillary and mandibular variables

Descriptive statistics for the changes caused by maxillary advancement surgery in the maxillary and mandibular skeletal variables (T3-T2) in each gender were computed (Tables 3.9 and 3.10). A Kolmogorov-Smirnov test demonstrated that the variable sagittal maxillary advancement (A point) in women was not normally distributed (P = 0.009), considering a level of significance of 0.01. Independent t tests did not detect significant differences between men and women for any of the normally distributed variables (Table 3.9).

Table 3.9: Descriptive statistics and results of the independent t test to compare the changes produced by Le Fort 1 maxillary advancement surgery in maxillary and mandibular skeletal variables between the 32 men and 48 women (T3-T2)

Cephalometric variable	Descriptive statistics										Independent t test		
	Men					Women					95% CI of the Difference		*P*-Value
	Mean	SD	SE	Min. value	Max. value	Mean	SD	SE	Min. value	Max. value	Lower	Upper	
Sagittal maxillary advancement (Prosthion)	4.30	3.11	0.55	0.1	13.6	3.96	2.42	0.35	0.1	9.8	-1.58	0.89	0.584
Sagittal mandibular change (B point)	-2.15	4.17	0.74	-10.6	9.2	-1.35	3.65	0.53	-12.3	6.5	-0.96	2.55	0.370
Vertical maxillary change (A point)	-0.50	2.34	0.41	-5.3	4.5	-0.65	1.89	0.27	-3.8	2.8	-1.10	0.79	0.749
Vertical maxillary change (Prosthion)	-0.55	2.36	0.42	-6.4	4.2	-0.69	1.95	0.28	-4.9	2.6	-1.10	0.83	0.785
Vertical mandibular change (B point)	-2.38	3.75	0.66	-10.2	5.5	-2.87	3.61	0.52	-11.7	6.6	-2.16	1.18	0.561
Maxillary inclination change	0.62	2.82	0.50	-4.2	5.2	0.11	2.06	0.30	-5.3	3.9	-1.59	0.58	0.355

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: Maximum value, CI of the difference: Confidence Interval of the Difference

Table 3.10: Descriptive statistics and results of the Mann Whitney test to compare the changes produced by Le Fort 1 maxillary advancement surgery in the variable Sagittal maxillary advancement (A point) between the 32 men and 48 women (T3-T2)

Cephalometric variable	Descriptive statistics										Mann Whitney test
	Men					Women					*P*-Value
	Mean	SD	SE	Min. value	Max. value	Mean	SD	SE	Min. value	Max. value	
Sagittal maxillary advancement (A point)	4.04	2.81	0.50	0.4	12.6	3.60	2.25	0.33	0.3	9.6	0.742

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: Maximum value

The Mann Whitney test did not detect a gender-based difference for changes in the non-normally distributed sagittal maxillary advancement (A point) (Table 3.10).

3.5.4.2 Variables measured in frontal photographs

Descriptive statistics for the changes caused by maxillary advancement surgery in the soft tissue nasal variables measured in frontal photographs (T3-T2) were calculated for each gender (Table 3.11 and 3.12). The Kolmogorov-Smirnov test demonstrated that the variables nasal root width (P=0.009), columella width (P=0.002) and frontal nasal length (P=0.000) in men and the variables columella width (P=0.003) and frontal nasal length (P=0.000) in women were not normally distributed, at a 1% level of significance. An independent t test was performed to determine the influence of patient gender on the changes in the frontal variables that were normally distributed (Table 3.11). Women exhibited a greater increase in the bilateral width of the nostril floor and inferior alar angle (P<0.05) and a larger reduction in frontal nasal length/morphological width ratio (P<0.01) and frontal nasal height/morphological width ratio (P<0.05) than men. A Mann Whitney test did not detect significant gender-based differences for changes in the non-normally distributed variables (Table 3.12)

Table 3.11: Descriptive statistics and results of the independent t test to compare the changes produced by Le Fort 1 maxillary advancement surgery in nasal morphometric variables measured in frontal photographs between the 32 men and 48 women (T3-T2)

Cephalometric variable	Descriptive statistics										Independent t test		
	Men					Women					95% CI of the difference		*P*-Value
	Mean	SD	SE	Min. value	Max. value	Mean	SD	SE	Min. value	Max. value	Lower	Upper	
Morphological width	2.19	1.42	1.42	0.1	6.7	2.36	1.51	0.22	-0.7	5.7	-0.50	0.84	0.615
Alar base width	2.11	1.52	1.52	-0.7	6.7	2.47	1.52	0.22	-1.0	5.0	-0.33	1.05	0.300
Bilateral width of the nostril floor	1.09	0.93	0.16	-0.1	4.2	1.71	1.22	0.18	-0.8	4.3	0.11	1.12	0.017*
Right nasal base width	0.56	1.52	0.27	-2.4	4.4	0.81	0.99	0.14	-1.1	2.6	-0.30	0.81	0.370
Left nasal base width	0.46	1.37	0.24	-3.6	2.8	0.78	1.17	0.17	-1.6	3.2	-0.26	0.89	0.274
Right frontal subnasale-alare distance	1.11	1.26	0.22	-1.8	4.4	1.05	1.38	0.20	-2.1	4.6	-0.66	0.55	0.849
Left frontal subnasale-alare distance	1.26	1.27	0.23	-1.8	3.4	1.09	1.35	0.19	-2.2	4.6	-0.77	0.43	0.572
Right diagonal nostril width	0.95	1.21	0.21	-1.1	4.8	0.70	1.15	0.17	-1.4	3.2	-0.78	0.29	0.367
Left diagonal nostril width	0.87	1.30	0.23	-1.7	4.7	0.65	1.10	0.16	-1.6	3.2	-0.76	0.31	0.405
Right dorsal axis-alare distance	0.84	1.28	0.23	-1.5	4.2	1.17	1.31	0.19	-1.8	3.7	-0.26	0.92	0.263
Left dorsal axis-alare distance	1.30	1.26	0.22	-1.0	3.2	1.19	1.12	0.16	-1.7	4.5	-0.64	0.43	0.688
Frontal nasal height	0.92	2.96	0.52	-5.7	8.7	0.11	2.41	0.35	-5.5	5.1	-2.02	0.38	0.180
Frontal nasal length/ morphological width ratio	-0.09	0.05	0.01	-0.22	-0.03	-0.13	0.07	0.01	-0.33	0	-0.07	-0.01	0.006**
Frontal nasal height/ morphological width ratio	-0.05	0.08	0.01	-0.23	0.13	-0.11	0.10	0.01	-0.47	0.08	-0.10	-0.01	0.013*
Alar slope angle	7.29	7.63	1.35	-7.5	29.9	9.08	8.74	1.26	-11.3	23.6	-1.99	5.56	0.349
Superior alar angle	1.84	2.08	0.37	-2.8	6.9	2.35	2.15	0.31	-2.3	7.9	-0.46	1.47	0.298
Inferior alar angle	-0.34	6.74	1.19	-13.8	11.8	2.87	6.52	0.94	-11.1	17.2	0.21	6.22	0.036*
Right lateral alar angle	-0.40	3.83	0.68	-7.6	7.6	-1.74	3.93	0.57	-8.7	6.2	-3.11	0.42	0.134

SD: Standard deviation, Min value: Minimum value, Max value: Maximum value, CI of the difference: Confidence Interval of the Difference, P<0.05*, P<0.01**, P<0.001***

Table 3.12: Descriptive statistics and results of the Mann Whitney test to compare the changes produced by Le Fort 1 maxillary advancement surgery in non-normally distributed variables that measure nasal form and dimension in frontal photographs between the 32 men and 48 women (T3-T2)

Cephalometric variable	Descriptive statistics										Mann Whitney test *P*-value
	Men					Women					
	Mean	SD	Std error	Min. value	Max value	Mean	SD	Std error	Min. value	Max value	
Nasal root width	0.03	0.16	0.03	-0.2	0.3	0.05	0.19	0.03	-0.5	0.5	0.654
Columella width	0.23	0.30	0.05	-0.2	1.1	0.40	0.42	0.06	-0.2	1.2	0.160
Frontal nasal length	-1.28	1.08	0.19	-3.8	-0.1	-1.49	1.26	0.18	-4.2	0.2	0.701

SD: Standard deviation, Min value: Minimum value, Max value: Maximum value

3.5.4.3 Nasal variables measured in profile photographs and lateral cephalograms

Tables 3.13 and 3.14 contain the descriptive statistics for the changes caused by maxillary advancement surgery in the nasal variables measured in lateral cephalograms and profile photographs (T3-T2) in the 32 men and 48 women. The Kolmogorov-Smirnov test demonstrated that the variables columella exposure *(P*=0.000) in men and upper dorsal convexity *(P*=0.000) in women were not normally distributed, at a level of significance of 0.01. An independent t test did not detect significant gender-based differences for the alterations in any of the normally distributed variables (Table 3.13). A Mann Whiney test did not verify significant differences between the genders for changes in the non-normally distributed profile variables (Table 3.14).

Table 3.13: Descriptive statistics and results of the independent t test to compare the changes produced by Le Fort 1 maxillary advancement surgery in nasal morphometric variables measured in lateral cephalograms and profile photographs between the 32 men and 48 women (T3-T2)

Cephalometric variable	Descriptive statistics										Independent t test		
	Men					Women					95% CI of the Difference		*P*-Value
	Mean	SD	SE	Min. value	Max. value	Mean	SD	SE	Min. value	Max. value	Lower	Upper	
Nasal height	-0.31	0.99	0.18	-1.8	1.8	-0.61	1.11	0.16	-3.7	2.3	-0.79	0.18	0.213
Nasal length	-0.44	1.24	0.22	-4.0	1.7	-0.75	1.07	0.15	-3.0	1.2	-0.82	0.22	0.250
Soft tissue thickness at rhinion	-0.05	0.63	0.11	-1.4	1.2	0.01	0.72	0.10	-1.5	1.6	-0.24	0.38	0.667
Depth of the supratip break	-0.67	0.73	0.13	-2.1	0.6	-0.58	0.68	0.10	-2.4	0.7	-0.23	0.41	0.578
Lower dorsal convexity	-0.22	0.50	0.09	-1.3	0.7	-0.26	0.45	0.06	-1.4	0.9	-0.25	0.17	0.712
Columella depth	0.14	0.53	0.09	-1.0	1.1	0.12	0.52	0.07	-0.9	1.3	-0.26	0.22	0.849
Sagittal position of point pronasale	0.92	1.05	0.19	-0.7	4.0	0.84	1.19	0.17	-1.3	4.3	-0.59	0.44	0.764
Sagittal position of point subnasale	1.88	1.46	0.26	-0.3	6.2	1.89	1.50	0.22	-0.2	7.2	-0.66	0.69	0.963
Nasal projection	-2.34	2.01	0.35	-5.9	2.1	-2.05	1.81	0.26	-6.0	1.9	-0.57	1.15	0.501
Subnasale projection	-1.38	1.85	0.33	-5.1	2.0	-1.00	1.86	0.27	-5.5	3.2	-0.47	1.22	0.379
Nostril projection	-2.03	1.86	0.33	-5.8	1.4	-1.74	1.58	0.23	-5.4	1.6	-0.48	1.06	0.455
Nasal protrusion	-0.97	0.97	0.17	-3.5	0.2	-1.03	0.97	0.14	-3.3	1.6	-0.51	0.38	0.772
Vertical position of point pronasale	-1.09	1.34	0.24	-4.0	1.3	-1.24	1.21	0.17	-4.5	0.4	-0.73	0.42	0.599
Vertical position of point subnasale	-0.62	0.93	0.16	-2.6	1.0	-0.80	1.04	0.15	-3.1	1.9	-0.63	0.27	0.432
Nasal prominence angle	-0.43	0.98	0.17	-3.4	1.0	-0.51	1.00	0.14	-2.7	1.6	-0.53	0.37	0.727
Apical nasal angle	-0.23	5.16	0.91	-12.5	12.3	-0.24	4.80	0.69	-12.7	7.0	-2.26	2.24	0.993
Nasal tip angle	1.11	3.01	0.53	-4.3	8.2	1.25	2.75	0.40	-5.4	6.6	-1.16	1.43	0.836
Nasal projection angle	1.52	1.63	0.29	-1.3	5.3	1.48	1.56	0.22	-1.3	4.6	-0.76	0.69	0.925
Dorsal contour angle	2.57	3.45	0.61	-4.3	11.1	2.42	3.10	0.45	-5.0	9.1	-1.62	1.33	0.841
Supratip break angle	-2.78	4.00	0.71	-11.2	6.1	-2.73	3.92	0.57	-14.9	5.4	-1.74	1.85	0.953
Nasolabial angle	-1.38	8.92	1.58	-30.1	18.6	-3.37	10.5(	1.52	-41.1	15.1	-6.49	2.51	0.380
Columella rotation angle	-0.27	5.20	0.92	-9.1	11.1	-0.34	4.68	0.68	-7.8	9.9	-2.30	2.15	0.949
Nasal tip rotation angle	-3.58	3.23	0.57	-12.2	1.1	-3.51	3.35	0.48	-10.5	5.5	-1.43	1.57	0.930
Columella-lobule angle	1.51	7.01	1.24	-14.0	12.8	1.43	7.38	1.07	-9.7	18.2	-3.37	3.20	0.959

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: Maximum value, CI of the difference: Confidence Interval of the Difference

Table 3.14 Descriptive statistics and results of the Mann Whitney test to compare the changes produced by Le Fort 1 maxillary advancement surgery in non-normally distributed nasal variables measured in profile photographs between the 32 men and 48 women (T3-T2)

Cephalometric variable	Descriptive statistics										Mann Whitney test *P*-value
	Men					Women					
	Mean	SD	SE	Min. value	Max value	Mean	SD	SE	Min. value	Max value	
Upper dorsal convexity	-0.11	1.12	0.20	-2.4	4.3	-0.33	1.12	0.16	-6.6	0.9	0.996
Columella exposure	0.11	0.69	0.12	-1.7	2.1	0.07	0.75	0.11	-1.5	2.3	0.434

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: Maximum value

3.5.5 Multiple regression analysis between the magnitude of the sagittal, vertical and rotational maxillary movements and changes in nasal morphometric variables

A multiple regression analysis was performed using sagittal maxillary advancement (A point), vertical maxillary change (A point) and the change in maxillary inclination as independent variables and the nasal variables as dependent ones (Tables 3.15 and 3.16). Pearson correlation coefficient (R) and the coefficient of determination (R^2) were calculated. An R value of ±1 indicates a 100% correlation whereas an R of 0 indicates no correlation and thus maximal unpredictability. The intercept represents the change in the variable produced by the surgical procedure itself when maxillary movement in all dimensions has been reduced to zero.

3.5.5.1 Variables measured in frontal photographs

Sagittal maxillary advancement (A point) was responsible for 9% of the variation in morphological width and left dorsal axis-alare distance and 8% that of inferior alar angle. The vertical maxillary change (A point) explained 10% and 8% of the variations in alar slope angle and superior alar angle, respectively. Change in maxillary inclination was not an explanatory factor for any of the frontal variables (Table 3.15).

Every millimetre of sagittal maxillary advancement (A point) increased the morphological width by 0.18 mm in a weak to moderate correlation ($P<0.01$) while the surgery itself produced 1.62 mm widening. The left dorsal axis-alare distance increased 0.14 mm for every millimetre of sagittal maxillary advancement in a weak to moderate correlation ($P<0.01$) and an additional 0.71 mm due to the surgery itself. The alar slope angle increased 1.29° ($P<0.01$) and superior alar angle decreased 0.28° ($P<0.05$), for each millimetre of vertical maxillary change in moderate and weak correlations, respectively. The inferior alar angle increased 0.77° for each millimetre of sagittal maxillary advancement in a weak correlation ($P<0.05$). The surgery itself increased the alar slope and superior alar angles by 9.12° and 1.98°, respectively but decreased the inferior alar angle by 1.34° (Table 3.15).

The changes in nasal root width, alar base width, columella width, bilateral width of the nostril floor, right and left nasal base widths, subnasale-alare distances, diagonal nostril widths, right dorsal axis distance, frontal nasal length, frontal nasal height, frontal nasal length/ morphological width ratio, frontal nasal height/morphological width ratio and lateral alar angle were not significantly correlated with the hard tissue movement.

Table 3.15 Results of the multiple stepwise regression analysis to determine the correlation between the magnitude of the sagittal (A point), vertical (A point), and rotational (SN-PP) maxillary movements and changes in nasal morphometric variables in frontal photographs

Dependent variable	Independent variable/s	B	SE	Beta	t	R	R^2	P-value
Morphological width	Intercept	1.62	0.29		5.61	0.30	0.09	0.000***
	Sagittal maxillary advancement (A point)	0.18	0.06	0.30	2.81			0.006**
Left dorsal axis-alare distance	Intercept	0.71	0.23		3.08	0.30	0.09	0.003**
	Sagittal maxillary advancement (A point)	0.14	0.05	0.30	2.73			0.008**
Alar slope angle	Intercept	9.12	0.92		9.90	0.32	0.10	0.000***
	Vertical maxillary change (A point)	1.29	0.43	0.32	2.99			0.004**
Superior alar angle	Intercept	1.98	0.24		8.26	0.28	0.08	0.000***
	Vertical maxillary change (A point)	-0.28	0.11	-0.28	-2.53			0.014*
Inferior alar angle	Intercept	-1.34	1.33		-1.01	0.29	0.08	0.318
	Sagittal maxillary advancement (A point)	0.77	0.30	0.29	2.62			0.010*

B: unstandardized regression coefficient, SE: Standard error of the regression coefficient, Beta: standardized regression coefficient, R: Multiple regression coefficient, R^2:Coefficient of determination, $P<0.05$*, $P<0.01$**, $P<0.001$***

3.5.5.2 Variables measured in profile photographs and lateral cephalograms

Sagittal maxillary advancement (A point) and vertical maxillary change (A point) together contributed to 14% of the variation in nasal height, 9% that of columella depth, 30% that of nasal projection, 28% that of subnasale projection, 25% that of nostril projection and 18% that of Vertical position of point subnasale and the nasolabial angle. Sagittal maxillary advancement alone accounted for 19% of the variation in sagittal position of point pronasale and sagittal position of point subnasale, 5% that of the nasal projection angle and 4% of the columella-lobule angle. Vertical maxillary change (A point) was responsible for 5% of the variation in the apical nasal angle and columella rotation angle and 6% in the nasal tip angle.

Nasal height decreased 0.08 mm for every millimetre of sagittal maxillary advancement (A point) and increased 0.16 mm for every mm of vertical maxillary change ($P<0.01$), in a moderate correlation with the two variables while the surgery itself produced a 0.10 mm reduction in this variable.

Each millimetre of sagittal maxillary advancement (A point) and vertical maxillary change (A point) reduced columella depth by 0.04 ($P=0.086$) and 0.06 mm ($P<0.05$), respectively, in a moderate correlation while the surgery increased it by 0.24 mm.

Every millimetre of sagittal maxillary advancement (A point) resulted in anterior movement of points pronasale and subnasale by 0.20 and 0.26 mm, respectively ($P<0.001$) in a moderate correlation. The surgery itself advanced these points by 0.11 and 0.90 mm, respectively. Nasal projection decreased 0.26 mm ($P<0.01$) for each millimetre of sagittal maxillary advancement (A point) but increased 0.37 mm ($P<0.001$) for every mm of vertical maxillary change (A point) in a moderate correlation. Subnasale projection decreased 0.21mm ($P<0.01$) for each millimetre of sagittal maxillary advancement (A point) but increased 0.39 mm ($P<0.001$) for every mm of vertical maxillary change (A point) in a moderate correlation. Nostril projection decreased 0.23 mm ($P<0.01$) for each millimetre of sagittal maxillary advancement (A point) but increased 0.29 mm ($P<0.01$) for every millimetre of vertical maxillary change (A point) in a moderate correlation. The surgery itself caused reductions of 0.97, 0.13 and 0.83 mm in the nasal projection, subnasale projection and nostril projection, respectively.

Table 3.16: Results of the multiple stepwise regression analysis to determine the correlation between the magnitude of the sagittal (A point), vertical (A point), and rotational (SN-PP) maxillary movements and changes in nasal morphometric variables in lateral cephalograms and profile photographs

Dependent variable	Independent variable/s	B	SE	Beta	t	R	R^2	*P*-value
Nasal height	Intercept	-0.10	0.21		-0.46	0.37	0.14	0.645
	Sagittal maxillary advancement (A point)	-0.08	0.05	-0.19	-1.75			0.084
	Vertical maxillary change (A point)	0.16	0.06	0.31	2.92			0.005**
Columella depth	Intercept	0.24	0.10		2.36	0.30	0.09	0.021
	Sagittal maxillary advancement (A point)	-0.04	0.02	-0.19	-1.74			0.086
	Vertical maxillary change (A point)	-0.06	0.03	-0.24	-2.23			0.029*
Sagittal position of point pronasale	Intercept	0.11	0.21		0.54	0.44	0.19	0.592
	Sagittal maxillary advancement (A point)	0.20	0.05	0.44	4.33			0.000***
Sagittal position of point subnasale	Intercept	0.90	0.27		3.31	0.44	0.19	0.001
	Sagittal maxillary advancement (A point)	0.26	0.06	0.44	4.32			0.000***
Nasal projection	Intercept	-0.97	0.33		-2.94	0.55	0.30	0.004**
	Sagittal maxillary advancement (A point)	-0.26	0.07	-0.34	-3.57			0.001**
	Vertical maxillary change (A point)	0.37	0.09	0.40	4.19			0.000***
Subnasale projection	Intercept	-0.13	0.33		-0.39	0.53	0.28	0.696
	Sagittal maxillary advancement (A point)	-0.21	0.07	-0.28	-2.90			0.005**
	Vertical maxillary change (A point)	0.39	0.09	0.43	4.47			0.000***
Nostril projection	Intercept	-0.83	0.31		-2.73	0.50	0.25	0.008
	Sagittal maxillary advancement (A point)	-0.23	0.07	-0.33	-3.37			0.001**
	Vertical maxillary change (A point)	0.29	0.08	0.35	3.53			0.001**
Vertical position of point subnasale	Intercept	-0.31	0.19		-1.63	0.42	0.18	0.106
	Sagittal maxillary advancement (A point)	-0.08	0.04	-0.21	-2.01			0.048*
	Vertical maxillary change (A point)	0.17	0.05	0.35	3.40			0.001**
Apical nasal angle	Intercept	0.09	0.56		0.15	0.23	0.05	0.880
	Vertical maxillary change (A point)	0.55	0.26	0.23	2.08			0.041*
Nasal tip angle	Intercept	1.38	0.32		4.29	0.24	0.06	0.000***
	Vertical maxillary change (A point)	0.32	0.15	0.24	2.13			0.036*
Nasal projection angle	Intercept	0.94	0.32		2.97	0.23	0.05	0.004**
	Sagittal maxillary advancement (A point)	0.15	0.07	0.23	2.11			0.038*
Nasolabial angle	Intercept	3.10	1.87		1.66	0.42	0.18	0.101
	Sagittal maxillary advancement (A point)	-1.32	0.41	-0.33	-3.20			0.002**
	Vertical maxillary change (A point)	1.15	0.50	0.24	2.32			0.023*
Columella rotation angle	Intercept	-0.62	0.56		-1.12	0.22	0.05	0.265
	Vertical maxillary change (A point)	-0.52	0.26	-0.22	-2.01			0.048*
Columella-lobule angle	Intercept	3.58	1.45		2.46	0.19	0.04	0.040*
	Sagittal maxillary advancement (A point)	-0.56	0.32	-0.19	-1.74			0.040*

B: unstandardized regression coefficient, SE: Standard error of the regression coefficient, Beta: standardized regression coefficient, R: Multiple regression coefficient, R^2: Coefficient of determination, $P<0.05$*, $P<0.01$**, $P<0.001$***

Vertical position of point subnasale decreased 0.08 mm ($P<0.05$) for each millimetre of sagittal maxillary advancement (A point) but increased 0.17 mm ($P<0.01$) for every millimetre of vertical maxillary change (A point) in a moderate correlation and was reduced a further 0.31 mm due to the surgery itself (Table 3.16).

Apical nasal angle and nasal tip angle increased 0.55 and 0.32° ($P<0.05$) for every millimetre of vertical maxillary change (A point), in a weak correlation, and a further 0.09 and 1.38° due to the surgery itself. Nasal projection angle increased 0.15° ($P<0.05$) for every millimetre of sagittal maxillary advancement (A point) in a weak correlation and an additional 0.94° due to the surgery. Nasolabial angle was reduced by 1.32° ($P<0.01$) for each millimetre of sagittal maxillary advancement (A point) and increased by 1.15° for each millimetre of vertical maxillary change (A point) ($P<0.05$), in a moderate correlation, and a further 3.10° due to the surgical

procedure. Columella rotation angle decreased 0.52° (P<0.05) for every millimetre of vertical maxillary change (A point) in a weak correlation and a further 0.62° due to the surgery. Columella-lobule angle decreased by 0.56° (P<0.05) for every millimetre of sagittal maxillary advancement (A point) in a weak correlation. However, the surgery itself increased this angle by 3.58°.

Nasal length, soft tissue thickness at rhinion, upper dorsal convexity, depth of the supratip break, lower dorsal convexity, columella depth, columella exposure, nasal protrusion, nasal prominence angle, dorsal contour angle, supratip break angle and nasal tip rotation angle did not correlated significantly with any of the skeletal variables.

3.5.6 Ratios

Ratios were also calculated between the changes in the sagittal and vertical positions of the points pronasale and subnasale and the sagittal maxillary advancement at points A and prosthion (Table 3.17 and 3.18). They were also determined for the alteration in Morphological width and Alar base width and the same skeletal variables (Table 3.19).

Table 3.17: Ratios between sagittal maxillary advancement at A point and Prosthion and the change in sagittal position of Pronasale and Subnasale

	Sagittal position of Pronasale	Sagittal position of Subnasale
Sagittal maxillary advancement (A point)	0.23	0.50
Sagittal maxillary advancement (Prosthion)	0.21	0.46

Table 3.18: Ratios between sagittal maxillary advancement at A point and Prosthion and the change in vertical position of Pronasale and Subnasale

	Vertical position of Pronasale	Vertical position of Subnasale
Sagittal maxillary advancement (A point)	-0.31	-0.19
Sagittal maxillary advancement (Prosthion)	-0.29	-0.18

Table 3.19: Ratios between sagittal maxillary advancement at A point and Prosthion and the change in morphological and alar base widths

	Morphological width	Alar base width
Sagittal maxillary advancement (A point)	0.60	0.61
Sagittal maxillary advancement (Prosthion)	0.56	0.57

3.6 Discussion

3.6.1 Tools used to investigate the results of Le Fort 1 maxillary advancement osteotomy

This retrospective investigation used serial lateral cephalograms and photographs that are an essential part of routine clinical patient records in all phases of orthodontic-surgical treatment. Lateral cephalograms are the most commonly used tool to study the changes produced by Le Fort 1 maxillary osteotomy, with or without mandibular surgery (Altug-Atac et al., 2008; Betts et al., 1993; Carlotti et al., 1986; Esenlik et al., 2011; Khamashta-Ledezma & Naini, 2015; McCollum et al., 2009; Rosenberg et al., 2002; Stella et al., 1989).

Photographs have also been used to detect post-surgical change (Bottini et al., 2013; Edler et al., 2011; Hackney et al., 1988; Hemmatpour et al., 2016; Khamashta-Ledezma & Naini, 2015; Muradin et al., 2012; Phillips et al., 1986; Ritto et al., 2011).

Photography is a fast, cheap, non-invasive and environmental-friendly technique for soft tissue evaluation that requires minimal, portable equipment and does not involve radiation (Aksu et al., 2010; Gomes et al., 2013; Khavkin & Ellis, 2011; Nechala et al., 1999). It is essential for diagnosis, monitoring clinical progress and the evaluation and demonstration of treatment results (Claman et al., 1990; Edler et al., 2011; Zhang et al., 2007). It helps in orthognathic surgery planning and in communicating with the patient (Edler et al., 2011; Khavkin & Ellis, 2011). Morphing is often used to simulate post-surgical predictions (Claman et al., 1990; Nechala et al., 1999; Persichetti et al., 2007). Photography is also considered the easiest and most reliable method for nasal evaluation (Naeem et al., 2015; Prinsley, 1992). Frontal photographs permit transverse measurements (Phillips et al., 1984). Profile photographs have the advantage of displaying both midsagittal landmarks and laterally located ones, such as the alar curvature (Farkas & Deutsch, 1996; Nguyen & Turley, 1998; Ritto et al., 2011).

3.6.2 Cephalometric reference planes

A horizontal (x) and vertical (y) coordinate system based on cranial base cephalometric landmarks is generally used to measure surgically induced changes in facial parameters. Wolford (1988) suggested that the Frankfurt horizontal plane is the most appropriate reference for alterations caused by orthognathic surgery. This plane has been used in several investigations (Stella et al., 1989). In such cases, a perpendicular to the Frankfurt plane passing through sella (Altug-Atac et al., 2008; Mommaerts et al., 2000) or nasion (Esenlik et al., 2011; Shmuly et al., 2019; Shoji et al., 2012; Starck & Epker, 1996; Vasudavan et al., 2012) served as the y axis. Yet, the low reliability of the points orbitale and anatomical porion hamper its use (Adenwalla et al., 1988; Baumrind & Frantz, 1971a). Ear rod porion has been suggested as a reliable landmark (Baumrind & Frantz, 1971a). Yet, slight patient movement, improper ear rod seating and the thickness of the ear canal cartilage affect its accuracy (Ellis & McNamara, 1988).

The sella-nasion plane has also been used to study post-surgical alterations (Esenlik et al., 2011; Freihofer, 1977; Rosen, 1988) wherein a perpendicular at sella serves as the vertical reference line (Altug-Atac et al., 2008; Betts et al., 1993; Ritto et al., 2011). A study in Chinese located the sella-nasion plane at an average 7.26° above the FHP (Alves et al., 2008). Both sella and nasion are reliable cephalometric points (Baumrind & Frantz, 1971a). However, the use of this plane has been criticised due to variations in the position of sella (do Vale 2004).

Legan and Burstone (1980) proposed the constructed FHP at 7° from the sella-nasion plane with its origin at nasion for the cephalometric analysis of patients requiring orthognathic surgery and used a perpendicular at the same point as the vertical reference line. Many authors have opted to use this coordinate system in their investigations (Mansour et al., 1983; Misir et al., 2011; Tomlak et al., 1984). Variations that affect linear measurements from the planes have also been used. Some authors designed the horizontal plane with its origin at sella, but continue to use a perpendicular passing through nasion (Aydil et al., 2013; Ghassemi, Modabber, et

al., 2014; Marşan et al., 2009, 2015). Others used a perpendicular to the nasion horizontal with its origin at sella (Chew, 2005; Chew, Sandham, et al., 2008; Clemente-Panichella et al., 2000; Dantas et al., 2015; McFarlane et al., 1995).

This investigation used sella as the vertex for both the 7° horizontal reference plane and the perpendicular. These planes have been used previously (Abeltins & Jakobsone, 2011; Aydemir et al., 2015; Chandra et al., 2013; Coban et al., 2020; Muradin et al., 2011; Nkenke et al., 2008; Rosenberg et al., 2002). Negative values for surgically induced change indicate movement in a cranial or posterior direction and positive ones, in a caudal or anterior one (Rosenberg et al., 2002). The advantage of constructing the vertical plane at sella is that all distances of skeletal and soft tissue profile points from the plane have a positive value, making it easy to understand the surgical change.

3.6.3 Sample composition according to gender

The sample, consisting of 32 men and 48 women was appropriate, as women generally form 2/3 of any population of patients seeking orthognathic surgery (Phillips, Hill, & Cannac, 1995; Sinko, Tran, et al., 2018; Xu et al., 2008). Metzler et al. (2004) achieved a male:female ratio of 0.7 but with a sample size of only 44 patients.

The number of patients used in other investigations has varied widely, with most researchers using samples of convenience. Some investigations used a greater number of women such as Betts et al.1993 (23 women, 9 men), Chew 2005 (20 women, 14 men), Chew et al. 2007 (21 women, 9 men), Chung et al. 2008 (36 women, 29 men), Hack et al. 1993 (19 women, 6 men), Hackney et al. 1988 (19 women, 12 men), Honrado et al., 2006 (26 women, 6 men), Khamashta-Ledzema and Naini 2015 (19 women, 12 men), Lin and Kerr 1998 (16 women, 1 man), McFarlane et al. 1995 (40 women, 10 men), Muradin et al. 2011, 2012 (39 women, 24 men), Radney and Jacobs 1981 (9 women, 1 man), Rauso et al. 2011 (30 women, 12 men), Rosenberg et al., 2002 (31 women, 20 men), Ryckman et al. 2010 (20 women, 10 men), Sarver and Weissman 1998 (34 women, 2 men), Shmuly et al. 2019 (20 women, 12 men) and Shoji et al., 2012 (26 women, 4 men). Yamada et al., (2010) and Marsan et al., (2009) used samples of 12 and 44 women, respectively.

Other authors have used samples with men and women in approximately equal proportions such as Altug Atac et al. 2008 (11 women, 9 men), Aydil et al. 2013 (15 women, 16 men), Bottini et al. 2013 (13 women, 12 men), Coban et al. 2020 (20 women, 20 men), Hellak 2015 (16 women, 17 men), Marsan et al. 2015 (10 women, 10 men), Park et al. 2012 (15 men, 15 women), Fernandéz-Sanromán et al. 2014 (8 women, 7 men), Soncul and Bamber 2004 (24 women, 22 men) and Worasakwutiphung et al. 2015 (20 women,18 men).

Yet other researchers included a greater number of men such as Abeltins and Jakobsone 2011 (29 women, 54 men); Conley and Boyd 2007 (4 women, 27 men), Jakobsone et al. 2012 (28 women, 52 men) and Mommaerts et al. 1997 (16 women, 30 men).

3.6.4 Age of the sample

The age ranges of patients used in samples to study the soft tissue impact of maxillary or bimaxillary surgery has varied widely. While some authors did not specify the age range used in their samples (Soncul & Bamber, 2004; Westermark et al., 1991), others mention the inclusion of ´non-growing patients` (Jensen et al., 1992; McCollum et al., 2009).

The average age of most surgical patients varies between 17 and 35 years (Al Taki & Guidoum, 2014; Siow et al., 2002). Thus, many authors use younger patients within this age range (Altug-Atac et al., 2008; Aydil et al., 2013; Chew, 2005; Coban et al., 2020; Fernández Sanromán et al., 2014; Kim et al., 2011; Lin & Kerr, 1998; Park et al., 2012; Rauso et al., 2010; Shoji et al., 2012). Yet other authors used a much older upper range limit close to 50 years (Abeltins & Jakobsone, 2011; Almukhtar et al., 2016; Honrado et al., 2006; Jakobsone et al., 2012; Khamashta-Ledezma & Naini, 2015). Ageing is known to produce facial soft tissue alterations, including epidermal thinning, reduced collagen, degradation of elastic fibres and the ptosis of fat compartments, which are compounded by the effect of gravity (Farkas et al., 2013; Kahn & Shaw, 2010). These age-related changes in soft tissue thickness and tonicity can affect the response to skeletal movement and thus, the final facial appearance (Burstone, 1958; Kim et al., 2011; Louis et al., 2001). Thus, this study included individuals subjected to maxillary or bimaxillary surgery within the age range of 18 to 30 years and with an average age of 24±3 years at the time of surgery. The time interval between the presurgical photographs and the final post-treatment records did not exceed ten months and thus, avoided the influence of ageing as a confounding variable.

3.6.5 Type of surgery

Maxillary advancement, impaction and inferior repositioning can each potentially affect the nasal subunits in their own specific manner (Collins & Epker, 1982; Mitchell et al., 2007; O'Ryan & Schendel, 1989b; Rauso et al., 2011; Sarver & Weissman, 1991). Thus, ideally, only one vector of maxillary movement should be studied at a time (Betts et al., 1993; Esenlik et al., 2011; Khamashta-Ledezma & Naini, 2015; Stella et al., 1989,Wolford 1988). Large maxillary advancements will have different soft tissue effects compared to large impactions (Sarver & Weissman, 1991).

Some authors have attempted to study the nasal alterations produced by isolated Le Fort 1 maxillary advancement osteotomy (Carlotti et al., 1986; Coban et al., 2020; DeSesa et al., 2016; Ghassemi et al., 2015; Marşan et al., 2015; Metzler et al., 2014; Peled et al., 2004; Rauso et al., 2011; Shmuly et al., 2019; Stella et al., 1989; Vasudavan et al., 2012). Other authors investigated the effects of maxillary advancement surgery performed concomitantly with mandibular setback (Abeltins & Jakobsone, 2011; Altug-Atac et al., 2008; Aydil et al., 2013; Becker et al., 2014; Chew, 2005; Chew, Sandham, et al., 2008; Enacar et al., 1999; Ghassemi, Ghassemi, et al., 2014; Hemmatpour et al., 2016; Jokić et al., 2013; Kim et al., 2011; Liebregts et al., 2016; Lin & Kerr, 1998; McCance et al., 1992; Misir et al., 2011; Moroi et al., 2014; Rauso et al., 2010; van Loon et al., 2016; Yuan et al., 2013). Honrado et al. (2006) divided a sample subjected to bimaxillary surgery into groups

of maxillary advancement alone or with superior or inferior repositioning. Yet others studied the consequences of bimaxillary advancement (Conley & Boyd, 2007; Louis et al., 2001; Ryckman et al., 2010).

However, any Le Fort 1 maxillary impaction surgery will always incorporate some degree of anteroposterior motion regardless of the skill and intent of the surgeon due to telescoping of the mobile fragment while maintaining adequate bone contact (Muradin et al., 2011; Sarver & Weissman, 1991). Similarly, irrespective of planned movement, maxillary advancement generally includes vertical repositioning (Becker et al., 2014; Louis et al., 2001; Peled et al., 2004; Stella et al., 1989). Mansour et al. (1983) recognized the arbitrary nature of their division of patients treated with Le Fort 1 osteotomy into advancement or impaction groups depending on whether posterior impaction was greater than 2 mm, stating that many impactions involve sagittal movement and many advances include some vertical shift. Rosenberg et al. (2002) divided patients who underwent isolated maxillary surgery into subgroups of impaction, dorsal impaction, advancement and advancement and impaction depending on whether the sagittal or vertical A point or vertical posterior nasal spine movements exceeded 2 mm. Thus, even authors who define their samples as having been subjected to maxillary advancement register vertical change that could vary from -0.8±2.9 (Carlotti et al., 1986) to 2.03±1.04 mm (Coban et al., 2020), including those that use cases of obstructive sleep apnoea (2.20±2 mm) (Conley and Boyd 2007). Similarly, researchers who tried to create a sample of patients treated with isolated maxillary impaction acknowledged an average sagittal maxillary movement of 1.5 or 2 mm (Jensen et al., 1992; Phillips et al., 1986). Also, the frequent need for different magnitudes and directions of maxillary movement during the surgical correction of a specific deformity makes it difficult to construct homogeneous groups for one specific vector of movement (Esenlik et al., 2011; Gassmann et al., 1989).

The sample in this study included 17 patients treated with maxillary advancement alone and 63 patients treated with simultaneous mandibular setback surgery. Amongst these, 7 and 16 of the patients who had been subjected to maxillary and bimaxillary surgery, respectively, underwent a simultaneous mentoplasty. Several authors included patients treated by both maxillary advancement and bimaxillary surgery in their sample (Clemente-Panichella et al., 2000; Hui et al., 1994; McCollum et al., 2009; van Loon et al., 2016; Verzé et al., 2014). McCollum et al. (2009) used a sample treated with Le Fort 1 maxillary advancement with or without mandibular setback or reduction genioplasty or a combination of both. Esenlik et al. (2011) divided patients treated with bimaxillary or maxillary surgery into two groups of maxillary advancement and maxillary advancement and impaction. Clemente Panichella et al. (2000) observed that soft to hard tissue ratios did not differ whether maxillary surgery was performed alone or as part of a bimaxillary procedure. Enacar et al. (1999) concluded that mandibular setback does not affect nasal tip position. Ghassemi, Modabber, et al. (2014) found that the nasolabial angle decreased after both maxillary advancement and bimaxillary surgery.

Due to the difficulty in obtaining homogenous samples, many authors define their sample as having being subjected to a combination of vectors such as maxillary advancement and impaction performed alone (Almukhtar et al., 2016; Chandra et al., 2013) or together with mandibular setback (Marşan et al., 2009; Park et al., 2012; Soncul & Bamber, 2004) and maxillary advancement with posterior impaction and mandibular setback (Baik & Kim, 2010; Oh et al., 2013). Freihofer (1977) defined the sample as having been subjected to maxillary

advancement with anticlockwise rotation. Bottini et al. (2013) divided patients treated with bimaxillary surgery into groups of maxillary advancement with inferior repositioning or impaction.

Yet other researchers combined data obtained from with a variety of movements including isolated Le Fort 1 advancement with or without superior or inferior repositioning (Betts et al., 1993), advancement with or without impaction implemented alone (Dantas et al., 2015; Guymon et al., 1988; Howley et al., 2011; Ritto et al., 2011; Westermark et al., 1991) or together with mandibular surgery (Aydemir et al., 2015; Edler et al., 2011; Hellak et al., 2015; Khamashta-Ledezma & Naini, 2015; Stewart & Edler, 2011; Worasakwutiphong et al., 2015), maxillary impaction with or without advancement (Mommaerts et al., 1997, 2000; Muradin et al., 2011, 2012) and bimaxillary surgery including maxillary advancement or vertical or horizontal rotation (Yamada et al., 2010). Hackney et al. (1988) used a sample constituted by patients treated with Le Fort 1 osteotomies with different vectors of movement and with or without mandibular surgery.

In this study, A point moved anteriorly 3.78±2.48 mm and elevated -0.59±2.07, indicating that the principal movement was one of advancement with a slight posterior rotation of 0.31±2.39°. The magnitude of A point advancement ranged from 0.3 mm to 12.6 mm and the sample included cases of vertical repositioning that ranged from impactions of 5.3 to downfractures of 4.5 mm. The B point was set back 1.67±3.86 mm, while its 2.68±3.65 elevation also reflected the mentoplasty performed in 21 patients. The anterior nasal spine was recontoured in all patients. In cases of simultaneous impaction, the nasal septum was trimmed vertically, a common procedure to avoid buckling (Metzler et al., 2014; Shmuly et al., 2019) .

3.6.6 Post-surgical orthodontic tooth movement

Orthodontic tooth movement is inevitable during the post-surgical period (Radney & Jacobs, 1981). The change in anterior maxillary teeth position during this period may affect upper lip position and the nasolabial angle (Esenlik et al., 2011; Ghassemi, Modabber, et al., 2014; Legan & Burstone, 1980; Louis et al., 2001; Ubaya et al., 2012). It may also contribute to the inability of skeletal regression equations to explain all observed soft tissue changes (Betts et al., 1993). Thus, cases with minimal post-surgical orthodontic movement should be included in studies, to decrease its effects on the soft tissue profile (Khamashta-Ledezma & Naini, 2015; Mansour et al., 1983; McCollum et al., 2009; Rosen, 1988). In the study sample, orthodontists coordinated arches and decompensated incisors so that a stable occlusion is obtained in pre-surgical study models, thus requiring minimal corrective tooth movement to compensate discrepancies between the planned and actual post-surgical occlusion. Moreover, A point and prosthion were used as hard tissue landmarks in this investigation rather than the incisal edge, although the differential effect of incisor inclination on these landmarks was a possible confounding factor.

Bracket removal only in some postsurgical cephalograms can introduce a systematic bias (Brooks et al., 2001). Wolford (1988) indicated that the presence of orthodontic appliances may cause slight discrepancies in the assessment of sagittal lip movement. While the confounding effect of presence of brackets in the pre-surgical records cannot be avoided, interpatient variation can be avoided by obtaining all pre-surgical patient records

with brackets present and final records after terminating orthodontic treatment with bracket removal, as implemented in this investigation (Muradin et al., 2011; Ritto et al., 2011). The only variable that depended on lip position was the nasolabial angle. Also, the presence or absence of orthodontic brackets did not affect outcomes evaluated between 3 months and one year after mandibular setback, maxillary advancement or bimaxillary surgery (Jokić et al., 2013).

3.6.7 Post-surgical records

Soft tissue oedema that develops immediately makes it difficult to assess changes after surgery (Park et al., 2012). Hui et al. (1994) suggested that oedema should disappear within 6 to 9 post-surgical weeks. However, Ryckman et al. (2010) recognized that cone-beam computed tomography scans obtained at an average of 10 post-surgical weeks could have been performed too early. The lower post-surgical time limits for patient records varied from three (DeSesa et al., 2016), four (Carlotti et al., 1986), nine (Jensen et al., 1992) to 10 months (Misir et al., 2011) in various studies.

In this investigation, the records at T3 were obtained at least 6 months after surgery, in accordance with most authors' recommendation to allow the complete resolution of oedema and soft tissue adaptation (Bundgaard et al., 1986; Chew, Sandham, et al., 2008; Chung et al., 2008; Conley & Boyd, 2007; Freihofer, 1977; Gassmann et al., 1989; Ghassemi et al., 2015; Hackney et al., 1988; Hellak et al., 2015; Khamashta-Ledezma & Naini, 2015; Kim et al., 2011; Liebregts et al., 2015; Louis et al., 2001; Mansour et al., 1983; McFarlane et al., 1995; Mommaerts et al., 2000; Oh et al., 2013; Radney & Jacobs, 1981; Rauso et al., 2010, 2011; Soncul & Bamber, 2004; Stella et al., 1989; Vasudavan et al., 2012; Verdenik & Ihan Hren, 2014; Westermark et al., 1991; Yuan et al., 2013). A few authors used records obtained at least one year after surgery (Betts et al., 1993; Chandra et al., 2013; Guymon et al., 1988; Muradin et al., 2012; Nkenke et al., 2008; Verzé et al., 2014).

Soft tissue changes after initial inflammation, besides weight changes, are a combination of remodelling and relocation and hard tissue relapse and occur mainly during the first four months but may continue beyond six months (Day & Robert, 2006; Ryckman et al., 2010; Verdenik & Ihan Hren, 2014). Oh et al. (2013) verified that the alar base, chellion-alar area and nasal tip retraction between 2 and 6 months after surgery was caused more by soft tissue and muscular remodelling and by the resolution of oedema than by the non-significant relapse in maxillary position. Alar base width decreased during this time due to perioral muscle remodelling and relocation after their lateral retraction during surgery. Freihofer (1977) concluded that two thirds of lip profiles and one third of nasal profiles changed considerably up to 4 to 6 months after surgery. The upper lip area may stabilize 6 to 9 months after surgery (Tomlak et al., 1984).

Moss et al. (1994), however, did not observe soft tissue changes between 3 post-surgical months and 1 year. Laser scans verified that the largest reduction in oedema occurred in the first month with facial morphology, recovering up to 90% within the first 3 post-surgical months (Kau et al., 2006). Alar and alar base width did not change significantly between 3 and 6 months after maxillary advancement and posterior impaction

surgery with or without ACVY reconstruction or anterior nasal spine recontouring (Khamashta-Ledezma & Naini, 2015). Ritto et al. (2011) suggested that the alar base region could be assessed 4 months after surgery. A few authors suggest that the resolution of oedema and soft tissue adaptation is a process that takes a year to complete (Altman & Oeltjen, 2007; Bottini et al., 2013; Sarver & Weissman, 1991).

Sarver and Weissman (1991) found that vertical and sagittal nasal tip and subnasale positions and the nasolabial angle did not differ significantly between the time periods of 1, 3 and 5 years after maxillary impaction surgery. The changes were so small that they could not be measured or due to tracing errors. Bailey et al. (1996) stated that the minimal changes observed in the lip and mandibular regions after one year and especially between 3 and 5 years after surgery could be attributed to the normal ageing process. In this study, records were obtained between seven and ten months after surgery.

3.6.8 Alterations in nasal morphology caused by the Le Fort 1 maxillary advancement osteotomy

3.6.8.1 Changes produced by the Le Fort 1 maxillary advancement osteotomy in the transverse dimension

In this study, Le Fort 1 maxillary advancement osteotomy significantly increased the transverse nasal dimensions at the level of the root, alae, alar base and bilateral nostril floor. The columella, nostrils and right and left nasal base widths and dorsal axis-alare distances also reflected nasal widening.

The larger inter-alar distance increased the values of the superior and inferior alar angles and contributed to reduce the frontal nasal length/morphological width and frontal nasal height/ morphological width ratios. The regression equation demonstrated that each millimetre of maxillary impaction increased the superior alar angle 0.28°, although the surgical procedure had a greater amplifying effect at 1.98°. The inferior alar angle decreased 1.34° due to the surgery itself but increased 0.77° for each millimetre of sagittal maxillary advancement. The alar slope angle, which did not change significantly as pronasale elevation counterbalanced the interalar widening, decreased 1.29° for each millimetre of maxillary impaction, but increased 9.12° due to the surgery itself. Alar base widening reduced the lateral alar angle, a variable that was not significantly affected by skeletal movement.

The alar base widening observed in this investigation is in conformity with the findings of several authors after maxillary advancement osteotomy with or without impaction (Baik & Kim, 2010; Bottini et al., 2013; Chandra et al., 2013; Choi et al., 2014; DeSesa et al., 2016; Metzler et al., 2014; Yamada et al., 2010). Larger interalar width has also been previously verified (DeSesa et al., 2016; Metzler et al., 2014; Rosen, 1988; Yamada et al., 2010). The tripod theory states that due to the finite nasal soft tissue volume, a change in one dimension affects its other parts (Betts et al., 1993; Metzler et al., 2014). While maxillary advancement carries the caudal part of the nose forward increasing its prominence in the face, the simultaneous compression of the nasal cartilaginous skeleton decreases nasal tip protrusion and causes a compensatory widening (Almukhtar et al., 2016; Freihofer, 1977; Honrado et al., 2006; Metzler et al., 2014). Hence, the nasal base advances more than the tip with a compensatory increase in nasal width (Betts et al., 1993; DeSesa et al., 2016; Enacar et al., 1999; Esenlik et al., 2011; Freihofer, 1977; Honrado et al., 2006; Metzler et al., 2014; Park et al.,

2012; Worasakwutiphong et al., 2015; Yamada et al., 2010). Thus, maxillary surgery leaves the total nasal area unaffected (Coban et al., 2020).

In this investigation, the morphological and alar base width increased 2.29±1.47 mm and 2.32±1.52 mm, respectively, after maxillary advancement and impaction of 3.78±2.48 and -0.59±2.07 mm, respectively, with the use of the AC-VY suture. Howley et al. (2011) measured an average alar base widening of 1.9 mm and 2.7 mm with and without the AC suture, respectively but did not reveal the magnitude of maxillary advancement with or without impaction. Rosen (1988) observed a larger morphological width increase of 3.4±1.1 mm while combining data from 30 patients subjected to 5.9±2.3 mm maxillary advancement, measured at the upper incisor and 30 patients who underwent 5.9±2.5 mm impaction with or without advancement, but did not use AC-VY reconstruction or anterior nasal spine recontouring. Hellak et al. (2015) also found larger values of 3.17±1.32 mm and 2.59±1.26 mm for interalar and alar base widening with the AC suture after a greater average advancement of 5.58 mm, with or without impaction, but included segmental surgeries in their sample. Guymon et al. (1988) did not present absolute measurements but concluded that the alar base widened 2.89±4.17% in a group that underwent advancement and impaction of 3±1 mm and 1.9±1.3 mm, respectively with the AC suture and 10.75±7.30% in the non-suture group subjected to a 2.8±2.1 mm advancement and 2.7±1.9 mm impaction. Westermark et al. (1991) demonstrated smaller alar base widening of 1.6±1.2 or 4.6% with the suture in Swedes, but a similar value of 2.3±1.3 mm or 6.9% without it in an investigation that also used anterior nasal spine resection, despite larger average 4.5 and 4.2 mm maxillary advancements and 5.2 and 5.8 mm impactions, respectively, in the suture vs the non-suture group, but remarked on the confounding variable of tightening force.

Every millimetre of A point advancement increased the morphological width 0.18 mm and the alar base width non-significantly by 0.13 mm, while the surgery itself produced 1.62 and 1.85 mm, widening, respectively. The morphological and alar base widths generated ratios of 0.60:1. and 0.61:1 with A point advancement, respectively. Metzler et al. (2014) observed that the morphological width increased by a similar percentage of 50% of a 5.5±1.9 mm maxillary advancement, although they did not mention whether the AC suture had been used. A similar ratio and a strong correlation was found in more than 80% of cases after an average 5.58 mm advancement with or without impaction that used the AC suture and included cases of segmental surgery (Hellak et al., 2015).

Liebregts et al. (2016) also identified a weak to moderate correlation between interalar widening and the magnitude of maxillary advancement performed with and without vertical rotation, but calculated a smaller 0.24:1 ratio that they suggested was unaffected by the use of the AC, VY or ACVY closure. The average A point advancement in that investigation was only 0.31±1.98 mm while the impaction was 1.61±1.64 mm. However, Rauso et al. (2011) calculated a much lower ratio of 0.05 to 0.08 mm for each millimetre of maxillary advancement between 3 and 7 mm in cases of Class III malocclusions treated with bimaxillary surgery which they attributed to AC-VY closure. Coban et al. (2020), using stereophotogrammetry, revealed that without the AC suture, the change in interalar and alar base widths did not correlate with A point advancement but the former correlated with impaction. Morphological and alar base width increased 10 and 20% of the

advancement and 36 and 32% of the impaction, respectively (Coban et al., 2020). The average advancement was 4.56±1.34 mm in that study while the impaction was 2.03±1.04 mm and thus, larger than that used in this investigation.

However, Westermark et al. (1991) concluded that the magnitude of maxillary impaction or advancement did not influence the amount of alar widening with or without the AC suture in Swedes when performed with anterior nasal spine recontouring but without VY closure. Rosen (1988) also did not verify a correlation with the magnitude of surgical maxillary advancement and/or vertical repositioning without the AC-VY suture. Interalar and alar base widening were unrelated to the magnitude of advancement after maxillary advancement or horizontal or vertical rotation osteotomy without AC-VY reconstruction, in a limited sample of 12 women (Yamada et al., 2010).

Sagittal A point advancement explained only 9% of the alteration in the morphological width in this investigation. Ryckman et al. (2010), after bimaxillary advancement with AC-VY closure, observed different interalar widening of 1.7±1.0 mm and 2.8±1.1 mm depending on whether the magnitude of maxillary advancement was less or more than 4 mm and concluded that this factor, along with soft tissue factors, was an important variable in determining the final transverse nasal dimension. That study, however, used cone beam computerized tomography performed as early as 10 weeks after surgery suggesting that oedema may have played a role in the results.

Apart from different magnitudes and directions of surgical movement (Howley et al., 2011; Moroi et al., 2014; Stewart & Edler, 2011), the AC suture is a confounding factor because it can be used in varying degrees of laxity or tension (Guymon et al., 1988; Yamada et al., 2010). Moreover, the surgeon may actually permit widening when they subjectively consider the pre-surgical alar base too narrow (Hackney et al., 1988; Mommaerts et al., 1997; Ryckman et al., 2010). The individual variation present in the soft tissue response also has to be considered (Honrado et al., 2006; Howley et al., 2011). This might be due to biological differences or unique variations in soft tissue movement (Coban et al., 2020). The surgical recontouring of the anterior nasal spine that supports the feet of the medial crura, the release of periosteum and muscle insertions and oedema are all causal factors for widening, increasing variability (Guymon et al., 1988; Jensen et al., 1992; Stewart & Edler, 2011, Wolford 1988). Howley et al. (2011) stated that patients should be informed of the probability of a 2-3 mm alar base widening, but nonetheless highlighted the unpredictability and large range of values observed.

Other authors have mentioned a similar tendency for greater widening at the alar base than in morphological width (Stewart & Edler, 2011). Betts et al. (1993) demonstrated that interalar and alar base widening were 7% and 9%, respectively, in 97% of patients submitted to maxillary advancement, with or without vertical repositioning and without the AC suture. Hellak et al. (2015) suggested that a 5 mm maxillary advancement would increase alar base and morphological widths by approximately 2.8 mm and 2.2 mm, respectively.

The columella width increased 0.33±0.39 mm but did not correlate with the change in the skeletal variables. Metzler et al (2014) did not detect changes in this variable after maxillary advancement surgery, but measured this distance at the sagittal midpoint of the columella using three-dimensional photogrammetry.

In this investigation, the right and left diagonal nostril widths increased 0.80±1.17 mm and 0.74±1.18 mm, respectively, but did not correlate significantly with maxillary repositioning. Increased frontal nostril exposure and nostril width after maxillary advancement surgery have been confirmed in studies using three-dimensional methods (Metzler et al., 2014; Worasakwutiphong et al., 2015) and anthropometry (Chung et al., 2008) and, along with nasal tip elevation, have been attributed to columella buckling secondary to maxillary advancement and alar cartilage retraction and superior rotation (Metzler et al., 2014). Greater nasal tip elevation than that of subnasale, partially caused by the AC suture, is a causal factor (Worasakwutiphong et al., 2015). This post-surgical change is undesirable because of its association with a ´Miss Piggy` appearance (Mitchell et al., 2007; Schendel & Carlotti, 1991; Worasakwutiphong et al., 2015).

In keeping with the tripod theory, this frontal nostril widening is also related to the simultaneous sagittal nasal compression verified in this investigation and confirmed by other authors (Betts et al., 1993). 3D photogrammetry indicated that maxillary advancement surgery increased diagonal nostril width in the frontal view but decreased sagittal nostril length (Metzler et al., 2014). Computerized tomography demonstrated sagittal compression and anterior nostril widening after maxillary advancement and impaction surgery with the AC suture and anterior nasal spine recontouring (Almukhtar et al., 2016). 3D photogrammetry demonstrated that sagittal nostril length decreased but direct transverse width increased in patients undergoing Le Fort 1 maxillary advancement or Le Fort 1 segmental advancement and expansion surgery (DeSesa et al., 2016).

In this study, the change in maxillary inclination did not correlate significantly with any of the transverse nasal measurements. The effect of this variable on nasal width has not been extensively studied. Chung et al (2008) opined that the maxillary rotation incorporated in posterior impaction and advancement surgery advanced the nasal base more than the dentition and consequently, amplified nasal enlargement. However, Choi et al. (2014) proposed the use of posterior impaction alone rather than maxillary advancement as a form of minimizing interalar widening in Asians whose class III discrepancy is caused principally by mandibular excess. After maxillary impaction surgery, Phillips et al. (1986) concluded that the presurgical maxillary inclination and vertical upper incisor position, together with the surgical vertical anterior nasal spine displacement, explained only 35% of the variability in alar base widening.

3.6.8.2 Changes produced by the Le Fort 1 maxillary advancement osteotomy in the sagittal dimension.

The advancing pyriform aperture pushes the nose and its subunits the alae, subnasale, columella and the tip forward during maxillary advancement surgery (Metzler et al., 2014). Pronasale and subnasale advanced 0.20 and 0.26 mm, respectively, with every millimetre of maxillary advancement and an additional 0.11 and 0.90 mm, respectively due to the surgery itself. They demonstrated ratios of 0.23:1 and 0.5:1, respectively, with A point advancement and of 0.21:1 and 0.46:1, respectively, with prosthion advancement. Hence,

maxillary advancement made subnasale advance approximately twice as much as pronasale. The larger nasal projection angle also reflected the nasal tip advancement and elevation. It increased 0.15° for every millimetre of sagittal maxillary advancement and an additional 0.94° due to the surgery.

Shoji et al. (2012) also revealed nasal tip and base advancement after bimaxillary surgery including maxillary advancement or rotation and the AC suture in Class III malocclusions. However, the literature varies in ratios published and in the hard tissue points used to generate them. Dann et al. (1976) demonstrated a sagittal 0.28:1 ratio between the nasal tip and maxillary incisor in 8 patients who underwent maxillary advancement surgery. Enacar et al. (1999) yielded a much higher 0.8:1 ratio, with the average 2.5 mm advancement of the intact anterior nasal spine, albeit in a weak correlation, in 24 patients after maxillary advancement and mandibular set back surgery without ACVY closure.

Subnasale is generally reported to advance more than the nasal tip although authors differ as to the magnitude of this difference in movement. Some authors obtained ratios that resemble those ascertained by this study using the A point as the skeletal reference. Esenlik et al. (2011) observed correlations of 0.48 and 0.7 and ratios of 0.24:1 and 0.51:1 for pronasale and subnasale advancement, respectively, after maxillary advancement with or without anterior nasal spine recontouring. Pronasale and subnasale generated ratios of 0.25:1 and 0.50:1, respectively, after maxillary advancement with slight posterior descent and with or without anterior nasal spine contouring in 25 patients (Freihofer, 1977). Altug-Atac et al. (2008) calculated ratios of 0.25:1 and 0.40:1, respectively, after maxillary advancement and mandibular setback surgery in Turks, although they did not mention the type of closure and surgical technique. McCollum et al. (2009) calculated non-significant and significant moderate correlations and ratios of 0.17:1 and 0.56:1, respectively, after maxillary advancement with AC-VY closure and with or without mandibular set back surgery. Pronasale and subnasale advancement correlated moderately with that of the upper incisor producing ratios of 0.26:1 and 0.52:1, respectively. The authors revealed a moderate correlation between pronasale and anterior nasal spine advancement and a ratio of 0.34:1, despite its surgical recontouring. Rosen (1988) observed a strong correlation and a sagittal 0.51±0.13 ratio between subnasale and the upper incisal edge after an average 5.9±2.3mm surgical maxillary advancement without adjunctive procedures but no correlation for nasal tip advancement.

A few authors demonstrate higher ratios. Chew (2005) calculated a moderate correlation and a 0.35:1 ratio between sagittal pronasale and anterior nasal spine movement and a strong correlation and a 0.60:1 ratio between subnasale and A point movement after maxillary advancement and impaction of 3.3±1.9 mm and 0.4±1.4 mm, respectively and mandibular setback osteotomy. The study did not describe the type of closure and surgical technique and was performed in 34 Chinese patients and thus, results cannot be applied to Caucasians (Coban et al., 2020). Lin and Kerr (1998) calculated 0.638:1 for the subnasale: A point ratio, despite weak correlations for pronasale and subnasale advancement relative to this point, and ratios of 0.348:1 and 0.368:1 ratios, respectively for the two points´ movement relative to that of the anterior nasal spine in 17 patients, despite citing anterior nasal spine modification as a reason for low correlations observed after maxillary advancement and mandibular setback surgery. Rosenberg et al. (2002), using VY closure without anterior nasal spine modification, revealed that pronasale and subnasale advanced 0.34 mm and 0.64 mm,

respectively, for each millimetre of A point advancement in 9 patients subjected to advancement and impaction of 2.6±1.4 mm and 0.4±1.5 mm, respectively, and advanced and retracted 0.001 mm and 0.05 mm, respectively, due to the surgical procedure itself. Carlotti et al. (1986) observed a non-significant antero-superior nasal tip movement in 25 patients subjected to maxillary advancement surgery with AC-VY closure but generated a 0.67:1 ratio for sagittal subnasale movement, using the maxillary incisor as a reference in patients subjected to maxillary advancement and impaction of 4.1±2.9 mm and 0.8±2.9 mm, respectively.

However, pronasale and subnasale advanced only 16 and 39% of the upper incisor movement, in moderate and strong correlations, respectively, after maxillary advancement and VY closure in obstructive sleep apnoea patients (Louis et al., 2001). The larger 8.0±2.5 mm upper incisor advancement and the resulting soft tissue tension in these patients without dead space and anterior nasal spine recontouring could have been a cause for the lower ratios. Mansour et al. (1983) also yielded lower ratios of 17:1 and 0.24:1, respectively, for pronasale and subnasale movement relative to the incisor in 7 patients subjected to Le Fort 1 advancement osteotomy with less than 2 mm posterior impaction, possibly explained by post-surgical orthodontic movement. Hui et al. (1994) did not detect significant correlations for pronasale and subnasale movement despite their substantial movement after le Fort 1 maxillary advancement osteotomy, with or without segmentation, in Chinese. An average 3.19±3.63 mm maxillary advancement and mandibular setback surgery in 31 Turks without anterior nasal spine modification did not significantly advance the nasal tip (Aydil et al., 2013). Misir et al. (2011) revealed that nasal tip advancement was influenced by the sagittal and vertical upper incisor movement but not that of the A point in 27 patients subjected to A point advancement and impaction of 3.87±2.35 mm and 1.03±2.49 mm, respectively, and mandibular setback surgery without anterior nasal spine modification,.

Nasal tip advancement has also been found after maxillary advancement and posterior impaction osteotomy with mandibular setback in Asians (Baik & Kim, 2010; Chung et al., 2008). Mansour et al. (1983) demonstrated substantial though unpredictable tip movement in 14 cases of maxillary advancement with greater than 2 mm posterior impaction. Pronasale and subnasale advanced 46 and 38% of each millimetre of A point advancement, although surgery itself penalized the former more than the latter point after posterior maxillary impaction and VY closure, maintaining the anterior nasal spine intact (Rosenberg et al., 2002).

In this study, the non-significant change in maxillary inclination of 0.31±2.39° did not affect nasal tip and subnasale advancement. Authors who used samples with multiple vectors of maxillary movement have verified that maxillary base rotation did not influence nasal tip position (Bundgaard et al., 1986; Gassmann et al., 1989). Mommaerts et al. (2000) found a correlation between nasal tip advancement and the magnitudes of maxillary advancement and anterior palatine plane rotation calculated using two points in the anterior and posterior palate after Le Fort 1 advancement or impaction osteotomy with anterior nasal spine recontouring and AC-VY reconstruction, but did not specify the average degree of palatal plane rotation which was possibly greater.

This study revealed that the average 0.59±2.07 mm A point impaction did not affect nasal tip and subnasale advancement. Rosen (1988) also concluded that isolated impaction did not affect nasal tip projection.

Mommaerts et al., (2000) did not observe a correlation between nasal tip projection and impaction when anterior nasal spine recontouring and AC-VY reconstruction were used. Radney and Jacobs (1981) stated that maxillary impaction tended to advance the nasal tip slightly, despite the lack of a significant sagittal correlation and a highly variable soft tissue response. Surgical impaction is known to always involve a degree of sagittal movement (Sarver & Weissman, 1991). Both points advanced after maxillary impaction with AC-VY reconstruction and with or without advancement and anterior nasal spine resection in 13 women (de Assis et al., 1996b). Jensen et al. (1992) found that the infralobule and subnasale points advanced 66 and 72% of the sagittal 2 mm bone movement, although without a significant correlation, after maxillary impaction, mandibular advancement and AC-VY reconstruction.

Investigations that register a greater magnitude of impaction can also register different results. Esenlik et al. (2011) observed that pronasale advanced more after advancement and impaction surgery than after isolated advancement with minimal impaction. They also demonstrated a non-significant correlation for pronasale, but a strong one between subnasale and sagittal A point movement, yielding a ratio of 0.47:1 after maxillary advancement and impaction of 6.06±2.45 mm and 3.48±1.46 mm, respectively, with or without anterior nasal spine recontouring in Turks. Bimaxillary surgery involving maxillary advancement and impaction that averaged 2.69±3.34 mm and 1.53±5.04 mm in Turks revealed 0.24:1 pronasale: unmodified anterior nasal spine and 0.26:1 subnasale: A point ratios (Marşan et al., 2015). The nasal tip advanced in 80% of 20 Brazilian patients with Class II or III malocclusions and was an average 40% of the skeletal movement after maxillary advancement and/or impaction surgery with ACVY reconstruction (Dantas et al., 2015). Yet, optical scans revealed that while the nasal tip advanced 29% of a 3 mm maxillary advancement in Class III patients treated with bimaxillary surgery with or without an unspecified amount of impaction, subnasale advanced much more at 81% (Soncul & Bamber, 2004). In the 6 mm and 9 mm advancement group, these percentages were 80 and 34% and 75 and 33% respectively.

In this investigation, the larger advancement at subnasale compared to the nasal tip significantly reduced nasal protrusion and the nasal prominence angle. The nasal, subnasale and nostril projection also decreased, indicating greater advancement at the alar base curvature. Hence, maxillary advancement osteotomy had a greater sagittal effect on the posterior parts of the nasal profile.

Other studies indicated similar results. Subnasale advanced more than the tip reducing nasal protrusion in 65% of patients submitted to maxillary advancement osteotomy and/ or vertical repositioning (Betts et al., 1993). Nasal protrusion decreased after maxillary advancement and posterior impaction surgery with mandibular setback and the AC suture in Koreans (Chung et al., 2008). It also decreased after maxillary advancement performed with AC-VY reconstruction as part of bimaxillary surgery in Caucasians (Rauso et al., 2011). Cone beam computerized tomography revealed that bimaxillary surgery, including maxillary advancement and impaction and AC-VY reconstruction, reduced this variable (Park et al., 2012). 3D photogrammetry revealed that while nasal tip prominence increased relative to the tragus, nasal protrusion was reduced after Le Fort 1 advancement or segmental advancement with expansion (DeSesa et al., 2016).

Another investigation using 3D photogrammetry concluded that although the tip followed the forward movement of the whole nasal complex, increasing its distance from the tragus, the alar-tip distance and nasal protrusion decreased (Metzler et al., 2014). Cone beam computerized tomography also revealed greater alar curvature advancement than that of the nasal tip with sagittal nostril compression and columella shortening after maxillary advancement with minimal impaction and the AC suture and anterior nasal spine recontouring (Almukhtar et al., 2016). 3D photogrammetry also demonstrated that the nasal tip advanced less than subnasale and the alare after maxillary advancement with or without posterior impaction and the AC suture in Taiwanese (Worasakwutiphong et al., 2015). Laser scans after maxillary advancement or horizontal or vertical maxillary rotation without AC-VY closure also indicated that though the nasal tip advanced relative to soft tissue nasion, the alar base advanced and the nasal protrusion decreased (Yamada et al., 2010).

In this study, the change in nasal tip protrusion and nasal prominence angle were not significantly correlated with the skeletal variables used in the regression equation while the reduction in nasal, subnasale and nostril projections corelated moderately with the sagittal and vertical A point movement. The nasal, subnasale and nostril projections decreased by 0.26, 0.21 and 0.23 mm, respectively, for each millimetre of sagittal maxillary advancement, 0.37, 0.39 and 0.29 mm, respectively, for each millimetre of maxillary impaction and an additional 0.97, 0.13 and 0.83 mm, respectively, due to the surgery itself.

Esenlik et al. (2011), in Turks, found that the reduction in nasal tip distance from the soft tissue glabella -subnasale line, nostril, subnasale and pronasale projections from the nasal wings and nasal protrusion in two groups of patients subjected to an average advancement and impaction of 5.25±2.4 mm and 0.11±1.26 mm, respectively, or 6.06±2.45 mm and 3.48±1.46 mm, respectively, with or without anterior nasal spine contouring, correlated with the magnitude of advancement in the former group. The nasal prominence angle decreased significantly only in the latter group despite the greater nasal tip advancement in that group. However, in a study with a very small sample size, Honrado et al. (2006) did not detect a significant change in nasal protrusion and no correlation with the magnitude of bone movement in patients treated with maxillary advancement, with or without vertical rotation, and with AC-VY reconstruction using 3D photogrammetry. There was a non-significant tendency for a decrease only in 6 patients who underwent advancement with upward rotation. Coban et al. (2020) also did not reveal significant alterations in nasal protrusion after an average maxillary advancement and impaction of 4.56±1.34 mm and 2.03±1.04 mm, respectively, without the AC suture. Both authors emphasized the role of large individual variability.

This study demonstrated a large variation in the soft tissue response. The superimpositions and measurements in the cases that could be classified as outliers were reverified. Many authors have emphasized that individual variability can lead to unpredictable outcomes despite careful planning (Freihofer, 1977). Louis et al. (2001) obtained a very wide range of ratios after maxillary advancement with VY closure, even when vertical bone movement was restricted to less than 0.7±1.8 mm. Soncul and Bamber (2004) revealed that despite the nasal tip advancement and elevation observed in most patients, it only advanced or remained unchanged in some cases after bimaxillary surgery involving maxillary advancement, with or without impaction. Subnasale mostly moved antero-superiorly but also showed pure advancement or anteroinferior

movement and very rarely, remained unchanged. Mansour et al. (1983) measured a range of -0.8 to 1.5 and -1.7 to 2.3 mm, respectively for horizontal pronasale and subnasale movement after maxillary advancement with greater than 2 mm posterior impaction.

Several reasons have been proposed for the variability at subnasale. Thinner soft tissue can yield better correlations with the magnitude of maxillary advancement than a thicker layer that absorbs the osseous movement and reflects it less (Abeltins & Jakobsone, 2011; McCollum et al., 2009; Stella et al., 1989). While the overall sagittal subnasale: A point ratio was 0.56:1 at 3 to 16 months after maxillary advancement, with or without mandibular surgery or the VY closure but with anterior nasal spine recontouring, McCollum et al. (2009) calculated a significant correlation and a 0.79:1 ratio for lips less than 15 mm thick but a non-significant one and a 0.22:1 ratio for thicker lips. After maxillary advancement osteotomy without ACVY reconstruction or anterior nasal spine resection, sagittal subnasale movement generated a strong correlation and a 0.5±0.1 ratio for 12 to17 mm thick lips, while thicker lips presented a weak correlation and a 0.3±0.2 ratio (Stella et al., 1989).

Lin and Kerr (1998) attributed the weak correlation at subnasale after maxillary advancement and mandibular setback surgery to the surgical anterior nasal spine modification and the firm soft tissue union at the nasal base, which restricted its movement. Mansour et al. (1983) also emphasized the greater soft tissue attachment to skeletal structures at the nasal tip and base than at the level of the upper lip.

Another factor is the presurgical upper lip pseudo-position that is necessary to ensure lip competence wherein support is provided by the lower lip and incisors and the maxillary base, rather than the upper incisor, in the presence of a severely negative overjet and deep overbite (Freihofer, 1976; Soncul & Bamber, 2004). As the magnitude of advancement has to be sufficient to eliminate the dead space that exists between the maxillary dentoalveolar structures and upper labial mucosa and allow the maxilla to come into contact with the soft tissues before their displacement can occur, lower soft tissue-hard tissue ratios are generated (Louis et al., 2001; Soncul & Bamber, 2004; Stella et al., 1989). This pseudoposition is why the subnasale-A point distance decreases, even after mandibular setback surgery (Jokić et al., 2013). In the absence of a dead space, soft tissue tension caused by advancements of great magnitude makes this layer more resistant to movement and reduces ratios (Carlotti et al., 1986; Chew, 2005). Stella et al. (1989) found a moderate sagittal correlation for subnasale when the maxilla was advanced less than 5 mm but attributed the weak correlation after larger advancements to soft tissue tension. In Class III patients treated with bimaxillary surgery involving maxillary advancement with or without impaction, subnasale advanced 81% of a 3 mm bone displacement, but only 75% of a 9 mm bone movement (Soncul & Bamber, 2004).

3.6.8.3 Changes produced by the Le Fort 1 maxillary advancement osteotomy in the vertical dimension.

Pronasale and subnasale elevated 1.18±1.26 and 0.72±1.00 mm, respectively, and reduced profile nasal length and height by 0.63±1.15 and 0.49±1.07 mm, respectively. The shorter frontal nasal length and wider interalar distance contributed to decreasing the frontal nasal length/morphological width ratio.

Surgical A point advancement and elevation generally rotates the nasal tip upward (Gassmann et al., 1989; Mitchell et al., 2007). Several authors have registered the tendency for antero-superior nasal tip movement after maxillary surgery (Altug-Atac et al., 2008; Betts et al., 1993; Chung et al., 2008; Honrado et al., 2006; Mansour et al., 1983; McCollum et al., 2009; Vasudavan et al., 2012; Westermark et al., 1991). Nasal tip elevation following maxillary advancement osteotomy has been confirmed using 3D photogrammetry (Metzler et al., 2014), cephalometry (Ghassemi, Modabber, et al., 2014; Mansour et al., 1983; Marşan et al., 2015) and laser scans (Yamada et al., 2010). Almukhtar et al. (2016) revealed nasal tip and alar base curvature elevation after an average 5.9±1.7 mm maxillary advancement with minimal impaction, AC suture and anterior nasal spine recontouring.

Coban et al. (2020) concluded that alare, alar base, nasal tip and subnasale elevated and advanced after maxillary advancement and impaction surgery. Antero-superior nasal tip rotation occurred as a consequence of isolated Le Fort 1 advancement and impaction osteotomy with either the VY or simple continuous suture in Indians (Chandra et al., 2013) and when performed as part of a bimaxillary surgery with AC-VY reconstruction in Asians (Park et al., 2012). Dantas et al. (2015) observed nasal tip elevation in 85% of Brazilian patients who underwent maxillary advancement and/or impaction surgery with ACVY reconstruction. Assis et al. (1996) concluded that maxillary impaction, with or without advancement, performed with anterior nasal spine resection and AC-VY reconstruction elevated the nasal tip. Chung et al. (2008) revealed a tendency for antero-superior nasal tip movement after maxillary advancement with posterior impaction and mandibular setback with the AC suture. Pronasale elevated more than subnasale after advancement with or without posterior impaction with the AC suture in Asians (Worasakwutiphong et al., 2015). Yet, in Turks, Enacar et al. (1999) registered a non-significant nasal tip elevation after an average 2.5 mm advancement of the intact anterior nasal spine when maxillary advancement was performed as part of bimaxillary surgery without nasolabial reconstruction. Bottini et al. (2013) observed nasal tip projection without its elevation in a sample that included quadrangular Le Fort 1 maxillary advancement surgeries.

The 0.31±2.39° change in maxillary inclination could not explain the vertical nasal tip movement in this study. Essenlik et al. (2011) verified that maxillary rotation did not affect nasal tip movement after maxillary advancement with or without impaction or anterior nasal spine recontouring and VY closure in Turks. It also did not affect nasal tip elevation after Le Fort 1 advancement or impaction osteotomy with anterior nasal spine recontouring and AC-VY reconstruction (Mommaerts et al., 2000). Bundgaard et al. (1986) concluded that occlusal plane inclination did not affect pronasale and subnasale positions after multi-directional osteotomies. However, Mansour et al. (1983) demonstrated that occlusal plane steepening after greater than 2 mm maxillary posterior impaction elevated the nasal tip more. They did not observe this effect when the maxilla was mainly advanced.

In this investigation, A point advancement and impaction did not contribute to nasal tip elevation but explained 18% of the variability in subnasale elevation. Subnasale elevated 0.08 mm and 0.17 mm for each millimetre of A point advancement and impaction, respectively, and a further 0.31 mm due to the surgery itself.

Authors generally confirm lower correlations in the vertical than in the sagittal plane after maxillary advancement osteotomy (Chew, 2005; Lin & Kerr, 1998; Mansour et al., 1983). Bundgaard et al. (1986) attributed the lack of a significant correlation between A point and the vertical nasal tip movement after maxillary osteotomy in various directions to a considerable individual variability in the soft tissue response. Coban et al. (2020) did not yield significant correlations between pronasale and subnasale elevation and A point movement after 4.56±1.34 mm and 2.03±1.04 mm of maxillary advancement and impaction, respectively. Marsan et al. (2009) did not detect correlations between subnasale and A point elevation after bimaxillary surgery involving maxillary advancement and impaction in Turkish women. Rosenberg et al. (2002), using regression analysis, did not reveal significant correlations for nasal tip elevation after advancement and impaction osteotomy, although subnasale elevated 30% of the upper incisor advancement and additionally due to the surgery itself. Mommaerts et al. (2000) also concluded that horizontal and vertical movement of a point in the anterior palate did not influence nasal tip elevation after Le Fort 1 subspinal or conventional advancement or impaction osteotomy with anterior nasal spine recontouring and AC-VY reconstruction.

Other researchers demonstrated correlations between sagittal hard tissue and vertical nasal tip movement. Rosenberg et al. (2002) verified that pronasale and subnasale elevated 0.29 and 0.38 mm, respectively, for each millimetre of upper incisor advancement while the maxillary advancement surgical procedure itself with VY closure and an intact anterior nasal spine lowered subnasale by 0.56 mm and elevated pronasale by 0.30 mm. McCollum et al. (2009) also observed significant correlations between sagittal A point change and nasal tip elevation after maxillary advancement with anterior nasal spine recontouring and with or without mandibular surgery or VY closure, although some of the patient records were obtained 3 months after surgery. The magnitude of advancement affected nasal tip position at 5-6 months after maxillary advancement surgery with posterior impaction and with or without AC-VY reconstruction or anterior nasal spine recontouring (Khamashta-Ledezma & Naini, 2014).

A point elevated 0.59±2.07 mm in this study and did not seem to affect nasal tip movement. McFarlane et al. (1995) demonstrated that the magnitude of advancement was a stronger prognostic factor than that of impaction for nasal tip elevation. A few authors, however, found correlations with vertical skeletal movement after maxillary advancement and mandibular setback osteotomy. Chew (2005) revealed moderate correlations between vertical nasal tip and anterior nasal spine movement, and between vertical subnasale and A point movement in Chinese and emphasized racial variation. Lin and Kerr (1998) observed weak and moderate correlations for pronasale and subnasale elevation relative to that of the anterior nasal spine, respectively, in 17 patients. The correlation between vertical subnasale and A point movement was weak despite an average impaction of 4.32±3.12 mm.

Some authors reveal that nasal tip elevation is affected by both sagittal and vertical hard tissue movement after advancement with a greater magnitude of impaction. Vertical upper incisor and sagittal A point movements influenced nasal tip elevation after bimaxillary surgery, including A point advancement and impaction of 3.87±2.35 mm and 1.03±2.49 mm, respectively, when the anterior nasal spine was maintained

intact (Misir et al., 2011). Both sagittal and vertical A point movement were important after maxillary advancement and impaction of 2.69±3.34 mm and 1.53±5.04 mm, respectively, with anterior nasal spine recontouring in Turks (Marşan et al., 2015).

This investigation revealed ratios of 0.31:1 and 0.19:1 for nasal tip and subnasale elevation relative to A point advancement, respectively. Coban et al. (2020) observed that pronasale and subnasale elevated in ratios of 0.24:1 and 0.21:1, respectively, relative to A point advancement, after an average 4.56±1.34 mm maxillary advancement and 2.03±1.04 impaction without the AC suture. Both points moved upwards 16% of the upper incisor advancement after an average 8.0±2 mm maxillary advancement with less than 0.7±1.8 mm vertical movement and VY reconstruction and an intact anterior nasal spine in patients with obstructive sleep apnoea who did not suffer from sagittal maxillary deficiency (Louis et al., 2001).

It has been suggested that maxillary impaction performed alone (Sarver & Weissman, 1991) or as part of bimaxillary surgery (Moss et al., 1994) minimally affects the nasal tip. Schendel et al. (1976) demonstrated only slight nasal tip elevation 4 to 29 months after surgery. Le Fort 1 impaction osteotomy with VY closure also did not produce significant nasal changes (Rosenberg et al., 2002). However, other authors calculated ratios for larger magnitudes of maxillary impaction The nasal tip elevated 2.4±0.4 mm after an average 6.3±0.7 mm maxillary impaction with AC-VY closure in 10 patients (Schendel & Williamson, 1983). Radney and Jacobs (1981) revealed ratios of 0.25:1 and 0.20:1, respectively, for subnasale and pronasale elevation in relation to that of the upper incisor edge in 10 patients with or without anterior nasal spine recontouring. The nasal tip elevated 1 mm for every 6 mm elevation of the most anterior point on the upper incisor crown in relation to its axis (Radney & Jacobs, 1981). Infralobule and subnasale elevated in ratios of 0.21:1 and 0.18:1, respectively, with A point elevation, in a strong correlation after maxillary impaction, mandibular advancement and AC-VY reconstruction (Jensen et al., 1992).

The results after posterior impaction surgery also vary. Rosenberg et al. (2002) found that pronasale and subnasale elevated in ratios of 1.03:1 and 1.19:1, respectively, with A point elevation after posterior maxillary impaction and VY closure, although the surgery itself caused descent. Mansour et al. (1983) calculated ratios of 0.15:1 and 0.28:1 between nasal tip and subnasale elevation and the vertical incisal edge movement after maxillary advancement and posterior impaction surgery. However, laser scans in Asians did not reveal vertical correlations, despite superior movement of all osseous and soft tissue reference points after posterior maxillary impaction with a small magnitude of advancement and mandibular setback (Baik & Kim, 2010). Choi et al. (2014) observed slight cephalic nasal tip rotation after bimaxillary surgery with posterior maxillary impaction.

The AC suture is a confounding factor as authors suggest that it can rotate the lateral crura and the nasal tip antero-superiorly (Muradin et al., 2011; Schendel & Carlotti, 1991). However, Westermark et al. (1991) concluded that the AC suture did not cause additional nasal tip projection or elevation, although it increased the nasolabial angle after maxillary advancement and impaction surgery with anterior nasal spine resection.

Nasal tip advancement and elevation increased the nasal projection angle. Park et al. (2012) also observed an increased nasal projection angle when Class III malocclusions were treated with bimaxillary surgery, including maxillary advancement and impaction and AC-VY reconstruction. Gassman et al. (1989)

found that the nasal tip rotated upward with anterior and superior movement of A point, in a weak correlation that was responsible for only 20% of its change after multidirectional Le Fort 1 maxillary osteotomies with or without anterior nasal spine recontouring and VY closure. In this study where maxillary movement was mostly sagittal, A point advancement explained only 5% of its change. The angle increased 0.15° for every millimetre of A point advancement and an additional 0.94° due to the surgery itself. Gassman et al. (1989) also did not detect a correlation with maxillary rotation.

The 0.63±1.15 mm reduction in nasal length did not correlate significantly with changes in skeletal variables. The nasal height decreased 0.08 mm and 0.16 mm for every millimetre of sagittal maxillary advancement and impaction, respectively, in a moderate correlation and an additional 0.10 mm due to the surgery. Authors report conflicting results although all suggest a tendency for length to decrease. Nasal length decreased significantly by 0.91±1.43 mm in Turks subjected to an average advancement and impaction of 5.25±2.4 mm and 0.11±1.26 mm, respectively, and non-significantly by 0.73±1.5 mm when the average advancement and impaction were 6.06±2.45 and 3.48±1.46 mm, respectively, with or without anterior nasal spine contouring, but correlated with the magnitude of maxillary advancement only in the latter group (Esenlik et al., 2011). Chung et al. (2008), using direct anthropometry, detected a non-significant tendency for decrease with nasal tip elevation and advancement after bimaxillary surgery, including maxillary advancement with posterior impaction and mandibular setback with the AC suture in Koreans. Coban et al. (2020) also revealed a non-significant tendency for nasal length reduction after maxillary advancement and impaction osteotomy that averaged 4.56±1.34 mm and 2.03±1.04 mm, respectively, without the AC suture. Vasudavan et al. (2012) demonstrated nasal tip elevation and advancement and a smaller nasal length but an unchanged nasal height, after Le Fort 1 advancement osteotomy with or without vertical repositioning and the AC suture but included patients with cleft lip and/or palate.

Alar widening and a reduced frontal length decreased the frontal nasal length/ morphological width ratio. While frontal nasal height did not change significantly, interalar widening reduced the frontal nasal height/ morphological width ratio.

While columella exposure, which reflects vertical nostril exposure in profile, did not change significantly, subnasale and pronasale elevation and the decrease in nasal protrusion increased columella depth by 0.13±0.52 mm, a value that is unlikely to be clinically significant. Columella depth decreased non-significantly by 0.04 mm with each millimetre of A point advancement but increased 0.06 mm for each millimetre of impaction and a further 0.24 mm due to the surgery itself, in a moderate correlation. Esenlik et al. (2011), however, did not find significant changes in columella depth in Turks subjected to maxillary advancement or advancement and impaction, with or without anterior nasal spine recontouring and VY closure, although they did detect a correlation with the magnitude of maxillary advancement in the former group.

3.6.8.4 Changes caused by the Le Fort 1 maxillary advancement osteotomy in nasal rotation.

The columella rotation and the columella-lobule angles, which unlike the nasolabial angle are not affected by lip position and inclination, did not change significantly. Other authors have confirmed that the

columella-lobule angle remained unaltered after maxillary advancement and mandibular setback surgery, even when the anterior nasal spine was maintained intact (Aydil et al., 2013; Misir et al., 2011). de Assis et al. (1996) observed upward rotation at the columella-lobule junction, but after a much greater amount of impaction with or without advancement, AC-VY reconstruction and anterior nasal spine resection in women with vertical maxillary excess. In this investigation, the columella-lobule angle decreased 0.56° for every millimetre of A point advancement in a weak correlation but increased 3.58° due to the surgery itself.

The nasal tip rotation angle decreased significantly by 3.54±3.28°, indicating that the nasal tip elevated more than the alar base curvature, but this change was not influenced by the skeletal variables.

The nasolabial angle is influenced by the columella, maxillary and upper incisor position and inclination and thus, can be modified by nasal or maxillary surgery or by orthodontic treatment (Esenlik et al., 2011; Ghassemi, Modabber, et al., 2014; Legan & Burstone, 1980; Ubaya et al., 2012). Although the sample was composed of patients treated by orthodontists who, as a rule, achieve incisor decompensation and arch-coordination prior to surgery, minimal post-surgical orthodontic incisor movement could not be ruled out as a confounding factor.

A point movement explained 18% of the 2.57±9.89° reduction in the nasolabial angle. The angle decreased 1.32° and 1.15° for each millimetre of A point advancement and impaction, respectively in a moderate correlation and increased 3.10° due to the surgery itself.

Several other authors confirmed a reduction in this angle after maxillary advancement osteotomy. Dann et al. (1976) suggested that the obtuse nasolabial angle is the most important diagnostic criterion for maxillary advancement when they observed a 1.2±0.3° decrease for each millimetre of maxillary incisor advancement in a strong correlation in 8 patients with maxillary advancement surgery. Maxillary advancement also reduced the nasolabial angle in patients undergoing conventional or quadrangular Le Fort 1 maxillary advancement osteotomy with vertical repositioning (Bottini et al., 2013). Cone beam computerized tomography revealed a mean decrease of 6.65±7.71° after 5.58±2.14 mm maxillary advancement with the AC suture in 33 Caucasians, although the angle increased in 5 of the patients (Hellak et al., 2015). The angle decreased 3.78±9.6° after A point advancement and impaction of 4.81±3.01 mm and 0.28±2.80 mm, respectively, VY plasty and anterior nasal spine contouring, but did not correlate with the magnitude of advancement (Shmuly et al., 2019).

As the columella rotation angle did not change significantly, it was the post-surgical anterior upper lip inclination that was mainly responsible for the reduced nasolabial angle. Rosen (1988) observed that differential movement within the upper lip, wherein subnasale advanced less than the upper lip point, contributed to reduce this angle after maxillary advancement, with or without vertical repositioning. Greater upper incisor advancement that that of the anterior nasal spine due to dissection in this area during the Le Fort 1 osteotomy is another cause of anterior upper lip inclination (Carlotti et al., 1986). Lip advancement reduced the angle at 8 weeks after maxillary advancement surgery performed alone or as part of bimaxillary surgery, although oedema may have persisted at that time (Ghassemi, Ghassemi, et al., 2014; Ghassemi, Modabber, et al., 2014). Lip advancement was also suggested as a causal factor when the angle decreased or remained unchanged in 65% of patients submitted to maxillary advancement and/or vertical repositioning (Betts et al.,

1993). Louis et al. (2001) revealed that the nasolabial soft tissue complex represented by the pronasale, subnasale and upper lip rotated upwards as a unit and reduced the angle non-significantly by 5° after a 8.0±2 mm maxillary advancement with less than 0.7±1.8 mm vertical movement and VY closure, but without anterior nasal spine modification or the AC suture.

Other authors, however, demonstrated that the angle can increase due to upward columella rotation surpassing the differential upper lip advancement. A point advancement and the AC suture explained 52% of its increase in a moderate correlation at 5-6 months after maxillary advancement surgery with posterior impaction and with or without AC-VY reconstruction or anterior nasal spine recontouring (Khamashta-Ledezma & Naini, 2015). Esenlik et al. (2011) attributed a non-significant increase after maxillary advancement surgery with or without anterior nasal spine recontouring in Turks to superior columella inclination. Also in Turks, a larger nasolabial angle was observed after maxillary advancement and mandibular setback surgery without anterior nasal spine recontouring or AC-VY reconstruction (Enacar et al., 1999) and bimaxillary surgery involving maxillary impaction and advancement without additional procedures in women (Marşan et al., 2009). The columella inclined upwards and the nasolabial angle increased by 10.34±7.36° after bimaxillary surgery including maxillary advancement and anterior and posterior impaction of 2.73±1.23 mm, 3.41±1.77 mm and 3.27±1.26 mm, respectively with AC-VY reconstruction in Asians (Park et al., 2012). Bimaxillary surgery involving maxillary advancement with or without posterior impaction with the AC suture also increased the superior columella inclination and nasolabial angle in Taiwanese (Worasakwutiphong et al., 2015). It amplified after maxillary advancement and mandibular setback osteotomy in Chinese (Chew, 2005). Results from studies in other ethnicities, however, cannot be applied to Caucasians due to differences in pre-surgical morphology (Chew, 2005; Clemente-Panichella et al., 2000; Lew, 1990).

Freihofer (1977) observed antero-superior columella inclination in combined data that was more pronounced in patients with unilateral cleft lip and palate and with the anterior nasal spine intact, after an average 5.4 mm maxillary advancement with slight posterior descent. In this study, the columella rotation angle demonstrated a non-significant mean 0.32° anterior inclination with a large standard deviation of 4.86°. The columella rotation angle was reduced 0.62° by the surgical procedure itself but increased 0.52° for every millimetre of maxillary impaction possibly due to greater subnasale elevation.

Other authors found that the nasolabial angle was unaffected by maxillary surgery, performed alone or as part as a bimaxillary procedure (Aydil et al., 2013; Ghassemi et al., 2015; Metzler et al., 2014; Misir et al., 2011). Mommaerts et al. (2000) attributed the lack of significant change after both conventional Le Fort 1 osteotomy with AC-VY closure and anterior nasal spine recontouring and subspinal osteotomy to large individual variation. McCollum et al. (2009) also did not demonstrate change after maxillary advancement with anterior nasal spine recontouring and with or without mandibular surgery and AC-VY closure although they obtained some records at three months after surgery. Chandra et al. (2013) did not detect significant changes after Le Fort 1 advancement and impaction osteotomy performed with VY closure or the simple continuous suture, but without the AC suture, in Indians. It did not alter after Le Fort 1 advancement osteotomy

with or without vertical repositioning and the AC suture in a sample that included patients with clefts of the lip and/or palate (Vasudavan et al. 2012).

The angle´s response to maxillary surgery is generally considered unpredictable (Esenlik et al., 2011; Gassmann et al., 1989; Jensen et al., 1992; Mansour et al., 1983; Shmuly et al., 2019). In this study, it was the variable with the largest standard deviation (9.89°), reflecting the tendency for large individual variability. Shmuly et al. (2019) obtained a similar standard deviation of 9.65° after A point advancement and impaction of 4.81±3.01 mm and 0.28±2.80 mm, respectively. Lip position in photographs is important. Patients with a reduced pre-surgical angle due to upper lip pseudo-position and dead space (Louis et al., 2001; Soncul & Bamber, 2004; Stella et al., 1989) will display a larger angle when the post-surgical lip support is provided by the upper incisor.

Factors such as the magnitude of initial maxillary deficiency and vertical dimension (Bottini et al., 2013), upper lip volume and the location of the vestibular incision (Tomlak et al., 1984), the degree of soft tissue deflection (Pospisil, 1987), anterior nasal spine maintenance or resection (Freihofer, 1977; Jensen et al., 1992) and the method of surgical closure and alar base manipulation (Gassmann et al., 1989; Guymon et al., 1988; Jensen et al., 1992) contribute to the large variability in the nasolabial angle´s response (Mommaerts et al., 2000; Westermark et al., 1991). Some authors conclude that there is no current satisfactory explanation for this response (Mommaerts et al., 2000; O'Ryan & Schendel, 1989b).

Lip thickness and elasticity are also important factors (Kim et al., 2011; Louis et al., 2001; Soncul & Bamber, 2004). Thinner lips tend to respond better to hard tissue movement (Altug-Atac et al., 2008; Freihofer, 1976; Mansour et al., 1983; McCollum et al., 2009; Stella et al., 1989).

The angle´s unpredictability has also been attributed to variations in occlusal plane rotation and incisor inclination (Bundgaard et al., 1986; Jensen et al., 1992; Misir et al., 2011; Worasakwutiphong et al., 2015). Some authors even suggest that rotational maxillary changes are more important than its sagittal or vertical movements (Bundgaard et al., 1986; Jensen et al., 1992; Mansour et al., 1983; Radney & Jacobs, 1981). Honrado et al. (2006) found that the angle decreased significantly only with superior maxillary rotation although it tended to do so with inferior rotation even with the AC suture and demonstrated increases and decreases without rotation. Mansour et al. (1983) reported that, although largely unpredictable, the angle tended to decrease after minimal maxillary advancement with greater than 2 mm posterior impaction. Jensen et al. (1992) concluded that antero-superior maxillary rotation and incisor inclination increased the nasolabial angle while rotation in the opposite direction decreased it after maxillary impaction, mandibular advancement and AC-VY reconstruction. However, other authors did not detect a correlation with maxillary rotation after both conventional and subspinal advancement or impaction osteotomy (Gassmann et al., 1989; Mommaerts et al., 2000). In this study, the angle was not affected by maxillary rotation.

The average magnitude of impaction was only 0.59 mm in this investigation. As the maxilla slopes anteriorly between point A and the incisor edge, after large magnitudes of maxillary impaction, even without advancement, the new support provided by a more anterior region on the upper incisor causes anterior-superior lip movement and helps to reduce the nasolabial angle (Radney & Jacobs, 1981, Wolford 1988). Greater

subnasale elevation also contributes to the reduction (Radney & Jacobs, 1981). Yet, Honrado et al., (2006) demonstrated a slight tendency for increase in Class II malocclusions with the AC suture which was a contributing factor.

3.6.8.5 Changes caused by the Le Fort 1 maxillary advancement osteotomy in the angular measurements of nasal morphology

The lack of change in the apical nasal angle reflected the absence of significant change in columella inclination. The nasal tip angle increased significantly by 1.19±2.84°, reflecting the greater relative nasal tip elevation and larger relative subnasale advancement and thus, larger vertical frontal nostril exposure. Vertical A point change explained 6% and 5% of the change in these angles, respectively in a weak positive correlation. The apical nasal angle and nasal tip angle decreased 0.55° and 0.32° for every millimetre of A point impaction, in a weak correlation, and increased 0.09° and 1.38° due to the surgery itself.

3.6.8.6 Changes caused by the Le Fort 1 maxillary advancement osteotomy in the nasal dorsum

Pronasale projection and elevation increased the dorsal contour angle by 2.48±3.22° and reduced the lower dorsal convexity by 0.24±0.47 mm. Esenlik et al. (2011) however, did not detect significant changes in the lower dorsal convexity in both their Turkish advancement and the advancement and impaction groups, despite the alteration in nasal tip position, although they did not perform anterior nasal spine recontouring in all cases.

The depth of the supratip break averaged 0.061±1.09 mm before surgery and -0.55±1.13 mm post-surgery. Thus, nasal tip elevation and advancement that accompany maxillary advancement surgery significantly increased the depth of this landmark relative to the soft tissue nasion-pronasale line by 0.62±0.70 mm (T3-T2). Esenlik et al. (2011) did not detect a significant change in the depth of the supratip break in their group subjected to 5.25±2.4 mm of maxillary advancement with a minimal impaction of 0.11 ±1.2 mm. However, they observed a 0.5±0.54 mm deepening relative to the soft tissue nasion-pronasale line in their group of maxillary advancement with 3.48±1.46 mm impaction due to the greater nasal tip elevation in this group. De Assis et al. (1996), using the subjective classification of present or absent, noted a greater presence of the supratip break together with nasal tip elevation and advancement after maxillary impaction with or without advancement, AC-VY closure and anterior nasal spine resection in women with vertical maxillary excess. Choi et al. (2014) stated that bimaxillary surgery with posterior maxillary impaction without advancement caused a slight cephalic nasal tip rotation and supratip break deepening, although the measurement method was not mentioned. Park et al. (2012) stated that bimaxillary surgery including maxillary advancement and impaction and AC-VY reconstruction rotated the nasal tip antero-superiorly and made the supratip depression prominent but did not measure this variable.

Although pronasale projection and elevation increased the relative depth of the supratip break point in this investigation, the supratip break angle decreased 2.75±3.93° from its presurgical value of 7.10±5.13° to its post-surgical value of 4.36±5.67° revealing that this point advanced more than the mid-dorsum.

Also, no correlation was revealed between the skeletal variables and the changes in the linear and angular supratip break measurements. Gassman et al. (1989) also concluded that the supratip angle measured between the dorsal tangent and the supratip tangent was not influenced by sagittal and vertical A point movement or by the degree of maxillary rotation. They stated that it changed significantly after larger maxillary advancements but did not specify the direction of this change and did not present results.

The soft tissue thickness at rhinion did not change significantly. However, the upper dorsal convexity decreased 0.24±1.12 mm relative to the dorsal axis due to supratip break advancement. Esenlik et al. (2011) also verified a reduction in the upper dorsal convexity after both maxillary advancement and impaction and isolated advancement although it correlated weakly with A point advancement only in the former group. In this study, the upper dorsal convexity did not demonstrate any significant correlation with the maxillary surgical movements evaluated.

Esenlik et al. (2011) cautioned against the sub-millimetric results obtained at the level of the *hump* and supratip depression, despite their statistical significance. Mansour et al. (1983) declared that patients treated with Le Fort 1 advancement, with or without posterior impaction, did not demonstrate changes above the nasal tip, after failing to detect sagittal or vertical alterations in points located at 1/3 and 2/3 the nasal length. Cone beam computerized tomography demonstrated minimal vertical and lateral and no sagittal change in the dorsum after maxillary advancement and impaction osteotomy with the AC suture and anterior nasal spine recontouring (Almukhtar et al., 2016). Laser scans also demonstrated that bimaxillary surgery in Class II division 1 malocclusions caused little movement at the dorsum (Moss et al., 1994). However, while the nasal dorsum may be minimally affected by maxillary surgery, modifications in the spatial relationship of adjacent structures can affect its relative balance and proportion. As such, inferior nasal tip rotation accentuates the dorsum. Nasal tip elevation caused by maxillary advancement or impaction surgery can easily camouflage a small hump but will accentuate a dorsal deficiency (Esenlik et al., 2011; Mitchell et al., 2007; Schendel & Carlotti, 1991). Similarly, nasal tip projection after maxillary advancement can prevent the need for hump removal (Altman & Oeltjen, 2007; Rosen, 1988).

3.6.9 Differences between genders in the effects of Le Fort I maxillary advancement osteotomy on the nose.

The magnitudes of sagittal, vertical and rotational maxillary movements were similar in both genders. Very few gender-based differences were detected for the changes in the frontal nasal variables. Women exhibited a greater increase in the bilateral width of the nostril floor and inferior alar angle and a larger reduction in the frontal nasal length/morphological width and frontal nasal height/morphological width ratio. No differences were detected in the profile variables.

Liebregts et al. (2016) observed that gender did not influence interalar widening after advancement with and without vertical rotation and either the AC, VY or ACVY closure. Ubaya et al. (2012) concluded that although alar base width increased in both genders, only women demonstrated a more obtuse alar curvature-nasal tip-alar curvature angle in the basal view than a gender-specific control group, after maxillary advancement surgery performed with or without anterior nasal spine recontouring or the AC suture.

Males have larger noses in the vertical, sagittal, and transverse dimensions (Ferrario et al., 1994; Li et al., 2014; Park et al., 2014). However, the angles that describe nasal form and rotation are generally similar in both genders (Hwang et al., 2002; Sforza et al., 2011; Starck & Epker, 1996). The first part of this investigation demonstrated that the supratip break angle and the lower dorsal convexity were larger in men with class III malocclusion than in women. Both these variables were reduced by the surgery and thus the change, although similar may have a different effect on male and female noses.

The facial soft tissue layer is thicker in men than in women (Hu et al., 1999). Men generally have thicker skin than women, while females have thicker subcutaneous tissue than males (Kim et al., 2011; Louis et al., 2001). Age reduces skin thickness further in women (Kim et al., 2011). A thicker soft tissue layer may absorb a larger amount of skeletal movement without a perceptible change in soft tissue contour and produce smaller ratios of soft to hard tissue change (Abeltins & Jakobsone, 2011; Hu et al., 1999; Stella et al., 1989). Greater soft tissue thickness at the lower lip and pogonion in men cause smaller soft to hard tissue ratios after mandibular setback surgery (Hu et al., 1999). Higher percentages of soft tissue movement have been reported in women than in men which reached statistical significance at the upper lip (Mobarak et al., 2001), chin (Mobarak et al., 2001; Naoumova et al., 2008) and gnathion (Naoumova et al., 2008) after mandibular surgery. However, Chen et al. (2012) did not detect gender-based differences in soft-tissue profile changes after vertical ramus setback osteotomy.

Authors suggest that gender-based data should be used to improve prediction accuracy (Hu et al., 1999; Naoumova et al., 2008). While this may hold true for the face, maxillary advancement osteotomy affected the nasal profile similarly in both genders, even at the level of subnasale. Maxillary surgery reveals lower ratios than mandibular surgery due to a variety of factors, including the dead space and surgical technique that may overcome gender-based differences in soft tissue morphology. Hence, separate ratios were not calculated for men and women.

3.6.10 The use of sagittal and vertical A point movement and the change in maxillary inclination to predict the alteration in the nasal variables

The change in many variables including nasal protrusion did not reveal significant correlations with the skeletal variables. A point advancement was responsible for less than 10% of the variation in the morphological width, left dorsal axis-alare distance and inferior alar angle. The vertical maxillary change explained 10% or less of the variations in the alar slope and the superior alar angles.

In profile, A point advancement and vertical change could together explain 14% of the variation in nasal height and 9% that of columella depth. A point advancement alone accounted for ≤ 5% of the variability in the columella-lobule and nasal projection angles, while its vertical change was responsible for ≤ 6% of the variation in the apical nasal, columella rotation and nasal tip angles. While the change in maxillary inclination was not an important factor for any of the frontal variables, together with A point advancement, it explained 7% of the variability of columella exposure.

Maxillary movement could explain some of the profile variables to a slightly better extent. A point advancement and vertical change together accounted for 30%, 28% and 25% of the alterations in nasal, subnasale and nostril projections, respectively and 18% that of the vertical subnasale position and the nasolabial angle. Sagittal maxillary advancement accounted for 19% of the variability in the sagittal pronasale and subnasale positions. Hence, most of the change was left unexplained, with the surgical procedure itself contributing to alterations.

A general consensus exists regarding the difficulty in predicting nasal changes following Le Fort 1 maxillary advancement osteotomy (Eales et al., 1994; Esenlik et al., 2011). Even if the modifications may be predicted in a general manner, they are difficult to quantify (Marşan et al., 2015). Researchers confirm that the surgical procedure including the amount of soft tissue dissection and especially the handling of the vestibular incision can influence soft tissue changes more than the surgical bone movement itself (Betts et al., 1993; Louis et al., 2001; McCollum et al., 2009). Septal trimming during concomitant maxillary impaction affects tip position, as primary tip support is provided by the septum and medial crura (Mitchell et al., 2007). The resection or recontouring of the anterior nasal spine also influences subnasale projection and nasal tip support (Freihofer, 1977; Khamashta-Ledezma & Naini, 2015; Louis et al., 2001; Mansour et al., 1983; Rosen, 1988; Westermark et al., 1991). The AC suture used in this study also contributes to the variation in width, the nasolabial angle and frontal nostril exposure (Shoji et al., 2012; Worasakwutiphong et al., 2015). This suture can be applied in varying degrees of laxity or tension (Guymon et al., 1988; Yamada et al., 2010) depending on the surgeon´s evaluation of the pre-surgical alar base width (Hackney et al., 1988; Mommaerts et al., 1997; Ryckman et al., 2010).

The pre-surgical nasal morphology conditions the nasal response to maxillary surgery (Betts et al., 1993; Chung et al., 2008; McFarlane et al., 1995; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991). The highly variable nasal morphology and skeleto-cartilaginous composition contributes to a complex soft tissue response to skeletal change (Esenlik et al., 2011; Gassmann et al., 1989). Patients exhibit large variations in the soft tissue layer, musculature and nasal tip support (Altman & Oeltjen, 2007; Gassmann et al., 1989; Rauso et al., 2011). Firm soft tissue union at the nasal base can result in lower ratios at subnasale (Altug-Atac et al., 2008; Lin & Kerr, 1998). A dead space between the upper dentoalveolar structures and lip can cause less soft tissue movement (Altug-Atac et al., 2008; Chew, 2005; Louis et al., 2001; Stella et al., 1989). In the absence of a dead space, advancements of great magnitude cause soft tissue tension generating lower ratios (Carlotti et al., 1986; Chew, 2005). Post-surgical soft tissue healing (Altug-Atac et al., 2008; Becker et al., 2014; Esenlik et al., 2011; Gassmann et al., 1989; Louis et al., 2001; Moroi et al., 2014), surgical stability and relapse (Becker

et al., 2014; Louis et al., 2001) and orthodontic tooth movement (Betts et al., 1993; Louis et al., 2001) can also influence results.

The ratios calculated indicated that pronasale and subnasale advanced 0.23 mm and 0.5 mm and elevated 0.31 and 0.19 mm, respectively, for every millimetre of A point advancement. The morphological width of the nose and alar base width enlarged 0.60 and 0.61 mm, respectively, for each millimetre of A point advancement. Yet, the complex interaction of surgical dissection, vector of bone movement, soft-tissue healing and individual variation in nasal morphology and skin type make it difficult to predict the post-operative nasal appearance (Gassmann et al., 1989). Moreover, there is often difficulty in executing the surgical procedure exactly as planned (Mobarak et al., 2001). Any Le Fort 1 maxillary surgery will always incorporate some degree of sagittal and vertical motion, regardless of the skill and intent of the surgeon (Mansour et al., 1983; Muradin et al., 2011; Sarver & Weissman, 1991). Hence, while ratios were calculated to determine the response of key soft tissue variables to the maxillary movement, these serve only as a guideline and do not account for the variability in the individual response to surgery.

3.7 Clinical considerations

Patients should be informed of the nasal morphological changes that usually accompany maxillary surgery as these may be inaesthetic, depending on the initial nasal appearance (Altman & Oeltjen, 2007; DeSesa et al., 2016; Hellak et al., 2015; Mitchell et al., 2007; Rosen, 1988). They must be made aware that, in some cases, future nasal surgery may be required to achieve cosmetically pleasing results (Honrado et al., 2006; Rauso et al., 2011).

Maxillary advancement osteotomy widens the nose transversely, increases the columella depth, accentuates the supratip depression due to nasal tip projection and elevation and reduces the nasolabial angle (Altman & Oeltjen, 2007; Dann et al., 1976; Mommaerts et al., 1997; Rauso et al., 2011; Tartaro et al., 2008). Greater nasal tip elevation than that at subnasale may increase frontal nostril exposure resulting in a ´Miss Piggy` appearance (Mitchell et al., 2007; Schendel & Carlotti, 1991). However, the tip elevation can be beneficial in a person with inferior tip rotation and together with tip projection can reduce the subjective appearance of a larger dorsal *hump* (Altman & Oeltjen, 2007; Mitchell et al., 2007; Schendel & Carlotti, 1991).

Howley et al. (2011) stated that patients should be informed of the probability of a 2-3 mm alar base widening. Widening may actually be desirable in a very narrow nose (Honrado et al., 2006; Ritto et al., 2011; Schendel & Carlotti, 1991; Stewart & Edler, 2011; Ubaya et al., 2012). While the alar cinch suture may control unwanted widening to a certain degree, it also increases frontal nostril exposure. Hence, the amount of tension in the suture is guided by the pre-surgical morphology, but is another confounding factor in predicting post-surgical width (Hackney et al., 1988; O'Ryan & Carlotti, 1989).

Thus, special care has to be taken while performing maxillary advancement surgery in patients with adverse pre-surgical parameters, such as a prominent tip and broad alar bases, interalar width and nostrils (DeSesa et al., 2016). Moreover, individual soft tissue and muscular variability and variation in the surgical

soft tissue manipulation and healing make the nasal changes difficult to predict. The soft tissue changes can depend more on the position and method of closure of the soft tissue incision than on the surgical bone movement itself (Altman & Oeltjen, 2007; Betts et al., 1993; Phillips et al., 1986). Soft tissue response to surgical dissection, the degloving of the lower lateral cartilages and the separation of the nasal septum as well as healing and scar tissue formation can influence the outcomes of Le Fort 1 surgery (Esenlik et al., 2011). This difficulty is compounded by the difficulty in executing the surgical procedure exactly as planned and variability in skeletal stability among patients operated with the same procedure (Mobarak et al., 2001). Post-surgical orthodontic treatment itself can affect upper lip prominence and its relationship with the nose (Betts et al., 1993). Hence, while the expected alterations can be communicated to the patient and the ratios can serve as a general guide for soft tissue movement, both the clinician and the patient must bear in mind that, due to the interaction of multiple factors, the exact final nasal morphology is difficult to predict.

3.8 Conclusions

1. Le Fort 1 maxillary advancement osteotomy significantly increased the nasal root width, morphological width, alar base width, bilateral width of the nostril floor, nasal base widths, columella width, subnasale-alare distances, diagonal nostril widths, dorsal axis-alare distances and the alar slope, superior alar and inferior alar angles in the frontal photographs. The frontal nasal length, frontal nasal length/morphological width ratio, frontal nasal height/morphological ratio and lateral alar angle significantly decreased.
2. In the profile view, nasal height, nasal length, depth of the supratip break, upper and lower dorsal convexities, nasal, subnasale and nostril projections, nasal protrusion, vertical position of points pronasale and subnasale and the nasal prominence, supratip break, nasolabial and nasal tip rotation angles significantly decreased. The columella depth, the sagittal positions of point pronasale and subnasale and the nasal tip, nasal projection and dorsal contour angles increased.
3. Women exhibited a greater increase in the bilateral width of the nostril floor and inferior alar angle and a larger reduction in the frontal nasal length/morphological width and frontal nasal height/morphological width ratios than men.
4. Skeletal maxillary movement could not explain more than 10% of the alteration in any of the frontal variables or more than 30% of the change in any of the profile variables.
5. Sagittal maxillary advancement (A point) advanced pronasale and subnasale in ratios of 0.23:1 and 0.5:1, respectively. It elevated pronasale and subnasale in ratios of 0.31:1 and 0.19:1 respectively. The morphological width and alar base width increased with A point advancement in ratios of 0.60:1 and 0.61:1, respectively.

IV

The influence of Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose in subjects with Class III skeletal malocclusions

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4.1 Introduction

Patients cite dentofacial aesthetics as one of their main motives for seeking orthodontic-surgical treatment (Fabré et al., 2010; Finlay et al., 1995; Johnston et al., 2010; Juggins et al., 2005; Kiyak et al., 1981; Laufer et al., 1976; Rivera, Hatch, & Rugh, 2000). However, orthodontists often use Caucasian norms to assess aesthetics more objectively and may disagree with patients as to what this improvement entails (Giddon, 1983; Sushner, 1977; Vargo et al., 2003; Yin et al., 2014). Laypeople´s emotional perception of facial harmony is guided by their peers´ opinion and race, locality, time and media, dependent norms of beauty (Foster, 1973; Peck & Peck, 1970; Thomas, 1979; Yin et al., 2014). As patients are often unable to verbally express their feelings and expectations, investigations using panels are vital as they help find a physical basis for highly subjective adjectives such as "attractive" or "beautiful" and aid in patient-doctor communication (Giddon, 1995). They help in demarcating between clinician and patient preferences and in the shift from traditional, paternalistic treatment goals based on measurable outcomes to patient-centred ones (McKeta et al., 2012; Melo et al., 2017; Pişiren et al., 2018). The reconciliation of patients´ priorities and social influences with objective measurements leads to a scenario of treatment ´success` for all (Foster, 1973; McKeta et al., 2012; McKoy-White et al., 2006; Melo et al., 2017; Orsini et al., 2006). Determining the threshold of facial disharmony at which different panels seek surgical correction also helps clinicians meet patients' expectations and avoid unnecessary surgery (Pişiren et al., 2018). Thus, photographs, profile drawings and silhouettes help the orthodontist to understand the patient's own perception of his image and treatment need and to adjust therapy keeping in mind soft tissue response and ageing (Bonetti et al., 2011; Bullen et al., 2014; Kiyak & Zeitler, 1988). Rather than using golden rules of facial morphology, treatment planning should be tailored to the preferences of patients and of those close to them within biological limits (Nomura et al., 2009; Tole et al., 2014).

4.1.1 Factors that influence the assessment of facial aesthetics

4.1.1.1 Self-assessment

An individual´s perception of his own facial appearance is important because it affects his self-esteem more than the actual face morphology (Giddon, 1995; Korabik & Pitt, 1980; McKoy-White et al., 2006; Peck & Peck, 1970; Springer, Wiltfang, et al., 2012). Moreover, in a chicken and egg situation, psychological factors contribute to this self-perception. Adults with impaired well-being were more critical of their own appearance compared to equally attractive individuals without issues (Springer, Schulze, et al., 2012). Women with high self-esteem are more likely to mistakenly consider their own profiles ideal, while those with low self-

confidence do not, even if their images really are (Korabik & Pitt, 1980). Self-esteem displays a gender difference. Women generally have lower self-esteem and frequently express dissatisfaction with their appearance (Rivera, Hatch, & Rugh, 2000; Springer, Schulze, et al., 2012). Those requiring orthognathic surgery are unhappier with their dentofacial appearance than men and are more likely to see their profile in the mirror and consider it less attractive (Johnston et al., 2010). Chinese men diverged more from reality in their self-assessment than women, flattering themselves with aesthetic dentitions and more protrusive chins (Yin et al., 2014) .

Orthodontists´ assessment of the face and features such as the nose in frontal and profile photographs could not predict pre-surgical patients´ self-perception and satisfaction with their appearance (van Steenbergen et al., 1996). These feelings are often unrelated to objective measurements (Maxwell & Kiyak, 1991; van Steenbergen et al., 1996). Moreover, they affect patient motivation for surgical correction more than actual morphological anomalies (Giddon, 1995; Kiyak & Zeitler, 1988). Motivation essentially depends on the degree to which the patient perceives that his dentofacial appearance deviates from social and cultural norms (Mantzikos, 1998; Romani et al., 1993). People are less satisfied when they assess themselves as having a Class II or III discrepancy and thus, as different from the average (Al Taki & Guidoum, 2014; Johnston et al., 2010; Tufekci et al., 2008). They are also unhappier with their dental appearance when they evaluate themselves as having a Class III discrepancy (Tufekci et al., 2008). Bell et al. (1985) found that patients who opted for orthognathic surgery were more self-critical and evaluated themselves as having greater sagittal and vertical skeletal discrepancies in illustrative scales, while those who did not generally chose more ideal values.

The perception of others´ opinions affects a patient´s self-evaluation and treatment decision, enhancing the importance of psychological factors (Bell et al., 1985; Giddon, 1995). Chinese who tended to be less influenced by peers and social norms, selected more retrusive chins and a less attractive dentition in their self-assessment than individuals who were (Yin et al., 2014).

Self-perception also influences treatment expectations (Trehan et al., 2011) and satisfaction with surgical results (Giddon, 1995; Kiyak & Zeitler, 1988; van Steenbergen et al., 1996). Patients with a history of personality disorders, depression or anxiety or who are prone to make unrealistic comparisons between themselves and media-chosen images come with an inherent risk of low postoperative satisfaction, whatever the result obtained (Naini et al., 2006; Sarwer et al., 1998; Springer, Schulze, et al., 2012). About 10% to 15% of patients from all specialities suffer from body dysmorphism which causes an impairing preoccupation with a slight defect in appearance and dissatisfaction with surgical results (Springer, Schulze, et al., 2012).

Also, laypeople are usually unaware of their profile, unless it is specifically shown to them, as they do not see it in the mirror (Bell et al., 1985; Bonetti et al., 2011; Polk et al., 1995; Trehan et al., 2011; Tufekci et al., 2008; Yin et al., 2014). Almost half the general population cannot objectively describe their own profile (Al Taki & Guidoum, 2014; Tufekci et al., 2008). While 93% of mothers or parents of patients recognised profile anomalies in others, 43% could not identify their own mandibular position from a range of drawings (Korabik & Pitt, 1980; Pitt & Korabik, 1977). 65% of African Americans, including orthodontic patients, could not correctly select the profile silhouette that most resembled their own (Polk et al., 1995). Older patients are

more likely to have seen their own image in a mirror and are more self-critical (Johnston et al., 2010). However, they think they maintain their youthful lip protrusion despite age-related loss of volume and nose and chin growth (Bullen et al., 2014).

Hence, patients may not understand the clinician´s evaluation of their profile (Bonetti et al., 2011). They disagreed with clinicians and laypeople´s assessment of their profile jaw and dentoalveolar positions, although they could identify their frontal vertical dimension better in illustrative scales (Bell et al., 1985). Swedish women´s self-representative images also correlated poorly with actual profile measurements (Giddon et al., 1974).

Moreover, people tend to perceive themselves as being more beautiful than they really are (Mantzikos, 1998; Springer, Wiltfang, et al., 2012). While young men consistently considered all of their own features more attractive than judges, women regarded their own face, eyes, mouth and chin more attractive and did not differ from the judges only regarding their teeth and nose (Springer, Wiltfang, et al., 2012). Chinese men chose more protrusive chins as self-representative while women selected mildly convex, more feminine profiles (Yin et al., 2014).

85% of Chinese selected a straight self-representative silhouette although only 37% possessed this profile. 43.6% selected the first image in the aesthetic component of the Index of Orthodontic Treatment Need, although it could be applied to only 2.5% of them (Yin et al., 2014). Arabs also tended to select a straight profile silhouette which was present in only 51% of cases (Al Taki & Guidoum, 2014). Swedish women´s cardboard self-assessment profile correlated strongly with the one they considered ideal (Giddon et al., 1974). Orthodontic patients and laypeople´s ideal image revealed high correlations with their simulated self-image but very low ones with their actual profile (Hershon & Giddon, 1980).

Exposing patients to their own profile photograph may create self-awareness and reduce satisfaction (Bell et al., 1985; Bonetti et al., 2011; Bullen et al., 2014; Johnston et al., 2010). Viewing their own frontal and profile photographs made 50% of laypeople consider their profiles less attractive and 11% and 45% more motivated to change their smiles and profiles respectively (Bonetti et al., 2011). Johnston et al. (2010) found that patients with Class III malocclusions were more likely to have seen their mirror image than those with Class II discrepancies although perhaps this was because the former group contained more women.

Also, laypeople concentrate on specific features in their faces. Mantzikos (1998) concluded that the few who did think about their profile wanted to change isolated features such as lip thickness, nose contour or a double chin. 36% of African Americans of both genders also wished to modify specific features, which most frequently encompassed the lips, chin, nose or a combination of these, although 45% of the women disliked their entire profile (Polk et al., 1995). Marked features such as a larger chin and protrusive lips generally lead to the most correct self-assessments (Hershon & Giddon, 1980).

The level of dental education affects self-evaluation (Al Taki & Guidoum, 2014; Tufekci et al., 2008). Third year dentistry students correctly picked their own profile silhouette type more frequently than first year students, orthodontic patients and laypeople (Tufekci et al., 2008). Trehan et al. (2011), however, demonstrated

that dental awareness bestowed both orthodontic patients and final year dentistry students with a greater capacity to identify their own profile silhouette type than first year students and laypeople.

Orthodontic patients receive additional information right from their very first consultation (Trehan et al., 2011). They are more self-critical prior to treatment and revealed a larger disparity than laypeople between at least one of their actual facial lower third features and the rendition of that feature that they found the most pleasing in their own warped profiles images (Kitay et al., 1999). Pre-treatment surgical patients selected self-representative profiles that were divergent in several or all dimensions, even when their anomaly was limited to only one (Kiyak & Zeitler, 1988). They also understood mandibular and vertical anomalies better but characterized their maxillary deformities as a mandibular one in the opposite direction. Dissatisfaction and the desire for change made pre-treatment African American women chose a fuller profile photograph than reality in their self-assessment, while viewing sequential modifications between extreme bimaxillary protrusion and retrusion (McKoy-White et al., 2006). Greater orthodontic sophistication and awareness of treatment induced change led to greater accuracy in selecting their posttreatment image. Yet, Hershon and Giddon (1980) observed that post-treatment patients were more critical and overestimated their treatment-corrected lip protrusion. Kiyak and Zeitlar (1988) revealed that, two years after treatment, while other patients tended to choose normal profiles and focus on minor deviations in other facial features, a possible residual chin prominence made those treated for maxillary deficiency continue to focus on their ´protrusive mandible`.

4.1.1.2 Assessment by panels

Types of panels

Differences between dental professionals and laypeople

Profile assessment encompasses not only the relationship between the nose, lips and chin but additional factors such as race, gender, age and facial expression (Thomas, 1979). Hair style and colour, complexion, eyes and nasal shape are influencing factors (Abu Arqoub & Al-Khateeb, 2011; Fabré et al., 2009; Maple et al., 2005; Melo et al., 2017; Spyropoulos & Halazonetis, 2001). Photographs, unlike drawings and silhouettes, display these features and hence, detect differences between panels more easily (Abu Arqoub & Al-Khateeb, 2011; Falkensammer et al., 2014; Shelly et al., 2000; Spyropoulos & Halazonetis, 2001).

Clinicians demonstrate better assessment skills, higher inter-observer agreement and excellent reproducibility in their evaluations (Naini, Cobourne, et al., 2015, 2016c; Naini, Donaldson, et al., 2012). Conversely, laypeople´s tendency to evaluate global facial aesthetics can cause greater variability (Fabré et al., 2009; Hershon & Giddon, 1980; van Steenbergen et al., 1996). Orthodontists were more reliable than even oral surgeons, while laypeople tended to be the least consistent in scoring profile silhouettes before and after mandibular advancement surgery using a Likert scale (Tsang et al., 2009). Yet, laypeople were more reliable than both groups of clinicians while using a VAS to evaluate the attractiveness of profile photographs with vertical maxillary or sagittal jaw modifications (Maple et al., 2005).

Orthodontists and oral surgeons focus their attention primarily on the profile and over evaluate the lips, dentoalveolar region and chin (Chan et al., 2008; Fabré et al., 2009; Hershon & Giddon, 1980; Maple et al.,

2005; van Steenbergen et al., 1996). However, laypeople quickly punctuate their initial assessment of the entire face, giving little importance to the profile contour (Maple et al., 2005). As they do not see their profile in the mirror and but only in photographs (Bonetti et al., 2011; Lundström et al., 1989; Maple et al., 2005; van Steenbergen et al., 1996), they have difficulty assessing this view (Bell et al., 1985; Giddon, 1983; Spyropoulos & Halazonetis, 2001; Vargo et al., 2003; Wilmot et al., 1993). While laypeople and the subjects themselves did not distinguish between African origin Brazilians´ frontal and profile photographs, orthodontists agreed with them only on frontal attractiveness due to their ease in detecting skeletal discrepancies in profile (Melo et al., 2017).

Burcal et al. (1987) suggested that within the lower facial third, orthodontists and oral surgeons pay greater attention to the chin and laypeople to the mouth. Saudi Arabian dental students, dentists, oral surgeons and orthodontists believed that profile attractiveness in silhouettes depended most on the mandible, while laypeople gave more importance to the nose (Al Taki & Guidoum, 2014). Yet, given the option, orthodontists chose collective units of both the lips and chin, while the majority of dental students and laypeople focused on only one or two of these features (Chan et al., 2008) . In another Chinese study, 90.3% of orthodontists and oral surgeons, 67% of dental students and 52.6% of laypeople chose both the lips and chin (Soh et al., 2005a). In both investigations, all panels found the chin more important than the lips. However, the presence of a smile generally overshadows all other facial features (Godinho et al., 2020).

Yet, the media´s influence may make both laypeople and orthodontists prefer a class I profile (Chan et al., 2008; Farrow et al., 1993; Orsini et al., 2006). First year dentistry students and dentists preferred an androgenic normocephalic, class I profile silhouette (De Smit & Dermaut, 1984). Orthognathic profiles were favoured in Caucasian photographs (Dongieux & Sassouni, 1980; Falkensammer et al., 2014). Orthodontists and Caucasian laypeople preferred Class I and bimaxillary retrusive Chinese profiles (Chan et al., 2008).

Other authors suggest that clinicians demonstrate a greater bias towards Class I profiles. Orthodontists and oral surgeons preferred class I profile photographs more than laypeople when evaluating modifications in vertical maxillary or sagittal jaw positions (Maple et al., 2005). Compared to orthodontists, laypeople were more tolerant of greater profile convexity in male photographs (Barroso et al., 2012) and preferred more convex profile silhouettes in Japanese women (Murakami et al., 2016). Between the two favourites, orthodontists and oral surgeons preferred bimaxillary retrusion to the Chinese norm more than dental students and laypeople in profile photographs (Soh et al., 2005a). Orthodontists attributed better scores than laypeople to the favourite straight Arab profile silhouette (Al Taki & Guidoum, 2014).

Orsini et al. (2006) concluded that Caucasian orthodontists favoured a more anterior mandibular position than Caucasian and Japanese laypeople in both genders and races. However, in the implicit association test, orthodontists tolerated prognathism only for the Japanese woman. Laypeople were less critical of prognathism than retrognathism in all men but revealed the opposite for the Caucasian woman. Conversely, laypeople were more tolerant of Chinese female mandibular prognathism although all panels considered it the least attractive profile in photographs of both genders (Soh et al., 2005a). Laypeople were also more tolerant of female

mandibular prognathism than orthodontists when evaluating Arabian profile silhouettes of both genders (Al Taki & Guidoum, 2014).

Orthodontists and laypeople may prefer similar lip positions. Both preferred lip protrusion to camouflage a prognathic jaw in female Japanese silhouettes, especially for longer faces that accentuate prognathism and favoured lip retrusion in the excessively convex short profile with a retrusive mandible (Murakami et al., 2016). Orthodontists and Caucasian and African American laypeople preferred lips that were slightly more protrusive than white norms but more retrusive than ethnic ones in African American profile photographs (Farrow et al., 1993).

Orthodontists generally tend to dislike pre-treatment appearance more than laypeople (Kiekens et al., 2005). Orthodontists and oral surgeons, using illustrative scales, were more critical of frontal and profile photographs with modified sagittal and vertical jaw positions than laypeople (Bell et al., 1985). Orthodontists and maxillofacial surgeons were more disparaging of sagittal soft tissue pogonion modifications in Caucasian and Black photographs (de Almeida et al., 2010). Orthodontists were also less tolerant than laypeople when using a VAS to evaluate profile photographs of adults with skeletal Class I or III relationships (Fabré et al., 2009). 35 to 35 year old orthodontists were more critical of Class II profile silhouettes than laypeople (Klaus, Heumann, & Ruf, 2017). Orthodontists and dental students attributed lower scores on a 5 point scale than art students and patients´ parents to adolescents with different types of malocclusion (Kerr & O'Donnell, 2014). Clinicians and orthognathic surgery patients disapproved more of mandibular and chin asymmetries in frontal facial images than laypeople (Naini, Donaldson, et al., 2012a).

Orthodontists and maxillofacial surgeons recommended treatment for advanced, setback or vertically rotated jaws in Caucasian photographs more than laypeople and third and fifth-year dental students (Falkensammer et al., 2014). Orthodontists were twice as likely as laypeople to desire correction of modified chin or chin and lower lip prominence in silhouettes (Modarai, Donaldson, & Naini, 2013). Maxillofacial surgeons recommended surgery even more than orthodontists, and laypeople the least for modified mandibular sagittal position in Caucasian and Black profile photographs (de Almeida & Bittencourt, 2009).

As their higher standards make orthodontists run the peril of overtreating smaller discrepancies, authors recommend a calculated assessment between aesthetic improvement and surgical risk, keeping in mind laypeople´s less stringent requirements (Fabré et al., 2009; Falkensammer et al., 2014). When they considered profile photographs with mandibular prognathism their own, orthodontists and maxillofacial surgeons recommended surgery less often due to their knowledge of treatment complexity, while lack of information had the same effect on laypeople and artists (de Almeida & Bittencourt, 2009).

However, Torsello et al. (2010) suggested that their greater exposure to profile anomalies makes clinicians more generous than laypeople. Orthodontists attributed higher scores than laypeople to women's profile photographs and while both panels evaluated attractive warped faces with the same average soft tissue outline similarly, orthodontist´s focus on the identical profile rather than the whole face made them more generous for less attractive ones (Spyropoulos & Halazonetis, 2001). Orthodontists and maxillofacial surgeons were more benevolent than 1st year dental students when using a VAS to evaluate skeletal class II patients´

frontal and profile photographs taken before and after orthodontic camouflage or surgery (Phillips, Trentini & Douvartzidis, 1992). Orthodontists also attributed higher VAS scores than laypeople when either nose or chin protrusion was varied along with lip position in a woman´s profile photograph (Torsello et al., 2010). Maxillofacial surgeons and orthodontists were less critical of nasal dorsum variations in a Caucasian male silhouette than laypeople. While laypeople, surgical patients and clinicians recommended rhinoplasty at a similar level of flatness, they exhibited progressively increasing tolerance for the *hump* (Naini, Cobourne, et al., 2016b). Clinicians chose surgery to treat all submentocervical angle variations in profile silhouettes less often than laypeople and patients (Naini, Cobourne, et al., 2016c).

Some authors conclude that the panels may evaluate treatment results in a similar manner. Laypeople and plastic surgeons did not differ in the evaluation of frontal, oblique and profile photographs of patients who had undergone nasal reconstructive surgery (Moolenburgh et al., 2008b). Laypeople and orthodontic residents attributed similar scores to the initial attractiveness and the change in attractiveness caused by mandibular advancement surgery in silhouettes (Shelly et al., 2000). Laypeople did not differ from orthodontists and maxillofacial surgeons and post-graduate students in these areas in assessing the magnitude of improvement caused by orthodontic camouflage or surgery in frontal and profile photographs of skeletal class II patients using a VAS (Phillips, Trentini & Douvartzidis, 1992). Both orthodontists and laypeople detected a 12.6% VAS aesthetic improvement in profile silhouettes after bimaxillary, mandibular advancement or maxillary impaction surgery with or without genioplasty to treat Class II malocclusions (Klaus et al., 2017).

Other authors suggest that, due to their knowledge of treatment complexity and the variability in soft tissue response, oral surgeons and orthodontists are more generous when evaluating surgical results and accept smaller improvements or greater divergences from the norm (Chew et al., 2007; Montini et al., 2007). The lower ability to detect post-treatment change makes laypeople more critical of results (Barroso et al., 2012; Burcal et al., 1987; Montini et al., 2007). They may also be distracted by other features, such as the nose (Montini et al., 2007). Orthodontists and laypeople detected postural mandibular advancement in the profile photographs of a man with severe retrusion at 2 and only after 4 mm, respectively (Barroso et al., 2012). In another study, 51% of laypeople and 64% of orthodontists and oral surgeons detected a 4 mm mandibular advancement in profile photographs of both genders while 44% and 50%, respectively, recognized a 4 mm setback (Burcal et al., 1987). More than two-thirds of the lay people and 82% and 85% of clinicians detected 6 mm setbacks and advancement, respectively. However, although orthodontists were more sensitive to sagittal mandibular changes than laypeople and exhibited similar sensitivity for sagittal maxillary movements in frontal and profile photographs, their tendency to focus on a gingival smile or incisal exposure that were not visible in the photographs made them less efficient in detecting vertical maxillary movements especially in women (Romani et al., 1993).

While art students, parents and dental students were aware of a change in frontal and profile images of adolescents treated for Class II Division 1, only orthodontists noted an improvement in Class Ill faces (Kerr & O'Donnell, 2014). Oral surgeons and orthodontists found profile contour drawings of Chinese operated for various skeletal discrepancies more attractive than laypeople (Chew, Sandham, et al.,2007). Laypeople were

more critical of the results of isolated maxillary advancement and mandibular setback surgeries in Class III patients´ profile photographs than orthodontists and maxillofacial surgeons, although the panels did not differ regarding bimaxillary surgery (Fabré et al., 2010). Tsang et al. (2009) concluded that orthodontists and oral surgeons considered profile silhouettes more attractive even after minor mandibular advancement, whereas laypeople were less aware of change and disliked post-treatment aesthetics even in some severe initial Class II discrepancies. Montini et al. (2007) observed that orthodontists considered that profile silhouettes improved more frequently, followed by oral surgeons and finally by laypeople, after similar surgery. Yet, their higher expectations and focus on areas that are difficult to reconstruct made plastic surgeons more critical of post-nasal reconstruction facial photographs than laypeople using a 5-point Likert scale (Moolenburgh et al., 2008a).

Moreover, age, sex, socioeconomic level and culture affect individual perception (Faverani et al., 2013, Mantzikos, 1998). Thus, a low concordance within the panels of orthodontists and laypeople may indicate that beauty is in part a personal issue (Marchiori et al., 2015).

Panels consisting of patients

Patients are not synonymous with laypeople (McKeta et al., 2012; Sena et al., 2017). Their skeletal discrepancies make them more sensitive to facial anomalies and more reliable evaluators (Naini, Cobourne, et al., 2016c; Naini, Donaldson, et al., 2012). Sari-Rieger and Rustemeyer (2015) highlighted patients´ unique preferences when they did not share the high correlations seen between orthodontists, maxillofacial surgeons and laypeople in evaluating the surgical improvement of Class III aesthetics.

Pre-treatment orthodontic-surgical patients may be more critical and perceive a greater treatment need in others (Burcal et al., 1987; Naini, Donaldson, et al., 2012). Patients and clinicians were more critical of mandibular and chin asymmetries in frontal facial images than laypeople (Naini, Donaldson, et al., 2012a). Patients were the most critical of modified pogonion position in profile silhouettes amongst panels of laypeople, maxillofacial surgeons and orthodontists (Naini, Donaldson, et al., 2012c). In another study, clinicians scored concave profile silhouettes higher than patients and recommended their surgical correction less frequently than laypeople and even less frequently than patients (Naini, Donaldson, et al., 2012). Laypeople were less critical of profile convexity than the other panels and even of concavity compared to patients. Patients´ upper threshold level for correction of upper lip inclination relative to the columella was lower than for laypeople, orthodontists and maxillofacial surgeons although all panels exhibited a similar lower threshold (Naini et al., 2015). Patients, laypeople and surgeons required progressively larger submentocervical angles in profile silhouettes to recommend surgery (Naini, Cobourne, et al., 2016 c). In the latter two investigations, clinicians were the least likely to suggest surgery for all degrees of angles. Even after undergoing orthognathic surgery, patients, along with laypeople recommended surgical correction of sagittal soft tissue pogonion changes in photographs more often than clinicians (Pişiren et al., 2018). Plastic surgeons, laypeople and patients recommended the correction of female retrusion earlier than orthodontists and maxillofacial surgeons.

Patients are also more critical of their own pre-treatment images. Post-orthodontic treatment patients rated both function and aesthetics less favourably when viewing their own standard pre-treatment photographs, radiographs and study models, indicating greater treatment need than orthodontists who are used to treating truly difficult cases, although they were more benevolent than orthodontists for treatment results (McKeta et al., 2012). Prior to orthodontic treatment, dissatisfaction with their appearance led women of African descent to choose a fuller self-representative image than their true one, but greater orthodontic sophistication and awareness of change made them more accurate in selecting their posttreatment image (McKoy-White et al., 2006). Orthodontic-surgical patients are also less satisfied with their appearance than controls, although the complexity of the procedure may dissuade them from the surgical option (Johnston et al., 2010). Yet, Juggins et al. (2005) suggested that orthodontists and maxillofacial surgeons recognize a greater need for surgical correction than the patients themselves in their self-evaluation due to their emphasis on the quantitative profile analyses.

However, when patients do opt for treatment, they are highly aware of their goals. Patients with Class II and III malocclusions scheduled for mandibular surgery had a clear vision of desired aesthetics and were less tolerant of sagittal lip or chin or vertical chin deviations from this ideal than oral surgeons, significant others and orthodontists (Arpino et al., 1998).

Yet, orthodontic-surgical patients, clinicians and laypeople demonstrated similar preferences in their evaluation of soft tissue pogonion position in profile silhouettes (Naini, Donaldson, et al., 2012) and found similar values of the submentocervical angle (Naini, Cobourne, et al., 2016c) and nasolabial angle (Naini et al., 2015) acceptable. However, orthodontists preferred the orthognathic Turkish male profile more than orthodontic patients did (Türkkahraman & Gökalp, 2004).

Panels consisting of patients´ parents

Patients´ parents generally form a less critical group. They were less consistent in their evaluation and considered more intra-oral photographs and profile line-drawings acceptable and unneedful of orthodontic treatment than dentists and orthodontists did (Prahl-Andersen et al., 1979). Like patients, they demonstrated a smaller predilection for orthognathic profiles in Turks than orthodontists (Türkkahraman & Gökalp, 2004). They were more generous in evaluating bi-alveolar retrusion than orthodontists and Class II and III profiles with mandibular anomalies than both dentists and orthodontists in a woman. They tolerated the Class III profile with bimaxillary anomalies more than orthodontists in women and both dentists and orthodontists in men. However, 93% of parents demonstrated a notion of the orthodontic concept of the ideal when evaluating profile drawings with varying degrees of mandibular prognathism (Pitt & Korabik, 1977).

Panels consisting of dentists

General dentists possess a smaller diagnostic capacity than specialists (Abu Arqoub & Al-Khateeb, 2011; Falkensammer et al., 2014). Yet, dentists were more critical of initial aesthetics, function and treatment

need in standard patient records than orthodontists who are used to treating difficult cases. Both dentists and prosthodontists, who represent orthodontists´ referral base, were more demanding regarding final aesthetics and function (McKeta et al., 2012). However, dentists and orthodontists revealed perfect agreement in the evaluation of skeletally and dentally modified Turkish profile images of both genders (Türkkahraman & Gökalp, 2004).

Dentists differ from laypeople in their aesthetic preferences and detect profile discrepancies with greater ease due to their knowledge of facial malformation and larger exposure to anomalies (Abu Arqoub & Al-Khateeb, 2011; Falkensammer et al., 2014). Jordanian dentists considered the favourite normocephalic photograph more attractive but were less critical of a reduced lower facial height in a Class I male profile than laypeople (Abu Arqoub & Al-Khateeb, 2011). Surprisingly, Chinese dentists considered having an attractive facial profile or chin less important than patients and dental students (Jiang et al., 2018).

Panels consisting of dental students

While dental students may share laypeople´s and clinicians´ preference for a Class I normocephalic Caucasian profile, the lack of postgraduate training essential for ‘‘orthopaedic awareness’’ and better profile perception makes them comparable to laypeople in rating attractiveness and treatment need (Falkensammer et al., 2014). Thus, dental students could detect treatment induced change in profile and frontal images of Class II Division 1 patients, but, unlike orthodontists, failed to do so in Class III faces (Kerr & O'Donnell, 2014). Third and fifth-year dental students recommended treatment for advanced, setback or vertically rotated jaws in Caucasian photographs less than clinicians (Falkensammer et al., 2014).

As dental students are often used as lay evaluators, investigations that use both as panels are rare. However, both dental students and laypeople agreed when selecting the most and least attractive lip positions in silhouettes and profile photographs of a woman of African origin (Pithon et al., 2014). Both panels ranked normal and bimaxillary retrusive profiles the most attractive and mandibular protrusion the least attractive in Chinese profile photographs (Soh et al., 2005a). However, dental students disliked the latter profile more and considered female maxillary protrusion more attractive than laypeople. Students also differed from dentists in evaluating Chinese profile silhouettes. While a slightly longer chin was preferred by both in men and by dentists in women, students referred an average female vertical dimension (Jiang et al., 2018). Dentists favoured mild male protrusion more than students, while both liked the neutral sagittal chin position in women.

Dental students may tolerate shorter profiles better than specialists, especially in women. In Caucasians, clinical dental students and clinicians considered hyperdivergent and hypodivergent profiles the least attractive, respectively (Falkensammer et al., 2014). Unlike Japanese orthodontists who preferred profile silhouettes with an average lower facial height, dental students chose this option in men but a slightly shorter height in women. While orthodontists recommended surgery more frequently for shorter faces than for longer ones they considered their own, students revealed the opposite trend in women and did not distinguish between the anomalies in men (Ioi et al., 2006). Dental students also favoured slightly more lip retrusion than orthodontists in Japanese profile silhouettes of both genders (Ioi et al., 2005).

Differences between surgeons and orthodontists

Orthodontists and maxillofacial surgeons use similar technical criteria to evaluate photographs (Sena et al., 2017). Both tend to use the soft tissue profile to assess orthodontic-surgical treatment need (Vargo et al., 2003). Both consider the mandible the most important feature in terms of the attractiveness of profile silhouettes (Al Taki & Guidoum, 2014) and possess a similar capacity to detect changes in its position in profile photographs (Burcal et al., 1987). Furthermore, both demonstrate consistency in evaluating the appearance of pre-treatment orthognathic surgery patients (Juggins et al., 2005). They also demonstrated a higher agreement between themselves than with laypeople when evaluating standard extra-oral photographs of such patients (Vargo et al., 2003).

Both panels prefer a neutral Class I profile in Caucasian photographs (Falkensammer et al., 2014; Maple et al., 2005) and a straight Arab profile silhouette (Al Taki & Guidoum, 2014). Both panels found the normal and bimaxillary retrusive profiles the most attractive in Chinese photographs, although orthodontists favoured bimaxillary retrusion less than oral surgeons in women but, unlike surgeons, preferred it in men (Soh et al., 2005b).

Surgeons may show a greater bias against Class II profiles than orthodontists. Maxillofacial surgeons and orthodontists considered the most exaggerated class II and III black profiles the least friendly, respectively (Sena et al., 2017). Al Taki and Guidom (2014) concluded that oral surgeons disfavoured mandibular retrognathism in profile silhouettes, while orthodontists disliked male mandibular prognathism and female bimaxillary retrusion. Lines et al. (1978) verified that oral surgeons preferred more prominent chins in comparison with panels including orthodontists. Yet, both Asian orthodontists and oral surgeons found mandibular protrusion the least attractive in Chinese profile photographs (Soh et al., 2005b). Pisiren et al. (2018) concluded that plastic surgeons recommended surgery for female mandibular retrusion earlier than orthodontists and maxillofacial surgeons in profile photographs but agreed with them regarding other anomalies in mandibular position in both genders.

Surgeons may be more demanding as they are used to rapid, radical surgical transformations unlike time-consuming orthodontic treatments that produce little skeletal change except for the interceptive orthopaedic phase (Arpino et al., 1998). Oral surgeons were less tolerant than orthodontists of progressive sagittal lip or chin changes or vertical chin changes, although the two panels did not differ significantly regarding the most pleasant image (Arpino et al., 1998). They also noted a greater surgical need than orthodontists, despite the very high correlations displayed in assessing various combinations of sagittal jaw position and vertical dimension in frontal and profile photographs (Bell et al., 1985). Juggins et al. (2005) also found that maxillofacial surgeons indicated a greater surgical need based on the facial appearance and function than orthodontists.

However, Maple et al. (2005) noted that oral surgeons tolerated extreme sagittal mandibular positions in profile photographs more often than orthodontists. Maxillofacial surgeons were also less sensitive to sagittal

jaw changes than orthodontists in Caucasian profile photographs (Falkensammer et al., 2014). The two groups agreed that deviations from norm are unattractive but disagreed on the absolute value of these deviations.

Variability within the panels consisting of specialists

Experienced surgeons varied greatly while drawing an ideal lower facial third profile contour (Freihofer & Mooren, 1997). Two orthodontists agreed only 60% when diagnosing malocclusion from soft tissue profile silhouettes (Tufekci et al., 2008). Another investigation revealed an even lower agreement of 26.67% between two surgeons and 36.67% between two orthodontists when classifying sagittal profile contour in postoperative photographs. The concordance was 40% and 36.67% for profile aesthetics, 40% and 13.3%, for frontal aesthetics and 33.33% and 80%, for the nasolabial angle, respectively (Faverani et al., 2013). While 47.5% of post-graduate orthodontic students and orthodontists correctly identified the skeletal class from profile photographs of both genders, only 32.75% could correctly classify the vertical pattern (Romero-Maroto et al., 2012). The level of training is important as board certified orthodontists may be more critical than non-specialist ones (Falkensammer et al., 2014).

4.1.1.3 Ethnicity

Patients, although considered a homogeneous group, often come from a heterogeneous mix of genetic and cultural origins (Mantzikos, 1998; Oliveira et al., 2015) Thus, treatment planning should consider the patient´s cultural background that serves as a backdrop for his aesthetic perception (Chong et al., 2014; McKoy-White et al., 2006). For instance, Asians may desire a more prominent nasal hump as much as people in other parts of the world wants its removal (Springer et al., 2008). Yet, individual preferences differ even within the same ethnicity (Bronfman et al., 2015; Mantzikos, 1998; Oliveira et al., 2015; Sy et al., 2016).

Studies using multi-racial panels reflect that race influences perception (McKoy-White et al., 2006). While all races preferred the Crumley 1 rather than the Crumley 2 and Goode nasal tip position in composite profiles of Caucasian women of average or above-average attractiveness, native Americans expressed this preference to a greater extent (Ahmed et al., 2014). First year dentistry students from Rio de Janeiro, with its 32% population of African-origin, preferred more protrusive lips in a woman´s modified photograph than those from the 81.5% Caucasian Rio Grande de Sul (Oliveira et al., 2015). Kenyans preferred greater lip protrusion in Caucasian, African American and Japanese male profile silhouettes than Hispanic Americans and Japanese and tended to do so more than Caucasians, although all panels idealized more protrusive female lips (Nomura et al., 2009). Yet, both Caucasians and Chinese from Sydney and Hongkong shared a preference for the more protrusive Chinese norm to the Caucasian one in a Chinese profile photograph of each gender (Chong et al., 2014). However, surprisingly, Chinese found the Caucasian norm and greater lip retrusion more attractive than Caucasians.

African Americans also prefer greater protrusion in profile silhouettes of their race than that dictated by Caucasian norms (Polk et al., 1995). African American orthodontists favoured more protrusive upper lips in

silhouettes of 7 to 17 year olds of their own race, while their Caucasian colleagues and laypeople of both races preferred a position within the norm (Hall et al., 2000). Black orthodontists preferred more protrusive lips than Caucasian colleagues in pre- and post-treatment profile photographs of Black women who themselves preferred the most protrusion (McKoy-White et al., 2006).

Investigations differ as to whether Caucasians are less critical evaluators. Caucasian orthodontists considered profile silhouettes of 7-17 year old Blacks and Caucasians acceptable twice as often as African American colleagues and three times more than laypeople of that race (Hall et al., 2000). Caucasians recommended surgical correction of more concave profiles silhouettes half as frequently as other races (Naini, Donaldson, et al., 2012c). Yet, although race did not affect the aesthetic scores attributed, Caucasians recommended surgery to correct mandibular and chin asymmetries in frontal photographs 45% more than non-Caucasians (Naini, Donaldson, et al., 2012a). Also in frontal photographs, Black judges from various age groups were more generous than Caucasians when evaluating Black and Caucasian second graders, high school seniors and adults (Cross & Cross, 1971).

More convex profiles are consistently preferred in the African race. Evaluators preferred a 12° facial convexity angle in the profile photographs of Caucasian women and Blacks of both genders and an 8°angle with slight mandibular protrusion in a Caucasian man (de Almeida et al., 2010; Sena et al., 2017). Orthodontists and laypeople of both races preferred greater skeletal and soft tissue convexity in silhouettes of 7 to 17 year old African Americans than in Caucasians (Hall et al., 2000). Caucasians, Hispanic Americans, Kenyans and Japanese preferred the most and least protrusive lips in African American and Caucasian silhouettes, respectively, and an intermediate position for Japanese (Nomura et al., 2009). Caucasian orthodontists and post-graduate students preferred upper lips situated 1.5 mm anterior to Ricketts line in the photographs of adolescent Blacks (Hockley et al., 2012). Laypeople found lips situated 2 and 1 mm anterior to the same line the most attractive in profile photographs of Black men and women, respectively (Sushner, 1977). The upper lip contour was straight or convex as opposed to the Caucasian concave contour.

Asians generally dislike mandibular protrusion. Koreans with normal occlusions and harmonious profiles displayed less prominent chins compared to European-Americans (Hwang et al., 2002). Laypeople and orthodontists preferred more protrusive lips to camouflage mandibular protrusion in female Japanese silhouettes but did not differentiate between normal or retrusive chins regarding lip position (Murakami et al., 2016). Japanese who emigrated recently to the United states were more receptive to dentoalveolar changes than skeletal ones and demonstrated the strongest aversion to mandibular prognathism in a Japanese woman´s profile photograph (Mantzikos, 1998). In another investigation, Japanese disliked severe protrusion the most in a Japanese woman´s profile images (Kuroda et al., 2009). Concave profiles may be disliked even in Caucasian women (de Almeida & Bittencourt, 2009; de Almeida et al., 2010).

A shorter facial height may be disliked more in East Asian men. Laypeople attributed lower scores to longer lower facial proportions in a Caucasian male profile silhouette than shorter ones (Johnston, Hunt, Johnston, et al., 2005). However, in Japan, a higher percentage of orthodontists and dental students recommended surgical treatment when they considered the male composite profile silhouette with the shortest

lower facial height their own than for the longest one (Ioi et al., 2006). In China, orthodontic-surgical patients, dentists and dental students considered the shortest chin height the least attractive in male silhouettes while a possible association with ageing made them select the longest profile besides the shortest one in women. In Chinese women, while orthodontists maintained the Japanese trend wherein 66% and 81% recommended surgery for the longest and shortest profile, respectively, dental students desired to correct long profiles more than short ones (Jiang et al., 2018). Clinicians and laypeople also demonstrated a trend to consider greater anterior lower facial height percentage more attractive in photographs of Caucasian men and less so in women, although this parameter correlated minimally with attractiveness (Knight & Keith, 2005).

Yet, media-reinforced stereotypes have shifted the perception of beauty to one that is internationally pleasing (Bronfman et al., 2015; Sy et al., 2016). In 1964, both Caucasian and African American men considered the fashion magazine photographs of more negroid looking Black women less attractive than those with more Caucasian features (Martin, 1964). Although Nigerian men found negroid features more attractive than the Americans, a possible influence of the mass media made their rankings correlate positively with Caucasian features. Peck and Peck (1970) observed that two African American celebrities possessed many Caucasian features. Specialists and laypeople did not distinguish between Caucasian and Black profile photographs in recommending the surgical correction of sagittal mandibular position (de Almeida & Bittencourt, 2009).

Thomas (1979) stated that training and the media´s bias towards Caucasian features made both Caucasian and African American orthodontists favour straighter profile drawings with slight lip protrusion in African American women. Laypeople of both races, orthodontists and dentists preferred a lip position between the Caucasian and African American norms, followed by an even more retrusive one and finally, the more typical position in modified African American profile photographs of both genders (Farrow et al., 1993). Both Black and Caucasian laypeople considered the 2 mm lower lip position relative to the Ricketts aesthetic line the most attractive in a Black woman´s photographs and silhouettes (Pithon et al., 2014).

Yet, photographs in fashion magazines of African American women from the 1940s to the 1990s and of Caucasian models in the 1900s demonstrate a trend toward fuller, more protrusive lips (Auger & Turley, 1999; Yehezkel & Turley, 2004). Lips were flatter in African American female models and more protrusive with greater vermillion exposure in Caucasian ones than in race-appropriate Class I controls. Moreover, it was the Caucasian models´ more protrusive lips that were responsible for the larger similarity between the models of the two races than that verified between the controls (Sutter & Turley, 1998).

Racial levelling can be observed even in the Japanese. Despite the typically more convex Japanese profile, many Japanese film actors are orthognathic (Mantzikos, 1998). Japanese orthodontists and dental students preferred straighter profiles with slightly retrusive lips in composite silhouettes rather than the more common convex one (Ioi et al., 2005). The similar zone of acceptability for mandibular position in both Japanese and Caucasian profiles and for all panels of Caucasian orthodontists and Caucasian and Japanese American laypeople also suggested an influence of western culture (Orsini et al., 2006). A systematic review concluded that although the Japanese usually have a more acute nasolabial angle, bilabial protrusion, maxillary

and even greater chin retrusion and larger lower facial height, they prefer the Caucasian retrusive or straight profile with moderate mandibular and labial retrusion (Bronfman et al., 2015).

Moreover, minorities living in the West may suffer pressure to have their faces modified to fit a Caucasian mould (Chan et al., 2008). Caucasians preferred Class I and the bimaxillary retrusive profiles in Chinese and considered the commonly seen mandibular and bimaxillary protrusion the least attractive (Chan et al., 2008). United Kingdom-trained Asian orthodontists and oral surgeons preferred the Caucasian Class I norm and bimaxillary retrusive profile over the Chinese ethnic one and did not rank the common bimaxillary protrusion favourably (Soh et al., 2005a).

Some authors warn that Asians may not appreciate the fuller Caucasian norms that guide surgeons educated in the West (Lee et al., 2011; Sy et al., 2016). Acculturated Americans of East Asian origin preferred the fuller maxillary advancement profile in class III men and found the mandibular setback profile less attractive than less acculturated ones. They also preferred the fuller mandibular advancement profile to the flatter orthodontic camouflage result in Class II photographs and scored the former higher than less acculturated ones (Sy et al., 2016).

Moreover, people may have stronger opinions regarding their own race. Although Caucasian and Chinese orthodontists considered post-treatment photographs of both races equally attractive, mixed pairs showed similar correlations to same race pairs in evaluating the opposite ethnicity, but lower correlations than same race pairs for the same ethnicity (Xu et al., 2008). Caucasian orthodontists agreed with 90% of the profiles silhouettes of 7 to 17 year olds chosen by Caucasian lay people as acceptable for a Black sample and with all those chosen for a Caucasian one (Hall et al., 2000).

4.1.1.4 Evaluator gender

Women are important evaluators because they constitute two thirds of patients undergoing orthognathic surgery (Al Taki & Guidoum, 2014; Sinko, Tran, et al., 2018). Thus, they generally form the majority in samples that are unbalanced for gender (Baker & Woods, 2001; Johnston et al., 2010; Xu et al., 2008).

Women exhibited greater reproducibility in scoring profiles with skeletal and dentoalveolar modifications of other women when asked to imagine that these belonged to colleagues. Men were more consistent in evaluating the opposite gender, both as colleagues and as potential mates (Tole et al., 2014). Yet, both male and female orthodontists were more consistent in assessing post-surgical profiles of their own gender treated for Class III discrepancies (Sari-Rieger & Rustemeyer, 2015).

Men and women prefer different characteristics for themselves. Gender-specific profile composites of the ´optimal` noses selected based on three hundred and eleven Caucasians´ self-evaluation revealed a soft tissue nasion at the level of the pupils in women and the superior palpebral margin in men. The dorsal profile was concave to straight in women and straight in men. Yet, both considered the nasal *hump* unpleasant and the supratip break unimportant (Springer et al., 2008). Young Chinese men preferred straighter profile silhouettes while women chose a slightly convex profile, perhaps due to its social association with prettiness, naivety and non-dominance (Yin et al., 2014). Similarly, when asked to consider a concave facial profile drawing their

own, men opted for surgery 61% less frequently than women indicating that they consider a “strong” mandible less of an aesthetic problem (Naini, Donaldson, et al., 2012c).

They may also differ in their aesthetic preferences in others. Although overall rankings and those of male profiles were similar for both genders, men comparatively prefered more convex profiles and women more concave profiles in women (Türkkahraman & Gökalp, 2004). Even though Croatians of both genders preferred the orthognathic profile photograph modification in colleagues of the opposite sex, men found moderate bialveolar protrusion more attractive in a potential mate while women preferred mild bialveolar retrusion (Tole et al., 2014). While both genders considered nasal asymmetry more attractive than modified teeth in frontal and oblique photographs, male evaluators did not distinguish between male control photographs and those with nasal asymmetry (Bui et al., 2015). However, female evaluators considered the photographs with nasal asymmetry more unattractive than the controls, regardless of the gender of the subject.

Yet, other researchers suggest that men and women have similar taste in facial aesthetics. Male and female non-clinical dental students and dentists ranked androgynous profile silhouettes with modified sagittal intermaxillary relationship, lower facial height and nasal dorsal shape in a similar manner (De Smit & Dermaut, 1984). Evaluator gender did not affect the ideal nasal tip projection selected from among the Crumley 1 or 2 or Goode options in synthetic profile images of Caucasian women (Ahmed et al., 2014), African American orthodontic patients and laypeople´s choice of their preferred and least acceptable profile silhouettes (Polk et al., 1995) or the selection of the most and least attractive profile photographs with modified sagittal and vertical jaw positions in a Jordanian man and woman (Abu Arqoub & Al-Khateeb, 2011) and in a Caucasian of each gender (Falkensammer et al., 2014). Male and female first year dental students showed a similar perception of attractiveness when evaluating modified bialveolar and maxillary or mandibular sagittal positions in photographs of each gender (Oliveira et al., 2015). Male and female orthodontists and post-graduate orthodontic students did not differ when evaluating varying lip positions in profile photographs and silhouettes of African American adolescents (Hockley et al., 2012). The gender of American Caucasian, Hispanic American, Kenyan or Japanese laypeople did not affect their selection of the most aesthetic lip position in Caucasian, African American and Japanese profile silhouettes (Nomura et al., 2009).

4.1.1.5 Patient gender

Nasal asymmetry may be less tolerated in women (Bui et al., 2015). Male control photographs and those with asymmetrical noses were found equally attractive. However, while the woman´s frontal control oblique photograph was more attractive than the oblique one, the opposite was true for the ones depicting dorsal asymmetry, which was more obvious in the frontal view.

Shorter profiles may be preferred in women. The normal vertical dimension followed by a reduced one was found the most attractive in a modified Jordanian male Class I profile photograph, while this order was reversed for the woman (Abu Arqoub & Al-Khateeb, 2011). While average lower facial height was preferred by both panels in Japanese male profiles silhouettes and by orthodontists in women, senior dental students chose a slightly shorter one in women (Ioi et al., 2006). Chinese considered the Chinese norm and a slightly

longer chin the most attractive and the shortest height the least attractive in silhouettes of both genders (Jiang et al., 2018). In women, the longest chin was also considered the least attractive. Yet, De Smit and Dermaut (1984) did not find gender-based differences, when non-clinical dental students and dentists evaluated modified intermaxillary sagittal relationship, lower facial height and nasal dorsal shape in a male profile silhouette considered both male and female.

Mild mandibular protrusion is accepted better in men, while the youth and femininity conveyed by more protrusive lips lead authors to recommend non-extraction in female borderline cases (Foster, 1973; Türkkahraman & Gökalp, 2004). Arabs found bimaxillary and labial protrusion more acceptable in women than in men (Al Taki & Guidoum, 2014). Chinese, Caucasians and Africans preferred more protrusive lips in a woman´s profile silhouette than in a man, although orthodontists exhibited this gender-based difference to a smaller extent, as they preferred greater male protrusion than other evaluators (Foster, 1973). Caucasian, Hispanic American, Kenyan and Japanese laypeople also favoured greater lip protrusion in Caucasian, African American and Japanese female profile silhouettes than in men (Nomura et al., 2009). Moreover, while Japanese and Hispanic evaluators preferred more retrusive male lips than Kenyans, all ethnicities chose a similar protrusive female ideal.

De Almeida and Bittencourt (2009) concluded that evaluators recommended surgery primarily for convex profiles in men and concave profiles in women. De Almeida et al. (2010) also observed a gender-based difference wherein the extreme Class II profile was considered the least attractive in Black and Caucasian men and the extreme Class III profile was the most unpleasant in women.

Treatment choice may thus depend on patient gender. 79% of Caucasian and 73% of United States-trained Asian surgeons and 52% of Asian-trained surgeons recommended maxillary advancement to increase facial volume in the profile photograph of an Asian man with a -2mm overjet and mandibular prognathism (Lee et al., 2011). Acculturated East Asian -Americans also preferred the fuller maxillary advancement profile in a class III man and found the mandibular setback profile less aesthetic than less acculturated individuals (Sy et al., 2016). However, the association of a milder chin with femininity led both integrated and less integrated East Asians (Sy et al., 2016) and all Asian-trained and 63% of Caucasian and 65% of United States-trained Asian surgeons (Lee et al., 2011) to prefer mandibular setback in class III women.Yet, in Germany, maxillary advancement is performed more often than mandibular setback in women to avoid a double chin deformity, whereas the opposite is true for men (Ghassemi et al., 2017).

4.1.1.6 Evaluator´s socioeconomic status

The evaluator´s socioeconomic status can affect his aesthetic perception (de Almeida et al., 2010; Maple et al., 2005). Kočnar et al. (2019) observed that, despite a cross-cultural consensus on attractiveness, scores of facial photographs by Czechs converged more with those from evaluators from more socio-economically developed countries than with those from less developed ones. Judges of a lower socioeconomic status were more critical of children´s oblique photographs (Howells & Shaw, 1985). However, individuals that earned more than 50,000$ per year were less generous with facial, eye, nose and mouth asymmetry before and after

surgical correction of crooked noses (Roxbury et al., 2012). Socioeconomic status did not influence patients´ satisfaction with their appearance prior to orthodontic-surgical treatment (van Steenbergen et al., 1996).

4.1.1.7 Evaluator´s level of education

University graduates detected skeletal dysplasia earlier than primary school graduates indicating that aesthetic discernment improves with education (Türkkahraman & Gökalp, 2004). High school and university graduates preferred the generally favoured orthognathic profile more than primary school graduates. Conversely, primary school graduates ranked female dentoalveolar retrusion and the male Class II profile and Class III profile with increased overbite higher than university graduates.

Yet, the recommendation for correction of soft tissue pogonion position in profile photographs increased 1.256 fold as the level of education of laypeople and patients decreased (Pişiren et al., 2018). College graduates were also more generous in scoring facial, eye, nose and mouth asymmetry before and after surgical correction of crooked noses (Roxbury et al., 2012). However, education level did not affect the evaluation of nasal form (Springer et al., 2009).

4.1.1.8 Evaluators´ occlusion

Evaluators with Class I malocclusions attributed higher scores than those with Class II and Class III malocclusions for modified facial convexity in silhouettes (Naini, Donaldson, et al., 2012c). They also gave higher scores than those with sagittal discrepancies to mandibular and chin asymmetries in digital frontal images (Naini, Donaldson, et al., 2012a). Moreover, skeletal Class III patients were more sensitive to altered mandibular position in patient photographs than those with Class I and Class II relationships (Naini, Donaldson, et al., 2013).

Evaluators´ lower vertical facial height did not affect their aesthetic assessment of modified sagittal chin position (Naini, Donaldson, et al., 2012b) or of mandibular and chin asymmetries in frontal facial images (Naini, Donaldson, et al., 2012a).

4.1.1.9 Left versus right handedness of the evaluator

This factor did not affect post-orthognathic surgery patients' perceptions of facial profile attractiveness or the magnitude of mandibular sagittal deviation at which they desired surgery (Naini et al., 2013). However, left handed individuals were more critical of facial, eye, nose and mouth asymmetry before and after surgical correction of crooked noses (Roxbury et al., 2012). Right-handed evaluators found chin and mandibular asymmetry toward the left less attractive than that towards the right (Naini, Donaldson, et al., 2012a).

4.1.1.10 The importance given to facial attractiveness

Patients who consider facial attractiveness important did not differ in their evaluation of mandibular and chin asymmetries (Naini, Donaldson, et al., 2012a), but recommended surgery more than twice more frequently

for altered mandibular position (Naini et al., 2013), 3.4 times more for concave profile silhouettes (Naini, Donaldson, et al., 2012c) and 48% more for modified sagittal chin position (Naini, Donaldson, et al., 2012).

4.1.11 Initial attractiveness

The less attractive the vertical and sagittal modifications in Caucasian profile photographs, the greater was the perceived treatment need (Falkensammer et al., 2014). Also, the improvement potential after orthodontic-surgical treatment is inversely proportional to initial profile attractiveness (Klaus et al., 2017). Pre-treatment scores correlated negatively with Class II silhouettes´ aesthetic improvement, whether after mandibular advancement surgery without genioplasty (Shelly et al., 2000) or after mandibular advancement, maxillary impaction or bimaxillary surgery with or without genioplasty (Klaus et al., 2017). Orthodontists, maxillofacial surgeons and residents considered that aesthetics improved after mandibular advancement in 11 of 13 patients´ frontal and profile photographs and this improvement was greatest in the patients that were initially considered the least attractive (Proffit et al., 1992). Thus, while mandibular advancement surgery usually improves aesthetics, in some patients it may deteriorate, especially if they are evaluated favourably before treatment (Proffit et al., 1992; Shelly et al., 2000).

4.1.2 The attractiveness of different types of malocclusion

Both laypeople and clinicians generally find orthognathic profile photographs the most attractive (Maple et al., 2005). Caucasian orthodontists and Caucasian and Japanese-American laypeople preferred this profile in photographs of both races (Orsini et al., 2006). Japanese evaluators found it the most aesthetic in a woman´s modified photograph (Mantzikos, 1998). Turks preferred it in photographs with altered dentoalveolar and jaw positions (Türkkahraman & Gökalp, 2004). It was also the most favoured in Arab and Indian silhouettes (Al Taki & Guidoum, 2014; Trehan et al., 2011). Also, while Class I faces are equally attractive in the frontal and profile view, Class II and III malocclusions receive poorer scores in profile where the skeletal discrepancy is more obvious (Kerr & O'Donnell, 2014). The eyes diverge attention in the frontal view (Kerr & O'Donnell, 2014; Sinko, Tran, et al., 2018).

Conversely, people with sagittal discrepancies are considered less attractive (Falkensammer et al., 2014; Modarai et al., 2013; Naini, Donaldson, et al., 2012c). Profile photographs of Blacks and Caucasians with extreme sagittal discrepancies were regarded the least appealing (de Almeida et al., 2010; Sena et al., 2017). Orthodontists and laypeople recommended surgery 50% more for every millimetre of chin or chin and lip sagittal deviation in Caucasian silhouettes (Modarai et al., 2013). Johnston, Hunt, Burden,et al. (2005) found that laypeople attributed lower scores to profile silhouettes with SNB angles that progressively diverged from the most attractive 78° and higher ones after a small 2.5° correction from 70.5° and 85.5°.

Pre and post-treatment orthodontic-surgical patients also demonstrated this aversion for mandibular sagittal deviations (Naini et al., 2013). Along with dentists and dental students, they found Chinese profile silhouettes with larger chin modifications progressively less attractive (Jiang et al., 2018). Similarly, pre-

treatment Class II and III patients, laypeople and clinicians gave lower scores to altered soft tissue pogonion position in profile silhouettes and increased their surgical recommendation 45% for each millimetre of deviation (Naini, Donaldson, et al., 2012). Yet, although the same panels considered divergences of the facial convexity angle from the norm progressively less attractive in silhouettes, they deemed that a wide range of 10° to -12° did not need correction (Naini, Donaldson, et al., 2012c).

Furthermore, frontal and lateral photographs of patients with Class II division 1 and III malocclusions continued to be considered less attractive than those with Class I occlusions even after orthodontic treatment (Kerr & O'Donnell, 2014). Laypeople found Class I controls more attractive than women with Class II or III discrepancies before and even after surgical improvement whether profile photographs or videos with right to left profile rotation and a frontal smiling pose were used (Sinko et al., 2012; Sinko, Jagsch, et al., 2018).

Yet, the poor correlation verified between the facial convexity angle and laypeople and clinicians´ evaluations of post-surgical Chinese profile drawings indicated that other factors may be important (Chew et al., 2007). Knight and Keith (2005 abstract) also found that attractiveness correlated minimally with the sagittal discrepancy though clinicians and laypeople tended to find a Class I relationship attractive and soft tissue ANB angle variations beyond 5° less so. Johnston, Hunt, Burden et al. (2005) observed that at least two-thirds of evaluators did not want to correct SNB angle deviations that remained within the range of 73 or 83° in silhouettes and more than 20% did not even at 68° and 88°. Also, the psychosocial context of the assessment is important as men and women found orthognathic profiles more attractive in colleagues of the opposite gender, but preferred moderate bi-alveolar protrusion and mild bi-alveolar retrusion, respectively, in mates (Tole et al., 2014).

Results are contradictory about the relative attractiveness of Class II and Class III discrepancies. Some authors reveal that a Class II discrepancy is less attractive (Khosravanifard et al., 2013; Naini, Donaldson, et al., 2012c). Czarnecki et al. (1993) concluded that an androgenic profile silhouette with exaggerated facial convexity was the most disliked. In another investigation using profile silhouettes, surgical recommendation increased 60% and almost 100% for each degree of increase in concavity and convexity beyond the 10-12° range, respectively (Naini, Donaldson, et al., 2012c). The convex profile image with bimaxillary discrepancies was the least preferred amongst sagittal jaw and dentoalveolar modifications in Turks (Türkkahraman & Gökalp, 2004). Johnston, Hunt, Burden et al. (2005) demonstrated a slight preference for class III profile silhouettes. Falkensammer et al. (2014) suggested that Class III malocclusions may be considered more attractive in populations where they are more prevalent. De Almeida and Bittencourt (2009) concluded that although evaluators recommended surgery more frequently for skeletal Class II profiles, this difference was not verified when they considered the profiles their own.

Conversely, Indians considered Class III profile silhouettes the least attractive (Trehan et al., 2011). First year Brazilian dental students disliked the Class III modification the most in Caucasian profile photographs (Oliveira et al., 2015). Dongieux and Sassouni (1980) concluded that the frontal and profile photographs of Caucasian adolescent girls who displayed Class III malocclusions with or without open bite were the most displeasing. First year dental students and dentists considered the Class III relationship with

increased vertical dimension the least attractive in an androgynous profile silhouette (De Smit & Dermaut, 1984). Japanese evaluators disliked mandibular protrusion more than retrusion in a female profile photograph (Mantzikos, 1998).

Laypeople, dental students and clinicians found the Class III modification the least attractive and the most needful of treatment (Falkensammer et al., 2014). Modarai et al. (2013) observed that surgical recommendation was 19 times higher for chin protrusion than for retrusion in profile silhouettes although it decreased 54% when lower lip advancement camouflaged the protrusive chin. Pre and post-treatment surgical patients recommended surgery thrice more for every 2 mm of prognathism and twice more for every 2 mm of retrusion (Naini et al., 2013).

Mandibular protrusion is noticed earlier than retrusion (Burcal et al., 1987; Naini et al., 2013; Naini, Donaldson, et al., 2012; Pişiren et al., 2018). Patients recommended surgery for 3 and 4 mm protrusion and -9 and -10 mm retrusion relative to the norm in their pre and post-surgical phases respectively (Naini et al., 2013). In another study, pre-treatment surgical patients, laypeople and clinicians recommended surgery for protrusion greater than 3.1, 3.4 and 4.7 mm and retrusion greater than -8.4, -8.3, and -9 mm in silhouettes and three times more for the former compared to the latter (Naini, Donaldson, et al., 2012). Burcal et al. (1987) observed that 22 and 26% of laypeople noticed a 2 mm mandibular setback and advancement, respectively in photographs and 44 and 51%, respectively noted 4 mm ones. 50 and 64% of clinicians detected a 4 mm and 82 and 85%, a 6 mm setback and advancement, respectively.

Moreover, it was found that a higher percentage of patients with Class II malocclusions (97%) than with Class III (86%) and Class I malocclusions (59%) wanted to change their appearance (Johnston et al., 2010). Orthodontic correction of incisor prominence may convey more obvious aesthetic benefits in Class II non-surgical cases (Kerr & O'Donnell, 2014). While all panels could detect orthodontic treatment induced changes in photographs of patients with Class II Division 1 malocclusions, the persistence of chin prominence allowed only orthodontists to be aware of Class III improvements (Kerr & O'Donnell, 2014). Hence, Class II patients display greater motivation for orthodontic treatment than Class III patients, although this difference is not manifested in surgical cases (Wilmot et al., 1993). Moreover, surgery improved facial aesthetics more in class III than in class II malocclusions in videos that demonstrated facial rotation and a frontal smiling pose (Sinko, Jagsch, et al., 2018).

4.1.3 The influence of vertical facial anomalies on attractiveness

The average vertical dimension is considered the most attractive, although a shorter one may also be favoured in women. The normocephalic Class I profile was the most attractive in adolescent Caucasian girls´ frontal and profile photographs (Dongieux & Sassouni, 1980). A 55% lower anterior/total anterior facial height ratio was preferred in Caucasian adult profiles, whether in photographs of both genders or in a male silhouette (Falkensammer et al., 2014; Johnston, Hunt, Johnston, et al., 2005). First year dental students and dentists preferred the Class I profile with a normal vertical dimension followed by a smaller one in androgynous silhouettes (De Smit & Dermaut, 1984). Chinese orthodontic-surgical patients also preferred profile silhouettes

with an average chin height (Jiang et al., 2018). Jordanians considered Class I profiles with average and reduced facial height the most attractive in men and women, respectively (Abu Arqoub & Al-Khateeb, 2011). An average soft tissue lower facial height was favoured by both Japanese orthodontists and senior dental students in men and by orthodontists in women, while students chose a slightly shorter one in female profile silhouettes (Ioi et al., 2006).

Longer faces may be the least appreciated. Fabré et al. (2009) demonstrated that besides preferring Class I profiles to class III ones, orthodontists were also negatively influenced by a larger mandibular plane inclination. Laypeople found larger lower anterior/total facial height ratios less attractive than smaller ones in male profile silhouettes (Johnston, Hunt, Johnston, et al., 2005). De Smit and Dermaut (1984) concluded that the longest silhouettes were the least appreciated within each sagittal class.

Yet, Knight and Keith (2005 abstract) observed that the lower anterior facial height percentage correlated minimally with attractiveness although clinicians and non-clinicians tended to consider longer faces less attractive in female photographs and more attractive in men. Moreover, 63% of orthodontists and 27% of laypeople could not select any preferred female profile photograph when vertical maxillary height was modified to vary the upper to lower facial height ratio between 0.76 to 1.86% (Romani et al., 1993). 72.7 % of orthodontists and 41% of laypeople were even less critical regarding men and could not select a preferred image for 0.80 to 2.40% variations.

4.1.4 The interaction between the sagittal and vertical dimensions in influencing facial attractiveness

Laypeople and clinicians considered Class II profile photographs with vertical maxillary excess and Class III ones with vertical maxillary deficiency the most unpleasant (Maple et al., 2005). De Smit and Dermaut (1984) found that while Class I profile silhouettes were preferred for the normal and short dimensions, a long face minimized the aesthetic difference between Class I and II profiles which were liked more than the Class III silhouette. Dongieux and Sassouni (1980) concluded that although open bite cases were less attractive than the norm in frontal and profile photographs of adolescent Caucasian girls, both were equally disliked in Class III cases which were the least preferred.

Sagittal skeletal discrepancies may be more unattractive than vertical ones (Johnston, Hunt, Johnston, et al., 2005). 25 and 49% of laypeople, respectively recommended treatment for lower anterior/total facial height ratios that were larger or smaller by 8% or four standard deviations from the norm in profile silhouettes (Johnston, Hunt, Johnston, et al., 2005). 70% recommended treatment when the SNB angle deviated beyond three standard deviations from the norm (Johnston, Hunt, Burden, et al., 2005). Sagittal modifications also had a greater aesthetic impact than vertical ones in Caucasian profile photographs (Falkensammer et al., 2014).

4.1.5 The influence of the magnitude of initial discrepancy on the improvement after orthognathic surgery

Bimaxillary, mandibular advancement or maxillary impaction surgery consistently improved VAS scores of Class II profile silhouettes only when the initial ANB angle was $> 8°$ and the profile convexity angle

≤155° (Klaus et al., 2017). The lowest threshold values of the initial convexity angle for orthodontists, oral surgeons and laypeople to register improvement in silhouettes after mandibular advancement surgery were 159, 158 and 157°, respectively, while orthodontists and oral surgeons´ threshold levels for the ANB angle were 5.5 and 6.5°, respectively, with laypeople displaying no trend. Thus, the authors suggested that surgery be performed only when the initial profile angle was ≤160° and the ANB angle was ≥6° to avoid undesirable outcomes (Tsang et al., 2009). In another investigation, the initial ANB angle had to reach a value of ≥ 6º for 44% of lay people and 47% of orthodontists to note a consistent profile silhouette improvement after mandibular advancement surgery without genioplasty (Shelly et al., 2000).

Orthodontists and laypeople detected postural mandibular advancement in the profile photographs of a severely retrusive man at 2 mm and only after 4 mm, respectively (Barroso et al., 2012). 6 mm setbacks and advancements had to be performed in profile photographs of both genders before more than two-thirds of the lay people and 82% of clinicians could detect them (Burcal et al., 1987).

4.1.6 Factors associated with the nose

4.1.6.1 The relative positions of the nose, lips and chin

Treatment plans should not adhere to dentoskeletal norms but rather consider a harmonious soft tissue relationship between the nose, lips and chin (Czarnecki et al.,1993). Caucasian and African American orthodontists cited facial harmony and the relationship between the nose, lips and chin as important factors in choosing the most pleasing profiles (Thomas, 1979). Older orthodontists with more than 20 years of experience considered the Ricketts aesthetic line the most important reference for African American upper lip protrusion, although their younger colleagues cited the Burstone line more (Battle et al., 2018). Continual nose and chin growth during adulthood should be acknowledged when finishing treatment (Oliveira et al., 2015).

Thick lips and a small nose and chin contribute to men finding women´s faces more attractive (Baudouin & Tiberghien, 2004). Greater lip protrusion is accepted in both genders in the presence of a larger nose and chin (Czarnecki et al., 1993; Torsello et al., 2010). Moreover, protrusive lips can partially camouflage a large chin (Czarnecki et al., 1993; Modarai et al., 2013; Murakami et al., 2016). Profile aesthetics were found to improve as the angle between the Holdaway line and the soft tissue nasion-pogonion line and nasal tip projection beyond the former line approached the cephalometric norm (Marchiori et al., 2015). However, in Turks, orthodontists considered protrusive lips more attractive in the presence of a smaller nose, a retrusive chin and a more inclined mandibular angle, which themselves enhanced the perception of relative lip protrusion (Erbay et al., 2002). Attractive men presented smaller nasal tip projection beyond the Holdaway line and more protrusive upper lips than unattractive ones. Nasal tip projection was smaller in attractive women than in attractive men but did not differ between attractive and unattractive women.

4.1.6.2 Nasolabial angle

The nasolabial angle did not affect African American and Caucasian orthodontists and laypeople´s evaluations of profile silhouettes of 7 to 17 year olds of both races (Hall et al., 2000) and orthodontists´

assessments of African American photographs (Battle et al., 2018). It did not differ between the most pleasant and unpleasant profile photographs chosen by clinicians and laypeople from a sample of all malocclusion types (Fortes et al., 2014). It correlated only weakly with Chinese post-surgical profile aesthetic scores (Chew et al., 2007). The angle did not affect patient satisfaction with their post-rhinoplasty nasal appearance (Zojaji et al., 2019). Marchiori et al. (2015) suggested that it did not affect orthodontists and laypeople's evaluation of profile photographs because nasal morphological variations allow changes in its value without compromising aesthetics.Yet, the angle was closer to the norm in the most pleasant African American profile silhouettes than in the least pleasant ones (Polk et al., 1995).

Larger angles are usually preferred in women. Attractive Iranian women with good occlusions exhibited a larger nasolabial angle and nasal tip elevation, although no difference was verified in men (Khosravanifard et al., 2013). The most attractive Indian women also possessed a smaller, apically rotated nose with a larger nasolabial angle (Husein et al., 2010). Orthodontists preferred larger angles in silhouettes of Japanese women with normal occlusions than in men (Ioi et al., 2006). However, Hwang et al. (2002) did not detect significant differences between men and women in American Caucasians and Koreans with balanced profiles.

Laypeople preferred the largest value from the 96 to 116° range for the columella-subnasale line inclination relative to the perpendicular to the FHP in attractive synthetic Caucasian female profile images with ideal nasal tip positions (Ahmed et al., 2014). Yet, moderate columella rotations were considered the most attractive and extreme values the least in profile photographs of a Caucasian and an Asian woman each of ages 30 and 60 years (Biller & Kim, 2009). The wide variation in the least desired angles led the authors to emphasize that aesthetic nasal rotation depends on global facial features and proportions that outweigh any ethnic differences.

4.1.6.3 Dorsal convexity

Traditionally, the dorsal *hump* has been considered a male characteristic (Springer et al., 2008). However, Nuyen et al. (2009) concluded that while evaluators considered the straight or ski slope dorsal form feminine, they did not associate masculinity with any image. Moreover, this characteristic occurs with equal frequency in both genders (Springer et al., 2008).

The *hump* is generally considered unattractive. It was present in noses that Caucasians of both genders selected as most unpleasant in their self-evaluation and caused more dissatisfaction than other dorsal contours (Springer et al., 2008). Koreans´ favourite nasal characteristics were a straight dorsum and a straight upper nostril margin (Yu & Jang, 2014). Patients, clinicians and especially laypeople found *humps* the least attractive in an idealized male Caucasian profile drawing, although they also recommended rhinoplasty for ´ski slopes` (Naini, Cobourne, et al., 2016b).

Laypeople associated the normal or ski slope dorsum with youth, approachability, attractiveness, health and success and the dorsal *hump* with the least intelligence and leadership ability, when combinations of dorsum form and two options each of projection and columella rotation were generated in a male profile photograph (Nuyen et al., 2019). Both genders and especially women selected the image with a dorsal *hump*,

less projected tip and flatter base most frequently as least approachable, attractive, and healthy. The image with the dorsal *hump*, less projected tip and upwardly rotated base was found the oldest. In this investigation, the image with a ski slope dorsum, more projected tip and flatter nasal base was regarded the most attractive and given the most positive attributes. However, 47 to 61-year-old judges selected the face with the dorsal *hump*, more projected tip and upwardly rotated base as 'most successful'.

The *hump* affects attractiveness even more than tip position. While digital simulation of *hump* removal made a predominantly Caucasian panel find patients with a dorsal *hump* and tip ptosis younger, more attractive, approachable and healthier, correction of both improved only perceived attractiveness and health while tip derotation alone had no effect (Kandathil et al., 2018). Yet, De Smit and Dermaut (1984) found that dorsal shape was important only in the Class II androgynous profile silhouette with a normal vertical dimension, where a straight dorsum was preferred over a convex one.

4.2 Justification for the investigation

Attractive people are favoured over their less attractive peers in all sorts of life situations (Dion, 1972; Jacobson, 1984; Lazaridou-Terzoudi et al., 2003; Sigall & Ostrove, 1975). The positive reinforcement caused by this preferential treatment ingrains more positive patterns of behaviour (Landy & Sigall, 1974; Langlois et al., 2000). Beauty enhances social and professional success (Berscheid & Gangestad, 1982; Umberson & Hughes, 1987).

Facial aesthetics is one of the main reasons why patients seek orthodontic-surgical treatment (Laufer et al., 1976; Rivera, Hatch, Dolce, et al., 2000). Surgical aesthetic improvement is especially important for patients with Class III skeletal patterns as they feel less attractive, pay more importance to physical appearance and demonstrate stronger feelings of insecurity than individuals with other skeletal patterns (Gerzanic et al., 2002). Satisfaction with the positive aesthetics achieved by treatment endows psychological benefits, including a greater sense of personal well-being and higher self-esteem (Al Taki & Guidoum, 2014; Johnston et al., 2010; Klaus et al., 2017; Klima et al., 1979; Sinko et al., 2012; Tucker, 1995).

Orthodontic-surgical diagnosis and treatment planning involves the comparison of the patient's facial dimensions and proportions with age, race and gender specific population norms obtained through cross-sectional or longitudinal, cephalometric studies of normal individuals at different life stages (Naini, Donaldson, et al., 2012; Naini, Donaldson, et al., 2012c). Yet, a norm may represent the normal or average facial pattern but not necessarily the most beautiful one in the eyes of a given population (Erbay et al., 2002; Malkoc et al., 2009; Pogrel, 1991). Non-numerical factors, such as colour, can affect attractivity more than cephalometric values (Matoula & Pancherz, 2006; Rustemeyer et al., 2010). Hence, facial disproportion and attractiveness may coexist (Peck & Peck, 1970; Rosen, 2017). As orthodontic-surgical treatment aims to improve aesthetics, the visual perception of facial features should always take precedence over their quantitative measurement (Matoula & Pancherz, 2006). Also, significant differences from the norm are not necessarily clinically important (Chew et al., 2007). Thus, objective measures may not be the ideal tool to determine the highly

subjective concept of attractiveness (Zojaji et al., 2019). Thus, the tangible determination of proportions has to be confirmed through subjective assessments of attractiveness (Naini, Donaldson, et al., 2012; Naini, Donaldson, et al., 2012c). It is also important to assess when a facial parameter deviates enough from what is aesthetically acceptable to permit its perception as a facial deformity (Matoula & Pancherz, 2006; Naini, Donaldson, et al., 2012). Investigations into the perception of facial aesthetics provide evidence-based objective guides for orthodontic treatment plans.

Nasal shape, symmetry and projection are important characteristics of facial attractiveness (Crumley & Lanser, 1988; Springer et al., 2009). Several authors have confirmed the importance of the nose in facial aesthetics in different races (Cross & Cross, 1971; Husein et al., 2010; Melo et al., 2017; Soh et al., 2005a; Al Taki & Guidoum, 2014) Yet, nasal beauty is a relative concept that may be defined differently depending upon region, ethnicity and culture (Zojaji et al., 2019).

An inaesthetic nasal appearance is often considered the most undesirable consequence of maxillary surgery for the correction of Class II and III malocclusions (Coban et al., 2020, Ghorbani et al., 2018). 37% of Taiwanese patients with skeletal Class III malocclusion including those with cleft lip and palate considered that bimaxillary surgery performed with the alar cinch suture improved their nasal aesthetics although 5% expressed dissatisfaction (Worasakwutiphong et al., 2015). Although 91.7% of Iranians revealed better facial appearance after maxillary surgery, only 48.5% conveyed improved nasal aesthetics and only 25.8% were satisfied with their nose (Ghorbani et al., 2018).

Thus, this study aims to analyse the effect of the Le Fort 1 maxillary advancement osteotomy on the perception of nasal appearance by orthodontists and quantify the objective parameters that contribute to this assessment for the purpose of aiding clinician-patient communication regarding aesthetic expectations and actual foreseeable outcomes.

4.3 Aims of the investigation

This project had the following objectives:

1) To study the change in the aesthetic evaluation of the nose by orthodontists after Le Fort 1 maxillary advancement osteotomy, according to the following null hypotheses:

H0: The Le Fort 1 maxillary advancement osteotomy does not produce significant changes in the aesthetic evaluation of the nose by orthodontists.

H1: The Le Fort 1 maxillary advancement osteotomy produces significant changes in the aesthetic evaluation of the nose by orthodontists.

2) To determine the influence of evaluator gender on the effect of Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose, according to the following null hypotheses:

H0: Evaluator gender does not significantly influence the effect of Le Fort 1 osteotomy on the aesthetic evaluation of the nose.

H1: Evaluator gender significantly influences the effect of Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose.

3) To compare male and female patients regarding changes produced by Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the nose, according to the following null hypotheses:
H0: There are no significant differences between male and female patients in the effect of the Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose.
H1: There are significant differences between male and female patients in the effect of the Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose.

4) To evaluate the correlation between the evaluations of the effect of Le Fort 1 osteotomy on nasal aesthetics in frontal and profile views, according to the following null hypotheses
H0: There is no significant correlation between the evaluations of the effect of Le Fort 1 osteotomy on nasal aesthetics in the frontal and lateral views.
H1: There is a significant correlation between the evaluations of the effect of Le Fort 1 osteotomy on nasal aesthetics in the frontal and lateral views.

5) To determine the correlation between the evaluations of the effect of Le Fort 1 maxillary advancement osteotomy on facial and nasal aesthetics, according to the following null hypotheses.
H0: There is no significant correlation between the evaluations of the effect of Le Fort 1 maxillary advancement osteotomy on facial and nasal aesthetics.
H1: There is a significant correlation between the evaluations of the effect of Le Fort 1 maxillary advancement osteotomy on facial and nasal aesthetics.

6) To analyse the correlation between the evaluation of the changes in nasal aesthetics and the changes in nasal morphometric measurements, according to the following null hypotheses:
H0: The evaluation of the changes in nasal aesthetics does not correlate significantly with the changes in nasal morphometric measurements.
H1: The evaluation of the changes in nasal aesthetics correlates significantly with changes in nasal morphometric measurements.

7) To correlate the magnitude of each type of maxillary movement (sagittal, vertical and rotational) with the evaluation of change in nasal aesthetics, according to the following null hypotheses:
H0: The magnitude of each type of maxillary movement (sagittal, vertical and rotational) is not significantly correlated with the evaluation of the change in nasal aesthetics.
H1: The magnitude of each type of maxillary movement (sagittal, vertical and rotational) is significantly correlated with the evaluation of the change in nasal aesthetics.

4.4 Materials and methods

The patients participating in this study were chosen from pre-existing records from the Department of Orthodontics of the Faculty of Dental Medicine of the University of Lisbon and from the private clinics of various specialists in Orthodontics who form part of the Faculty staff at the university. Initial contact with all patients, explaining the nature of the investigation, was established either by telephone or in a routine consultation for the control of retention appliances, either by the investigator, one of the collaborating specialists or the dental hygienist from the Department of Orthodontics. The subject of the investigation and the context of use of lateral cephalograms and photographs were explained to the patients in person. Patients who agreed to participate in the study signed an informed consent. The investigation and the consent form were approved by the Ethics committee of the Faculty of Dental Medicine of the University of Lisbon.

4.4.1 Inclusion and exclusion criteria

The criteria for inclusion of individuals in the sample were:

- Le Fort 1 maxillary advancement surgery with rigid fixation.
- Use of the alar cinch and VY sutures
- Caucasian ancestry.
- Adult non-growing patients
- Skeletal Class III malocclusion
- Class III molar and canine relationship in the pre-treatment phase.
- A stable occlusion with canines in a class I position after treatment.
- Lips supported by natural teeth
- Patients with frontal and profile photographs and lateral cephalograms obtained before starting orthodontic treatment and at least 6 months after surgery and after the removal of the fixed orthodontic appliance.

The criteria for exclusion of individuals from the sample were:

- Extensive anterior teeth reconstruction.
- History of previous facial or nasal surgeries or osteotomies.
- Cleft lip and/or palate and other congenital anomalies.
- Marked facial asymmetry or canting of the lips.
- History of maxillo-facial trauma.
- Distinctive accessories such as piercings or tattoos.
- Segmental surgery and bone grafts.
- A non-neutral facial expression in any of the photographs.
- An obvious difference in hair style or colour or skin tan between the two phases

4.4.2 Sample preparation for the aesthetic evaluation

The luminosity and colour of the homologous photographs were homogenized using the Adobe Photoshop CS5 software (Adobe Systems Incorporated®, San José, CA, USA) to eliminate potential biases. The photographs were saved in uncompressed JPEG format. A Microsoft PowerPoint version 2007® presentation for Windows 10 (Microsoft Corporation®, Redmond, WA, USA) was prepared containing initial and post-treatment photographs of the same size and proportion inserted against a black background.

The homologous frontal photographs were homogenized in size by superimposing the pupils, inner and outer canthi of the eye and ear contour in the pre-treatment and post-treatment images using the Adobe Photoshop CS5 software (Adobe Systems Incorporated®, San José, CA, USA). The same program was used to superimpose homologous profile images using landmarks such as the forehead, the ear, the supraciliary margin and the anterior border of the orbit. Additionally, the eyes of the patients were blocked out in the photographs using a square shape of neutral colour.

Images of the isolated nose were obtained by proportionally cropping the photographs within the PowerPoint program in a rectangular shape. For the frontal images, the superior cut-off point was the upper margin of the eyebrow. The lateral cut off points selected were 10 mm on either side of the nasal wing of the photograph with the widest nose and the inferior cut-off point was situated 8 mm below the more inferiorly placed subnasale point.

For the cropped profile nasal images, the upper and left lateral borders selected were the superior borders of the eyebrows and the anterior orbital margin, respectively. The right border was situated 12.5 mm lateral to the photograph with the most protrusive nasal tip and the lower border 7.5 mm below the lower most subnasale or alar curvature point, depending upon which was in a more inferior position.

Each slide was numbered in the upper left corner depending on the order of appearance and contained the initial and post-treatment photographs of a single patient that were mixed at random. The evaluators were instructed to indicate the most attractive image in each slide by ticking the box below the preferred image. Evaluators were also asked to quantify the aesthetic difference between the two images by sliding the movable bar along a visual analogue scale that had the words ´Not different` and ´Very different` at the left and right extremities, respectively (Figures 4.1 and 4.2). The evaluators also had the option of not choosing any image and leaving the sliding bar untouched if they felt that both images were equally attractive.

There were six sessions of evaluations separated by weekly intervals. Each session included images of the same 61 patients arranged in random order. To decrease bias caused by age, adults between the ages of 18-30 years were used (Sinko, Tran, et al., 2018).

The first slide in each PowerPoint presentation included the instructions for that session. In one session, the evaluators were instructed to compare the overall facial attractiveness between the pair of initial and post-treatment frontal facial photographs in each slide. In a second session, evaluators had to score the difference in attractiveness between the cropped pre-treatment and post treatment of photographs of only the nose. In a third session, the full-frontal initial and post-treatment facial photographs were once again presented to the evaluators and they were requested to score the difference in attractiveness of only the nose, ignoring the other

facial features. The same procedure was repeated for the profile photographs. The decision to evaluate pairs of photographs rather than isolated photographs in each slide was made after conducting a pilot study.

The orthodontists were asked to score their first impression of the profiles based on their training (Sena et al., 2017; Sinko, Jagsch, et al., 2018). Therefore, they were not allowed to modify the initial scores (Sinko, Jagsch, et al., 2018). They were asked not to return to slides they had already rated to avoid comparisons (Barroso et al., 2012; Hockley et al., 2012; Melo et al., 2017; Pithon et al., 2014).

All photographs were evaluated in the same room with the same illumination in a Lenovo Laptop computer with a 15.6" screen. Each evaluator was alone during the evaluations so that he was not influenced by others (Sinko, Jagsch, et al., 2018). There was no time limit for each evaluation.

Figure 4.1: Evaluation of Attractiveness of frontal view of the nose

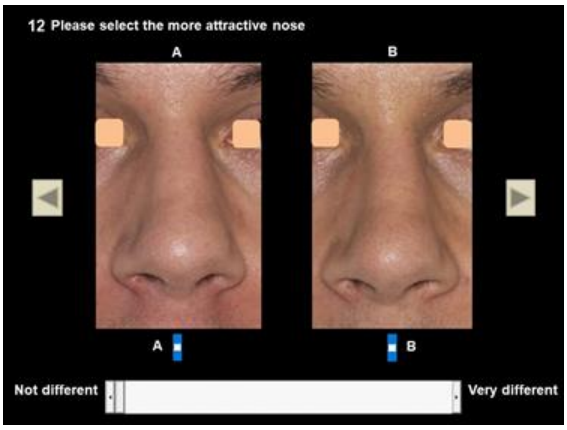
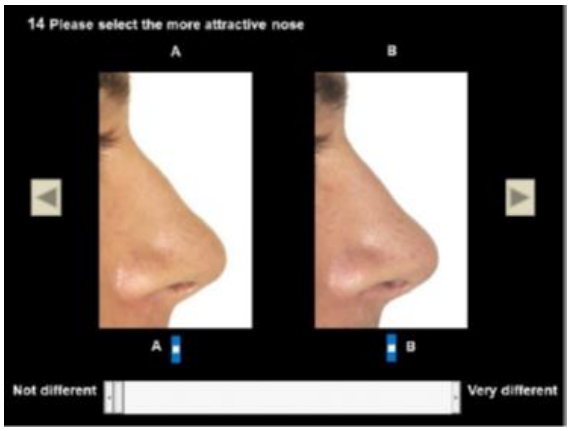


Figure 4.2 Evaluation of Attractiveness of profile view of the nose



4.4.3 Pilot study

The alteration caused by the Le Fort 1 osteotomy in the attractiveness of the nose can be determined by presenting the pre- and post-treatment images in two ways. The two images can be presented side by side in the same PowerPoint slide wherein the evaluator chooses the preferred image and quantifies the aesthetic difference between the images using the VAS. In the alternative method, the evaluator scores the aesthetic appearance of the initial or post-surgical image exhibited individually in each slide and the difference in attractiveness between the images is quantified using the formula: score of the post-treatment photograph - score of the initial photograph. A positive value indicates an improvement and a negative one a deterioration in aesthetics.

Both methods have been used previously. Sari Rieger and Rustemeyer (2015) asked evaluators to rate the aesthetic difference between pre and post-surgical profile photographs presented together using a 5 point scale. Sy et al. (2016) opted for ranking the treatment options of orthodontic camouflage or mandibular advancement in class II cases and mandibular setback or maxillary advancement in class III profiles when presented with the initial photograph. A modified method presented the pre-surgical profile photograph with the computerized predictions of the options of mandibular setback, Le Fort I advancement and bimaxillary

surgery each with their own individual VAS on the same page (Fabré et al., 2010). Montini et al. (2007) also used a separate VAS to evaluate the attractiveness of each pre and postsurgical silhouette when these were randomly paired in each page. Ng et al. (2013) asked various panels to assess individually presented pre- and post-mandibular advancement osteotomy frontal and lateral photographs of skeletal Class II patients. In a second phase, orthodontists re-evaluated the photographs when they were paired together.

Other investigators presented the images from each orthodontic or orthodontic-surgical treatment phase individually (Kerr & O'Donnell, 2014; Klaus et al., 2017; Phillips, Trentini & Douvartzidis, 1992; Tsang et al., 2009). Yet others divided pre- and post- rhinoplasty photographs into two distinct sessions (Nouraei et al., 2009; Roxbury et al., 2012)

A pilot study was carried out to determine whether side by side or individual photograph presentation had the least error. For this purpose, the formula ´score of the post-treatment photograph - score of the pre-treatment photograph` was used to calculate the surgical change when six orthodontists evaluated the attractiveness of individual pre- and post-treatment, frontal and profile facial photographs, of the nose within these photographs and of the isolated nose of 26 patients. The orthodontists also scored the aesthetic difference between the photographs from the two treatment phases when these were paired together in a random order. The evaluations were repeated after a month´s time. The descriptive statistics and normality of the 12 series evaluated within each period are presented in Appendix 2, annex 2. The variable ´Attractiveness of facial profile` did not have a normal distribution in the paired evaluations.

The systematic error was calculated using the paired sample t test. Random error was determined using the intraclass correlation coefficient calculated using the SPSS statistical package (SPSS Inc, Chicago, IL) based on a mean rating (K = 6), absolute agreement (Table 1).

Table 1 Systematic error according to the paired sample t test and random error according to the intra class coefficient

Variable	Difference		*t* -test *P* -value	Intra class coefficient		
	Mean	SD		Cronbach's α	Average Measures	*P*-value
In Attractiveness of frontal view of the face	-0.28	7.20	0.849	0.86	0.87	0.000***
P Attractiveness of frontal view of the face	3.32	14.34	0.259	0.91	0.91	0.000***
In Attractiveness of facial profile	2.18	6.04	0.083	0.93	0.92	0.000***
P Attractiveness of facial profile	-0.36	14.61	0.904	0.93	0.93	0.000***
In Attractiveness of frontal view of the nose	-1.74	5.65	0.137	0.85	0.84	0.000***
P Attractiveness of frontal view of the nose	-8.06	12.79	0.090	0.95	0.93	0.000***
In Attractiveness of profile view of the nose	-0.69	5.99	0.570	0.80	0.81	0.000***
P Attractiveness of profile view of the nose	0.98	14.19	0.734	0.89	0.89	0.000***
In Attractiveness of frontal view of the nose within the face	0.20	6.14	0.874	0.82	0.82	0.000***
P Attractiveness of frontal view of the nose within the face	0.75	15.03	0.806	0.87	0.83	0.000***
In Attractiveness of profile view of the nose within the face	1.31	6.35	0.314	0.72	0.72	0.002**
P Attractiveness of profile view of the nose within the face	1.77	17.81	0.623	0.81	0.80	0.000***

In: Individual evaluation, P: Paired evaluation, (difference) = 1st evaluation-2nd evaluation, $^{**}P<0.01$, $^{***}P<0.001$

While individual evaluations presented lower standard deviations than the paired ones, indicating that a smaller number of patients would be required if this method was used, they also demonstrated a lower Cronbach´s alpha for most variables except for the variables ´Attractiveness of facial profile` and ´Attractiveness of frontal view of the nose within the face` where it was similar. As the average measures ICC ranged from 0.80 to 0.93 with a 95% confidence interval, indicating a high degree of reliability for all paired evaluations, this method was used in the final investigation (Table 1).

Table 2 Systematic error (paired sample t test) and random error (intraclass coefficient) for groups of 6, 8,10,12 and 14 evaluators for the attractiveness of the frontal view of the face, facial profile, frontal view of the nose and profile view of the nose

Variable and number of evaluators	1st evaluation Mean (SD)	2nd evaluation Mean (SD)	Difference Mean (SD)	*t* test *P* value	Intraclass coefficient		
					Cronbach's α	Average measures	*P* value
AO frontal view of the face 6	33.62 (24.00)	31.75 (23.77)	1.87 (13.48)	0.543	0.91	0.92	0.000***
AO frontal view of the face 8	35.60 (23.39)	31.25 (19.95)	4.35 (12.25)	0.129	0.91	0.91	0.000***
AO frontal view of the face 10	38.30 (20.72)	32.20 (19.90)	6.10 (11.61)	0.030*	0.91	0.89	0.000***
AO frontal view of the face 12	39.52 (20.94)	34.17 (19.32)	5.34 (8.93)	0.015*	0.95	0.93	0.000***
AO frontal view of the face 14	41.03 (19.71)	36.08 (21.32)	4.95 (9.64)	0.033*	0.94	0.93	0.000***
AO facial profile 6	35.21 (27.14)	38.81 (24.21)	-3.60 (8.41)	0.081	0.97	0.97	0.000***
AO facial profile 8	34.62 (26.36)	38.46 (25.47)	-3.84 (5.49)	0.071	0.99	0.97	0.000***
AO facial profile 10	38.22 (23.88)	39.96 (23.64)	-1.74 (6.51)	0.247	0.98	0.98	0.000***
AO facial profile 12	38.50 (25.59)	40.70 (25.53)	-2.19 (7.85)	0.227	0.98	0.98	0.000***
AO facial profile 14	39.84 (25.83)	40.30 (26.79)	-0.46 (8.56)	0.813	0.97	0.97	0.000***
AO frontal view of the nose 6	2.73 (25.53)	1.01 (25.09)	1.72 (12.76)	0.554	0.95	0.96	0.000***
AO frontal view of the nose 8	-0.71 (20.93)	-0.31 (21.01)	-0.40 (9.30)	0.877	0.95	0.95	0.000***
AO frontal view of the nose 10	0.08 (20.75)	-0.17 (20.43)	0.25 (9.29)	0.927	0.93	0.93	0.000***
AO frontal view of the nose 12	1.20 (19.08)	0.13 (19.13)	1.06 (9.06)	0.642	0.94	0.94	0.000***
AO frontal view of the nose 14	1.12 (17.28)	-0.56 (16.41)	1.68 (7.09)	0.505	0.93	0.93	0.000***
AO profile view of the nose 6	7.31 (23.15)	6.61 (25.13)	0.70 (14.02)	0.827	0.91	0.91	0.000***
AO profile view of the nose 8	5.60 (17.46)	4.86 (19.72)	0.75 (10.73)	0.759	0.91	0.91	0.000***
AO profile view of the nose 10	6.03 (14.83)	4.51 (17.56)	1.52 (10.61)	0.529	0.88	0.88	0.000***
AO profile view of the nose 12	6.23 (12.24)	3.63 (14.84)	2.59 (9.65)	0.244	0.86	0.85	0.000***
AO profile view of the nose 14	5.87 (12.27)	4.43 (14.04)	1.44 (7.54)	0.403	0.91	0.91	0.000***

AO: Attractiveness of, Difference=1st evaluation – 2nd Evaluation, 6, 8,10,12,14: number of evaluators, * *P*<0.05, *** *P*<0.001

In a second phase which involved 4 male and 10 female orthodontists, the evaluations of 20 patients were repeated after a one-month period with the objective of deciding the appropriate number of evaluators for the investigation (Tables 2 and 3). Since the use of 8 evaluators generated an ICC above 0.80 indicating

reliability in the evaluation of the frontal and profile images of the nose, 4 men and 4 women were used in the final investigation.

Table 3 Systematic error (paired sample t test) and random error (intraclass coefficient) for groups of 6, 8,10,12 and 14 evaluators for the attractiveness of frontal view of the nose within the face and profile view of the nose within the face

Variable and number of evaluators	1st evaluation Mean (SD)	2nd evaluation Mean (SD)	Difference Mean (SD)	*t* test *P* value	Intraclass coefficient		
					Cronbach's α	Average measures	*P* value
AO frontal view of the nose within the face 6	7.68 (24.38)	11.25 (22.02)	-3.57 (16.39)	0.343	0.86	0.86	0.000***
AO frontal view of the nose within the face 8	6.77 (19.76)	9.59 (18.60)	-2.83 (12.87)	0.338	0.87	0.87	0.000***
AO frontal view of the nose within the face 10	12.45 (17.01)	10.05 (16.82)	2.40 (12.89)	0.416	0.83	0.83	0.000***
AO frontal view of the nose within the face 12	13.43 (15.33)	10.64 (15.31)	2.78 (10.26)	0.246	0.87	0.77	0.000***
AO frontal view of the nose within the face 14	13.92 (15.80)	9.44 (15.74)	4.48 (9.77)	0.054	0.89	0.78	0.000***
AO profile view of the nose within the face 6	14.84 (19.48)	13.36 (18.35)	1.48 (16.93)	0.701	0.75	0.76	0.000***
AO profile view of the nose within the face 8	12.84 (15.33)	12.19 (14.55)	0.65 (13.25)	0.829	0.79	0.78	0.000***
AO profile view of the nose within the face 10	11.52 (15.20)	11.95 (14.20)	-0.43 (12.36)	0.878	0.79	0.79	0.000***
AO profile view of the nose within the face 12	10.11 (13.49)	10.26 (12.32)	-0.14 (10.67)	0.952	0.79	0.80	0.000***
AO profile view of the nose within the face 14	10.76 (14.86)	9.96 (12.16)	0.80 (12.23)	0.772	0.75	0.61	0.000***

AO: Attractiveness of, Difference=1st evaluation – 2nd Evaluation, 6, 8,10,12,14: number of evaluators, *** *P*<0.001

It is uncertain how many millimetres of difference on the VAS are required to be clinically meaningful (Maple et al., 2005). In pain research, generally a minimum clinically significant difference ranges from 9 to 13 per cent of the VAS (Ioi et al., 2010; Powell et al., 2001; Todd et al., 1996). A conservative and arbitrary benchmark of a 15% VAS difference has been considered clinically significant in aesthetic evaluations (Ioi et al., 2010; Parekh et al., 2006). Maple et al. (2005) used a value of 8% for within groups comparisons and 11% for comparisons between panels of patients, orthodontists and oral surgeons. With a nondirectional alpha risk of 0.05, a power of 80% and assuming a standard deviation of 21.01 mm for the variable ´Attractiveness of frontal view of the nose`, a sample size of 57 patients was necessary to detect a mean difference of 8 mm between the pairs of initial and post-treatment photographs (www.hedwig.mgh.harvard.edu/sample_size). 23 patients would have been required if the 13 mm difference had been considered. The photographs of 61 patients were used in the final investigation.

4.4.4 Preparation for the cephalometric analysis

This investigation used lateral cephalograms obtained with the aid of a cephalostat and with the Frankfurt horizontal plane parallel to the floor. These lateral cephalograms, obtained in centric occlusion and with the lips in a resting position, had to be of adequate quality with highly visible skeletal structures and soft tissue contours. Radiographic films were scanned using an Epson Perfection V700 PHOTO scanner.

The lateral cephalograms after surgery and the removal of fixed orthodontic appliances (T3) were superimposed on those obtained prior to surgery (T2) by the principal investigator according to the Björk

method using the Adobe Photoshop CS5™ software (Adobe Systems Incorporated®, San José, CA, USA) so that both cephalograms were fixed in the same position and orientation (Björk, 1968; Björk & Skieller, 1983).

The horizontal reference plane (*x*) was constructed 7° below the Sella-Nasion line with its origin at Sella using the Adobe Photoshop CS5 program™ in an adaptation of the method used by Legan and Burstone (1980). A perpendicular to the horizontal plane at Sella was used as the vertical reference plane (*y*). The palatal plane (PP) that unites the points anterior nasal spine and posterior nasal spine was also used in the analysis.

All cephalometric variables were measured using the cephalometric program Nemoceph® (Nemotec, Madrid, Spain). Calibration was performed using the ruler that exists in each lateral cephalogram prior to the identification of cephalometric reference points. The profile and frontal photographs were superimposed on the lateral cephalogram using the Nemoceph program®.

Soft tissue nasion was marked in the midline on the line connecting the highest points of the superior palpebral sulci in the frontal photographs using the Adobe Photoshop CS5 program (Farkas et al., 1986; Furtado, 2016). A line was then designed passing through soft tissue nasion, menton and the midline of the philtrum. Frontal photographs were calibrated using the homologous distance between soft tissue nasion and menton in the profile photographs after they were superimposed on the lateral cephalogram with its incorporated ruler. The intercanthal distance also ensured that both the initial and post-treatment frontal photographs had the same dimension.

4.4.5 Cephalometric points

Hard tissue cephalometric points (Figure 4.4)

Nasion (N)	The most anterior point of the frontonasal suture in the midsagittal plane.
Sela (S)	The point situated in the radiographic centre of the skeletal concavity of the sella turcica.
Anterior nasal spine (ANS)	The point at the anterior extremity of the nasal spine.
Posterior nasal spine (PNS)	The point at the posterior extremity of the hard palate.
A point (A)	The deepest point on the anterior contour of the upper alveolar bone.
Prosthion (Pr)	The most anterior-inferior point of the upper alveolar bone between the upper central incisors.

Soft tissue cephalometric points

Frontal analysis (Figure 4.3)

Soft tissue Nasion (N´)	Lateral cephalogram: the soft tissue point that corresponds to the most anterior point on the frontonasal suture in the midsagittal plane
	Frontal photographs: The centre of the horizontal line connecting the highest points of the bilateral superior palpebral sulci.
Pronasale (Prn)	The most protrusive point of the nasal tip.
Frontal subnasale (Snf)	The most inferior point of the columella seen in the frontal view.
Alare (Al)	The most lateral point on the outer contour of each nasal wing.

Alar curvature (Ac)	The most lateral point on the basal curvature of each alar cartilage corresponding to the facial insertion of the base of the nasal wing.
Lateral Nostril (NrL)	The most superior and lateral point of each nostril in the frontal view.
Frontal Columella (Cmf)	The most posterior-inferior and lateral point of the columella in the frontal view.

Profile analysis (Figure 4.4)

Soft tissue Nasion (N´)	The midsagittal soft tissue profile intersection of a plane parallel to the horizontal plane *x* that passed through Nasion.
Nasal dorsum (Nd)	The most prominent point on the upper part of the nasal dorsum in the mid-sagittal plane.
Mid-dorsum (Mn)	The midpoint of the nasal length (N´-Prn) that separates the upper dorsum from the lower dorsum
Supratip concavity (Stp)	The deepest point of the inferior third of the nasal dorsum in the midsagittal plane situated between the points mid-dorsum and inferior dorsum.
Pronasale (Prn)	The most protrusive point of the nasal tip.
Subnasale (Sn)	The point of intersection between the columella and the labial philtrum.
Alar curvature (Ac)	The most lateral point on the basal curvature of each alar cartilage corresponding to the facial insertion of the base of the nasal wing.
Anterior Nostril (NrA)	The most anterior-inferior point of the nostril in the sagittal plane.
Superior Nostril (NrS)	The most superior point of the nostril identified in the profile view.

Figure 4.3. Soft tissue cephalometric points in the frontal view

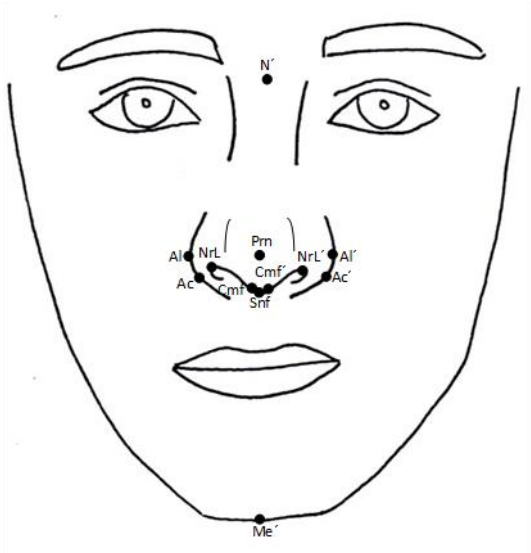
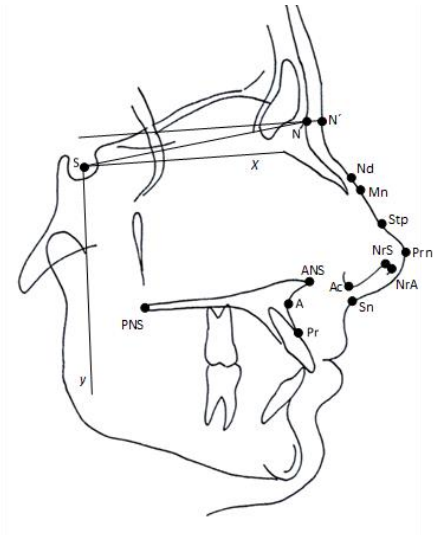


Figure 4.4. Hard and soft tissue cephalometric points in the profile view Horizontal (x) and vertical (y) reference planes



4.4.6 Cephalometric measurements

All linear and angular measurements were measured in units of millimetres and degrees, respectively.

The difference between the measurements at T3 and T2 (Value at T3 – Value at T2) were calculated for the following cephalometric variables:

I. Skeletal measurements

Sagittal measurements (Figure 4.5)

1	Sagittal maxillary advancement (A point) (A*x*)	Distance between the A point and the vertical plane *y*.
2	Sagittal maxillary advancement (prosthion) (Pr*x*)	Distance between the point prosthion (Pr) and the vertical plane *y*.

Vertical measurements (Figure 4.5)

3	Vertical maxillary change (A point) (A*y*)	Distance between the A point and the horizontal plane *x*.
4	Vertical maxillary change (prosthion) (Pr*y*)	Distance between the point prosthion (Pr) and the horizontal plane *x*.

Rotational measurements (Figure 4.5)

5	Change in maxillary inclination (SN-PP)	Angle between the sella-nasion line (SN line) and the palatal plane (PP).

II. Soft tissue measurements in frontal photographs

Direct transverse linear measurements (Figure 4.6)

1	Morphological nasal width (Al-Al´)	Distance between the alare point (Al) located on the right nasal contour and the corresponding point on the left side (Al´).
2	Alar base width (Ac-Ac´)	Distance between the alar curvature point (Ac) located on the right nasal contour and the corresponding point on the left side (Ac´).
3	Right diagonal nostril width (CmfNrL)	Distance between the points frontal columella (Cmf) and lateral nostril (NrL) located on the right side of the nose.
4	Left diagonal nostril width (Cmf´NrL´)	Distance between the points frontal columella (Cmf´) and lateral nostril (NrL´) located on the left side of the nose.
5	Right dorsal axis-alare distance (Al-N´Prn line)	Distance between the soft tissue nasion-pronasale line (N´Prn line) and the alare point (Al) located on the right nasal contour.
6	Left dorsal axis-alare distance (Al´-N´Prn line)	Distance between the soft tissue nasion-pronasale line (N´Prn line) and the alare point (Al´) located on the left nasal contour.
7	Bilateral dorsal axis-alare symmetry	Difference between the Right dorsal axis-alare distance (Al-N´Prn line) and Left dorsal axis-alare distance (Al´-N´Prn line).

Direct vertical linear measurements (Figure 4.6)

8	Frontal nasal length (N´Prn)	Distance between the points soft tissue nasion (N´) and pronasale (Prn).

Angular measurements (Figure 4.7)

9	Alar slope angle (AlPrnAl´ angle)	Angle between the right alare-pronasale line (AlPrn line) and the corresponding line on the left side.
10	Superior nasal angle (AlN´Al´ angle)	Angle between the right alare-soft tissue nasion line (AlN´ line) and the corresponding line on the left side.
11	Inferior nasal angle (AlSnfAl´ angle)	Angle between the right alare-frontal subnasale line (AlSnf line) and the corresponding line on the left side.

Figure 4.5 Skeletal facial measurements

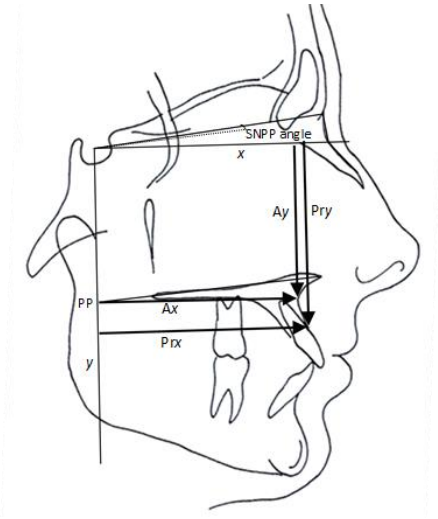


Figure 4.6 Direct frontal linear measurements

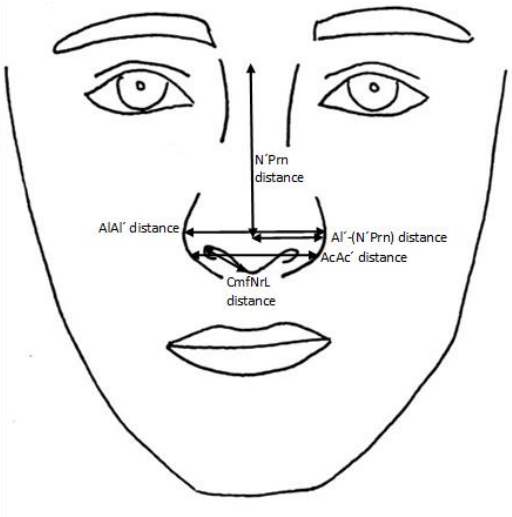


Figure 4.7 Frontal angular measurements

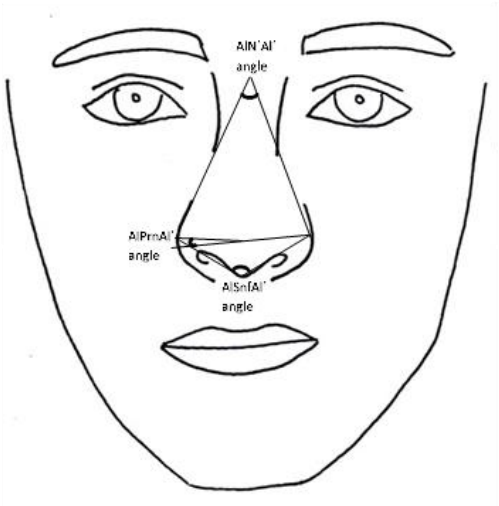


Figure 4.8 Direct profile linear measurements

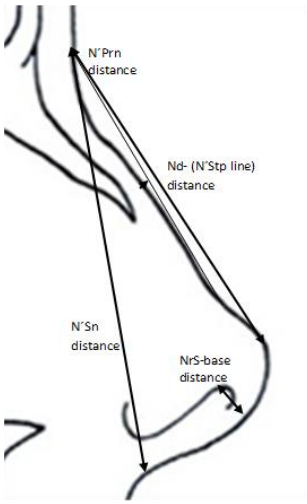


Figure 4.9 Linear measurements performed parallel to x and y

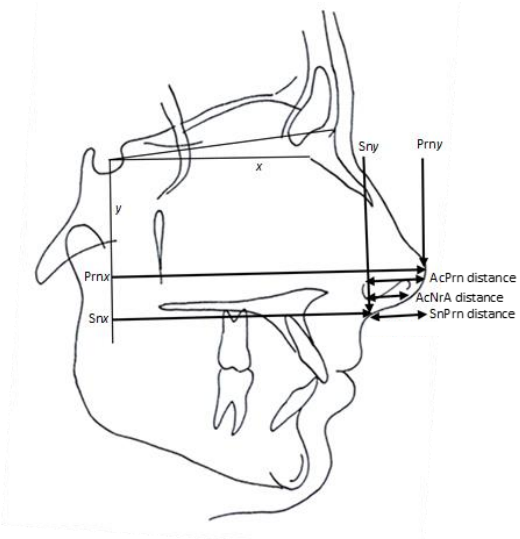


Figure 4.10 Angular profile measurements



III. Soft tissue measurements in profile photographs

Direct linear measurements (Figure 4.8)

1	Nasal height (N´-Sn)	Distance between the points soft tissue nasion (N´) and subnasale (Sn).
2	Nasal length (N´-Prn)	Distance between the points soft tissue nasion (N´) and pronasale (Prn).
3	Upper dorsal convexity (Nd-N´Stp line)	Perpendicular distance between the nasal dorsum point (Nd) and the soft tissue nasion-supratip concavity line (N´Stp line).
4	Columella exposure (NrS-columella base)	The shortest distance between the superior nostril point (NrS) and the columella base.

Linear measurements performed parallel to the horizontal reference line *x* (Figure 4.9)

5	Sagittal position of point pronasale (Prn*x*)	Distance between the point pronasale (Prn) and the vertical reference line *y*.
6	Sagittal position of point subnasale (Sn*x*)	Distance between the point subnasale (Sn) and the vertical reference line *y*.
7	Nasal projection (Ac-Prn)	Distance between the points alar curvature (Ac) and pronasale (Prn).
8	Nostril projection (Ac-NrA)	Distance between the points alar curvature (Ac) and anterior nostril (NrA).
9	Nasal protrusion (Sn-Prn)	Distance between the points subnasale (Sn) and pronasale (Prn).

Linear measurements performed parallel to the horizontal reference line *y* (Figure 4.9)

10	Vertical position of point pronasale (Prn*y*)	Distance between the point pronasale (Prn) and the horizontal reference line *x*.
11	Vertical position of point subanasale (Sn*y*)	Distance between the point subnasale (Sn) and the horizontal reference line *x*.

Angular measurements (Figure 4.10)

Angle of dorsal form

12	Supratip break angle (MnStpPrn)	Angle formed by the intersection of the mid-dorsum-supratip concavity line (MnStp line) with the supratip concavity-pronasale line (StpPrn line).

Angle of nasal rotation

13	Nasal tip rotation angle (AcPrn/ *y*)	Angle between the alar curvature-pronasale line (AcPrn line) and the vertical reference line *y*.

4.4.7 Method error

The cranial structures used for superimposition were traced and after the superimposition of pre-surgical and post-treatment lateral cephalograms of 15 randomly selected cases, frontal and profile cephalometric analyses were performed to determine the change caused by surgery (T3-T2) in each of the variables. The entire process including the tracing, superimposition and measurement was repeated after a month. The paired sample t test and determination of the interclass correlation coefficient did not detect systematic and random errors, respectively (Table 4.1 and 4.2).

Table 4.1: Systematic error according to the paired sample t test and random error according to the intraclass coefficient for the frontal nasal variables

Cephalometric variable	1st evaluation Mean ± SD	2nd evaluation Mean ± SD	Paired sample t test *P*-Value	Intraclass correlation	
				Single measures	Cronbach´s Alpha
Morphological nasal width	2.41 ± 1.31	2.19 ± 1.29	0.661	0.94	0.98
Alar base width	2.14 ± 1.46	2.07 ± 1.55	0.668	0.93	0.96
Right diagonal nostril width	0.79 ± 0.65	0.81 ± 0.80	0.871	0.81	0.89
Left diagonal nostril width	0.53± 1.23	0.44 ± 1.46	0.701	0.81	0.89
Right dorsal axis-alare distance	1.11 ±1.02	1.07 ± 0.85	0.751	0.83	0.90
Left dorsal axis-alare distance	1.33 ± 0.92	1.18 ± 1.25	0.317	0.86	0.93
Bilateral dorsal axis-alare symmetry	-2.44 ± 1.31	-2.24 ± 1.33	0.053	0.95	0.98
Frontal nasal length	0.54 ± 3.14	0.69 ± 3.45	0.461	0.97	0.98
Alar slope angle	0.60 ± 4.39	-1.36 ± 4.22	0.230	0.81	0.89
Superior alar angle	1.89 ± 2.57	2.02 ± 2.49	0.636	0.92	0.96
Inferior alar angle	0.46 ± 6.05	-0.59 ± 6.62	0.291	0.83	0.91

Table 4.2: Systematic error according to the paired sample t test and random error according to the intraclass coefficient for the profile variables

Cephalometric variable	1st evaluation Mean ± SD	2nd evaluation Mean ± SD	Paired sample t test *P*-Value	Intraclass correlation	
				Single measures	Cronbach´s Alpha
Sagittal maxillary advancement (A point)	2.60 ± 1.59	2.54 ± 1.44	0.548	0.84	0.98
Sagittal maxillary advancement (prosthion)	3.40 ± 1.73	3.43 ± 1.78	0.867	0.94	0.96
Vertical maxillary change (A point)	-0.33 ± 1.77	-0.37± 1.77	0.718	0.96	0.98
Vertical maxillary change (prosthion)	0.17 ± 1.39	0.09± 1.39	0.370	0.96	0.98
Change in maxillary inclination	0.47 ± 1.51	0.53 ± 1.36	0.719	0.87	0.93
Nasal height	-0.02 ± 1.18	0.17 ± 1.10	0.285	0.84	0.91
Nasal length	-0.03 ± 1.12	0.03 ± 1.03	0.696	0.86	0.92
Lower dorsal convexity	0.03 ± 0.38	0.01 ± 0.29	0.830	0.81	0.90
Columella depth	-0.06 ±0.44	-0.07 ± 0.58	0.931	0.85	0.91
Columella exposure	0.32 ± 0.89	0.37 ± 0.81	0.487	0.96	0.98
Sagittal position of point pronasale	0.79 ± 1.70	0.71 ± 1.49	0.573	0.96	0.98
Sagittal position of point subnasale	1.48 ± 2.15	1.33± 2.06	0.183	0.98	0.99
Nasal projection	-1.03 ± 2.03	-0.89± 1.96	0.331	0.96	0.98
Nostril projection	-0.71 ± 1.56	-0.61 ± 1.47	0.455	0.95	0.97
Nasal protrusion	-0.77 ± 1.04	-0.63 ± 1.03	0.273	0.90	0.95
Vertical position of point pronasale	-0.57 ± 1.13	-0.41 ± 1.22	0.172	0.94	0.97
Vertical position of point subnasale	-0.28 ± 1.09	-0.09 ± 1.21	0.248	0.86	0.93
Supratip break angle	-0.67 ± 1.88	-0.27 ± 2.58	0.271	0.82	0.90
Nasal tip rotation angle	-3.07 ± 3.13	-2.80 ± 2.73	0.573	0.80	0.90

4.4.8 Statistical method

For the maxillary and nasal cephalometric variables and the change caused by Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and nose, the Kolmogorov-Smirnov test was used to test the null hypothesis that the sample was derived from a normally distributed population. Non-parametric tests were used for non-normally distributed variables. As the number of male and female evaluators and male patients were less than 30, the normality of the values for the change in the attractiveness of the nose and face in these sub-groups was evaluated using the Shapiro-Wilk test. For all the variables, descriptive statistics including the mean, standard deviation, standard error of the mean and the minimum and maximum values were calculated for the vales obtained in the aesthetic evaluation using the VAS.

The aesthetic evaluations of the face and the nose measured on the VAS were used as dependent variables. The effect of the Le Fort 1 osteotomy, the magnitude of the surgical movement, patient and evaluator gender, the type of photograph (frontal or profile at rest), the anatomical region evaluated (face or nose) and the changes in the nasal morphometric measurements were used as independent variables.

The effect of the Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose and the face and on the maxillary and nasal cephalometric variables was determined using a one-sample t test.

The influence of patient and evaluator gender on the aesthetic evaluation of the nose and face was calculated using a repeated measures ANOVA. An independent t test was used to compare the 19 male and 42 female patients for the change caused by the Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and the nose in the frontal and profile views.

Pearson´s correlation coefficient was calculated to determine the correlation between the change in evaluations of the frontal and profile photographs and between the change in evaluations of the face and the nose.

The correlation between the surgical change in the aesthetic evaluation of the nose and the changes in nasal morphometric variables, as well as the magnitude of the maxillary surgical movement was determined using a multiple regression analysis. The level of statistical significance was fixed at 5%. The statistical program SPSS® version 25 for Windows (IBM Company, Armonk, NY, USA) was used.

4.5 Results

4.5.1 Effect of Le Fort 1 maxillary advancement osteotomy in the skeletal maxillary variables

The normality according to the Kolmogorov-Smirnov test and descriptive statistics for the changes caused by Le Fort 1 maxillary advancement surgery in the skeletal maxillary variables (T3-T2) in the 61 patients are reported in Tables 4.3 and 4.4. All variables, except for sagittal maxillary advancement (A point) were normally distributed at a 1% level of significance (P<0.01).

Table 4.3: Normality, descriptive statistics and results of the Wilcoxon signed-rank test for the changes caused by Le Fort 1 maxillary advancement osteotomy in the variable sagittal maxillary advancement (A point) measured in the 61 patients´ lateral cephalograms

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov *P*-value	Wilcoxon signed-rank Test *P*-value
Sagittal maxillary advancement (A point)	3.63	2.49	0.32	0.20	12.60	0.000**	0.000***

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: Maximum value, Normality **P<0.01, Wilcoxon signed-rank test, ***P<0.001

Table 4.4: Normality and descriptive statistics and results of the one sample t test for the changes caused by Le Fort 1 maxillary advancement osteotomy in the maxillary variables measured in the 61 patients´ lateral cephalograms

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov *P*-value	One sample t test *P*-value
Vertical maxillary change (A point)	-0.54	2.05	0.26	-5.30	2.80	0.184	0.043*
Sagittal maxillary advancement (Prosthion)	4.04	2.55	0.33	-0.10	12.30	0.039	0.000***
Vertical maxillary change (Prosthion)	-0.62	2.12	0.27	-5.80	4.20	0.200	0.025*
Change in maxillary inclination	0.17	2.39	0.31	-5.70	5.20	0.200	0.583

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: maximum value, *P<0.05, ***P<0.001

The Wilcoxon signed-rank test demonstrated that the variable sagittal maxillary advancement (A point) (P<0.001) significantly increased (Table 4.3). A one sample *t*- test revealed a significant reduction in vertical maxillary change (A point) and vertical maxillary change (Prosthion) (P<0.05). Sagittal maxillary

advancement (Prosthion) (P<0.001) increased significantly (Table 4.4). The mean sagittal and vertical maxillary movement at the A point of 3.63 and -0.54, respectively indicated repositioning mainly in the sagittal plane (Table 4.3 and 4.4).

4.5.2 Effect of Le Fort 1 maxillary advancement osteotomy in the nasal cephalometric variables measured in frontal photographs (T3-T2)

The normality according to the Kolmogorov-Smirnov test and descriptive statistics for the changes in the nasal cephalometric variables measured in frontal photographs (T3-T2) of the 61 patients are reported in Tables 4.5 and 4.6. Frontal nasal length was not normally distributed (P<0.01) (Table 4.6).

Table 4.5: Normality, descriptive statistics and results of the one sample t test for the changes caused by Le Fort 1 maxillary advancement osteotomy in the nasal cephalometric variables measured in the 61 patients´ frontal photographs

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov *P*-value	One sample t test *P*-value
Morphological nasal width	2.41	1.31	0.17	0.2	5.7	0.200	0.000***
Alar base width	2.49	1.37	0.18	-1.0	5.3	0.200	0.000***
Right diagonal nostril width	0.73	1.09	0.14	-1.4	3.2	0.200	0.000***
Left diagonal nostril width	0.52	1.05	0.13	-1.7	3.2	0.200	0.000***
Bilateral dorsal axis-alare symmetry	-0.04	1.77	0.23	-5.0	3.5	0.200	0.850
Alar slope angle	8.21	7.87	1.01	-11.3	23.6	0.091	0.000***
Superior alar angle	2.49	1.97	0.25	-1.2	7.9	0.200	0.000***
Inferior alar angle	3.11	6.12	0.78	-11.5	17.2	0.200	0.000***

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: maximum value, ***P<0.001

A one sample t test demonstrated significant increases in the morphological nasal width, alar base width, right diagonal nostril width, left diagonal nostril width, alar slope angle, superior alar angle and inferior alar angle measured in frontal photographs (P<0.001) (Table 4.5). The Wilcoxon signed-rank test demonstrated a significant reduction in frontal nasal length (P<0.001) (Table 4.6).

Table 4.6: Normality, descriptive statistics and results of the Wilcoxon signed rank test for the changes caused by Le Fort 1 maxillary advancement osteotomy in the non-normally distributed variable measured in the 61 patients´ frontal photographs

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov *P*-value	Wilcoxon signed-rank Test *P*-value
Frontal nasal length	-1.58	1.17	0.15	-4.20	0.20	0.000***	0.000***

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: maximum value, Normality **P<0.01, Wilcoxon signed-rank test ***P<0.001

4.5.3 Effect of Le Fort 1 maxillary advancement osteotomy in the nasal cephalometric variables measured in profile photographs (T3-T2)

The normality according to the Kolmogorov-Smirnov test and descriptive statistics for the alteration in the nasal cephalometric variables measured in profile photographs (T3-T2) of the 61 patients are reported in Tables 4.7 and 4.8. Upper dorsal convexity, columella exposure, sagittal position of point pronasale and supratip break angle (Table 4.8) were not normally distributed (P<0.01).

According to a one sample t test, nasal height, nasal length, nasal projection, nostril projection, nasal protrusion, vertical position of point pronasale, vertical position of point subnasale and nasal tip rotation angle were significantly reduced while the sagittal position of point subnasale was increased (P<0.001) (Table 4.7). The Wilcoxon signed-rank test demonstrated a significant decrease in upper dorsal convexity (P<0.01) and

supratip break angle (P<0.001) and a significant increase in sagittal position of point pronasale (P<0.001) (Table 4.8).

Table 4.7: Normality, descriptive statistics and results of the one sample t test for the changes caused by Le Fort 1 maxillary advancement osteotomy in the nasal cephalometric variables measured in the 61 patients´ profile photographs

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov *P*-value	One sample t test *P*-value
Nasal height	-0.56	1.01	0.13	-3.70	1.50	0.200	0.000***
Nasal length	-0.69	1.14	0.15	-4.00	1.70	0.024	0.000***
Sagittal position of point subnasale	1.85	1.49	0.19	-0.20	7.20	0.049	0.000***
Nasal projection	-2.04	1.90	0.24	-6.90	2.10	0.200	0.000***
Nostril projection	-1.82	1.66	0.21	-5.80	1.60	0.200	0.000***
Nasal protrusion	-0.95	0.95	0.12	-3.30	1.60	0.200	0.000***
Vertical position of point pronasale	-1.23	1.19	0.15	-3.80	1.30	0.056	0.000***
Vertical position of point subnasale	-0.78	0.97	0.12	-3.30	1.10	0.200	0.000***
Nasal tip rotation angle	-3.71	3.06	0.39	-10.50	1.10	0.200	0.000***

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: maximum value, ***P<0.001

Table 4.8: Normality, descriptive statistics and results of the Wilcoxon signed rank test for the changes caused by Le Fort 1 maxillary advancement osteotomy in the non-normally distributed nasal cephalometric variables measured in the 61 patients´ profile photographs

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov P-value	Wilcoxon signed-rank test *P*-value
Upper dorsal convexity	-0.35	1.01	0.13	-6.60	1.00	0.000**	0.002**
Columella exposure	0.04	0.68	0.09	-1.50	2.30	0.003**	0.059
Sagittal position of point pronasale	0.88	1.14	0.15	-0.80	4.30	0.000**	0.000***
Supratip break angle	-2.02	6.05	0.77	-15.40	25.20	0.000**	0.000***

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: maximum value, Normality **P<0.01, Wilcoxon signed-rank test **P<0.01, ***P<0.001

4.5.4 Descriptive statistics and normality of the changes in the aesthetic evaluation of the face and the nose in the frontal and profile views (T3-T2)

The normality according to the Kolmogorov-Smirnov test and descriptive statistics for the alteration caused by the Le Fort 1 maxillary advancement surgery in the aesthetic evaluation of the frontal and profile views of the face and the nose (T3-T2) of the 61 patients are presented in Table 4.9. All variables presented a normal distribution at an α of 1%. The mean values for the change caused by the maxillary advancement osteotomy (T3-T2) varied from -3.97% for attractiveness of the frontal view of the nose to 37.80% for attractiveness of the facial profile.

Table 4.9: Normality and descriptive statistics of the changes caused by Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and nose of the 61 patients in the frontal and profile views (T3-T2)

Variable	Mean	SD	SE	Min value	Max value	Kolmogorov-Smirnov *P*-Value
Attractiveness of the frontal view of the face	34.53	25.01	3.20	-32.24	75.25	0.193
Attractiveness of the facial profile	37.80	27.33	3.50	-43.35	88.38	0.078
Attractiveness of the frontal view of the nose	-3.97	18.32	2.35	-45.03	40.40	0.072
Attractiveness of the profile view of the nose	9.01	13.09	1.68	-25.67	36.45	0.049
Attractiveness of frontal view of the nose within the face	7.44	15.74	2.02	-31.06	45.12	0.200
Attractiveness of profile view of the nose within the face	13.37	13.22	1.69	-21.72	43.77	0.200

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max value: maximum value

4.5.5 Correlation between the change in the attractiveness of the nose and the attractiveness of the nose within the face in the frontal and profile views

Pearson´s correlation coefficient was calculated to determine the relationship between the change in attractiveness of the nose and the change in attractiveness of the nose within the face in frontal and profile

photographs. A multiple step-by step regression analysis was also performed to determine the contribution of change caused by the Le Fort I osteotomy in the attractiveness of the face and the attractiveness of the nose to the alteration in the attractiveness of the nose within the face, in the frontal and profile views.

Table 4.10: Determination of Pearson´s correlation coefficient between the changes caused by Le Fort I osteotomy in the variables Attractiveness of frontal view of the face and Attractiveness of frontal view of the nose within the face

Variables	Pearson´s correlation coefficient	*P*-value
Attractiveness of frontal view of the face Attractiveness of frontal view of the nose within the face	0.415	0.001**

**$P<0.01$

A significant, moderate correlation was verified between the change in the variables, attractiveness of frontal view of the face and attractiveness of frontal view of the nose within the face ($P<0.01$) (Table 4.10) and between the changes in the variables, attractiveness of facial profile and attractiveness of profile view of the nose within the face ($P<0.001$) (Table 4.11). Moreover, the multiple regression analysis demonstrated that the change in attractiveness of frontal view of the face and attractiveness of frontal view of the nose contributed 54% to the variation of the change in attractiveness of frontal view of the nose within the face (Table 4.12). The change in attractiveness of facial profile and attractiveness of profile view of the nose could explain 59% of the variation in the change in attractiveness of profile view of the nose within the face (Table 4.13). Hence, to eliminate a possible bias caused by the change in the global attractiveness of the face on the change in the evaluation of the nose, the variables attractiveness of frontal view of the nose within the face and attractiveness of profile view of the nose within the face were eliminated from all subsequent analyses.

Table 4.11: Determination of Pearson´s correlation coefficient between the changes caused by Le Fort I osteotomy in the variables Attractiveness of facial profile and Attractiveness of profile view of the nose within the face

Variables	Pearson´s correlation coefficient	*P*-value
Attractiveness of facial profile Attractiveness of profile view of the nose within the face	0.619	0.000***

***$P<0.001$

Table 4.12: Results of the multiple regression step-by step analysis to determine the contribution of the changes caused by Le Fort I advancement osteotomy in the attractiveness of frontal view of the face and the attractiveness of frontal view of the nose to the change in the attractiveness of frontal view of the nose within the face

Dependent variable	Independent variable	B	SE	Beta	t	R	R^2	*P*-value
Attractiveness of frontal view of the nose within the face	Intercept	4.16	2.5		1.65	0.74	0.54	0.105
	Attractiveness of frontal view of the face	0.16	0.06	0.25	2.7			0.009**
	Attractiveness of frontal view of nose	0.54	0.08	0.63	6.8			0.000***

B: Unstandardized regression coefficient, SE: standard error, Beta: Standardized regression coefficient, R: multiple correlation coefficient, R^2: Coefficient of determination, **$P<0.01$, ***$P<0.001$

Table 4.13: Results of the multiple regression step-by step analysis to determine the contribution of the changes caused by Le Fort I advancement osteotomy in the attractiveness of profile view of the face and the attractiveness of profile view of the nose to the change in the attractiveness of profile view of the nose within the face

Dependent variable	Independent variable	B	SE	Beta	t	R	R^2	*P*-value
Attractiveness of profile view of the nose within the face	Intercept	-0.99	1.97		-0.51	0.77	0.59	0.616
	Attractiveness of facial profile	0.28	0.04	0.57	6.66			0.000***
	Attractiveness of profile view of nose	0.44	0.09	0.44	5.10			0.000***

B: Unstandardized regression coefficient, SE: standard error, Beta: Standardized regression coefficient, R: multiple correlation coefficient, R^2: coefficient of determination, ***$P<0.001$

4.5.6 Effect of Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the face and nose in the frontal and profile views

The results of the one sample t test performed to determine whether the changes in the aesthetic evaluation of the frontal and profile views of the face and nose in the 61 patients (T3-T2) were statistically different from zero are presented in table 4.14. All the variables significantly improved (P<0.001) except attractiveness of frontal view of the nose which tended to deteriorate, albeit in a non-significant manner.

Table 4.14: Results of the one sample t test to determine the alteration caused by the Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and the nose in the 61 patients

Variable	Mean	SD	One sample t test		
			95% Confidence Interval of the Difference		*P*-Value
Attractiveness of the frontal view of the face	34.53	25.01	28.13	40.94	0.000***
Attractiveness of the facial profile	36.62	28.55	29.31	43.93	0.000***
Attractiveness of the frontal view of the nose	-3.97	18.32	-8.66	0.72	0.096
Attractiveness of the profile view of the nose	8.44	13.42	5.00	11.88	0.000***

SD: Standard Deviation, ***P<0.001

4.5.7 Influence of evaluator and patient gender on the changes in the attractiveness of the face and the nose

The normality and descriptive statistics of the change in the attractiveness of the nose and face in 19 men and 48 women are presented in tables 1 and 2 of Appendix II, annex 3. The normality and descriptive statistics of the change in attractiveness of the face and nose in 61 patients according to the 4 male and 4 female orthodontists are displayed in tables 1 and 2 of Appendix II, annex 4. The Shapiro Wilk test showed that the variable attractiveness of the frontal view of the face was not normally distributed (P=0.001) for male evaluators, at a 1% level of confidence (Table 1 of Appendix II, annex 4).

Table 4.15: Repeated measures ANOVA to determine the interaction between evaluator gender and patient gender in the alteration caused by Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the facial profile and frontal and profile views of the nose

Dependent variable:	Men Mean (SD)	Women Mean (SD)	Source of variation	Type III Sum of squares	Mean Square	Power	F value	*P*-value
Attractiveness of facial profile	42.93 (32.09)	32.67 (25.41)	Evaluator gender	2629.23	2629.23	0.96	14.24	0.000***
			Evaluator * Patient	9.88	9.88	0.06	0.05	0.818
Attractiveness of frontal view of the nose	-6.44 (23.24)	-1.49 (18.80)	Evaluator gender	843.24	843.24	0.48	3.75	0.058
			Evaluator * Patient	96.98	96.98	0.10	0.43	0.514
Attractiveness of profile view of the nose	13.23 (17.64)	4.79 (13.88)	Evaluator gender	1831.60	1831.60	0.91	11.19	0.001**
			Evaluator * Patient	0.76	0.76	0.05	0.01	0.946

Evaluator * Patient: Evaluator gender * Patient gender, SD: Standard deviation, **P<0.01, ***P<0.001

A repeated measures ANOVA found that the gender of the evaluator significantly influenced the change in the variables attractiveness of facial profile (P<0.001) and attractiveness of profile view of the nose (P <0.01) without an interference from the gender of the patient (Table 4.15 and Figure 4.11). Men were more generous than women in the evaluation of the improvement in these two variables. They tended to be more

critical of the change in attractiveness of the frontal view of the nose, although not in a significant manner (Table 4.15). The Wilcoxon Signed rank test performed demonstrated that men were more benevolent than women while evaluating the improvement in the variable attractiveness of the frontal view of the face (Table 4.16).

Figure 4.11: Interaction between evaluator and patient gender in the change caused by Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the facial profile and the frontal and the profile view of the nose (Evaluator gender 1: Male orthodontists, 2: Female orthodontists)

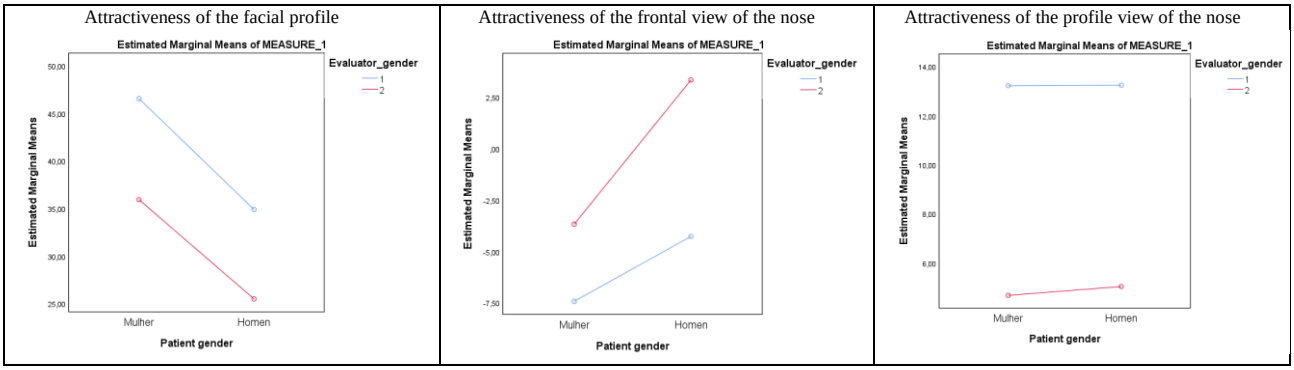


Table 4.16 Descriptive statistics and the Wilcoxon Signed rank test to determine the influence of evaluator gender on the effect of the Le Fort 1 maxillary advancement osteotomy in Attractiveness of the frontal view of the face of the 61 patients (T3-T2)

Variable	Descriptive statistics								Wilcoxon Signed rank test *P*-Value
	Male evaluators				Female evaluators				
	Mean	SD	Min. value	Max. value	Mean	SD	Min. value	Max. value	
Attractiveness of the frontal view of the face	40.28	31.05	-41.41	85.86	28.79	22.25	-24.92	77.44	0.000***

SD: Standard deviation, Min. value: Minimum value, Max. value: Maximum value, *P*<0.001***

An independent t test did not demonstrate significant differences between the 19 male and 42 female patients for the change caused by the Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and the nose in the frontal and profile views (T3-T2) (Table 4.17). Thus, all subsequent analyses were performed including both genders in a single group.

Table 4.17: Descriptive statistics and the independent t test to compare male and female patients regarding changes produced by Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and nose in the frontal and profile views (T3-T2)

Variable	Descriptive statistics								Independent t test		
	Men				Women				95% CI		*P*-Value
	Mean	SD	Min. value	Max. value	Mean	SD	Min. value	Max. value	Lower	Upper	
Attractiveness of the frontal view of the face	35.78	28.14	-25.84	75.25	33.97	23.81	-32.24	73.4	-16.98	13.36	0.809
Attractiveness of the facial profile	30.19	29.55	-43.35	87.29	41.25	25.90	-28.6	88.38	-4.99	27.11	0.170
Attractiveness of the frontal view of the nose	-0.47	14.42	-36.70	29.12	-5.55	19.78	-45.03	40.4	-14.14	3.98	0.265
Attractiveness of the profile view of the nose	9.14	11.66	-19.28	24.92	8.95	13.83	-25.67	36.45	-7.10	6.72	0.956

SD: Standard deviation, Min value: Minimum value, Max value: Maximum value, CI: Confidence Interval of the Difference

4.5.8 Correlation between the evaluations of the effect of Le Fort 1 osteotomy on nasal aesthetics in frontal and profile views

No significant correlation was verified between the variables; attractiveness of frontal view of the nose and attractiveness of profile view of the nose (Table 4.18).

Table 4.18: Pearson´s correlation coefficient to determine the correlation between the evaluations of the effect of the Le Fort I maxillary advancement osteotomy on nasal aesthetics in the frontal and profile views

Variables	Pearson´s correlation coefficient	*P*- value
Attractiveness of frontal view of the nose Attractiveness of profile view of the nose	0.067	0.609

4.5.9 Correlation between the evaluations of the effect of Le Fort 1 osteotomy on facial and nasal aesthetics

The alteration in attractiveness of frontal view of the nose demonstrated a weak, significant correlation with the change in attractiveness of frontal view of the face ($P<0.05$). The variables attractiveness of profile view of the nose and attractiveness of the facial profile were not significantly correlated (Table 4.19).

Table 4.19: Pearson´s correlation coefficient to determine the correlation between the evaluations of the effect of Le Fort 1 osteotomy on facial and nasal aesthetics

Variable	Pearson´s correlation coefficient	*P*- value
Attractiveness of frontal view of the nose Attractiveness of frontal view of the face	0.270	0.035*
Attractiveness of profile view of the nose Attractiveness of facial profile	0.203	0.117

*$P<0.05$

4.5.10 Multiple regression analysis to determine the correlation between the changes in nasal aesthetics in the frontal view and the changes in nasal morphometric measurements in frontal photographs

A multiple regression analysis was performed to determine the influence of the alteration in the cephalometric variables on the change in the attractiveness of the nose. Non-influencing variables were removed by the SPSS program in a stepwise manner. The analysis demonstrated that the change in morphological nasal width, alar base width and superior alar angle explained 19% of the variation in the change in attractiveness of frontal view of the nose (Table 4.20).

Table 4.20: Results of the multiple regression analysis to determine the contribution of the changes in nasal morphometric measurements performed in frontal photographs to the evaluation of the changes in frontal nasal aesthetics caused by Le Fort 1 maxillary advancement osteotomy

Dependent variable	Independent variables	B	SE	Beta	t	R	R^2	*P*-value
Attractiveness of frontal view of the nose	Intercept	1.98	4.90		- 0.40	0.44	0.19	0.688
	Morphological nasal width	6.77	2.64	0.49	2.57			0.013*
	Alar base width	-4.82	2.08	-0.36	-2.31			0.024*
	Superior alar angle	-4.11	1.54	-0.44	-2.68			0.010*

$P<0.05$, B: Unstandardized regression coefficient, SE: standard error, Beta: Standardized regression coefficient, R: multiple correlation coefficient, R^2: Squared multiple correlation coefficient, R: Pearson´s correlation coefficient for each contributing variable

Each millimetre of increase in morphological nasal width and decrease in alar base width and each degree reduction in superior alar angle enhanced attractiveness of frontal view of the nose by 6.77%, 4.82% and 4.11%

respectively, on the 100 mm VAS (P<0.05) while the surgical procedure itself added 1.98% to VAS measured attractiveness.

Table 4.21 Correlation coefficients for the change in morphometric variables that contributed to the variation of the change in frontal nasal aesthetics

Dependent variable	Independent variables	Pearson´s correlation coefficient	*P*-value
Attractiveness of	Morphological nasal width	-0.05	0.347
frontal view of the nose	Alar base width	-0.26	0.021*
	Superior alar angle	-0.28	0.014*

*P<0.05

Pearson´s correlation coefficients were calculated for each of the contributing variables. The weak, negative correlations were significant for alar base width and superior alar angle (P<0.05) and non-significant for morphological nasal width (Table 4.21).

4.5.11 Multiple regression analysis to determine the correlation between the changes in nasal aesthetics in the profile view and the changes in nasal morphometric measurements in profile photographs

The alteration in nasal height, vertical position of point pronasale and supratip break angle contributed 24% to the variation in the change in attractiveness of the profile view of the nose (Table 4.22). Each millimetre of decrease in nasal height and each degree reduction in supratip break angle increased attractiveness of profile view of the nose by 6.99% (P<0.001) and 0.52% (P<0.05) respectively, on the 100 mm VAS. Each millimetre reduction in the vertical position of point pronasale reduced attractiveness by 2.97% (P<0.05) while the surgery itself added 7.70%.

Correlation coefficients were calculated for each of the nasal morphometric variables that contributed to the variation in attractiveness of profile view of the nose (Table 4.23). A weak, negative significant correlation was detected for nasal height (P<0.01) and a weak, positive non-significant one for vertical position of point pronasale. The supratip break angle, which was not normally distributed, revealed a weak, negative non-significant correlation.

Table 4.22: Results of the multiple regression step-by step analysis to determine the contribution of the changes in nasal morphometric measurements performed in profile photographs to the changes in profile nasal aesthetics caused by Le Fort 1 maxillary advancement osteotomy

Dependent variable	Independent variables	B	SE	Beta	t	R	R^2	*P*-value
Attractiveness of	Intercept	7.70	2.27		3.39	0.49	0.24	0.001**
profile view of the nose	Nasal height	-6.99	1.71	-0.54	-4.09			0.000***
	Vertical position of point pronasale	2.97	1.41	0.27	2.11			0.040*
	Supratip break angle	-0.52	0.26	-0.24	-2.01			0.049*

*P<0.05, **P<0.01, ***P<0.001, B: Unstandardized regression coefficient, SE: standard error, Beta: Standardized regression coefficient, R: multiple correlation coefficient, $R^{2:}$ Squared multiple correlation coefficient

Table 4.23 Correlation coefficients for the change in morphometric variables that contributed to the variation in the change in profile nasal aesthetics

Dependent variable	Independent variables	Pearson´s correlation coefficient	*P*-value
Attractiveness of profile view of the nose	Nasal height	-0.37	0.003**
	Vertical position of point pronasale	0.012	0.930
		Spearman´s correlation coefficient	*P*-value
	Supratip break angle	-0.13	0.319

**P<0.01

4.5.12 Multiple regression analysis performed to determine the influence of each type of maxillary movement (sagittal, vertical and rotational) on the evaluation of change in nasal aesthetics

The multiple regression step-by step analysis verified that the magnitude of each of the sagittal, vertical and rotational surgical maxillary movements did not contribute significantly to the evaluation of change in nasal aesthetics in the frontal and profile views.

4.6 Discussion

Photographs are routinely used in clinical practice for diagnosis and the evaluation and demonstration of clinical progress and treatment results (Claman et al., 1990; Edler et al., 2011; Zhang et al., 2007). They allow reproducible, linear and angular measurements (Gomes et al., 2013; Zhang et al., 2007) and are the easiest and most reliable method for nasal evaluation (Naeem et al., 2015; Prinsley, 1992). Photographs help clinicians plan orthognathic surgery and patients express their aesthetic perception and soft tissue treatment expectations (Edler et al., 2011; Khavkin & Ellis, 2011). Morphing allows direct visualization of expected surgical changes and helps in the treatment decision and in communicating it to the patient (Chew, Koh, et al., 2008; Claman et al., 1990; Nechala et al., 1999; Persichetti et al., 2007). Moreover, photography requires minimal equipment and is a radiation-free technique (Aksu et al., 2010; Gomes et al., 2013; Khavkin & Ellis, 2011; Nechala et al., 1999).

Howells and Shaw (1985) deemed the use of photographs together with a panel of evaluators a valid, reproducible and representative method of evaluating facial appearance after they found a high correlation between VAS scores attributed to physically present children and to their oblique, resting photographs. In situ facial evaluations correlate better with those of photographs due to their more realistic depiction of facial aesthetics than silhouettes or profile drawings (de Almeida & Bittencourt, 2009; Ioi et al., 2005; Sena et al., 2017). Their exhibition of gender specific characteristics results in a truer picture of what is considered attractive (Hockley et al., 2012; Pişiren et al., 2018). Photographs divulge factors such as age, skin texture, hairstyle, hair and eye colour and makeup which influence the perception of attractiveness (de Almeida & Bittencourt, 2009; Fabré et al., 2010; Ioi et al., 2006; Kerr & O'Donnell, 2014; Melo et al., 2017; Spyropoulos & Halazonetis, 2001). They also display other features such as the forehead, eyebrows, nose, ears and neck that especially influence laypeople (Melo et al., 2017). Black and white photographs are an option for eliminating the bias caused by skin complexion and eye and hair colour (Oliveira et al., 2015; Pişiren et al., 2018). However, Sena et al. (2017), emphasized the importance of maintaining all extrinsic features that affect the aesthetic evaluation.

Profile silhouettes (Czarnecki et al., 1993; Modarai et al., 2013; Naini et al., 2015; Tufekci et al., 2008) and line drawings (Chew et al., 2007; Thomas, 1979) are also options for studies on facial attractiveness. They do not allow personality traits to be attributed as easily (Ioi et al., 2006) and remove distracting variables, such as emotional expression, hairstyle and make-up, allowing evaluators to focus exclusively on the profile outline (Abu Arqoub & Al-Khateeb, 2011; Fabré et al., 2009; Hockley et al., 2012; Ioi et al., 2006; Klaus et al., 2017; Polk et al., 1995; Shelly et al., 2000) or on specific areas of interest such as the lips (Nomura et al., 2009).

Hence, they reduce the subjectivity of facial evaluations (Foster, 1973; Ioi et al., 2005, 2006; Yin et al., 2014). However, authors emphasize that both silhouettes and line drawings represent an unrealistic situation and disregard important facial features and the smile (Fabré et al., 2009; Kiekens et al., 2005). Hence, scores of silhouettes do not represent the true perception of attractiveness which is conditioned by extrinsic variables, particularly for laypeople (Hockley et al., 2012; Murakami et al., 2016; Spyropoulos & Halazonetis, 2001). While warped photographs with the same average soft tissue outline were more attractive than the original female profile photographs from which they were produced, confirming the importance of the profile contour, morphed composite images with different hairstyles, which besides the average profile, had unblemished skin, received the highest scores, highlighting the importance of additional factors (Spyropoulos & Halazonetis, 2001). Investigations also generate different results, at least in terms of lip position, depending on whether silhouettes or photographs that form more natural stimuli are used. A lip position within the norm is considered more attractive in photographs than in silhouettes even though it is preferred in both (Hockley et al., 2012; Pithon et al., 2014). Conversely, silhouettes favour lip retrusion more than photographs (Hockley et al., 2012). Maple et al. (2005) concluded that while profile outlines and silhouettes may be valid for studying treatment effects, studies on attractiveness compel the evaluation of the entire face. Hence, these tools are best used to quantify a linear or angular profile change but not an aesthetic one (Hockley et al., 2012). Silhouettes also do not display important nasal features such as the nostril and the alar curvature.

Another possible stimulus for investigations into aesthetic preferences are digitally modified photographs (Bui et al., 2015; Burcal et al., 1987; de Almeida & Bittencourt, 2009; Lee et al., 2011; Romani et al., 1993; Tole et al., 2014; Torsello et al., 2010). Photographs and silhouettes have been altered using Dolphin imaging (Chong et al., 2014; Hockley et al., 2012; Sy et al., 2016), the Adobe Photoshop CC program (Jiang et al., 2018; Oliveira et al., 2015; Pişiren et al., 2018; Yin et al., 2014) or cephalometric programs (Falkensammer et al., 2014; Murakami et al., 2016; Soh et al., 2005a; Türkkahraman & Gökalp, 2004). Advances in the link between radiographs and photographs have imparted more realism to soft tissue morphing (Chew, Koh, et al., 2008). Modified photographs are more realistic than drawn profile contours (Fabré et al., 2009; Maple et al., 2005). They also eliminate the confounding effect of hairstyle and skin tone by representing all changes in the same image of a single person (Falkensammer et al., 2014; Maple et al., 2005). Yet, Muñoz-Reyes et al. (2015) recommended the use of original, unmodified rather than manipulated photographs to study attractiveness and especially, potential surgical changes, as the simulation of soft tissue movement, using algorithms based on previously published results, is often inaccurate and causes unnatural images. Algorithmic changes using ratios represent the overall expected outcome but do not account for individual patient variability (Maple et al., 2005).

Facial videos that have also been used as stimuli in aesthetic investigations provide more information, and hence, do not support subconscious, stereotypical associations of chin position with personality traits such as those of dominance and flexibility as much as photographs (Sinko, Jagsch, et al., 2018; Sinko, Tran, et al., 2018). Yet, Rhodes et al. (2011) found that attractiveness scores attributed to male facial photographs and videos were strongly correlated despite additional information such as multiple views and speech-related movements imparted by the latter. This is because people take only a fraction of a second to develop a reliable

view of attractiveness based on first impressions (Sinko, Tran, et al., 2018; Willis & Todorov, 2006). Both stimuli demonstrated excellent internal consistency and similar aesthetic scores when laypeople evaluated women´s right and left profile and frontal smiling photographs and a video demonstrating the interchange between the three views (Sinko, Tran, et al., 2018). Another study reported strong correlations between the attractiveness of photographs, frames obtained from videos and videos (Kościński, 2013), despite the frozen stills from videos causing an unattractive frozen face effect (Kościński, 2013; Post et al., 2012). Facial averageness, symmetry, sexual dimorphism, skin health and mouth expression affect the attractiveness of static images and videos in a similar manner (Kościński, 2013; Rhodes et al., 2011). Moreover, although they may provide additional information about the patient´s self-perception, standardization has not yet been achieved for the use of videos in research (Walder et al., 2013). They also are not part of the routine diagnostic tools used in clinical practice (Shafiee et al., 2008). Thus, the tendency to make rapid and robust judgements of attractiveness in both videos and photographs validates the use of the latter in research (Rhodes et al., 2011).

This investigation used frontal and profile facial photographs that are routinely used in clinics as diagnostic and medicolegal tools. Three-quarter colour photographs have also been used for facial evaluations (Howells & Shaw, 1985; Peerlings et al., 1995). Some authors used all three views (Kiekens et al., 2005; Pişiren et al., 2018). However, rigorous tests about the clinical usefulness of additional images beyond frontal and profile images are not available (Shafiee et al., 2008). This is especially true for the nose. The bird´s eye nasal view that was used in one investigation was not available in patient records and is unlikely to be important to the patient (Moolenburgh et al., 2008a).

Patient head position is very important during photography (Gomes et al., 2013; Persichetti et al., 2007; Sommer & Mendelsohn, 2004). Horizontal head rotation alters frontal symmetry while vertical rotation affects relative mandibular prognathism (Claman et al., 1990). Nasal width measured in frontal photographs varies little with vertical head rotation, which affects vertical dimensions more than transverse ones (Bishara, Cummins, et al., 1995). A 10° inferior head inclination lengthened the nasal dorsum by 11.93% and the chin by 13.67% while a 10° elevation shortened the dorsum by 32.34% and lengthened the chin by 6.82% in frontal photographs (Riml et al., 2011). Neck extension reduces submental tissue which can affect the aesthetic evaluation (Khavkin & Ellis, 2011).

The photographs were taken in the highly reproducible, natural head position that is generally recommended for clinical photography (Fabré et al., 2010; Leitao & Nanda, 2000; Lundström & Lundström, 1992; Solow & Tallgren, 1971). Natural head orientation was used when the clinician perceived that the patient´s head position was 'unnatural' (Arnett et al., 1999; Lundström & Lundström, 1995). Patients taller than the photographer were asked to sit in a rotating chair with their feet flat on the floor (Becker & Tardy, 1999; Bjehin, 1957; Swamy & Most, 2010).

An even, monochromatic, non-reflective, white background was used (Khavkin & Ellis, 2011; Persichetti et al., 2007; Swamy & Most, 2010). Illumination is important in studies on nasal aesthetics as it can alter the nasal tip appearance (Daniel et al., 1990; Strub et al., 2015). A reduction in the angle between the subject-camera axis and the light source results in a ‘‘photographic tip rhinoplasty’ which makes the nasal tip defining

points and light reflexes in the eyes appeared closer together (Swamy & Most, 2010). The use of an annular flash created even lighting (Becker & Tardy, 1999; Khavkin & Ellis, 2011).

Floor markings ensured uniformity in the operators and patient´s position (Khavkin & Ellis, 2011; Swamy & Most, 2010). The clinician and thus, camera remained at a fixed distance of 1.5 meters from the patient (Claman et al., 1990; Khavkin & Ellis, 2011). This distance was greater than the recommended minimum of 10 times the "breadth of the subject" to ascertain a less than 1% photographic distortion (Gavan et al., 1952; Muradin et al., 2007). Floor markings maintained the rotating chair or patient´s feet at 60 centimetres from the background (Khavkin & Ellis, 2011; Persichetti et al., 2007).

The axis of the lens was focused between the patient´s eyes and at their level and parallel to the horizontal plane (Claman et al., 1990; Khavkin & Ellis, 2011). A too high camera position makes the head appear tilted anteriorly with a deficient chin and longer dorsum while a camera placed too low has the opposite effect (Claman et al., 1990; Riml et al., 2011). The face was positioned in the centre of the frontal photograph with both ears, the crown of the head and the clavicle clearly visible (Claman et al., 1990; Nechala et al., 1999). Profile photographs did not allow the contralateral facial side to be seen (Claman et al., 1990; Persichetti et al., 2007).

Patient photographs were inspected to detect factors that could interfere with the evaluation. The same neutral expression had to be portrayed before and after treatment (Khavkin & Ellis, 2011; Persichetti et al., 2007; Swamy & Most, 2010). Riml et al. (2011) concluded that a slight smile shortened the upper lip by 23.20%, raised the cheek and reduced the nasolabial angle by 14.43% in frontal photographs. Thus, photographs that demonstrated subtle changes in expression were not used as these affect both measurements as well as attributed personality which could affect scores (Howells & Shaw, 1985). Images with distracting elements such as hats, spectacles, hearing aids, jewellery and scarves that interfered with facial visualization were eliminated (Fabré et al., 2010; Khavkin & Ellis, 2011; Persichetti et al., 2007; Swamy & Most, 2010). Those with accessories such as long earrings in only one of the phases and piercings were also not used (Pişiren et al., 2018). Beards, moustaches, excessive hair over the forehead and excessive shadows were also excluded (Bell et al., 1985). Different hairstyles did not affect the attractiveness of a morphed composite face, indicating that they may matter less in ideal faces (Spyropoulos & Halazonetis, 2001). Patients that need orthognathic surgery, however, do not belong to this group of people. Hence, patients with blatantly different hair colour or hairstyle between the two series of images, were also eliminated. Hairstyle was additionally important in women because ear contour helped to ensure that the initial and post-treatment images had the same orientation in the PowerPoint presentation. Photographs were selected only if hair was pulled away from the ears. A dramatically different skin complexion caused by tanning was also considered a possible confounding factor.

Post-surgical photographs were superimposed on the pre-treatment ones using the Adobe Photoshop CS5 program to ensure the same size and head orientation in both. This was essential because, besides its inherent variation, the natural head position may not be reliable after mandibular setback surgery in some skeletal class III patients who extend their heads to compensate for a reduced pharyngeal space (Cho et al., 2015). Structures that were not modified by the surgery such as the pupils, inner and outer canthi of the eye and ear contours

were used to superimpose the frontal photographs and the forehead, supraciliary margin, anterior border of the orbit and ear contours were used for the profile photographs.

Images with the same size and orientation were then paired in PowerPoint slides in a random order to avoid a systematic bias caused by knowledge of which treatment phase the photograph belonged to. Information about the surgical reconstruction of partially or totally amputated noses made evaluators attribute higher scores to patients and controls in a second screening session than when they were unaware of the nature of the study, indicating that familiarity with the cause of a different appearance will result in empathy and a more positive assessment (Moolenburgh et al., 2008b). Orthodontists tended to lower the VAS scores attributed for the attractiveness of pre-treatment images of patients with skeletal class II malocclusions and evaluated post-mandibular advancement photographs more favourably, resulting in a greater rated surgical improvement when these were presented in matched pairs with the treatment phase disclosed than when the same photographs were displayed individually (Ng et al., 2013). However, in this investigation, despite randomization, this bias probably persisted for the full facial photographs and especially for the profile where orthodontists could effortlessly detect the treatment phase.

The PowerPoint program was used for cropping and to harmonize illumination in each pair of photographs. Aesthetic studies have used different forms of cropping for the evaluation of the nasolabial regions in photographs of patients with cleft lip and palate. Some authors used a circle or oval that revealed the nose, mouth and chin but did not include the nasal root and presented a large portion of the paranasal and cheek area (Bongaarts et al., 2008; Prahl et al., 2006). Others use frontal images cropped in the form of an inverted triangle and a rectangular profile image with a diagonally cut posterior border (Asher-McDade et al., 1991; Nguyen et al., 2018). Stebel et al. (2016) used a cropped rectangular profile image with straight borders. However, bias can be introduced when photographs are not cropped symmetrically (Mosmuller et al., 2013). Divergence between the lateral contour of the nose and the margins of the cropped images could also possibly affect assessment. Hence, cropping was performed using rectangles and defined distances in a manner that eliminated the lips, paranasal area and the nasolabial angle from the image and maintained symmetry. Additionally, when the nose was evaluated in the full facial photographs, square shapes of neutral colour blocked out the patient´s eyes to prevent them from influencing the evaluations.

The PowerPoint presentation was macro-enabled to allow the evaluator to tick the box corresponding to the more attractive image and slide the movable bar along the VAS to quantify the difference in attractiveness between the images. An advantage of this method was that a deterioration in attractiveness and a lack of change after surgery could also be registered.

Quick and subconscious impressions are formed based on people´s faces (Finlay et al., 1995; Sinko, Tran, et al., 2018). A high correlation between judgments of attractiveness, likeability, trustworthiness, competence, and aggressiveness made after a 100-ms exposure and those made in the absence of time constraints suggested that this exposure was sufficient for a reliable opinion (Willis & Todorov, 2006). Accordingly, evaluators were asked to score their first impression of the attractiveness of the images (Sena et al., 2017; Sinko, Tran, et al., 2018). This may however been difficult for orthodontists who, as a group, tend to over-evaluate the profile and

specific areas of interest (Fabré et al., 2009; Maple et al., 2005). This tendency was also noted in the current study.

No time limit was imposed on each evaluation although evaluators were asked not to return to previous slides. Most authors did not limit the evaluation time (Hockley et al., 2012; Klaus et al., 2017; Lines et al., 1978; Naini, Cobourne, et al., 2016a; Nomura et al., 2009; Sena et al., 2017; Sinko, Tran, et al., 2018) . Shelly et al. (2000) projected images in 10 second intervals. Others used an exposure time of 15 seconds for a triplet of extra-oral photographs (Kiekens et al., 2005) or frontal and profile slides (Phillips, Trentini & Douvartzidis, 1992). Authors have even used 30 seconds (Ghorbanyjavadpour & Rakhshan, 2019; Marchiori et al., 2015; Melo et al., 2017) or even one minute (Barroso et al., 2012). Nouraei et al. (2009) utilized a 3 second viewing followed by a 3.5 second window for the observer to register his opinion.

Another factor that had to be considered was evaluator fatigue. Nouraei et al. (2009) introduced a 1-minute break after every 20 viewings to decrease fatigue. For the same purpose, other authors divided a much larger sample of 141-144 sets of four facial photographs into subgroups that were evaluated by between 17 to 50 individuals who scored their agreement with 9 questions using the VAS (Springer, Schulze, et al., 2012; Springer, Wiltfang, et al., 2012). Bell et al. (1985) randomly halved sets of pre-treatment frontal and profile photographs of 80 orthognathic surgery patients into two sessions as a pilot study determined that 14 orthodontists and oral surgeons could compare skeletal and dentoalveolar components of 40 profile images to illustrative scales and score their need for surgery on 5 point scales without fatigue. As this investigation involved only two decisions in each of the slides, one of the 6 complete sessions that included all 61 patients was performed each day. The lead researcher was present during these sessions to ensure that all evaluators ticked the preference boxes when they moved the VAS bar.

4.6.1 Number of patients and evaluators

Investigations into nasal asthetics have varied in the number of evaluators and patients used. Kandathil et al., (2018) asked 813 laypeople to assess modifications in the dorsal hump and tip in profile photographs of 2 men and 2 women. In another study, 100 individuals evaluated modified profile photographs of ten Caucasian women (McArdle et al., 2012). Pre and post-rhinoplasty facial photographs of 13 patients were evaluated by 473 laypeople (Nellis et al., 2018). Nouraei et al. (2009) asked 10 laypeople to score initial and post-rhinoplasty frontal photographs of 61 women and 39 men. In another investigation, 39 laypeople evaluated frontal photographs of 13 people with straight noses and 14 initial and post-operative photographs of people with crooked noses (Roxbury et al., 2012).

The number of subjects and evaluators used to detect the aesthetic change caused by orthodontic surgery also varies depending on the type of investigation. Some authors ask a larger number of evaluators to evaluate simulated incremental changes in a few images to determine the magnitude at which they become noticeable (Barroso et al., 2012; Burcal et al., 1987). Fifty post-treatment orthodontic-surgical patients were requested to evaluate mandibular changes in an idealized profile image (Naini et al., 2013). In another study, 19 male and 3 female orthodontists and 11 laypeople of each gender evaluated simulations of maxillary or mandibular

sagittal or maxillary vertical osteotomies in frontal and profile photographs of a man and women (Romani et al., 1993).

Authors can ask panels to choose the best treatment option among computerized predictions. 51 maxillofacial surgeons, 78 orthodontists and 61 laypeople evaluated computerized predictions of Le Fort I advancement, mandibular setback and bimaxillary surgery in 10 men and 8 women with class III malocclusions (Fabré et al., 2010). One hundred and ninety-eight Americans of East Asian origin chose between the options of orthodontic camouflage and mandibular advancement to treat class II malocclusions and mandibular setback or maxillary advancement to treat class III discrepancies in 2 profiles of each gender (Sy et al., 2016))

Some researchers only studied final aesthetics. Without considering the type of initial discrepancy or surgery used, 6 laypeople, 3 orthodontists and 3 oral surgeons assessed the postoperative profile contour drawings of 21 Chinese women and 9 men (Chew et al., 2007). Faverani et al. (2013) requested 2 orthodontists and 2 maxillofacial surgeons to evaluate 30 final frontal and profile photographs without specifying the type of surgery performed.

Other studies, like this one, compared initial and final aesthetics using either single or multiple panels. Twenty orthodontists and twenty oral surgeons evaluated profile silhouettes of 3 men and 17 women who underwent mandibular advancement surgery on a 5-point Likert scale (Tsang et al., 2009). Ten individuals in each panel of orthodontists, art students and laypeople assessed frontal and lateral photographs of skeletal Class II patients treated using mandibular advancement osteotomy (Ng et al., 2013). Twenty male orthodontists and twenty laymen scored initial and post-surgical profile silhouettes of 9 men and 11 women with Class II division 1 malocclusion (Klaus et al., 2017). Baker and Woods (2001) used evaluations of frontal and profile photographs of 36 women and 10 men by 2 members in each panel of orthodontists, oral surgeons, general dentists, artists, laypeople and people from the modelling industry. Twelve members in each panel of orthodontists, maxillofacial surgeons and laypeople provided reliability in evaluating changes caused by bimaxillary surgery in profile photographs of 20 patients of each gender with Class III malocclusion using a five-point scale (Sari-Rieger & Rustemeyer, 2015).

A panel of 9 randomly selected orthodontists or of 14 laypeople or a mixed panel of 13 laypeople and orthodontists were sufficient to satisfy the prerequisite of an intraclass correlation coefficient of 0.8 or greater to assess the aesthetic change produced by orthodontic treatment in triplets of frontal, three-quarter smiling and lateral photographs of adolescents using a five-point scale (Kiekens, Maltha, et al., 2008). The pilot study determined that a panel of 8 orthodontists was adequate for this investigation. Accordingly, 4 men and 4 women served as evaluators, allowing both genders to be equally represented (Sari-Rieger & Rustemeyer, 2015). It also indicated that a sample size of 57 patients was necessary to detect a mean difference of 8 mm on the VAS between the pairs of initial and post-treatment photographs. At the end of the selection process, photographs of 42 women and 19 men satisfied the criteria necessary to be included in the study. Although this was not done purposely, this number adequately represented any population of orthognathic patients in which 2/3rds are generally women (Al Taki & Guidoum, 2014; Phillips, Hill and Cannac, 1995; Sinko, Tran, et al., 2018; Xu et al., 2008). Most investigations into the result of orthognathic surgery, whether in Caucasians

or Asians usually include a greater number of women unless specifically matched for gender (Baker & Woods, 2001; Johnston et al., 2010; Siow et al., 2002; Xu et al., 2008). Many studies on nasal aesthetics also include a greater number of women or are focussed on women because they are more self-critical and seek rhinoplasty more often (McArdle et al., 2012; Nouraei et al., 2009).

The sample included 9 women and 5 men who underwent unimaxillary surgery. Six of these women had simultaneous mentoplasty. Twenty-five women and eight men had been subjected to bimaxillary surgery and 8 women and 6 men to bimaxillary surgery with mentoplasty. Multiple types of surgeries have been used by other investigators despite it being a possible confounding factor. In one sample, 23 patients underwent bimaxillary surgery, 4 maxillary surgery and 19 mandibular surgery (Baker & Woods, 2001). In another study, 15 patients with Class II division 1 malocclusion underwent maxillary impaction and mandibular advancement surgery, 4 patients had undergone mandibular advancement and 1 patient maxillary impaction. Additionally, genioplasty had been performed in 1 unimaxillary and 2 bimaxillary cases (Klaus et al., 2017). Sinko, Jagsch, et al. (2018) included 10 patients that had been treated using bimaxillary surgery and two patients with mandibular advancement surgery only. Ostwald et al. (2015) studied the association between surgical change in attractiveness and symmetry in a sample of patients without specifying the type of malocclusion or surgery.

At least one confounding variable, the final soft tissue convexity angle which is important to orthodontists in profile assessment may not differ after the different types of surgeries that are planned based on the initial Class III discrepancy. Ghassemi et al. (2017) demonstrated that mandibular setback and maxillary advancement surgery produced similar changes in this angle. The post-surgical angle was found not to differ significantly between Asian patients treated with bimaxillary and mandibular setback surgery (Asada et al., 2015). Chew et al. (2007) found that the average value after various types of orthognathic surgery was significantly lower than the Chinese aesthetic norm and correlated only weakly with aesthetic scores from laypeople and clinicians. It also did not affect the choice between profile predictions of Le Fort 1 advancement, mandibular setback or bimaxillary surgery in patients with class III malocclusions (Fabré et al., 2010).

4.6.2 Age of the patients and the evaluators

The decision to use a sample within the age group of 18-30 years was based on several factors. Age is known to affect attractiveness. Youthful protrusive lips are considered more appealing (Foster, 1973; Nguyen & Turley, 1998). Johnston and Franklin (1993) observed that beautiful composite faces generated from algorithms based on scores attributed to well-known attractive women´s faces from evaluators of both genders had features and proportions generally found in much younger girls than the normative group of women with a mean age of 19.8, including the lip protrusion of a 14 year old. Panels of various ages considered frontal photographs of 17 year old Blacks and Caucasians more attractive than those of adults and 7-year-old children (Cross & Cross, 1971). Foos and Clark (2011) reported that older women´s faces were scored the lowest.

The association of neoteny with attractiveness is more evident in women than in men, especially when evaluated by the opposite gender (Baudouin & Tiberghien, 2004; Cunningham, 1986; Keating, 1985). However, although these predominate and may elicit caretaking and affection, more mature characteristics are

also present in the most attractive female faces and encourage respect (Cunningham, 1986). Men, individually, may differ in their preferences for relatively mature appearing women or cute, child-women although both may have to include large eyes and a small nose while differing in features such as cheek width and skin tone (Cunningham, 1986).

There may also be an interaction between evaluator and subject age. Foos and Clark (2011) reported that young and middle-aged adults prefer younger faces whereas older adults consider faces of all ages equally attractive. Udry in 1965, however, concluded that older people are more critical of younger faces (Giddon, 1995; Maple et al., 2005).

Age is thus a confounding factor in aesthetic studies. Hall et al. (2000) did not reveal the age of the patients whose silhouettes were evaluated to avoid a bias between panels created by orthodontists´ awareness of the effects of ageing. The sample in aesthetic investigations are often limited to 18 to 30 year old adults to minimize age related bias (Sinko, Jagsch, et al., 2018). Researchers that perform nasal anthropometric measurements also use this age range (Farkas et al., 2005; Uzun et al., 2006). This is to minimize the confounding effect of aging on the nose (Porter & Olson, 2003). Perhaps, the most important factor is that the age of most surgical patients varies between 17 and 35 years (Al Taki & Guidoum, 2014; Siow et al., 2002). Moreover, age-related changes in soft tissue thickness and tonicity can affect the response to skeletal movement and thus, the final facial appearance (Burstone, 1958; Kim et al., 2011; Louis et al., 2001). This investigation studied the change in attractiveness produced by a surgical procedure with treatment performed over a short period of time. The time lapse between the initial and final photographs used in this study was never more than three and a half years.

The age of the evaluator can also be a confounding factor. Previous exposure to many dysmorphic faces can cause older clinicians to become more generous evaluators and display greater tolerance for deviations from the norm (Klaus et al., 2017). On the other hand, young laypeople may prefer idealized images as they grow up with the concept that displeasing features can easily be altered (Todd et al., 2005).

Scores attributed to mandibular and chin asymmetries in frontal facial images increased by 10% for every 10 year increase in the evaluator's age (Naini, Donaldson, et al., 2012a). Older laypeople were more generous in evaluating skeletal and dentoalveolar modifications in profile photographs with surgical recommendation decreasing 3% for each year of increase in their age (Tole et al., 2014). The desire for surgery decreased 2% for each additional year in the observer´s age when the sagittal soft tissue pogonion position was modified in profile silhouettes (Naini, Donaldson, et al., 2012). Older clinicians, laypeople and surgical patients assigned higher scores than younger ones for more convex but not for more concave profile silhouettes and reduced surgical recommendation for the former by 5% for every additional year in their age (Naini, Donaldson, et al., 2012c). Forty-six to fifty-six year old orthodontists and laypeople were less critical of initial profile silhouettes of surgical patients with Class II discrepancies than 35 to 45 year old orthodontists (Klaus et al., 2017). However, older maxillofacial surgeons were less generous regarding post-surgical aesthetic improvement for Class III malocclusions although age was not important for orthodontists, laypeople and

patients (Sari-Rieger & Rustemeyer, 2015). Todd et al. (2005) concluded that the tolerance displayed by older individuals for skeletal discrepancies and non-class I malocclusions was restricted only to women.

Profile preferences may also transition with age. While Turks older than 20 years preferred the favourite orthognathic profile more than adolescents in women, the converse was true for female bimaxillary dentoalveolar protrusion (Türkkahraman & Gökalp, 2004). However, Jordanian younger than 20 years preferred the favourite Class I normocephalic male profile photograph more frequently than adults (Abu Arqoub & Al-Khateeb, 2011). Orthodontists with more than 10 years of experience preferred less protrusive lips than younger ones, in African Americans (Battle et al., 2018). Ricketts aesthetic line and relative nose and chin positions were important for older orthodontists, but a younger group used the Burstone line as a reference.

The evaluators' age can even affect nasal shape preferences. Young adults preferred the Crumley 2 nasal tip position and those closer to 50 years of age preferred the Goode ideal position in composite images of Caucasian women of average and above average attractiveness, although the Crumley 1 position was the favourite for both. Younger assessors also favoured the 116° columella-facial angle that was the favourite for all nasal tip positions slightly more than the older ones (Ahmed et al., 2014). Participants who were less than 46 years old selected the image of a man with a dorsal hump, less projected tip and upwardly rotated base as the oldest more often than older individuals, indicating a generational preference (Nuyen et al., 2019). Evaluators younger than 33 years selected an image with a ski slope dorsum, more projected tip and flatter nasal base as the "most successful" while 47 to 61-year-old judges selected the face with a dorsal hump, more projected tip and upwardly rotated base.

However, age was not an influencing factor in another evaluation of nasal form (Springer et al., 2009). It did not influence 122 laypeople and 2 research assistants´ evaluation of children's oblique facial photographs (Howells & Shaw, 1985). It was not important when 12, 17 and 28-57 year old Blacks and Caucasians judged the beauty of frontal photographs of second graders, high school seniors and adults of both races (Cross & Cross, 1971). It did not impact patients' satisfaction with their appearance prior to orthodontic-surgical treatment (van Steenbergen et al., 1996). The age of clinicians, surgical patients and laypeople did not influence their recommendation for the correction of soft tissue pogonion position in profile photographs (Pişiren et al., 2018). Age did not affect laypeople´s and patients´ assessment of improvement after orthognathic surgery for Class III discrepancies (Sari-Rieger & Rustemeyer, 2015) and orthodontists, art students and laypeople´s evaluation of change in frontal and lateral photograph aesthetics of Class II patients treated by mandibular advancement osteotomy (Ng et al., 2013). Both older and younger orthodontists found a 12.6% aesthetic improvement on the VAS after bimaxillary, mandibular advancement or maxillary impaction surgery with or without genioplasty in class II patients (Klaus et al., 2017).

Battle et al. (2017) suggested that the larger age range and consequent exposure to more varied educational philosophies and media influences was the reason why orthodontists with more than 10 years of experience showed greater variability while choosing their favourite African American lip position. In this study, the age range of the evaluators was uniformly distributed between 32 to 63 years, making a clear demarcation

impossible. However, all orthodontists were either part of the teaching faculty or former post-graduate students from the Department of the Orthodontics of Lisbon University.

4.6.3 The Visual analogue scale and other methods of subjective facial evaluation

The visual analogue scale (VAS) requires that evaluators choose a position along a continuous line with antagonistic adjectives at each end that measures their reactions to specific stimuli (Sena et al., 2017; Zealley & Aitken, 1969). The score is calculated as the distance in millimetres between the evaluator´s chosen position and the scale´s beginning (Baker & Woods, 2001; de Almeida & Bittencourt, 2009; Howells & Shaw, 1985).

The VAS has been used in a wide variety of studies on facial attractiveness (Bui et al., 2015; Devcic et al., 2011; Fabré et al., 2009; Howells & Shaw, 1985; Ioi et al., 2010; Maple et al., 2005; Phillips, Trentini & Douvartzidis 1992; Torsello et al., 2010). It has been also been used for self-evaluation (Johnston et al., 2010) and to assess treatment need (Juggins et al., 2005), post-surgical aesthetics (Klaus et al., 2017), patient satisfaction with surgical results (Rustemeyer et al., 2010) and to compare the actual postsurgical image with the computerized prediction (Chew, Koh, et al., 2008). This scale was also used by evaluators to judge their own noses (Springer et al., 2008), those of others (Bui et al., 2015; Devcic et al., 2011; Torsello et al., 2010) and the results of nasal reconstructive surgery (Moolenburgh et al., 2008b).

The VAS is popular amongst researchers for a variety of reasons. It permits a simple, easy to understand and valid evaluation of subjective characteristics that cannot be directly measured (Maple et al., 2005; Phillips, Trentini & Douvartzidis, 1992; Zealley & Aitken, 1969). Unlike discrete scales, the VAS measures very fine gradations and does not limit the score to a finite number of options (Funke & Reips, 2012; Zealley & Aitken, 1969) Thus, it is more sensitive and avoids the bias towards preferred values seen in numeric or interval scales (Hall et al., 2000; Maple et al., 2005). Scores are attributed quickly and are recorded as continuous variables in millimetres allowing powerful parametric statistics (Maple et al., 2005; Phillips, Trentini & Douvartzidis, 1992; Schabel et al., 2009; Zealley & Aitken, 1969). Scores can also be ranked and permit variance, covariance, regression and correlation analyses (Phillips, Trentini & Douvartzidis, 1992; Zealley & Aitken, 1969). The VAS demonstrates high reliability in detecting differences between various panels´ perception of facial attractiveness (Baker & Woods, 2001; Bui et al., 2015; Howells & Shaw, 1985). The difference between initial and post-treatment scores indicates both the direction and magnitude of change (Phillips, Trentini & Douvartzidis ,1992). Also, the use of the average score from evaluators for each stimulus and the subsequent paired analysis decreases the impact of inter-rater variability and focuses the analysis on the difference in values (Phillips, Trentini & Douvartzidis, 1992).

However, it has inherent disadvantages. Evaluators may not interpret the end-point adjectives in exactly the same way and a similar score may not imply the same feeling or intensity of feeling for different evaluators or for the same evaluator at different times and thus, may not represent the same assessment (Giddon, 1995; Maple et al., 2005). As with other scales, judges tend to avoid extremes, irrespective of their actual preferences, especially at the beginning of the test when they expect that there will be an item further on that requires this position (Naini, Donaldson, et al., 2012; Schabel et al., 2009). Phillips, Griffin and Bennett (1995) ranked

patients according to their VAS aesthetic scores to overcome the difference in score distribution between judges due to their neglecting certain parts of the scale. This cannot be done when numeric scores are required to seek a correlation between the magnitude of post-surgical aesthetic improvement and the alteration in a facial variable (Baker & Woods, 2001).

A few authors used reference photographs to guide evaluators. In one study, evaluators were asked to calibrate their scores against a profile photograph that had been validated as having a score of 6 on a 100 mm VAS of 10 values and had presented the least variance in a prior study (Fabré et al., 2009, 2010). Malkoç and Fidancioglu (2015) mounted a triplet of extraoral photographs of each gender, which had received scores close to the average in a previous study, in the centre of the VAS to represent a score of 50. Another study used multiple faces to represent different VAS values (Kerr & O'Donnell, 2014). Kiekens et al. (2005) used a reference set consisting of a triplet of each gender, that received a score close to the median value with a standard deviation close to the smallest one registered in a prior evaluation of photographs. In this investigation, this was not required as it was the change in attractiveness that was important rather than the absolute attractiveness of the initial and post treatment photographs.

Other scales have been used in aesthetic studies. The Q-sort method generates a valid 9-category ordinal ranking of 48 or 96 subjects in a sample by a progressive forced choice narrowing (Oliveira et al., 2015; Schabel et al., 2009). As an example, evaluators may sequentially eliminate the 2, 4, 5 and 8 least and most attractive images to leave 10 images representing neutral attractiveness. Scores are assigned to the images and to a boundary line drawn by the evaluator between attractive and unattractive images. Q-sort or other categorical rating scales eliminate the disadvantages of the VAS of introducing a level of precision beyond the discriminatory ability of judges and of unequal distribution of scores between evaluators due to neglect of certain parts of the scale (Phillips, Trentini & Douvartzidis, 1992; Schabel et al., 2009). However, unlike the VAS which is absolute and requires that every individual be evaluated separately, the Q-sort method, which generates a quasi-normal distribution, evaluates individuals relative to each other and is thus, limited to a single treatment phase.

Silhouettes and profile photographs have also been ranked in descending or ascending order of attractiveness (Abu Arqoub & Al-Khateeb, 2011; Chong et al., 2014; Czarnecki et al., 1993; Lee et al., 2011; Mantzikos, 1998; Modarai et al., 2013; Pithon et al., 2014). This cannot be done for surgical improvement in patient´s photographs as a deterioration cannot be registered (Dunlevy et al., 1987; Phillips, Trentini & Douvartzidis, 1992).

Rating and rank-order ordinal scales also delineate differences that are relative and not absolute and impose statistical limitations (Schabel et al., 2009). Ordinal scales require shared ranks when the number of response options is smaller than the number of items in the sample, making it impossible to correctly score the relation between all items. Hence, they require decisions about compromises and increase the cognitive burden as the evaluator has to master segmentation and mapping to the nearest category when scoring continuous concepts (Funke & Reips, 2012). 5 and 10 point scales have been used to evaluate attractiveness (Spyropoulos & Halazonetis, 2001; Tole et al., 2014; Tufekci et al., 2008; van Steenbergen et al., 1996). A 10-point ordinal

scale was used to assess facial, eye, nose and mouth asymmetry in frontal photographs (Roxbury et al., 2012)). The bipolar Likert scale allows the description of categories using words and has an equal number of positive and negative positions or responses to a statement that are bilaterally symmetrical around the neutral position (Langlois et al., 2000; Likert, 1932). Some researchers use a "forced choice" method by eliminating the "Neither agree nor disagree" option which is an easy choice for the unsure (Allen & Seaman, 2007; Armstrong, 1987). The scale has been used often, including in the evaluation of facial attractiveness in the self (Bonetti et al., 2011) and others (Kerr & O'Donnell, 2014; Lundström et al., 1987; Naini et al., 2015; Vargo et al., 2003), nasal tip projection (Crumley & Lanser, 1988), the need for orthognathic surgery (Vargo et al., 2003), the results of this surgery (Sari-Rieger & Rustemeyer, 2015) and of nasal reconstructive surgery (Moolenburgh et al., 2008a).

In the semantic differential scale, a battery of bipolar verbal anchors for mood, such as calm-excited and depressed-cheerful, is presented in the form of a matrix when respondents are faced with different aspects of a single latent variable (Funke & Reips, 2012). Orsini et al. (2006) asked participants to evaluate profiles using the words "cold", "neutral" and "warm" at values of -4, 0 and +4 respectively. The implicit association test assesses the relative strength of the association between test stimuli such as photographs and evaluative attributes using positive and negative words like win, lose, smart, stupid and friend or enemy (Orsini et al., 2006).

Peerlings et al. (1995) used a photograph of average attractiveness as an anchor to evaluate other photographs in two ways. In the first method, the anchor´s attractiveness was represented by a line of defined length. The evaluator drew another line whose length depended upon the test photograph´s attractiveness relative to the reference photograph. In the second method, the reference photograph was given a value of 100 and the evaluator attributed a relative score to the test photograph. Thus, scores of 200 and 50 signified that the photograph was twice as or half as attractive, respectively. In the perceptometric method, an isolated facial feature in an image is sequentially modified over a specific dimension. Apart from the "most pleasant profile", it allows each evaluator to select a range of acceptable facial morphologies or 'acceptability zone' by pressing the mouse button when the image becomes acceptable and releasing it when it stops being so (Arpino et al., 1998; McKoy-White et al., 2006; Mejia-Maidl et al., 2005; Orsini et al., 2006). Treatment need can be evaluated by the dichotomic yes or no choice (Falkensammer et al., 2014). Some authors also forced evaluators to decide whether a patient improved after treatment (Barrer & Ghafari, 1985; Dunlevy et al., 1987). However, a deterioration cannot be registered and it is impossible to discern whether the magnitude of change considered an improvement is equal for all evaluators (Phillips, Trentini & Douvartzidis, 1992).

4.6.4 The use of cropped images for nasal evaluation

In this study, the nose was evaluated in images of the entire face as well as in cropped photographs that eliminated the relative, confounding influence of the chin and lips. Some of the orthodontists expressed difficulty in evaluating the nose when presented with images of the entire face. Hence, it was decided to determine whether the change in global facial aesthetics affected the evaluated change in nasal aesthetics when

it was not presented in an isolated form. The change in frontal nasal aesthetics when evaluated within the face demonstrated a significant correlation (r = 0.415) with that in frontal facial attractiveness. The change in frontal facial attractiveness and that of the isolated nose contributed 54% to the variation in the change in attractiveness of the nose when evaluated within the face. A significant correlation (r = 0.619) was also detected between the change in the attractiveness of the facial profile and that of nasal profile when evaluated within the face. The changes in the attractiveness of the facial and isolated nasal profiles were responsible for 59% of the variation in that of the nasal profile when assessed within the face.

Studies on nasal aesthetics generally use images of the whole face (Ahmed et al., 2014; Bui et al., 2015; Choi et al., 2013; Czarnecki et al., 1993; Gu et al., 2018; Moolenburgh et al., 2008a). Yet, these investigations either digitally modify the nose within a facial image (Kandathil et al., 2018; McArdle et al., 2012; Naini, Cobourne, et al., 2016b; Nuyen et al., 2019) or study the nasal changes produced by rhinoplasty (Nellis et al., 2018; Nouraei et al., 2009; Roxbury et al., 2012). Hence, they did not involve the dramatic, distracting changes in other facial components such as the chin and paranasal area that are produced by maxillary advancement or bimaxillary osteotomy. The influence of skeletal class and jaw position on perceived nasal dorsal shape was demonstrated when a straight dorsum was considered more aesthetic than a convex one only in a Class II profile silhouette with a normal vertical dimension (De Smit & Dermaut, 1984).

This study required a professional assessment of nasal aesthetics by orthodontists. Orthodontists are known to focus on the profile relationship between the nose, lips and chin (Battle et al., 2018; McKoy-White et al., 2006; Thomas, 1979). Moreover, they consider the latter two structures, and especially the chin, more important than the nose (Burcal et al., 1987; Chan et al., 2008; Soh et al., 2005a). Dental students, dentists, oral surgeons and orthodontists believed that the mandible most influenced the attractiveness of Arabic profile silhouettes while laypeople gave more importance to the nose (Al Taki & Guidoum, 2014). Similarly, 90% of orthodontists chose both the lips and chin collectively as the most important feature in Chinese profiles while 61% of dental students and 68% of laypeople focused on only one or two of these features (Chan et al., 2008). In another Chinese study, 90.3% of orthodontists and oral surgeons, 67% of dental students and 52.6% of laypeople chose both the lips and chin (Sohet al., 2005a). Moreover, 4.2% of laypeople in the first Chinese investigation and 6.6% of dental students and 15.8% of laypeople in the second but none of the orthodontists considered the nose the most important feature.

A systematic review concluded that while it may be much more realistic to assess the whole face that people see daily, a professional assessment in the case of cleft lip and palate was best performed by cropping photographs to the nasolabial area (Mosmuller et al., 2013). Cropped photographs permit more reliable evaluations due to the elimination of the surrounding facial features that influence scores (Mosmuller et al., 2013). Even large skeletal changes can fail to produce perceptual impact as they can be overwhelmed by the individual's general facial appearance and factors such as hairstyle and skin texture (Tulloch et al., 1993). Hence, due to the bias created by the change in global facial aesthetics, the data for the attractiveness of the nose within the face, both in the frontal and profile view, was not considered further.

4.6.5 Changes produced by the Le Fort Maxillary advancement osteotomy on maxillary and nasal morphometric variables

The A point and Prosthion advanced significantly by 3.63±2.49 and 4.04±2.55 mm, respectively and demonstrated significant vertical changes of -0.54±2.05 and -0.62±2.12 mm, respectively, with post-surgical change in incisor inclination or position possibly contributing to the difference in movement registered between the two points. The maxillary inclination change, which averaged 0.17±2.39°, was not significant.

The post-surgical increase in morphological, alar base and bilateral diagonal nostril widths and superior alar and inferior alar angles reflected general nasal widening ($P<0.001$). The frontal nasal length was significantly reduced ($P<0.001$).

In profile, subnasale and pronasale elevation decreased nasal height and length, respectively. Nasal and nostril projection decreased, reflecting greater alar base advancement. Nasal protrusion decreased indicating that subnasale advanced more than pronasale. The smaller, post-surgical, nasal tip rotation angle reflected greater nasal tip elevation compared to the alar curvature and the shorter distance between the two. The upper dorsal convexity decreased and the supratip break flattened.

4.6.6 Influence of evaluator gender on the changes in the attractiveness of the face and the nose

When the whole face was considered, the repeated measures ANOVA concluded that the orthodontist´s gender significantly influenced the evaluation of the change in attractiveness of the facial profile without an interference from the patient´s gender. Male orthodontists considered that the facial profile aesthetics improved more than female orthodontists in both men and women. The Wilcoxon Signed rank test performed demonstrated that men were also more benevolent than women while evaluating facial improvement in the frontal view.

Other authors have confirmed that women are more critical of others´ appearance than men. Female orthodontists, plastic and maxillofacial surgeons, post-treatment orthodontic-surgical patients and laypeople recommended surgery 1.28 times more often than men and for milder sagittal modifications in pogonion position in profile photographs of both genders (Pişiren et al., 2018). Women attributed lower scores than men, especially to other women, when asked to evaluate profile images as those of colleagues (Tole et al., 2014). They may also be more critical of treatment results. A study that used a 5-point scale and profile photographs concluded that female orthodontists were more critical than male colleagues of post-surgical improvement in patients with Class III discrepancies although maxillofacial surgeons and laypeople did not manifest this gender based difference (Sari-Rieger & Rustemeyer, 2015).

This criticism of others may be an extension of women´s dissatisfaction with their own appearance (Johnston et al., 2010; Springer et al., 2009). African American women, for instance, were more self-critical than men and 45% of them wished to change their own profile (Polk et al., 1995). Chinese men, being more self-benevolent, differed more in their self-assessment from orthodontists´ evaluations than women, bestowing themselves with a more protrusive chin and a more attractive dental appearance than the real one (Yin et al., 2014).

The higher standards they have for their own image also makes women seek treatment more often. Male orthodontists and laypeople were 40% less likely than women to recommend surgical correction of sagittal chin or chin and lip modifications in profile silhouettes they considered their own (Modarai et al., 2013). Male pre and post-orthognathic surgery patients recommended surgery 85% less than women when they regarded profile silhouettes with varying degrees of mandibular prominence as their own (Naini et al., 2013). Men demonstrated a 63% lower probability of wanting surgery than women when they assumed modified sagittal chin positions in profile silhouettes as their own (Naini, Donaldson, et al., 2012b). Male orthognathic surgery patients, clinicians and laypeople manifested a 53% lower desire for surgical correction than women when they deemed mandibular and chin asymmetries in frontal facial images as their own (Naini, Donaldson, et al., 2012a).

Other authors, however, suggest that men and women have similar standards for facial aesthetics. Evaluator gender was not important when laypeople and 2 research assistants evaluated children's oblique facial photographs (Howells & Shaw, 1985). The gender of clinicians and orthognathic surgery patients did not affect their assessment of mandibular and chin asymmetries in frontal facial images (Naini, Donaldson, et al., 2012a). Men and women did not differ in scoring videos of patients with different skeletal relationships before and after orthodontic surgical treatment (Sinko, Jagsch, et al., 2018). Male and female orthodontists, oral surgeons and laypeople revealed no differences in their perception of the aesthetic difference between frontal and profile photographs taken before and after orthodontic camouflage or surgical treatment of Class II skeletal cases (Phillips, Trentini & Douvartzidis, 1992). Orthodontists, art students and laypeople´s gender did not affect their assessment of improvement caused by mandibular advancement osteotomy in frontal and lateral photographs (Ng et al., 2013).

Yet others suggest that women are less critical. While both genders scored frontal photographs of Caucasian and Black adult men similarly, female children, adolescents and adults were less critical of women and of second graders and high school seniors of both genders than male evaluators (Cross & Cross, 1971). Women considered control frontal and oblique photographs more aesthetic than men (Bui et al., 2015). They were also more generous in evaluating aesthetics and personality in profile and smiling frontal photographs and a video of women with different sagittal mandibular positions (Sinko, Tran, et al., 2018). Female clinicians, pre-treatment orthognathic surgery patients and laypeople recommended surgical correction of sagittal soft tissue pogonion variations in silhouettes 50% less often than men (Naini, Donaldson, et al., 2012).

In this study, the orthodontist´s gender significantly influenced the evaluation of the change in attractiveness of the profile view of the nose without an interference from the patient´s gender. Men were more generous than women in evaluating the alteration in nasal profile attractiveness in both men and women. Yet, they tended to be more critical of the change in attractiveness of the frontal view of the nose, although not to a significant extent.

Women are more generally more critical of their own nasal profile and are less likely than men to think that their noses are small, leading them to seek rhinoplasty in a greater percentage (Springer et al., 2009). Evaluators that assessed the average composite nasal profiles obtained from 128 randomly selected men and

women and the 16 optimal and 8 most unpleasant nasal profiles for each gender selected on the basis of the self-evaluation of 311 Caucasians agreed with women´s self-evaluation of both profile and nose and considered the optimal female nose more attractive than the average and unpleasant ones (Springer et al., 2008). However, the optimal noses chosen by men in their self-evaluation were considered less attractive than the average male nose.

Authors have also found women to be more generous in the evaluation of the nose in studies of an entirely different nature. Women attributed higher scores for facial attractiveness to modified frontal and oblique photographs with nasal asymmetry of each gender (Bui et al., 2015). They were more generous than men in the evaluation of composite images of optimal and unpleasant noses of both genders although both preferred optimal and average noses (Springer et al 2009). In this study, the change in attractiveness was the important factor rather than the absolute attractiveness in each treatment phase.

4.6.7 Influence of patient gender on the change in the attractiveness of the face and the nose

The alterations caused by the Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the frontal and profile views of the face and the nose did not differ significantly between male and female patients.

This was surprising because many studies demonstrate that relative mandibular protrusion is generally better tolerated in men and logically, its correction in women should have improved facial aesthetics more. A prominent chin decreases relative lip protrusion which is an important feature in girls (Murakami et al., 2016). Health professionals preferred a straighter profile with a slightly more prominent chin and less protrusive lips in men and a slightly convex one with greater labial protrusion than the norm in women (Czarnecki et al., 1993). A 12° facial convexity angle was the most attractive in a Caucasian woman and the 8° angle with slight mandibular protrusion in a man when soft tissue pogonion was modified in profile photographs (de Almeida et al., 2010; Sena et al., 2017). Clinicians, artists and laypeople recommended the surgical correction of mandibular prognathism more frequently in women and of retrognathism more often in men when they considered modified Caucasian and Black profile photographs their own (de Almeida & Bittencourt, 2009). In Turks, fuller protrusive lips and retrusive ones with a prominent nose and chin were preferred in the woman and man, respectively (Türkkahraman & Gökalp, 2004). Chinese found a chin prominence of -3 to +3 in relation to the norm more attractive in the silhouettes of a man and between -3 mm and the norm more attractive in a woman (Jiang et al., 2018).

Other authors demonstrate that maxillary sagittal discrepancies and their correction may be more easily detected in women. Romani et al. (1993) concluded that orthodontists were more sensitive to 2 and 5 mm maxillary sagittal changes in a woman than in a man, but were less capable of detecting vertical changes in this gender. However, laypeople detected both sagittal and vertical maxillary changes better in frontal and profile photographs of a woman than in a man. Findings for the mandible are also not as clear. Although Burcal et al. (1987) concluded that laypeople, orthodontists and oral surgeons recognized sagittal mandibular changes

more easily in the profile photographs of women than those of men, orthodontists did not distinguish between genders in another study (Romani et al., 1993). Moreover, Pisiren et al. (2018) demonstrated that clinicians, post-treatment orthognathic surgery patients and laypeople found soft tissue pogonion protrusion perceptible at the same level in both genders while retrusion was less perceptible in a female profile photograph.

Other confounding factors may have been at play including the mentoplasty performed (Klaus et al., 2017; Tsang et al., 2009). Since the entire face was evaluated, the double chin deformity caused by mandibular set back in some patients could also have affected the results (Baik et al., 2000; Bailey et al., 1995; Ghassemi et al., 2017).

Women´s faces are generally considered more attractive than those of men. Battle et al. (2017) suggested that the media´s emphasis on female attractiveness contributed to orthodontists´ preferring African American women´s lower facial third in profile photographs than that of men. Laypeople, dental students and maxillofacial surgeons but not orthodontists considered a female Caucasian profile photograph with modified sagittal or vertical rotational jaw positions more attractive than that of a man (Falkensammer et al., 2014). Caucasian and Black children, adolescents and adults deemed frontal photographs of female second graders, high school seniors and adults more attractive than those of males (Cross & Cross, 1971). Adult patients and companions were more critical of the smiling frontal and oblique photographs of two men modified to display either a normal occlusion or 1 of 6 malocclusions than those of women. They expressed a stronger desire to interact with women who they deemed more attractive, intelligent, conscientious and open to experiences and less neurotic (Olsen & Inglehart, 2011). Yet, Caucasian laypeople considered a man´s unmodified frontal and oblique photographs more attractive than those of a woman, although clinicians found both to be of average attractiveness (Bui et al., 2015).

Female noses are also considered more attractive. At least half of 308 evaluators thought that the average composite nose created from 128 randomly selected men and the optimal composite male nose created on the basis of Caucasian men´s self-evaluation were female (Springer et al., 2008). Moreover, the most unpleasant female noses were considered male.

In this study, however, the factor of interest was the change in attractiveness caused by the maxillary advancement osteotomy rather than the absolute attractiveness of the initial and final photographs. Patient gender also did not influence orthodontists, art students and laypeople´ assessment of improvement in frontal and lateral photographs after mandibular advancement osteotomy to correct skeletal Class II discrepancies (Ng et al., 2013).

4.6.8 Correlation between the evaluations of the effect of the Le Fort I maxillary advancement osteotomy on the nose in the frontal and the profile views

No significant correlation was found between the change in the aesthetic evaluation of the nose in the frontal and the profile views. Nasal profile aesthetics demonstrated a statistically significant improvement of 8.44 ± 13.42 mm on the VAS. The average change of -3.97±18.32 mm in frontal nasal aesthetics revealed a non-significant tendency for deterioration.

Profile photographs are frequently used in aesthetic studies because of the emphasis imparted by clinicians to this view (Barroso et al., 2012; Battle et al., 2018; Chan et al., 2008; Erbay et al., 2002). Frontal facial photographs are used less frequently when the smile is not being evaluated and are generally either paired with profile photographs (Bell et al., 1985; Dongieux & Sassouni, 1980; Phillips, Trentini & Douvartzidis, 1992) or used alone in studies conducted by non-orthodontists (Cross & Cross, 1971). Some researchers have used them as the sole stimulus for nasal evaluation (Nouraei et al., 2009; Roxbury et al., 2012).

Frontal and profile photographs depict entirely different aspects of the face that are at a right angle to each other. Frontal photographs are considered more attractive than profile ones in people with sagittal discrepancies that are more obvious in the latter view (Kerr & O'Donnell, 2014; Melo et al., 2017). The eyes generally help to diverge attention from lower facial disharmony in the frontal view (Kerr & O'Donnell, 2014; Sinko, Tran, et al., 2018). Claman et al. (1990) observed that profile photographs show mandibular prognathism better and allowed the detection of 1.8 mm differences while 7.5 mm differences were detected in frontal photographs with some difficulty. Melo et al. (2017) observed that although laypeople and patients did not distinguish between frontal and profile photographs in their evaluations, their ability to detect skeletal discrepancies more easily made orthodontists disagree with laypeople for the profile view. Using frontal and profile photographs, Romani et al. (1993) agreed that orthodontists were more sensitive to sagittal mandibular changes but concluded that although they exhibited similar sensitivity for sagittal maxillary movements, their tendency to focus on a gingival smile or incisal exposure, which were not visible in the frontal photographs, made them less efficient in detecting vertical maxillary movements.

The lack of differences and a high correlation between the scores attributed to attractiveness of portrait and left and right profile photographs of male athletes led authors to suggest that due to the highly overlapping information about structural facial elements conveyed by the different views, a single view was sufficient for research in facial aesthetics (Třebický et al., 2018). Yet, in another study, none of the views were consistently ranked as most attractive across all patients as the relative attractiveness of each view was highly dependent on the individual patient (Phillips, Tulloch, & Dann, 1992). Melo et al. (2017) verified that while the whole face and the mouth were more important in the frontal view, the nose and chin attracted attention in profile photographs. Another investigation concluded that a thin upper lip, convex nasal dorsum and obtuse cervicomental angle were characteristics that contributed to outlier scores and disagreement between the attractiveness of Caucasian women´s frontal and profile images, despite a strong linear association between the two views (Gu et al., 2018).

The use of both views was especially important in this study as maxillary advancement osteotomy can affect the nose in the transverse, sagittal and vertical dimensions. Frontal photographs permit transverse measurements (Phillips et al., 1984) and may be more important to the patient because they represent their reflection in the mirror (Hemmatpour et al., 2016). However, they have to be used together with profile images, as they cannot assess changes in depth (Vasudavan et al., 2012). Profile photographs display both midsagittal landmarks and laterally located ones such as the alare and alar curvature, allowing the quantification of

complex changes in the vertical and sagittal dimensions (Farkas & Deutsch, 1996; Nguyen & Turley, 1998; Ritto et al., 2011). Thus, many nasal features are not simultaneously seen in both views and the two views present entirely different effects of the osteotomy. Nasal widening may affect frontal aesthetics in a manner and degree that contrasts with the influence of nasal tip elevation amongst other factors in the profile view. Therefore, simultaneous changes in nasal height, projection and width can only be adequately evaluated by two views that are perpendicular to each other (Betts et al., 1993; Bottini et al., 2013).

4.6.9 Correlation between the effect of Le Fort I maxillary advancement osteotomy on the aesthetic evaluations of the nose and the face

The attractiveness of the frontal view of the face improved significantly by 34.53±25.01%. The mean -3.97% change with a larger standard deviation of 18.32 indicated a tendency for a deterioration in frontal nasal aesthetics. Yet, the change in frontal nasal aesthetics demonstrated a significant, albeit weak, correlation of 0.270 with that in frontal facial attractiveness. Thus, overall nasal changes contributed to improve frontal facial aesthetics, perhaps due to greater harmony with the larger facial middle third volume caused by maxillary advancement. The nose attracts attention in the frontal view due to its central location in the face (Altman & Oeltjen, 2007; Begg & Harkness, 1995; Isiekwe et al., 2015; Pearson & Adamson, 2004; Uzun & Ozdemir, 2014). People may pay more attention to frontal nasal aesthetics that they see in their mirror image (Schendel & Carlotti, 1991). When evaluators were asked to choose the most striking facial feature in patients who underwent nasal reconstruction surgery, faces were considered more attractive and less abnormal if no facial feature was regarded as striking. However, when the nose was chosen as the most striking feature, patients were considered less attractive and more abnormal (Moolenburgh et al., 2008b). The choice of the nose as the most striking feature decreased facial attractiveness but did not affect abnormality scores in the control group, while other facial features did not present statistically significant correlations. The nose is one of the features that distracts laypeople during post-surgical facial evaluations (Montini et al., 2007).

Nasal symmetry affects facial attractiveness (Bui et al., 2015). It also affects the psychophysical perception of facial symmetry. Faces were considered asymmetrical in people with crooked noses but did not differ from controls after their surgical correction although laypeople acknowledged that some degree of nasal asymmetry persisted. Surgery improved scores for facial attractiveness and facial and nasal symmetry (Roxbury et al., 2012). The authors stated that the assessment of the mouth as being more symmetrical after surgery may have been an optical illusion as in the face, an anatomical result or a combination of both factors.

Nouraei et al. (2009) concluded that the increase in average alar symmetry in relation to the midline from 91.1% to 93.8% was the only variable that significantly contributed to the subjective perception of faces as more symmetrical after rhinoplasty, perhaps because it was the only one that surpassed a 2% increase. On the other hand, minimal improvement or loss of nasal symmetry led to the illusion of facial asymmetry (Nouraei et al., 2009). Hatch et al. (2017) also concluded that canting of the nasal floor, amongst other factors, contributed significantly to lower the attractiveness of frontal and profile images. This study did not detect significant differences between the changes in the right and left alare-dorsal axis distances, thus excluding

nasal symmetry which is more obvious in this view as a possibly contributory factor towards the change in frontal nasal and facial aesthetics

Facial profile aesthetics improved significantly by 36.62± 28.55 mm on the VAS. The profile view of the nose also showed a numerically smaller improvement of 8.44±13.42% but did not correlate significantly with the change in facial profile aesthetics. The profile relationship between the nose, lips and chin is of special importance to orthodontists (Battle et al., 2018; McKoy-White et al., 2006; Thomas, 1979). Rickett´s aesthetic line which incorporates the nasal tip is often used to quantify lip position (Hockley et al., 2012; Pithon et al., 2014; Ricketts, 1961). However, orthodontists are more interested in the chin and lips and often consider the nose only because of its relative effect on lip protrusion (Czarnecki et al., 1993; Modarai et al., 2013; Murakami et al., 2016). Ahmed et al. (2014) suggested that while the ideal Crumley 1 tip position was preferred in attractive women, the lack of a single favourite tip position in women of average attractiveness indicated that it may be undermined by other less than-ideal facial and nasal features. Devcic et al. (2011) attributed the lack of correlation between objectively measured tip projection and subjective assessment of attractiveness to distraction by other facial features such as the nasolabial angle, the chin and the forehead. In the facial images, the aesthetic changes in the nose could have been overwhelmed by the more obvious changes in the mandible, paranasal areas and the nasolabial angle that were not exhibited in the cropped images. These facial changes are less obvious in the frontal view and here, the nasal changes could have attracted more attention (Kerr & O'Donnell, 2014; Melo et al., 2017).

4.6.10 Correlation between the change in nasal morphometric variables and the change in attractiveness of the nose in frontal profile photographs

The change in the alar base width, morphological nasal width and superior alar angle explained 19% of the variation in the change in the attractiveness of the nose in the frontal view. Pearson´s coefficients indicated that increases in the alar base width and superior alar angle reduced frontal nasal attractiveness in a weak correlation while the morphological width´s extremely low negative correlation was non-significant. However, the regression analysis indicated that when morphological width decreased and alar base width increased by one millimetre and the superior alar angle increased by a degree, frontal nasal aesthetics was reduced by 6.77%, 4.82% and 4.11%, respectively. The surgical procedure itself enhanced attractiveness by 1.98%. The variance inflation factor for the three predictor variables was below the limit value of 3. When the regression coefficient and the slope in the regression analysis do not have the same sign, the original relationship between the two has been suppressed. The change in sign for the morphological nasal width could have been due to the fact that the original relationship with attractiveness was so close to zero that the difference in sign only reflects random variation around zero or is caused by real suppression from another more important predictor variable (Falk & Miller 1992). The superior nasal angle, unlike the morphological width, is also affected by vertical alare position. Thus, alar base widening and increase in the superior alar angle were better predictors for frontal nasal attractiveness than morphological width.

Maxillary surgery can cause larger widening at the base than at the wings (Stewart & Edler, 2011). This makes a case for the alar cinch suture which has a greater effect at the base (Almukhtar et al., 2016; Stewart & Edler, 2011; Worasakwutiphong et al., 2015). Yet, Shmuly et al. (2019) expressed a personal dislike for the alar cinch suture as according to them, the rounded nostril appearance with a narrow alar base was unattractive. Moreover, increased nasal width may be beneficial in patients who demonstrate a very narrow presurgical nose (Ritto et al., 2011; Stewart & Edler, 2011).

Pearson´s correlation indicated that nasal profile attractiveness increased with a reduction in nasal height and decreased with pronasale elevation and supratip break accentuation in weak correlations. The regression analysis revealed that each millimetre of decrease in nasal height enhanced nasal profile attractiveness by 6.99%. Each millimetre of pronasale elevation and each degree of supratip break angle enlargement or supratip deepening reduced attractiveness by 2.97% and 0.52%, respectively, while the surgery itself added 7.70%. The three nasal variables accounted for 24% of the variation in the change of the attractiveness of the nasal profile.

Patients with skeletal Class III malocclusions have longer noses with larger heights than class I individuals. The association of a smaller nasal height to nose aesthetics in the profile view may reflect the tendency for smaller noses to be considered more attractive (Baudouin & Tiberghien, 2004; Rossetti et al., 2013). Ten to seventeen year old adolescents had significantly smaller noses than reference subjects of the same age and sex (Sforza et al., 2008). The most attractive American Indian women possessed a smaller nose with decreased height and length than their peers (Husein et al., 2010)). Although this study did not find gender-based differences, a small nose is one of the features that makes female faces more attractive to the opposite sex (Baudouin & Tiberghien, 2004; Cunningham, 1986). Lines et al. (1978) suggested that aesthetically pleasing noses in women are smaller than those in men.

Investigations of a different nature have revealed other results. Nasal height did not differ in profile photographs of patients of all malocclusion types considered unpleasant and pleasant by orthodontists (Fortes et al., 2014). The decrease in alar base width and nasal length achieved by cosmetic rhinoplasty did not affect patient satisfaction with their nasal appearance in a sample that was 86.6% female (Zojaji et al., 2019).

Authors generally report that elevated nasal tips are considered more attractive in studies that did not involve surgical changes. Hatch et al. (2017) concluded that laypeople considered frontal and profile photographs less attractive in the presence of a down turned tip. Iranian laypeople considered greater elevation more attractive in nasal tips with normal prominence in profile silhouettes with Class I occlusions, when both genders were considered (Ghorbanyjavadpour & Rakhshan, 2019). Khosravanifard et al. (2013) concluded that elevated nasal tips were preferred in attractive women with good occlusion but not in men. The most attractive Indian women also demonstrated greater apical tip rotation than their peers (Husein et al., 2010).

Absolute measurements of nasal tip elevation or alar widening can have different aesthetic consequences depending on individual pre-surgical nasal morphology, such as an initially wide or narrow structure (Muradin et al., 2012). The small deleterious effect of nasal tip elevation on nasal aesthetics could have been caused by an excessive upward movement that was greater than that of subnasale. Larger comparative nasal tip elevation

is known to increase unattractive nostril exposure in the frontal view, resulting in a ´Miss Piggy` appearance (Mitchell et al., 2007; Schendel & Carlotti, 1991; Worasakwutiphong et al., 2015).

The accentuation of the supratip break caused by nasal tip elevation and projection reduced profile aesthetics. Springer et al. (2008) suggested that the supratip break was not an important characteristic as it was not present in the noses considered optimal in the self-evaluation of three hundred and eleven Caucasians of both genders. McArdle et al. (2012) found that 60.6% of men and 63.4% of women, including nurses, doctors, medical students and laypeople preferred a subtle supratip break angle rather than a deeper one in modified profile photographs of Caucasian women.

Most authors have highlighted the importance of the dorsal form in nasal attractiveness (Gu et al., 2018; Kandathil et al., 2018; Nuyen et al., 2019; Springer et al., 2008; Yu & Jang, 2014). All these studies, however, referred to exaggerated dorsal convexities that may not have been seen in these patients. Moreover, the factor of interest was the change in its dimension rather than its absolute size. Although maxillary advancement surgery does not have a direct effect on the size of the hump, nasal tip protrusion and elevation can camouflage an excessive *hump* (Altman & Oeltjen, 2007). Esenlik et al. (2011) emphasized that the change in the upper dorsal convexity after maxillary surgery can be sub-millimetric. The -0.35±1.01 mm change in this variable may not have been easily detected by evaluators.

The change in columella exposure was not significant and did not affect the change in nasal aesthetics. Increased columella exposure did not affect patients´ satisfaction with their nasal appearance after cosmetic rhinoplasty in a sample that was 86.6% female (Zojaji et al., 2019).

Subnasale position also was not found to be important. Subnasale prominence relative to the vertical reference line also did not affect scores attributed by orthodontists and laypersons of both races to attractive profile silhouettes of 7 to 17 year old African American and Caucasians (Hall et al., 2000).

The change in the sagittal position of point pronasale, nasal projection and protrusion also did not affect aesthetics. Zojaji et al. (2019) also observed that the decrease in nasal tip projection after cosmetic rhinoplasty did not affect patient satisfaction with their nasal appearance. Nasal protrusion measured perpendicular to the FHP did not affect Chinese and American orthodontists´ ranking of triplets of post orthodontic treatment photographs of American and Chinese adolescents with Class I and II malocclusions (Oh et al., 2009).

Some authors suggest that less prominent noses may be preferred only in women. Women with good occlusion, and attractive profile photographs tended to have less prominent noses although this difference was not seen in men (Khosravanifard et al., 2013). Evaluators preferred smaller nasal prominence angles in female than in male silhouettes (Lines et al., 1978).

Other authors concluded that nasal tip prominence is important only when other facial features are considered. Prominent noses can detract from facial aesthetics by making the lips seem less protrusive (Ghorbanyjavadpour & Rakhshan, 2019). Harmonious Chinese and Iranian facial profiles displayed an upper lip to pronasale distance measured parallel to the Legan and Burstone horizontal plane that was much smaller than the Caucasian norm (Ghorbanyjavadpour & Rakhshan, 2019; Lew et al., 1992). Marchiori et al. (2017) observed that facial profiles were more attractive when nasal tip projection beyond the Holdaway line

decreased and approached the cephalometric norm. Fortes et al. (2014) suggested that although unpleasant profiles showed greater nasal tip projection beyond the Holdaway line than pleasant ones, the lack of differences in nasal height and the alar-pronasale/nasal height ratio indicates that the size of the nose is not important but rather its relationship to other structures, such as the upper lip and chin.

4.6.11 The influence of the sagittal, vertical and rotational surgical maxillary movements on the change in the attractiveness of the nose in the frontal and profile views

In this study, Le Fort I osteotomy caused sagittal and vertical A point movements of 3.63±2.49 and -0.54 ±2.05 mm, respectively and non-significant 0.17±2.39° maxillary posterior rotation. Yet, the multiple regression analysis indicated that the magnitude of each of the sagittal, vertical and rotational surgical maxillary movements did not contribute significantly to explain the change in frontal and profile attractiveness of the nose. Therefore, the extent to which nasal aesthetics changes because of maxillary surgical movement is largely unpredictable.

Individual biological differences play an important role in soft tissue response to hard tissue movement (Baik & Kim, 2010; Coban et al., 2020; Soncul & Bamber, 2004; Verdenik & Ihan Hren, 2014). Post-surgical nasal morphology depends on multiple factors beyond hard tissue movement such as pre-surgical nasal anatomy (McFarlane et al., 1995; O'Ryan & Schendel, 1989a; Schendel & Carlotti, 1991) and the dead space between the lip and alveolus (Altug-Atac et al., 2008; Louis et al., 2001; Stella et al., 1989).

Results are also affected by surgical procedures, such as the anterior nasal spine resection or reduction (Altug-Atac et al., 2008; Becker et al., 2014; Freihofer, 1977; Gassmann et al., 1989; Khamashta-Ledezma & Naini, 2015; Louis et al., 2001; Mansour et al., 1983; Rosen, 1988).

Moreover, soft tissue changes may be related more to soft tissue manipulation and the method of closure of the incision than to actual surgical maxillary movement (Betts et al., 1993; Phillips et al., 1986). The degree of soft tissue dissection and deflection (Becker et al., 2014; Louis et al., 2001; Shoji et al., 2012), the degloving of the lower lateral cartilages and the separation of the nasal septum (Gassmann et al., 1989) affect nasal morphology. The alar base suture is of special interest in both the horizontal and vertical dimensions. The post-surgical width depends on the amount of tension placed on the aponeurotic suture (O'Ryan & Carlotti, 1989; Schendel & Williamson, 1983; Shams & Motamedi, 2002). Moreover, the suture may rotate the nasal base upward as it crosses and compresses the midline (Shoji et al., 2012; Westermark et al., 1991). A slightly lax AC suture can be used even when alar base widening is desired to prevent it from becoming excessive (Guymon et al., 1988) Other authors recommend a slight overcorrection as the loosening of sutures or stretching of fibroareolar tissue in the immediate postoperative period can cause minor relapse (O'Ryan & Carlotti, 1989; Schendel & Williamson, 1983; Shams & Motamedi, 2002). Soft tissue healing also affects surgical results (Altug-Atac et al., 2008; Becker et al., 2014; Gassmann et al., 1989).

4.7 Clinical considerations

Laypeople tend to focus much more on the nose than orthodontists (Chan et al., 2008; Soh et al., 2005a; Al Taki & Guidoum, 2014). Hence, while orthodontists noted greater surgical benefits in global facial aesthetics and to a lesser extent in the nasal profile, a study using a panel of laypeople could have generated different results.

The tendency for frontal nasal aesthetics to deteriorate was correlated with nasal changes in the transverse dimension that invariably accompany the osteotomy. Moreover, due to the complex interaction of surgical dissection, soft tissue healing and patient variation in nasal morphology, the change in nasal attractiveness could not be predicted by the amount and direction of surgical movement. Laypeople are more likely to see the frontal aspect of their nose in the mirror and notice nasal widening (Hemmatpour et al., 2016; Schendel & Carlotti, 1991). Thus, orthodontists must inform patients about these changes to avoid post-surgical discontent (Hellak et al., 2015; Mitchell et al., 2007; Rosen, 1988). The need for a possible secondary corrective nasal surgery must also be discussed (Rauso et al., 2011).

Moreover, male orthodontists were more generous whilst evaluating nasal profile aesthetics than female orthodontists. Yet, most surgical patients are women who are also known to be more critical of their own nasal aesthetics (Springer et al., 2008, 2009). Rhinoplasty is the most common plastic surgical procedure performed in individuals below the age of 35 and the majority of individuals who seek it are women (Bui et al., 2015; Springer et al., 2009; Zojaji et al., 2019). A predominantly female panel considered patients more attractive, successful and healthier after rhinoplasty (Nellis et al., 2018). Hence, special care must be taken regarding female patients.

4.8 Conclusions

1) Le Fort 1 maxillary advancement osteotomy significantly improved both frontal and profile facial attractiveness and nasal aesthetics in the profile view.
2) Female orthodontists were more critical than their male colleagues of the aesthetic improvement caused by the Le Fort 1 advancement osteotomy in the frontal view of the face, the facial profile and the profile view of the nose.
3) The changes caused by the Le Fort 1 maxillary advancement osteotomy in the aesthetic evaluation of the face and the nose in the frontal and profile views were similar in male and female patients.
4) There was no significant correlation between the evaluations of the effect of the Le Fort I maxillary advancement osteotomy on the nose in the frontal and the profile views
5) The alteration in the attractiveness of the frontal view of the nose demonstrated a weak, significant correlation with the change in the attractiveness of frontal view of the face. The change in the attractiveness of profile view of the nose did not correlate significantly with that of the attractiveness of the facial profile.
6) The change in the morphological width, alar base width and superior alar angle explained 19% of the variation in the change in the attractiveness of the nose in the frontal view. Modification in the nasal height,

vertical position of point pronasale and the supratip break angle contributed 24% to the variation in the change in the attractiveness of the profile view of the nose.

7) Changes in the aesthetics of the nose in the frontal and profile views, evaluated by orthodontists, cannot be predicted from the magnitude of the sagittal, vertical and rotational surgical maxillary movements.

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Appendix I (Chapter II)

Annex 1: Published values of morphological nasal variables for different races

Frontal variables

Race	Men	Women	Age	Author	Race	Men	Women	Age	Author
Nasal root width at the level of maxillofrontale									
Indian		15.5±1.6	18-35	(Patil et al., 2011)	Turk	17.83±2.40 29.74±0.46	17.36±2.10	18-20 18-30	(Ozdemir & Uzun, 2015) (Uzun et al., 2006)
Caucasian	19.6±1.9	18.4±1.9	18-25	(Farkas et al., 2007)	African American	22.8±2.8 27.0±0.39	21.3±2.3	18-25 18-30	(Farkas et al., 2007) (Porter, 2004)
Saudi Arabian	20.8±2.9	23.1 ±2.4	18-27	(Al-Qattan et al., 2012)	Korean		21.1±4.1	18-35	(Choe et al., 2006)
Intercantal distance									
Greek	30.0±3.6	29.5±2.5	18-30	(Farkas et al., 2005)	Italian	30.2±2.4	27.6±3.2	18-30	(Farkas et al., 2005)
Polish	30.3±2.8	29.2±2.2	18-30	(Farkas et al., 2005)	Portuguese	30.5±3.6	29.1±2.8	18-30	(Farkas et al., 2005)
Czech	30.9 ±3.1	29.1±2.4	18-30	(Farkas et al., 2005)	British	31 ±0.3	29±0.4	18-55	(Leong & White, 2004)
German	31.2±2.6	28.6±3.0	18-30	(Farkas et al., 2005)	Croatian	31.5±2.7	29.7±2.4	18-30	(Farkas et al., 2005)
Saudi Arabian	31.6±2.7	32.6±2.8	18-27	(Al-Qattan et al., 2012)	Hungarian	31.7± 2.3	31.2±1.8	18-30	(Farkas et al., 2005)
Turk	31.76±1.54	31.56±1.43	18-30	(Borman et al., 1999)	Bulgarian	32.30±3.5	29.7±2.2	18-30	(Farkas et al., 2005)
Iranians /Class I	32±3	30±3	20	(Fariaby et al., 2006)	Indian		31.2±3.7	18-30	(Husein et al., 2010)
Chilean	30.3±5.03	30.3±4.36	18-30	(Troncoso Pazos et al., 2008)	American Caucasian	32.9 ± 2.7 33.3± 2.7	31.6±2.4 31.8± 2.3	18-30 18-25	(Farkas et al., 2005) (Farkas et al., 2007)
Russian	34.2±1.9	32.7±3.0	18-30	(Farkas et al., 2005)	Young attractive caucasian		31.9±1.7		(Farkas et al., 1986)
African A	35.8±2.9 32.8±0.26	34.4±3.4	17-25 18-30	(Farkas et al., 2007) (Porter, 2004)					
Mal,Sing,HK	35±0.3	34± 0.3	18-55	(Leong & White, 2004)	Han Chinese Han Chinese Central China M 22-29yrs W 20-31	35.6±3.5 36.54±2.40 36.86	35.5 ± 3.5 35.68±2.43 35.30 mm	17-24 18-21	(Li et al., 2014) (Zhang et al., 1990) (Dong et al., 2010)
Morphological width									
North American	32.1 ±2.6	31.4 ±1.9	18-30	(Farkas et al., 2005)	Italian	32.1±4.2	29.5±4.8	18-30	(Farkas et al., 2005)
Caucasian	34.9±2.1	31.4 ±2.0 31.1±1.8	18-25	(Farkas et al., 2007) (Farkas et al., 1986)		32.31±3.10 33.86±2.36	28.9±3.30 30.29±2.52	18-30 31-40	(Sforza et al., 2011)
Young attractive Canadian	36.9±2.8	32.9 ±2.7	18-40	(Farkas et al., 1998)		34.10±1.97 36.22±2.28	32.31±2.97 33.13±2.11	41-50 20-27	(Ferrario et al., 1993)
Egyptian	32.4± 8	29.3±7.4	18-30	(Farkas et al., 2005)	Slovakian	33.6 ± 4.4	30.6±3.6	18-30	(Farkas et al., 2005)
Turks	33.61±2.12 33.63±0.27 35.24±2.7 36.8±4.6	33.28±2.08 31.59±2.50 32.9± 4.8	20-30 18-30 18-20 18-30	(Borman et al., 1999) (Uzun et al., 2006) (Ozdemir & Uzun 2015) (Farkas et al., 2005)	German Polish Iranian HF/Class I	34 ± 4.4 35.2 ± 4 35.3±6 36.7±25	31±5.4 32.6±5.4 32.1±5 32.8±2.2	18-30 18-30 18-30 18-30	(Farkas et al., 2005) (Farkas et al., 2005) (Farkas et al., 2005) (Amini et al., 2014)
Azerbaijan	35.7 ± 4.5	33.8±5.4	18-30	(Farkas et al., 2005)	Class I	39±3	35±3	20	(Fariaby et al., 2006)
Greek	35.7 ± 5.8	32.4±4.8	18-30	(Farkas et al., 2005)	Russian	35.8 ± 4.6	33.2±4.4	18-30	(Farkas et al., 2005)
Slovenia	35.9 ± 5.8	33.1± 5	18-30	(Farkas et al., 2005)	Bulgarian	36 ± 6.6	33±9.4	18-30	(Farkas et al., 2005)
Czech	36.2 ± 5	33.8±5	18-30	(Farkas et al., 2005)	Croatia	36.5 ± 5.4	32.9±4	18-30	(Farkas et al., 2005)
Portuguese	36.6 ± 5.8	31.9±5.8	18-30	(Farkas et al., 2005)	Serbian	36.7± 2.86	34.72± 3.38	18-65	(Jovanović et al., 2014)
Han Chinese	36.78±2.11	35.18±2.09	18-21	(Zhang et al., 1990)	British	37± 4	34±0.3	18-55	(Leong & White, 2004)
Han Chinese	36.12± 3.29	35.8±4.13	17-24	(Li et al., 2014)	Hungarian	37.3 ± 5	33.5±3.8	18-30	(Farkas et al., 2005)
Singaporean	39.2±5.8	37.2±4.2	18-30	(Farkas et al., 2005)	Chilean	37.34±5.04	35.17±5.54	18-30	(Troncoso Pazos et al., 2008)
Eastern	39.49±2.95	37.63±3.47		(Aung et al., 2000)	American Korean		35.5±3.4	18-35	(Choe et al., 2006)
Mal, Sing, HK	41.0±3	38±0.3	18-55	(Leong & White, 2004)	Indian	37.9±7	33.8±4.8	18-30	(Farkas et al., 2005)
Central China	42.88	37.48	22-29 20-31\	(Dong et al., 2010)			35.6±2.2 35.6±3.3	18-35 18-35	(Patil et al., 2011) (Husein et al., 2010)
Japanese	38.2± 5 mm 36.3±3.4	37.1± 4.8	18-30 20-48	(Farkas et al., 2005) (Ochi & Ohashi, 2002)	Saudi Arabian Thai	38.5 ± 3.1 40.8±4.4	35.6±3.3 40.2±6	18-27 18-30	(Al-Qattan et al., 2012) (Farkas et al., 2005)
Vietnamese	40.2±4.2	39.8±4.2	18-30	(Farkas et al., 2005)	African	44.1 ± 6.8	40.1±6.4	18-30	(Farkas et al., 2005)
Zulus	42 ± 5.8	38±5.8	18-30	(Farkas et al., 2005)	American	44.1 ±3.4 42.1±0.28	40.1±3.2	18-25 18-30	(Farkas et al., 2007) (Porter, 2004)
Angolans	46.3±4.8	40.8±6.2	18-30	(Farkas et al., 2005)					
Nasal base width									
Turks	23.14±0.28 25.33±3.30	28.83±3.02	18-30 18-20	(Uzun et al., 2006) (Ozdemir & Uzun, 2015)	Han Chinese Inferior view	25.67±2.79	24.93 ± 3.35	17-24	(Li et al., 2014)
Saudi Arabian	25.6±4.9	29.9±3.0	18-27	(Al-Qattan et al., 2012)	Central China M 22-29 W 20-31	34.46	31.56		(Dong et al., 2010)
Italians	31.48±3.31 33.21±2.74 35.24±2.93	28.70±3.51 29.66± 2.46 33.47±2.09	18-30 31-40 41-50	(Sforza et al., 2011)	Indian American Canadian	32.8 ±2.3 35.0±3.0	31.9 ± 5.1 30.5± 2.2 31.6±2.8	18-30 18-25 18-40	(Husein et al., 2010) (Farkas et al., 2007) (Farkas et al., 1998)
Iranian Class I	35.39±3.32	33.6±2.1	16-18	(Moshkelgosha et al 2015)	African American	40±4.5	37.7±3.5	18-25	(Farkas et al., 2007)

Columella width									
Turks	5.34±8.55		18-30	(Uzun et al., 2006)	Indian		5.8±0.6	18-35	(Patil et al., 2011)
	5.77±1.15	5.60±1.48	18-20	(Ozdemir & Uzun, 2015)	Han Chinese	6.1±0.94	6.11±0.91	17-24	(Li et al., 2014)
Korean		7.3±1.1	18-35	(Choe et al., 2006)	Eastern	7.21±1.44	7.41±1.11	18	(Aung et al., 2000)
American Caucasian		6.8 ±0.7		Cited by (Choe et al., 2006)	Caucasian	8.10±0.60	7.60±0.70		Cited by (Aung et al., 2000)
Young attractive Caucasian		6.6± 0.6		(Patil et al., 2011) (Farkas et al., 1986)					
Bilateral width of the nostril floor									
Turks	17.63±2.14	20.63±2.84	18-20	(Ozdemir & Uzun, 2015)	Caucasian	21±2.4	19.9±1.9	18-25	(Farkas et al., 2007)
African American	23.1±3.4	22.7±3.5	18-25	(Farkas et al., 2007)					
Unilateral nasal base width (Sn-Sbal distance)									
Young attractive Caucasian		10.9±1.5		(Farkas et al., 1986)	Turks	11.00±0.17		18-30	(Uzun et al., 2006)
Caucasians	12.80±1.7	11.30±1.70		Cited by	Eastern	12.78 ± 1.46	11.83± 1.45		(Aung et al., 2000)
Right and left	12.50±1.60	11.40±1.70		(Aung et al., 2000)	Right and left	12.94±1.49	11.97 ± 1.403		
Root width /morphological width index									
Korean		59.6 ±12.1	18-35	(Choe et al., 2006)	Young attractive Caucasians		60.8±6.0		(Farkas et al., 1986)
Saudi Arabian	55.5 ±7.9	66.7 ±7.1	18-27	(Al-Qattan et al., 2012)					
Turks	88.63±13.13		18-30	(Uzun et al., 2006)					
Morphological width /length ratio									
British	0.84±0.15	0.82±0.12	18-55	(Leong & White, 2004)	Korean x 100		82.3±11.2	18-35	(Choe et al., 2006)
					Indian		95.1 ± 8.1	18-35	(Patil et al., 2011)
					Mal, Sing, HK	1.1±0.13	1.2±0.14	18-55	(Leong & White, 2004)
Superior alar angle									
Italian	43.23±0.52	42.26±0.54	20-27	(Ferrario et al., 1993)					
Inferior alar angle									
Italian	123.61±1.34	124.41±1.33	20-27	(Ferrario et al., 1993)					

Distances in millimetres, angles in degrees

Profile variables

Race	Men	Women	Age	Author	Race	Men	Women	Age	Author
Total facial convexity angle Glabella									
Croatian Class I HF	130.5± 3.7	130.2 ±3.5	23-28	(Anić-Milošević et al., 2008)	Iranian Class I	137.85 ±3.95	139.2±4	16-18	(Moshkelgosha et al., 2015)
Caucasians Acceptable occlusion, HF	140.2±4.9	138.9±6.2	25.5	(Bishara et al., 1984)	Spanish	139.9±5.3	139.2±4.5	18-20	(Fernández-Riveiro et al., 2003)
Caucasians	142.3±6.1	140.2±5.9	45	(Bishara et al., 1998)	Brazilian Caucasian Pleasant profiles	141.60 ± 5.30	143.73 ± 3.95	17.9-32	(Fortes et al., 2014)
Turks Class I	142.35±5.36	142.57±5.29	19-25	(Malkoc et al., 2009)					
Soft tissue nasion									
Iranian	120-132		18-47	(Zojaji et al., 2019)	Korean		128 ±4.1	18-35	(Choe et al., 2006)
Class I	125±6	124±4	20	(Fariaby et al., 2006)	Turks Class I	128.6±3.4	129.1±3.3	21-40	(Kale-Varnk, 2008)
Attr Caucasians	129.64± 3.80	131.60 ±3.70	14-22	(Matoula & Pancherz, 2006)	Turks	129.35±6.56	129.83±5.76	20-30	(Borman et al., 1999)
					Croatian class I	130.47±3.73	130.19±3.47	23-28	(Anić-Milošević et al., 2008)
Attr Caucasians HF,normal OJ/OB	130.4 ±5.4°		22-32	(Zylinski et al., 1992)	Saudi Arabian	130.8±4.9	128.9±6.5	18-27	(Al-Qattan et al., 2012)
Caucasian Normal skeletal profile	133	131	18	(Subtelny, 1959)					
Facial convexity angle Glabella									
Chinese HP	10.5±3.5		18-24	(Lew et al., 1992)	Caucasians HP	11.3±4		16.5-3(	(Burstone 1959)
Turks Class I	170.60±6.15	168.78±5.44	19-25	(Malkoc et al., 2009)		12±4		Adults	(Legan & Burstone, 1980)
Recommended range	162 -172				Caucasians Class I	165 to 173°			(Bergman, 1999)
Turks Class I	169.3±5.3	167.9±4.7	21-40	(Kale-Varnk, 2008)	Caucasians Class I	165-175			(Arnett & Bergman, 1993a)
					Brazilian Caucasian HP	168.80±4.44	169.60±3.33	17.9-32	(Fortes et al., 2014)
Turks	Class I 12.90±5.14		18-30	(Gulsen et al., 2006)	Spanish All skeletal classes	168.2±4.96	167±5.36	18-20	(Fernández-Riveiro et al., 2003)
	Class II 20.62±5.47				Croatian Class I	168.8±4.96°	169.07±4.72	23-28	(Anić-Milošević et al., 2008)
	Class III 5.94±6.03				Iranian Class I	165.17±4.51	165.9 ±4.1	16-18	(Moshkelgosha et al., 2015)
All skeletal classes	14.23±8.14	12.87±7.36			Pakistanis	Class I 16.75±10.01		18-40	(Arshad et al., 2013)
						Class II 21.87±7.33			
						Class III 6.25±5.28			
					All skeletal classes	18.73±10.54	18.25±9.00		

Nasomental angle N´Stp/PrnPg´									
Turks	Class I 124.44±6.69		18-30	(Gulsen et al., 2006)	Pakistani	Class I 128.33±10.95		18-40	(Arshad et al., 2013)
	Class II 119.20±4.61					Class II 122.14±8.56			
	Class III 128.30 ±6.82					Class III 136.50±5.80			
North Indian Class I M 22.89±0.78 W 21.27±1.79	128.89±6.25	119.80±4.82		(Maurya et al., 2014)	All skeletal classes	124.71±9.85	126.64±10.67		
Tangent to the upper dorsum/ PrnPg´									
Caucasian New Zealanders M 18.9-29.9 W 18.9-22	121.93±4.86	123.28±4.50		(Begg & Harkness, 1995)					
Nasofacial angle (PrnN´Pg)									
Statue Doryphoros Polycleitos de Argos	25 to 30°			(Lines et al., 1978; Naini, 2012)	Greek statues	25			(Lines et al., 1978; Naini, 2012)
Jacques Joseph	Ideal 30, Range 23-37			(Naini, 2012)	Profile silhouettes	30	25		(Lines et al., 1978)
Croatian Class I	29.53±2.38	30.36±2.51	23-28	(Anić-Milošević et al., 2008)					
Iranian	30-40			(Zojaji et al., 2019)	Indian		31.8±4.5	18-30	(Husein et al., 2010)
Korean		32.3±5.1	18-35	(Choe et al., 2006)			31.48±3.2	18-35	(Patil et al., 2011)
Iranian Class I	36±4	36±3	20	(Fariaby et al., 2006)	Chinese	34.7±6.8	33.7±5.5	18-55	(Leong & White, 2004)
British	36.7±7	36.6±5.2	18-55	(Leong & White, 2004)	Saudi Arabian	41.4±6.8	33.3±4	18-27	(Al-Qattan et al., 2012)
Nasal bone angle									
Pakistanis	Class I 167.57±8.50		18-40	(Arshad et al., 2013)	Turks	Low 165±8.36		18-30	(Gulsen et al., 2006)
	Class II 164.96±12.61				Mandibular plane-sella nasion angle	Normal 170 ±7.0			
	Class III 171.12±6.22					High 171±6.93			
All skeletal classes	167.16±9.07	166.37±11.21							
Nasal bone length									
Koreans	20.6 ±3.7	18.23 ±3.19	> 20	(Kim et al., 2015)	Multiple nationalities	22.18±3.7	17.43 ±2.49	> 20	(Kim et al., 2015)
Koreans	21.57	17.84	20-29	(Moon et al., 2013)	Pakistanis	Class I 26.44±3.05		18-40	(Arshad et al., 2013)
	21.77	18.92	30-39			Class II 25.72±3.47			
	20.39	17.47	> 40			Class III 27.50±3.02			
Average	21.28	18.02			All skeletal classes	27.21±2.79	25.70±3.37		
Nasal height									
Indian	47.2±7.4	43.7±7.2	18-30	(Farkas et al., 2005)	Angolan	49.8±7.2	46.6±9.8	18-30	(Farkas et al., 2005)
		43.26±2.9	18-35	(Patil et al., 2011)	Zulu	50.2±11.2	49.5±14.6	18-30	(Farkas et al., 2005)
		45.6±3	18-30	(Husein et al., 2010)	African American	50.6±0.38		18-30	(Porter, 2004)
Thai	51.5±4.4	49.5±6.4	18-30	(Farkas et al., 2005)		51.8±3.1	48.8±3.7	18-25	(Farkas et al., 2007)
Russian	51.7±5.2	50.4±6.8	18-30	(Farkas et al., 2005)		51.9±5.6	48.8±7.4	18-30	(Farkas et al., 2005)
Vietnamese	52±6	50.4±8	18-30	(Farkas et al., 2005)	North American	53±3.5	48.9±2.6	18-30	(Farkas et al., 2005)
German	52±11.2	51.4±5.6	18-30	(Farkas et al., 2005)		54.8±3.3	50.6±3.1	18-25	(Farkas et al., 2007)
Saudi Arabian	53.5±3.7	49.4±3.9	18-27	(Al-Qattan et al., 2012)	Young attractive Caucasians		50.8±2.6		(Farkas et al., 1986)
Slovakian	53.5±5.6	49.4±4.8	18-30	(Farkas et al., 2005)	Caucasians Class I	57.1±4.2	54.3±4.8	20-35	(Scheideman et al., 1980)
Polish	53.7±6.8	51.2±6.4	18-30	(Farkas et al., 2005)					
Croatian	53.8±6	50±7.2	18-30	(Farkas et al., 2005)	Korean		51.8±4.3	18-35	(Choe et al., 2006)
Singaporean Chinese	53.8 ±6	51.7 ±6.6	18-30	(Farkas et al., 2005)	Serbian	54.32±3.7	52.6±4.61	18-65	(Jovanović et al., 2014)
Han Chinese	54.19±4.02	53.87±4.43	17-24	(Li et al., 2014)	Turk	54.38±4.60	50.90±4.20	18-20	(Ozdemir & Uzun, 2015)
Han Chinese	57.80 ± 3.68	55.36±3.24	18-21	(Zhang et al., 1990)		55.15±4.57	54.48±4.03	20-30	(Borman et al., 1999)
Central China	54.31	52.44	20-31	(Dong et al., 2010)		58.1±7	55.2±8	18-30	(Farkas et al., 2005)
Bulgarian	54±7.6	52.1±6.4	18-30	(Farkas et al., 2005)		56.92±0.44		18-20	(Uzun et al., 2006)
Egyptian	54.6±11.2	47.4±10.4	18-30	(Farkas et al., 2005)	Czech	54±8.2	52.1±7.4	18-30	(Farkas et al., 2005)
Hungarian	55±5.2	52.5±7	18-30	(Farkas et al., 2005)	Greek	55.5±8.2	52.8±6.6	18-30	(Farkas et al., 2005)
Italian Class I	55.66±4.10	51.76±3.65	20-27	(Ferrario et al., 1993)	Azerbaijan	55.9±6.8	52.3±7.2	18-30	(Farkas et al., 2005)
Overjet < 5mm	55.65±3.31	51.17±3.57	18-30	(Sforza et al., 2004)	Slovenian	56.2±8	52±4.6	18-30	(Farkas et al., 2005)
	57.30±4.17	52.69±3.64	31-40		Japanese	56.9± 9.8	53.3± 9.8	18-30	(Farkas et al., 2005)
	58.68±4.04	53.02±3.92	41-50						
Italians	56.2±7.2	52.1± 13.6	18-30	(Farkas et al., 2005)	Iranian Class I / HF	58.0 ±3.7	56.8±3.4	18-30	(Amini et al., 2014)
New Zealander M 18.9- 29.9 W 18.9-22	58.1±4.18	53.66±3.10		(Begg & Harkness, 1995)				18-30	
					Iranians	62.6±6.4	58.5±5.6		(Farkas et al., 2005)
					Portuguese	59.5±7.8	57.8±8.8	18-30	(Farkas et al., 2005)
Nasal length									
Indian		37.27±4.5	18-35	(Patil et al., 2011)	African American	45.4±0.42		18-30	(Porter, 2004)
		39.2±3.9	18-30	(Husein et al., 2010)		45.6±3.5	42.6 ±3.7	18-25	(Farkas et al., 2007)
	50,26±4.18	48.86±3.54	18-28	(Prasad et al., 2014)	Korean		43.5±3.9	18-35	(Choe et al., 2006)
Japanese	47.7±4.2		20-48	(Ochi & Ohashi, 2002)	North American	50±3.6	44.7±3.4	18-25	(Farkas et al., 2007)

Han Chinese	48.43±4.43	48.34±4.71	17-24	(Li et al., 2014)	Skeletal Class I	51.0±3.6	46.9±3.7	(Starck & Epker, 1996)
	49.68±3.53	47.06±3.17	18-21	(Zhang et al., 1990)	M 18-35, W 15-35			
Central China M 22-29, W 20-31	48.84	46.68		(Dong et al., 2010)	Young attractive Caucasians		44.6±3.0	Young (Farkas et al., 1986)
Chilean	50.09±5.87	46.86± 6.61	18-30	(Troncoso Pazos et al. , 2008)	Iranian Class I	50 ±3	45±3	20 (Fariaby et al., 2006)
Italians OJ < 5 mm	50.33±4.81	47.88±3.84	18-30	(Sforza et al., 2004)	Saudi Arabian	50.6±4.2	43.3±4.1	18-27 (Al-Qattan et al., 2012)
	52.58±4.80	47.90±4.38	31-40		New Zealander	51.45±3.69	46.18±4.19	W 18.9 (Begg & Harkness, 1995)
	51.90±4.35	48.21±4.44	41-50		M 18.9- 29.9,			
Caribbean		48	25-56	(Milgrim et al., 1996)	Turk	52.95±5.40	47.81 ± 4.60	18-20 (Ozdemir & Uzun, 2015)
Pakistani	Class I 53.30±5.54		18-40	(Arshad et al., 2013)	Turks Class I	54.8±2.8		17 (Akgüner et al., 1998)
	Class II 51.83±4.53				Turks	55.26±0.36		18-20 (Uzun et al., 2006)
	Class III 53.37±5.12				Turks	58.36 ±5.04	53.25±4.75	18-30 (Gulsen et al., 2006)
All classes	55.52±4.88	51.27±4.60						
Upper dorsal convexity								
Turks	1.13±1.08	0.69±0.79	18-30	(Gulsen et al., 2006)	Pakistanis	Class I 0.40±1.28		18-40 (Arshad et al., 2013)
Indians	-2.01±1.76	-2.02±1.62	18-28	(Prasad et al., 2014)		Class II 0.48±0.85		
						Class III 0.62±1.15		
					All skeletal classes	0.82±1.00	0.27±1.09	
Lower dorsal convexity					**Columella convexity**			
Pakistanis	Class I 2.35±0.67		18-40	(Arshad et al., 2013)	Pakistanis	Class I 2.87±1.06		18-40 (Arshad et al., 2013)
	Class II 2.30±0.81					Class II 2.74±0.69		
	Class III 1.62±0.74					Class III 3.00±1.06		
					All skeletal classes	3.10±1.00	2.69±0.83	
All skeletal classes	2.26±0.72	2.29±0.78			Indians	4.31±1.26	3.41±1.13	18-28 (Prasad et al., 2014)
Columella exposure								
Iranians	3-5			(Zojaji et al., 2019)	Caucasians	2 mm		(Altman & Oeltjen, 2007)
Nasal projection AcPrn								
Han Chinese Basal view	16.68±3.71	15.72±4.41	17-24	(Li et al., 2014)	Turks	19.93±0.53		18-30 (Uzun et al., 2006)
Indian		29.2±3.0	18-30	(Husein et al., 2010)	Right	30.22±2.82	33.43±2.89	18-20 (Ozdemir & Uzun, 2015)
Korean		29.9±3.1	18-35	(Choe et al., 2006)	Left	30.09 ± 2.92	33.61±2.98	
African American	38.6±0.35			(Porter, 2004)	Young attractive Caucasian		31.0±1.8	Young (Farkas et al., 1986)
Nasal protrusion								
Korean	16.38±2.75	15.26±3.91	19-20	(Park et al., 2014)	African American	17.2±0.17		18-30 (Porter, 2004)
		19.6±1.4	18-35	(Choe et al., 2006)		17.5±2.1	16.1± 2.1	18-25 (Farkas et al., 2007)
	17.31±1.95	17.02±2.44	>20	(Kim et al., 2015)	Indian		16.3±1.4	18-35 (Patil et al., 2011)
Han Chinese	17.73±1.14	16.51±1.36	18-21	(Zhang et al., 1990)			19.1±2.0	18-30 (Husein et al., 2010)
	19.09±2.45	19.26±2.31	17-24	(Li et al., 2014)	Italian	19.17±2.15	17.69±1.92	18-30 (Sforza et al., 2011)
Central China	20.48	19.38	22-29	(Dong et al., 2010)		20.24±2.16	18.78±2.35	31-40
Multiple nationalities	19.3 ±4.65	16.9 ±1.69	>20	(Kim et al., 2015)		22.65±3.26	19.26±1.59	41-50
North American	19.5±1.9	19.7±1.6	18-25	(Farkas et al., 2007)	Overjet<5mm	19.56±2.33	18.18± 1.99	18-30 (Sforza et al., 2004)
Young attractive Caucasian		19.3±1.3		(Farkas et al., 1986)		20.21±2.15	18.78± 2.34	31-40
Caribbean		18.48	25-56	(Milgrim et al., 1996)		22.24±3.11	19.26±1.58	41-50
Saudi Arabian	20.7±2.9	22.1±2.2	18-27	(Al-Qattan et al., 2012)	Turks Class I	22.5±2.3	21.2±1.9	17 (Akgüner et al., 1998)
					Turks	22.81±3.02	21.15±2.56	18-20 (Ozdemir & Uzun, 2015)
Nasal tip angle (N´PrnSn)								
Turk Class I	64.23±14.10	70.85±12.3	21-40	(Kale-Varnk, 2008)	Korean		78.50±7.1	18-35 (Choe et al., 2006)
Turk	82.16±9.98	77.91±9.8	18-30	(Uzun & Ozdemir, 2014)	Korean Class I /HP	102.15±4.73	105.50±4.66	(Hwang et al., 2002)
Eastern	82.55±9.19	83.87±7.39		(Aung et al., 2000)	M 17.6-23.6			
Saudi Arabian	90.5±6.0	97.3±5.1	18- 27	(Al-Qattan et al., 2012)	W17.11-20.9			
Italian	93.84±6.33	94.99±5.01	18-30	(Sforza et al., 2011)	American Class I /HP, M 18.9-33.9	99.37±7.41	97.33±4.38	(Hwang et al., 2002)
	92.86±5.77	93.82±6.05	31-40					
	94.70±6.49	93.49±5.10	41-50		W 19.11-34.11			
Nasal tip rotation angle (AcPrn/perpendicular to the FHP)								
British	103±9	104.6±9.3	18-55	(Leong & White, 2004)	Malyasia, Sing, HK	102.6±10.3°	112.3±6.6	18-55 (Leong & White, 2004)
Nasal prominence angle (SnN´Prn)								
Italian	20.06±2.54	20.19±2.68	18-30	(Sforza et al., 2011)	African American	22.8±2	23.0±2	18-48 (Flynn et al., 1989)
	20.67±2,68	20.87±3.23	31-40					
	22.54±3.09	21.27±2.08	41-50					
Apical nasal angle (N´Stp/SnCm) Values for tangent to the dorsum/columella tangent								
Young attractive Caucasian		73.1±8.0		(Farkas et al., 1986)	Caucasian Class I M 18-35 W 15-35	74.9±9.3	74.1±8	(Starck & Epker, 1996)

Dorsal contour angle									
Spanish	174±4	172.6±6	18-20	(Fernández-Riveiro et al., 2003)	Turks Class I	174.78±4.74	175.71±5.24	19-25	(Malkoc et al., 2009)
Iranian	183.3±5.5	180±4.3	16-18	(Moshkelgosha et al., 2015)					
Supratip break angle									
New Zealander M 18.9-29.9 W 18.9-22	5.31±5.47	9.07±3.84°		(Begg & Harkness, 1995)					
Columella rotation angle (CmSn/ y)									
CmSn/Perpendicular to the FHP									
Caucasian Class I M 18-35 W15-35	70.9±9.2	72.6±7.5		(Starck & Epker, 1996)	African American	75.5 ±10.2	71.2 ±13.1	18-25	(Farkas et al., 2007)
Caucasian HP Reverse angle	72.46±7.28	71.39±7.61	22-33	(Fitzgerald et al., 1992)	Multiple races Reverse angle	104.18±10.17	107.95±8.74		(Kim & Egan, 2006)
Caucasian	77.9±8.9	78.2±7.5	18-25	(Farkas et al., 2007)	Young attractive Caucasian Reverse angle		103.9± 8.5		(Farkas et al., 1986)
Nasolabial angle									
Recommended value									
Caucasian	85-105			(Arnett & Bergman, 1993b)	Caucasian	90- 95	95 to 105		(Kim & Egan, 2006)
Caucasian	102±8			(Bergman, 1999)					
Investigations									
Indians	87.26±13.79	89.39±15.72	18-28	(Prasad et al., 2014)	Turks	90.32±11.88		18-30	(Uzun et al., 2006)
		96.75± 8.3	18-35	(Patil et al., 2011)		97.79±9.13	95.07±10.42	20-30	(Borman et al., 1999)
		97.2±10.6	18-30	(Husein et al., 2010)		97.91±8.78	98.91±10.01	18-20	(Uzun & Ozdemir, 2014),
Malayasia, Sing,HK	86.2±12.5	87.6±13.7	18-55	(Leong & White, 2004)	Turk Class I	98.7±13.7	104.4±12.7	21-40	(Kale-Varnk, 2008)
Chinese HP	95±3		18-24	(Lew et al., 1992)	Turk Class I	101.09±10.19	102.94±10.43	19-25	(Malkoc et al., 2009)
Eastern	99.91±12.65	97.71±9.69		(Aung et al., 2000)	African A Class I	96.3±14.8	87.7±12.8	17-49	(Flynn et al., 1989)
Han Chinese	100.99±15.33	98.97±9.74	17-24	(Li et al., 2014)	African A		86±11	16-30	(Porter & Olson, 2003)
Central China M 22-29 W 20-30	104.30	103.42		(Dong et al., 2010)	British	96.8±7.8	101.8±8.8	18-55	(Leong & White, 2004)
					Iranian Class I	97±11	98±10	20	(Fariaby et al., 2006)
					Iranian Class I, HF	97±8.9	94.6±10	18-30	(Amini et al., 2014)
Korean		92.1±9.2	18-35	(Choe et al., 2006)					
Koreans Class I/HF M 17.6-23.6 W17.11-20.9	91.11±8.12	92.00±9.55		(Hwang et al., 2002)	Pakistanis	Class I 99.23 ± 13.99 Class II 100.63±16.58 Class III 92.25±15.35		18-40	(Arshad et al., 2013)
Saudi Arabian	100.4±16.4	102.3±10.0	18- 27	(Al-Qattan et al., 2012)	All skeletal classes	100.55±14.52	98.87±15.76		
Chilean	104.8 ±10.53	109.9 ±9.69	18-30	(Troncoso Pazos et al., 2008)	Spanish	105.2±13.28	107.6±8.5	18-20	(Fernández-Riveiro et al., 2003)
Caucasian Class I, HF	105.8 ± 9	110.7± 10.9		(Nanda et al., 1990)	Croatian Class I, HF	105.42±9.52	109.39±7.84	23-28	(Anić-Milošević et al., 2008)
Male Caucasian models 1930-1995	109.6±6.11			(Nguyen & Turley, 1998)	New Zealanders M 18.9 -29.9 W 18.9-22	110.06 ±8.32	112.15±9.08		(Begg & Harkness, 1995)
Caucasian	110.8±7.6		22-32	(Zylinski et al., 1992)					
Lips in contact					Japanese	119.56±8.59	122.00± 10.04		(Mishima et al., 2001)
Americans Class I, HF, M 18.9-33.9 W 19.11-34.11	112.05±9.86	109.71 ±7.60		(Hwang et al., 2002)	M 23 -29, W 19-26				
					Caucasian	102±8		20-30	(Legan & Burstone, 1980)

Class I: class I occlusion, HF: harmonious face, African A: African Americans, Mal, Sing, HK: Malaysia, Singapore, Hong Kong, C Chinese: central Chinese, M: Men, W:Women, (Farkas et al., 2005): Except for American Caucasians, values with 2 standard deviations,

Annex 2: Results of the investigation: Descriptive statistics and normality of the variables in the groups with class I and class III malocclusions and men and women within the groups

Table 1: Descriptive statistics and normality of skeletal facial variables in the group with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial height	118.14	7.23	0.81	100.8	130.7	0.200
Lower facial height	68.63	5.76	0.64	56.3	79.1	0.200
Lower facial height/Total facial height ratio	0.58	0.02	0.00	0.53	0.63	0.200
Sagittal maxillary position	65.57	5.41	0.60	52.8	79.8	0.200
Maxillary length	44.47	4.02	0.45	35.9	54.3	0.200
SNA angle	80.33	3.41	0.38	72.1	90.4	0.200
SNB angle	78.21	3.44	0.39	68.9	87.5	0.200
ANB angle	2.12	1.08	0.12	0.4	4.8	0.018
Maxillary inclination angle	7.85	3.57	0.40	-0.3	15.1	0.200
Mandibular plane inclination	33.78	6.95	0.78	15	47	0.200
Vertical intermaxillary angle	25.93	6.67	0.75	10.8	39.7	0.200

Table 2: Descriptive statistics and normality of skeletal facial variables in the group with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial height	123.70	8.49	0.95	108.2	149.3	0.200
Lower facial height	72.15	6.93	0.77	56.0	96.9	0.200
Lower facial height/Total facial height ratio	0.58	0.02	0.00	0.52	0.65	0.038
Sagittal maxillary position	62.16	5.30	0.59	47.6	74.3	0.200
Maxillary length	42.11	4.10	0.46	30.3	51.0	0.200
SNA angle	78.15	3.80	0.43	67.2	88.7	0.200
SNB angle	81.02	4.08	0.46	67.50	92.10	0.200
ANB angle	-2.87	2.43	0.27	-10.1	2.2	0.026
Maxillary inclination angle	9.13	3.18	0.36	2.5	16.8	0.200
Mandibular plane inclination	39.62	6.03	0.67	28.7	55.0	0.200
Vertical intermaxillary angle	30.49	6.00	0.67	16.6	44.6	0.200

Table 3: Descriptive statistics and normality of skeletal facial variables in men with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial height	121.45	6.59	1.04	104.2	130.7	0.065
Lower facial height	70.77	5.11	0.81	57.5	79.1	0.200
Lower facial height/Total facial height ratio	0.58	0.02	0.00	0.53	0.63	0.200
Sagittal maxillary position	68.54	4.55	0.72	61	79.8	0.022
Maxillary length	46.78	3.19	0.50	38.5	54.3	0.131
SNA angle	81.11	3.48	0.55	74.6	90.4	0.200
SNB angle	78.94	3.32	0.52	74.20	87.50	0.200
ANB angle	2.17	1.18	0.19	0.4	4.8	0.147
Maxillary inclination angle	7.90	3.18	0.50	1.6	13.4	0.200
Mandibular plane inclination	31.65	6.65	1.05	20	42.7	0.127
Vertical intermaxillary angle	23.75	5.76	0.91	10.8	34.1	0.200

Table 4: Descriptive statistics and normality of skeletal facial variables in women with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial height	114.84	6.33	1.00	100.8	128.7	0.200
Lower facial height	66.48	5.63	0.89	56.3	78.0	0.200
Lower facial height/Total facial height ratio	0.58	0.03	0.00	0.53	0.62	0.200
Sagittal maxillary position	62.60	4.51	0.71	52.8	72.9	0.098
Maxillary length	42.16	3.40	0.54	35.9	49.5	0.200
SNA angle	79.55	3.20	0.51	72.1	85.7	0.200
SNB angle	77.48	3.46	0.55	68.90	84.00	0.200
ANB angle	2.07	0.99	0.16	0.5	3.9	0.074
Maxillary inclination angle	7.80	3.97	0.63	-0.3	15.1	0.200
Mandibular plane inclination	35.91	6.66	1.05	15.0	47.0	0.174
Vertical intermaxillary angle	28.11	6.88	1.09	15.3	39.7	0.200

Table 5: Descriptive statistics and normality of skeletal facial variables in men with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial height	129.32	7.27	1.15	116.9	149.3	0.098
Lower facial height	76.42	5.98	0.95	68.1	96.9	0.055
Lower facial height/Total facial height ratio	0.59	0.02	0.00	0.55	0.65	0.136
Sagittal maxillary position	64.47	4.71	0.74	47.6	74.3	0.200
Maxillary length	43.52	3.84	0.61	30.3	51.0	0.200
SNA angle	78.47	4.08	0.65	67.2	86.1	0.200
SNB angle	81.45	4.30	0.68	67.50	92.10	0.175
ANB angle	-2.98	2.76	0.44	-10.1	-0.1	0.007**
Maxillary inclination angle	8.10	2.83	0.45	2.5	13.1	0.200
Mandibular plane inclination	39.11	6.55	1.03	28.7	55.0	0.200
Vertical intermaxillary angle	31.01	6.60	1.04	18.1	44.6	0.200

***P*<0.01

Table 6: Descriptive statistics and normality of skeletal facial variables in women with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial height	118.09	5.32	0.84	108.2	133.6	0.200
Lower facial height	67.87	4.89	0.77	56.0	84.6	0.121
Lower facial height/Total facial height ratio	0.57	0.02	0.00	0.52	0.63	0.140
Sagittal maxillary position	59.85	4.88	0.77	51.2	69.4	0.200
Maxillary length	40.70	3.89	0.62	34.1	49.7	0.200
SNA angle	77.83	3.53	0.56	70.4	88.7	0.200
SNB angle	80.59	3.85	0.61	73.90	90.50	0.127
ANB angle	-2.77	2.09	0.33	-6.9	2.2	0.200
Maxillary inclination angle	10.16	3.21	0.51	2.8	16.8	0.200
Mandibular plane inclination	40.13	5.50	0.87	28.7	50.4	0.200
Vertical intermaxillary angle	29.97	5.37	0.85	16.6	39.3	0.200

Table 7: Descriptive statistics and normality of variables measured in frontal photographs of the group with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Nasal root width	14.80	2.17	0.24	11.20	20.80	0.200
Inner endocanthal distance	32.43	2.81	0.31	26.00	37.80	0.200
Morphological width of nose	36.17	3.15	0.35	30.40	45.30	0.200
Alar base width	33.18	3.05	0.34	27.00	42.80	0.086
Columella width	6.57	1.34	0.15	4.30	10.70	0.018
Bilateral width of the nostril floor	19.03	2.69	0.30	12.00	24.70	0.200
Right nasal base width	10.11	1.59	0.18	7.10	13.70	0.200
Left nasal base width	9.25	1.66	0.19	6.20	13.00	0.200
Right frontal subnasale-alare distance	20.20	2.05	0.23	16.10	25.90	0.200
Left frontal subnasale-alare distance	19.39	1.76	0.20	15.70	23.60	0.200
Right diagonal nostril width	10.08	1.72	0.19	6.70	14.20	0.200
Left diagonal nostril width	9.89	1.51	0.17	7.00	14.10	0.200
Right dorsal axis-alare distance	18.73	1.95	0.22	14.30	24.20	0.200
Left dorsal axis-alare distance	17.42	1.74	0.20	13.50	21.90	0.200
Frontal nasal length	43.98	4.27	0.48	34.90	52.10	0.200
Frontal nasal height	55.05	4.22	0.47	45.60	63.90	0.200
Root width/morphological width ratio	0.41	0.06	0.01	0.29	0.64	0.200
Frontal nasal length/morphological width ratio	1.22	0.14	0.02	0.82	1.55	0.200
Frontal nasal height/morphological width ratio	1.53	0.15	0.02	1.09	1.88	0.200
Alar slope angle	20.23	11.33	1.27	0.60	51.40	0.200
Superior alar angle	42.03	4.06	0.45	34.50	57.50	0.055
Inferior alar angle	133.19	9.61	1.07	113.90	172.10	0.200
Lateral alar angle	81.93	6.53	0.73	64.60	95.60	0.200

Table 8: Descriptive statistics and normality of variables measured in frontal photographs of the group with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Nasal root width	14.75	2.31	0.26	9.6	22.6	0.200
Inner endocanthal distance	31.86	2.78	0.31	25.4	40.8	0.056
Morphological width of nose	36.17	3.76	0.42	28.9	48.7	0.200
Alar base width	33.12	3.55	0.40	25.7	46.3	0.092
Columella width	7.13	1.33	0.15	4.7	10.7	0.200
Bilateral width of the nostril floor	19.21	2.53	0.28	14.0	26.4	0.200
Right nasal base width	10.23	1.58	0.18	5.5	14.0	0.200
Left nasal base width	9.37	1.55	0.17	5.8	14.9	0.200
Right frontal subnasale-alare distance	20.58	2.21	0.25	16.5	27.9	0.200
Left frontal subnasale-alare distance	19.39	1.89	0.21	15.4	24.4	0.200
Right diagonal nostril width	10.01	1.76	0.20	4.6	14.1	0.200
Left diagonal nostril width	9.50	1.87	0.21	5.6	15.3	0.035
Right dorsal axis-alare distance	19.04	2.27	0.25	14.2	26.0	0.200
Left dorsal axis-alare distance	17.12	1.92	0.21	13.3	22.5	0.200
Frontal nasal length	46.52	4.56	0.51	34.5	56.9	0.200
Frontal nasal height	57.16	4.61	0.51	45.2	67.8	0.200
Root width/morphological width ratio	0.41	0.05	0.01	0.29	0.52	0.200
Frontal nasal length/morphological width ratio	1.30	0.18	0.02	0.91	1.84	0.200
Frontal nasal height/morphological width ratio	1.60	0.20	0.02	1.19	2.14	0.200
Alar slope angle	14.71	12.12	1.36	-14.5	43.6	0.200
Superior alar angle	40.70	4.40	0.49	30.3	52.9	0.200
Inferior alar angle	130.76	11.14	1.25	103.2	154.9	0.200
Lateral alar angle	83.44	7.97	0.89	64.0	99.1	0.200

Table 9: Descriptive statistics and normality of variables measured in frontal photographs of men with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Nasal root width	15.25	2.01	0.32	11.3	20.8	0.200
Dorsal width	24.90	2.40	0.38	17.8	29.4	0.200
Inner endocanthal distance	32.97	2.99	0.47	26.9	37.8	0.200
Morphological width of nose	38.14	2.22	0.35	33.9	45.3	0.097
Alar base width	35.00	2.16	0.34	31.4	42.8	0.199
Columella width	6.96	1.52	0.24	4.4	10.7	0.200
Bilateral width of the nostril floor	20.22	2.47	0.39	14.5	24.7	0.200
Right nasal base width	10.82	1.42	0.22	7.6	13.7	0.200
Left nasal base width	9.74	1.58	0.25	6.7	13.0	0.069
Right frontal subnasale-alare distance	21.33	1.69	0.27	17.0	25.9	0.200
Left frontal subnasale-alare distance	20.30	1.38	0.22	17.8	23.5	0.200
Right diagonal nostril width	10.75	1.48	0.23	7.7	14.2	0.200
Left diagonal nostril width	10.45	1.28	0.20	8.6	14.1	0.200
Right dorsal axis-alare distance	19.77	1.62	0.26	16.1	24.2	0.200
Left dorsal axis-alare distance	18.35	1.31	0.21	15.8	21.9	0.165
Frontal nasal length	44.84	4.16	0.66	34.9	51.8	0.200
Frontal nasal height	56.04	3.99	0.63	46.1	63.9	0.200
Root width/morphological width ratio	0.40	0.06	0.01	0.29	0.56	0.200
Frontal nasal length/morphological width ratio	1.18	0.12	0.02	0.82	1.45	0.200
Frontal nasal height/morphological width ratio	1.47	0.13	0.02	1.09	1.74	0.200
Alar slope angle	18.35	11.12	1.76	0.6	51.4	0.200
Superior alar angle	43.53	3.80	0.60	37.6	57.5	0.200
Inferior alar angle	134.09	10.30	1.63	116.3	172.1	0.050
Lateral alar angle	80.50	5.99	0.95	64.6	92.2	0.200

Table 10: Descriptive statistics and normality of variables measured in the frontal photograph of women with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Nasal root width	14.36	2.26	0.36	11.2	20.6	0.012
Inner endocanthal distance	31.90	2.55	0.40	26.0	36.8	0.200
Morphological width of nose	34.21	2.70	0.43	30.4	43.0	0.076
Alar base width	31.35	2.73	0.43	27.0	40.3	0.045
Columella width	6.18	1.00	0.16	4.3	9.1	0.143
Bilateral width of the nostril floor	17.84	2.37	0.38	12.0	22.7	0.200
Right nasal base width	9.41	1.45	0.23	7.1	12.4	0.200
Left nasal base width	8.76	1.61	0.25	6.2	12.0	0.200
Right frontal subnasale-alare distance	19.08	1.75	0.28	16.1	23.1	0.200
Left frontal subnasale-alare distance	18.48	1.64	0.26	15.7	23.6	0.200
Right diagonal nostril width	9.41	1.69	0.27	6.7	13.4	0.101
Left diagonal nostril width	9.33	1.52	0.24	7.0	13.7	0.200
Right dorsal axis-alare distance	17.69	1.69	0.27	14.3	21.6	0.200
Left dorsal axis-alare distance	16.50	1.64	0.26	13.5	21.3	0.200
Frontal nasal length	43.12	4.26	0.67	35.3	52.1	0.200
Frontal nasal height	54.06	4.26	0.67	45.6	61.8	0.200
Root width/morphological width ratio	0.42	0.07	0.01	0.32	0.64	0.200
Frontal nasal length/morphological width ratio	1.27	0.15	0.02	0.95	1.55	0.200
Frontal nasal height/morphological width ratio	1.59	0.15	0.02	1.28	1.88	0.200
Alar slope angle	22.12	11.36	1.80	1.7	47.1	0.200
Superior alar angle	40.54	3.78	0.60	34.5	50.3	0.006**

Inferior alar angle	132.29	8.91	1.41	113.9	150.7	0.096
Lateral alar angle	83.37	6.80	1.07	66.9	95.6	0.200

**P<0.01

Table 11: Descriptive statistics and normality of variables measured in the frontal photograph of men with Class III occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov P-value
Nasal root width	15.23	2.20	0.35	10.3	22.6	0.031
Inner endocanthal distance	32.75	2.63	0.42	27.2	40.8	0.163
Morphological width of nose	38.13	3.28	0.52	31.8	48.7	0.200
Alar base width	34.76	3.40	0.54	28.1	46.3	0.006**
Columella width	7.36	1.27	0.20	4.7	10.6	0.200
Bilateral width of the nostril floor	19.84	2.53	0.40	14.9	26.4	0.200
Right nasal base width	10.58	1.51	0.24	7.3	14	0.200
Left nasal base width	9.66	1.71	0.27	6.7	14.9	0.200
Right frontal subnasale-alare distance	21.41	2.13	0.34	17.6	27.9	0.200
Left frontal subnasale-alare distance	20.29	1.85	0.29	16.2	24.4	0.200
Right diagonal nostril width	10.49	1.62	0.26	6.1	14.1	0.200
Left diagonal nostril width	10.21	2.05	0.32	6.5	15.3	0.200
Right dorsal axis-alare distance	20.02	2.06	0.33	16.6	26	0.200
Left dorsal axis-alare distance	18.09	1.77	0.28	14	22.5	0.200
Frontal nasal length	46.95	4.86	0.77	34.5	56.9	0.200
Frontal nasal height	57.77	4.99	0.79	45.2	67.8	0.200
Root width/morphological width ratio	0.40	0.05	0.01	0.29	0.51	0.200
Frontal nasal length/morphological width ratio	1.24	0.16	0.03	0.91	1.73	0.144
Frontal nasal height/morphological width ratio	1.52	0.17	0.03	1.19	2.05	0.079
Alar slope angle	15.39	12.37	1.96	-14.5	43.6	0.200
Superior alar angle	42.26	4.25	0.67	31.6	52.9	0.156
Inferior alar angle	133.38	9.87	1.56	113.4	154.3	0.137
Lateral alar angle	81.23	6.97	1.10	64	96	0.096

**P<0.01

Table 12: Descriptive statistics and normality of variables measured in frontal photographs of women with Class III occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov P-value
Nasal root width	14.27	2.35	0.37	9.6	20.1	0.200
Inner endocanthal distance	30.98	2.66	0.42	25.4	36.2	0.200
Morphological width of nose	34.22	3.17	0.50	28.9	41.8	0.105
Alar base width	31.48	2.91	0.46	25.7	38.4	0.200
Columella width	6.91	1.36	0.22	4.9	10.7	0.029
Bilateral width of the nostril floor	18.58	2.39	0.38	14	24.9	0.200
Right nasal base width	9.88	1.59	0.25	5.5	14	0.200
Left nasal base width	9.08	1.33	0.21	5.8	12.5	0.200
Right subnasale-alare distance	19.75	1.98	0.31	16.5	23.8	0.085
Left subnasale-alare distance	18.50	1.47	0.23	15.4	21.9	0.200
Right diagonal nostril width	9.53	1.79	0.28	4.6	12.7	0.200
Left diagonal nostril width	8.79	1.36	0.22	5.6	11.3	0.200
Right dorsal axis-alare distance	18.05	2.04	0.32	14.2	22	0.200
Left dorsal axis-alare distance	16.15	1.54	0.24	13.3	19.8	0.200
Frontal nasal length	46.09	4.25	0.67	36.7	55.7	0.200
Frontal nasal height	56.54	4.16	0.66	46.8	65.7	0.200
Root width/morphological width ratio	0.42	0.06	0.01	0.31	0.52	0.200
Frontal nasal length/morphological width ratio	1.36	0.18	0.03	0.98	1.84	0.200

Frontal nasal height/morphological width ratio	1.67	0.20	0.03	1.26	2.14	0.200
Alar slope angle	14.03	11.98	1.89	-13.3	42.3	0.200
Superior alar angle	39.14	4.02	0.64	30.3	49	0.200
Inferior alar angle	128.14	11.83	1.87	103.2	154.9	0.200
Lateral alar angle	85.66	8.36	1.32	67.6	99.1	0.165

Table 13: Descriptive statistics and normality of facial and nasal profile variables in the group with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial convexity angle	138.91	4.37	0.49	127.7	150.1	0.200
Facial convexity angle	13.67	4.39	0.49	3.9	24.8	0.200
Nasomental angle	132.04	5.26	0.59	117.6	144	0.200
Nasofacial angle	27.82	2.77	0.31	21.6	34	0.200
Nasal bone angle	167.24	6.67	0.75	150.7	179.8	0.200
Nasal bone length	23.18	3.47	0.39	11.5	33.2	0.182
Nasal height	56.28	3.95	0.44	45.2	66.2	0.200
Nasal length	49.78	3.71	0.42	37.9	60.3	0.200
Upper dorsal convexity	-1.97	1.20	0.13	-5.5	0	0.002**
Depth of the supratip break	0.14	1.11	0.12	-2.7	2.5	0.200
Lower dorsal convexity	1.42	0.37	0.04	0.6	2.3	0.001**
Columella depth	2.50	0.75	0.08	0.9	4.3	0.200
Columella exposure	4.79	1.43	0.16	1.3	7.7	0.200
Nasal projection	27.23	2.23	0.25	22.1	32.5	0.200
Nostril projection	18.88	2.26	0.25	13.1	25.7	0.200
Subnasale projection	11.47	1.55	0.17	8.7	15.7	0.200
Nasal protrusion	15.75	1.83	0.20	10.1	21.1	0.200
Nasal prominence angle	19.88	2.18	0.24	14.6	25.1	0.200
Apical nasal angle	82.13	8.00	0.89	64.9	104.3	0.200
Nasal tip angle	99.33	5.09	0.57	86.4	109.9	0.200
Nasal projection angle	26.15	4.48	0.50	15.2	37.3	0.200
Dorsal contour angle	5.82	7.14	0.80	-10.2	24.3	0.200
Supratip break angle	7.64	5.09	0.57	-5.3	17.4	0.200
Nasolabial angle	109.24	9.44	1.06	84.4	129.9	0.024
Columella rotation angle	71.50	6.80	0.76	56.1	86.1	0.016
Nasal tip rotation angle	70.57	4.61	0.52	60.4	83.9	0.200
Columella-lobule angle	13.00	7.55	0.84	-4.3	31.9	0.200

**$P<0.01$

Table 14: Descriptive statistics and normality of facial and nasal profile variables in the group with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial convexity angle	144.52	5.73	0.64	131.1	159.2	0.200
Facial convexity angle	7.25	5.52	0.62	-4.9	20.4	0.200
Nasomental angle	138.25	5.91	0.66	123.6	151.7	0.200
Nasofacial angle	24.41	3.30	0.37	17.0	32.9	0.200
Nasal bone angle	166.02	6.61	0.74	149	180.0	0.200
Nasal bone length	24.28	3.26	0.36	17.9	34.2	0.200
Nasal height	58.04	3.95	0.44	50.9	69.4	0.200
Nasal length	51.26	4.11	0.46	43.0	61.0	0.095
Upper dorsal convexity	-1.83	1.18	0.13	-5.2	1.0	0.059
Depth of the supratip break	-0.20	1.11	0.12	-2.9	2.6	0.200
Lower dorsal convexity	1.41	0.46	0.05	0.6	2.6	0.045

Columella depth	2.59	0.72	0.08	1.1	4.5	0.094
Columella exposure	4.72	1.43	0.16	0.6	8.2	0.200
Nasal projection	27.90	3.17	0.35	21.1	34.5	0.200
Nostril projection	18.71	2.55	0.29	12.9	24.7	0.200
Subnasale projection	11.53	2.23	0.25	5.7	17.2	0.037
Nasal protrusion	16.38	2.19	0.25	11.9	22.1	0.200
Nasal prominence angle	19.82	1.88	0.21	14.1	24.2	0.200
Apical nasal angle	82.07	8.29	0.93	64.8	102.8	0.026
Nasal tip angle	99.78	5.65	0.63	88.2	121.4	0.200
Nasal projection angle	25.07	4.67	0.52	6.7	37.3	0.200
Dorsal contour angle	6.55	6.22	0.70	-7.5	22.3	0.200
Supratip break angle	5.62	5.64	0.63	-6.2	16.7	0.200
Nasolabial angle	106.74	12.48	1.40	65.2	132.5	0.200
Columella rotation angle	73.26	8.57	0.96	53	93.3	0.008*
Nasal tip rotation angle	70.66	5.74	0.64	54.7	80.4	0.200
Columella-lobule angle	13.00	7.30	0.82	-2.2	30.4	0.200

**$P<0.01$

Table 15: Descriptive statistics and normality of facial and nasal profile variables in men with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial convexity angle	139.37	4.13	0.65	129.4	147.0	0.200
Facial convexity angle	13.39	5.11	0.81	4.2	24.8	0.200
Nasomental angle	132.32	5.16	0.82	121.8	142.5	0.200
Nasofacial angle	27.72	2.36	0.37	22.9	31.8	0.200
Nasal bone angle	167.09	6.83	1.08	150.7	179.8	0.200
Nasal bone length	23.45	3.49	0.55	15.5	33.2	0.200
Nasal height	57.48	3.68	0.58	45.2	66.2	0.200
Nasal length	50.94	3.66	0.58	37.9	60.3	0.012
Upper dorsal convexity	-2.06	1.27	0.20	-5.5	0	0.060
Depth of the supratip break	0.14	1.28	0.20	-2.7	2.5	0.200
Lower dorsal convexity	1.46	0.32	0.05	0.8	2.1	0.148
Columella depth	2.52	0.80	0.13	0.9	4.3	0.200
Columella exposure	4.86	1.62	0.26	1.3	7.7	0.200
Nasal projection	27.87	2.06	0.33	23.7	32.5	0.126
Nostril projection	19.37	2.19	0.35	15.3	25.7	0.200
Subnasale projection	12.02	1.61	0.26	8.7	15.7	0.200
Nasal protrusion	15.84	1.82	0.29	12	21.1	0.200
Nasal prominence angle	19.73	1.98	0.31	16.5	25.1	0.200
Apical nasal angle	82.16	7.54	1.19	68.5	97.3	0.191
Nasal tip angle	99.23	5.05	0.80	90	109.9	0.200
Nasal projection angle	26.93	4.26	0.67	19.3	37.3	0.200
Dorsal contour angle	5.68	7.55	1.19	-8.2	19.8	0.200
Supratip break angle	7.69	5.06	0.80	-5.3	17.3	0.134
Nasolabial angle	109.05	9.74	1.54	84.4	129.9	0.009**
Columella rotation angle	70.67	5.97	0.94	59.1	81.5	0.011
Nasal tip rotation angle	70.52	4.06	0.64	60.7	79.3	0.200
Columella-lobule angle	12.31	7.09	1.12	-2.9	26.3	0.200

**$P<0.01$

Table 16: Descriptive statistics and normality of facial and nasal profile variables in women with Class I occlusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial convexity angle	138.45	4.60	0.73	127.7	150.1	0.200
Facial convexity angle	13.95	3.57	0.56	3.9	21.9	0.200
Nasomental angle	131.76	5.40	0.85	117.6	144.0	0.200
Nasofacial angle	27.92	3.16	0.50	21.6	34.0	0.200
Nasal bone angle	167.38	6.59	1.04	150.7	177.8	0.200
Nasal bone length	22.90	3.48	0.55	11.5	30.3	0.129
Nasal height	55.08	3.88	0.61	46.9	64.1	0.200
Nasal length	48.62	3.43	0.54	41.7	56.4	0.200
Upper dorsal convexity	-1.89	1.15	0.18	-5.1	0	0.073
Depth of the supratip break	0.14	0.93	0.15	-1.8	2.1	0.200
Lower dorsal convexity	1.39	0.42	0.07	0.6	2.3	0.009**
Columella depth	2.48	0.71	0.11	0.9	3.9	0.200
Columella exposure	4.72	1.22	0.19	2.3	7.2	0.026
Nasal projection	26.59	2.24	0.35	22.1	31.1	0.200
Nostril projection	18.39	2.26	0.36	13.1	23.1	0.200
Subnasale projection	10.92	1.29	0.20	8.8	14.6	0.200
Nasal protrusion	15.65	1.85	0.29	10.1	19.3	0.200
Nasal prominence angle	20.04	2.37	0.37	14.6	25.0	0.200
Apical nasal angle	82.11	8.53	1.35	64.9	104.3	0.200
Nasal tip angle	99.43	5.20	0.82	86.4	109.6	0.200
Nasal projection angle	25.38	4.60	0.73	15.2	36.6	0.200
Dorsal contour angle	5.97	6.80	1.08	-10.2	24.3	0.200
Supratip break angle	7.59	5.18	0.82	-2.1	17.4	0.200
Nasolabial angle	109.44	9.24	1.46	89.1	124.1	0.030
Columella rotation angle	72.34	7.52	1.19	56.1	86.1	0.200
Nasal tip rotation angle	70.62	5.15	0.81	60.4	83.9	0.125
Columella-lobule angle	13.69	8.03	1.27	-4.3	31.9	0.200

**$P<0.01$

Table 17: Descriptive statistics and normality of facial and nasal profile variables in men with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial convexity angle	144.07	5.89	0.93	134.3	159.2	0.200
Facial convexity angle	8.35	5.85	0.92	-4.4	20.4	0.158
Nasomental angle	137.68	5.74	0.91	123.6	148.5	0.200
Nasofacial angle	24.72	3.50	0.55	17.0	32.9	0.069
Nasal bone angle	164.26	7.06	1.12	149	178.9	0.200
Nasal bone length	24.66	3.71	0.59	17.9	34.2	0.200
Nasal height	59.62	3.94	0.62	51.0	69.4	0.200
Nasal length	52.98	4.01	0.63	43.2	61	0.200
Upper dorsal convexity	-1.93	1.28	0.20	-5.2	-0.2	0.046
Depth of the supratip break	0.09	1.04	0.16	-1.9	2.6	0.200
Lower dorsal convexity	1.54	0.43	0.07	0.7	2.5	0.200
Columella depth	2.63	0.78	0.12	1.1	4.5	0.051
Columella exposure	4.70	1.16	0.18	2.7	7.2	0.200
Nasal projection	29.20	2.81	0.44	23.7	34.5	0.200
Nostril projection	19.66	2.29	0.36	15.5	24.7	0.200
Subnasale projection	12.49	1.99	0.31	5.7	17.2	0.200
Nasal protrusion	16.72	2.20	0.35	12.5	21.1	0.200
Nasal prominence angle	19.73	2.06	0.33	14.1	22.8	0.200
Apical nasal angle	80.89	9.10	1.44	64.8	102.8	0.200
Nasal tip angle	99.05	6.34	1.00	88.2	121.4	0.200
Nasal projection angle	25.54	5.51	0.87	6.7	37.3	0.200

Dorsal contour angle	5.56	6.05	0.96	-7.5	22.3	0.200
Supratip break angle	7.56	4.74	0.75	-2.8	16.7	0.149
Nasolabial angle	106.79	11.22	1.77	83.8	128.9	0.200
Columella rotation angle	73.53	9.41	1.49	53.0	93.3	0.200
Nasal tip rotation angle	70.88	5.57	0.88	58.5	78.7	0.200
Columella-lobule angle	12.80	7.74	1.22	-2.2	27.3	0.200

Table 18: Descriptive statistics and normality of facial and nasal profile variables in women with Class III malocclusion

Cephalometric variable	Mean	Standard deviation	Standard error	Minimum value	Maximum value	Kolmogorov-Smirnov *P*-value
Total facial convexity angle	144.97	5.61	0.89	131.1	155.4	0.034
Facial convexity angle	6.15	5.00	0.79	-4.9	18.7	0.200
Nasomental angle	138.81	6.11	0.97	125.6	151.7	0.200
Nasofacial angle	24.09	3.10	0.49	19.3	32.5	0.200
Nasal bone angle	167.79	5.69	0.90	158.6	180.0	0.200
Nasal bone length	23.89	2.72	0.43	18.2	31	0.200
Nasal height	56.46	3.32	0.52	50.9	63.3	0.200
Nasal length	49.54	3.47	0.55	43.0	57.5	0.200
Upper dorsal convexity	-1.74	1.07	0.17	-3.8	1.0	0.200
Depth of the supratip break	-0.49	1.12	0.18	-2.9	1.6	0.200
Lower dorsal convexity	1.28	0.46	0.07	0.6	2.6	0.023
Columella depth	2.55	0.67	0.11	1.4	4.2	0.127
Columella exposure	4.74	1.67	0.26	0.6	8.2	0.200
Nasal projection	26.61	3.00	0.48	21.1	33.5	0.073
Nostril projection	17.75	2.46	0.39	12.9	24.4	0.200
Subnasale projection	10.57	2.05	0.32	6.4	14.3	0.200
Nasal protrusion	16.04	2.16	0.34	11.9	22.1	0.200
Nasal prominence angle	19.92	1.69	0.27	15.6	24.2	0.052
Apical nasal angle	83.26	7.32	1.16	69.3	100.2	0.014
Nasal tip angle	100.52	4.83	0.76	91.6	110.3	0.200
Nasal projection angle	24.60	3.66	0.58	18.9	34.0	0.200
Dorsal contour angle	7.55	6.30	1.00	-7.3	20.3	0.200
Supratip break angle	3.69	5.85	0.92	-6.2	15.3	0.200
Nasolabial angle	106.69	13.77	2.18	65.2	132.5	0.200
Columella rotation angle	73.00	7.75	1.23	57.3	87.3	0.002**
Nasal tip rotation angle	70.43	5.97	0.94	54.7	80.4	0.200
Columella-lobule angle	13.21	6.91	1.09	2.4	30.4	0.200

** $P < 0.01$

Appendix II (Chapter IV)

Annex 1: Panels of evaluators used in various studies

Investigation	Stimulus	Panels							
		Laypeople	Artists / Art students	Dental students	Patients	Dentists	Orthodontists	OS / MFS/ PS	OE
(Abu Arqoub & Al-Khateeb, 2011)	Modified profile P	353				101			
(Arpino et al., 1998)	Modified profile P	11			11		3	3OS	
(Baker & Woods, 2001)	Frontal and profile P	4	2			2	2	2 OS	
(Barroso et al., 2012)	Profile P	30					30		
(Battle et al., 2018)	Profile P						20		
(Bell et al., 1985)	Frontal and profile P/SE	33			80		46	37	
(Bonetti et al., 2011)	SE / frontal and profile P	200							
(Bullen et al., 2014)	SE/ profile S	85							
(Burcal et al., 1987)	Modified profile P	100			51 S		52	51 MFS	
(Chan et al., 2008)	Profile P	80		31			31		
(Chong et al., 2014)	Modified profile P	166				47	27		11
(Chew et al., 2007)	Profile D	6					3	3 OS	
(Chew, Koh, et al., 2008)	Modified profile P	3					3	3 MFS	
(Cross & Cross, 1971)	Frontal P	300							
(de Almeida & Bittencourt, 2009)	Modified profile P	20	20				20	20 MFS	
(de Almeida et al., 2010)	Modified profile P	20	20				20	20 MFS	
(Melo et al., 2017)	Frontal and profile P /Included SE	10			30		10		
(De Smit & Dermaut, 1984)	Modified profile S			249					
(Dongieux & Sassouni, 1980)	Frontal and profile P	20	17				10		
(Erbay et al., 2002)	Profile P						3		
(Fabré et al., 2009)	Profile P	18					18		
(Fabré et al., 2010)	Modified profile P	61					56	23 MFS	
(Falkensammer et al., 2014)	Modified profile P	100		50 3rd year, 50 5th year			52	52 MFS	
(Farrow et al., 1993)	Modified profile P	393				41	31		
(Faverani et al., 2013)	Frontal and profile P						2	2 MFS	
(Foster, 1973)	Modified profile S	90	30			30	30		
(Giddon et al., 1974)	SE/ cardboard pieces	21							
(Hall et al., 2000)	Profile S	40					39		
(Hershon & Giddon, 1980)	SE/acrylic pieces	42			42				
(Hockley et al., 2012)	Modified profile P and S						15		
(Howells & Shaw, 1985)	Oblique P	2, 122							
(Ioi et al., 2005)	Modified profile S			42 clinical			42		
(Ioi et al., 2006)	Modified profile S			50 clinical			41		
(Ioi et al., 2007)	Modified profile S			50 clinical			41		
(Jiang et al., 2018)	Profile S			100	30 S	70			
(Johnston, Hunt, Burden, et al., 2005)	Modified profile S	102							
(Johnston et al., 2010)	SE without stimulus	157			162 S				
(Juggins et al., 2005)	Extraoral/intraoral photographs, study models, SE				40		20	20 MFS	
(Kerr & O'Donnell, 2014)	Frontal and profile P	4 parents	4	4		4			
(Kiekens et al., 2005)	Frontal, 3/4 smiling, profile P	78					89		
(Kiekens, Kuijpers-Jagtman, et al., 2008)	Frontal, 3/4 smiling, profile P	76							
(Klaus et al., 2017)	Profile S	20					20		
(Korabik & Pitt, 1980)	SE /Profile D	148 mothers							
(Kuroda et al., 2009)	Modified profile images	262							
(Kaipainen et al., 2016)	Stereophotogrammetry	12							
(Kitay et al., 1999)	SE/ modified profile P	14			16				
(Lee et al., 2011)	Modified profile P							72MFS	
(Lines et al., 1978)	Modified profile S	44					96	31 OS	74
(Malkoc & Fidancioglu, 2016)	Frontal and profile P	50					50		
(Mantzikos, 1998)	Modified profile P	2651							
(Maple et al., 2005)	Modified profile P	50					25	25 OS	
(Marchiori et al., 2015)	Profile P	10					10		
(Martin, 1964)	Frontal P	150 +15							
(McKoy-White et al., 2006)	Modified profile P, also SE				15		30		
(McKeta et al., 2012)	Extraoral / intraoral P, panoramic radiographs, lateral cephalograms and study models, SE				30	3	5		2
(Modarai et al., 2013)	Modified profile S	100					30		
(Montini et al., 2007)	Profile S	42					53	32 OS	
(Murakami et al., 2016)	Modified profile S	77					30		
(Naini, Donaldson, et al., 2012b, 2012c)	Modified profile S	75			75 S		16	19MFS	
(Naini, Donaldson, et al., 2012a)	Computer generated frontal images.	75			75 S		35 orthodontists/MFS		
(Naini et al., 2013)	Modified profile S				50 S				
(Naini et al., 2015)	Modified profile S	75			75 S		35 orthodontists/MFS		
(Naini, Cobourne, et al., 2016 c)	Modified profile S	75			75 S		16	19MFS	
(Nomura et al., 2009)	Modified profile S	120							

Investigation	Stimulus	Laypeople	Artists / Art students	Dental students	Patients	Dentists	Orthodontists	OS / MFS/ PS	OE
(Ng et al., 2013)	Frontal and profile P	10	10				10		
(Oliveira et al., 2015)	Modified profile P			65 1st year					
(Olsen & Inglehart, 2011)	Modified frontal and oblique P				889 or accompanying adults				
(Orsini et al., 2006)	Profile D, Modified profile P	112					28		
(Phillips, Trentini & Douvartzidis 1992)	Frontal and profile P			33 1st year			23	14 MFS	
(Pişiren et al., 2018).	Modified profile P	164			140 S		150	138 PS 139 MFS	
(Pithon et al., 2014)	Modified profile S and P	53		47					
(Pitt & Korabik, 1977) Abstract	Profile D	207 parents							
(Polk et al., 1995)	Profile S	150							
(Prahl-Andersen et al., 1979)	Profile D/ dentition P	1150 parents				72	54		
(Romani et al., 1993)	Modified frontal and profile P	22					22		
(Romero-Maroto et al., 2012)	Profile P						9/19 orthodontic students		
(Sena et al., 2017)	Modified profile P	22	20				20	20 MFS	
(Shelly et al., 2000)	Profile S	9					9 residents		
(Sinko et al., 2012)	Profile P	92							
(Sinko, Jagsch, et al., 2018)	Videos	155							
(Sinko, Tran, et al., 2018)	Videos / frontal and profile P	200							
(Sari-Rieger & Rustemeyer, 2015)	Profile P/also SE	12			40 S		12	12 MFS	
(Soh et al., 2005b)	Modified profile P						20	11 OS	
(Soh et al., 2005a)	Modified profile P	152		92			20	11 OS	
(Springer, Wiltfang, et al., 2012)	Frontal and profile P/also SE	141, 17- 50							
(Spyropoulos & Halazonetis, 2001)	Original and modified profile P	10					10		
(Sy et al., 2016)	Modified profile P	198							
(Sushner, 1977)	Profile P	Unspecified number of evaluators from various social classes							
(Al Taki & Guidoum, 2014)	Profile S	60		60		60	26	16 OS	
(Thomas, 1979)	Profile D						86		
(Todd et al., 2005)	Modified 2D and 3D scan images	78					47	25 MFS	
(Tole et al., 2014)	Modified profile P	1444							
(Třebický et al., 2018)	Frontal and profile photographs	62, 60, 94, 195, 176, 150							
(Trehan et al., 2011)	SE/ profile S	50		50 final year 50 1st year	50		2		
(Tsang et al., 2009)	Profile S	20					20	20 OS	
(Tufekci et al., 2008)	ProfileS	75		75 1st year, 75 3rd year	75		75		
(Türkkahraman & Gökalp, 2004)	Modified profile images	186 parents	,		81	67	66		
(Vargo et al., 2003)	Frontal and profile P	18					10	4 OS	
(Xu et al., 2008)	Profile and frontal P						45		
(Yin et al., 2014)	SE/ profile S	892							
Evaluations including the nose									
(Ahmed et al., 2014)	Modified profile composites	2156, 1822							
(Armijo et al., 2012)	Modified profile P	16 including plastic surgeons and office staff							
(Bui et al., 2015)	Modified frontal and oblique P	226					6		
(Choi et al., 2013)	Profile and frontal P							2 PS	
(Crumley & Lanser, 1988)	Profile P							5 PS	
(Czarnecki et al., 1993)	Modified profile S			229			316 orthodontists, OS, paediatric and general dentists		
(Devcic et al., 2011)	Modified profile composites	78							
(Gu et al., 2018)	Frontal and profile composites	600							
(Hatch et al., 2017)	Fontal and profile P	10							
(Kandathil et al., 2018)	Modified nasal profile P	813							
(McArdle et al., 2012)	Modified profile P	100 (nurses, doctors, medical students, laypeople)							
(Moolenburgh et al., 2008a)	Frontal, oblique, profile and basal nose P /also SE				39			5 PS	
(Moolenburgh et al., 2008b)	Frontal, oblique and profile P	20						5 PS	
(Naini, Cobourne, et al., 2015, 2016)	Modified profile S	75			75 S		16	19MFS	
(Nellis et al., 2018)	Frontal P	473							
(Nouraei et al., 2009)	Frontal P	10							
(Ostwald et al., 2015)	Oblique, frontal 2 D images	100							
(Roxbury et al., 2012)	Frontal P	39							
(Springer et al., 2008)	Profile composites	308							
(Torsello et al., 2010)	Modified profile P	15					15		
(van Steenbergen et al., 1996)	Frontal and profile P						5		
(Young, 2019)	Modified frontal P and D				419 PS				
(Yu & Jang, 2014)	Modified frontal and profile P								3

P: photographs, S: silhouettes, D: drawings SE: self-evaluation, Art S: Art students, S: Orthognathic surgery patients, OS: Oral surgeons, MFS: Maxillofacial surgeons, PS: Plastic surgeons, OE other specialities

Annex 2: Descriptive statistics and normality for the data from the 24 sets of evaluations during the first phase of the pilot study.

Variable	Mean	SD	SE	Minimum value	Maximum value	Shapiro-Wilk *P*-value
In Attractiveness of frontal view of the face 1	10.23	10.98	2.20	-13.36	29.42	0.825
In Attractiveness of frontal view of the face 2	10.51	9.66	1.93	-6.23	29.9	0.638
P Attractiveness of frontal view of the face 1	35.47	25.72	5.14	-23.48	70.86	0.051
P Attractiveness of frontal view of the face 2	32.15	25.15	5.03	-25.3	70.4	0.472
In Attractiveness of facial profile 1	13.75	11.64	2.33	-7.63	36.12	0.257
In Attractiveness of facial profile 2	11.57	11.80	2.36	-9.73	35.57	0.947
P Attractiveness of facial profile 1	38.01	29.82	5.96	-45.79	75.76	0.001**
P Attractiveness of facial profile 2	38.37	27.29	5.46	-29.43	73.38	0.007**
In Attractiveness of frontal view of the nose 1	-1.81	7.79	1.56	-17.27	14.12	0.918
In Attractiveness of frontal view of the nose 2	-0.07	7.74	1.55	-17.69	13.23	0.669
P Attractiveness of frontal view of the nose 1	-3.41	30.90	6.18	-48.22	53.51	0.236
P Attractiveness of frontal view of the nose 2	4.66	27.52	5.50	-36.45	51.13	0.157
In Attractiveness of profile view of the nose 1	1.01	6.56	1.31	-11.13	13.49	0.708
In Attractiveness of profile view of the nose 2	1.70	8.09	1.62	-18.42	16.13	0.288
P Attractiveness of profile view of the nose 1	5.99	23.97	4.79	-49.92	54.71	0.777
P Attractiveness of profile view of the nose 2	5.01	20.93	4.19	-29.45	48.27	0.476
In Attractiveness of frontal view of the nose within the face 1	1.21	7.51	1.50	-12.92	16.02	0.658
In Attractiveness of frontal view of the nose within the face 2	1.02	8.02	1.60	-15.22	14.42	0.610
P Attractiveness of frontal view of the nose within the face 1	13.53	26.25	5.25	-43.4	54.44	0.372
P Attractiveness of frontal view of the nose within the face 2	3.63	24.69	4.94	-33.3	56.3	0.287
In Attractiveness of profile view of the nose within the face 1	3.75	6.59	1.32	-6.76	16.02	0.489
In Attractiveness of profile view of the nose within the face 2	2.44	6.90	1.38	-10.63	16.68	0.977
P Attractiveness of profile view of the nose within the face 1	9.69	22.39	4.48	-38.66	44.24	0.202
P Attractiveness of profile view of the nose within the face 2	7.92	21.16	4.23	-39.58	41.54	0.128

In: Individual evaluation, P: Paired evaluation, 1:1st evaluation, 2: 2nd evaluation SD: Standard deviation, SE: standard error, ** $P<0.01$

Annex 3: Normality and descriptive statistics of the alteration caused by maxillary advancement surgery in the aesthetic evaluation of the frontal and profile views of the nose and the face when the sample was divided according to patient gender

Table 1: Normality and descriptive statistics of the alteration caused by maxillary advancement surgery in the aesthetic evaluation of the frontal and profile views of the nose and the face in the 19 men (T3-T2)

Variable	Mean	SD	SE	Min value	Max value	Shapiro Wilk *P*-Value
Attractiveness of the frontal view of the face	35.78	28.14	6.46	-25.84	75.25	0.530
Attractiveness of the facial profile	30.19	29.55	6.78	-43.35	87.29	0.692
Attractiveness of the frontal view of the nose	-0.47	14.42	3.31	-36.70	29.12	0.037
Attractiveness of the profile view of the nose	9.14	11.66	2.67	-19.28	24.92	0.080
Attractiveness of frontal view of the nose within the face	6.62	15.98	3.67	-27.53	32.24	0.927
Attractiveness of profile view of the nose within the face	10.94	14.17	3.25	-15.57	43.77	0.758

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max. value: Maximum value

Table 2: Normality and descriptive statistics of the alteration caused by maxillary advancement surgery in the aesthetic evaluation of the frontal and profile views of the nose and the face in the 42 women (T3-T2)

Variable	Mean	SD	SE	Min value	Max value	Kolgomorov-Smirnov test *P*-Value
Attractiveness of the frontal view of the face	33.97	23.81	3.67	-32.24	73.4	0.053
Attractiveness of the facial profile	41.25	25.90	4.00	-28.6	88.38	0.200
Attractiveness of the frontal view of the nose	-5.55	19.78	3.05	-45.03	40.4	0.200
Attractiveness of the profile view of the nose	8.95	13.83	2.13	-25.67	36.45	0.200
Attractiveness of frontal view of the nose within the face	7.81	15.82	2.44	-31.06	45.12	0.200
Attractiveness of profile view of the nose within the face	14.47	12.79	1.97	-21.72	35.44	0.044

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max. value: Maximum value

Annex 4: Normality and descriptive statistics of the alteration caused by maxillary advancement surgery in the aesthetic evaluation of the frontal and profile views of the nose and the face when the sample was divided according to gender of the evaluator

Table 1: Normality and descriptive statistics of the alteration caused by maxillary advancement surgery in the aesthetic evaluation by 4 male orthodontists of the frontal and profile views of the nose and the face in the 61 patients (T3-T2)

Variable	Mean	SD	SE	Min value	Max value	Shapiro Wilk *P*-Value
Attractiveness of the frontal view of the face	40.28	31.05	3.98	-41.41	85.86	0.001**
Attractiveness of the facial profile	42.93	32.09	4.11	-47.14	91.92	0.029
Attractiveness of the frontal view of the nose	-6.44	23.24	2.98	-56.57	48.99	0.556
Attractiveness of the profile view of the nose	13.23	17.64	2.26	-35.52	42.09	0.068
Attractiveness of frontal view of the nose within the face	5.65	20.81	2.66	-40.24	49.66	0.579
Attractiveness of profile view of the nose within the face	14.13	17.48	2.24	-18.52	54.21	0.069

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max. value: Maximum value, ***P*<0.01

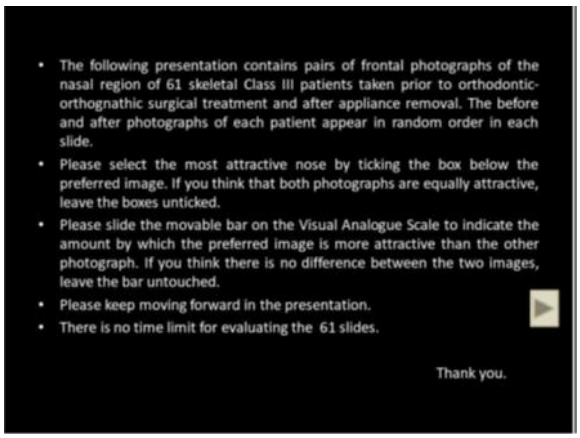
Table 2: Normality and descriptive statistics of the alteration caused by maxillary advancement surgery in the aesthetic evaluation by 4 female orthodontists of the frontal and profile views of the nose and the face in the 61 patients (T3-T2)

Variable	Mean	SD	SE	Min value	Max value	Shapiro Wilk *P*-Value
Attractiveness of the frontal view of the face	28.79	22.25	2.85	-24.92	77.44	0.195
Attractiveness of the facial profile	32.67	25.41	3.25	-39.56	90.40	0.274
Attractiveness of the frontal view of the nose	-1.49	18.80	2.41	-41.41	38.55	0.275
Attractiveness of the profile view of the nose	4.79	13.88	1.78	-34.34	35.52	0.341
Attractiveness of frontal view of the nose within the face	9.23	15.56	1.99	-40.07	40.57	0.033
Attractiveness of profile view of the nose within the face	12.59	13.50	1.73	-29.80	46.46	0.001**

SD: Standard deviation, SE: Standard error, Min value: Minimum value, Max. value: Maximum value, ***P*<0.01

Annex 5: Instructions for the evaluations

[4]



Appendix III: Informed consent

Faculdade de Medicina Dentária da Universidade de Lisboa

CONSENTIMENTO LIVRE E INFORMADO PARA O PROJETO DE INVESTIGAÇÃO SOBRE A INFLUÊNCIA DA OSTEOTOMIA LE FORT 1 SOBRE O NARIZ

O presente formulário tem por objetivo obter um acordo escrito que autoriza o uso restrito das fotografias da face e das radiografias realizadas antes do tratamento ortodôntico ou antes, durante e depois do tratamento ortodôntico-cirúrgico. Todas as informações contidas neste formulário foram dadas e explicadas verbalmente, assim como todas as dúvidas foram esclarecidas pela investigadora deste projeto, Dra Natascha Sequeira Fernandes (cédula profissional número 1831, da Ordem dos Médicos Dentistas) ou por meu ortodontista_____.

Objetivos do estudo: Esta investigação tem como objetivos 1) Estudar a morfologia nasal de pessoas adultas com maloclusões de Classe III e compará-la com a forma nasal de pessoas com maloclusões esqueléticas de Classe I 2) Avaliar as alterações produzidas pela osteotomia Le Fort 1 de avanço maxilar na forma e nas dimensões do nariz, em comparação com a fase pré-cirúrgica em pessoas com maloclusões esqueléticas de Classe III 3) Correlacionar as mudanças nas medições do nariz com as alterações na avaliação estética do nariz por clínicos, após a osteotomia Le Fort 1 de avanço maxilar.

Procedimento: As teleradiografias de todos os pacientes e as fotografias dos pacientes que não foram submetidos a tratamento ortodôntico-cirúrgico serão analisadas apenas pela investigadora deste projeto. A atratividade das fotografias antes e depois do tratamento ortodôntico-cirúrgico será avaliada por um grupo de clínicos pós-graduados em Ortodontia usando uma escala apropriada e o programa Microsoft PowerPoint 2007. Apenas serão usadas as fotografias ou parte das mesmas, sem qualquer dado pessoal de identificação.

Confidencialidade: Todos os registos relativos aos dados pessoais e à informação clínica serão confidenciais e apenas acedidos pela investigadora, Dra Natascha Sequeira Fernandes. As fotografias serão avaliadas de forma anónima. A apresentação ou publicação dos resultados da investigação e as fotografias e radiografias relacionadas manterá sob anonimato a identidade de todos os participantes.

Declaro que li e compreendi toda a informação contida no presente documento e que fui esclarecido/a sobre os procedimentos inerentes do estudo. Autorizo a utilização dos meus registos na realização deste projeto de investigação e ficarei com uma cópia do presente documento.

Data_____

Assinatura_____

Appendix IV: Values of the variables measured in Chapter II

Comparative study of nasal morphology in people with Class I and Class III skeletal malocclusions using lateral cephalograms and facial photographs

IV.1 Values for the skeletal facial variables in the Group with Class I occlusion

N°		Distances in mm		Ratio	Distances in mm		Angles					
	Gender	NMe	ANSMe	ANSMe/ NMe	A*y*	PtmP-A	SNA	SNB	ANB	SN-PP	SN-MP	PP-MP
1	F	119.40	67.40	0.56	59.60	41.10	77.00	74.50	2.50	8.40	39.50	31.10
2	F	111.30	59.50	0.53	63.50	42.00	80.20	78.80	1.40	10.80	26.80	16.00
3	F	112.90	66.30	0.59	68.30	47.10	84.40	83.10	1.30	4.00	35.30	31.30
4	F	108.20	58.10	0.54	70.50	49.50	81.90	81.10	0.80	8.50	28.20	19.70
5	F	112.70	64.20	0.57	63.50	43.80	82.00	80.80	1.20	8.20	31.50	23.30
6	F	114.80	65.30	0.57	63.90	44.10	79.00	78.50	0.50	9.60	33.70	24.10
7	F	118.90	72.70	0.61	61.50	40.60	78.20	74.40	3.80	4.40	43.90	39.50
8	F	109.10	66.10	0.61	61.40	41.70	84.00	82.40	1.60	3.00	35.00	32.00
9	F	100.80	58.40	0.58	68.30	48.20	85.00	84.00	1.00	-0.30	15.00	15.30
10	F	119.70	71.10	0.59	54.20	36.50	75.50	73.10	2.40	7.60	47.00	39.40
11	F	110.60	65.30	0.59	63.70	43.80	84.60	83.00	1.60	5.20	28.90	23.70
12	F	128.70	75.20	0.58	58.10	39.00	77.50	73.60	3.90	7.10	39.10	32.00
13	F	125.10	76.60	0.61	52.80	37.40	73.70	71.70	2.00	5.00	44.70	39.70
14	F	113.40	66.30	0.58	66.50	45.70	80.40	79.60	0.80	5.40	32.30	26.90
15	F	113.10	68.20	0.60	64.20	45.00	76.40	74.00	2.40	5.80	32.60	26.80
16	F	111.20	61.20	0.55	59.80	40.90	77.20	75.80	1.40	13.90	35.90	22.00
17	F	119.20	69.30	0.58	59.30	36.90	74.10	72.50	1.60	13.60	42.30	28.70
18	F	112.60	62.10	0.55	67.20	44.80	81.50	80.20	1.30	8.10	29.80	21.70
19	F	113.80	65.90	0.58	56.10	40.40	77.30	74.40	2.90	9.60	37.00	27.40
20	F	104.30	64.70	0.62	61.90	41.80	80.80	78.90	1.90	0.10	30.90	30.80
21	F	109.00	57.40	0.53	63.60	41.30	80.50	78.00	2.50	9.10	25.60	16.50
22	F	109.90	65.50	0.60	62.70	42.20	80.20	77.30	2.90	7.90	35.00	27.10
23	F	117.40	71.70	0.61	62.80	43.60	79.40	78.20	1.20	4.40	41.00	36.60
24	F	123.40	74.90	0.61	69.80	46.40	85.70	81.90	3.80	5.00	38.50	33.50
25	F	114.20	67.70	0.59	59.00	39.40	78.70	77.50	1.20	7.50	42.60	35.10
26	F	107.00	60.10	0.56	64.10	43.70	81.20	80.30	0.90	6.30	29.80	23.50
27	F	122.80	71.10	0.58	61.00	43.00	81.30	78.90	2.40	5.10	37.40	32.30
28	F	116.60	70.20	0.60	59.20	38.40	74.20	72.30	1.90	13.10	45.00	31.90
29	F	122.30	70.70	0.58	72.90	47.90	81.40	78.90	2.50	9.80	36.50	26.70
30	F	110.40	58.70	0.53	64.30	45.70	83.80	79.90	3.90	10.00	29.70	19.70
31	F	125.00	78.00	0.62	67.70	38.90	81.00	77.20	3.80	3.20	41.80	38.60
32	F	122.70	68.70	0.56	60.60	43.30	79.50	78.10	1.40	11.80	44.90	33.10
33	F	111.30	60.00	0.54	59.80	41.00	79.30	78.70	0.60	13.60	32.70	19.10
34	F	114.50	66.10	0.58	62.00	42.30	78.70	75.20	3.50	12.70	38.30	25.60
35	F	117.40	65.30	0.56	61.40	37.10	80.00	77.40	2.60	13.40	39.00	25.60
36	F	121.80	73.70	0.61	70.30	45.70	77.70	76.30	1.40	3.50	36.60	33.10
37	F	116.90	73.00	0.62	63.30	40.80	77.60	75.60	2.00	1.80	40.70	38.90
38	F	116.70	64.50	0.55	55.70	38.60	72.10	68.90	3.20	13.00	44.80	31.80
39	F	102.90	56.30	0.55	61.70	41.00	81.50	79.30	2.20	7.60	28.00	20.40
40	F	111.50	61.70	0.55	57.60	35.90	77.40	74.80	2.60	15.10	38.90	23.80
41	M	122.00	68.70	0.56	68.30	46.30	78.50	74.80	3.70	13.40	42.70	29.30
42	M	126.10	74.50	0.59	68.60	44.40	80.80	78.60	2.20	8.60	33.40	24.80
43	M	117.80	67.40	0.57	64.20	45.70	78.20	74.80	3.40	9.40	29.80	20.40
44	M	120.00	70.20	0.59	78.20	52.40	86.30	83.60	2.70	2.70	26.10	23.40
45	M	113.40	64.80	0.57	66.80	46.30	82.90	81.10	1.80	5.70	21.90	16.20
46	M	120.70	69.00	0.57	68.30	48.50	82.40	81.20	1.20	4.70	32.60	27.90
47	M	130.30	78.10	0.60	69.10	46.90	80.00	77.60	2.40	10.90	37.90	27.00
48	M	117.20	68.10	0.58	76.90	53.30	89.30	87.50	1.80	2.30	20.00	17.70
49	M	104.20	57.50	0.55	70.60	49.30	82.60	82.10	0.50	4.10	21.20	17.10
50	M	126.80	75.20	0.59	64.80	45.30	82.00	79.70	2.30	9.20	30.70	21.50
51	M	116.70	67.30	0.58	68.10	45.30	80.60	80.20	0.40	6.80	29.60	22.80
52	M	118.20	66.80	0.57	70.00	47.90	79.60	78.40	1.20	4.10	26.50	22.40
53	M	120.40	70.50	0.59	65.30	44.00	81.20	77.70	3.50	7.80	39.20	31.40
54	M	127.40	77.90	0.61	62.60	45.40	76.00	74.80	1.20	4.40	38.50	34.10
55	M	130.70	77.50	0.59	63.90	41.70	76.50	75.90	0.60	8.60	37.20	28.60
56	M	122.10	68.70	0.56	67.70	45.90	77.80	76.80	1.00	8.10	31.40	23.30
57	M	128.80	79.10	0.61	73.60	48.30	83.00	79.20	3.80	6.40	33.80	27.40
58	M	130.10	77.60	0.60	66.20	46.60	76.60	74.60	2.00	9.80	39.50	29.70
59	M	115.00	67.50	0.59	68.70	45.90	84.40	81.80	2.60	5.20	22.30	17.10
60	M	128.40	73.70	0.57	66.80	46.00	80.40	79.30	1.10	10.00	35.10	25.10
61	M	129.00	69.80	0.54	63.90	42.00	77.20	76.10	1.10	10.60	35.40	24.80
62	M	123.40	74.30	0.60	69.00	46.30	86.20	84.80	1.40	6.80	29.00	22.20
63	M	117.10	67.90	0.58	78.90	54.30	90.40	87.30	3.10	6.80	21.60	14.80
64	M	127.70	75.80	0.59	74.00	51.20	79.70	78.60	1.10	10.80	41.00	30.20
65	M	126.40	76.90	0.61	67.10	45.20	80.80	76.90	3.90	6.30	39.40	33.10

M: male, F: female

Table IV.1 (continued)

N°	Distances in mm			Ratio	Distances in mm		Angles					
	Gender	NMe	ANSMe	ANSMe/ NMe	A*y*	PtmP-A	SNA	SNB	ANB	SN-PP	SN-MP	PP-MP
66	M	124.30	71.50	0.58	71.10	48.70	81.70	79.10	2.60	9.30	31.40	22.10
67	M	106.40	67.30	0.63	67.10	47.80	84.70	82.70	2.00	1.60	20.00	18.40
68	M	116.70	62.20	0.53	69.60	46.50	79.90	77.60	2.30	10.00	27.00	17.00
69	M	120.00	70.10	0.58	66.90	47.70	82.40	78.80	3.60	4.40	38.20	33.80
70	M	126.30	70.10	0.56	61.00	38.50	76.50	75.50	1.00	12.80	38.70	25.90
71	M	126.60	74.60	0.59	79.80	51.20	80.30	79.90	0.40	8.90	30.80	21.90
72	M	114.10	65.60	0.57	63.70	43.10	74.60	74.20	0.40	7.20	23.00	15.80
73	M	115.40	68.60	0.59	72.30	47.90	83.50	81.20	2.30	3.80	29.00	25.20
74	M	117.30	70.70	0.60	61.30	44.10	80.90	76.10	4.80	12.70	37.70	25.00
75	M	111.50	61.00	0.55	73.70	51.50	86.00	82.90	3.10	10.20	21.00	10.80
76	M	126.90	76.70	0.60	68.40	46.50	81.30	76.90	4.40	7.10	34.70	27.60
77	M	118.90	69.60	0.59	64.80	43.50	78.90	76.40	2.50	13.30	32.40	19.10
78	M	118.90	67.10	0.56	67.60	46.30	79.70	77.30	2.40	13.30	29.80	16.50
79	M	130.70	78.70	0.60	67.40	49.10	78.20	76.50	1.70	7.40	38.80	31.40
80	M	124.10	72.20	0.58	65.40	44.50	82.30	78.90	3.40	10.50	37.50	27.00

M: male, F: female

Table IV.2 Values for the skeletal facial variables in the Group with Class III occlusion

N°	Distances in mm			Ratio	Distances in mm		Angles					
	Gender	NMe	ANSMe	ANSMe/ NMe	A*y*	PtmP-A	SNA	SNB	ANB	SN-PP	SN-MP	PP-MP
1	F	124.30	73.00	0.59	67.90	49.70	82.10	83.90	-1.80	6.20	35.20	29.00
2	F	113.90	65.70	0.58	60.00	39.60	76.10	78.90	-2.80	10.30	48.70	38.40
3	F	115.90	63.30	0.55	69.40	46.30	84.40	90.50	-6.10	9.20	28.70	19.50
4	F	120.10	70.10	0.58	62.90	45.20	78.10	80.10	-2.00	10.50	35.20	24.70
5	F	113.00	65.70	0.58	56.50	38.90	75.10	78.10	-3.00	4.50	42.20	37.70
6	F	121.70	72.10	0.59	69.00	47.70	88.70	89.80	-1.10	9.70	33.70	24.00
7	F	115.20	60.70	0.53	63.60	43.00	76.40	78.60	-2.20	12.50	35.20	22.70
8	F	114.00	66.00	0.58	55.50	37.00	75.80	81.20	-5.40	11.10	44.00	32.90
9	F	119.40	65.50	0.55	53.90	36.20	78.10	85.00	-6.90	13.60	38.00	24.40
10	F	118.20	70.90	0.60	55.10	38.10	73.00	79.20	-6.20	11.60	44.90	33.30
11	F	123.60	72.90	0.59	53.20	36.70	75.90	79.20	-3.30	12.20	45.60	33.40
12	F	115.00	66.60	0.58	61.30	41.20	76.80	79.40	-2.60	10.60	39.30	28.70
13	F	119.70	66.40	0.55	67.10	47.60	82.70	84.50	-1.80	7.30	35.60	28.30
14	F	120.80	68.60	0.57	54.90	34.70	76.00	76.30	-0.30	16.80	47.70	30.90
15	F	110.90	64.30	0.58	63.90	43.60	79.10	83.30	-4.20	2.80	34.30	31.50
16	F	111.90	65.90	0.59	59.10	37.60	75.50	79.80	-4.30	7.00	41.00	34.00
17	F	113.60	68.10	0.60	55.90	39.00	78.20	78.50	-0.30	11.60	40.50	28.90
18	F	117.50	65.80	0.56	62.40	42.00	74.80	77.20	-2.40	8.90	36.90	28.00
19	F	124.90	76.20	0.61	57.90	38.50	76.10	73.90	2.20	10.80	47.40	36.60
20	F	125.80	73.80	0.59	60.80	39.40	79.00	80.90	-1.90	7.80	44.10	36.30
21	F	125.50	74.60	0.59	56.80	37.10	73.90	74.00	-0.10	11.10	50.40	39.30
22	F	118.80	68.50	0.58	61.20	43.40	82.10	84.20	-2.10	7.70	33.70	26.00
23	F	116.10	63.10	0.54	53.60	35.50	75.20	76.50	-1.30	15.20	39.80	24.60
24	F	117.80	68.80	0.58	62.30	41.20	78.20	78.40	-0.20	9.00	40.50	31.50
25	F	111.80	62.60	0.56	51.20	34.10	74.90	76.30	-1.40	14.10	47.80	33.70
26	F	120.10	63.30	0.53	64.70	43.80	80.10	83.30	-3.20	12.70	36.10	23.40
27	F	124.50	71.30	0.57	51.80	36.90	70.40	75.10	-4.70	12.60	45.30	32.70
28	F	113.90	65.00	0.57	54.10	39.60	80.10	80.10	0.00	9.70	44.90	35.20
29	F	119.20	68.30	0.57	60.20	41.00	76.60	79.00	-2.40	9.70	38.60	28.90
30	F	115.80	68.20	0.59	64.90	41.80	84.80	87.90	-3.10	6.70	30.50	23.80
31	F	110.00	64.40	0.59	61.90	42.30	79.70	85.70	-6.00	5.90	32.70	26.80
32	F	116.80	68.80	0.59	60.30	39.80	77.40	78.70	-1.30	14.20	41.20	27.00
33	F	126.20	71.90	0.57	55.60	36.80	76.00	81.80	-5.80	10.50	43.10	32.60
34	F	111.90	65.80	0.59	58.90	42.50	79.50	81.70	-2.20	7.40	39.80	32.40
35	F	121.20	67.30	0.56	60.70	35.30	74.60	80.90	-6.30	16.50	45.50	29.00
36	F	118.50	68.20	0.58	53.60	38.30	73.30	77.70	-4.40	5.60	42.50	36.90
37	F	108.20	56.00	0.52	60.80	41.90	77.90	81.00	-3.10	14.60	31.20	16.60
38	F	133.60	84.60	0.63	67.40	45.50	78.90	79.10	-0.20	8.10	44.50	36.40
39	F	114.00	62.40	0.55	63.00	45.40	80.20	83.80	-3.60	10.00	35.80	25.80
40	F	120.10	70.00	0.58	60.60	43.80	77.30	80.20	-2.90	10.20	43.00	32.80
41	M	129.30	74.70	0.58	65.10	41.60	76.80	79.90	-3.10	5.80	40.40	34.60
42	M	128.50	74.60	0.58	65.80	45.70	79.50	80.10	-0.60	8.20	37.10	28.90
43	M	137.60	80.70	0.59	56.90	39.90	79.90	80.80	-0.90	9.30	46.40	37.10
44	M	131.40	82.00	0.62	60.50	42.00	75.90	77.00	-1.10	5.00	41.30	36.30
45	M	124.20	72.90	0.59	68.40	41.60	84.30	84.60	-0.30	7.50	33.10	25.60
46	M	146.80	87.60	0.60	62.50	40.20	71.80	75.30	-3.50	10.10	53.20	43.10
47	M	131.40	79.40	0.60	60.40	38.10	70.70	74.90	-4.20	13.10	47.20	34.10
48	M	130.60	72.50	0.56	74.30	51.00	84.30	86.30	-2.00	10.60	28.70	18.10

M: male, F: female

Table IV.2 (continued)

N°	Distances in mm			Ratio	Distances in mm		Angles					
	Gender	NMe	ANSMe	ANSMe/ NMe	A*y*	PtmP-A	SNA	SNB	ANB	SN-PP	SN-MP	PP-MP
49	M	129.30	76.40	0.59	64.50	43.50	74.50	84.60	-10.10	9.60	30.30	20.70
50	M	131.10	73.40	0.56	68.20	46.50	81.40	84.70	-3.30	9.60	36.70	27.10
51	M	133.20	82.20	0.62	59.80	40.10	78.20	80.50	-2.30	2.80	39.90	37.10
52	M	121.30	72.60	0.60	70.90	48.90	85.50	92.10	-6.60	2.50	32.80	30.30
53	M	123.10	75.10	0.61	68.80	47.40	83.50	87.70	-4.20	2.80	30.70	27.90
54	M	149.30	96.90	0.65	63.60	42.60	77.90	80.70	-2.80	4.10	48.70	44.60
55	M	142.20	85.20	0.60	61.40	41.80	72.50	80.90	-8.40	10.70	45.70	35.00
56	M	133.50	82.20	0.62	62.30	42.90	81.20	82.50	-1.30	4.90	45.40	40.50
57	M	141.40	83.10	0.59	47.60	30.30	67.20	67.50	-0.30	12.70	55.00	42.30
58	M	125.40	73.70	0.59	63.80	42.70	75.80	79.70	-3.90	10.30	33.30	23.00
59	M	123.10	73.60	0.60	61.20	40.60	76.70	77.70	-1.00	7.70	42.80	35.10
60	M	127.40	76.00	0.60	65.30	45.80	76.80	82.20	-5.40	6.30	36.10	29.80
61	M	119.30	69.80	0.59	61.50	42.70	74.20	83.90	-9.70	8.50	28.80	20.30
62	M	130.50	75.90	0.58	65.80	47.20	81.20	81.60	-0.40	7.20	38.00	30.80
63	M	130.70	79.80	0.61	61.10	42.80	73.90	74.50	-0.60	7.70	44.10	36.40
64	M	122.00	68.30	0.56	59.50	38.10	79.70	88.20	-8.50	10.30	31.70	21.40
65	M	132.30	82.00	0.62	63.90	43.60	80.00	81.80	-1.80	4.90	43.40	38.50
66	M	133.60	80.80	0.60	62.80	40.40	76.20	82.00	-5.80	7.10	41.90	34.80
67	M	120.30	70.40	0.59	61.90	42.90	77.90	80.50	-2.60	8.60	43.10	34.50
68	M	125.70	73.00	0.58	64.30	41.40	78.90	79.80	-0.90	10.00	41.30	31.30
69	M	135.80	79.80	0.59	65.50	42.70	77.30	78.70	-1.40	12.70	45.80	33.10
70	M	131.70	80.10	0.61	69.00	47.30	82.50	82.60	-0.10	6.50	44.00	37.50
71	M	116.90	68.10	0.58	64.00	45.30	81.10	81.40	-0.30	10.60	36.70	26.10
72	M	123.70	72.30	0.58	68.20	47.00	79.30	84.80	-5.50	6.20	28.70	22.50
73	M	132.10	79.00	0.60	74.00	50.00	86.10	87.50	-1.40	5.20	36.80	31.60
74	M	127.80	74.90	0.59	63.70	44.30	77.40	81.80	-4.40	7.90	34.70	26.80
75	M	119.20	69.60	0.58	65.80	43.00	81.80	82.30	-0.50	9.50	33.00	23.50
76	M	129.90	74.50	0.57	67.70	44.60	77.70	78.70	-1.00	11.80	37.00	25.20
77	M	124.80	73.40	0.59	70.90	48.90	82.80	83.00	-0.20	6.90	34.90	28.00
78	M	122.80	68.40	0.56	67.90	49.00	81.00	85.60	-4.60	6.00	35.70	29.70
79	M	131.20	72.60	0.55	64.30	43.90	78.90	79.40	-0.50	11.00	38.40	27.40
80	M	122.20	69.40	0.57	65.60	42.50	76.40	80.00	-3.60	11.80	41.70	29.90

M: male, F: female

Table IV.3a Values for the variables measured in frontal photographs in the Group with Class I occlusion

N°	Distances in mm												
	Gender	EnEn´	RR´	AlAl´	AcAc´	CmfCmf´	SbalSbal´	SnfSbal	SnfSbal´	SnfAl	SnfAl´	CmfNrL	Cmf´Nrl´
1	F	33.30	14.20	38.40	35.40	7.20	21.30	10.20	11.10	21.30	20.40	10.50	11.60
2	F	28.20	13.60	31.60	28.90	5.70	16.00	9.90	6.20	19.90	17.80	11.30	9.40
3	F	33.80	14.90	38.60	36.00	4.80	17.30	9.40	7.90	22.20	19.90	13.40	11.30
4	F	32.30	20.60	32.10	28.10	5.90	19.80	9.70	11.20	18.80	19.40	8.50	8.60
5	F	28.50	12.70	32.30	29.60	5.40	20.40	9.80	10.70	17.20	18.70	9.30	10.30
6	F	36.80	18.80	39.60	36.90	6.40	21.90	11.50	10.50	22.50	21.20	11.30	10.90
7	F	32.40	13.70	32.90	29.40	6.90	17.80	9.30	8.60	18.90	18.50	8.60	9.10
8	F	29.20	12.40	30.70	27.00	5.80	17.20	9.20	8.70	16.20	16.50	6.90	7.60
9	F	29.40	11.30	35.80	32.90	5.80	16.30	7.80	8.60	19.40	20.40	9.40	8.00
10	F	28.50	17.50	35.70	32.90	5.10	20.60	11.10	9.60	20.60	18.70	11.60	10.30
11	F	31.50	13.80	34.30	30.40	5.20	18.10	10.10	8.00	19.40	16.70	9.00	7.30
12	F	36.10	14.10	37.70	31.00	6.30	16.60	10.90	6.80	22.00	18.70	10.20	8.70
13	F	26.00	16.10	33.10	30.70	7.30	16.70	8.50	8.30	17.50	18.70	8.60	9.20
14	F	33.20	12.70	33.00	29.60	6.00	18.40	9.90	8.80	17.40	16.80	9.00	9.50
15	F	34.50	14.30	32.30	28.90	4.30	16.30	7.10	9.80	16.20	17.20	9.00	9.70
16	F	30.50	14.20	33.10	29.80	6.30	18.60	12.40	7.00	19.20	16.40	9.40	9.30
17	F	29.50	15.60	33.40	32.10	6.40	15.40	8.70	6.70	19.70	18.10	10.50	10.10
18	F	35.50	16.00	43.00	40.30	6.60	20.70	9.20	11.50	23.10	23.60	13.10	13.70
19	F	29.10	12.70	33.60	30.50	5.40	16.60	8.00	8.80	18.70	18.60	9.20	9.30
20	F	35.20	13.20	30.40	29.00	5.00	14.30	7.50	7.50	16.10	16.10	7.60	7.00
21	F	29.10	16.50	34.50	32.60	5.80	16.20	8.00	8.40	18.50	19.30	8.30	8.70
22	F	29.00	14.10	30.40	29.30	6.70	18.80	9.10	9.80	16.70	16.80	7.50	7.40
23	F	32.10	13.50	32.00	29.70	5.70	16.00	9.30	7.10	18.00	16.10	7.90	7.10
24	F	32.50	11.80	37.30	34.90	5.00	12.00	7.30	6.40	19.70	19.00	9.70	8.50
25	F	34.40	16.00	35.90	34.70	9.10	20.20	10.10	10.20	20.00	19.60	10.40	10.30
26	F	33.90	16.20	34.10	31.80	5.80	14.90	7.10	8.10	18.00	19.40	6.90	7.10
27	F	34.60	17.80	36.30	33.30	6.90	13.80	7.10	6.80	21.00	21.20	8.40	9.80
28	F	31.60	12.60	32.40	28.90	5.30	17.20	9.00	8.40	18.20	18.30	11.50	11.50
29	F	33.50	15.00	33.90	32.20	7.80	19.90	11.10	9.10	20.70	17.80	8.00	7.50
30	F	31.60	11.40	34.50	31.90	5.70	20.40	10.00	10.60	19.10	19.90	11.70	12.00
31	F	32.40	19.70	32.80	29.60	7.00	21.00	11.90	10.10	18.00	17.30	6.70	7.00

M: male, F: female

Table IV.3a (continued)

N°	Distances in mm												
	Gender	EnEn´	RR´	AlAl´	AcAc´	CmfCmf´	SbalSbal´	SnfSbal	SnfSbal´	SnfAl	SnfAl´	CmfNrL	Cmf´Nrl´
32	F	31.50	12.80	33.80	31.10	6.90	19.40	10.00	9.40	19.00	18.50	8.80	9.20
33	F	31.10	14.00	34.20	32.60	6.30	17.10	10.00	7.00	20.30	17.60	12.30	10.30
34	F	34.20	12.20	36.30	32.70	6.50	18.00	8.20	12.00	18.30	19.30	7.50	9.00
35	F	30.90	11.20	31.20	29.70	5.30	19.50	11.10	8.60	18.30	15.70	11.10	9.60
36	F	35.30	13.60	34.80	31.80	8.70	17.40	10.60	6.80	20.70	18.70	9.20	9.00
37	F	30.80	15.40	31.40	28.50	5.80	15.80	9.50	6.50	18.20	16.00	7.70	7.90
38	F	28.40	13.10	31.40	28.20	5.50	17.50	7.20	10.30	16.90	18.60	8.80	10.40
39	F	33.80	12.00	34.30	29.60	6.10	15.50	7.90	7.70	17.90	18.30	8.00	9.90
40	F	31.60	12.90	35.30	31.60	7.30	22.70	11.80	10.90	19.20	19.20	9.60	10.00
41	M	35.10	11.30	35.00	31.90	4.40	23.10	13.50	9.70	22.10	18.80	11.20	9.50
42	M	36.80	17.50	36.70	32.90	8.00	14.50	8.10	7.20	20.90	19.10	11.00	9.50
43	M	36.30	17.70	36.40	31.40	6.50	18.00	9.40	9.70	19.20	19.60	9.80	10.70
44	M	29.00	12.80	33.90	32.40	5.40	22.20	12.20	10.20	20.10	18.70	11.30	11.20
45	M	33.40	16.60	35.80	31.70	6.70	20.10	10.90	9.40	20.20	18.20	10.40	9.90
46	M	33.10	16.80	36.20	32.20	6.50	23.00	10.40	13.00	19.40	19.40	8.70	8.60
47	M	34.00	17.20	38.90	34.20	5.90	22.30	11.20	11.10	21.10	20.50	12.20	9.00
48	M	37.10	15.10	41.40	36.70	6.10	22.30	10.30	12.00	21.60	22.30	10.90	12.40
49	M	30.50	15.70	37.20	33.70	9.20	22.90	11.60	11.80	20.50	20.70	11.60	10.90
50	M	32.90	15.20	34.70	31.50	5.80	15.90	7.60	8.40	18.00	19.90	7.70	9.70
51	M	31.10	15.20	37.80	35.10	5.10	18.90	9.70	9.20	20.90	21.10	7.90	10.30
52	M	32.50	16.70	40.20	36.70	8.90	21.90	11.10	11.60	20.60	20.80	9.10	10.80
53	M	31.40	17.90	37.60	35.40	10.10	24.30	13.70	10.70	21.70	20.60	9.50	8.70
54	M	37.80	20.80	37.00	34.30	6.80	16.70	10.00	6.70	22.10	17.80	11.80	8.90
55	M	33.90	12.00	39.50	35.20	7.00	20.00	10.70	9.60	21.90	20.80	11.30	9.90
56	M	33.70	15.90	38.20	35.10	5.00	19.70	12.10	7.80	22.00	19.00	12.00	10.20
57	M	34.70	14.70	37.70	34.50	6.20	21.60	11.50	11.20	19.90	19.90	9.70	11.00
58	M	37.80	18.90	38.40	35.40	5.30	18.80	11.60	7.20	22.80	20.60	11.60	10.50
59	M	28.60	12.90	35.90	34.60	5.70	22.90	12.00	12.90	17.00	18.90	7.90	10.10
60	M	34.40	13.90	40.20	36.60	7.80	24.40	13.70	10.70	22.80	21.60	12.00	10.40
61	M	35.20	13.30	37.40	34.50	9.40	19.80	10.20	9.60	20.70	20.70	9.10	9.60
62	M	26.90	14.10	37.70	34.80	5.10	18.80	9.30	9.70	20.50	19.60	10.00	10.40
63	M	28.10	13.80	38.20	35.30	6.10	23.50	11.90	12.10	20.70	20.90	11.30	12.00
64	M	31.50	14.70	38.00	35.10	7.50	20.20	11.40	8.80	21.30	19.50	10.40	9.90
65	M	32.80	13.70	41.70	37.90	10.70	20.70	11.50	9.40	24.50	20.50	10.00	9.40
66	M	36.80	17.50	40.60	36.70	9.20	20.50	10.20	10.40	24.10	23.10	9.50	8.90
67	M	35.10	12.30	42.40	37.70	5.50	24.70	12.40	12.40	23.00	22.00	12.70	12.60
68	M	28.20	16.60	39.70	36.30	7.50	18.90	9.60	9.50	23.30	22.80	14.20	14.10
69	M	31.20	13.00	37.20	35.00	6.60	20.40	11.30	9.20	20.00	19.80	9.90	10.10
70	M	29.00	15.40	35.50	31.50	6.10	18.20	10.50	8.80	19.00	18.60	9.60	9.10
71	M	36.70	16.80	45.30	42.80	9.40	21.40	12.20	9.20	25.90	23.50	11.90	11.50
72	M	35.50	14.80	37.40	35.60	7.40	15.80	9.20	6.80	22.00	22.10	11.60	12.10
73	M	30.20	15.00	36.20	35.30	5.70	20.90	11.00	9.90	20.20	20.10	11.40	12.00
74	M	35.80	15.70	37.60	35.10	6.90	19.10	10.20	9.10	21.10	19.60	10.30	8.70
75	M	33.60	15.90	38.40	36.20	6.80	19.20	10.80	8.50	22.60	20.30	11.90	10.60
76	M	35.00	14.50	37.90	33.90	7.00	20.00	10.70	9.40	21.60	20.10	12.30	12.40
77	M	30.50	16.40	38.60	36.70	8.10	18.40	10.00	8.40	22.50	19.70	13.20	10.00
78	M	31.50	14.40	38.70	35.80	5.70	16.50	7.70	8.80	22.30	21.00	12.50	12.30
79	M	28.30	15.00	40.20	37.00	7.90	18.80	9.80	9.10	21.60	21.80	9.70	10.70
80	M	32.80	12.40	38.10	35.30	7.30	19.30	11.40	10.20	21.50	17.80	10.70	9.40

M: male, F: female

Table IV.3b Values for the variables measured in frontal photographs in the Group with Class I occlusion

N°	Distances in mm				Ratios			Angles			
	Al-N´Prn	Al´-N´Prn	N´Prn	N´Snf	RR´/ AlAl´	N´Prn/ AlAl´	N´Snf/ AlAl´	AlPrnAl´	AlN´Al´	N´AcSnf´	AlSnfAl´
1	18.10	20.30	48.60	60.50	0.37	1.27	1.58	21.30	40.40	86.10	133.50
2	16.90	14.70	45.00	56.40	0.43	1.42	1.78	8.00	37.90	95.60	113.90
3	21.20	17.40	42.00	53.50	0.39	1.09	1.39	19.60	46.30	82.50	133.50
4	15.50	16.60	49.70	60.40	0.64	1.55	1.88	2.70	35.60	93.90	114.40
5	16.00	16.30	44.10	54.60	0.39	1.37	1.69	18.80	38.10	90.20	128.30
6	21.50	18.10	42.40	51.80	0.47	1.07	1.31	1.70	49.80	83.80	130.30
7	16.90	16.00	42.00	54.30	0.42	1.28	1.65	23.70	39.80	86.90	123.40
8	14.30	16.40	38.50	48.00	0.40	1.25	1.56	28.90	39.80	76.70	140.30
9	17.40	18.40	39.30	50.60	0.32	1.10	1.41	16.30	46.30	88.00	128.10
10	19.30	16.40	42.40	55.10	0.49	1.19	1.54	28.60	41.60	82.10	130.60
11	19.10	15.10	41.90	50.60	0.40	1.22	1.48	21.10	41.60	77.50	143.70
12	20.80	16.90	49.00	60.50	0.37	1.30	1.60	23.30	39.30	75.80	135.40
13	16.80	16.30	46.10	56.00	0.49	1.39	1.69	17.70	37.60	85.70	132.50
14	17.00	16.00	40.10	50.00	0.38	1.22	1.52	36.10	39.90	79.50	149.20
15	16.70	15.60	41.00	49.80	0.44	1.27	1.54	32.40	38.90	79.80	150.70

M: male, F: female

Table IV.3b (continued)

N°	Distances in mm				Ratios			Angles			
	Al-N´Prn	Al´-N´Prn	N´Prn	N´Snf	RR´/ AlAl´	N´Prn/ AlAl´	N´Snf/ AlAl´	AlPrnAl´	AlN´Al´	N´AcSnf´	AlSnfAl´
16	18.60	14.50	44.20	55.60	0.43	1.34	1.68	32.80	37.40	84.40	136.40
17	18.90	14.50	44.80	56.90	0.47	1.34	1.70	22.10	38.20	87.30	123.80
18	21.60	21.30	40.70	54.90	0.37	0.95	1.28	26.20	50.30	80.40	133.90
19	17.10	16.40	47.30	56.60	0.38	1.41	1.68	9.00	38.10	89.20	128.90
20	15.10	15.30	35.70	45.60	0.43	1.17	1.50	33.10	41.50	73.80	141.30
21	17.50	17.00	40.10	53.00	0.48	1.16	1.54	32.90	41.70	83.50	131.70
22	15.30	15.10	36.80	48.40	0.46	1.21	1.59	33.90	40.20	83.70	130.80
23	18.20	13.80	37.70	48.40	0.42	1.18	1.51	34.40	41.10	73.60	140.10
24	19.30	18.00	36.90	49.00	0.32	0.99	1.31	41.50	46.00	67.00	149.50
25	17.80	18.10	44.90	53.60	0.45	1.25	1.49	2.40	43.20	83.70	130.30
26	16.40	17.60	35.30	46.70	0.48	1.04	1.37	24.50	47.20	79.90	131.20
27	18.40	17.90	49.60	60.80	0.49	1.37	1.67	3.10	39.90	90.50	119.00
28	17.30	15.10	43.50	54.00	0.39	1.34	1.67	15.40	39.10	88.70	125.40
29	18.50	15.40	52.10	61.80	0.44	1.54	1.82	4.40	35.60	89.80	123.30
30	17.80	16.70	43.70	54.20	0.33	1.27	1.57	9.70	41.80	88.10	124.50
31	16.30	16.50	42.40	53.20	0.60	1.29	1.62	26.80	38.80	73.40	136.30
32	17.20	16.60	48.30	60.40	0.38	1.43	1.79	26.40	35.80	90.30	128.60
33	18.60	15.50	42.90	53.00	0.41	1.25	1.55	12.70	41.80	86.60	128.30
34	17.50	18.80	35.50	48.30	0.34	0.98	1.33	47.10	45.40	66.90	149.30
35	17.20	13.90	44.60	54.60	0.36	1.43	1.75	23.30	36.10	86.60	132.80
36	18.10	16.70	46.00	57.50	0.39	1.32	1.65	14.80	39.60	85.30	123.80
37	17.80	13.50	40.60	52.40	0.49	1.29	1.67	36.30	37.90	82.50	133.70
38	14.90	16.50	48.30	58.80	0.42	1.54	1.87	16.70	34.50	95.40	124.50
39	17.00	17.30	43.70	54.00	0.35	1.27	1.57	28.90	39.20	80.60	142.40
40	17.80	17.50	47.00	58.60	0.37	1.33	1.66	26.10	38.10	79.40	133.80
41	18.10	16.90	40.90	54.40	0.32	1.17	1.55	18.90	43.50	84.70	117.70
42	19.90	16.80	51.00	60.90	0.48	1.39	1.66	11.60	38.10	82.00	132.80
43	18.40	18.00	43.10	53.10	0.49	1.18	1.46	21.70	42.80	76.90	140.20
44	17.90	16.00	49.30	59.10	0.38	1.45	1.74	2.90	37.60	91.40	121.90
45	19.90	15.80	39.30	51.60	0.46	1.10	1.44	33.70	43.70	73.90	137.30
46	19.40	16.80	44.20	54.90	0.46	1.22	1.52	23.80	41.40	78.90	138.10
47	19.30	19.50	44.50	54.00	0.44	1.14	1.39	12.50	45.30	78.20	138.10
48	21.10	20.30	44.70	56.10	0.36	1.08	1.36	22.30	46.00	76.70	141.10
49	18.70	18.50	44.60	53.50	0.42	1.20	1.44	0.60	45.20	87.40	129.40
50	16.10	18.60	43.90	54.60	0.44	1.27	1.57	20.60	40.50	81.00	132.40
51	18.50	19.30	42.40	53.60	0.40	1.12	1.42	12.60	46.10	82.00	128.30
52	19.30	20.90	41.10	51.70	0.42	1.02	1.29	31.80	46.50	70.80	152.80
53	19.20	18.40	45.90	56.60	0.48	1.22	1.51	6.40	43.60	82.80	125.50
54	20.40	16.60	47.30	58.10	0.56	1.28	1.57	21.50	40.00	79.00	136.10
55	19.50	20.00	49.90	62.20	0.30	1.26	1.57	23.80	40.10	81.70	135.70
56	20.60	17.70	45.20	54.80	0.42	1.18	1.43	12.60	44.00	76.40	137.40
57	20.00	17.70	42.50	53.80	0.39	1.13	1.43	29.70	43.20	75.20	143.10
58	20.50	17.90	51.00	62.70	0.49	1.33	1.63	9.90	40.00	88.30	124.50
59	16.70	19.20	36.90	46.70	0.36	1.03	1.30	51.40	43.00	64.60	172.10
60	20.60	19.40	48.50	58.30	0.35	1.21	1.45	2.10	44.50	81.00	129.60
61	17.90	19.50	51.60	63.90	0.36	1.38	1.71	20.80	37.60	88.00	129.40
62	19.30	18.40	42.40	54.00	0.37	1.12	1.43	27.70	43.60	76.70	139.30
63	19.50	18.70	51.80	60.20	0.36	1.36	1.58	0.90	40.40	88.20	133.30
64	20.00	17.90	46.70	58.20	0.39	1.23	1.53	25.30	40.70	77.90	138.00
65	24.20	17.50	48.00	57.90	0.33	1.15	1.39	8.40	45.70	79.10	135.20
66	22.60	18.00	48.20	60.50	0.43	1.19	1.49	1.50	45.40	84.10	118.60
67	21.60	20.80	34.90	46.10	0.29	0.82	1.09	20.30	57.50	71.40	141.20
68	21.10	18.60	48.00	61.10	0.42	1.21	1.54	7.60	43.80	92.20	118.80
69	19.10	18.10	46.50	56.50	0.35	1.25	1.52	18.60	41.20	82.30	138.90
70	18.30	17.10	45.00	57.00	0.43	1.27	1.61	36.40	38.40	75.10	141.40
71	23.50	21.90	46.10	58.50	0.37	1.02	1.29	13.40	49.90	75.30	133.30
72	18.80	18.50	37.20	52.00	0.40	0.99	1.39	19.30	49.70	88.80	116.30
73	18.30	17.90	46.30	57.20	0.41	1.28	1.58	12.30	41.10	87.80	127.70
74	18.80	18.70	37.70	50.00	0.42	1.00	1.33	26.60	48.00	77.20	134.30
75	21.10	17.30	41.50	53.60	0.41	1.08	1.40	15.60	47.10	82.40	126.90
76	19.60	18.20	48.20	59.50	0.38	1.27	1.57	15.80	40.70	79.70	130.60
77	20.90	17.60	42.50	55.60	0.42	1.10	1.44	27.10	44.60	80.70	132.40
78	20.00	18.70	44.60	56.10	0.37	1.15	1.45	10.90	45.20	85.70	126.70
79	21.20	19.00	47.90	59.20	0.37	1.19	1.47	17.90	42.90	82.30	135.70
80	20.80	17.10	42.30	53.60	0.33	1.11	1.41	37.20	42.70	72.00	151.40

M: male, F: female

V.4 a Values for the variables measured in frontal photographs in the Group with Class III occlusion

N°	Distances in mm												
	Gender	EnEn´	RR´	AlAl´	AcAc´	CmfCmf´	SbalSbal´	SnfSbal	SnfSbal´	SnfAl	SnfAl´	CmfNrL	Cmf´Nrl´
1	F	33.30	14.40	30.30	28.20	5.90	15.50	8.60	7.30	17.80	17.20	9.40	9.80
2	F	31.40	15.50	38.00	34.30	6.40	21.50	11.40	11.00	20.60	19.20	8.20	8.30
3	F	32.40	15.30	36.10	30.90	5.80	18.00	9.30	8.80	19.90	19.40	7.80	8.20
4	F	31.00	14.20	35.50	32.80	7.50	19.70	10.30	9.50	21.00	18.50	10.00	8.10
5	F	35.70	18.00	34.30	32.00	9.90	21.20	11.40	9.80	20.00	17.80	6.80	7.10
6	F	33.20	20.10	39.80	35.80	6.10	20.10	10.70	9.50	22.50	20.30	11.10	9.40
7	F	27.50	12.30	36.00	33.00	7.00	21.70	14.00	9.20	23.80	20.40	12.60	10.10
8	F	32.70	18.10	35.80	34.10	6.90	17.50	9.80	7.70	20.30	18.50	11.00	9.60
9	F	25.40	9.60	31.20	29.30	6.00	19.50	10.50	9.00	18.00	16.80	8.80	8.50
10	F	31.70	15.60	31.10	29.60	9.00	18.20	10.80	8.00	21.10	16.00	9.10	6.90
11	F	33.90	17.60	37.30	35.40	6.50	18.90	10.30	9.40	22.00	20.80	12.40	10.80
12	F	28.40	12.60	28.90	25.70	6.70	20.10	11.00	9.30	17.60	15.40	9.10	6.60
13	F	29.40	13.70	36.30	33.70	7.20	21.50	11.10	10.60	21.40	20.10	12.60	9.80
14	F	31.60	14.10	32.90	29.90	6.50	15.90	7.90	8.00	18.30	19.10	10.00	11.00
15	F	27.30	13.70	30.60	28.70	6.50	19.50	9.50	10.00	16.50	16.80	6.80	7.60
16	F	30.40	13.40	31.20	29.30	5.00	17.90	8.90	9.00	17.10	17.80	8.50	8.00
17	F	29.20	12.70	35.30	32.80	5.60	15.80	8.00	7.80	20.20	18.90	10.80	10.40
18	F	33.50	11.60	33.30	30.00	5.70	16.70	9.10	8.50	18.20	17.40	9.10	7.70
19	F	36.20	16.30	41.80	36.60	6.30	21.70	11.50	10.70	22.00	21.90	10.80	11.30
20	F	34.00	16.20	35.10	33.20	8.70	16.80	9.40	7.40	21.60	18.60	9.60	7.30
21	F	31.00	14.70	38.00	35.20	8.30	21.50	12.00	10.70	19.90	19.30	9.20	9.60
22	F	30.60	12.40	35.70	33.90	8.10	18.80	9.40	9.60	20.60	19.80	10.60	8.90
23	F	31.00	10.70	33.00	30.40	5.50	14.20	8.40	5.80	19.90	18.30	9.60	9.90
24	F	36.10	16.70	39.00	34.90	10.70	19.00	11.80	9.40	21.00	19.00	8.70	7.60
25	F	28.90	13.40	37.10	34.70	7.50	15.80	9.00	6.80	22.00	18.00	11.70	8.30
26	F	28.90	12.60	31.30	28.70	5.60	16.70	8.70	8.00	18.50	16.60	9.40	8.40
27	F	30.10	15.90	33.40	30.90	6.70	16.20	8.90	7.30	20.30	19.90	9.60	10.20
28	F	29.80	11.30	32.40	29.50	4.90	16.60	8.50	8.30	16.60	18.40	8.70	11.00
29	F	35.10	11.40	32.20	28.60	6.50	17.20	8.70	8.80	19.00	16.60	6.90	7.30
30	F	27.90	13.40	34.90	31.80	6.90	17.20	9.10	8.40	19.50	18.30	8.10	8.70
31	F	30.20	16.20	30.90	28.50	7.90	19.70	10.00	9.70	18.40	16.80	8.50	8.00
32	F	33.90	14.50	35.40	31.50	6.80	20.90	10.40	10.50	20.00	20.10	11.30	9.90
33	F	28.60	14.50	30.40	27.70	5.50	14.00	5.50	8.50	17.30	18.20	8.60	9.90
34	F	33.50	16.30	33.20	30.60	7.00	20.60	10.90	10.80	17.30	16.70	8.30	7.70
35	F	30.40	14.30	32.90	32.30	8.20	21.10	12.00	11.10	22.90	19.00	12.70	8.20
36	F	26.50	13.40	29.00	25.90	6.00	16.80	8.00	8.90	16.50	17.00	4.60	5.60
37	F	29.30	12.90	32.60	30.20	4.90	19.40	10.60	9.60	19.90	17.80	11.60	8.50
38	F	28.40	18.30	40.90	38.40	7.70	24.90	12.40	12.50	23.40	21.00	11.20	10.50
39	F	29.30	11.00	32.30	29.90	6.70	17.70	9.60	8.50	19.90	19.20	9.50	9.10
40	F	31.30	11.90	33.30	30.40	9.60	17.00	7.60	9.40	17.20	19.00	7.70	7.70
41	M	33.30	14.90	38.50	34.40	6.00	19.80	10.20	10.10	21.50	19.90	9.40	10.20
42	M	32.10	13.10	38.70	35.90	7.20	21.40	9.50	11.90	19.10	22.20	10.10	13.40
43	M	30.40	13.20	31.80	28.10	5.00	16.70	9.90	6.80	18.80	17.80	8.20	7.70
44	M	33.30	15.30	39.10	35.70	5.60	18.30	10.70	7.70	23.90	18.40	11.40	8.00
45	M	31.50	18.40	43.20	38.00	8.40	26.40	11.80	14.90	24.00	23.60	13.20	12.30
46	M	36.50	22.60	44.00	41.20	7.40	20.70	12.30	8.40	24.10	22.20	12.60	11.50
47	M	35.70	16.90	38.00	35.90	7.40	20.90	10.60	10.30	20.80	19.00	11.40	10.20
48	M	38.80	20.50	48.70	46.30	8.40	19.50	11.00	8.60	27.90	24.40	14.10	15.30
49	M	33.20	13.50	39.40	35.40	8.50	22.10	11.30	11.30	22.60	20.90	11.40	10.50
50	M	32.10	15.90	37.50	35.30	7.90	22.90	14.00	9.10	22.70	19.30	12.30	9.90
51	M	34.00	14.60	39.90	34.60	7.90	21.60	13.00	8.70	24.00	20.50	12.10	8.30
52	M	30.30	14.60	38.00	34.00	9.00	17.60	9.20	9.00	20.40	20.10	7.40	10.60
53	M	31.20	15.90	37.20	33.20	7.20	21.70	11.90	9.90	21.40	18.40	9.60	7.90
54	M	33.80	14.40	32.90	30.60	6.40	14.90	9.30	9.90	17.60	16.20	7.90	6.70
55	M	34.80	16.10	36.30	34.40	7.90	22.40	12.20	10.30	22.10	20.10	11.20	10.20
56	M	34.20	15.90	37.60	34.50	7.40	22.80	12.40	11.80	21.70	22.10	10.30	12.80
57	M	34.00	16.60	41.70	40.30	8.70	21.60	10.30	11.50	23.60	23.20	12.90	12.40
58	M	34.80	16.00	41.50	38.50	7.20	23.10	11.30	12.00	22.30	22.60	12.40	15.00
59	M	34.00	15.40	37.10	32.50	6.40	21.40	12.30	9.20	21.60	19.00	9.20	9.60
60	M	40.80	10.30	35.30	31.30	5.50	16.80	8.10	9.30	18.40	18.80	9.80	10.10
61	M	32.20	16.40	36.00	33.70	10.40	21.10	12.20	10.20	23.40	19.70	10.30	8.50
62	M	33.30	14.60	40.90	36.80	6.70	19.30	9.70	9.60	24.10	22.80	11.90	9.70
63	M	34.00	14.50	35.10	31.60	6.30	18.30	10.60	8.10	19.20	18.00	11.20	10.30
64	M	29.50	13.70	35.60	31.20	6.30	20.70	9.00	11.80	17.70	20.50	11.00	12.90
65	M	33.20	15.90	37.40	31.60	4.70	19.10	10.20	9.80	19.60	19.10	11.70	11.20
66	M	30.40	13.70	37.50	34.00	7.80	23.20	12.20	12.00	21.30	22.40	10.90	12.20
67	M	29.80	14.20	39.60	35.40	8.00	21.10	10.00	11.20	20.90	20.40	10.20	10.10
68	M	31.90	18.10	39.90	35.20	9.00	18.80	10.80	8.00	23.00	19.90	10.10	8.40
69	M	31.90	14.00	43.80	39.60	10.60	17.50	10.60	7.20	23.30	22.60	9.80	9.40
70	M	29.20	13.60	38.20	34.80	6.70	16.10	7.90	8.20	20.70	20.10	9.80	10.00

M: male, F: female

IV.4 a (Continued)

N°	Distances in mm											
	Gender	EnEn´	RR´	AlAl´	AcAc´	CmfCmf´	SbalSbal´	SnfSbal	SnfSbal´	SnfAl	SnfAl´	CmfNrL	Cmf´Nrl´
71	M	34.70	15.50	37.90	35.70	7.20	18.70	9.60	9.50	19.90	20.60	8.90	11.10
72	M	33.40	17.90	35.70	32.80	7.70	19.10	10.40	8.70	20.20	19.50	9.40	9.20
73	M	33.30	14.90	32.60	29.00	7.50	17.80	10.70	7.30	19.80	16.60	9.20	8.30
74	M	30.90	15.10	37.10	34.70	8.10	15.80	9.10	6.70	20.50	19.00	9.40	9.50
75	M	30.00	14.00	35.80	33.20	5.70	19.20	10.30	9.20	20.20	19.90	10.20	10.10
76	M	33.50	15.20	38.90	35.70	7.40	19.20	10.80	8.70	22.10	20.20	9.50	7.50
77	M	33.80	14.40	40.40	38.10	6.90	23.90	12.90	11.20	22.20	21.00	11.00	11.90
78	M	28.80	13.20	35.50	32.20	6.40	17.10	9.20	8.30	20.30	19.50	11.00	10.70
79	M	30.00	15.10	35.80	33.50	8.00	18.60	8.20	10.60	21.20	21.60	11.00	8.20
80	M	27.20	11.00	35.10	31.50	7.50	16.50	7.30	9.40	18.20	19.30	6.10	6.50

M: male, F: female

IV.4 b Values for the variables measured in frontal photographs in the Group with Class III occlusion

N°	Distances in mm				Ratios			Angles			
	Al-N´Prn	Al´-N´Prn	N´Prn	N´Snf	RR´/ AlAl´	N´Prn/ AlAl´	N´Snf/ AlAl´	AlPrnAl´	AlN´Al´	N´AcSnf	AlSnfAl´
1	15.60	14.70	55.70	64.70	0.48	1.84	2.14	1.60	30.30	99.10	119.90
2	20.90	17.10	40.10	51.60	0.41	1.06	1.36	33.50	45.10	74.80	145.90
3	18.20	18.00	43.80	53.80	0.42	1.21	1.49	14.30	42.80	80.70	133.80
4	19.30	16.10	46.00	56.40	0.40	1.30	1.59	11.20	40.80	87.60	127.30
5	19.20	15.00	46.10	55.40	0.52	1.34	1.62	10.00	39.70	82.80	130.20
6	21.40	18.40	44.00	55.20	0.51	1.11	1.39	19.20	45.60	77.30	137.20
7	20.90	15.10	50.90	61.60	0.34	1.41	1.71	-13.30	40.50	95.50	108.70
8	19.00	16.80	44.00	54.10	0.51	1.23	1.51	17.50	41.90	84.10	135.40
9	15.80	15.40	50.40	61.00	0.31	1.62	1.96	20.50	32.60	92.90	126.90
10	17.10	14.00	45.60	55.70	0.50	1.47	1.79	1.10	37.60	90.90	113.60
11	19.30	18.00	49.60	60.10	0.47	1.33	1.61	0.20	41.20	92.70	121.10
12	15.60	13.30	39.00	49.30	0.44	1.35	1.71	18.50	38.50	83.50	121.70
13	18.20	18.10	48.70	59.30	0.38	1.34	1.63	3.60	40.50	89.60	122.20
14	16.20	16.80	47.20	58.20	0.43	1.43	1.77	15.10	36.90	92.80	123.40
15	15.80	14.80	41.60	52.00	0.45	1.36	1.70	28.70	37.20	89.80	134.10
16	15.40	15.80	45.60	55.10	0.43	1.46	1.77	11.60	36.50	88.10	126.30
17	19.20	16.20	44.10	53.90	0.36	1.25	1.53	9.50	42.40	84.20	129.40
18	17.10	16.10	40.90	52.10	0.35	1.23	1.56	32.10	39.90	71.50	138.10
19	22.00	19.80	41.00	52.50	0.39	0.98	1.26	26.00	49.00	70.30	144.60
20	19.30	15.90	51.70	61.20	0.46	1.47	1.74	-0.80	37.70	90.20	121.90
21	20.10	17.60	50.70	60.80	0.39	1.33	1.60	30.80	37.20	69.30	151.70
22	18.50	17.20	50.50	60.40	0.35	1.41	1.69	2.60	38.60	89.00	124.00
23	17.90	15.10	51.60	61.50	0.32	1.56	1.86	2.60	35.30	92.70	119.70
24	20.30	18.70	44.00	52.50	0.43	1.13	1.35	24.00	44.10	67.90	154.40
25	21.70	15.20	48.50	58.40	0.36	1.31	1.57	16.00	40.00	82.10	135.80
26	16.50	14.80	50.80	59.80	0.40	1.62	1.91	8.70	33.60	88.20	126.50
27	17.70	15.70	48.10	59.00	0.48	1.44	1.77	-1.80	38.50	90.50	112.80
28	15.60	16.80	45.10	55.10	0.35	1.39	1.70	23.10	37.00	87.60	135.10
29	17.50	14.60	45.20	54.50	0.35	1.40	1.69	11.90	37.90	83.70	128.90
30	18.20	16.60	43.20	54.30	0.38	1.24	1.56	24.80	40.70	80.80	134.40
31	16.40	14.50	39.30	49.90	0.52	1.27	1.61	15.90	40.90	87.10	122.30
32	17.90	17.50	45.20	55.00	0.41	1.28	1.55	1.40	42.50	86.20	123.60
33	14.90	15.50	49.00	60.70	0.48	1.61	2.00	20.00	32.80	95.40	118.20
34	17.40	15.80	36.70	46.80	0.49	1.11	1.41	42.30	42.10	67.60	154.90
35	19.10	13.70	53.50	65.70	0.43	1.63	2.00	-5.00	34.30	95.90	103.20
36	14.20	14.80	48.50	57.90	0.46	1.67	2.00	7.60	32.70	94.50	119.50
37	17.10	15.50	46.90	58.10	0.40	1.44	1.78	12.20	37.00	90.20	119.50
38	21.50	19.30	42.80	56.40	0.45	1.05	1.38	26.90	46.40	80.80	134.00
39	17.50	14.80	44.20	57.20	0.34	1.37	1.77	13.20	38.50	97.80	111.20
40	16.40	16.80	43.70	54.30	0.36	1.31	1.63	23.90	38.80	80.60	134.00
41	20.40	17.90	40.70	53.50	0.39	1.06	1.39	29.40	45.60	79.00	136.10
42	18.60	20.00	49.20	59.60	0.34	1.27	1.54	18.10	40.60	85.00	138.80
43	17.70	14.10	55.00	65.20	0.42	1.73	2.05	8.40	31.60	93.20	120.50
44	23.50	15.60	46.20	58.40	0.39	1.18	1.49	25.70	42.20	76.60	134.90
45	22.60	20.60	48.40	58.60	0.43	1.12	1.36	1.10	48.00	84.70	130.20
46	22.90	21.10	50.50	62.00	0.51	1.15	1.41	22.40	43.80	78.30	143.90
47	19.70	18.30	46.10	55.80	0.44	1.21	1.47	22.60	41.70	77.70	145.20
48	26.00	22.50	46.10	59.60	0.42	0.95	1.22	19.10	51.80	77.40	137.20
49	21.40	18.00	49.60	61.20	0.34	1.26	1.55	13.60	41.50	85.20	129.70
50	21.00	16.50	54.70	65.40	0.42	1.46	1.74	8.00	37.00	89.50	126.30
51	21.60	18.30	50.50	61.20	0.37	1.27	1.53	5.30	42.50	82.10	127.50
52	19.60	18.40	34.50	45.20	0.38	0.91	1.19	22.00	52.90	72.20	139.40
53	20.70	16.50	43.50	51.50	0.43	1.17	1.38	5.60	45.30	74.60	138.20
54	17.90	15.00	44.10	54.40	0.44	1.34	1.65	43.60	35.90	64.00	154.30

M: male, F: female

IV.4 b (continued)

N°	Distances in mm				Ratios			Angles			
	Al-N´Prn	Al´-N´Prn	N´Prn	N´Snf	RR´/ AlAl´	N´Prn/ AlAl´	N´Snf/ AlAl´	AlPrnAl´	AlN´Al´	N´AcSnf	AlSnfAl´
55	19.70	16.60	48.10	59.10	0.44	1.33	1.63	2.10	41.10	84.60	118.90
56	18.80	18.80	56.90	65.80	0.42	1.51	1.75	-14.50	38.10	96.00	118.10
57	21.90	19.80	53.70	67.40	0.40	1.29	1.62	16.80	40.30	81.50	125.90
58	21.90	19.60	45.60	57.30	0.39	1.10	1.38	17.60	46.10	83.90	135.40
59	19.90	17.10	40.50	50.90	0.42	1.09	1.37	13.50	47.00	74.10	131.80
60	17.00	18.20	40.50	50.50	0.29	1.15	1.43	25.40	43.20	76.80	142.30
61	19.40	16.70	51.30	61.70	0.46	1.43	1.71	-8.60	39.70	91.70	113.50
62	20.80	20.00	45.00	57.10	0.36	1.10	1.40	3.70	48.20	89.00	121.70
63	18.10	16.90	46.70	58.30	0.41	1.33	1.66	34.10	37.30	78.90	140.90
64	16.80	18.80	46.10	54.90	0.38	1.29	1.54	11.80	40.80	81.00	137.20
65	19.80	17.60	44.40	56.10	0.43	1.19	1.50	39.60	40.20	71.00	149.80
66	18.10	19.40	50.30	61.20	0.37	1.34	1.63	-2.10	41.10	95.60	118.10
67	20.60	19.00	42.00	51.20	0.36	1.06	1.29	18.80	47.30	76.50	146.40
68	21.20	18.70	48.30	58.10	0.45	1.21	1.46	11.40	43.40	79.30	137.10
69	23.70	20.10	54.00	64.70	0.32	1.23	1.48	19.90	41.50	76.00	144.90
70	20.00	18.20	44.10	56.00	0.36	1.15	1.47	27.20	42.80	79.40	138.50
71	18.30	19.60	41.50	51.80	0.41	1.09	1.37	19.10	45.90	76.30	138.80
72	18.80	17.00	42.00	54.40	0.50	1.18	1.52	23.80	42.60	84.40	128.50
73	18.60	14.00	48.20	56.80	0.46	1.48	1.74	4.50	36.90	78.80	126.80
74	20.10	17.00	46.60	56.90	0.41	1.26	1.53	21.80	40.60	79.10	139.60
75	18.50	17.30	44.40	54.50	0.39	1.24	1.52	7.50	42.90	85.70	127.00
76	20.90	17.90	46.10	57.80	0.39	1.19	1.49	20.20	42.90	81.80	133.80
77	21.80	18.70	48.50	59.60	0.36	1.20	1.48	19.80	42.40	76.00	138.80
78	17.90	17.60	44.40	55.80	0.37	1.25	1.57	15.20	41.50	83.10	126.40
79	18.10	17.70	56.70	67.80	0.42	1.58	1.89	-4.30	35.40	94.20	113.40
80	16.60	18.50	43.00	53.60	0.31	1.23	1.53	26.50	40.90	74.80	139.30

M: male, F: female

IV.5a Values for the facial soft tissue variables and nasal skeletal and soft tissue variables measured in profile photographs and lateral cephalograms in the group with Class I occlusion

N°		Angles						Distances in mm				
	Gender	G´PrnPg´	G´SnPg´	N´Stp/ PrnPg´	N´Prn/ N´Pg´	NRh mm	N1N2Rh	N´Sn	N´Prn	Nd- N´Stp	Stp- N´Prn	Id- MnPrn
1	F	139.50	14.90	134.10	27.00	24.00	165.90	60.40	51.40	-1.80	-1.10	1.00
2	F	132.50	16.70	128.00	29.30	24.50	174.90	55.10	49.40	-2.50	0.40	1.30
3	F	137.10	15.40	128.50	33.60	23.00	164.60	53.10	43.70	-1.20	-1.00	0.90
4	F	143.10	10.00	137.50	23.70	23.30	169.90	53.50	47.90	-1.60	-0.40	1.20
5	F	135.10	13.40	126.60	28.50	25.60	166.40	55.40	51.90	-1.50	1.20	2.20
6	F	142.40	10.10	135.80	24.80	25.80	163.10	57.10	50.00	-2.60	-0.20	2.30
7	F	141.40	15.60	134.80	28.30	21.60	172.30	55.30	46.90	-1.20	-0.30	1.20
8	F	138.90	12.20	130.20	29.40	18.50	172.40	50.40	45.50	-1.50	0.10	1.20
9	F	127.70	17.80	117.60	34.00	11.50	158.80	46.90	43.70	-1.30	2.10	1.30
10	F	138.00	13.30	138.80	25.50	30.30	171.80	57.50	49.20	-1.70	-1.60	1.00
11	F	150.10	10.00	144.00	21.60	22.30	155.20	49.90	44.90	-2.60	-0.80	1.90
12	F	132.50	17.20	127.70	28.30	28.70	168.80	64.10	56.40	-2.60	1.40	1.60
13	F	137.80	12.70	130.70	29.00	21.40	175.60	60.40	49.80	-0.90	1.20	1.30
14	F	131.70	18.90	124.50	32.20	21.30	150.70	53.80	47.60	-1.20	0.70	1.20
15	F	140.70	10.80	134.00	29.40	19.90	163.80	51.40	43.70	-1.50	-0.80	1.30
16	F	132.50	16.30	129.10	29.40	24.20	170.80	55.30	49.80	-0.90	-0.60	1.20
17	F	139.80	12.20	136.60	27.60	24.90	166.00	57.20	47.60	-1.10	-1.50	0.80
18	F	145.80	3.90	139.60	23.90	22.80	173.30	57.80	49.10	-2.30	-1.00	1.70
19	F	138.40	10.20	132.70	26.70	25.50	164.90	56.00	49.80	-0.70	-0.20	1.30
20	F	136.40	13.60	126.10	31.80	21.50	153.20	47.80	41.70	-0.30	0.60	1.20
21	F	140.10	14.00	133.10	26.70	26.10	177.20	55.90	47.20	-3.60	0.50	1.70
22	F	138.00	11.30	129.30	29.10	16.80	162.40	48.70	44.30	-2.40	0.70	1.80
23	F	136.70	13.40	126.20	30.20	23.20	171.60	52.00	47.60	-0.50	1.70	1.40
24	F	136.30	16.80	126.30	32.50	21.30	170.50	53.10	47.60	-2.80	0.90	1.50
25	F	138.00	16.10	132.00	26.80	22.20	162.60	53.20	49.10	-0.10	1.10	0.90
26	F	144.40	6.70	135.30	25.60	19.30	164.00	51.20	43.90	-3.70	0.00	1.80
27	F	134.90	19.60	129.20	29.80	28.10	159.60	60.60	53.30	-2.70	-0.40	1.30
28	F	138.90	16.50	132.20	27.70	17.80	177.50	54.80	49.10	0.00	0.30	0.70
29	F	142.00	13.70	134.50	25.10	22.40	161.40	58.50	52.60	-1.50	0.70	0.60
30	F	138.10	13.70	130.30	26.50	24.30	163.20	55.90	51.30	-1.40	0.70	1.30
31	F	145.10	14.30	141.60	26.10	19.10	173.00	54.00	46.10	-5.10	-1.80	2.20
32	F	142.60	11.80	134.70	25.20	26.20	169.70	59.70	52.40	-3.40	0.40	1.10
33	F	145.70	9.50	139.30	22.00	26.10	173.90	55.00	50.30	-2.30	0.20	1.40
34	F	132.50	17.00	124.60	33.30	23.40	167.70	54.10	47.60	-3.40	-0.30	2.20
35	F	141.60	12.20	132.80	24.90	24.40	177.80	59.90	54.70	-3.40	1.00	1.90
36	F	140.40	13.10	136.60	24.80	25.30	161.00	55.20	49.70	-0.50	0.00	0.90

IV.5a (continued)

N°	Angles							Distances in mm				
	Gender	G´PrnPg´	G´SnPg´	N´Stp/ PrnPg´	N´Prn/ N´Pg´	NRh mm	N1N2Rh	N´Sn	N´Prn	Nd- N´Stp	Stp- N´Prn	Id- MnPrn
37	F	135.30	16.60	128.80	33.60	18.60	167.90	50.90	44.20	-0.80	-0.50	1.40
38	F	135.60	15.50	130.20	26.70	24.60	166.60	61.80	55.40	-2.40	0.80	1.40
39	F	131.80	21.90	123.30	30.10	23.70	174.70	52.80	48.00	-1.20	1.40	1.60
40	F	138.40	19.20	133.20	25.90	22.40	170.50	57.50	50.50	-3.40	0.00	1.30
41	M	129.40	24.80	121.80	31.80	24.40	170.70	58.70	53.20	-0.40	1.40	1.60
42	M	142.00	9.30	133.90	27.40	19.70	178.40	59.10	52.20	-4.00	0.00	1.20
43	M	140.30	13.50	135.10	29.50	23.70	161.60	55.90	44.90	-2.60	-1.40	1.60
44	M	137.00	16.90	127.50	27.60	23.20	164.50	57.50	51.40	-0.20	2.30	1.80
45	M	130.70	22.70	123.60	31.20	21.70	162.90	54.80	50.30	-1.20	0.90	1.90
46	M	141.10	11.40	134.10	26.30	24.60	174.80	55.90	50.60	-1.20	0.50	1.00
47	M	143.00	9.90	140.60	26.00	23.00	163.00	59.60	52.00	-2.60	-2.00	1.80
48	M	142.90	5.40	132.60	26.30	22.30	169.40	54.60	50.20	0.00	1.00	1.10
49	M	137.30	14.70	126.10	29.00	23.20	161.40	54.10	51.30	-1.60	0.10	1.50
50	M	139.20	12.50	131.60	28.40	24.70	172.30	59.50	52.50	-1.30	0.10	1.10
51	M	145.50	6.70	138.00	24.30	20.90	167.30	55.00	48.00	-5.50	0.30	1.80
52	M	142.30	6.90	138.10	26.10	22.00	170.90	54.10	46.80	-3.70	-0.90	1.10
53	M	136.50	15.80	130.20	29.60	26.30	150.70	54.60	50.10	-1.50	-0.30	1.00
54	M	140.30	11.50	131.70	26.50	20.40	170.90	57.70	53.00	-0.60	1.40	1.40
55	M	143.50	9.80	135.70	24.10	30.90	159.00	62.40	56.90	-1.20	1.50	2.00
56	M	138.70	6.70	126.10	30.10	21.60	172.20	58.70	51.80	-1.70	1.70	1.20
57	M	134.50	20.90	125.40	31.00	19.40	162.80	58.50	50.70	-0.50	2.10	1.30
58	M	138.90	19.70	135.30	27.20	26.00	164.40	63.20	53.70	-2.20	-0.70	1.30
59	M	139.30	14.10	128.50	28.90	22.80	155.00	52.80	48.10	-2.10	1.30	1.30
60	M	135.90	22.00	132.10	28.20	25.10	159.00	61.60	54.70	-3.70	-0.40	1.40
61	M	139.30	13.30	136.10	23.60	33.20	162.30	66.20	60.30	-0.80	0.00	1.20
62	M	145.60	7.40	142.00	24.70	24.80	166.50	55.20	47.90	-2.50	-1.70	1.60
63	M	137.00	17.80	124.50	29.10	19.50	169.30	57.20	53.70	-0.50	2.50	1.80
64	M	142.80	13.10	138.80	25.90	25.20	164.90	57.60	48.40	-1.20	-0.70	1.00
65	M	143.60	11.20	133.20	26.50	26.80	164.70	57.00	52.20	-0.90	1.60	1.20
66	M	135.40	13.60	127.50	30.10	26.30	155.40	58.00	53.50	-1.30	0.20	1.80
67	M	147.00	8.90	133.20	30.20	15.50	173.40	45.20	37.90	-3.10	-1.80	2.10
68	M	136.30	10.80	130.80	28.00	22.90	165.70	59.20	51.50	-2.80	0.00	2.00
69	M	137.20	17.30	131.60	28.10	23.80	173.90	56.50	50.30	-4.00	0.50	1.50
70	M	137.00	17.10	135.20	24.90	25.80	179.80	62.00	53.20	-2.90	0.20	1.30
71	M	141.10	13.70	138.20	26.40	23.70	178.90	58.20	50.80	-4.30	-1.20	1.70
72	M	141.90	4.20	133.30	25.30	20.80	177.00	56.20	49.20	-1.50	1.10	1.40
73	M	146.50	7.40	134.40	27.10	19.00	164.30	54.50	46.30	-2.90	0.10	2.00
74	M	137.50	11.60	129.70	31.80	15.80	170.90	50.90	45.20	-2.50	-0.60	1.50
75	M	137.70	15.60	127.90	27.70	22.10	176.20	57.00	51.10	-2.40	1.60	1.40
76	M	134.30	20.40	128.60	30.70	22.60	159.30	61.70	53.30	-1.40	0.30	1.40
77	M	132.40	20.90	125.10	31.60	29.30	170.80	60.40	53.00	-1.50	0.30	1.60
78	M	140.50	10.40	134.40	27.10	25.70	163.90	58.80	51.50	-1.70	-0.70	1.20
79	M	144.30	11.20	142.50	22.90	23.00	168.90	61.90	54.90	-3.00	-2.20	0.80
80	M	139.10	14.50	137.70	27.50	26.40	166.40	57.10	51.00	-3.30	-2.70	1.40

M: male, F: female

IV.5 b Values for the nasal soft tissue variables measured in profile photographs in the group with Class I occlusion

N°	Distances in mm							Angles		
	Gender	Cm- PrnSn	NrS-columella base	AcPrn	AcNrA	AcSn	SnPrn	SnN´Prn	N´Stp/SnCm	N´PrnSn
1	F	2.00	6.00	29.00	18.60	13.30	15.70	18.90	92.30	106.50
2	F	3.90	6.30	28.80	20.20	11.60	17.20	21.40	68.00	95.20
3	F	3.90	5.60	25.70	18.90	10.80	14.90	23.90	82.10	102.70
4	F	1.50	3.60	24.50	17.20	11.20	13.30	17.80	89.30	100.30
5	F	2.80	5.90	28.50	20.60	11.20	17.40	20.70	71.70	89.80
6	F	2.50	5.70	26.90	19.80	11.60	15.20	18.70	86.90	102.40
7	F	1.90	5.30	25.70	18.00	10.90	14.80	19.20	94.40	106.30
8	F	2.00	3.40	25.80	16.80	11.10	14.70	21.40	75.80	94.50
9	F	3.20	4.60	29.10	21.20	12.50	16.70	25.00	64.90	86.40
10	F	2.90	4.00	26.50	13.10	10.10	16.40	19.10	89.70	105.30
11	F	1.40	2.30	22.30	16.00	12.30	10.10	14.60	87.60	105.50
12	F	2.90	5.80	28.60	20.80	9.50	19.10	20.20	84.00	99.40
13	F	3.30	6.50	31.10	23.10	11.80	19.30	22.30	87.60	104.80
14	F	1.50	3.70	26.10	16.60	10.00	16.20	22.20	84.80	96.10
15	F	2.30	3.70	26.80	18.90	10.60	16.20	22.30	89.00	101.00
16	F	3.80	5.70	29.30	21.80	11.70	17.60	21.20	74.60	95.20
17	F	1.80	4.30	26.70	17.20	9.80	16.80	21.00	96.40	105.90

M: male, F: female

IV.5 b (continued)

N°		Distances in mm						Angles		
	Gender	Cm- PrnSn	NrS-columella base	AcPrn	AcNrA	AcSn	SnPrn	SnN´Prn	N´Stp/SnCm	N´PrnSn
18	F	3.00	5.10	25.10	18.40	8.80	16.30	20.60	90.40	104.00
19	F	2.60	5.40	27.50	17.50	9.60	17.90	21.10	78.80	96.90
20	F	2.00	3.60	24.30	15.90	9.10	15.20	23.30	81.20	96.60
21	F	1.30	3.90	24.90	17.20	10.70	14.10	19.00	97.50	107.20
22	F	2.80	4.40	25.70	18.30	9.90	15.80	22.00	72.70	92.80
23	F	1.70	2.90	28.50	20.10	11.60	16.90	21.90	78.70	92.20
24	F	2.40	3.50	26.80	19.40	11.10	15.60	22.10	78.60	94.60
25	F	2.20	3.60	25.50	18.10	11.30	14.20	17.80	76.60	95.50
26	F	2.10	3.40	24.20	17.10	10.00	14.20	20.70	88.20	102.30
27	F	2.50	5.20	26.40	16.60	10.70	15.70	19.40	81.10	101.10
28	F	2.20	5.80	28.40	19.00	13.30	15.00	18.20	77.30	99.90
29	F	2.50	3.20	23.90	14.60	9.50	14.40	17.30	73.30	100.50
30	F	3.10	7.20	30.20	22.60	14.60	15.60	19.00	71.50	94.90
31	F	0.90	3.90	22.10	14.70	9.80	12.30	16.90	104.30	109.60
32	F	2.60	6.10	28.30	19.40	12.80	15.40	18.10	81.80	103.10
33	F	2.50	6.00	23.00	16.50	9.50	13.40	16.40	78.50	99.10
34	F	2.20	4.50	28.00	20.50	9.80	18.20	23.50	84.90	95.40
35	F	2.20	6.60	25.90	18.30	9.70	16.20	17.90	82.80	97.20
36	F	2.50	3.30	25.80	16.80	10.70	15.10	18.20	77.00	99.30
37	F	2.90	3.70	29.20	20.80	12.30	16.90	23.80	79.80	96.70
38	F	3.50	5.90	30.10	21.50	11.50	18.60	19.00	77.70	98.60
39	F	3.10	3.80	25.00	18.00	11.10	13.90	18.90	69.70	96.60
40	F	2.70	5.40	23.20	15.60	9.50	13.60	16.40	82.90	105.80
41	M	3.30	7.10	29.40	22.20	13.10	16.30	19.10	74.60	96.80
42	M	2.00	6.40	31.70	22.80	14.10	17.50	20.60	86.90	98.50
43	M	2.80	7.30	26.80	18.40	11.00	15.80	21.40	97.30	109.30
44	M	2.00	4.30	27.00	20.30	13.20	13.80	18.40	83.40	99.80
45	M	2.80	5.80	27.60	21.20	13.30	14.30	18.90	74.90	94.90
46	M	2.00	3.90	28.60	18.20	13.10	15.50	19.20	76.90	96.50
47	M	1.50	4.70	28.80	17.80	11.90	16.90	19.80	93.60	101.50
48	M	3.30	4.20	29.20	20.40	12.80	16.40	21.70	68.50	91.40
49	M	1.20	1.40	26.30	17.10	11.80	14.50	18.50	79.50	90.00
50	M	2.10	5.40	27.90	18.30	10.90	17.00	20.60	84.50	98.60
51	M	1.70	3.40	26.70	18.40	11.70	15.00	19.60	88.00	101.70
52	M	1.90	1.30	28.90	20.90	12.70	16.30	21.40	89.40	100.10
53	M	1.90	3.60	27.20	17.90	11.30	15.90	19.70	78.30	93.90
54	M	2.20	3.60	28.50	19.10	11.20	17.20	19.60	76.50	94.00
55	M	2.30	4.60	28.90	18.10	12.00	16.90	17.70	76.50	97.60
56	M	4.20	7.60	32.50	25.70	11.40	21.10	24.90	75.20	93.30
57	M	2.70	4.70	27.80	20.60	13.10	14.80	19.60	84.20	102.50
58	M	2.90	5.80	28.30	20.50	13.70	14.60	17.00	91.70	109.90
59	M	3.00	4.90	25.10	16.60	10.30	14.70	19.80	74.40	94.90
60	M	2.90	5.70	29.70	22.30	15.70	14.00	16.80	81.80	103.50
61	M	3.10	3.30	27.50	18.40	10.40	17.10	16.90	78.40	98.80
62	M	2.30	3.30	23.70	16.30	9.30	14.40	19.30	89.60	102.70
63	M	2.30	4.90	26.80	19.50	13.50	13.30	17.70	71.20	92.50
64	M	3.10	4.10	26.10	19.00	12.50	13.70	18.20	87.50	109.30
65	M	2.40	4.30	25.60	17.60	10.10	15.60	18.40	75.50	96.20
66	M	3.80	2.70	32.20	23.50	14.20	18.00	21.60	68.80	91.10
67	M	2.00	4.60	24.40	16.40	12.40	12.00	22.10	82.60	103.10
68	M	3.40	7.70	31.80	23.20	13.40	18.40	22.30	80.00	98.40
69	M	1.60	4.30	28.60	18.80	14.10	14.50	18.50	85.50	100.50
70	M	2.10	5.60	26.60	17.90	10.90	15.70	17.60	93.40	107.40
71	M	2.70	3.70	28.60	19.10	13.50	15.10	18.70	81.70	103.10
72	M	3.30	5.70	28.70	18.80	9.40	19.20	22.60	77.30	97.00
73	M	2.60	6.70	25.90	20.40	12.00	13.90	20.40	90.30	104.30
74	M	4.30	4.50	27.00	20.10	8.70	18.30	25.10	71.70	92.40
75	M	2.60	6.50	24.80	16.80	11.10	13.70	18.50	77.70	99.30
76	M	2.40	6.40	28.40	19.00	11.50	16.80	20.00	86.10	102.50
77	M	3.90	7.70	27.60	20.00	10.00	17.60	20.80	77.70	99.20
78	M	1.60	6.50	29.90	19.90	12.40	17.40	20.60	90.10	99.80
79	M	0.90	3.20	28.60	17.90	14.00	14.60	16.50	94.80	104.10
80	M	1.50	2.90	25.00	15.30	9.10	15.90	19.10	90.30	98.80

M: male, F: female

IV.5 c Values for the nasal soft tissue variables measured in profile photographs in the group with Class I occlusion

N°		Angles					
	Gender	N´Prn/ *y*	N´MnPrn	MnStpPrn	CmSnLs	CmSn/ *y*	AcPrn/ *y*
1	F	23.00	9.60	0.00	115.00	66.40	69.70
2	F	26.60	5.10	8.30	110.00	84.80	73.30
3	F	34.80	7.80	-1.80	115.30	64.80	60.40
4	F	26.40	7.50	6.20	114.20	65.10	68.00
5	F	28.10	1.80	12.00	118.50	78.60	74.90
6	F	23.50	11.50	8.20	94.30	69.80	75.50
7	F	22.70	6.30	4.00	114.90	63.40	67.50
8	F	32.60	4.60	6.90	102.20	71.40	66.70
9	F	36.60	-10.20	10.80	105.60	74.50	74.00
10	F	17.10	14.70	0.30	98.70	75.70	68.30
11	F	23.60	14.00	8.80	116.90	70.20	66.40
12	F	22.20	3.30	14.10	118.20	72.00	71.70
13	F	21.00	-1.80	9.20	121.60	69.50	72.30
14	F	31.80	1.70	8.40	123.60	62.40	69.90
15	F	24.50	8.90	7.70	105.60	68.20	68.20
16	F	23.80	2.90	-2.10	114.60	82.60	75.40
17	F	22.00	11.30	-2.00	120.80	64.20	67.60
18	F	25.10	10.70	2.10	105.10	66.20	64.40
19	F	21.50	2.20	0.80	94.30	80.00	76.40
20	F	30.50	-1.40	5.40	108.70	67.30	65.70
21	F	25.10	15.50	17.40	124.10	56.60	66.90
22	F	27.50	7.30	14.70	97.00	78.50	71.90
23	F	27.40	-4.60	12.70	112.80	71.10	75.10
24	F	33.30	6.10	14.40	110.60	66.70	64.80
25	F	24.60	-5.00	5.50	98.20	77.20	74.10
26	F	27.80	13.90	14.40	100.70	63.90	66.30
27	F	28.60	12.00	7.30	107.10	70.80	66.40
28	F	20.40	-2.10	0.70	116.10	81.80	78.10
29	F	24.70	0.20	6.30	95.20	81.00	67.00
30	F	26.00	2.30	8.60	102.00	81.50	81.30
31	F	22.70	24.30	11.20	122.80	56.10	62.30
32	F	23.00	10.30	11.90	115.60	74.70	71.90
33	F	22.20	6.60	8.40	99.30	79.00	76.60
34	F	27.70	15.00	11.80	115.90	67.90	69.20
35	F	21.80	7.80	15.30	115.00	74.00	77.90
36	F	20.80	1.70	2.00	89.10	82.20	72.10
37	F	28.90	6.40	4.10	105.10	72.30	69.10
38	F	15.20	4.30	10.30	108.50	86.10	83.90
39	F	29.50	-3.80	9.80	118.70	78.30	66.30
40	F	20.40	10.00	9.30	105.60	76.70	67.20
41	M	26.00	-4.80	6.50	110.60	77.20	76.00
42	M	24.90	7.00	6.20	114.10	68.20	72.70
43	M	23.90	17.40	6.80	124.20	61.40	64.60
44	M	31.90	-8.20	10.50	123.90	61.10	68.00
45	M	32.10	-0.10	10.40	119.60	71.40	68.80
46	M	26.40	1.70	6.40	84.40	75.90	71.80
47	M	23.10	14.60	3.30	113.30	66.60	70.90
48	M	34.60	-3.40	7.40	100.30	75.50	68.60
49	M	32.10	5.00	6.00	112.00	68.20	72.90
50	M	27.70	2.10	3.30	111.00	67.80	66.60
51	M	25.30	16.10	16.80	116.80	66.20	68.50
52	M	25.50	16.50	6.40	100.90	66.40	68.80
53	M	26.90	7.50	6.80	103.80	75.20	71.20
54	M	23.00	-1.30	10.70	108.20	78.40	73.50
55	M	20.50	3.20	15.50	88.70	81.10	74.80
56	M	28.10	-3.50	11.90	117.50	74.30	75.70
57	M	30.20	-5.10	14.00	118.60	62.40	65.60
58	M	22.00	7.20	1.00	112.20	67.40	72.10
59	M	30.90	5.20	17.30	103.00	72.80	65.30
60	M	26.60	10.90	7.40	119.50	72.10	71.20
61	M	20.20	8.90	5.70	112.60	81.50	74.60
62	M	26.80	14.50	4.00	99.60	66.70	64.50
63	M	37.30	-6.70	14.00	110.80	67.80	71.20
64	M	25.00	6.00	0.70	110.80	68.60	63.70
65	M	24.60	-2.60	12.40	96.50	77.70	73.70
66	M	31.80	3.40	6.20	92.50	79.10	70.60
67	M	33.80	11.90	6.60	110.90	63.20	60.70
68	M	27.70	7.90	9.70	110.90	72.30	75.10

M: male, F: female

IV.5 c (continued)

N°		Angles					
	Gender	N´Prn/ *y*	N´MnPrn	MnStpPrn	CmSnLs	CmSn/ *y*	AcPrn/ *y*
69	M	27.20	11.90	14.10	119.30	66.70	70.80
70	M	19.30	8.60	9.40	129.90	67.00	69.50
71	M	24.70	17.50	8.90	103.70	75.60	69.10
72	M	20.70	-4.10	5.80	104.90	80.00	79.30
73	M	30.40	7.00	11.40	114.00	59.10	66.60
74	M	30.10	12.20	7.20	97.40	79.20	68.90
75	M	32.60	-0.90	13.40	114.60	67.20	68.20
76	M	26.30	-1.20	0.70	114.10	67.20	71.30
77	M	26.40	3.30	7.50	101.70	75.40	76.30
78	M	24.20	9.10	3.60	100.20	66.80	76.30
79	M	22.20	12.70	-5.30	111.00	66.00	74.70
80	M	24.00	19.80	-3.20	103.90	69.90	68.20

M: male, F: female

IV.6 a Values for the facial soft tissue variables and nasal skeletal and soft tissue variables measured in profile photographs and lateral cephalograms in the group with Class III occlusion

N°		Angles						Distances in mm				
	Gender	G´PrnPg´	G´SnPg´	N´Stp/ PrnPg´	N´Prn/ N´Pg´	NRh mm	N1N2Rh	N´Sn	N´Prn	Nd- N´Stp	Stp- N´Prn	Id- MnPrn
1	F	137.20	9.30	129.70	29.40	24.00	161.90	58.30	49.20	-1.10	1.20	1.40
2	F	142.30	8.20	134.00	27.50	23.10	160.50	52.20	46.50	-1.80	-0.10	0.80
3	F	148.70	0.90	142.30	23.10	20.70	169.10	53.20	46.50	-2.90	-1.00	1.90
4	F	143.90	6.00	139.90	23.90	20.50	179.50	58.00	52.10	-2.20	-1.50	1.40
5	F	148.40	7.10	141.30	22.90	22.40	175.60	52.20	46.90	-1.40	-0.30	1.00
6	F	154.80	-2.60	151.70	19.90	25.00	160.10	53.60	45.30	-1.90	-2.40	0.60
7	F	131.70	9.30	125.60	27.00	22.30	177.30	63.30	57.50	1.00	1.20	0.90
8	F	145.90	1.90	142.30	22.90	24.80	173.20	53.50	47.80	-2.10	-1.80	1.50
9	F	150.00	1.00	145.50	19.40	24.90	161.70	58.30	51.70	-2.60	-0.70	2.10
10	F	149.10	3.10	139.60	23.30	20.00	163.40	54.50	46.40	-0.80	0.90	0.80
11	F	147.10	-2.20	140.60	21.10	26.40	168.40	60.40	53.10	-0.70	0.30	0.80
12	F	147.70	7.90	139.00	24.20	22.80	168.60	53.90	44.70	-2.80	0.40	1.90
13	F	147.20	5.10	141.50	23.10	26.70	160.50	56.80	49.80	-0.90	-0.80	1.10
14	F	137.00	14.00	129.90	26.90	29.40	162.00	59.90	54.10	-2.60	0.50	1.10
15	F	149.40	2.50	143.90	22.80	22.10	169.40	52.80	43.00	-2.70	-1.50	1.10
16	F	140.90	6.80	131.40	26.20	20.80	173.40	54.10	48.60	0.20	1.60	1.00
17	F	139.30	10.60	130.50	29.50	21.70	163.90	51.80	46.00	-2.30	-0.10	1.30
18	F	141.00	13.10	136.30	25.50	23.20	180.00	56.40	48.70	-1.70	-0.20	1.00
19	F	136.20	14.10	129.30	29.30	23.90	165.70	58.70	52.00	-1.70	1.20	1.80
20	F	143.10	7.30	139.70	24.70	26.00	169.40	57.00	50.60	-0.80	-1.20	0.90
21	F	131.10	18.70	127.60	32.50	28.20	167.90	59.60	53.40	-0.80	-1.80	1.00
22	F	146.80	2.30	140.10	22.90	24.80	165.80	56.00	50.70	-1.30	-0.80	0.70
23	F	135.10	13.60	132.70	26.20	31.00	166.20	62.90	55.70	-0.50	-1.30	1.50
24	F	146.30	4.00	139.90	23.20	24.70	164.50	55.80	50.50	-3.40	-0.20	2.00
25	F	143.60	7.70	136.70	24.10	23.60	164.40	56.20	50.10	-2.50	-0.60	1.60
26	F	148.50	6.60	143.40	19.60	29.30	170.20	59.80	54.10	0.10	-0.10	0.90
27	F	144.50	6.60	136.00	24.90	25.70	163.40	59.50	52.30	-0.30	0.90	1.20
28	F	145.60	9.40	135.20	24.90	22.70	172.60	52.60	49.00	-1.80	1.00	1.90
29	F	147.90	4.80	141.40	23.80	25.20	175.20	56.50	49.50	-1.90	-1.50	1.80
30	F	146.10	7.60	137.30	27.10	22.40	160.30	53.10	46.70	-2.70	-1.30	1.60
31	F	146.20	10.30	138.30	24.70	18.20	158.60	52.00	44.10	-2.00	0.30	0.80
32	F	150.60	3.50	148.60	20.20	21.10	166.10	54.00	46.40	-1.90	-2.20	1.40
33	F	148.80	4.50	146.00	21.10	23.30	170.60	60.60	50.50	-2.90	-1.60	1.00
34	F	148.90	2.90	146.30	22.50	20.10	175.40	50.90	44.20	-2.60	-2.90	1.30
35	F	151.00	-0.60	143.60	19.70	23.10	165.10	62.50	56.10	-1.00	-1.00	1.00
36	F	147.80	2.00	143.50	21.10	24.50	171.50	56.20	48.50	-1.80	-0.30	0.60
37	F	155.40	-4.90	148.70	19.30	25.10	171.80	55.30	47.20	-2.60	-2.00	1.20
38	F	142.80	12.40	136.10	27.10	21.50	161.60	59.20	50.50	-0.60	0.30	1.10
39	F	141.60	5.60	135.60	23.90	24.60	172.10	58.50	52.10	-3.30	-0.30	1.50
40	F	149.20	5.60	141.50	22.10	25.70	164.60	58.20	49.50	-3.80	0.10	2.60
41	M	146.00	9.50	137.90	25.20	26.70	170.70	60.40	49.80	-2.10	-0.10	1.40
42	M	137.40	13.30	132.60	26.30	25.20	162.30	59.40	55.50	-0.60	0.60	1.00
43	M	137.90	10.90	131.60	26.90	28.80	161.70	65.90	61.00	-1.20	1.20	1.80
44	M	138.90	11.80	132.30	26.10	23.40	169.90	60.40	55.30	-0.50	1.20	1.20
45	M	144.40	7.90	134.10	27.30	23.20	160.50	57.60	51.30	-2.10	-0.20	1.70
46	M	145.10	3.60	143.00	22.10	29.60	164.90	66.80	59.50	-2.80	-0.70	1.50
47	M	151.40	2.80	146.90	19.60	23.70	167.00	55.90	50.50	-3.40	0.10	1.60
48	M	141.40	5.10	133.70	25.20	27.40	172.50	63.70	58.80	-3.50	0.20	2.20
49	M	159.20	16.30	142.20	18.50	17.90	167.80	59.90	55.90	-0.60	2.60	1.50
50	M	144.70	4.50	138.40	22.80	31.60	162.30	64.80	56.30	-2.10	-0.10	1.80

M: male, F: female

IV.6 a (continued)

N°		Angles						Distances in mm				
	Gender	G´PrnPg´	G´SnPg´	N´Stp/ PrnPg´	N´Prn/ N´Pg´	NRh mm	N1N2Rh	N´Sn	N´Prn	Nd- N´Stp	Stp- N´Prn	Id- MnPrn
51	M	141.60	9.20	137.90	26.20	20.30	175.60	60.30	52.00	-3.80	-0.70	1.60
52	M	151.70	-4.10	142.70	21.70	20.00	169.60	54.20	46.70	-3.00	0.90	1.30
53	M	148.80	1.70	143.50	25.80	18.60	163.50	51.00	43.20	-3.50	-1.90	1.50
54	M	143.00	10.50	134.90	28.50	20.70	170.90	62.00	52.80	-1.70	-0.60	1.10
55	M	152.60	-4.40	148.50	17.00	29.70	155.70	64.60	57.50	-0.50	0.70	1.30
56	M	140.70	8.60	133.30	27.80	23.40	151.30	58.70	53.60	-0.20	0.60	0.70
57	M	150.20	10.10	145.70	19.40	34.20	153.50	69.40	57.00	-0.60	0.50	0.70
58	M	145.70	8.90	137.70	26.00	21.20	167.00	56.20	48.00	-3.00	0.20	1.70
59	M	138.00	10.80	133.70	26.40	26.20	162.20	56.50	52.70	-1.50	0.20	1.80
60	M	150.80	3.00	146.60	21.30	21.50	168.30	56.50	48.60	-4.60	-0.90	1.60
61	M	148.70	-0.30	139.50	21.60	23.60	172.80	57.70	53.20	-1.00	0.50	0.80
62	M	140.30	5.20	138.30	26.00	27.10	178.90	63.00	55.10	-2.20	-1.90	1.90
63	M	135.20	16.10	126.50	29.70	28.70	171.40	60.30	54.60	-1.70	2.20	2.50
64	M	142.50	6.20	137.70	25.70	25.40	156.30	55.90	50.60	-0.90	-0.60	1.90
65	M	149.60	9.70	137.60	25.10	25.00	162.50	56.70	48.90	-2.80	0.80	1.70
66	M	157.00	-4.10	146.30	18.40	27.40	155.60	60.60	53.10	-0.30	1.20	1.60
67	M	138.20	15.50	134.00	29.10	24.70	166.60	55.90	50.00	-1.90	-1.30	1.50
68	M	140.00	13.90	136.40	26.70	23.40	164.30	57.20	51.70	-2.30	-0.90	1.60
69	M	138.50	9.50	135.20	25.80	28.70	174.30	64.60	60.30	-1.00	-0.60	1.80
70	M	138.50	13.90	131.70	29.20	22.40	166.70	59.10	50.40	-1.90	0.50	1.80
71	M	138.00	12.00	130.50	28.40	22.40	159.20	55.60	49.90	-1.70	0.40	1.40
72	M	147.90	1.90	140.20	24.80	21.10	149.40	56.30	47.80	-2.80	-0.80	2.20
73	M	134.30	20.40	123.60	32.90	25.40	161.20	62.90	55.10	-0.40	1.80	2.00
74	M	148.50	8.20	143.80	20.60	22.90	166.20	57.80	50.70	-5.20	0.10	1.80
75	M	143.00	9.50	140.00	24.50	21.20	167.80	56.10	49.90	-0.80	-1.30	1.00
76	M	142.60	8.80	141.50	23.30	27.00	157.70	61.40	54.80	-3.00	-1.50	1.80
77	M	141.60	15.60	134.50	24.80	25.90	163.40	58.40	53.90	-0.90	1.30	1.20
78	M	147.70	5.90	142.60	22.40	20.60	168.40	58.40	50.60	-0.70	-0.80	0.90
79	M	143.40	10.30	139.80	21.70	29.50	161.40	65.80	60.20	-0.60	0.00	1.00
80	M	137.90	15.90	130.40	28.10	20.80	149.00	56.90	52.20	-3.60	0.50	2.20

M: male, F: female

IV.6 b Values for the nasal soft tissue variables measured in profile photographs in the group with Class III occlusion

N°		Distances in mm						Angles		
	Gender	Cm- PrnSn	NrS- columella base	AcPrn	AcNrA	AcSn	SnPrn	SnN´Prn	N´Stp/SnCm	N´PrnSn
1	F	3.20	5.70	32.30	24.40	14.20	18.10	24.20	82.20	99.40
2	F	2.50	2.00	22.90	15.30	6.40	16.50	21.70	81.40	96.10
3	F	2.80	2.90	27.40	19.80	12.80	14.60	21.40	80.60	99.10
4	F	3.10	5.60	28.20	17.80	11.40	16.90	19.80	70.40	97.30
5	F	2.10	0.60	22.70	14.30	8.70	14.00	17.70	79.70	100.30
6	F	2.10	1.70	21.10	12.90	7.30	13.80	19.80	93.10	105.80
7	F	4.20	6.20	33.50	22.70	11.40	22.10	23.20	69.30	91.60
8	F	3.60	5.50	26.20	18.90	9.70	16.50	20.90	77.80	96.40
9	F	2.90	5.70	26.50	18.00	11.50	15.00	18.10	82.00	101.60
10	F	3.50	4.60	25.90	17.30	10.20	15.70	20.30	79.00	104.00
11	F	2.90	7.40	27.40	18.10	7.50	19.90	21.80	82.20	97.50
12	F	2.40	8.20	27.20	20.30	13.80	13.40	18.90	90.60	109.90
13	F	2.60	6.60	25.00	15.20	10.10	14.90	19.20	81.10	101.50
14	F	3.30	6.80	28.60	18.90	10.10	18.60	20.20	73.50	95.70
15	F	1.70	5.80	24.20	16.50	10.50	13.60	20.30	99.70	109.50
16	F	1.80	4.60	29.20	18.40	11.60	17.60	21.90	78.10	94.50
17	F	2.50	5.00	31.30	21.50	14.30	17.00	22.90	78.90	95.00
18	F	2.10	3.70	25.00	17.40	10.50	14.60	18.50	88.90	105.00
19	F	2.90	5.60	31.20	20.80	12.40	18.80	21.30	76.30	97.20
20	F	3.00	4.80	27.30	17.40	10.60	16.60	20.30	78.10	98.20
21	F	1.80	2.90	32.10	19.10	12.50	19.60	22.20	82.20	94.50
22	F	3.00	4.40	27.20	18.90	10.80	16.40	20.20	76.30	95.40
23	F	2.30	4.20	30.20	19.40	11.60	18.70	20.10	86.20	98.90
24	F	2.50	1.80	26.20	17.10	10.10	16.10	19.30	78.10	96.50
25	F	2.70	4.30	23.70	16.60	7.80	15.90	19.10	84.10	99.30
26	F	1.40	3.90	26.60	17.50	13.30	13.30	15.60	86.90	102.30
27	F	2.90	5.00	30.50	19.70	12.10	18.40	20.30	77.50	99.60
28	F	1.40	3.70	26.40	17.20	12.50	13.90	17.90	78.40	93.60
29	F	2.90	3.10	26.70	19.60	10.70	16.00	19.60	86.50	101.10
30	F	2.10	4.50	25.50	16.90	12.10	13.40	20.20	83.50	99.80
31	F	1.70	5.40	24.30	17.40	12.50	11.90	18.30	93.10	107.70
32	F	1.70	4.20	22.20	13.90	8.50	13.70	17.70	96.30	107.10

M: male, F: female

IV.6 b (continued)

N°		Distances in mm						Angles		
	Gender	Cm- PrnSn	NrS-columella base	AcPrn	AcNrA	AcSn	SnPrn	SnN´Prn	N´Stp/SnCm	N´PrnSn
33	F	2.10	5.30	26.70	19.00	11.70	15.00	18.30	100.20	110.30
34	F	2.80	4.10	22.10	13.50	8.10	13.90	19.50	81.90	102.60
35	F	3.30	6.70	25.60	16.10	8.20	17.40	18.40	77.10	99.10
36	F	2.00	2.80	26.00	15.50	9.50	16.50	19.80	86.10	103.00
37	F	2.70	4.70	22.20	13.70	6.90	15.30	19.40	87.60	105.00
38	F	1.80	7.40	27.50	16.80	11.40	16.20	20.00	90.40	104.10
39	F	3.70	6.40	25.10	19.50	8.00	17.10	20.40	80.10	97.60
40	F	1.90	5.60	24.30	16.80	9.40	14.80	18.10	94.80	107.80
41	M	1.40	5.00	26.80	18.40	12.00	14.70	19.10	101.50	110.10
42	M	3.30	4.00	31.20	21.00	13.90	17.20	18.90	64.80	92.10
43	M	3.30	4.60	33.80	24.40	13.40	20.40	20.50	73.80	91.70
44	M	2.30	3.70	24.60	16.90	5.70	18.90	20.30	79.70	93.80
45	M	3.50	6.40	26.90	18.60	11.50	15.40	20.20	73.50	97.80
46	M	3.30	4.30	34.50	22.00	13.30	21.10	20.10	78.20	98.10
47	M	2.40	3.20	27.80	17.20	12.40	15.40	17.40	71.60	99.90
48	M	3.10	5.90	29.70	18.70	9.80	20.00	21.20	73.10	91.30
49	M	2.20	3.70	32.90	19.60	12.20	20.70	22.80	67.30	88.20
50	M	4.20	5.90	29.80	21.50	12.20	17.60	19.90	80.80	101.80
51	M	2.30	5.70	31.70	22.20	14.40	17.30	20.70	89.50	101.70
52	M	1.70	4.20	27.80	17.30	12.30	15.50	22.70	83.70	99.00
53	M	2.10	4.00	27.70	17.90	12.80	14.90	22.80	87.80	100.90
54	M	1.10	6.20	34.10	23.10	17.20	16.90	21.10	96.70	102.70
55	M	3.00	5.70	30.30	19.70	11.70	18.60	18.70	76.30	100.30
56	M	4.30	3.30	33.40	24.30	15.00	18.40	22.10	65.40	92.20
57	M	2.40	5.00	27.70	15.50	12.20	15.50	14.10	102.80	121.40
58	M	2.60	5.30	28.60	19.90	13.70	14.90	19.50	84.20	104.80
59	M	2.30	2.90	30.20	20.50	12.30	17.90	20.20	74.50	90.70
60	M	1.70	5.10	29.10	21.00	13.90	15.20	18.80	94.30	104.70
61	M	2.70	4.30	28.10	18.50	10.70	17.40	20.00	76.80	92.90
62	M	4.50	6.50	29.90	20.50	9.80	20.00	22.50	79.80	97.30
63	M	3.60	6.20	31.80	24.70	13.20	18.60	20.60	73.30	95.00
64	M	2.80	7.20	28.90	21.20	11.90	17.00	21.80	79.00	93.60
65	M	2.00	3.70	25.20	18.00	12.80	12.50	16.90	88.40	108.00
66	M	2.80	6.00	25.40	16.90	9.40	16.00	18.20	81.70	103.20
67	M	1.80	4.00	31.80	21.90	16.30	15.50	19.80	85.40	97.90
68	M	3.00	2.70	28.40	19.60	12.40	16.00	19.30	77.80	97.10
69	M	3.80	4.10	32.70	21.50	11.80	21.00	20.80	69.80	90.30
70	M	2.70	5.40	29.60	19.40	13.40	16.30	21.40	81.70	102.30
71	M	2.70	4.70	30.00	18.50	13.20	16.80	21.40	69.50	95.30
72	M	2.20	6.20	28.80	20.00	13.00	15.90	21.90	88.40	101.70
73	M	2.30	5.60	30.50	21.30	14.80	15.70	20.90	82.70	99.20
74	M	2.00	3.50	24.00	17.60	11.10	12.90	16.00	91.50	107.20
75	M	3.00	3.80	25.10	17.50	10.10	15.00	19.20	81.70	99.60
76	M	2.20	3.30	29.80	19.00	12.90	17.00	18.50	85.00	100.00
77	M	2.20	3.10	23.70	15.60	10.80	13.00	15.60	75.00	98.40
78	M	2.20	5.20	25.60	17.50	11.60	14.00	18.10	90.60	105.20
79	M	2.30	4.00	29.70	17.90	14.20	15.60	16.00	79.40	99.50
80	M	1.70	4.40	30.20	19.60	14.10	16.10	19.00	78.70	94.90

M: male, F: female

IV.6 c Values for the nasal soft tissue variables measured in profile photographs in the group with Class III occlusion

N°		Angles					
	Gender	N´Prn/ *y*	N´MnPrn	MnStpPrn	CmSnLs	CmSn/ *y*	AcPrn/ *y*
1	F	32.20	-0.70	10.80	123.30	63.70	68.40
2	F	25.60	8.30	5.90	121.10	73.10	65.80
3	F	33.00	12.20	5.90	98.10	68.20	63.50
4	F	24.50	12.10	-1.10	81.60	87.30	75.70
5	F	20.00	6.90	2.90	101.90	80.70	68.70
6	F	27.10	15.90	-5.10	89.10	64.20	54.70
7	F	25.80	-7.30	0.50	113.10	83.10	80.40
8	F	24.70	15.80	-0.10	104.70	80.40	72.30
9	F	24.30	9.70	4.70	97.70	74.80	71.20
10	F	22.40	2.10	10.70	106.30	77.20	74.50
11	F	20.70	-1.00	1.30	101.60	76.80	78.70
12	F	30.90	11.60	15.30	123.60	57.80	61.60
13	F	26.90	6.00	1.70	87.30	73.30	68.90
14	F	21.30	6.20	9.10	106.30	84.70	80.10

M: male, F: female

IV.6 c (continued)

N°		Angles					
	Gender	N´Prn/ *y*	N´MnPrn	MnStpPrn	CmSnLs	CmSn/ *y*	AcPrn/ *y*
15	F	26.00	14.00	0.00	115.10	57.30	67.20
16	F	25.40	-5.00	11.20	112.60	74.20	75.50
17	F	27.90	8.80	6.60	106.10	73.30	74.40
18	F	23.30	6.90	5.00	132.50	68.00	62.60
19	F	21.60	1.40	11.50	95.00	80.40	73.60
20	F	25.20	5.10	-6.20	99.30	78.50	71.50
21	F	25.20	8.40	-4.40	117.20	75.30	67.80
22	F	27.40	7.70	-0.30	90.20	77.50	74.70
23	F	22.50	5.40	-4.40	120.40	73.20	79.90
24	F	23.20	11.90	11.50	99.70	79.10	66.80
25	F	21.90	10.50	4.50	104.80	74.90	68.70
26	F	23.80	-0.10	-0.90	118.20	69.40	73.80
27	F	18.90	-2.40	5.60	115.40	82.10	80.40
28	F	26.90	3.80	13.20	99.30	73.10	71.10
29	F	22.70	13.00	2.70	109.10	73.30	68.60
30	F	34.00	15.80	6.70	114.40	64.80	56.90
31	F	28.50	4.00	8.40	115.30	57.70	66.60
32	F	20.10	12.30	-4.50	115.00	67.80	68.50
33	F	21.90	12.90	1.80	115.80	60.60	65.80
34	F	24.20	20.30	-6.20	84.60	79.00	63.80
35	F	20.40	4.60	-3.90	65.20	84.00	73.90
36	F	19.50	6.90	4.10	109.30	74.80	70.10
37	F	21.40	18.00	0.50	104.30	74.50	71.90
38	F	25.30	0.50	3.60	131.90	63.70	71.50
39	F	26.20	8.80	5.90	106.40	74.10	74.80
40	F	21.00	10.50	13.10	114.80	64.10	72.40
41	M	25.60	7.90	6.70	121.80	53.00	65.10
42	M	24.10	-1.00	4.20	99.70	90.20	73.90
43	M	26.40	0.50	9.90	102.80	78.30	76.10
44	M	22.30	-2.10	7.90	92.40	76.40	76.30
45	M	33.00	7.00	6.00	98.80	73.80	63.80
46	M	16.30	10.90	4.50	105.00	86.20	78.70
47	M	14.90	11.50	11.20	89.50	93.30	78.30
48	M	28.90	10.30	11.20	97.00	77.70	72.20
49	M	28.70	-7.50	14.80	100.60	80.70	74.40
50	M	27.00	9.10	8.70	102.80	72.40	69.00
51	M	25.50	11.30	8.80	124.30	66.10	70.80
52	M	33.60	3.90	11.80	121.30	61.30	64.70
53	M	31.50	22.30	5.60	114.60	64.30	59.10
54	M	29.70	5.80	3.00	128.90	54.50	62.50
55	M	17.50	-1.20	4.50	91.40	85.30	77.80
56	M	31.30	-1.80	4.00	99.50	82.50	71.00
57	M	6.70	4.40	8.30	116.60	69.90	69.20
58	M	24.70	9.90	12.80	121.20	70.70	70.10
59	M	23.20	3.70	6.30	95.10	81.90	77.20
60	M	21.90	12.50	10.60	121.40	65.40	71.50
61	M	24.80	4.90	8.80	96.40	77.70	76.80
62	M	27.10	11.10	9.40	103.80	76.60	72.40
63	M	24.00	-3.10	16.70	113.40	79.20	74.70
64	M	31.20	4.10	0.00	105.80	70.90	72.90
65	M	25.80	7.90	15.90	111.10	64.50	58.50
66	M	21.40	-0.90	9.80	110.40	75.00	76.30
67	M	27.90	9.70	2.80	105.80	69.10	75.00
68	M	25.50	9.80	5.30	95.10	78.30	69.30
69	M	23.30	2.60	-1.50	83.80	87.80	75.30
70	M	30.10	1.20	9.10	112.80	67.20	65.30
71	M	28.20	5.10	8.70	100.70	81.60	73.60
72	M	30.60	12.00	11.00	101.60	62.50	66.40
73	M	37.30	-3.70	11.10	125.30	57.40	67.90
74	M	22.30	14.60	14.10	102.00	66.10	64.70
75	M	26.70	8.30	-0.70	98.20	73.80	71.60
76	M	20.90	10.60	1.70	99.10	76.40	74.40
77	M	26.80	-1.80	9.70	107.30	76.30	64.00
78	M	26.90	4.40	-2.80	113.40	63.70	61.70
79	M	22.90	1.20	1.50	118.10	77.60	77.60
80	M	25.00	7.10	10.90	122.60	75.50	75.00

M: male, F: female

Appendix V: Values of the variables measured in Chapter III

Influence of Le Fort 1 maxillary advancement osteotomy on nasal morphology in people with Class III skeletal malocclusions

V.1 a Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in skeletal variables measured in lateral cephalograms and soft tissue nasal variables measured in frontal photographs

N°			Distances in mm						Angle	Distances in mm			
	Gender	Surgery	A*x*	Pr*x*	B*x*	A*y*	Pr*y*	B*y*	SNPP	RR´	AlAl´	AcAc´	CmfCmf´
1	F	Bimaxillary	4.40	2.70	-4.10	0.30	1.00	-1.40	0.20	0.10	2.20	2.80	1.10
2	F	Bimaxillary	2.40	3.40	-3.40	-0.90	-1.50	-1.70	-0.60	-0.10	0.30	1.20	0.20
3	F	Bimaxillary	0.80	1.90	-1.00	-1.40	0.60	-5.60	-0.40	-0.50	1.80	1.90	0.30
4	F	Bimaxillary	1.30	1.20	-2.90	0.30	0.50	1.00	2.90	0.20	0.40	-1.00	0.70
5	F	Bimaxillary	2.10	3.00	-2.70	-1.10	-0.20	3.70	-3.10	-0.30	3.20	2.00	0.30
6	F	Bimaxillary	0.10	0.70	2.90	-3.70	-3.70	-4.80	-0.60	0.00	0.40	-0.30	-0.10
7	F	Bimaxillary	1.60	3.60	1.60	-2.90	-2.60	0.40	-1.70	0.20	2.20	4.10	1.10
8	F	Bimaxillary	3.20	2.70	-4.20	2.80	1.60	-0.50	-1.10	0.10	1.90	2.40	0.50
9	F	Bimaxillary with mentoplasty	3.50	3.10	-0.50	0.80	0.40	-0.70	-2.00	-0.10	2.80	3.00	0.50
10	F	Bimaxillary	2.70	3.70	-2.70	1.40	2.20	1.40	1.00	0.20	3.60	3.70	1.10
11	F	Bimaxillary	2.10	1.50	-4.50	0.60	0.00	-1.10	0.60	0.30	2.20	3.10	0.60
12	F	Bimaxillary	1.50	3.50	-4.90	0.40	0.60	-4.10	-0.10	-0.10	1.90	2.70	-0.10
13	F	Bimaxillary	0.40	-0.10	-9.20	0.90	0.60	0.80	-0.30	0.20	3.50	2.90	1.00
14	F	Bimaxillary	0.20	0.90	-3.80	1.10	0.90	6.60	1.00	0.00	2.90	3.70	0.40
15	F	Bimaxillary	3.40	3.40	-2.00	-1.50	-0.70	-3.70	1.80	0.30	1.60	1.00	0.20
16	F	Bimaxillary	3.20	3.90	-11.00	0.80	2.60	1.00	2.00	0.00	0.70	0.80	0.10
17	F	Bimaxillary	0.80	0.00	0.00	0.20	0.00	0.00	0.00	0.10	3.80	3.90	1.20
18	F	Bimaxillary	6.70	7.50	2.80	-1.60	-1.10	-4.60	-0.70	0.10	1.50	3.70	0.90
19	F	Bimaxillary	4.70	5.50	-1.70	2.00	1.50	-2.30	-0.40	0.30	0.20	0.70	1.20
20	F	Bimaxillary	1.90	2.00	-4.20	-1.70	-2.30	-5.10	-1.60	0.10	1.90	2.00	0.10
21	F	Bimaxillary	2.40	1.50	-3.00	1.40	1.00	-4.10	0.90	-0.20	1.70	2.70	0.80
22	F	Unimaxillary with mentoplasty	6.70	8.90	-0.90	0.00	-2.10	-7.30	-0.60	0.50	2.50	3.30	0.60
23	F	Unimaxillary with mentoplasty	3.10	2.20	1.30	0.30	-0.40	-0.50	3.50	0.00	2.60	2.80	0.00
24	F	Bimaxillary with mentoplasty	3.50	4.40	-0.50	-1.80	-0.60	-5.50	-3.10	-0.20	0.40	1.10	1.10
25	F	Unimaxillary with mentoplasty	9.60	9.80	6.50	-2.40	-3.80	-7.30	3.70	0.00	5.70	4.80	0.90
26	F	Bimaxillary	6.50	8.10	1.40	-3.60	-4.70	-10.20	0.30	-0.10	4.00	3.80	-0.10
27	F	Bimaxillary with mentoplasty	3.00	3.40	1.50	2.10	1.70	-4.60	-0.20	-0.20	5.40	5.00	0.20
28	F	Unimaxillary	3.10	4.40	1.00	0.90	1.40	-4.60	1.30	0.30	3.40	4.60	0.40
29	F	Unimaxillary	4.20	2.20	-12.30	1.70	0.50	-0.20	0.40	0.20	4.00	0.80	0.10
30	F	Unimaxillary with mentoplasty	7.60	7.20	3.90	-2.00	-2.30	-5.10	-2.00	-0.30	4.00	0.80	0.40
31	F	Bimaxillary with mentoplasty	2.00	2.60	-1.60	-0.60	-1.20	-7.00	-2.80	-0.10	2.60	3.10	0.00
32	F	Bimaxillary	0.30	2.80	-2.90	-1.80	-2.00	-2.40	0.90	0.00	3.10	2.40	0.90
33	F	Unimaxillary	3.30	3.10	0.70	1.90	-0.80	-2.00	1.10	0.30	0.90	1.60	0.10
34	F	Bimaxillary	3.20	3.70	-6.30	-0.80	0.10	0.50	2.00	0.10	2.50	1.10	0.00
35	F	Bimaxillary with mentoplasty	3.60	4.50	0.70	-0.90	-0.20	-5.00	0.70	0.00	1.90	3.90	0.50
36	F	Bimaxillary with mentoplasty	2.10	1.90	-2.30	1.40	-1.10	-9.10	-1.60	0.10	1.30	0.90	-0.20
37	F	Bimaxillary	6.70	8.20	2.00	-3.80	-2.80	-11.70	-1.70	0.10	5.20	4.50	0.50
38	F	Unimaxillary with mentoplasty	5.50	6.80	-0.60	2.70	2.60	-2.20	1.80	0.00	2.60	2.70	0.10
39	F	Bimaxillary	4.40	5.60	0.50	-3.30	-2.70	0.20	0.80	0.00	3.80	4.90	0.10
40	F	Bimaxillary	7.20	7.80	0.70	-2.70	-3.10	-3.50	-5.30	0.20	2.10	2.10	0.00
41	F	Bimaxillary	3.10	3.80	1.20	-3.80	-4.50	-6.00	2.10	0.00	2.80	2.60	0.00
42	F	Bimaxillary	7.10	7.00	-2.70	-2.10	-2.40	-2.40	-3.40	0.20	1.90	3.50	0.00
43	F	Bimaxillary with mentoplasty	2.70	4.20	-0.40	-3.80	-1.20	-2.00	-3.30	-0.10	0.70	2.10	0.40
44	F	Bimaxillary	3.20	5.90	4.60	-3.00	-4.90	-9.60	1.00	0.00	5.40	5.00	0.00
45	F	Bimaxillary with mentoplasty	4.10	2.40	-1.80	-1.70	1.00	-2.20	3.90	0.00	2.40	1.20	0.00
46	F	Unimaxillary with mentoplasty	6.60	5.70	2.60	0.30	-2.10	-1.00	2.50	-0.10	2.70	3.30	-0.10
47	F	Bimaxillary with mentoplasty	3.70	1.40	-2.70	-2.00	-0.40	-3.40	3.70	0.20	-0.60	0.00	0.20
48	F	Unimaxillary	7.50	6.30	0.00	-0.70	1.70	1.00	1.70	0.20	-0.70	-0.40	1.00
49	M	Bimaxillary	5.50	5.40	-5.40	1.00	1.70	-0.20	-2.40	0.10	0.10	-0.60	0.00
50	M	Bimaxillary	3.30	4.50	-2.80	-1.40	1.10	-3.20	3.00	0.30	3.70	2.20	0.10
51	M	Bimaxillary	1.20	0.90	-4.60	-2.10	-0.40	-3.50	-4.00	0.20	2.20	2.40	0.00
52	M	Bimaxillary	2.80	1.30	-2.10	-0.30	0.00	-1.00	1.30	-0.10	1.80	2.50	0.10
53	M	Bimaxillary with mentoplasty	8.30	8.20	3.80	-5.30	-5.40	-10.20	-1.50	0.20	1.30	1.30	1.00
54	M	Unimaxillary	3.10	3.80	2.00	-2.00	-2.20	-3.80	1.30	0.10	2.90	2.90	-0.10
55	M	Bimaxillary	1.20	1.70	-3.80	0.30	-3.60	-3.20	2.00	0.30	0.40	0.30	0.30
56	M	Bimaxillary	6.00	5.60	-2.40	-0.60	-1.30	-7.10	1.30	0.00	3.30	1.20	0.10
57	M	Bimaxillary	2.50	2.60	-6.40	0.00	0.70	-1.70	5.00	0.00	1.80	1.90	0.20
58	M	Unimaxillary	2.00	4.60	-1.30	4.50	2.80	1.30	1.20	0.10	3.70	3.70	0.10
59	M	Bimaxillary	2.40	2.60	-2.40	-0.80	0.60	-1.10	-3.30	0.00	1.00	1.20	0.20
60	M	Bimaxillary	3.40	3.70	-1.10	0.30	-1.40	-2.30	0.40	-0.20	2.90	1.60	0.50
61	M	Bimaxillary	0.40	1.60	-7.20	-2.90	-1.90	-3.00	3.70	-0.10	1.90	3.70	0.20
62	M	Bimaxillary	3.20	1.60	-0.40	-1.10	-0.30	-1.70	-1.20	-0.10	0.50	2.10	0.00

M: male, F: female

V.I a (continued)

N°			Distances in mm						Angle	Distances in mm			
	Gender	Surgery	A*x*	Pr*x*	B*x*	A*y*	Pr*y*	B*y*	SNPP	RR´	AlAl´	AcAc´	CmfCmf´
63	M	Bimaxillary with mentoplasty	3.70	3.00	-4.30	2.80	1.30	-4.80	3.90	-0.10	0.80	0.70	0.50
64	M	Unimaxillary	12.60	12.30	3.90	2.60	2.70	4.50	1.50	0.10	2.90	1.80	0.10
65	M	Unimaxillary	3.00	1.40	-1.20	-3.20	-1.80	-7.90	-3.00	0.10	2.10	0.90	0.70
66	M	Unimaxillary	7.60	7.00	1.10	-1.20	0.90	-1.20	-1.30	-0.20	4.90	5.30	0.40
67	M	Bimaxillary	6.00	5.10	-4.00	0.90	-0.80	0.80	0.60	0.20	2.50	2.70	0.10
68	M	Bimaxillary	2.60	3.30	-2.90	-4.30	-6.40	-9.10	-3.30	-0.10	1.00	2.70	0.10
69	M	Bimaxillary with mentoplasty	1.60	2.20	-0.20	0.90	-0.10	-6.40	-4.20	-0.10	0.40	-0.70	-0.20
70	M	Bimaxillary	4.70	5.30	-10.60	2.70	4.20	1.30	-1.50	-0.20	1.40	3.40	0.10
71	M	Bimaxillary with mentoplasty	0.80	0.50	-2.60	-1.80	-0.90	-3.10	3.40	-0.20	1.30	2.10	-0.10
72	M	Unimaxillary	5.50	6.90	-6.10	1.80	0.20	5.50	-3.00	0.10	3.20	2.50	0.30
73	M	Bimaxillary with mentoplasty	2.90	3.90	4.20	1.80	1.80	-0.50	5.20	-0.10	1.80	2.20	0.20
74	M	Unimaxillary with mentoplasty	6.20	6.60	-0.30	-1.40	-1.10	-0.70	0.40	0.10	1.90	1.40	0.50
75	M	Bimaxillary	3.80	2.20	-6.60	2.80	1.60	0.00	2.60	-0.10	0.80	1.60	0.10
76	M	Bimaxillary with mentoplasty	1.80	4.50	-2.50	-1.30	-0.20	-6.60	1.10	0.20	2.70	2.70	0.30
77	M	Bimaxillary	10.30	13.60	9.20	-4.20	-4.00	-3.70	-1.10	0.30	6.70	6.70	0.60
78	M	Bimaxillary	6.10	7.20	-10.40	0.00	-0.70	3.20	4.50	0.10	3.80	2.50	1.10
79	M	Bimaxillary with mentoplasty	0.60	0.00	0.90	-3.70	-4.30	-7.20	2.70	0.00	1.60	-0.30	0.00
80	M	Bimaxillary	4.10	4.40	-2.20	-0.80	-0.50	0.30	4.40	0.20	2.80	2.80	0.00

M: male, F: female

V.1 b Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in soft tissue nasal variables measured in frontal photographs

N°	Distances in mm											Ratio	
	SbalSbal´	SnfSbal	SnfSbal´	SnfAl	SnfAl´	CmfNrL	Cmf´Nrl´	Al-N´Prn	Al´-N´Prn	N´Prn	N´Snf	N´Prn/AlAl´	N´Snf/AlAl´
1	1.90	0.40	1.20	-0.90	1.90	0.10	0.40	-0.20	2.40	-0.20	0.40	-0.12	-0.13
2	3.90	0.90	3.00	-2.10	1.30	-0.10	2.00	-1.40	1.70	-2.50	-1.90	-0.08	-0.06
3	1.90	1.00	1.20	1.10	0.50	0.70	1.70	1.30	0.50	0.20	0.30	-0.05	-0.06
4	0.90	0.80	-0.10	1.30	-2.20	0.00	-1.60	1.60	-1.10	-3.40	-2.90	-0.12	-0.10
5	0.60	0.10	0.40	2.00	0.30	0.60	2.10	2.10	1.20	-0.50	1.80	-0.11	-0.07
6	0.70	-0.70	0.50	-1.40	3.40	-0.80	2.80	-1.80	2.20	-2.40	-1.30	-0.07	-0.05
7	3.60	1.00	2.50	1.40	0.60	0.40	-0.60	1.90	0.30	-3.30	-2.10	-0.16	-0.14
8	2.90	1.50	0.80	0.40	1.40	-0.90	0.80	0.50	1.40	-2.30	1.20	-0.13	-0.05
9	2.70	1.90	1.30	1.20	1.50	0.60	-1.10	1.60	1.20	0.10	0.70	-0.12	-0.14
10	1.70	2.00	1.40	4.60	2.30	2.90	-0.60	3.50	0.10	-0.90	4.40	-0.17	-0.05
11	2.20	0.70	1.30	0.20	0.90	-0.80	1.10	0.50	1.70	-3.90	-2.40	-0.23	-0.21
12	2.60	-0.10	2.70	0.00	1.70	1.50	1.30	0.00	1.90	-2.80	-1.10	-0.15	-0.12
13	1.10	-1.10	2.30	1.80	2.30	2.10	1.50	2.20	1.30	-1.10	3.30	-0.17	-0.07
14	0.10	0.70	-0.50	2.60	1.50	3.10	0.60	1.60	1.30	-0.20	5.00	-0.11	0.02
15	2.10	2.50	-1.00	0.80	-0.60	1.50	-0.20	1.80	-0.20	-1.00	1.10	-0.09	-0.05
16	2.20	2.10	-0.30	1.30	-0.40	1.40	-0.20	2.30	-1.70	-0.30	2.80	-0.03	0.05
17	1.30	1.00	0.40	3.60	3.30	0.70	0.70	2.40	1.40	-1.00	3.40	-0.18	-0.09
18	0.40	0.40	0.30	0.50	2.70	2.40	1.50	0.40	1.10	-0.30	2.70	-0.08	0.00
19	0.00	-1.00	1.20	-0.60	-0.70	-0.60	-0.40	-0.20	0.20	-2.30	-1.00	-0.07	-0.04
20	1.00	1.70	-0.80	1.90	-1.00	1.30	-0.30	1.30	0.50	-2.80	-2.80	-0.16	-0.18
21	2.20	2.10	-0.10	1.70	0.20	-0.60	-0.40	0.50	1.20	-0.40	0.80	-0.07	-0.05
22	3.90	1.80	2.10	1.60	1.60	-0.50	0.30	0.90	1.60	-4.20	-2.40	-0.23	-0.20
23	2.10	0.30	1.90	0.90	1.30	0.30	0.90	0.60	2.10	-3.30	-3.00	-0.17	-0.19
24	0.00	-0.60	0.70	-1.10	0.80	-0.30	-0.60	-0.90	1.30	-0.80	-0.80	-0.04	-0.05
25	3.60	-0.80	3.20	1.40	1.80	0.50	-0.50	2.90	2.80	-2.90	-5.50	-0.33	-0.47
26	4.30	1.70	2.50	1.50	0.80	1.70	1.30	-0.50	4.50	-3.20	-1.30	-0.28	-0.26
27	3.00	0.60	2.50	1.00	3.90	1.10	0.90	2.50	2.90	-2.80	-3.90	-0.26	-0.34
28	2.50	0.90	1.60	1.40	1.80	0.50	-0.30	2.20	1.30	-0.50	-0.40	-0.13	-0.16
29	0.70	1.30	-1.60	1.90	0.40	-0.30	0.10	2.80	1.20	-2.50	-0.20	-0.24	-0.21
30	1.70	0.80	0.90	1.10	1.50	1.70	0.80	2.00	2.00	-1.60	-1.80	-0.12	-0.15
31	1.80	1.80	-0.20	2.60	-0.50	2.50	1.50	1.80	0.90	-0.70	-0.80	-0.12	-0.15
32	2.10	2.50	-0.60	3.70	1.30	2.20	2.70	3.10	0.00	-0.30	5.10	-0.14	-0.01
33	3.80	2.60	1.30	1.40	0.20	-0.50	0.80	0.10	0.80	-0.10	3.10	-0.04	0.05
34	0.10	0.30	-0.70	1.40	-0.20	1.70	0.40	1.60	1.00	-0.90	1.80	-0.13	-0.07
35	1.10	1.00	-0.50	0.30	0.80	0.40	-0.50	1.10	0.80	-4.10	-4.00	-0.21	-0.22
36	1.80	0.70	1.10	0.90	-0.50	0.90	0.40	0.80	0.50	-0.70	0.40	-0.07	-0.05
37	1.60	1.00	0.90	2.10	4.60	2.00	2.40	3.30	1.80	0.00	1.90	-0.19	-0.18
38	-0.80	-0.90	-0.40	0.20	0.40	0.70	0.90	0.50	2.10	-1.70	-0.80	-0.17	-0.17
39	0.90	1.20	-0.30	3.20	0.50	3.20	1.30	3.70	0.20	-1.00	0.20	-0.18	-0.18
40	3.20	2.20	1.00	-1.40	1.30	0.00	0.00	0.90	1.20	-2.00	-1.90	-0.15	-0.16
41	0.60	-0.90	1.90	0.70	1.60	0.60	1.70	1.20	1.60	-0.30	1.00	-0.09	-0.08
42	1.40	0.00	1.40	-0.60	1.90	-1.40	1.30	-0.60	2.50	-0.70	0.60	-0.08	-0.06
43	0.70	-0.10	0.30	0.40	-0.20	1.40	0.30	0.00	0.70	-2.30	-1.90	-0.08	-0.08
44	2.60	0.90	0.60	2.90	3.10	0.10	3.20	2.50	2.90	-0.60	1.40	-0.25	-0.25
45	1.90	0.30	1.40	0.60	2.40	0.10	1.20	0.00	2.50	-0.30	3.10	-0.11	-0.03

V.1 b (continued)

N°	Distances in mm											Ratio	
	SbalSbal´	SnfSbal	SnfSbal´	SnfAl	SnfAl´	CmfNrL	Cmf´Nrl´	Al-N´Prn	Al´-N´Prn	N´Prn	N´Snf	N´Prn/AlAl´	N´Snf/AlAl´
46	0.40	0.20	-0.10	1.80	1.10	1.10	1.10	2.20	0.30	-1.60	-0.30	-0.15	-0.14
47	0.20	1.40	-1.20	-0.80	-0.10	-0.80	-0.10	-0.10	-0.60	-0.60	1.90	0.00	0.08
48	0.80	1.00	-0.20	0.10	-0.40	-0.60	-1.60	-0.30	-0.30	-0.70	1.20	0.00	0.06
49	0.30	-1.30	1.40	-0.30	-0.40	0.40	-1.20	-0.40	0.40	-3.60	-3.50	-0.09	-0.09
50	1.60	1.10	-0.10	1.30	1.30	1.00	0.80	2.80	0.90	-1.40	-0.40	-0.22	-0.23
51	4.20	2.90	1.50	2.40	1.90	1.80	2.10	2.60	-0.50	-0.90	1.00	-0.08	-0.04
52	2.60	1.20	1.50	-1.80	2.20	1.00	3.30	-1.50	3.20	-3.80	-4.20	-0.17	-0.19
53	0.20	2.60	-0.60	1.00	-0.40	0.40	-1.70	0.80	0.50	-0.20	-0.10	-0.04	-0.05
54	2.00	-0.30	2.00	1.20	3.40	1.10	2.40	-1.10	3.00	-0.60	3.70	-0.08	0.00
55	0.20	-0.60	0.70	-0.30	1.30	-1.10	0.70	0.30	0.20	-1.10	-0.50	-0.04	-0.03
56	0.50	-2.40	2.80	0.00	3.30	2.10	2.00	0.20	3.10	-3.00	-0.70	-0.16	-0.12
57	0.60	0.50	0.50	0.90	0.30	-0.50	0.60	1.00	0.80	-2.90	-1.60	-0.12	-0.10
58	1.00	2.30	-1.40	2.20	1.40	1.30	0.80	1.90	1.80	-0.60	3.50	-0.11	-0.04
59	1.70	-0.40	2.30	2.00	0.20	1.30	1.00	0.00	1.00	-0.90	2.70	-0.06	0.03
60	0.20	-1.40	-0.30	0.90	3.20	2.80	1.10	-0.20	2.90	-0.20	8.70	-0.07	0.13
61	0.00	0.40	-0.70	2.60	1.20	2.60	0.20	0.40	1.50	-0.30	3.40	-0.06	0.02
62	0.80	0.20	0.70	-0.20	0.40	-0.50	1.30	1.40	-1.00	-1.60	-0.30	-0.06	-0.03
63	0.00	-1.00	1.10	-1.20	1.20	0.70	0.30	-1.00	1.80	-0.60	-0.60	-0.04	-0.05
64	1.60	-0.90	2.50	0.40	2.10	0.10	1.20	0.70	2.20	-1.50	4.60	-0.11	0.02
65	1.60	3.40	-1.70	2.10	-1.80	1.70	-0.30	2.40	-0.40	-2.80	-5.70	-0.10	-0.18
66	1.80	0.60	1.00	2.00	2.70	0.60	-0.60	2.20	2.70	-0.90	1.00	-0.18	-0.17
67	1.00	0.30	-0.40	1.80	1.90	2.30	0.90	-0.10	2.60	-0.50	5.50	-0.07	0.05
68	-0.10	-0.60	0.50	-0.20	1.50	0.30	-0.40	-1.00	2.00	-0.10	1.60	-0.03	0.00
69	0.30	-0.50	0.70	-0.90	2.00	-0.20	1.40	1.40	-1.00	-2.30	0.80	-0.07	0.00
70	0.90	1.70	-0.80	1.70	-1.10	-0.40	0.90	0.80	0.50	-0.80	2.10	-0.07	0.00
71	2.10	0.40	1.70	1.80	-0.40	0.30	0.20	0.10	1.20	-0.90	0.20	-0.06	-0.04
72	0.50	0.10	0.60	1.10	2.00	1.90	0.40	2.10	1.10	-1.00	1.10	-0.11	-0.08
73	0.70	1.80	-1.10	1.70	0.60	1.50	0.10	1.20	0.60	-0.50	0.40	-0.06	-0.06
74	1.70	2.70	-0.90	1.70	0.80	0.80	0.40	1.90	0.00	-0.50	2.00	-0.06	-0.01
75	0.20	0.50	0.10	0.90	1.50	-0.20	0.90	0.30	0.60	-0.50	1.30	-0.03	0.01
76	1.40	0.00	1.50	1.80	1.20	1.50	2.30	0.20	2.40	-1.30	0.40	-0.11	-0.09
77	0.90	4.40	-3.60	4.40	2.80	4.80	4.70	4.20	2.40	-0.80	0.80	-0.19	-0.21
78	1.10	0.50	1.10	1.80	1.40	1.00	0.80	1.00	2.80	-0.80	0.70	-0.12	-0.11
79	2.20	0.10	1.60	1.10	0.00	-0.80	-1.00	1.80	-0.20	-3.50	-3.70	-0.10	-0.12
80	1.10	-0.30	0.50	1.70	2.50	0.70	2.30	0.40	2.50	-0.50	5.30	-0.09	0.03

V.1 c Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in soft tissue nasal variables measured in frontal photographs

N°	Angles in frontal photographs			
	AlPrnAl´	AlN´Al´	N´AcSnf´	AlSnfAl´
1	10.00	1.40	-3.60	8.90
2	10.20	0.80	-3.20	6.50
3	-0.40	1.60	-2.50	1.90
4	11.60	2.00	-6.30	7.10
5	15.70	1.20	-4.10	6.50
6	-6.70	3.40	4.70	-11.10
7	8.00	4.30	-0.60	2.60
8	17.70	1.10	-3.60	1.40
9	1.30	2.70	-4.50	2.80
10	15.80	2.40	-3.80	-6.30
11	16.10	3.30	-5.90	7.70
12	10.20	2.90	-0.90	2.30
13	21.90	1.90	2.60	-1.00
14	18.70	0.60	3.40	-6.70
15	21.70	-0.10	-4.00	7.50
16	14.70	-1.10	2.00	-1.90
17	7.00	3.90	3.20	-10.40
18	5.60	1.20	6.20	-9.10
19	19.60	-0.40	0.20	9.50
20	5.50	3.40	-6.40	7.90
21	3.20	1.60	-0.60	-0.60
22	3.00	4.90	-3.70	-2.50
23	2.20	4.20	-7.00	5.30
24	4.60	0.30	-2.30	6.50
25	-9.00	7.90	-5.40	13.90
26	20.00	4.60	-1.80	11.40
27	-11.30	7.80	-7.80	6.10

V.1 .c (continued)

N°	Angles in frontal photographs			
	AlPrnAl´	AlN´Al´	N´AcSnf´	AlSnfAl´
28	-2.10	4.10	0.20	3.50
29	21.70	3.50	-6.20	11.10
30	4.90	4.10	-8.70	9.40
31	-0.30	3.40	-5.70	4.30
32	19.40	1.40	4.40	-8.30
33	13.70	-0.50	1.50	-4.70
34	23.60	0.80	-1.30	7.90
35	3.90	4.10	-6.30	5.10
36	12.80	0.20	-7.00	7.50
37	-5.90	5.20	0.60	-5.80
38	18.00	2.30	-1.60	12.10
39	4.80	3.80	-4.30	3.60
40	16.80	1.70	-0.80	17.20
41	7.70	1.80	-3.80	5.10
42	9.10	1.10	1.10	5.60
43	2.80	1.50	-6.10	1.70
44	1.00	5.50	4.60	-0.70
45	14.50	1.00	3.20	-3.10
46	4.90	3.60	1.90	1.20
47	17.50	-2.30	3.00	1.00
48	10.00	-1.50	3.40	-2.00
49	6.10	1.80	-1.80	4.80
50	9.60	3.20	-7.00	8.00
51	-5.40	3.90	2.60	-11.00
52	5.70	3.60	-4.10	11.80
53	6.10	0.30	-7.60	8.80
54	6.80	2.30	7.60	-11.00
55	0.40	1.40	2.40	-2.60
56	9.30	3.70	-2.70	1.70
57	9.90	2.80	-1.20	4.70
58	18.80	1.00	0.30	2.20
59	13.00	0.20	2.30	-5.50
60	29.90	-2.80	3.40	-12.20
61	4.50	1.40	3.10	-11.50
62	8.70	0.50	2.60	1.40
63	3.20	0.60	-1.80	5.20
64	10.20	-1.20	1.20	4.20
65	-7.50	6.50	-1.60	7.40
66	5.50	4.50	-5.60	3.60
67	17.80	-0.40	3.40	-7.10
68	4.70	0.20	0.80	-2.10
69	11.30	0.50	0.20	-3.90
70	22.10	-0.80	-0.80	5.40
71	3.20	1.40	-2.10	-0.30
72	7.70	2.30	-5.10	1.50
73	-0.60	1.90	-4.50	-2.00
74	8.10	0.90	0.80	-2.00
75	-0.50	1.40	4.60	-7.10
76	5.40	3.30	1.60	0.50
77	-2.40	6.90	3.80	-0.40
78	8.20	2.50	-7.10	5.90
79	1.70	4.00	-4.00	4.40
80	11.80	1.00	3.60	-13.80

V.2 a Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in soft tissue nasal variables measured in lateral cephalograms and profile photographs

N°	Distances in mm												
	N´Sn	N´Prn	RhRh´	Nd- N´Stp	Stp- N´Prn	Id- MnPrn	Cm-PrnSn	NrS-columella base	Prn*x*	Sn*x*	AcPrn	AcNrA	AcSn
1	0.00	0.00	0.10	-0.30	-0.60	0.00	0.10	-0.40	1.00	2.20	-2.10	-2.20	-1.10
2	-1.50	-0.10	0.60	0.20	-0.50	0.90	0.90	0.40	-0.50	1.20	-3.00	-1.50	-1.20
3	0.70	0.00	0.20	-0.40	-0.60	-0.60	-0.10	-0.30	1.10	1.70	0.10	0.70	0.70
4	-1.20	-0.40	-0.20	0.40	-0.20	-0.50	0.40	0.50	-0.80	0.70	1.30	-0.20	2.70
5	-0.20	0.90	-0.20	0.90	0.50	0.10	0.10	1.20	0.10	0.60	-0.50	-2.50	-0.10
6	-1.40	-3.00	-1.20	0.40	-2.40	-1.40	0.10	-1.40	-1.30	-0.20	-4.30	-4.80	-3.10
7	-0.80	-0.30	-0.10	-0.40	-1.20	-0.30	1.30	-1.50	-0.50	1.80	-4.50	-2.10	-2.20
8	0.40	-0.60	0.60	-0.80	-1.20	0.10	0.00	0.10	4.30	7.20	-3.40	-2.20	-0.50
9	0.80	-1.00	1.00	0.60	-0.70	-0.60	-0.30	-0.50	2.20	2.20	-0.80	-0.80	-0.80
10	1.50	-0.10	1.60	0.40	-0.90	-0.70	0.80	1.40	2.40	3.40	1.90	1.60	2.90

V.2 a (continued)

N°	Distances in mm												
	N´Sn	N´Prn	RhRh´	Nd- N´Stp	Stp- N´Prn	Id- MnPrn	Cm-PrnSn	NrS-columella base	Prn*x*	Sn*x*	AcPrn	AcNrA	AcSn
11	-1.10	-2.10	-0.90	-0.20	-0.90	-0.60	0.10	-0.30	0.40	1.30	-1.90	-1.20	-1.00
12	-1.50	-0.30	0.20	0.80	0.10	0.00	0.70	-0.20	-0.30	0.50	0.20	-0.20	1.20
13	0.60	0.60	0.00	0.00	0.20	-0.80	0.40	0.60	-0.80	0.60	1.10	0.10	2.40
14	-1.80	-1.70	0.30	-0.90	0.00	-0.50	0.20	-0.50	0.40	2.00	-0.30	0.60	1.40
15	0.40	-1.90	-0.40	-6.60	-0.30	-0.60	0.50	2.30	2.60	3.80	-3.60	-2.90	-2.30
16	2.30	1.10	-0.10	0.50	-0.50	-0.50	0.50	0.30	0.30	0.50	-1.10	-0.80	-1.10
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	-0.70	0.10	1.50	-0.60	0.20	0.10	0.30	-1.10	3.40	2.70	-0.90	-2.10	-2.50
19	-0.10	-2.10	-1.40	0.20	-1.60	-0.60	0.20	-0.20	0.90	2.40	-1.80	-0.20	-0.20
20	-1.70	-1.30	0.70	0.00	0.10	0.10	0.10	-0.80	0.40	0.80	1.00	1.30	1.30
21	-0.50	-1.30	-0.50	-1.00	-0.80	-0.60	-0.10	0.10	-0.40	0.60	-1.70	-2.20	-0.70
22	-3.70	-2.50	-0.10	-0.30	-1.30	0.40	-0.50	-0.30	-0.70	2.50	-3.20	-3.00	-0.10
23	-1.40	-1.70	-0.60	-0.10	-0.30	-1.10	-0.90	0.20	-0.30	1.50	-2.10	-1.90	-0.40
24	-0.70	-0.60	0.30	0.80	0.70	-0.60	1.00	-0.20	-0.20	0.30	-3.30	-2.30	-2.70
25	-1.50	-0.20	1.10	-0.40	-1.70	0.00	0.70	0.20	3.40	5.10	-2.40	-1.40	-0.60
26	-1.80	-2.10	0.60	-0.20	-1.10	-0.50	1.00	-0.90	0.60	-0.20	-3.90	-3.10	-4.70
27	-1.40	-2.00	-1.50	-0.50	0.30	-0.40	0.00	0.80	0.20	0.60	-3.80	-3.80	-3.30
28	-0.40	-0.30	-0.20	-0.80	-0.10	-0.50	-0.50	-0.70	0.50	0.30	-1.80	-2.50	-1.80
29	0.90	-0.20	-0.10	-1.10	-1.00	-0.20	-0.20	-0.10	0.70	0.10	0.30	-0.70	-0.30
30	-0.20	-2.10	-0.70	-1.40	-0.20	-0.20	-0.50	2.00	1.70	3.40	-3.00	-2.90	-1.30
31	-2.00	-1.10	0.50	0.00	-0.70	0.40	0.00	-0.60	0.30	1.80	-4.30	-2.70	-2.70
32	-0.10	-1.60	0.10	-1.30	-0.30	-0.30	0.30	0.30	1.00	2.70	-2.80	-2.10	-1.20
33	0.70	0.50	-0.90	0.20	-2.00	0.10	-0.20	-0.20	0.70	0.90	-0.40	0.30	-0.20
34	-1.10	0.50	0.30	-0.20	-0.20	0.60	-0.60	0.10	0.70	2.30	-1.70	-1.30	0.00
35	-0.60	-0.40	0.10	0.80	-0.50	-0.10	0.50	-0.20	0.50	0.10	-0.90	-1.40	-1.30
36	-0.40	-0.50	1.20	0.00	-0.30	-0.30	0.00	0.30	2.10	2.60	-3.60	-2.90	-3.10
37	-1.90	0.50	1.30	0.00	0.10	0.00	0.10	-0.10	1.40	1.80	-6.00	-5.40	-5.50
38	-0.50	-0.60	-0.70	-0.40	-0.20	-0.20	-0.50	0.40	0.70	1.70	-2.40	-1.80	-1.30
39	-0.10	1.20	0.10	-0.40	-0.60	0.40	-0.10	0.70	2.40	2.70	-4.80	-5.00	-4.50
40	-1.00	-0.90	-0.70	-0.10	-0.60	-0.70	0.10	0.00	0.20	0.90	-3.80	-3.30	-2.90
41	-2.00	-2.80	0.00	0.50	-1.30	-0.50	1.30	-0.20	0.70	2.00	-3.10	-2.20	-1.80
42	-0.80	-0.60	0.30	-1.00	-1.30	-0.40	0.20	0.10	1.10	2.60	-2.40	-2.30	-1.00
43	-0.80	-1.10	-1.00	-0.30	-0.60	-0.60	-0.10	0.60	1.60	3.20	-2.70	-2.00	-1.10
44	0.50	-0.40	-0.60	-0.80	-1.50	-0.80	0.60	0.10	-0.20	1.20	-2.10	-1.60	-0.70
45	0.00	-0.50	-0.30	-2.10	0.40	-0.20	-0.50	-0.70	2.00	3.50	-4.20	-3.90	-2.70
46	-2.20	-2.40	0.90	-0.50	-0.90	-0.30	-0.50	0.60	1.50	3.80	-3.40	-2.60	-1.20
47	0.70	1.10	-0.50	0.80	0.20	0.60	-0.20	0.30	1.30	3.30	-2.50	-1.20	-0.60
48	-1.90	-1.50	0.00	-0.20	-1.50	0.00	-0.90	1.20	1.40	4.20	0.40	0.90	3.20
49	0.60	-1.10	-0.50	0.20	-0.60	-0.40	-0.20	0.60	0.90	4.00	-4.10	-3.10	-1.20
50	-0.40	-1.50	-0.60	-0.50	-0.90	-0.60	1.10	0.00	0.90	2.00	-3.50	-3.40	-2.40
51	1.10	0.70	0.20	-0.70	-0.10	0.70	0.40	-0.90	1.50	2.50	-1.20	-0.50	-0.20
52	-1.60	0.40	-0.50	-1.40	-1.80	-0.20	-0.20	0.40	0.10	3.60	-4.40	-3.60	-0.70
53	-1.20	-1.20	-0.50	0.10	-0.80	-0.60	0.20	0.00	0.10	0.80	-5.30	-4.20	-4.60
54	0.50	0.20	-0.30	0.20	0.40	0.00	0.60	-1.40	1.00	1.80	-3.30	-0.80	-2.60
55	0.00	-1.20	1.10	-0.30	-1.30	0.20	-0.50	0.00	0.70	0.70	2.10	1.40	2.00
56	-0.70	-1.30	0.00	-1.20	-0.50	-0.20	0.00	0.90	0.70	1.80	-0.10	0.90	0.90
57	0.80	0.00	-0.60	-0.30	-1.20	-0.30	0.00	0.50	-0.20	0.20	0.40	-0.20	0.80
58	1.80	0.70	-0.80	-0.30	-0.40	-0.90	1.00	0.30	2.40	3.40	0.00	-0.70	1.20
59	0.60	-0.30	0.50	1.40	-1.10	0.40	0.90	-0.80	-0.70	-0.30	-1.80	-1.10	-1.50
60	-1.00	-1.90	-0.70	-2.40	-2.00	-1.30	1.00	-1.70	1.50	1.60	-0.30	-1.40	-0.20
61	-0.10	-0.20	0.30	-0.20	-0.50	0.40	0.40	0.00	-0.70	-0.20	-2.40	-1.50	-1.80
62	0.30	-0.20	0.50	-0.90	-0.70	-0.30	0.70	-0.50	2.80	4.10	-2.70	-0.30	-1.40
63	-1.20	0.70	0.20	-1.00	-0.40	-0.30	0.00	0.00	0.90	1.10	-1.20	-1.60	-0.80
64	-1.10	-0.40	-1.00	-0.60	-1.70	0.00	-1.00	-0.30	4.00	6.20	-5.90	-5.80	-3.80
65	-1.40	0.30	0.10	-1.50	0.00	0.30	-0.90	0.00	0.10	0.40	-5.10	-5.80	-4.80
66	-0.30	1.40	0.10	0.70	-0.20	0.30	-0.10	0.10	0.40	3.40	-3.20	-3.10	-0.30
67	-0.50	-0.50	0.80	-0.50	-0.30	0.10	0.10	0.10	1.30	1.70	-0.40	1.00	-0.10
68	-1.70	-2.00	0.20	0.10	-1.30	-0.30	-0.20	0.00	0.10	0.60	-5.20	-4.00	-4.40
69	-1.30	-1.10	-0.50	4.30	-0.20	-0.20	0.40	0.40	0.20	0.00	-0.30	-0.20	-0.60
70	0.60	1.00	-0.60	1.00	0.50	-0.30	-0.20	0.20	0.90	0.80	-0.40	-1.60	-0.40
71	-0.40	-2.00	-0.40	-0.50	-1.70	-1.20	-0.10	0.00	0.70	2.50	-1.90	-2.20	0.00
72	-1.60	-4.00	0.60	-0.60	-2.10	-0.70	0.10	-0.10	0.40	3.00	-3.10	-2.80	-0.70
73	0.80	1.70	0.40	0.30	0.00	-0.20	-0.70	0.20	1.70	1.90	-3.80	-2.40	-3.60
74	-0.20	0.20	-0.10	0.40	-0.10	0.00	0.00	1.00	0.90	1.30	-3.60	-3.20	-3.10
75	1.10	-0.80	-1.40	-0.30	-1.00	0.10	0.10	0.20	-0.60	0.70	-2.20	-1.70	-0.90
76	-1.20	-1.40	1.20	0.30	0.00	-0.10	-0.20	0.70	1.20	1.30	-2.80	-3.40	-2.80
77	-1.40	0.60	1.10	0.00	0.60	0.50	1.00	0.50	2.30	2.70	-5.40	-5.00	-5.10
78	0.20	-1.50	0.10	-0.70	-0.40	-0.70	0.30	2.10	1.70	3.00	-1.30	-1.40	0.00
79	-1.80	-1.10	-0.30	0.90	-1.40	-1.20	0.20	0.30	0.00	1.40	-2.40	-3.00	-0.90
80	0.80	1.60	-0.30	0.40	-0.20	0.00	0.40	0.70	2.10	2.10	0.00	-0.40	0.00

V.2 b Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in soft tissue nasal variables measured in profile photographs (continuation)

N°	Distances in mm			Angles									
	SnPrn	Prn*y*	Sn*y*	SnN´Prn	N´Stp/ SnCm	N´PrnSn	N´Prn/*y*	N´MnPrn	MnStpPrn	CmSnLs	CmSn/ *y*	AcPrn/ *y*	SnCmIn
1	-1.00	0.20	-0.20	-1.20	0.00	1.50	-0.50	2.60	-3.20	-4.60	1.40	-3.50	1.40
2	-1.80	0.10	-1.80	-2.00	-8.10	-1.40	-0.90	0.20	-3.80	-17.30	9.90	5.50	15.30
3	-0.60	-0.50	0.10	-0.60	2.60	2.20	0.60	2.80	-3.30	9.50	-2.20	-1.70	1.00
4	-1.40	-0.20	-1.00	-1.40	-9.80	-0.30	1.90	-0.80	-3.10	2.30	8.50	-2.80	7.90
5	-0.30	-1.30	-1.30	0.00	-10.20	-3.00	4.20	-1.10	4.20	-12.80	5.20	-4.20	9.00
6	-1.20	-3.50	-1.40	0.80	2.70	3.80	2.90	6.30	-14.90	1.40	-1.60	-10.30	-0.40
7	-2.30	-1.10	-1.60	-2.30	-5.10	1.70	-0.10	4.80	-8.20	-8.40	7.10	-6.30	18.20
8	-2.90	-2.20	-0.50	-1.80	5.60	5.40	3.60	4.20	2.30	0.40	-7.10	-10.40	1.30
9	0.00	-2.70	0.30	1.20	4.80	2.90	4.10	-0.20	-6.50	3.40	-7.80	-7.50	-1.50
10	-1.00	-1.10	1.10	-0.50	-1.00	4.00	1.40	0.80	-5.40	4.80	0.60	-5.60	13.80
11	-0.90	-2.20	-1.00	0.00	4.10	3.80	1.00	3.10	-6.20	4.00	-3.80	-5.00	-5.60
12	-0.90	-1.00	-1.30	-0.20	-12.70	-2.70	3.10	-2.70	-2.20	-11.20	9.50	-0.60	17.40
13	-1.40	0.20	0.40	-1.50	-5.40	1.80	0.70	-1.60	-0.70	10.60	4.10	-0.60	3.80
14	-1.60	-1.00	-1.70	-1.30	-0.80	1.80	-0.70	0.10	1.70	1.30	1.60	0.40	4.10
15	-1.20	-2.40	0.00	-0.30	4.30	6.60	0.70	4.30	-3.90	4.60	-3.60	-4.40	2.20
16	0.00	0.30	1.90	-0.10	0.20	3.20	0.90	-0.20	-4.60	-2.10	-0.50	-3.10	-1.30
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	1.60	0.40	-0.20	1.60	-5.80	-4.50	1.30	-0.40	1.80	-41.10	4.20	0.50	-1.80
19	-1.60	-2.20	-0.10	-0.70	6.60	6.60	1.00	5.40	-8.30	-2.40	-5.10	-9.00	5.80
20	-0.30	-1.70	-1.90	0.20	-1.90	-1.00	0.80	-0.10	0.80	-5.60	1.00	1.10	0.00
21	-1.10	-1.20	-0.60	-0.30	4.70	2.80	1.10	7.90	-0.40	10.50	-4.20	-2.50	-7.10
22	-3.30	-2.70	-3.10	-1.70	2.30	1.40	2.70	8.30	-3.60	-12.60	-2.80	-2.90	7.10
23	-1.70	-1.10	-0.80	-1.00	7.00	2.80	0.70	4.00	-2.10	8.30	-7.30	-2.80	-9.70
24	-0.60	-1.20	-1.30	-0.40	-3.80	0.60	-0.10	-3.70	-0.40	-14.40	2.90	-4.50	15.80
25	-1.70	-1.20	-1.40	-1.20	-7.70	-2.30	3.00	6.40	-4.10	-10.50	7.10	-2.30	7.50
26	0.80	-2.70	-1.90	1.60	-6.30	-1.10	1.30	4.10	-4.80	-22.90	6.30	-6.10	0.20
27	-0.30	-2.50	-1.10	0.90	0.00	0.70	2.80	0.00	-2.30	-9.70	-3.50	-7.40	-1.90
28	0.20	0.00	-0.60	-0.20	2.60	-0.10	-1.30	2.40	-0.30	3.60	-1.10	0.60	-4.50
29	0.60	-0.50	1.00	1.00	4.90	2.10	1.00	1.20	-7.20	7.00	-4.80	-7.30	-5.50
30	-1.80	-2.80	-0.20	-0.60	-0.40	6.40	2.90	6.10	5.40	-0.40	-2.30	-4.50	-3.70
31	-1.60	-1.20	-2.30	-1.10	0.80	-0.40	0.30	3.80	-2.10	-0.50	-0.10	-2.30	-0.30
32	-1.70	-2.20	-0.30	-0.60	2.40	5.60	2.50	5.80	-0.10	4.00	-4.60	-10.50	5.60
33	-0.20	0.40	0.70	-0.30	6.40	1.10	0.30	5.50	-10.00	-4.30	-3.80	-0.20	-6.50
34	-1.70	0.00	-1.80	-2.70	-0.50	-0.90	0.00	-0.60	-3.20	0.90	0.70	-0.90	-7.60
35	0.40	-2.20	-1.20	1.10	-5.00	-1.90	3.50	0.70	-3.80	-13.80	2.20	-4.40	6.80
36	-0.60	-1.30	-0.90	-0.10	1.90	0.40	1.60	1.70	-0.40	0.70	-3.00	-3.40	-2.40
37	-0.40	0.40	-1.90	-0.50	-4.60	-5.40	0.00	0.40	3.20	-6.70	4.60	0.80	5.50
38	-1.00	-0.20	-0.20	-0.90	2.80	1.20	0.10	2.30	0.20	-10.80	-2.40	-3.00	0.30
39	-0.20	0.00	-0.60	-0.30	-2.60	-2.90	1.90	5.10	-0.30	-10.10	1.70	-1.50	-6.30
40	-0.80	-1.30	-1.10	-0.30	2.10	0.30	1.30	4.50	-2.10	-9.40	-2.50	-5.20	-9.10
41	-1.30	-4.50	-2.50	1.10	-4.20	1.20	4.60	4.70	-3.10	-13.80	2.00	-6.30	11.80
42	-1.50	-1.10	-0.90	-0.80	0.80	1.10	2.20	3.90	-7.00	-12.40	-1.10	-2.00	4.20
43	-1.60	-2.50	-1.10	-0.30	1.10	1.40	4.00	2.10	-2.60	15.10	-4.30	-6.30	-1.40
44	-1.40	0.10	0.20	-1.40	-1.30	4.10	-1.10	9.10	-7.90	-17.90	4.60	0.30	8.00
45	-1.50	-0.90	-0.10	-1.20	2.30	3.60	1.00	3.60	3.60	9.30	-3.80	-5.30	-8.30
46	-2.10	-3.50	-2.60	-0.80	4.80	2.70	3.60	2.00	-5.90	9.70	-7.00	-5.90	-8.40
47	-1.90	0.00	0.60	-1.40	3.00	0.90	4.10	-5.00	-0.40	-3.20	-7.60	-4.50	-5.00
48	-2.80	-1.70	-2.00	-2.00	4.80	2.10	1.10	2.50	-5.60	5.80	-3.80	-0.60	-7.20
49	-3.00	-2.30	-0.30	-1.60	5.60	6.40	2.90	1.80	-2.10	13.20	-7.60	-12.20	-2.70
50	-1.00	-2.10	-0.50	0.00	-2.90	2.70	1.70	3.00	-4.00	-4.60	2.60	-5.80	9.70
51	-0.90	0.40	0.80	-1.10	1.60	2.10	0.10	4.40	2.80	5.30	-1.60	0.30	12.80
52	-3.50	0.80	-1.10	-3.40	-0.40	-0.10	0.70	5.20	-9.80	-6.80	2.40	-1.50	9.80
53	-0.80	-2.90	-2.00	0.50	0.40	-0.40	3.30	1.60	-5.10	-3.60	-2.10	-4.40	-4.50
54	-0.70	-2.70	-0.70	0.50	-1.10	0.50	5.30	-2.40	0.90	-9.40	-4.90	-8.40	-0.50
55	0.00	-1.40	-0.40	0.40	12.30	2.90	-0.90	1.40	-7.40	0.00	-9.10	1.10	-14.00
56	-1.00	-1.10	-0.20	-0.40	2.80	2.40	0.90	5.10	-2.10	2.80	-3.20	-4.00	-4.20
57	-0.40	0.10	0.70	-0.70	-6.30	3.30	-0.90	3.00	-5.70	-4.70	9.10	-3.20	8.30
58	-1.50	-1.70	0.50	0.00	-10.20	1.80	4.30	1.70	-1.60	-7.10	6.40	-6.40	11.80
59	-0.40	-1.50	0.10	0.60	-4.00	1.50	2.60	-1.70	-7.80	0.30	2.90	-4.20	2.70
60	-0.10	-1.10	-0.50	0.40	-0.90	2.00	-0.70	10.50	-2.00	-11.20	5.10	-3.90	3.60
61	-0.50	0.10	-0.40	-0.90	-1.30	1.40	-1.30	4.50	-1.90	-1.60	3.30	1.00	12.10
62	-1.30	-1.30	-0.50	-0.60	-0.50	2.60	2.30	4.50	-0.40	-4.40	-1.00	-7.60	7.80
63	-0.50	0.00	-1.70	-0.70	-5.60	-3.50	0.40	0.90	-4.10	3.90	5.90	-0.40	6.60
64	-2.20	-2.00	-1.90	-1.30	4.60	0.30	3.50	6.60	-8.00	-13.30	-5.60	-6.00	-3.80
65	-0.30	0.80	-1.10	-0.60	2.70	-2.50	-0.20	5.60	6.10	3.70	-2.40	-2.20	3.40
66	-2.90	-0.70	-1.80	-2.90	-2.70	-0.60	1.90	3.90	0.90	-13.10	1.10	-4.10	3.80
67	-0.30	-0.60	-0.30	0.10	4.40	-0.40	2.60	1.20	0.30	1.50	-6.70	-2.30	-11.00

V.2 b (continued)

N°	Distances in mm			Angles									
	SnPrn	Prn*y*	Sn*y*	SnN´Prn	N´Stp/ SnCm	N´PrnSn	N´Prn/*y*	N´MnPrn	MnStpPrn	CmSnLs	CmSn/ *y*	AcPrn/ *y*	SnCmIn
68	-0.70	-4.00	-2.60	1.00	4.60	-0.10	3.40	1.60	-9.20	-3.00	-6.60	-4.30	-8.10
69	0.20	-1.40	-1.20	0.80	-5.30	-1.10	1.30	4.40	1.00	1.00	4.30	0.80	4.30
70	0.10	0.20	0.50	0.10	-2.00	-1.80	2.90	-4.30	-0.20	5.30	-1.80	-2.80	-5.40
71	-1.80	-2.00	-0.40	-1.10	4.00	6.80	0.10	6.20	-4.60	10.40	-1.10	-3.80	-3.50
72	-2.50	-3.80	-1.70	-0.60	5.10	8.20	1.20	11.10	-6.20	6.40	-3.30	-10.20	-1.50
73	-0.20	1.30	1.00	-0.40	4.50	-2.10	2.00	-0.10	0.20	2.30	-6.60	-3.20	-6.80
74	-0.40	-1.40	-1.00	-0.10	0.50	-1.00	2.50	-0.10	-1.50	-5.20	-2.60	-4.80	-1.70
75	-1.30	-0.40	1.00	-0.70	4.80	5.30	-0.60	3.30	-2.90	2.40	-2.50	-4.00	2.80
76	0.00	-2.00	-1.20	0.90	2.00	-0.40	2.30	-1.00	-1.70	4.30	-4.20	0.90	-5.60
77	-0.30	0.70	-1.30	-0.70	-12.50	-4.30	0.60	-1.00	3.50	-30.10	11.10	0.40	8.60
78	-1.30	-2.30	-0.30	-0.20	0.70	5.40	1.70	2.50	-2.10	18.60	-1.90	-5.30	6.10
79	-1.50	-0.70	-1.40	-1.00	-6.50	0.50	0.40	1.10	-11.20	0.10	8.00	-3.10	1.90
80	0.00	0.20	0.20	-0.10	-5.80	-2.20	2.20	-2.20	-3.00	-7.40	3.90	-0.80	5.60

Appendix VI: Values of the variables measured in chapter IV

The influence of Le Fort 1 maxillary advancement osteotomy on the aesthetic evaluation of the nose in subjects with Class III skeletal malocclusions

VI.1 a Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in skeletal facial variables in lateral cephalograms and soft tissue nasal measurements in frontal photographs

N°			Distances in mm				Angle	Distances in mm			
	Gender	Surgery	A*x*	Pr*x*	A*y*	Pr*y*	SNPP	AlAl´	AcAc´	CmfNrL	Cmf´Nrl´
1	F	Unimaxillary	4.20	2.20	1.70	0.50	0.40	4.00	0.80	-0.30	0.10
2	F	Unimaxillary with mentoplasty	7.60	7.20	-2.00	-2.30	-2.00	4.00	0.80	1.70	0.80
3	F	Bimaxillary	4.40	2.70	0.30	1.00	0.20	2.20	2.80	0.10	0.40
4	F	Bimaxillary	0.30	2.80	-1.80	-2.00	0.90	3.10	2.40	2.20	2.70
5	F	Unimaxillary	3.30	3.10	1.90	-0.80	1.10	0.90	1.60	-0.50	0.80
6	F	Bimaxillary	3.20	3.70	-0.80	0.10	2.00	2.50	1.10	1.70	0.40
7	F	Bimaxillary	0.40	-0.10	0.90	0.60	-0.30	3.50	2.90	2.10	1.50
8	F	Bimaxillary with mentoplasty	3.60	4.50	-0.90	-0.20	0.70	1.90	3.90	0.40	-0.50
9	F	Bimaxillary	2.10	3.00	-1.10	-0.20	-3.10	3.20	2.00	0.60	2.10
10	F	Bimaxillary with mentoplasty	2.10	1.90	1.40	-1.10	-1.60	1.30	0.90	0.90	0.40
11	F	Unimaxillary with mentoplasty	5.50	6.80	2.70	2.60	1.80	2.60	2.70	0.70	0.90
12	F	Unimaxillary with mentoplasty	6.60	5.70	0.30	-2.10	2.50	2.70	3.30	1.10	1.10
13	F	Bimaxillary with mentoplasty	1.30	3.40	0.70	-0.70	1.50	0.70	0.00	-0.80	-1.50
14	F	Bimaxillary	2.10	2.40	-1.40	2.00	-1.60	3.90	3.40	1.90	2.20
15	F	Unimaxillary with mentoplasty	6.70	8.90	0.00	-2.10	-0.60	2.50	3.30	-0.50	0.30
16	F	Bimaxillary	4.40	5.60	-3.30	-2.70	0.80	3.80	4.90	3.20	1.30
17	F	Bimaxillary	2.70	3.70	1.40	2.20	1.00	3.60	3.70	2.90	-0.60
18	F	Bimaxillary	7.20	7.80	-2.70	-3.10	-5.30	2.10	2.10	0.00	0.00
19	F	Unimaxillary with mentoplasty	3.10	2.20	0.30	-0.40	3.50	2.60	2.80	0.30	0.90
20	F	Bimaxillary with mentoplasty	3.50	4.40	-1.80	-0.60	-3.10	0.40	1.10	-0.30	-0.60
21	F	Bimaxillary	7.10	7.00	-2.10	-2.40	-3.40	1.90	3.50	-1.40	1.30
22	F	Bimaxillary	3.40	3.40	-1.50	-0.70	1.80	1.60	1.00	1.50	-0.20
23	F	Bimaxillary	1.60	3.60	-2.90	-2.60	-1.70	2.20	4.10	0.40	-0.60
24	F	Unimaxillary with mentoplasty	9.60	9.80	-2.40	-3.80	3.70	5.70	4.80	0.50	-0.50
25	F	Bimaxillary	6.50	8.10	-3.60	-4.70	0.30	4.00	3.80	1.70	1.30
26	F	Bimaxillary	2.40	1.50	1.40	1.00	0.90	1.70	2.70	-0.60	-0.40
27	F	Bimaxillary with mentoplasty	3.00	3.40	2.10	1.70	-0.20	5.40	5.00	1.10	0.90
28	F	Unimaxillary	3.10	4.40	0.90	1.40	1.30	3.40	4.60	0.50	-0.30
29	F	Bimaxillary	3.20	5.90	-3.00	-4.90	1.00	5.40	5.00	0.10	3.20
30	F	Bimaxillary with mentoplasty	0.80	2.80	-4.80	-5.80	-3.80	3.10	3.20	0.20	-0.20
31	F	Bimaxillary with mentoplasty	2.70	4.20	-3.80	-1.20	-3.30	0.70	2.10	1.40	0.30
32	F	Bimaxillary	0.20	0.90	1.10	0.90	1.00	2.90	3.70	3.10	0.60
33	F	Bimaxillary	0.80	0.00	0.20	0.00	0.00	3.80	3.90	0.70	0.70
34	F	Bimaxillary	0.80	1.90	-1.40	0.60	-0.40	1.80	1.90	0.70	1.70
35	F	Bimaxillary	4.70	5.50	2.00	1.50	-0.40	0.20	0.70	-0.60	-0.40
36	F	Bimaxillary	1.90	2.00	-1.70	-2.30	-1.60	1.90	2.00	1.30	-0.30
37	F	Bimaxillary	2.10	1.50	0.60	0.00	0.60	2.20	3.10	-0.80	1.10
38	F	Bimaxillary	1.50	3.50	0.40	0.60	-0.10	1.90	2.70	1.50	1.30
39	F	Bimaxillary	6.70	7.50	-1.60	-1.10	-0.70	1.50	3.70	2.40	1.50
40	F	Bimaxillary	1.30	1.20	0.30	0.50	2.90	0.40	-1.00	0.00	-1.60
41	F	Bimaxillary	3.20	2.70	2.80	1.60	-1.10	1.90	2.40	-0.90	0.80
42	F	Bimaxillary with mentoplasty	3.50	3.10	0.80	0.40	-2.00	2.80	3.00	0.60	-1.10
43	M	Unimaxillary	12.60	12.30	2.60	2.70	1.50	2.90	1.80	0.10	1.20
44	M	Unimaxillary	3.00	1.40	-3.20	-1.80	-3.00	2.10	0.90	1.70	-0.30
45	M	Unimaxillary	7.60	7.00	-1.20	0.90	-1.30	4.90	5.30	0.60	-0.60
46	M	Bimaxillary	4.70	5.30	2.70	4.20	-1.50	1.40	3.40	-0.40	0.90
47	M	Bimaxillary with mentoplasty	0.80	0.50	-1.80	-0.90	3.40	1.30	2.10	0.30	0.20
48	M	Unimaxillary	5.50	6.90	1.80	0.20	-3.00	3.20	2.50	1.90	0.40
49	M	Bimaxillary with mentoplasty	3.70	3.00	2.80	1.30	3.90	0.80	0.70	0.70	0.30
50	M	Bimaxillary with mentoplasty	2.90	3.90	1.80	1.80	5.20	1.80	2.20	1.50	0.10
51	M	Unimaxillary	3.10	3.80	-2.00	-2.20	1.30	2.90	2.90	1.10	2.40
52	M	Bimaxillary	2.50	2.60	0.00	0.70	5.00	1.80	1.90	-0.50	0.60
53	M	Bimaxillary with mentoplasty	2.30	1.30	0.50	-0.10	2.50	1.50	0.70	0.10	-1.10
54	M	Bimaxillary with mentoplasty	8.30	8.20	-5.30	-5.40	-1.50	1.30	1.30	0.40	-1.70
55	M	Bimaxillary with mentoplasty	1.80	4.50	-1.30	-0.20	1.10	2.70	2.70	1.50	2.30
56	M	Bimaxillary	6.00	5.60	-0.60	-1.30	1.30	3.30	1.20	2.10	2.00
57	M	Bimaxillary	3.20	1.60	-1.10	-0.30	-1.20	0.50	2.10	-0.50	1.30
58	M	Bimaxillary	3.30	4.50	-1.40	1.10	3.00	3.70	2.20	1.00	0.80
59	M	Bimaxillary	0.40	1.60	-2.90	-1.90	3.70	1.90	3.70	2.60	0.20
60	M	Bimaxillary	1.20	1.70	0.30	-3.60	2.00	0.40	0.30	-1.10	0.70
61	M	Bimaxillary	4.10	4.70	-4.50	-4.70	-5.70	0.60	1.80	0.80	0.30

M: Male, F: Female

VI 1 b Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in soft tissue nasal variables measured in frontal photographs (continuation)

N°	Distance in mm		Angles		
	Bilateral dorsal axis-alare symmetry	N´Prn	AlPrnAl´	AlN´Al´	AlSnfAl´
1	1.60	-2.50	21.70	3.50	11.10
2	0.00	-1.60	4.90	4.10	9.40
3	-2.60	-0.20	10.00	1.40	8.90
4	3.10	-0.30	19.40	1.40	-8.30
5	-0.70	-0.10	13.70	-0.50	-4.70
6	0.60	-0.90	23.60	0.80	7.90
7	0.90	-1.10	21.90	1.90	-1.00
8	0.30	-4.10	3.90	4.10	5.10
9	0.90	-0.50	15.70	1.20	6.50
10	0.30	-0.70	12.80	0.20	7.50
11	-1.60	-1.70	18.00	2.30	12.10
12	1.90	-1.60	4.90	3.60	1.20
13	-0.60	-3.30	6.00	2.50	7.00
14	-0.70	-2.00	2.50	6.20	0.00
15	-0.70	-4.20	3.00	4.90	-2.50
16	3.50	-1.00	4.80	3.80	3.60
17	3.40	-0.90	15.80	2.40	-6.30
18	-0.30	-2.00	16.80	1.70	17.20
19	-1.50	-3.30	2.20	4.20	5.30
20	-2.20	-0.80	4.60	0.30	6.50
21	-3.10	-0.70	9.10	1.10	5.60
22	2.00	-1.00	21.70	-0.10	7.50
23	1.60	-3.30	8.00	4.30	2.60
24	0.10	-2.90	-9.00	7.90	13.90
25	-5.00	-3.20	20.00	4.60	11.40
26	-0.70	-0.40	3.20	1.60	-0.60
27	-0.40	-2.80	-11.30	7.80	6.10
28	0.90	-0.50	-2.10	4.10	3.50
29	-0.40	-0.60	1.00	5.50	-0.70
30	-0.20	-1.00	2.00	3.50	8.60
31	-0.70	-2.30	2.80	1.50	1.70
32	0.30	-0.20	18.70	0.60	-6.70
33	1.00	-1.00	7.00	3.90	-10.40
34	0.80	0.20	-0.40	1.60	1.90
35	-0.40	-2.30	19.60	-0.40	9.50
36	0.80	-2.80	5.50	3.40	7.90
37	-1.20	-3.90	16.10	3.30	7.70
38	-1.90	-2.80	10.20	2.90	2.30
39	-0.70	-0.30	5.60	1.20	-9.10
40	2.70	-3.40	11.60	2.00	7.10
41	-0.90	-2.30	17.70	1.10	1.40
42	0.40	0.10	1.30	2.70	2.80
43	-1.50	-1.50	10.20	-1.20	4.20
44	2.80	-2.80	-7.50	6.50	7.40
45	-0.50	-0.90	5.50	4.50	3.60
46	0.30	-0.80	22.10	-0.80	5.40
47	-1.10	-0.90	3.20	1.40	-0.30
48	1.00	-1.00	7.70	2.30	1.50
49	-2.80	-0.60	3.20	0.60	5.20
50	0.60	-0.50	-0.60	1.90	-2.00
51	-4.10	-0.60	6.80	2.30	-11.00
52	0.20	-2.90	9.90	2.80	4.70
53	1.60	-2.70	6.90	2.50	2.80
54	0.30	-0.20	6.10	0.30	8.80
55	-2.20	-1.30	5.40	3.30	0.50
56	-2.90	-3.00	9.30	3.70	1.70
57	2.40	-1.60	8.70	0.50	1.40
58	1.90	-1.40	9.60	3.20	8.00
59	-1.10	-0.30	4.50	1.40	-11.50
60	0.10	-1.10	0.40	1.40	-2.60
61	1.80	-2.10	4.90	1.30	1.20

VI 2 Changes caused by the Le Fort 1 maxillary advancement osteotomy (T3-T2) in soft tissue nasal variables measured in profile photographs

N°	Distances in mm											Angles	
	N´Sn	N´Prn	Nd-N´Stp	NrS-Columella base	Prn*x*	Sn*x*	AcPrn	AcNrA	SnPrn	Pr*y*	Sn*y*	MnStpPrn	AcPrn/y
1	-0.20	0.90	-1.10	-0.10	0.70	0.10	0.30	-0.70	0.60	-0.50	1.00	-7.20	-7.30
2	-2.10	-0.20	-1.40	2.00	1.70	3.40	-3.00	-2.90	-1.80	-2.80	-0.20	5.40	-4.50
3	0.00	0.00	-0.30	-0.40	1.00	2.20	-2.10	-2.20	-1.00	0.20	-0.20	-3.20	-3.50
4	-1.60	-0.10	-1.30	0.30	1.00	2.70	-2.80	-2.10	-1.70	-2.20	-0.30	-0.10	-10.50
5	0.50	0.70	0.20	-0.20	0.70	0.90	-0.40	0.30	-0.20	0.40	0.70	-10.00	-0.20
6	0.50	-1.10	-0.20	0.10	0.70	2.30	-1.70	-1.30	-1.70	0.00	-1.80	-3.20	-0.90
7	0.60	0.60	0.00	0.60	-0.80	0.60	1.10	0.10	-1.40	0.20	0.40	-0.70	-0.60
8	-0.40	-0.60	0.80	-0.20	0.50	0.10	-0.90	-1.40	0.40	-2.20	-1.20	-3.80	-4.40
9	0.90	-0.20	0.90	1.20	0.10	0.60	-0.50	-2.50	-0.30	-1.30	-1.30	4.20	-4.20
10	-0.50	-0.40	0.00	0.30	2.10	2.60	-3.60	-2.90	-0.60	-1.30	-0.90	-0.40	-3.40
11	-0.60	-0.50	-0.40	0.40	0.70	1.70	-2.40	-1.80	-1.00	-0.20	-0.20	0.20	-3.00
12	-2.40	-2.20	-0.50	0.60	1.50	3.80	-3.40	-2.60	-2.10	-3.50	-2.60	-5.90	-5.90
13	0.80	-0.20	0.50	0.10	1.30	1.90	-1.30	-1.70	-0.60	0.10	-0.50	-10.60	-1.90
14	-0.30	0.10	0.10	0.10	0.30	0.70	-0.50	-2.20	-0.40	-0.80	-0.10	19.10	-2.80
15	-2.50	-3.70	-0.30	-0.30	-0.70	2.50	-3.20	-3.00	-3.30	-2.70	-3.10	-3.60	-2.90
16	1.20	-0.10	-0.40	0.70	2.40	2.70	-4.80	-5.00	-0.20	0.00	-0.60	-0.30	-1.50
17	-0.10	1.50	0.40	1.40	2.40	3.40	1.90	1.60	-1.00	-1.10	1.10	-5.40	-5.60
18	-0.90	-1.00	-0.10	0.00	0.20	0.90	-3.80	-3.30	-0.80	-1.30	-1.10	-2.10	-5.20
19	-1.70	-1.40	-0.10	0.20	-0.30	1.50	-2.10	-1.90	-1.70	-1.10	-0.80	-2.10	-2.80
20	-0.60	-0.70	0.80	-0.20	-0.20	0.30	-3.30	-2.30	-0.60	-1.20	-1.30	-0.40	-4.50
21	-0.60	-0.80	-1.00	0.10	1.10	2.60	-2.40	-2.30	-1.50	-1.10	-0.90	-7.00	-2.00
22	-1.90	0.40	-6.60	2.30	2.60	3.80	-3.60	-2.90	-1.20	-2.40	0.00	-3.90	-4.40
23	-0.30	-0.80	-0.40	-1.50	-0.50	1.80	-4.50	-2.10	-2.30	-1.10	-1.60	-8.20	-6.30
24	-0.20	-1.50	-0.40	0.20	3.40	5.10	-2.40	-1.40	-1.70	-1.20	-1.40	-4.10	-2.30
25	-2.10	-1.80	-0.20	-0.90	0.60	-0.20	-3.90	-3.10	0.80	-2.70	-1.90	-4.80	-6.10
26	-1.30	-0.50	-1.00	0.10	-0.40	0.60	-1.70	-2.20	-1.10	-1.20	-0.60	-0.40	-2.50
27	-2.00	-1.40	-0.50	0.80	0.20	0.60	-3.80	-3.80	-0.30	-2.50	-1.10	-2.30	-7.40
28	-0.30	-0.40	-0.80	-0.70	0.50	0.30	-1.80	-2.50	0.20	0.00	-0.60	-0.30	0.60
29	-0.40	0.50	-0.80	0.10	-0.20	1.20	-2.10	-1.60	-1.40	0.10	0.20	-7.90	0.30
30	-2.70	-2.90	-0.10	-0.90	0.00	2.30	-6.90	-5.40	-2.40	-3.20	-3.30	25.20	-8.60
31	-1.10	-0.80	-0.30	0.60	1.60	3.20	-2.70	-2.00	-1.60	-2.50	-1.10	-2.60	-6.30
32	-1.70	-1.80	-0.90	-0.50	0.40	2.00	-0.30	0.60	-1.60	-1.00	-1.70	1.70	0.40
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.70	-0.40	-0.30	1.10	1.70	0.10	0.70	-0.60	-0.50	0.10	-3.30	-1.70
35	-2.10	-0.10	0.20	-0.20	0.90	2.40	-1.80	-0.20	-1.60	-2.20	-0.10	-8.30	-9.00
36	-1.30	-1.70	0.00	-0.80	0.40	0.80	1.00	1.30	-0.30	-1.70	-1.90	0.80	1.10
37	-2.10	-1.10	-0.20	-0.30	0.40	1.30	-1.90	-1.20	-0.90	-2.20	-1.00	-6.20	-5.00
38	-0.30	-1.50	0.80	-0.20	-0.30	0.50	0.20	-0.20	-0.90	-1.00	-1.30	-2.20	-0.60
39	0.10	-0.70	-0.60	-1.10	3.40	2.70	-0.90	-2.10	1.60	0.40	-0.20	1.80	0.50
40	-0.40	-1.20	0.40	0.50	-0.80	0.70	1.30	-0.20	-1.40	-0.20	-1.00	-3.10	-2.80
41	-0.60	0.40	-0.80	0.10	4.30	7.20	-3.40	-2.20	-2.90	-2.20	-0.50	2.30	-10.40
42	-1.00	0.80	0.60	-0.50	2.20	2.20	-0.80	-0.80	0.00	-2.70	0.30	-6.50	-7.50
43	-0.40	-1.10	-0.60	-0.30	4.00	6.20	-5.90	-5.80	-2.20	-2.00	-1.90	-8.00	-6.00
44	0.30	-1.40	-1.50	0.00	0.10	0.40	-5.10	-5.80	-0.30	0.80	-1.10	6.10	-2.20
45	1.40	-0.30	0.70	0.10	0.40	3.40	-3.20	-3.10	-2.90	-0.70	-1.80	0.90	-4.10
46	1.00	0.60	1.00	0.20	0.90	0.80	-0.40	-1.60	0.10	0.20	0.50	-0.20	-2.80
47	-2.00	-0.40	-0.50	0.00	0.70	2.50	-1.90	-2.20	-1.80	-2.00	-0.40	-4.60	-3.80
48	-4.00	-1.60	-0.60	-0.10	0.40	3.00	-3.10	-2.80	-2.50	-3.80	-1.70	-6.20	-10.20
49	0.70	-1.20	-1.00	0.00	0.90	1.10	-1.20	-1.60	-0.50	0.00	-1.70	-4.10	-0.40
50	1.70	0.80	0.30	0.20	1.70	1.90	-3.80	-2.40	-0.20	1.30	1.00	0.20	-3.20
51	0.20	0.50	0.20	-1.40	1.00	1.80	-3.30	-0.80	-0.70	-2.70	-0.70	0.90	-8.40
52	0.00	0.80	-0.30	0.50	-0.20	0.20	0.40	-0.20	-0.40	0.10	0.70	-5.70	-3.20
53	0.00	-0.10	-0.50	-0.80	0.60	0.80	-1.40	-1.10	-0.20	-0.50	-0.30	-15.40	-5.40
54	-1.20	-1.20	0.10	0.00	0.10	0.80	-5.30	-4.20	-0.80	-2.90	-2.00	-5.10	-4.40
55	-1.40	-1.20	0.30	0.70	1.20	1.30	-2.80	-3.40	0.00	-2.00	-1.20	-1.70	0.90
56	-1.30	-0.70	-1.20	0.90	0.70	1.80	-0.10	0.90	-1.00	-1.10	-0.20	-2.10	-4.00
57	-0.20	0.30	-0.90	-0.50	2.80	4.10	-2.70	-0.30	-1.30	-1.30	-0.50	-0.40	-7.60
58	-1.50	-0.40	-0.50	0.00	0.90	2.00	-3.50	-3.40	-1.00	-2.10	-0.50	-4.00	-5.80
59	-0.20	-0.10	-0.20	0.00	-0.70	-0.20	-2.40	-1.50	-0.50	0.10	-0.40	-1.90	1.00
60	-1.20	0.00	-0.30	0.00	0.70	0.70	2.10	1.40	0.00	-1.40	-0.40	-7.40	1.10
61	-2.40	-2.80	-0.50	-0.60	1.00	2.30	-1.80	-1.50	-1.30	-2.90	-2.60	4.60	-2.50

VI 3 Average VAS scores for the alteration caused by Le Fort 1 maxillary advancement osteotomy (T3-T2) in the aesthetic evaluation of the face and nose of the 61 patients in the frontal and profile views

N°			Attractiveness of:					
	Gender	Surgery	FV of the face	PV of the face	FV of the nose	PV of the nose	FV of the nose within the face	PV of the nose within the face
1	F	Unimaxillary	61.28	88.38	29.97	7.07	36.11	35.44
2	F	Unimaxillary with mentoplasty	26.01	-2.61	-22.56	-25.67	-11.95	-21.72
3	F	Bimaxillary	30.39	74.33	40.40	-0.76	32.74	26.01
4	F	Bimaxillary	45.37	63.89	1.18	-12.96	1.60	4.29
5	F	Unimaxillary	41.84	37.71	-6.14	31.82	11.87	21.30
6	F	Bimaxillary	57.83	53.96	24.33	12.96	34.51	24.49
7	F	Bimaxillary	49.16	83.08	-0.76	-1.18	14.98	0.42
8	F	Bimaxillary with mentoplasty	30.89	52.69	-33.50	13.38	8.25	14.14
9	F	Bimaxillary	39.23	8.25	-3.62	1.35	-3.54	-5.13
10	F	Bimaxillary with mentoplasty	47.39	51.52	8.84	0.93	12.71	15.57
11	F	Unimaxillary with mentoplasty	18.18	9.43	-23.32	15.49	2.10	20.71
12	F	Unimaxillary with mentoplasty	-4.55	52.95	-27.86	8.50	-31.06	7.15
13	F	Bimaxillary with mentoplasty	6.31	44.53	-26.77	13.64	-3.54	31.57
14	F	Bimaxillary	51.35	35.61	-20.37	0.25	17.68	15.57
15	F	Unimaxillary with mentoplasty	57.74	47.90	7.83	29.55	10.19	17.68
16	F	Bimaxillary	68.10	76.43	-21.89	24.92	10.94	34.18
17	F	Bimaxillary	25.08	18.69	0.67	-1.52	9.09	9.26
18	F	Bimaxillary	73.40	38.55	-19.36	9.60	8.50	9.76
19	F	Unimaxillary with mentoplasty	55.72	66.67	-10.77	14.06	1.26	18.69
20	F	Bimaxillary with mentoplasty	30.22	-28.60	11.70	-2.44	1.43	5.13
21	F	Bimaxillary	44.44	41.84	-17.26	1.01	3.45	22.56
22	F	Bimaxillary	28.54	40.91	0.17	-13.22	23.32	20.88
23	F	Bimaxillary	44.70	44.95	-4.97	18.69	-1.94	16.33
24	F	Unimaxillary with mentoplasty	-20.20	26.09	-13.13	-5.89	6.31	-2.61
25	F	Bimaxillary	61.28	62.96	28.70	33.25	45.12	32.07
26	F	Bimaxillary	27.53	36.28	-5.89	4.63	1.60	6.40
27	F	Bimaxillary with mentoplasty	-32.24	23.48	-9.09	18.86	-11.95	24.07
28	F	Unimaxillary	23.15	18.10	-27.19	-13.22	-10.86	0.67
29	F	Bimaxillary	47.47	31.06	-11.20	36.45	22.90	28.20
30	F	Bimaxillary with mentoplasty	33.00	70.03	-28.20	16.16	-6.73	20.37
31	F	Bimaxillary with mentoplasty	48.32	14.81	-22.73	25.84	4.38	25.51
32	F	Bimaxillary	33.50	-4.12	6.23	24.92	13.38	1.26
33	F	Bimaxillary	50.51	46.89	13.05	19.28	18.94	22.14
34	F	Bimaxillary	19.28	54.55	5.64	-9.26	20.12	15.07
35	F	Bimaxillary	46.13	-12.37	-2.95	-1.18	7.91	-11.78
36	F	Bimaxillary	19.36	31.14	-24.92	13.89	-5.47	12.54
37	F	Bimaxillary	43.10	56.90	5.30	19.70	3.11	19.44
38	F	Bimaxillary	43.43	45.03	14.56	11.95	5.13	15.74
39	F	Bimaxillary	39.90	52.19	-32.07	1.43	4.71	-8.25
40	F	Bimaxillary	-3.28	68.43	32.41	12.12	26.26	17.59
41	F	Bimaxillary	40.57	58.08	-2.61	8.00	25.00	17.76
42	F	Bimaxillary with mentoplasty	-22.64	51.77	-45.03	13.55	-30.47	27.19
43	M	Unimaxillary	11.62	36.11	29.12	24.24	0.67	15.15
44	M	Unimaxillary	-0.84	24.83	-36.70	22.39	-27.53	22.73
45	M	Unimaxillary	33.67	37.12	-3.11	24.92	-10.77	18.69
46	M	Bimaxillary	29.46	47.64	-27.02	1.52	-17.00	8.75
47	M	Bimaxillary with mentoplasty	-25.84	27.69	-5.22	-2.86	11.45	7.41
48	M	Unimaxillary	37.29	87.29	1.18	12.29	5.89	43.77
49	M	Bimaxillary with mentoplasty	-1.01	52.61	0.25	13.47	6.06	11.95
50	M	Bimaxillary with mentoplasty	49.33	-43.35	2.61	13.22	24.66	-15.57
51	M	Unimaxillary	75.25	40.32	-0.17	-19.28	-8.16	9.18
52	M	Bimaxillary	19.02	12.63	-2.61	-14.06	3.11	-1.26
53	M	Bimaxillary with mentoplasty	61.62	-5.89	-3.62	5.05	-4.12	-13.30
54	M	Bimaxillary with mentoplasty	72.56	73.91	18.27	17.42	24.49	33.33
55	M	Bimaxillary with mentoplasty	68.77	3.45	14.48	12.37	32.24	10.52
56	M	Bimaxillary	58.59	37.29	-5.72	7.83	6.57	13.55
57	M	Bimaxillary	38.22	6.65	11.70	5.13	13.47	15.82
58	M	Bimaxillary	9.18	7.15	4.88	14.39	31.23	-0.84
59	M	Bimaxillary	42.51	51.94	-1.85	15.82	13.13	20.29
60	M	Bimaxillary	62.63	32.91	-1.26	12.46	18.69	2.95
61	M	Bimaxillary	37.79	43.27	-4.12	7.32	1.67	4.71

FV: Frontal view, PV: Profile view, M: Male, F: Female

VI 4 Average VAS scores for the alteration caused by Le Fort 1 maxillary advancement osteotomy (T3-T2) in the aesthetic evaluation of the face and nose of the 61 patients in the frontal and profile views according to male evaluators

N°			Attractiveness of:					
	Gender	Surgery	FV of the face	PV of the face	FV of the nose	PV of the nose	FV of the nose within the face	PV of the nose within the face
1	F	Unimaxillary	60.44	88.72	34.85	14.31	39.39	42.09
2	F	Unimaxillary with mentoplasty	14.31	-7.07	-25.76	-35.52	-26.94	-13.64
3	F	Bimaxillary	27.27	85.52	48.99	0.00	41.08	33.00
4	F	Bimaxillary	61.45	78.62	1.68	-24.07	-6.06	-2.19
5	F	Unimaxillary	42.42	49.33	-18.86	29.97	12.29	25.42
6	F	Bimaxillary	69.19	59.93	32.32	11.45	40.57	33.00
7	F	Bimaxillary	53.20	80.30	6.57	6.06	7.58	-9.43
8	F	Bimaxillary with mentoplasty	63.64	63.47	-42.26	23.74	11.78	22.05
9	F	Bimaxillary	31.82	-2.53	-13.80	4.38	-22.73	-6.73
10	F	Bimaxillary with mentoplasty	61.62	52.69	10.10	-0.34	17.85	20.20
11	F	Unimaxillary with mentoplasty	11.95	19.87	-22.22	26.26	-9.09	21.89
12	F	Unimaxillary with mentoplasty	-24.58	69.70	-34.51	14.98	-37.37	-8.08
13	F	Bimaxillary with mentoplasty	8.92	69.36	-34.51	3.20	-18.01	24.75
14	F	Bimaxillary	56.90	38.22	-27.10	2.69	6.90	22.90
15	F	Unimaxillary with mentoplasty	66.50	60.77	-20.54	38.05	12.12	22.73
16	F	Bimaxillary	81.14	91.92	-32.15	42.09	0.67	54.21
17	F	Bimaxillary	24.24	4.04	-9.76	-13.47	3.37	9.09
18	F	Bimaxillary	85.86	43.27	-27.78	19.36	-1.85	5.39
19	F	Unimaxillary with mentoplasty	69.87	78.79	-40.40	14.65	11.45	19.19
20	F	Bimaxillary with mentoplasty	40.91	-33.96	27.10	-10.44	17.51	-16.67
21	F	Bimaxillary	54.04	27.78	-20.71	15.49	0.84	31.99
22	F	Bimaxillary	32.66	35.19	4.38	-9.60	31.65	24.24
23	F	Bimaxillary	55.05	40.07	2.53	23.57	-7.58	18.86
24	F	Unimaxillary with mentoplasty	-33.50	37.04	5.56	22.56	-12.63	17.85
25	F	Bimaxillary	60.77	70.03	27.61	34.68	49.66	26.94
26	F	Bimaxillary	29.63	35.02	-1.68	21.72	6.06	-11.95
27	F	Bimaxillary with mentoplasty	-39.56	47.64	-15.82	25.08	-11.45	32.83
28	F	Unimaxillary	33.50	27.27	-34.34	-23.57	-7.24	-13.47
29	F	Bimaxillary	65.49	31.65	-7.91	37.37	45.62	37.54
30	F	Bimaxillary with mentoplasty	37.54	76.94	-35.02	31.31	-15.49	22.73
31	F	Bimaxillary with mentoplasty	59.43	9.26	-17.68	29.97	-11.78	25.76
32	F	Bimaxillary	45.29	-6.57	7.24	37.04	20.20	1.68
33	F	Bimaxillary	63.64	56.40	26.60	25.76	14.48	22.90
34	F	Bimaxillary	31.48	73.40	1.85	-5.72	23.40	18.52
35	F	Bimaxillary	58.25	-25.08	-14.81	6.90	1.35	-3.54
36	F	Bimaxillary	23.57	35.02	-25.42	30.81	-15.66	18.18
37	F	Bimaxillary	56.23	75.93	8.75	26.43	-2.86	21.89
38	F	Bimaxillary	53.87	59.09	29.12	14.98	-9.60	23.57
39	F	Bimaxillary	63.13	51.01	-31.48	-9.93	-3.37	-16.33
40	F	Bimaxillary	3.70	76.60	26.26	17.68	29.97	26.43
41	F	Bimaxillary	56.23	62.29	-10.27	18.52	25.08	23.23
42	F	Bimaxillary with mentoplasty	-41.41	68.86	-48.65	16.84	-37.71	34.51
43	M	Unimaxillary	9.09	51.18	25.93	32.66	16.16	4.04
44	M	Unimaxillary	4.04	43.10	-56.57	36.03	-14.98	29.46
45	M	Unimaxillary	36.20	40.91	-25.93	39.90	-4.21	27.44
46	M	Bimaxillary	14.98	62.46	-34.51	22.90	-40.24	14.81
47	M	Bimaxillary with mentoplasty	-28.96	29.46	-18.35	-9.60	13.80	-1.85
48	M	Unimaxillary	38.72	84.18	1.52	18.35	10.10	41.08
49	M	Bimaxillary with mentoplasty	-0.84	60.44	8.42	16.50	10.94	12.79
50	M	Bimaxillary with mentoplasty	67.17	-47.14	-4.21	26.77	23.57	-18.52
51	M	Unimaxillary	73.06	45.96	10.27	-21.38	-8.59	3.87
52	M	Bimaxillary	40.24	20.20	-16.50	-1.35	-2.19	-4.55
53	M	Bimaxillary with mentoplasty	74.75	-14.65	-14.14	-1.35	-11.28	-10.94
54	M	Bimaxillary with mentoplasty	84.18	91.75	-1.18	9.43	20.54	44.44
55	M	Bimaxillary with mentoplasty	81.31	4.88	2.19	0.84	39.23	4.04
56	M	Bimaxillary	57.74	26.26	-5.39	10.61	-3.03	4.04
57	M	Bimaxillary	37.54	17.68	16.67	-1.18	-0.67	15.82
58	M	Bimaxillary	26.09	7.41	26.43	26.43	37.88	-6.23
59	M	Bimaxillary	43.27	49.33	-4.88	23.23	19.02	16.67
60	M	Bimaxillary	76.09	38.22	7.74	10.94	27.27	-4.88
61	M	Bimaxillary	46.46	51.35	1.35	11.78	-2.36	6.73

FV: Frontal view, PV: Profile view, M: Male, F:Female

VI 5 Average VAS scores for the alteration caused by Le Fort 1 maxillary advancement osteotomy (T3-T2) in the aesthetic evaluation of the face and nose of the 61 patients in the frontal and profile views according to female evaluators

N°			Attractiveness of:					
	Gender	Surgery	FV of the face	PV of the face	FV of the nose	PV of the nose	FV of the nose within the face	PV of the nose within the face
1	F	Unimaxillary	62.12	88.05	25.08	-0.17	32.83	28.79
2	F	Unimaxillary with mentoplasty	37.71	1.85	-19.36	-15.82	3.03	-29.80
3	F	Bimaxillary	33.50	63.13	31.82	-1.52	24.41	19.02
4	F	Bimaxillary	29.29	49.16	0.67	-1.85	9.26	10.77
5	F	Unimaxillary	41.25	26.09	6.57	33.67	11.45	17.17
6	F	Bimaxillary	46.46	47.98	16.33	14.48	28.45	15.99
7	F	Bimaxillary	45.12	85.86	-8.08	-8.42	22.39	10.27
8	F	Bimaxillary with mentoplasty	-1.85	41.92	-24.75	3.03	4.71	6.23
9	F	Bimaxillary	46.63	19.02	6.57	-1.68	15.66	-3.54
10	F	Bimaxillary with mentoplasty	33.16	50.34	7.58	2.19	7.58	10.94
11	F	Unimaxillary with mentoplasty	24.41	-1.01	-24.41	4.71	13.30	19.53
12	F	Unimaxillary with mentoplasty	15.49	36.20	-21.21	2.02	-24.75	22.39
13	F	Bimaxillary with mentoplasty	3.70	19.70	-19.02	24.07	10.94	38.38
14	F	Bimaxillary	45.79	33.00	-13.64	-2.19	28.45	8.25
15	F	Unimaxillary with mentoplasty	48.99	35.02	36.20	21.04	8.25	12.63
16	F	Bimaxillary	55.05	60.94	-11.62	7.74	21.21	14.14
17	F	Bimaxillary	25.93	33.33	11.11	10.44	14.81	9.43
18	F	Bimaxillary	60.94	33.84	-10.94	-0.17	18.86	14.14
19	F	Unimaxillary with mentoplasty	41.58	54.55	18.86	13.47	-8.92	18.18
20	F	Bimaxillary with mentoplasty	19.53	-23.23	-3.70	5.56	-14.65	26.94
21	F	Bimaxillary	34.85	55.89	-13.80	-13.47	6.06	13.13
22	F	Bimaxillary	24.41	46.63	-4.04	-16.84	14.98	16.50
23	F	Bimaxillary	34.34	49.83	-12.46	13.80	3.70	13.80
24	F	Unimaxillary with mentoplasty	-6.90	15.15	-31.82	-34.34	25.25	-23.06
25	F	Bimaxillary	61.78	55.89	29.80	31.82	40.57	37.21
26	F	Bimaxillary	25.42	37.54	-10.10	-12.46	-2.86	24.75
27	F	Bimaxillary with mentoplasty	-24.92	-0.67	-2.36	12.63	-12.46	15.32
28	F	Unimaxillary	12.79	8.92	-20.03	-2.86	-14.48	14.81
29	F	Bimaxillary	29.46	30.47	-14.48	35.52	0.17	18.86
30	F	Bimaxillary with mentoplasty	28.45	63.13	-21.38	1.01	2.02	18.01
31	F	Bimaxillary with mentoplasty	37.21	20.37	-27.78	21.72	20.54	25.25
32	F	Bimaxillary	21.72	-1.68	5.22	12.79	6.57	0.84
33	F	Bimaxillary	37.37	37.37	-0.51	12.79	23.40	21.38
34	F	Bimaxillary	7.07	35.69	9.43	-12.79	16.84	11.62
35	F	Bimaxillary	34.01	0.34	8.92	-9.26	14.48	-20.03
36	F	Bimaxillary	15.15	27.27	-24.41	-3.03	4.71	6.90
37	F	Bimaxillary	29.97	37.88	1.85	12.96	9.09	17.00
38	F	Bimaxillary	33.00	30.98	0.00	8.92	19.87	7.91
39	F	Bimaxillary	16.67	53.37	-32.66	12.79	12.79	-0.17
40	F	Bimaxillary	-10.27	60.27	38.55	6.57	22.56	8.75
41	F	Bimaxillary	24.92	53.87	5.05	-2.53	24.92	12.29
42	F	Bimaxillary with mentoplasty	-3.87	34.68	-41.41	10.27	-23.23	19.87
43	M	Unimaxillary	14.14	21.04	32.32	15.82	-14.81	26.26
44	M	Unimaxillary	-5.72	6.57	-16.84	8.75	-40.07	15.99
45	M	Unimaxillary	31.14	33.33	19.70	9.93	-17.34	9.93
46	M	Bimaxillary	43.94	32.83	-19.53	-19.87	6.23	2.69
47	M	Bimaxillary with mentoplasty	-22.73	25.93	7.91	3.87	9.09	16.67
48	M	Unimaxillary	35.86	90.40	0.84	6.23	1.68	46.46
49	M	Bimaxillary with mentoplasty	-1.18	44.78	-7.91	10.44	1.18	11.11
50	M	Bimaxillary with mentoplasty	31.48	-39.56	9.43	-0.34	25.76	-12.63
51	M	Unimaxillary	77.44	34.68	-10.61	-17.17	-7.74	14.48
52	M	Bimaxillary	-2.19	5.05	11.28	-26.77	8.42	2.02
53	M	Bimaxillary with mentoplasty	48.48	2.86	6.90	11.45	3.03	-15.66
54	M	Bimaxillary with mentoplasty	60.94	56.06	37.71	25.42	28.45	22.22
55	M	Bimaxillary with mentoplasty	56.23	2.02	26.77	23.91	25.25	17.00
56	M	Bimaxillary	59.43	48.32	-6.06	5.05	16.16	23.06
57	M	Bimaxillary	38.89	-4.38	6.73	11.45	27.61	15.82
58	M	Bimaxillary	-7.74	6.90	-16.67	2.36	24.58	4.55
59	M	Bimaxillary	41.75	54.55	1.18	8.42	7.24	23.91
60	M	Bimaxillary	49.16	27.61	-10.27	13.97	10.10	10.77
61	M	Bimaxillary	29.12	35.19	-9.60	2.86	5.70	2.69

FV: Frontal view, PV: Profile view. M: Male, F: Female

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