UNIVERSIDADE DE LISBOA
FACULDADE DE MEDICINA VETERINÁRIA

OCULAR DISEASES IN BRACHYCEPHALIC CATS – A RETROSPECTIVE STUDY OF 50 CASES

JOANA RODRIGUES SOARES BARATA

ORIENTADORA:
Doutora Esmeralda Sofia da Costa Delgado

TUTOR:
Dr. Raimundo Tamagnini

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RESUMO

DOENÇAS OCULARES EM GATOS BRAQUICEFÁLICOS –ESTUDO RETROSPECTIVO DE 50 CASOS

Introdução**:** As raças braquicefálicas de gatos apresentam alterações anatómicas que os predispõem a doenças respiratórias, dermatológicos, dentários e oculares. A proeminência dos globos oculares, a reduzida sensibilidade da córnea e a menor frequência de pestanejo aumentam o risco de lesões oculares.

Objetivo: Este estudo retrospetivo teve como objetivo identificar os sinais oculares mais prevalentes, as doenças mais frequentemente diagnosticadas e os protocolos terapêuticos utilizados numa amostra de gatos braquicefálicos, bem como avaliar se determinadas raças apresentam maior predisposição para certas doenças.

Materiais e Métodos: Cinquenta gatos braquicefálicos foram submetidos a exames oftalmológicos completos, incluindo avaliação neuro-oftalmológica, teste lacrimal de Schirmer, tonometria, biomicroscopia, fundoscopia e coloração com fluoresceína, quando necessário. As variáveis analisadas incluíram o motivo da consulta, se a consulta era referenciada, sinais clínicos oculares, doenças oculares diagnosticadas e os respetivos protocolos terapêuticos. Os dados foram analisados com recurso ao Microsoft Excel e ao Epitools 2025, Ausvet Pty Lt, Austrália.

Resultados: Foram examinados, no total, 193 gatos por um especialista em oftalmologia, dos quais 143 eram não braquicefálicos e os restantes 50 eram braquicefálicos. A população em estudo (50 gatos, 54% fêmeas, 46% machos, com idade média de 5,6 ± 4,0 anos) incluiu 56% da raça Persa, 20% British Blue, 12% Scottish Fold e 12% Himalaia. Os sinais clínicos mais comuns foram epífora em 80% dos pacientes, blefarospasmo em 78% e placa escura da córnea em 48% dos casos. As doenças oculares mais prevalentes foram sequestro da córnea (48%), entrópion (22%) e ulceração da córnea (16%). O tratamento cirúrgico foi realizado em 28 casos – 75% relacionados com sequestro da córnea e 32% com entrópion. O tratamento médico foi sempre recomendado.

Conclusões: O sequestro da córnea e o entrópion foram as doenças oculares mais comuns em gatos braquicefálicos na amostra, frequentemente com múltiplos sinais clínicos. Este estudo destaca a importância do rastreio oftalmológico precoce e da criação responsável face aos riscos associados a fenótipos extremos de braquicefalia.

Palavras-chave: Gato, raças braquicefálicas, síndrome ocular braquicefálica, sequestro da córnea

ABSTRACT

OCULAR DISEASES IN BRACHYCEPHALIC CATS – A RETROSPECTIVE STUDY OF 50 CASES

Background: Cat brachycephalic breeds have anatomical abnormalities that predispose them to respiratory, dermatological, dental, and ocular disorders. The prominent globes, reduced corneal sensitivity, and lower blinking rates increase the risk of ocular conditions
Purpose: This retrospective study aimed to identify the most prevalent ocular signs, the most commonly diagnosed diseases and the therapeutic protocols in this studied sample of brachycephalic cats and assess whether certain breeds are more prone to certain diseases.
Materials and Methods: Fifty brachycephalic cats underwent complete ophthalmological exams, including neuro-ophthalmological assessment, Schirmer tear testing, tonometry, biomicroscopy, fundoscopy, and fluorescein staining when needed. Variables at study included iatrotropic stimulus, whether the consultation was a referral, ocular signs, ocular diseases and the therapeutic protocols. Data were analyzed using Microsoft Excel and Epitools 2025, Ausvet Pty Lt, Australia.
Results: There was a total of 193 cats that were examined by the ophthalmology specialist, however, of these, 143 were non-brachycephalic, while the remaining 50 were brachycephalic. The study population (50 cats, 54% female, 46% male, aged 5.6 ± 4.0 years) included 56% Persian, 20% British Blue, 12% Scottish Fold, and 12% Himalayan breeds. Common clinical signs were epiphora observed in 80% of patients, blepharospasm in 78%, and a corneal dark plaque in 48% of the cases. Corneal sequestrum (48%), entropion (22%), and corneal ulceration (16%) were the most prevalent ocular diseases. Treatment included surgery in 28 cases, 75% of them were related with corneal sequestrum and consisted in keratectomy, amniotic membrane graft, bandage contact lens and tarsorrhaphy while 32% cases presented with entropion and underwent Hotz-Celsus blepharoplasty. Medical treatment was always advised.
Conclusions: Ocular diseases were common in brachycephalic cats, with corneal sequestrum and entropion being the most prevalent. Patients exhibited two or more clinical signs, reinforcing the complexity of brachycephalic ocular syndrome, as these breeds are frequently affected by more than one ocular condition. Corneal involvement was the most likely ophthalmological problem in brachycephalic cats. Early diagnosis and treatment are crucial to prevent irreversible damage. This study reinforces the need for early ophthalmological routine evaluations and responsible breeding practices due to the health risks associated with the more pronounced phenotypes of these feline brachycephalic breeds.
Keywords: Cat, brachycephalic breeds, ocular brachycephalic syndrome, corneal sequestrum

RESUMO ALARGADO

DOENÇAS OCULARES EM GATOS BRAQUICEFÁLICOS –ESTUDO RETROSPECTIVO DE 50 CASOS

Introdução: As raças braquicefálicas apresentam alterações anatómicas que as tornam predispostas para doenças respiratórias, dermatológicas, dentárias e oculares. Os globos oculares proeminentes, sensibilidade da córnea diminuída, e menor taxa de pestanejo aumentam o risco de doença ocular nestes animais doentes. As doenças oculares mais comuns incluem conjuntivite, sequestro da córnea, úlceras, queratopatia de exposição, epífora e entrópion, podendo causar danos irreversíveis se não forem tratadas. Uma reprodução responsável de gatos braquicefálicos, favorecendo exemplares com características anatómicas e fisiológicas menos extremas, devia ser adotada como chave para o controlo das doenças associadas à síndrome ocular braquicefálica, tendo como principal objetivo a saúde e o bem-estar animal.

Objetivo: Este estudo tem como objetivo estudar uma amostra de gatos braquicefálicos no que concerne as suas doenças oculares. Para tal pretende-se identificar o estimulo iatrotrópico, os sinais clínicos mais comuns, as doenças oculares mais frequentemente diagnosticadas e os protocolos terapêuticos utilizados através de uma análise retrospetiva de uma amostra de gatos braquicefálicos.

Materiais e Métodos: Amostra total e depois a seleção dos gatos braquicefálicos. Apenas animais doentes pertencentes a raças braquicefálicas foram incluídos na amostra do estudo Cinquenta gatos de quatro raças braquicefálicas (Persa, Himalaio, British Blue, Scottish Fold) foram submetidos a exames oftalmológicos sistemáticos completos, incluindo avaliação neuro-oftalmológica, teste lacrimal de Schirmer, tonometria, biomicroscopia, fundoscopia e coloração com fluoresceína quando necessário. Os critérios adicionais de inclusão exigiam que cada doente selecionado possuísse um registo clínico completo, fosse submetido a um exame oftalmológico sistemático e completo com resultados documentados e tivesse um diagnóstico confirmado por um especialista em oftalmologia. As variáveis avaliadas neste estudo incluíram o estímulo iatrotrópico dos animais doentes, idade, género, raça, peso, sinais clínicos oculares, resultados do exame oftalmológico sistemático, diagnóstico ocular, exames complementares, comorbilidades e se eram casos referenciados. Os dados recolhidos destes animais doentes foram organizados numa base de dados utilizando o Microsoft Office Excel, e a análise inferencial foi realizada com o mesmo software e Epitools 2025, Ausvet Pty Lt, Austrália. Subsequentemente, foram analisadas possíveis correlações entre diferentes variáveis, incluindo a presença de sequestro da córnea em gatos Persas e a presença de entrópion em casos de sequestro.

Esta análise foi realizada utilizando o teste do qui-quadrado, com um nível de confiança de 95% e um nível de significância definido em $p<0,05$.

Resultados: Um total de 193 gatos foram observados pelo oftalmologista de referência da clínica (143 de raças não-braquicefálicas e 50 de raças braquicefálicas). A população em estudo correspondeu a 50 gatos de raças braquicefálicas, 54% fêmeas e 46% machos, com idades compreendidas entre 5.6 ± 4.0 anos. Esta amostra incluiu 56% gatos da raça Persa, 20% British Blue, 12% Scottish Fold e 12% Himalaios. Foi realizada uma análise global dos resultados para avaliar quais foram os três estímulos iatrotrópicos mais comuns. Esta análise revelou que 80% dos tutores relataram epífora (40/50 animais doentes), tornando esta a principal queixa. O segundo estímulo iatrotrópico mais comum foi o blefarospasmo, que afetou 78% da população amostrada (39/50 animais doentes). Por fim, a terceira queixa mais frequente foi a presença de uma placa de cor escura à superfície da córnea (correspondendo a sequestro da córnea), que afetou 48% da população amostrada (24/50 animais doentes). A análise cumulativa mostrou que foram estabelecidos 78 diagnósticos definitivos dentro da população amostrada. Dentro destes, 53,8% (42/78) afetaram a córnea, 15,4% (12/78) envolveram as pálpebras e 7,7% (6/78) afetaram a órbita e o globo ocular. Além disso, 5,1% (4/78) afetaram individualmente o trato uveal, o fundo ocular e a lente, 3,8% (3/78) envolveram o sistema lacrimal, 2,6% (2/78) afetaram a conjuntiva e 1,3% (1/78) foram casos de glaucoma. As doenças oculares mais frequentemente diagnosticadas na população amostrada foram sequestro da córnea (48%), entrópion (22%) e ulceração da córnea (16%). Além disso, a córnea foi significativamente mais afetada do que outras partes do globo ocular, representando mais de metade dos diagnósticos totais (53,8%).

Discussão: Estes resultados estão de acordo com o esperado, uma vez que as raças braquicefálicas são conhecidas por apresentarem maior exposição corneal devido às suas características anatómicas, predispondo-as a uma maior incidência de doenças da córnea. Os resultados dos animais doentes com sequestro da córnea mostraram que 62,5% dos animais doentes diagnosticados com esta condição também apresentavam outras alterações oculares, entre as quais a ulceração da córnea. O tratamento cirúrgico foi realizado em 28 casos: 75% casos de sequestro da córnea foram submetidos a queratectomia, enxerto de membrana amniótica, lente de contacto terapêutica e tarsorrafia; 32,1% casos de entrópion foram tratados pela técnica de blefaroplastia de Hotz-Celsus; e 3,6% de cataratas foram tratados pela técnica de facoemulsificação. O tratamento médico variou consoante a gravidade, necessidade cirúrgica e consentimento do tutor. Foi realizada uma análise inferencial para testar as duas hipóteses previamente mencionadas: (1) a existência de uma correlação entre a presença de sequestro da córnea e a raça Persa e (2) a presença de entrópion em casos de sequestro a córnea. Ao analisar a primeira hipótese,

os resultados obtidos no teste do qui-quadrado mostraram um valor de p de 0,2568. Já a análise da segunda hipótese revelou um valor de p de 0,2549.

Os resultados do presente estudo sugerem que as raças de gatos braquicefálicos, devido às alterações anatómicas oculares associadas à síndrome braquicefálica, apresentam uma predisposição para diversas doenças oculares. As condições mais frequentemente diagnosticadas na amostra, listadas por ordem decrescente de prevalência, foram sequestro da córnea, entrópion e úlcera da córnea. Adicionalmente, este estudo identificou a córnea como a estrutura ocular mais frequentemente afetada. Os animais doentes da amostra em estudo apresentavam dois ou mais sinais clínicos oculares, reforçando a ideia que as doenças oculares resultantes da síndrome ocular braquicefálica são complexas, e estas raças têm uma predisposição para desenvolver mais do que uma condição ocular. Não foi encontrada uma associação estatisticamente significativa entre a presença de sequestro da córnea e a raça Persa, nem entre a presença de entrópion nos casos de sequestro na amostra em estudo.

Conclusões: O estudo confirma os achados de investigações anteriores ao evidenciar que o sequestro da córnea, úlcera da córnea e a queratite são as condições da córnea mais frequentemente diagnosticadas em raças braquicefálicas. Estes resultados reforçam a hipótese de que as raças braquicefálicas estão predispostas a doenças da córnea devido a vários fatores anatómicos, incluindo a sua maior suscetibilidade ao entrópion, uma condição que provoca um trauma crónico na superfície corneana causado pelos cílios, contribuindo assim para o desenvolvimento de lesões da córnea. Tendo em conta as limitações do estudo – nomeadamente a distribuição desigual das raças e a representatividade da amostra – recomenda-se que futuras investigações considerem uma distribuição mais equilibrada de animais doentes entre as diversas raças, um tamanho de amostra maior e, idealmente, uma gama mais ampla de raças braquicefálicas. As características anatómicas das raças de gatos braquicefálicos, nomeadamente os globos oculares proeminentes, a sensibilidade da córnea reduzida e a taxa de pestanejo mais reduzida, aumentam a sua suscetibilidade a doenças oculares, como a queratite de exposição, sequestro da córnea, úlcera corneal e outras doenças da superfície ocular. Assim, é crucial adotar uma abordagem de reprodução mais seletiva, que favoreça exemplares com características anatómicas menos acentuadas, evitando o uso de indivíduos com fenótipos exagerados. A implementação de práticas de reprodução responsáveis pode ajudar a reduzir a prevalência e a gravidade das condições oculares associadas à braquicefalia. No entanto, até graus leves de braquicefalia estão associados a doenças oculares, pelo que é importante avaliar criticamente as implicações éticas da reprodução de gatos com alterações anatómicas que poderão estar associadas a desconforto e complicações de saúde. Considerando a maior

predisposição das raças braquicefálicas para desenvolver doenças oculares, recomenda-se a realização de exames oftalmológicos regulares, de preferência anualmente. Esta abordagem proativa permite a deteção precoce de problemas oculares, possibilitando a intervenção atempada.

Palavras-chave: Gato, raças braquicefálicas, síndrome ocular braquicefálica, sequestro da córnea.

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ABREVIATIONS

CT: Computed Tomography

FECAVA: Federation of European Companion Animal Veterinary Associations

FHV-1: Feline Herpesvirus 1

FVE: Federation of Veterinarians of Europe

IOP: Intra-Ocular Pressure

ISFM: International Society of Feline Medicine

min: Minute

mm: Millimeters

NSAID: Non-Steroid Anti-Inflammatory Drug

PLR: Pupillary Light Reflex

PPM: Persistent Pupillary Membrane

PRS: Progressive Retinal Atrophy

STT: Schirmer Tear Test

UEVP: Union of European Veterinary Practitioners

I. TRAINEESHIP REPORT

I did my traineeship at The Cat Vet Clinic - Dubai, United Arab Emirates - from the 2nd of September until the 3rd of November 2024, completing a total of 500 hours.

Every morning between 7:00 and 8:00 AM, I worked alongside the nursing team to address the full spectrum of needs for hospitalized patients, including medication administration and the execution of basic medical procedures. From 8:00 AM to 4:30 PM, I had the opportunity to shadow and assist the clinic's veterinarians during routine and emergency consultations, as well as during a range of surgical procedures. Every day, at 2:30 PM, I observed the case handovers, during which all the doctors convened in the hospital to discuss the cases of the hospitalized patients.

As the sole trainee at The Cat Vet Clinic, I had the flexibility to rotate across various specialties, adapting to the weekly schedule of consultations and surgical procedures. This allowed me to primarily participate in Internal Medicine consultations and medical procedures, which are the most common cases at the clinic.

Every time we had visiting specialists in the medical fields of Ophthalmology, Endoscopy and Cardiology, I was able not only to observe and assist their consultations but also gain valuable experience by witnessing multiple specialized medical procedures.

In the Endoscopy department, I had the opportunity to observe a variety of procedures, including upper and lower gastrointestinal endoscopies with biopsy sampling, laparoscopic biopsy sampling, otoendoscopies, and respiratory endoscopies. During these procedures, the veterinary specialist performed various techniques, such as alar fold lifts, sulcus pull-downs, upper respiratory endoscopies, and nasal debridement.

During my time in the Ophthalmology department, I assisted with consultations and was given the opportunity to independently perform various examinations, including tonometry and slit-lamp biomicroscopy, under the supervision of the veterinary specialist and with the consent of the patient's owner. Additionally, I had the chance to observe several surgical procedures, such as cataract surgery using the phacoemulsification technique, corneal sequestrum surgery involving keratectomy, amniotic membrane grafts, lens placement, and temporary tarsorrhaphies.

Additionally, throughout my experience in the Cardiology department, I had the opportunity to observe numerous cardiac ultrasound scans.

As part of my daily routine, I encountered numerous patients that presented for emergency consultations and subsequently underwent complementary diagnostic examinations, such as X-rays, ultrasounds, blood tests, and urinalysis, in which I had the opportunity to assist.

During my Internship at The Cat Vet Clinic, I had the opportunity to enhance my skills in carrying out a consult and gained valuable experience using diagnostic tools, such as ultrasound and X-ray interpretation. As part of the surgical team, although only assuming a role as an observant, I gained knowledge of protocols for performing endoscopies and colonoscopies, with focus on correct collection of biopsies and proper handling techniques which are crucial for an accurate diagnosis.

Working in a cat-exclusive and cat-friendly clinic offered insights into several strategies and techniques specialized specifically for cats. These consisted of approaches for stress-free handling during consultations, surgical preparation of the patient, collection of blood samples, and assistance of hospitalized feline patients. These techniques not only encourage easier handling of the patients but also contribute to creating a stress-free environment for both staff and patients.

Over the course of my internship, I observed a total of 580 consultations. In the field of endoscopy, I followed 6 cases, whereas in internal medicine, I followed 551 consultations. Additionally, I also had the opportunity of observing 8 cardiology cases and 15 ophthalmology cases. The ophthalmology consultations involved routine cases with the clinic's ophthalmologist, as well as consultations conducted by a visiting specialist who comes to the clinic every three months to handle referred cases and perform microsurgeries when necessary. Through the consultations performed by the ophthalmology specialist, I had the opportunity to develop practical skills in the ophthalmological examination techniques, including direct and indirect ophthalmoscopy, further expanding my skills and knowledge in the field of ophthalmology.

This internship allowed me to develop essential skills, such as collecting and processing blood samples. The flexibility to choose which doctor to shadow offered me varied learning experiences. On days with complex or ophthalmology-related cases, I was encouraged to prioritize these. While most consultations focused on internal medicine, some cases were referred to specialists in cardiology, ophthalmology, surgery, diagnostic imaging, and endoscopy. For example, a few patients with heart murmurs were referred to cardiology.

Reflecting on my time at The Cat Vet Clinic, I can confidently say each day was unique, offering a dynamic range of experiences and broadening my knowledge across veterinary medicine.

II. BIBLIOGRAPHIC REVIEW

1 Introduction

Over the past 150 years, humans have selectively bred domestic cats (*Felis catus*) to enhance various characteristics deemed desirable, including temperament, physical build, facial structure, coat type and colour. This intensive selection has culminated in the recognition of over 70 distinct cat breeds. However, increasing concerns have been raised regarding the unintended health consequences associated with these practices. Specifically, the selective breeding for extreme physical conformations in popular breeds has led to a rise in breed-specific health issues, largely due to inbreeding and the emphasis on certain exaggerated traits. A prominent example of this phenomenon is seen in brachycephalic breeds, such as the Persian and the British Shorthair, both of which have experienced a surge in popularity in recent decades (Plitman et al. 2019) due to their child-like characteristics, which appear to evoke an instinctive attraction in humans (Schlueter et al. 2009).

The term “brachycephalic” refers to animals characterized by a shortened and broadened facial structure. This deviation from typical physiological norms involves alterations in skull morphology, resulting in reduced skull length but preserved width. Over time, and due to selective breeding by humans, these anatomical changes have led brachycephalic animals to develop an excess of soft tissues relative to their shortened skull (Mullen 2004 Jan 1). In light of this, literature has adopted the term “brachycephalic syndrome” to describe the combination of primary and secondary anatomical abnormalities common in brachycephalic breeds, leading to varying levels of airway obstruction and dysfunction (Costello 2009 Jan 1), as well as predisposition to certain dermatological, dental, and ophthalmological disorders (Ekenstedt et al. 2020).

Despite the increasing interest in brachycephalic breeds, ocular diseases in these cats have not been extensively studied, and the existing literature on this subject remains limited. Available studies suggest that brachycephalic feline breeds are at an elevated risk of developing various ocular conditions, including chronic conjunctivitis, corneal erosion, corneal sequestrum, exposure keratopathy, corneal ulcers, corneal perforation (Demir 2024) chronic epiphora, and entropion (Schlueter et al. 2009). These ocular diseases, which are associated with the brachycephalic syndrome, are of significant concern within the veterinary community. They not only threaten the well-being and health of affected patients but also raise ethical questions regarding the breeding of brachycephalic cats with extreme physical conformations.

Considering the exponentially growing global concern for animal health and welfare, it seemed very contradictory for such breeds to be so popular, and even more so that their popularity has been increasing over the past years. For this reason, and due to the various medical consequences that have direct impact on these patient's wellbeing, I found it extremely interesting and valuable to further investigate this topic. My goal was to raise awareness both within the medical community and among the general public regarding the consequences of selective breeding brachycephalic patients, particularly cats, with extreme anatomical features, in the hope of contributing to more responsible breeding practices.

This study aims to provide a comprehensive retrospective analysis of 50 cases of ocular diseases in brachycephalic cats, with the objective of identifying the most prevalent ocular conditions and their clinical manifestations. Additionally, it seeks to determine whether a specific breed within the study sample, when presenting with an ocular disease, is more likely to be affected in particular sections of the eye. By reviewing the medical records of these cats, this study aims to offer valuable insights into the most common ocular diseases affecting brachycephalic feline breeds, contributing to a better understanding of these conditions.

1.1 Anatomical and physiological considerations of brachycephalic feline breeds

A wide variety of brachycephalic breeds have been identified, examples include the Persian, British Blue, Scottish Fold, Himalayan, Exotic Shorthair, Selkirk Rex, Bombay, and Burmilla. However this study's population sample only includes patients from the first four breeds mentioned above (Persian, British Blue, Scottish Fold, and Himalayan).

A recent study published in 2024, in the *Pakistan Veterinary Journal* (Özkan et al. 2024), conducted a comparative analysis of skull morphology and ocular biometric parameters in brachycephalic versus non-brachycephalic cats, utilizing computed tomography-based measurements. This investigation focused on specific cranial parameters, including the greatest length of the skull, skull width, postorbital breadth, zygomatic breadth and greatest breadth of braincase (as illustrated in figure 1). The study demonstrated that brachycephalic cats exhibited a significantly lower mean value for the greatest length of the skull and a higher mean value for postorbital breadth in comparison to non-brachycephalic cats, with a p-value of <0.05, indicating statistical significance. Additionally, the study analyzed sex-based variations among brachycephalic cats, seeking to identify any significant differences attributable to sex. Findings revealed that male cats presented with a notably greater skull width compared to female cats, supported by a p-value <0.05. In summary, the findings published in the *Pakistan Veterinary Journal* reinforce that brachycephalic cats possess a reduced skull length and a rounder cranial shape relative to non-brachycephalic cats. These

structural abnormalities in the skull, characteristic of brachycephalic breeds, likely contribute to the predisposition of these breeds to various health conditions (Özkan et al. 2024).

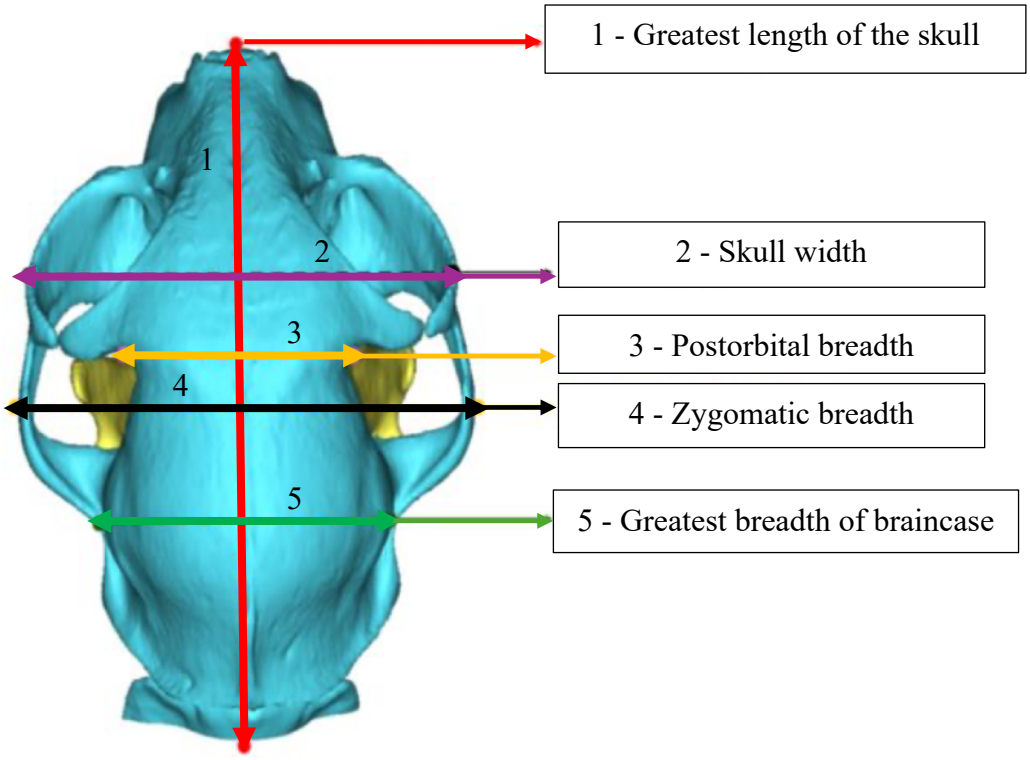


Figure 1: Measurements of a Feline Skull Using Three-Dimensional Modelling Techniques (Adapted from Özkan et al. 2024).

Brachycephaly in cats is classified into four distinct categories: Category I (mild), Category II (moderate), Category III (profound), and Category IV (severe). These classifications are based on the positioning of the upper canine teeth, the alignment of the jaw, and the extent of developmental and anatomical changes in the facial and neurocranial bone structures (Schlueter et al. 2009).

Cats in category I have nearly vertical upper canine teeth, no dorsally rotated jaw, a subtle stop, and well-defined facial and neurocranial bones. Category II shows slight dorsorotation of the jaw and upper canine teeth, a clear stop, decreased nasal bone structure, and a rounded or apple-shaped neurocranium. Category III features a pronounced jaw and upper canine rotation, a distinct stop, underdeveloped nasal and neurocranial bones, and a nose tip higher than the lower eyelid. Category IV, the most severe, has nearly horizontal upper canine teeth, significant jaw rotation, a prominent stop, insufficiently developed facial bones, and a rounded neurocranium (Schlueter et al. 2009).

1.2 Ocular Anatomical Traits in Brachycephalic Feline Breeds

Brachycephalic breeds have an elevated risk of ophthalmological disease due to their skull and orbit structure. Compared to non-brachycephalic breeds like the Domestic Shorthair,

brachycephalic breeds have a more rounded cranium, as shown in figure 2. This anatomical feature predisposes them to exophthalmos, the abnormal protrusion of the ocular globe (Demir 2024).

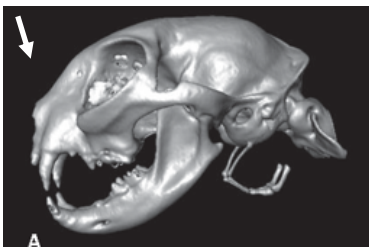
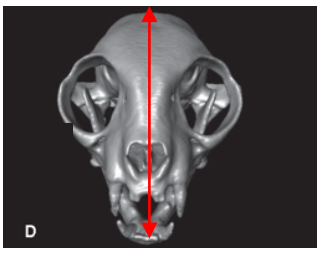
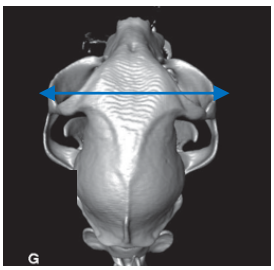
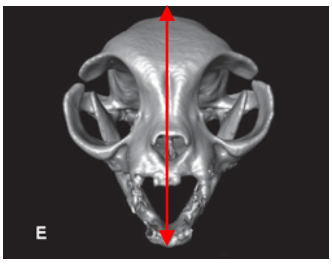
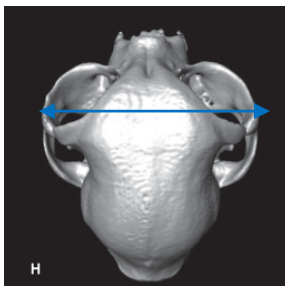
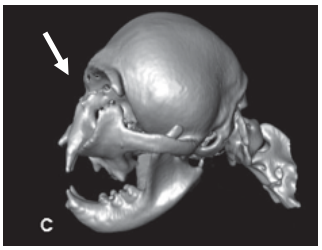
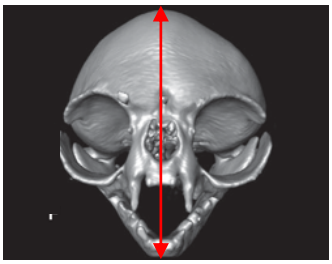
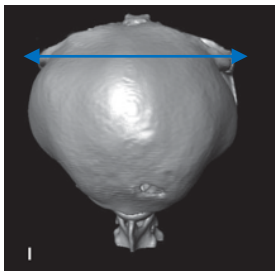
Breed	Lateral View of the Skull	Frontal View of the Skull	Dorsal View of the Skull
Domestic Shorthair			
Doll-face Persian			
Peke-face Persian			

Figure 2: Lateral, frontal, and dorsal views of Domestic Shorthair, Doll-Face Persian, and Peke-Face Persian skulls compare non-brachycephalic and brachycephalic morphologies (Adapted from Schmidt et al. 2017) – arrows indicate breed-related skull variations: a shortened nose (white, left), a wider skull (red, middle), and a shorter skull length (blue, right).

Due to their prominent and protruding eyeballs, brachycephalic breeds are more vulnerable to permanent ocular damage, which increases their susceptibility, relative to non-brachycephalic breeds, to a range of ocular diseases. Among these, corneal diseases are of particular concern due to their persistent and recurrent nature. Furthermore, the shallow orbital sockets and prominent position of the eyeballs in these breeds lead to diminished corneal sensitivity which is correlated with an elevated risk of developing keratitis (Özkan et al. 2024). As a result of their decreased corneal sensitivity, in the presence of foreign bodies on the ocular surface or exposure of the cornea, brachycephalic breeds do not have the expected reaction of blinking and reflex lacrimation as non-brachycephalic breeds that exhibit normal corneal

sensitivity (Nutbrown-Hughes 2021). Consequently, decreased blinking observed in these patients makes them more susceptible to exposure keratitis because the distribution of the tear film is not done properly.

Additionally, as a consequence of exophthalmos, certain patients may exhibit signs of abnormal eyelid closure, known as lagophthalmos. While this condition has been extensively studied and reported in dogs, it is recognized that brachycephalic cats may also be affected due to their skull conformation. It is essential, however, in these instances, to exclude other potential causes of lagophthalmos, such as mechanical displacement due to orbital lesions or facial nerve lesions (E. Hamor 2023 Feb). Furthermore, the pronounced nasal skin folds characteristic of brachycephalic breeds, in conjunction with elongated nasal hairs, contribute to frictional trauma. This trauma, along with the exophthalmos commonly observed in these breeds, elevates the risk of developing ocular surface disorders, including but not limited to chronic conjunctivitis, exposure keratopathy, corneal erosion, corneal sequestrum, corneal ulcers, and corneal perforation (Demir 2024).

It has also been reported that these breeds are highly susceptible to chronic epiphora, which may be attributed to various factors, including inadequate drainage of the tear excretion pathway, narrowing of the upper drainage structures or nasolacrimal duct, congenital absence of the lacrimal puncta due to genetic factors or spontaneous defects, failure of the nasolacrimal duct to develop, obstruction of the tear drainage system, or a lacrimal sac that is too small. Additionally, epiphora may result from corneal irritation caused by hair or entropion, as well as obstruction of the drainage system by masses (Schlueter et al. 2009).

It has been reported that the breeds most frequently affected by ocular disorders in brachycephalic cats include the Persian, Himalayan, Exotic Shorthair, and British Blue. These breeds are particularly susceptible to conditions such as inadequate eyelid and periocular conformation, compromised corneal surface health, and the formation of corneal sequestrum, all of which elevate their risk of developing corneal disease (Rhodes 2020 Apr 1).

1.3 Most common ocular diseases in brachycephalic feline breeds

As previously mentioned, brachycephalic cats have anatomical differences of the skull when compared to non-brachycephalic breeds, putting them at a higher risk of developing certain ocular diseases. This could be explained by the unique anatomy of their skull and, consequently, changes in soft tissues. Due to these alterations, these breeds are prone to conditions such as chronic epiphora, caused by abnormalities in their tear drainage systems. Additionally, their exposed ocular globes and decreased corneal sensitivity increase the probability of exposure keratopathy. Other ocular diseases are also expected to have higher

prevalence in these breeds as a result of their distinct cranial morphology and the direct and indirect consequences of its uniqueness.

Since there is very scarce information and research done on brachycephalic feline breeds, research on brachycephalic dog breeds has been used as an example and reference for extrapolation. It is believed that due to the similarity of the brachycephalic syndrome between these two species, in anatomical and soft tissue differences as well as direct and indirect consequences in different health compartments, it would be expected to see a similar pattern in ocular diseases in brachycephalic feline breeds as it is seen in dogs. Hence, research and statistics performed in dogs were used as a model for cats.

1.3.1 The Orbit and Globe

Brachycephalic cats may suffer from a range of abnormalities of the orbit and the globe. Although there are a few ocular abnormalities to which these breeds are predisposed, they are not exclusive to brachycephalic patients and can also be found in non-brachycephalic cats. Examples of orbital conditions include lack of enophthalmia, proptosis, euryblepharon, prominent nasal folds, prolapse of the nictitans membrane gland, and other less commonly identified conditions, such as orbital pneumatosis (Matas Riera 2022).

Lack of Enophthalmia

As mentioned above, brachycephalic breeds have a different skull anatomy compared to non-brachycephalic breeds, characterized by a reduced length and rounder cranial shape. Consequently, these changes lead to a shorter orbital space that limits the mechanisms of enophthalmia and orbital protection. Hence, when there is an insult to the eye, the eyelids and the nictitating membrane are not capable of offering protection, as would occur in non-brachycephalic breeds (Matas Riera 2022).

Proptosis

Proptosis consists of a rostral shift of the globe, in which the eyelids become confined between the orbital rim and the globe. This condition is similar to exophthalmia, which is seen in brachycephalic breeds and refers to their protruding eye globes. Although in non-brachycephalic breeds exophthalmia is not considered normal and is usually a result of various conditions, such as trauma, in brachycephalic breeds, it is considered normal because of the anatomical uniqueness of these patients. However, it is crucial to know how to distinguish proptosis, an abnormal condition of the globe, from exophthalmia, which is considered predictable in brachycephalic breeds.

Proptosis can be distinguished from exophthalmia because, contrary to what is observed in exophthalmia, the margin of the eyelid is entrapped within the orbital rim and the rostrally repositioned eye globe, which consequently makes the eyelid margin impossible to be observed (Matas Riera 2022). This rostral displacement of the globe increases the risk of avulsion of the extraocular muscles and optic nerve. Additionally, as a result of proptosis, the globe becomes more susceptible to deviation (Matas Riera 2022).

Euryblepharon

Euryblepharon, also known as macropalpebral fissure, is condition that is characterized by a larger palpebral fissure, which leads to corneal exposure as a result of insufficient closure of the eyes, resulting in inadequate protection of the globe (Matas Riera 2022).

The presence of a larger palpebral fissure in brachycephalic breeds is associated with more exposed sclera, which consequently increases the likelihood of developing corneal ulceration by approximately three times when compared to non-brachycephalic breeds with smaller palpebral fissures. Due to the fact that there is a greater area of the sclera that is visible in brachycephalic breeds, the eye is more exposed to chronic irritation, as well as secondary scleral and corneal pigmentation (Matas Riera 2022).

Although, in theory, canthoplasties could be performed to correct this condition (a technique that aims to narrow the palpebral fissure), it is not yet certain whether this surgical correction would reduce the risk of corneal ulceration, because a cause-and-effect relation has not yet been established (Matas Riera 2022).

Nasal Folds

The presence of nasal folds often results in various ophthalmic complications. A common problem related to the presence of large nasal folds, especially in patients with long hair, is trichiasis. Patients with this condition often present corneal irritation or ulceration as a result of the contact between the hairs of the nasal folds and the ocular surface (Matas Riera 2022).

This condition can be more or less pronounced and is regarded as one of the defining traits of brachycephalic breeds.

Treatment is recommended, especially in patients with large nasal folds, to prevent the ocular problems mentioned above and dermatological symptoms under the fold. Surgery is the most effective and frequently used treatment for nasal folds. However, it is crucial to identify other problems in the globe such as medial canthal entropion or euryblepharon, both frequent in these breeds, in order to treat all abnormalities in the same surgical procedure (Matas Riera 2022).

Prolapse of the Nictitating Membrane Gland

Prolapse of the nictitating membrane gland, also known as 'cherry eye', although not exclusive to brachycephalic breeds, is an ocular condition that frequently affects brachycephalic breeds. Research conducted in dogs has identified particular breeds with a higher prevalence of this condition; however, this had not yet been studied in feline patients (Matas Riera 2022). Figure 3, below, illustrates a case of prolapse of the nictitating membrane gland, associated with the presence of corneal sequestrum.

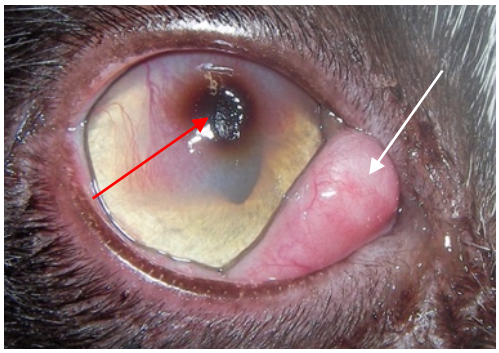


Figure 3: Photo of a cat's eye showing a dark brown corneal paracentral plaque due to a corneal sequestrum (red arrow) and superficial neovascularization, accompanied by a prolapsed gland of the third eyelid (white arrow) – image kindly provided by Prof[a] Esmeralda Delgado.

The most frequently used treatment for this condition consists of surgical correction, which may be performed using different technique such as the Morgan and Moore technique (Matas Riera 2022).

1.3.2 The Eyelids

There are numerous eyelid abnormalities that can affect both brachycephalic and non-brachycephalic patients. However, studies conducted in brachycephalic dogs have identified certain conditions that are more frequently diagnosed in these patients with brachycephalic syndrome. Although similar studies have not been conducted in brachycephalic cats, it can be suggested that this species would present similar patterns regarding the most prevalent eyelid abnormalities because of their similar anatomical conformation. The most frequently diagnosed eyelid abnormalities in canine brachycephalic patients include diamond eye and cilia abnormalities such as distichiasis, ectopic cilia, and trichiasis (Matas Riera 2022).

With respect to the third eyelid, although studies have identified brachycephalic dog breeds with higher prevalence of third eyelid abnormalities such as prolapse of the nictitating membrane, there is no statistical data available in the literature for feline breeds (Sebbag and Sanchez 2023).

Diamond Eye

Diamond Eye, also known as Pagoda Eye, is an ocular condition that results from a large palpebral fissure associated with an excess of loose skin on the head – both anatomical characteristics often found in brachycephalic patients. The combination of these traits may be responsible for causing both entropion and ectropion in upper and lower eyelids. Additionally, difficulty in opening the eyes and the rolling of the eyelids into the ocular surface, leading to entropion, may arise due to the excess periocular and forehead skin (Matas Riera 2022).

Furthermore, the presence of excess periocular and forehead skin, associated with its weight, can frequently cause lower eyelid ectropion, particularly in the central region. As a result, in the areas affected with entropion or ectropion, there is ineffective gliding of the eyelids over the ocular surface (Matas Riera 2022).

This condition is usually observed in large brachycephalic breeds. However, it is not exclusive to these breeds and is also frequently observed in large non-brachycephalic breeds. Although studies have identified certain dog breeds with a higher prevalence of this condition, research on cats needs to be conducted to establish similar results in this species (Matas Riera 2022).

Patients affected with diamond eye, especially those presenting signs of entropion or irritation of the ocular surface, usually require surgical treatment which aims to recover proper eyelid function and typically consists of shortening of the eyelid and entropion correction (Matas Riera 2022).

Entropion

Entropion, illustrated in figure 4, is an eyelid abnormality that can be classified as primary (or conformational) or secondary. The first results from abnormalities in structural development of the tarsus, orbit, globe, and their interactions; whereas the latter can be further subdivided into spastic entropion and cicatricial entropion. Spastic entropion results from contractions of the orbicularis oculi muscle which may occur as a response to intense pain or irritation. On the other hand, cicatricial entropion is triggered by eyelid abnormalities due to previous surgeries, injuries, trauma, or long-term inflammation (Sandmeyer et al. 2022).

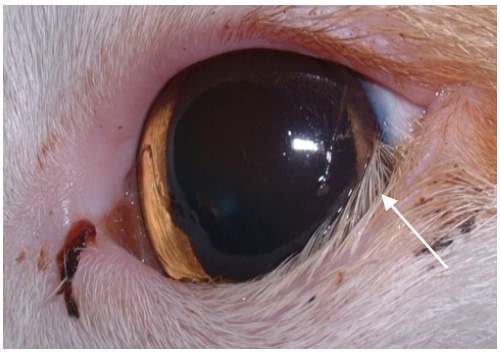


Figure 4: Cat's eye affected by lower eyelid entropion; the white arrow indicates the inward rolling of the eyelid, resulting in contact between the eyelashes and the corneal surface – image kindly provided by Profª Esmeralda Delgado.

Primary entropion is very common in Persian cats, although other brachycephalic feline breeds are also commonly affected by this condition. Studies suggest that brachycephalic feline breeds have a higher predisposition to entropion compared to non-brachycephalic patients, essentially because these breeds have an abnormality in the conformation of the medial lower eyelid which increases the risk of developing entropion (Mitchell and Oliver 2015).

There are temporary treatments for entropion, which aim to relieve the symptoms until the underlying cause is managed; however studies have shown that most cases require surgical intervention to correct this condition. Various surgical techniques may be used to correct entropion, including the Modified Hotz-Celsus, wedge excision, a combination of the Modified Hotz-Celsus with permanent lateral canthal closure, or a combination of the Modified Hotz-Celsus with a wedge resection (Sandmeyer et al. 2022).

Cilia Abnormalities

There are various cilia abnormalities that can be found in brachycephalic breeds, such as distichiasis, ectopic cilia and trichiasis. Although these conditions are frequently found in brachycephalic breeds, they are not exclusive to these breeds and can also be found in non-brachycephalic patients.

Distichiasis

Distichiasis is a condition characterized by the presence of hairs emerging from the meibomian gland opening, which can be observed in the eyelid margins of both upper and lower eyelids, and is usually associated with some degree of discomfort (Matas Riera 2022).

There are various treatments for distichiasis, including LASER treatment, cryosurgery, electrolysis and diathermia; however, all treatments are associated with a risk of regrowth of the hairs, which may or may not require a second treatment depending on reappearance of clinical signs (Matas Riera 2022).

Ectopic Cilia

Ectopic cilia is characterized by the emergence of cilia through the conjunctiva, usually observed approximately 4-6 mm from the upper eyelid margin. Patients with ectopic cilia may have one or more foci of cilia. Studies show that this condition is commonly diagnosed in

young dogs; however, there is a lack of data regarding its prevalence in cats. Hence, further investigation is needed in feline patients (Matas Riera 2022).

Patients diagnosed with ectopic cilia usually present with non-healing corneal ulceration, which tends to affect the upper half of the cornea and does not respond to the standard broad spectrum topical antibiotic treatment used for corneal ulceration (Matas Riera 2022).

Surgical treatment for this condition is recommended and consists of using a punch biopsy or a surgical knife to ressect the cilia and its follicle under general anesthesia (Matas Riera 2022).

Trichiasis

Trichiasis is a condition in which cilia grow in a normal position; however, their direction causes irritation of the surface of the eye, which may lead to corneal lesions or discomfort.

There are different treatments for this condition, which may or may not require medical intervention. Depending on the origin of the cilia, it may be necessary to shorten the palpebral fissure in order to reduce the exposure. Another strategy that may be adopted by the tutors would be to apply an ophthalmic oil-based lubricant and groom the hairs in the periocular region away from the surface of the eye (Matas Riera 2022).

1.3.3 The Lacrimal System

The nasolacrimal system consists of ducts approximately 1mm in diameter that are responsible for draining tears from the surface of the eye to the nose. There are two openings of this system located approximately 4-6 mm from the medial canthi: an upper and a lower lacrimal puncta. Both the upper and lower ducts of the nasolacrimal system converge in the lacrimal sac, located in the lacrimal fossa. After converging in the lacrimal sac, the lacrimal duct extends to the nose, where it opens at the nasal ostium (Matas Riera 2022).

Studies show that brachycephalic feline breeds have a higher prevalence of abnormalities in the nasolacrimal system, essentially due to their shortened and tortuous nasolacrimal ducts that assume a V-shape which compromises their correct function; hence, patients from these breeds are more likely to exhibit clinical signs such as chronic epiphora and wetness of the periocular region (Matas Riera 2022).

Chronic Epiphora

Epiphora is a condition characterized by an accumulation of tears on the surface of the eye. Chronic epiphora may be due to various etiologies, including reduced drainage of the nasolacrimal ducts, narrowing of the nasolacrimal duct or its proximal drainage system,

congenital malformation of the lacrimal puncta, absence of the nasolacrimal drainage system, a lacrimal sac with reduced size or underdevelopment of the nasolacrimal duct (Schlueter et al. 2009). Additional causes include imperforate lacrimal punctum, lower lacrimal micropuncta, or displacement of the lower lacrimal punctum (N. Gelatt et al. 2021); although there are a few studies that evaluate the frequency of these development abnormalities in brachycephalic dogs, there are no studies available in the literature that mention its incidence in feline brachycephalic breeds. Chronic epiphora may also result from excessive tear production due to eye inflammation or irritation. Causes include eyelid abnormalities like entropion or ectropion, as well as ocular issues such as aberrant eyelashes, caruncular hair, or allergies, which can contribute to conjunctivitis or keratitis (Allen M. Schoen 2015 Mar 30). Brachycephalic breeds have a predisposition to epiphora because of their shortened and tortuous nasolacrimal ducts, which compromise the process of draining the tears from the ocular surface (N. Gelatt et al. 2021). This anatomical characteristic contributes to tear accumulation and, consequently, signs of epiphora. In these breeds, chronic epiphora is frequently caused by nasolacrimal duct obstruction due to irregular anatomical configuration. Surgical treatment for this condition can be performed through canaliculorhinostomy, a surgical procedure that involves placing silicone tubing to create a connection between the canaliculi and the nasal cavity. This facilitates proper tear drainage and reduces signs of chronic epiphora (Wallin-Haakansson and Berggren 2020). When chronic epiphora is due to an imperforate lacrimal punctum, surgical intervention involves excising the mucosal tissue covering the punctum, most commonly affecting the lower punctum. Alternatively, an incision may be performed to restore patency (N. Gelatt et al. 2021). Lower lacrimal micropuncta can be corrected surgically by enlarging the affected punctum (N. Gelatt et al. 2021). In cases of lacrimal puncta atresia, where both the punctum and the corresponding canaliculus are absent, more complex surgical procedures are required to create a functional punctum (N. Gelatt et al. 2021). In cases of displaced lower lacrimal punctum, where the punctum is not located in its normal position, initial treatment involves dilation of the displaced punctum and its canaliculus. If this is unsuccessful, surgical relocation of the punctum to its correct position may be necessary (N. Gelatt et al. 2021).

Moreover, any coexisting ocular abnormalities, such as entropion or ectropion, which may contribute and exacerbate chronic epiphora, should also be addressed.

1.3.4 The Conjunctiva

There are various ocular diseases that can affect the conjunctiva and the third eyelid.

Conjunctivitis, an inflammation of the conjunctiva, is categorized as acute if clinical signs persist for less than 3 to 4 weeks, or chronic if they last longer than 4 weeks (Barnes et al.

2015). Additionally, conjunctivitis can be categorized based on its etiology, which may be primary or secondary (Donaldson et al. 2014).

Due to their conformation, brachycephalic feline breeds are predisposed to conditions such as entropion, which may lead to irritation of the cornea and, consequently, increase the risk of conjunctival disease; however, there is no statistical data available in literature demonstrating this correlation.

Conjunctivitis

Conjunctivitis is an ocular condition that affects the conjunctiva, and can be further categorized as primary or secondary. Primary conjunctivitis is usually a result of an infection of the eye by viral, bacterial, or other pathogens. Whereas, secondary conjunctivitis appears as a result of other conditions, such as systemic disease, extension from localized infections, or intraocular disorders (Donaldson et al. 2014).

A study conducted by Carlton L. Gyles suggests that brachycephalic dogs are predisposed to conjunctivitis due to increased ocular exposure caused by the protrusion of their eyes (Gyles 2017). However, there is no available statistical data in literature suggesting that brachycephalic feline breeds are more prone to developing this condition. Nevertheless, since both brachycephalic species exhibit similar anatomical and physiological changes – such as protruding eyes, abnormal eyelid closure, higher values of tear-film breakup time, and eyelid abnormalities - it could be expected that they are predisposed to similar ocular conditions, such as conjunctivitis.

Primary Conjunctivitis

Primary conjunctivitis is an infectious disease that frequently affects cats and is linked to infection with various pathogens such as feline herpesvirus-1 (FHV-1), feline calicivirus (as illustrated in figure 5), *Chlamydophila felis* (as illustrated in figure 6), *Mycoplasma spp.* (Donaldson et al. 2014).

Figure 5: Bilateral purulent ocular discharge in a severe conjunctivitis case in a kitten due to calicivirus infection – image kindly provided by Profª Esmeralda Delgado.

Figure 6: Close-up image of a cat's eye showing upper and lower chemosis, marked hyperemia and ocular discharge due to conjunctivitis caused by chlamydial infection – image kindly provided by Profª Esmeralda Delgado.

Other pathogens including β-haemolytic *Streptococcus spp.* and non-haemolytic *Steptococcus spp*. and *Staphylococcus epidermidis* have been identified in feline patients with primary conjunctivitis; however, these are considered opportunistic pathogens and tend to appear together with other infectious agents (Donaldson et al. 2014).

Studies suggest that half of the feline patients that suffer from latent FHV-1 infection may experience the virus reactivating spontaneously in later years. When the FHV-1 virus is reactivated, ocular signs are usually confined to the eye that was initially affected; however, clinical signs may be unilateral or bilateral (Donaldson et al. 2014). Since primary conjunctivitis can be caused by FHV-1, a virus that becomes latent and reactivates later in life, patients often experience chronic conjunctivitis with recurrent episodes triggered by immune system compromise, leading to virus reactivation (Thiry et al. 2009). Chronic cases of primary conjunctivitis, particularly in adult feline patients, may lead to complications such as dry eye disease. Due to the strong association between chronic conjunctivitis and FHV-1 infections, treatment is often challenging, with frequent relapses as clinical signs vary with the virus's latent and active phases. Research published in the *Veterinary Quarterly Journal* indicated that topical antiviral therapy has limited efficacy; therefore, systemic treatment with Acyclovir is considered the most effective approach for managing chronic herpetic conjunctivitis (Nasisse 1995).

Secondary Conjunctivitis

Secondary conjunctivitis can be a result of conditions that target the conjunctiva such as systemic disease, extension from localized infections, or intraocular disorders. It is also very frequent for patients infected with FHV-1, feline calicivirus and *Chlamydophila felis* to exhibit signs of secondary bacterial infection of the eye. Studies suggest that, in contrast with healthy

cats, those affected with secondary conjunctivitis have higher values of tear film break-up time. However, it is not clear whether the more rapid tear film break-up time predisposes patients to this disease or if it is a direct result of secondary conjunctivitis (Donaldson et al. 2014).

Conjunctival Trauma

Several traumatic events can affect the conjunctiva; however, cat fights and foreign bodies are the most frequently identified causes in cats. Other etiologies of conjunctival trauma include chemical injuries and those caused by car accidents (Donaldson et al. 2014).

Dry Eye Disease

Dry eye disease is an ocular condition characterized by reduced tear production, which results in abnormalities of the ocular surface, including enhanced mucoid secretion, hyperaemia of the conjunctiva and neovascularization of the cornea. Patients with this condition typically have abnormal readings on the Schirmer tear test (STT), often falling below the normal range of 15 to 25 millimeters/minute (mm/min) for each eye. This condition can be diagnosed when, in the presence of clinical signs, STT readings are below 15 mm/1min (Matas Riera 2022).

Studies conducted in dogs have shown that numerous brachycephalic breeds are predisposed to immune-mediated keratoconjunctivitis sicca; however, similar studies have not been performed in brachycephalic cats. Due to their predisposition to immune-mediated keratoconjunctivitis sicca and their large palpebral fissure, which increase tear film evaporation, brachycephalic patients are more susceptible to chronic diseases of the surface of the eye (Nicholas and Tammen 2024).

1.3.5 The Cornea

Brachycephalic breeds are predisposed to various corneal diseases, such as exposure keratopathy, corneal ulceration, and sequestrum formation. While these ocular conditions are not exclusive to brachycephalic breeds, studies in dogs indicate that these animals are more vulnerable to these conditions due to their unique anatomical features (Matas Riera 2022). However, similar studies have not been conducted in cats to determine if this species also exhibits a similar predisposition to the same corneal diseases.

Other corneal abnormalities that may affect brachycephalic cats, though not as frequently and not exclusively, include dermoid, corneal abscess, corneal pigmentation, and corneal neoplasia.

Exposure Keratopathy

It is essential to recognize that exposure keratopathy, which results from the previously mentioned anatomical singularities of brachycephalic breeds, increases the risk of corneal sequestrum due to the chronic exposure of the cornea - especially the central region - to the external environment (Demir 2024). Medically, patients with exposure keratopathy can be treated with tear replacement preparations, commonly referred to as “artificial tears”, which serve as lacrimomimetic agents to prevent excessive dryness of the corneal surface (J. Maggs et al. 2007).

Corneal Ulcers

Corneal ulcers are frequently caused by FHV-1, which is often considered the primary causative agent until proven otherwise (Hartley 2010). This condition may present with different levels of severity, and an example is illustrated in figure 7.

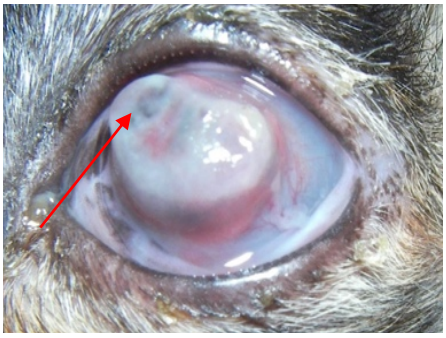


Figure 7: Left eye of a kitten presenting with an extense and deep infected corneal ulcer accompanied by queratomalacia and corneal perforation; the red arrow points to the corneal perforation – image kindly provided by Prof. Esmeralda Delgado.

Corneal ulceration may be more superficial, affecting only the superficial layers of the cornea, like corneal erosions; it may affect more layers of the cornea, like melting ulcers; and it may affect a greater extent of the cornea, up to all layers, like corneal perforation.

Corneal erosion is a superficial type of corneal ulcer, in which the corneal epithelium is unable to adhere adequately to a structurally compromised basement membrane. Corneal perforation, on the other hand, is a type of deep corneal ulcer which usually results from trauma. Finally, melting ulcer is a type of corneal ulcer with infection.

Studies suggest that brachycephalic breeds are predisposed to this condition because of the increased exposure of their eyes, incomplete eyelid closure, medial canthal entropion, and instability of the tear film. These conditions not only predispose these breeds to develop corneal ulceration, but are also associated with a faster development and aggravation of this condition, often resulting in more severe cases of melting ulcers which may lead to corneal perforation. While certain brachycephalic dog breeds have a higher prevalence of this disease, there is no statistical data available for feline breeds in the literature. However, due to the

similarity of the brachycephalic syndrome, it would be expected to see a similar predisposition to corneal ulceration in brachycephalic feline breeds as it is seen in dogs (Matas Riera 2022).

When deciding between medical or surgical treatment options, several factors must be carefully considered. These include the depth and progression of the ulcer, the presence of coexisting ocular conditions, the general health of the patient, the patient's demeanor, as well as the owner's compliance and financial considerations.

Medically, corneal ulcers in cats, especially those that are more superficial, are typically managed with topical eye drop antibiotics and/or antivirals, in conjunction with systemic analgesia (Hartley 2010). The use of topical corticosteroids is contraindicated in these cases, as they increase the risk of infection. Likewise, topical nonsteroidal anti-inflammatory drugs (NSAIDs) should be avoided due to their potential to impede corneal healing and should only be administered systemically if uveitis is also present (J. Maggs et al. 2007). It is also critical to avoid ointments in cases of corneal perforation due to the risk of severe granulomatous uveitis, which may occur if the petrolatum base of the ointment enters the eye (J. Maggs et al. 2007). Additionally, recent studies have suggested that subconjuntival injections of autologous platelet-rich plasma may serve as an adjective treatment for corneal ulcers in cats, promoting healing and reducing inflammation (Farghali et al. 2021). Surgically, corneal ulcers may be managed using various techniques, depending on the severity of the case. When surgically treating corneal perforations, various techniques can be employed depending on the severity and specifics of the case. Grafting is commonly utilized in cases of corneal perforation to provide additional structural support to the compromised cornea. In feline patients, several graft materials can be used, including homologous and heterologous corneal transplants, porcine bladder, porcine small intestinal submucosa, bovine pericardium, and equine amniotic membrane (Telle and Betbeze 2022). In addition to grafting, other surgical techniques are available, such as suturing the corneal defect directly or creating a conjunctival flap (Ali and Hassan 2020).

Corneal Sequestrum

Corneal sequestrum, also referred to as *nigrum*, is an ocular condition that can affect patients of any species or breed. It is characterized by an epithelial defect manifesting as a plaque or deposit with a color ranging from brown to black. This lesion typically assumes a central or paracentral position on the cornea but can occur in any corneal region. Corneal sequestrum is often associated with signs of neovascularization and has the potential to increase in both width and depth, sometimes extending to deeper corneal layers rather than remaining superficial. This condition may be unilateral or bilateral and can present with or without varying degrees of pain. Although the hallmark coloration of corneal sequestrum is consistently within

the brown-to-black spectrum, the underlying mechanism behind this pigmentation remains incompletely understood (L. Martin et al. 2019).

While the pathogenesis of feline corneal sequestrum is not fully understood, certain causal associations have been identified that relate chronic corneal irritation to sequestrum formation. Risk factors include eyelid abnormalities like distichiasis and entropion, as well as exophthalmos, lagophthalmos, medial canthal trichiasis, and entropion – alterations linked to brachycephalic syndrome. Decreased corneal sensitivity, inadequate precorneal tear film, FHV-1 infection, and iatrotropic causes may also contribute to corneal sequestrum (Enache and Tee 2023 Sep 29).

When deciding between medical and surgical treatment for corneal sequestrum, several factors must be considered, including the extent and depth of corneal damage, the presence of ocular discomfort, and the financial resources of the patient's guardian. It is important to note that reliably assessing the depth of conceal sequestrum is often challenging. As the condition progresses, the stroma becomes darker, denser, and necrotic, obscuring deeper corneal layers and making depth assessment frequently inconclusive. For this reason, whenever a surgical approach is chosen, the surgeon should be prepared to perform a grafting procedure if needed. If the medical approach is chosen, treatment generally includes the topical application of antibiotic eye drops or ointment, a lacrimomimetic agent (preferably hyaluronate-based), and, when suitable, a systemic nonsteroidal anti-inflammatory drug (NSAID). However, in cases of FHV-1 infection, NSAIDs should be avoided, and antiviral treatments – either topical or systemic – are recommended instead. When surgical approach is indicated, early intervention is recommended to increase the chances of fully excising the corneal sequestrum with minimal scarring. The most common technique is keratectomy, which may be superficial or may involve deeper excision depending on the lesion's extent; in the latter cases, a graft is often necessary to repair the corneal defect. Postoperative care typically includes the use of soft bandage contact lens and/or a temporary tarsorrhaphy to improve comfort and protect the cornea during the healing process (Enache and Tee 2023 Sep 29).

Dermoid Cyst

Dermoid cyst is a corneal lesion consisting of ectopic ectodermal tissue located in an unusual position but with normal structural characteristics. Dermoid cysts may contain skin, glands and hair follicles, and can affect only the cornea or extend to the lateral conjunctiva and lateral canthus. Typically, this ocular condition is diagnosed early in life, as it is present at birth and, due to its noticeable appearance, is often identified quickly (Matas Riera 2022).

While this condition can affect any breed, brachycephalic or not, studies show that some brachycephalic dog breeds are predisposed to dermoids. However, similar statistical data regarding its prevalence in brachycephalic cats is currently unavailable (Matas Riera 2022).

Dermoid cysts should be surgically addressed through resection techniques, although some patients may need additional grafting procedures (Matas Riera 2022).

Corneal Pigmentation

The presence of pigment on the corneal surface is generally considered a result of chronic inflammation, often due to conditions such as chronic superficial keratitis. Corneal pigmentation is usually a progressive ocular disease in which there is a gradual development of a pigment layer whose density may vary, possibly affecting the sight in cases where the pigment layer is dense and when the visual axis is targeted (Matas Riera 2022).

Although studies show that specific brachycephalic dog breeds are more frequently affected by this condition, corneal pigmentation may appear in any breed, brachycephalic and non-brachycephalic. According to literature, certain dog breeds have predisposition to this condition (Matas Riera 2022); however, there is no statistical data available for feline breeds in literature.

1.3.6 The Sclera, Episclera and Limbus

The sclera, episclera and limbus may be involved in various ocular abnormalities. Studies suggest that, compared to dogs, feline patients are less frequently affected by inflammatory processes of these parts of the eye, such as episcleritis and scleritis; however, research comparing their prevalence in brachycephalic and non-brachycephalic breeds has not been conducted. Among the conditions that may affect the sclera, episclera, and limbus, acquired traumatic lesions are the most commonly diagnosed in cats (Donaldson et al. 2014).

Penetrating injuries, often associated with cat scratch incidents, are a common form of trauma in cats. These injuries may result in rupture of the sclera or limbus with prolapse of the iris. In cases of iris prolapse due to laceration of the sclera or limbus, the prolapsed tissue is typically coated with a thin film of tan-colored coagulated aqueous humor. Additionally, iris prolapse is commonly accompanied by dyscoria, characterized by an abnormal pupil shape (Donaldson et al. 2014).

1.3.7 The Uveal Tract

The uveal tract consists of a continuous layer of tissue that is anatomically divided into the iris, ciliary body, and choroid. All parts of the uveal tract can be affected by various abnormal

conditions which may be categorized into development or acquired abnormalities. This region of the eye can be affected by different development and acquired abnormalities, which are not exclusive to brachycephalic breeds and may affect any cat. Given the extensive list of abnormalities that can affect this region of the eye, this study focuses only on the diseases of the uveal tract identified in the study population.

Persistent Pupillary Membrane

Persistent pupillary membrane (PPM) is a development abnormality that consist of vestiges of the pupillary membrane and the anterior tunica vasculosa lentis, structures that supply nutrients to the lens and the eye's anterior segment during development. These structures may persist beyond 6 weeks old, gradually regressing in the following months, or they may stay throughout life (Donaldson et al. 2014).

This condition can be further classified based on its extent. Minor PPMs are frequently observed and appear as pigmented areas concentrated in the central anterior lens capsule with a similar colour as the surface of the iris of the involved eye. Typically, PPMs appear as thin, thread-like extensions from the iris, starting at the iris collarette, and blending in with the iris color. These blood vessel remnants can connect different parts of the iris (iris-to-iris PPMs), stretch from the iris to the lens (iris-to-lens PPMs), link the iris to the cornea (iris-to-cornea PPMs), or even have a free-floating end within the anterior chamber. Vision may be impacted based on the quantity, size, and placement of the PPM attachments, and whether they involve the cornea or lens (Donaldson et al. 2014).

Studies conducted in dogs have identified breeds that are genetically predisposed to this ocular condition through a recessively inherited gene; however, similar studies on this condition’s genetic inheritability have not been conducted in cats (Donaldson et al. 2014).

Due to the several complications associated with this condition, medical therapy may be necessary to manage corneal oedema, and surgical intervention may be required in certain cases. However, iris-to-iris and free-floating PPMs are usually not associated with complications, hence therapy is not required (Donaldson et al. 2014).

Uveitis

Uveitis is an inflammatory condition that tends to be chronic and presents with mild clinical signs in feline patients. Clinical signs often seen in cats with this condition include keratic precipitates, and hyperpigmentation and hyparaemia of the iris. Additionally, neovascularization of the iris, also known as rubeosis iridis, can also be observed in cats with uveitis (Donaldson et al. 2014), as illustrated in figure 8.

Figure 8: Right eye of a cat with uveitis, showing signs of iris edema, *rubeosis iridis*, leucocoria due to a cataract and posterior synechiae – image kindly provided by Prof. Esmeralda Delgado.

This ocular condition can have various etiologies, including infections caused by viruses, bacteria, protozoa, and fungi, lens-induced factors, or lymphoplasmocytic uveitis (Donaldson et al. 2014).

Treating uveitis requires anti-inflammatories to reduce inflammation, manage pain, and prevent complications, with the choice of medication depending on the suspected cause. While structures in the anterior segment of the eye can be treated with topical medication, to achieve therapeutic concentrations in the posterior segment, systemic treatment is required. The use of corticosteroids, both topically and systemically, is subject to strict conditions. Topical corticosteroids can only be used if the fluorescein stain test is negative for corneal defects. The most commonly used topical corticosteroids are 0.1% Dexamethasone Acetate and 1% Prednisolone Acetate. Systemic corticosteroids, on the other hand, should only be administered after ruling out underlying infectious causes of uveitis. However, due to the high prevalence of infectious diseases in cats with uveitis, systemic corticosteroid treatment is generally contraindicated in this species. Additionally, corticosteroids are indicated in cases of immune-mediated uveitis, which is typically treated with immunosuppressive doses. For patients in whom corticosteroids are contraindicated, systemic NSAIDs are a good alternative. Chronic cases of uveitis may benefit from immunomodulatory medications, such as Azathioprine, Cyclophosphamide, Ciclosporine, and Methotrexate, particularly when the condition is immune-mediated. Finally, Atropine 1% may be used to relieve symptoms of ocular pain, discomfort, and inflammation due to its mydriatic properties (Donaldson et al. 2014).

Feline Diffuse Iris Melanoma

Feline diffuse iris melanoma is the most commonly diagnosed primary eye tumor in cats. Early on, affected cats may show one or more small areas of increased pigmentation on the iris, which tend to grow or spread over time, as it is illustrated in figure 9.

Figure 9: Left eye of a cat with feline diffuse iris melanoma, showing multiple areas of increased pigmentation of the iris – image kindly provided by Profª Esmeralda Delgado.

These lesions can alter the texture of the iris surface, becoming slightly raised or velvety, and may lead to changes in the pupil's shape. Less commonly, the condition can originate from the ciliary body or choroid and form solid, localized masses instead of spreading diffusely. Additionally, amelanotic forms of the tumor can sometimes be mistaken for inflammation (Donaldson et al. 2014).

This condition may gradually increase in size without causing ocular complications or signs of metastatic disease. However, in some cases, it progresses rapidly and can lead to glaucoma, secondary uveitis, and metastasis, which more often affects the abdominal organs rather than the lungs (Donaldson et al. 2014). Ocular signs that may suggest the presence of feline diffuse iris melanoma include areas of pigmentation with changes in the iris surface, such as raised or altered textures. Other indicators may include pupil anomalies like anisocoria and dyscoria, ectropion uveae, the presence of exfoliative cells in the anterior chamber, invasion of the drainage angle, development of pigmented areas, and signs of secondary glaucoma and uveitis (Donaldson et al. 2014).

Treatment for feline diffuse iris melanoma may vary depending on the speed at which the condition is developing and potentially spreading. However, the most common approach is to perform enucleation of the affected eye, which should then be analyzed histopathologically to serve as an indicator of anticipated lifespan (Donaldson et al. 2014).

Lymphoma

Uveal lymphoma is the second most frequently diagnosed intraocular neoplasm in feline patients. This condition can present with a range of clinical signs, including persistent uveitis that does not respond to treatment, the formation of nodular masses, or widespread infiltration affecting the anterior uveal tract. Additionally, eye-related symptoms may appear before any signs of systemic involvement (Donaldson et al. 2014).

Primary intraocular lymphoma, also referred to as the round cell variant of feline post-traumatic ocular sarcoma, is a form of lymphoma that can occur in cats with a history of ocular trauma. This condition is often linked to lens rupture and has a widespread global distribution (Donaldson et al. 2014).

1.3.8 Glaucoma

Glaucoma is a serious ocular condition that is characterized by changes in the blood flow to the eye, intraocular pressure (IOP), and alterations to the optic nerve. This condition can be classified as primary or secondary. Primary glaucoma is caused by a disruption in the outflow of the aqueous humor from the eye, which results in increased IOP and decreased blood flow to the ocular tissues. On the other hand, secondary glaucoma can be a result of either ocular chronic inflammation or intraocular tumors (Matas Riera 2022).

Studies suggest that brachycephalic feline breeds such as the Persian and Burmese have predisposition to glaucoma (L. Martin et al. 2019).

Treatment for glaucoma can be medical or surgical. Typically, patients with glaucoma are treated with hypotensive and topical medications to manage the condition. Surgical treatments, such as ablation surgeries (where the ciliary processes responsible for producing aqueous humor are partially destroyed) or procedures that enhance aqueous humor outflow, may also be used. If left untreated, glaucoma can cause significant pain in the affected eye and lead to blindness (Matas Riera 2022).

1.3.9 The Lens

There are two categories of lens abnormalities. The most frequently diagnosed is a partial or complete loss of lens transparency, a condition known as cataract. The second category involves abnormalities related to an incorrect position of the lens, usually resulting from damage to the zonular filaments, which are responsible for supporting the lens (Matas Riera 2022).

Cataracts

Cataracts can be classified as early or late onset. Studies conducted in brachycephalic dogs have proven that this ocular condition is heritable in certain breeds, while in others, it is suspected to be heritable; however, similar statistical data does not exists in brachycephalic cats, which is why the genetic pattern of cataracts is not known in this species (Nicholas and Tammen 2024). Figure 10 illustrates a cat with cataract.

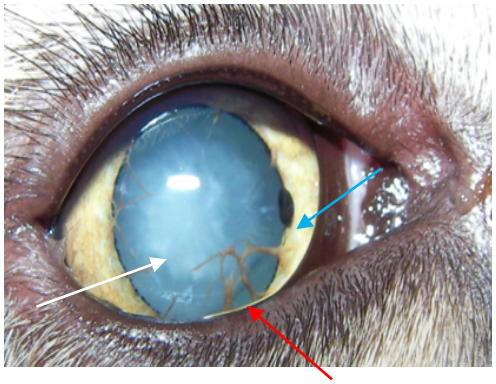


Figure 10: Right eye of a cat with cataract (white arrow), PPM (red arrow) and an iris cyst of approximately 2mm on the medial canthus of the pupil (blue arrow) – image kindly provided by Profª Esmeralda Delgado.

Cataracts are an irreversible condition characterized by the loss of transparency of the lens and, consequently, loss of vision, which can only be restored through surgical intervention known as phacoemulsification of the lens. When untreated, cataracts may lead to other ocular conditions such as uveitis induced by the lens, chronic glaucoma, lens luxation and retinal detachment. Since all of these conditions may cause pain, patients that cannot be surgically treated for cataracts undergo long-term treatment with topical NSAIDs, which play an important role in reducing intraocular inflammation that may be caused by cataracts (Matas Riera 2022).

Different studies have identified certain brachycephalic feline breeds that seem be predisposed to cataracts. In 1975, Robert L. Peiffer and Kirk N. Gelatt reported a case of congenital cataracts in a Persian kitten (Narfström 1999). Later in 1983, Irby NI identified congenital cataracts on a British short-haired cat, suggesting it would be a result of an autosomal recessive gene (Narfström 1999). Additionally, in 1986, Lionel Rubin diagnosed three Himalayan cats with congenital cataracts before the age of twelve weeks old (Narfström 1999). Hence, the same way certain brachycephalic dog breeds have been identified as predisposed to cataracts, there may also be certain brachycephalic feline breeds that show a similar hereditary pattern. However, more studies need to be conducted including a wider range of brachycephalic breeds in order to establish this hypothesis.

1.3.10 The Vitreous

The vitreous humor is a clear gel found in the posterior segment of the eye. It is responsible for transmitting light between the lens and the retina and also offering support and securing the eye's internal components during movement (Donaldson et al. 2014). This segment of the eye can be affected by both congenital and acquired abnormalities, equally in both brachycephalic and non-brachycephalic breeds. Abnormal conditions that may affect the vitreous, despite being uncommon, include congenital abnormalities such as the presence of

a persistent hyaloid artery, and acquired abnormalities like chronic feline uveitis and vitreous hemorrhage (Donaldson et al. 2014).

The most frequently diagnosed abnormality in the vitreous of feline patients is chronic feline uveitis, an acquired condition that typically affects the uveal tract but can also extend to the vitreous. Patients affected by this condition show a build-up of inflammatory cells in the anterior vitreous in association with pars planitis. Although it is believed that this ocular condition is associated with infection by the feline immunodeficiency virus, the relationship has not yet been confirmed (Donaldson et al. 2014)

1.3.11 The Fundus

The fundus refers to the posterior segment of the eye, which includes structures such as the retina and its vasculature, the choroid and the optic nerve.

1.3.12 The Retina and Choroid

There are developmental, inherited, and acquired conditions that may affect the retina and choroid. Although many of these conditions are uncommon and not exclusive to brachycephalic feline breeds, some are more frequently observed, such as progressive retinal atrophy that commonly affects brachycephalic breeds such as the Persian (Donaldson et al. 2014).

Developmental and inherited conditions affecting the fundus include retinal dysplasia and feline progressive retinal atrophy. Acquired conditions involve retinal detachment, chorioretinitis, retinal vascular diseases (e.g., coagulopathies, hypertensive chorioretinopathy, hyperviscosity syndrome, lipaemia retinalis), fluoroquinolone toxicity (e.g., enrofloxacin), nutritional retinal degeneration from taurine deficiency, neuronal ceroid lipofuscinoses, photic retinopathy, and neoplasia (Donaldson et al. 2014).

Feline Progressive Retinal Atrophy

Various genetic mechanisms of feline progressive retinal atrophy (PRA) have been identified in different feline breeds, including both brachycephalic and non-brachycephalic cats. While not exclusive to brachycephalic breeds, only Persian cats are known to have a genetically inherited form of PRA. In Persians, PRA is inherited in an autosomal recessive manner and is characterized by rod-cone dysplasia, where photoreceptors fail to fully develop. Clinical signs typically appear at 2-3 weeks of age, and complete blindness occurs by 16 weeks (Donaldson et al. 2014).

Retinal Detachment

Retinal detachment is an acquired condition of the retina that usually refers to the splitting of the neurosensory retina from the retinal pigment epithelium, instead of a complete detachment of the retina from the posterior part of the eye (Donaldson et al. 2014). Figure 11 illustrates a case of retinal detachment on a cat.

Figure 11: Complete bilateral retinal detachment causing total mydriasis and acute blindness in a cat – image kindly provided by Profª Esmeralda Delgado.

When observing with an ophthalmoscope, areas affected by retinal detachment present as localized gray patches in the tapetal fundus, accompanied by a decrease in tapetal reflectivity. In the non-tapetal fundus, they appear lighter in color compared to the surrounding tissue. Retinal detachment is categorized according to how much of the retina is affected and can be described as focal, multifocal, or total. Consequently, depending on the extent of the retinal detachment, clinical signs vary. Cases of focal retinal detachment may not be linked to clinical signs of impaired vision; on the other hand, total retinal detachment is invariably linked to blindness and significantly diminished or absent pupillary light reflexes.

There are various complications that may result from retinal detachment, including preretinal and intravitreal hemorrhage or hyphaema, as well as glaucoma and cataract (Donaldson et al. 2014).

Studies have identified numerous causes of retinal detachment, which can be either congenital or acquired. These include congenital malformations, choroidal and/or subretinal infiltrates and exudates, vasculopathy, trauma, vitreoretinal traction, lens disease, retinal thinning, globe or retinal stretching, and idiopathic factors. Although various causes have been identified, exudative or serous detachment is the most commonly diagnosed (Donaldson et al. 2014). Additionally, as long as the retina is not torn, if the underlying cause is identified and treated, regions of serous detachment may reattach; however, more complicated cases require surgical intervention (Donaldson et al. 2014).

1.3.13 The Optic Nerve and Optic Disc

The optic nerve and optic disc may be affected by both congenital and acquired conditions. Congenital conditions that affect these structures of the fundus include optic nerve hypoplasia and optic nerve coloboma. In contrast, acquired conditions include papiloedema, neoplasia, and optic atrophy. Although these conditions are uncommon and not exclusive to brachycephalic feline breeds, they may occur and should always be considered as differentials for fundus anomalies (Donaldson et al. 2014).

1.4 Ethical Considerations and Patient's Wellbeing

With increasing attention to animal welfare and ethical concerns surrounding selective breeding, it is essential to acknowledge the significance of these issues particularly regarding brachycephalic feline breeds. These breeds have undergone extensive selective breeding to develop specific physical attributes deemed aesthetically appealing. However, these same characteristics are closely associated with a higher prevalence of various health issues, as previously noted. In the present era, it is crucial to question the extent to which humans can ethically and responsibly continue to manipulate feline breeds, as they have done in the past and continue to do now. Figure 12 illustrates the anatomical differences between a brachycephalic (Persian) and a non-brachycephalic (Domestic Shorthair), highlighting the significant structural disparities that are linked to various health issues.

	Brachycephalic (Persian)	Non-brachycephalic (Domestic Shorthair)
Lateral View		
Frontal View		

Figure 12: Images of a brachycephalic (left) and a non-brachycephalic (right) cat, shown in lateral views on top and frontal views below.

A recent study emphasizes that cats with severe brachycephaly (category III or IV) should not be bred, while those with broader facial bones are preferred for breeding (Özkan et al. 2024).

However, it remains essential to question where ethical boundaries should be drawn - if they can indeed be clearly defined - in relation to animal welfare. Although cats with severe brachycephaly experience more pronounced symptoms and higher susceptibility to secondary diseases associated with brachycephalic syndrome, even those with broader facial bones often endure various health issues linked to their brachycephalic anatomy. This concern has prompted some countries, such as the Netherlands, to consider legislation prohibiting the breeding of brachycephalic feline breeds to safeguard animal welfare (Ross 2023 Feb 21). However, the veterinary community should advocate for implementing such legislation globally to effectively end the suffering of brachycephalic animals.

Organizations such as the Federation of European Companion Animal Veterinary Associations (FECAVA), the Federation of Veterinarians of Europe (FVE), the Union of European Veterinary Practitioners (UEVP) and the International Society of Feline Medicine (ISFM) jointly issued a letter to the companies that feature brachycephalic animals in advertisements. This initiative aims to encourage companies to reconsider using these breeds in their marketing content, with the hope that reducing their visibility could ultimately decrease their popularity (FECAVA, FVE, UEVP and ISFM Unite Against Promotion of Brachycephalic Animals in Advertisements - FECAVA 2023 Sep 3).

Ultimately, as veterinarians, we have the ethical responsibility to advocate for the well-being of brachycephalic patients. However, this responsibility is also shared with breeders, who must consider factors like the severity of brachycephaly when selecting animals for breeding, and with owners, who should be aware that clinical signs - like those indicating respiratory distress and ophthalmological disease resulting from the brachycephalic syndrome - should never be accepted as typical or normal (Campbell 2019).

III. OCULAR DISEASES IN BRACHYCEPHALIC CATS – A RETROSPECTIVE STUDY OF 50 CASES

1 Introduction

Brachycephalic breeds, both feline and canine, have gained significant popularity in recent years. However, this trend has raised concerns among veterinary professionals due to the adverse effects of the brachycephalic syndrome on these animals' overall wellbeing. This syndrome is associated with a range of health issues, including dermatological, respiratory, and ophthalmologic problems. Additionally, it brings into question the ethical implications of selectively breeding animals with such extreme anatomical features.

In a time when society is becoming increasingly mindful of animal welfare, the high demand for these breeds is particularly controversial. It is imperative to raise awareness about the health complications and impacts on the quality of life that the brachycephalic syndrome causes in cats.

Adopting more responsible breeding practices to prioritize individuals with less extreme anatomical traits is a crucial step in reducing the prevalence of ocular conditions and mitigating the negative impacts of this syndrome on affected animals. Such measures could improve the health and wellbeing of these patients significantly.

Furthermore, it is crucial to educate both the veterinary community and the general public about the growing prevalence of ocular diseases in brachycephalic feline patients. Emphasizing the negative consequences of breeding for extreme physical traits can help people better understand the ethical and medical issues involved, promoting more thoughtful and responsible approaches to breeding and pet ownership.

2 Objectives

This study aims to investigate the most prevalent ocular diseases in brachycephalic feline breeds through a retrospective analysis, identifying patterns and clinical features associated with these conditions, thereby contributing to the broader understanding of ocular diseases in brachycephalic feline breeds.

Furthermore, this study also aims to: characterize the study population based of gender, breed, age, indoor or outdoor living condition, vaccination status, and whether it was a first opinion consultation or a referred case; identify the iatrotropic stimuli that led to the consultation; identify the most frequent clinical manifestations of the ocular diseases present; evaluate the medical and surgical treatment options available for each condition; and

contribute to the knowledge surrounding the diagnosis and prevention of the most common ocular conditions in brachycephalic cats.

3 Materials and Methods

3.1. Study Design and Study Sample

This is an observational retrospective study that was conducted in a total of 50 brachycephalic cats who attended the Ophthalmology Specialist consultation at The Cat Vet Clinic in Dubai between December 5, 2019, and November 3, 2024.

All information from the patients included in this study was extracted from the clinic's veterinary platform, called Ezyvet, in which all medical records of the clinic's patients during the time of the study were carefully recorded. First, general data was collected, which included compiling information on all patients, both brachycephalic and non-brachycephalic, who attended the Ophthalmology Specialist consultation during the study period. This data included the breed, age, and gender of every patient. After gathering this information, a more thorough clinical investigation of brachycephalic patients was conducted, in which all existing medical record of each brachycephalic patient was documented. This included information not directly related to the ophthalmology consults, such as comorbidities, current medication, living situation (outdoor or indoor), vaccination status, and history of previous diseases. The selection of patients for this study followed a detailed inclusion criteria, mentioned below.

The guardians of all patients included in this study provided prior written consent by signing a consent form allowing the use of photographs, clinical reports, and data for medical research purposes.

3.2. Inclusion Criteria

Only patients belonging to brachycephalic breeds were included in this study sample. The additional inclusion criteria required that each selected patient possess a comprehensive clinical record, undergo a complete systematic ophthalmologic examination with documented results, and have a confirmed diagnosis established by a specialist in ophthalmology. Patients that did not fulfill these inclusion criteria were excluded from the study sample.

3.3. Systematic Ophthalmologic Examination

At the onset of each consultation, following the collection of the patient's medical history, the clinician performed a visual inspection of the eyes to assess the external structures. This evaluation was performed by a trained veterinarian ophthalmologist.

This evaluation aimed to identify any abnormalities in the eyelids, eyelashes, conjunctiva, and sclera, with particular attention to signs of inflammation such as redness or opacities. The clinician also looked for the presence of discharge, noting its type, as well as checking for any asymmetry of the eyes or the presence of masses or foreign bodies. When the patient permitted, tonometry and the Schirmer tear test were performed.

A comprehensive and standardized ophthalmologic examination was conducted for each patient presenting at the consultation, which included the following elements:

- Neuro-ophthalmological assessment, examining the palpebral reflex, menace response, dazzle reflex, direct and indirect pupillary reflex using a transilluminator (Finoft, New York, USA).
- Measurement of tear production in each eye using Schirmer Tear Test strips (MSD Rahway, NJ, USA).
- Measurement of IOP using a tonometer (Tonovet Plus Icare, Tiolat Ltd, Finland).
- Examination in both eyes of the palpebral region, conjunctiva, sclera, cornea, anterior chamber, and lens with slit-lamp biomicroscopy (Kowa SL-15, Nagoya, Aichi, Japan) in order to detect possible abnormalities.
- Evaluation in both eyes of the optic disc, macula, retinal blood vessels, and peripheral retina with direct fundoscopy using a direct ophthalmoscope (Welch Allyn, New York, USA) and a transilluminator (Finoft, New York, USA).
- Assessment in both eyes of the fundus and its structures, including the retina, optic disc, choroid, and associated blood vessels with an indirect binocular ophthalmoscope (Welch Allyn, model 12500, New York, USA) and indirect ophthalmoscopy lenses (30D and 20D Volk, Ohio, USA).
- If necessary, administration of fluorescein dye in both eyes (Fluoro Touch, Ophthalmus, New Delhi, India), followed by examination with a slit-lamp biomicroscopy (Kowa SL-15, Nagoya, Aichi, Japan) equipped with a cobalt blue filter to assess corneal staining patters, tear film breakup time, and potential abnormalities.
- If required, sample collection could be performed.

Complementary examinations were conducted based on the individual needs of each case, such as ocular ultrasound, fluorescein staining, blood pressure measurement, computed tomography (CT) scan, conjunctival biopsy, iris biopsy, corneal swab.

All devices and materials used to perform the ophthalmologic examination are illustrated in figure 13, and they included the following: transilluminator, Schirmer tear test strips, tonometer, slit-lamp biomicroscope, direct ophthalmoscope, indirect binocular ophthalmoscope, indirect ophthalmoscopy lenses, and fluorescein dye.

Transilluminator	Schirmer Tear Test strips
	
Tonometer	Slit-lamp biomicroscope
	
Direct ophthalmoscope	Indirect binocular ophthalmoscope
	
Indirect ophthalmoscopy lenses	Fluorescein dye
	

Figure 13: Devices and materials used in the ophthalmologic examination.

3.4. Inferential analysis

The variables evaluated in this study included the patients' iatrotropic stimulus, age, gender, breed, weight, ocular clinical signs, results of the systematic ophthalmologic examination, ocular diagnosis, complementary diagnostic tests, comorbidities, whether they were referred cases, and the treatment plan.

The data collected from these patients was organized into a database using Microsoft Office Excel, and descriptive inferential analysis was conducted using the same software and Epitools 2025, Ausvet Pty Lt, Australia.

Subsequently, possible correlations between different variables were analyzed. These included the presence of corneal sequestrum in Persian cats, and the presence of sequestrum in entropion cases. This analysis was performed using a chi-square test, with a confidence

level of 95% and a significance level set at p<0.05. If the p-value was less than 0.05, the null hypothesis would be rejected, and the alternative hypothesis would be accepted.

There were different null and alternative hypothesis depending on the correlation that was being studies. These included the following:

- H_1 – There is an association between Persian cats and the presence of corneal sequestrum; H_0 – There is no association between Persian cats and the presence of corneal sequestrum.
- H_1 – There is an association between the presence of corneal sequestrum and entropion; H_0 – There is no association between the presence of corneal sequestrum and entropion.

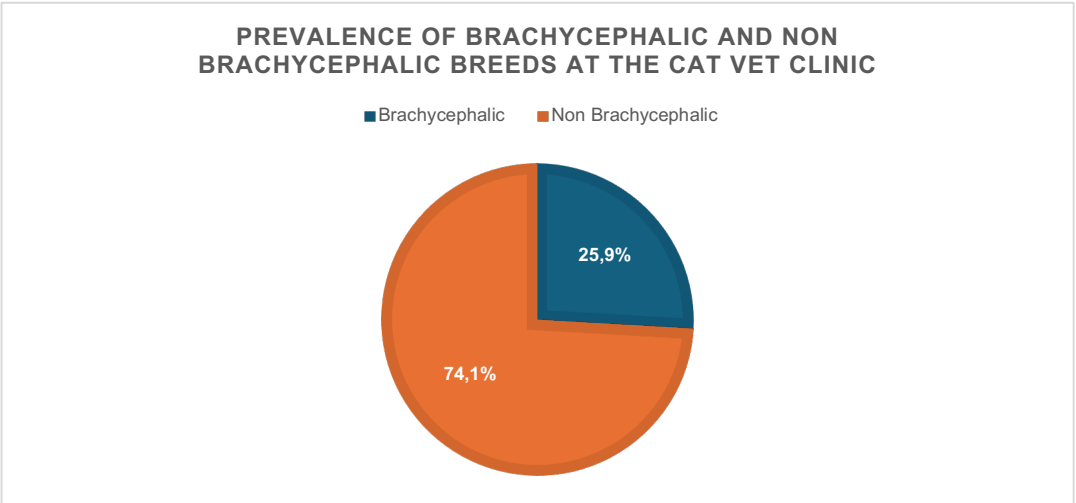
4 Results

4.1. Demographics of the Study Population

This study aimed to identify the most prevalent ocular diseases in brachycephalic feline breeds through the historical analyzes of clinical records of patients from these breeds. The same veterinary ophthalmology specialist performed a detailed and systematic examination of all patients included in the sample population, which represented different ages, genders, breeds, and clinical presentations.

The results indicated that, among the 193 cats examined by the ophthalmology specialist, 143 were non-brachycephalic, whereas the remaining 50 were brachycephalic. The prevalence of the brachycephalic and non-brachycephalic patients at The Cat Vet Clinic was evaluated, and the results are summarized in graphic 1.

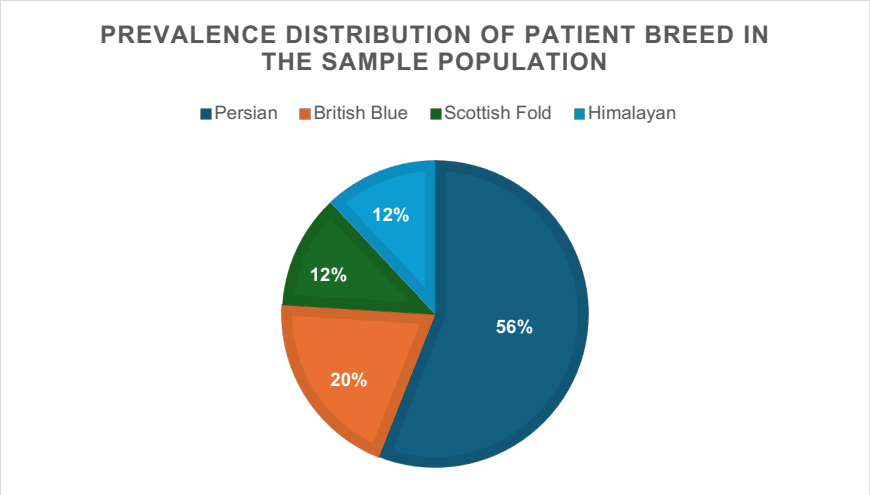
Graphic 1: Pie chart illustrating the prevalence of brachycephalic (25.9%) and non-brachycephalic patients (74.1%) at The Cat Vet Clinic.



All 50 brachycephalic patients that met the inclusion criteria were included in this study.

The study sample population consisted of 50 patients of four distinct brachycephalic breeds. The prevalence of the brachycephalic each brachycephalic breed was evaluated, and the results are summarized in graphic 2.

Graphic 2: Pie chart illustrating the prevalence distribution of patient breed in the sample population.



The mean age of the population was 5.6 ± 4.0 years, with ages ranging from 0.44 years to 11.34 years.

Among the sample, there was a total of 27 females (54%), of which 13 were spayed, and 23 male (46%), of which 14 were neutered.

Regarding their living condition, results indicated that all patients (100%) included in the sample population were indoor, and did not have any access to outdoor space.

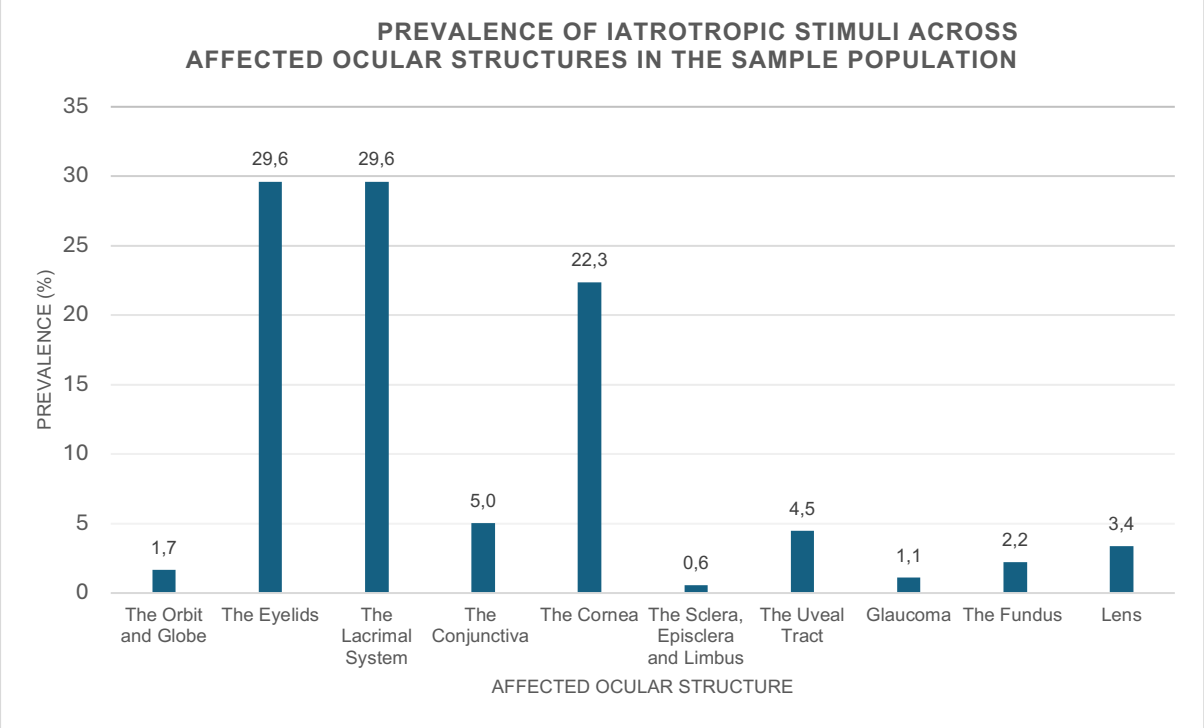
Of the 50 patients selected for this study, 11 came for a first opinion consultation, hence, were not referred cases to the ophthalmology specialty consultation. These included 3 Persians, 5 British Blues, 1 Scottish Fold, and 2 Himalayans, representing 22% of the total sample population, whereas the remaining 78% were referred cases.

4.2. Iatrotropic Stimulus

There were various iatrotropic stimuli that motivated the patients' guardians to bring them for an ophthalmology consultation. However, when analyzing these stimuli it is necessary to systematically organize data considering the structure the eye, therefore, analyzing the most common iatrotropic stimulus in each compartment. Nevertheless, a global analysis of results was performed in order to evaluate what the three most common iatrotropic stimuli were. This analysis revealed that 80% of guardians complained of epiphora (40/50 patients), making this

the primary complaint. The second most common iatrotropic stimulus was blepharospasm, affecting 78% of the sample population (39/50 patients). Finally, the third most frequent complaint was the presence of a dark or brown central or paracentral plaque due to a corneal sequestrum, affecting 48% of the sample population (24/50 patients). Several other iatrotropic stimuli were identified in the sample population; however, these have been organized and systematized based on the compartments of the eye, as illustrated in graphic 3.

Graphic 3: Bar graphic illustrating the prevalence of iatrotropic stimuli across affected ocular structures in the sample population.



When analyzing the total number of iatrotropic stimuli affecting each section of the eye, it was acknowledged that this number could exceed the sample population. This is because a single patient might present with more than one iatrotropic stimulus in the same section of the eye. For instance, a patient could simultaneously have corneal ulceration and a dark or brown central or paracentral plaque due to a corneal sequestrum, resulting in multiple iatrotropic stimuli affecting the cornea. In such cases, the same patient would contribute with two iatrotropic stimuli to the cornea. The cumulative analysis of the results showed that 179 iatrotropic stimuli were registered in the sample population. Out of these, 53/179 affected the eyelids and lacrimal system each; 40/179 targeted the cornea; 48/179 affected the uveal tract; 6/179 involved the lens; 4/179 targeted the fundus; 3/179 affected the orbit and globe; 2/179 were glaucoma; and 1/179 involved the sclera, episclera and limbus.

An analysis was conducted to determine whether patients presented with one or multiple clinical signs during consultation. The results indicated that all patients (100%) exhibited more

than one clinical sign. Additionally, the distribution of clinical signs across different sections of the eye was evaluated to assess the prevalence of patients with multiple signs affecting the same or different ocular regions. The findings revealed that 38% of patients (19/50) presented with clinical signs in multiple sections of the eye, whereas the remaining 62% (31/50) exhibited clinical signs confined to a single section of the globe.

The Orbit and Globe

Out of the 50 patients presented at the ophthalmology consultation, 2% (1/50) had exophthalmos. Additionally, strabismus was reported in 4% of the population (2/50 patients), with cases evenly distributed between divergent and dorsal strabismus.

The Eyelids

There were different iatrotropic stimuli observed in the sample population affecting the eyelids. Blepharospasm affected 78% of the sample population (39/50 patients), inward rolling of the eyelid was observed in 20% of patients (10/50), and proptosis affected 2% (1/50 patients).

With respect to the third eyelid, 6% of patients (3/50) had third eyelid prolapse.

The Lacrimal System

As previously mentioned, 80% of the sample population (40/50 patients) presented at the consultation with epiphora, as illustrated in figure 14.

Figure 14: Persian cat with bilateral blepharospasm and chronic epiphora, where tears accumulate around the inner canthus, causing discoloration of the surrounding fur due to tear staining – image kindly provided by Prof[a] Esmeralda Delgado.

Additionally, 26% of patients (13/50) had ocular discharge, which was classified according to its color, consistency, and laterality.

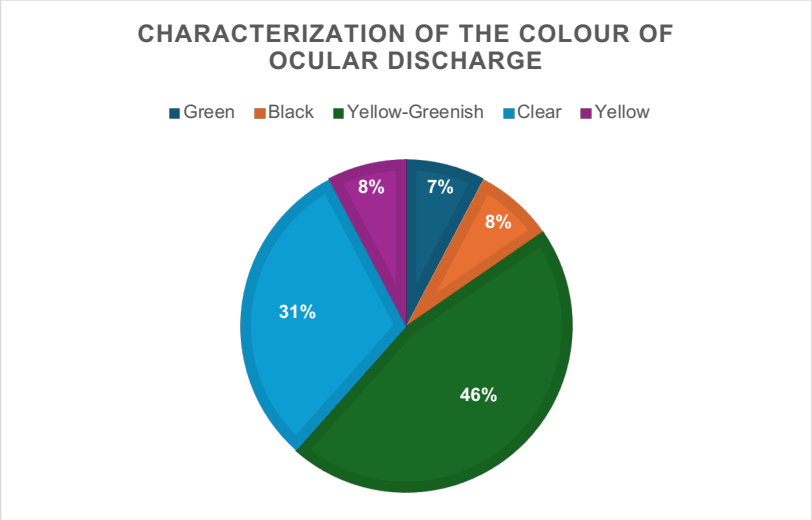
Ocular Discharge Characteristics

The discharge varied in laterality, color, and consistency.

Ocular discharge was unilateral in 61.5% of cases and bilateral in the remaining 38.5%.

Ocular discharge was also characterized, its prevalence was evaluated, and the results are summarized in graphic 4.

Graphic 4: Pie chart illustrating the characterization of the ocular discharge characteristics in the sample population.



The Conjunctiva

Concerning the conjunctiva, 18% of patients (9/50) exhibited conjunctival hyperemia.

The Cornea

Various iatrotropic stimuli affecting the cornea were identified in the sample population. A dark or brown central or paracentral plaque due to corneal sequestrum affected 48% of patients (24/50); corneal ulceration was diagnosed in 14% of the sample population (7/50 patients); corneal edema affected 8% of patients (4/50); corneal perforation was found in 4% of patients (2/50); ruptured cornea, corneal scar and exposure keratitis each affected 2% of patients (1/50 patients for each ocular condition).

The Sclera, Episclera and Limbus

Scleral hyperemia was observed in 2% of the sample population (1/50 patients).

The Uveal Tract

Different iatrotropic stimuli affecting the uvea tract were observed in the sample population. Anisocoria affected 4% of patients (2/50); persistent pupillary membrane, acquired heterochromia, iris hemorrhage, miosis, mydriasis, and melanosis/pigmentation each affected 2% of the sample population (1/50 patients for each ocular condition). An example of iris-to-cornea PPM found in a patient of the study population is illustrated in figure 15 below.

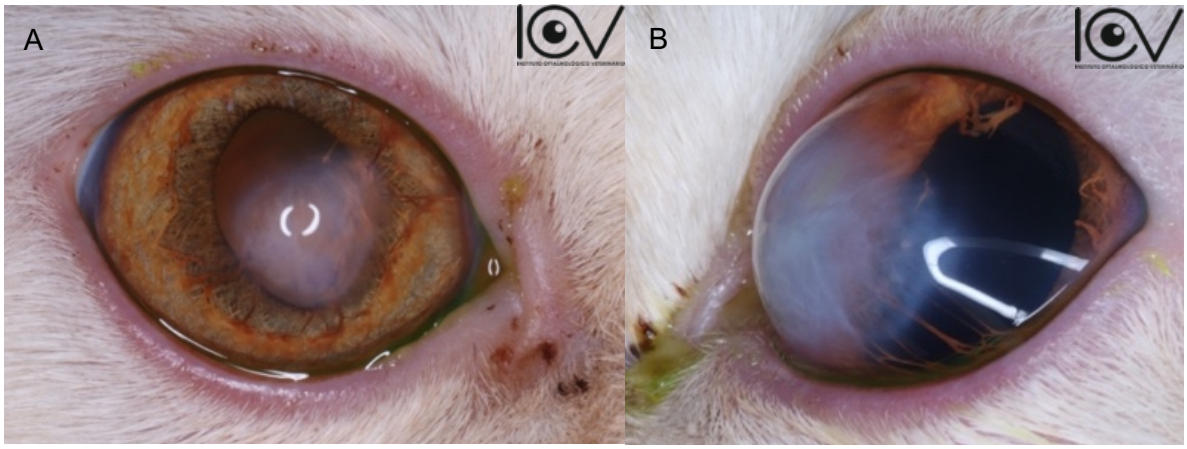


Figure 15: Iris-to-Cornea PPM in one of the study population's patients, A - frontal view, B - lateral view – images kindly provided by Dr. Rui Oliveira.

Glaucoma

Glaucoma was found in 4% of the sample population (2/50 patients).

The Lens

Lens opacity was observed in 8% of the sample population (4/50 patients).

The Fundus

Blindness was observed in 8% of the sample population (4/50 patients), with 75% of cases being bilateral and 25% unilateral (3/50 and 1/50 patients, respectively).

4.3. Comorbidities

Comorbidities within the sample population were also analyzed. Results showed that out of the 50 patients, 30% (15/50) presented comorbidities such as FHV-1 infection, heart disease, kidney disease or a predisposition to it (indicated by elevated SDMA levels), cancer, intermittent vomiting, irritable bowel disease, chronic anemia, chronic gingivitis, hypertension, bradycardia, and weight loss.

4.4. Ophthalmologic Examination Findings

Ocular Reflexes

As part of the systematic ophthalmologic examination, reflex evaluations were conducted on 47 out of the 50 patients. Among these, abnormalities were identified in 9 patients.

Schirmer Tear Test

The Schirmer tear test, used to evaluate tear production, was performed on 25 patients from the sample population of 50 cats. The mean tear production recorded was 15.7±5.6 mm for the right eye and 14.7±5.8 mm for the left eye. For the right eye, the lowest value was 6 mm, observed in a patient without any ocular abnormalities in that eye. For the left eye, the lowest value was 4 mm, recorded in three patients: two exhibited no ocular abnormalities in the left eye, while the third was diagnosed with a corneal sequestrum in the left eye.

Tonometry

Out of the sample population of 50 cats, a total of 38 underwent tonometry evaluation and abnormal values were found in 6 cases. Hypertension was registered in 3 patients that were diagnosed with an intraocular mass, cataract, and retinal detachment. On the other hand, hypotension was recorded in 3 patients, which exhibited retinal degeneration, corneal sequestrum, and ocular melanoma. Additionally, there was a patient that had hypertension in one eye due to and hypotension in the other eye due to anterior uveitis.

4.5. Complementary Exams Performed

Fluorescein Test

When considered appropriate by the ophthalmologist and if the patient allowed, a fluorescein test was conducted. This diagnostic procedure was performed on 52% (26/50) of the 50 patients in the study population. Among these, 57.7% (15/50) showed a positive result, while 42.3% (11/50) presented a negative result. Patients that tested positive in this test had corneal ulcer, corneal sequestrum, entropion, keratitis, cataract, persistent pupillary membrane, corneal laceration/puncture, or perforated cornea.

Swabs and Biopsies

A conjunctival biopsy was carried out on a patient diagnosed with Chlamydia infection, corresponding to 2% of the cases (1/50). An iris biopsy was performed on a patient with stable diffuse ocular melanosis, which the biopsy confirmed to be melanoma. Lastly, a corneal swab

was taken from a patient with bullous keratopathy and a severely infected cornea to rule out bacterial infection; the bacteriology results were negative.

CT Scan

A CT scan was conducted on a patient subsequently diagnosed with a malignant neoplastic mass in the orbit corresponding to 2% of the cases (1/50).

Blood Pressure Measurement

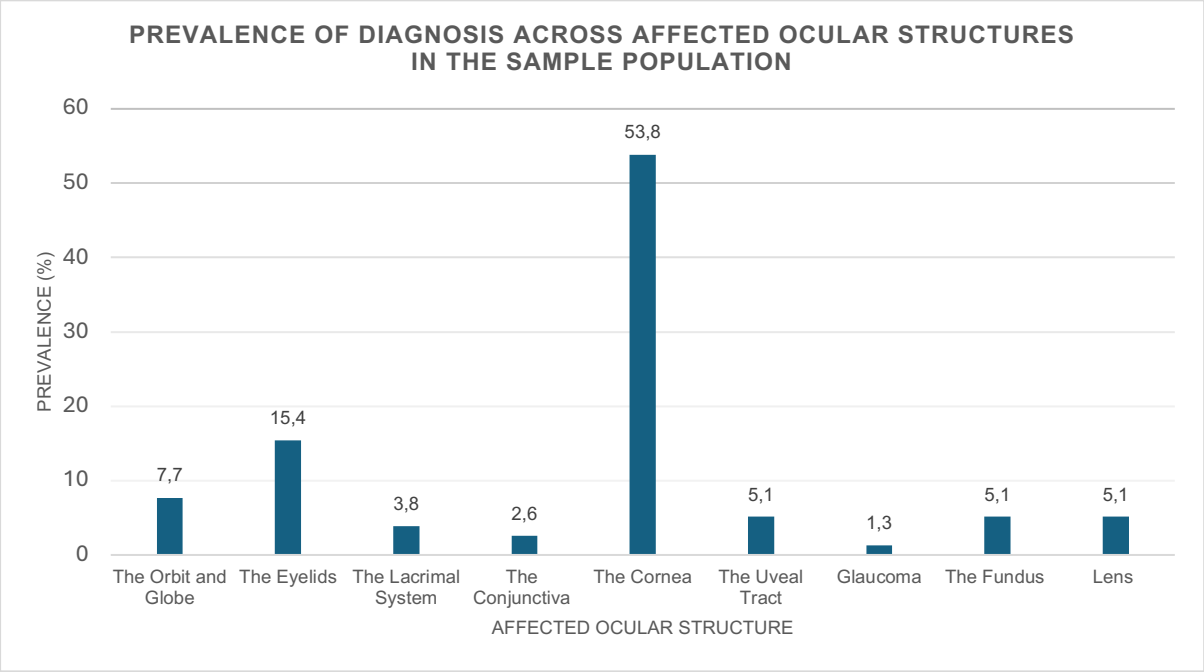
Blood pressure measurement was performed on a patient with a history of hypertension who presented with blindness, facial paralysis, and dorsal strabismus corresponding to 2% of the cases (1/50).

4.6. Prevalence of the diagnosed ocular diseases

When reviewing the results in relation to the established diagnoses for the 50 patients in the sample population, various ocular diseases were identified. These conditions were categorized according to the anatomical regions of the globe they affected and further analyzed in terms of their frequency and prevalence.

When analyzing the total number of diagnosis affecting each section of the eye, it was acknowledged that this number could exceed the sample population. This is because a single patient might present with more than one diagnosis in the same section of the eye. For instance, a patient could simultaneously have third eyelid prolapse and entropion, resulting in multiple diagnosis affecting the eyelids. In such cases, the same patient would contribute with two iatrotropic stimuli to the eyelids. The cumulative analysis of the results showed that 78 definite diagnosis were made within the sample population. Out of these, 42/78 affected the cornea, 12/78 involved the eyelids, and 6/78 targeted the orbit and globe. Additionally, 4/78 affected the uveal tract, fundus, and lens individually, 3/78 involved the lacrimal system, 2/78 targeted the conjunctiva, and 1/78 were cases of glaucoma. The prevalence of the diagnosis across affected ocular structures in the sample population was evaluated, and the results are summarized in graphic 5.

Graphic 5: Bar graphic illustrating the prevalence of diagnosis across affected ocular structures in the sample population.



The Orbit and Globe

Among the total diagnoses established by the referred ophthalmologist, 7.7% involved the orbit and globe. These included 2 patients diagnosed with an orbital/intraocular mass, with a prevalence of 4%; 2 patients diagnosed with strabismus, also with a prevalence of 4%; and 1 patient diagnosed with exophthalmos, with a prevalence of 2%.

The Eyelids

The eyelids represented 15.4% of the total diagnosis. Among these, 11 patients were diagnosed with entropion (prevalence of 22%), while 1 patient was diagnosed with blepharitis (prevalence of 2%).

The Lacrimal System

Only one ocular disease affecting the lacrimal system was found in the sample population, accounting for 3.8% of the established diagnosis. This disease was blocked nasolacrimal duct, which was diagnosed in 3 patients, with a prevalence of 6%.

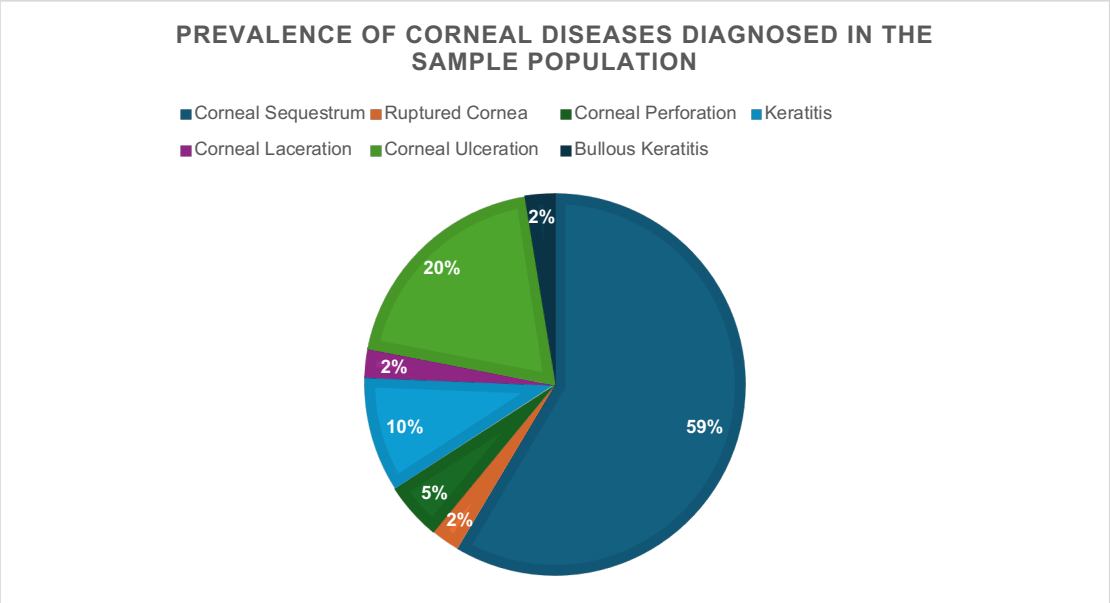
The Conjunctiva

Only one disease affecting the conjunctiva was diagnosed in the sample population, which represented 2.6% of the total diagnosis. This condition was conjunctivitis, which affected 1 patient, with a prevalence of 2%.

The Cornea

There were various ocular diseases affecting the cornea in the sample population, accounting for more than half of the established diagnosis (53.8%). The prevalence of each corneal disease diagnosed in the sample population was evaluated, and results are summarized in graphic 6.

Graphic 6: Pie chart illustrating the prevalence of each corneal disease diagnosed in the sample population.



Diagnostic and Clinical Findings in Sequestrum Cases

Upon further analysis of the patients diagnosed with corneal sequestrum, it was observed that out of the 24 cases, 9 patients (37.5%) were diagnosed exclusively with corneal sequestrum, with no other ocular abnormalities identified. In contrast, the remaining 15 patients (62.5%) had corneal sequestrum in conjunction with another ocular condition.

Additionally, the corneal depth affected in the 24 cases of corneal sequestrum was analyzed. The results revealed that 41.7% of patients (10/24) had 50% of the corneal depth affected, while the remaining 58.3% (14/24) exhibited involvement of 75% of the corneal depth. When considering the color of the corneal sequestrum, it was found that 70.8% of patients (17/24) had a black corneal sequestrum, while the other 29.2% (7/24) exhibited a dark brown sequestrum. Regarding the location of the corneal sequestrum, 91.7% of patients (22/24) had a sequestrum positioned centrally in the cornea, whereas 8.3% (2/24) had a sequestrum located in a laterodorsal position. Finally, when analyzing the size of the corneal sequestrum, both the length and width were considered. The mean length was calculated to be 7.1 mm, and the mean width was 5.7 mm, resulting in an average size of 7.1 mm x 5.7 mm (length x width) for the plaques.

The Uveal Tract

Different ocular conditions affected the uveal tract, representing 5.1% of the diagnosis. These included uveitis, which affected 2 patients, with a prevalence of 4%; diffused ocular melanosis and persistent pupillary membrane, each observed in 1 patient, with a prevalence of 2% for each condition.

Glaucoma

One of the patients diagnosed with an intraocular mass was also diagnosed with secondary glaucoma, with a prevalence of 2%, representing 1.3% of the established diagnosis.

The Lens

Only one disease affecting the lens was diagnosed in the sample population, which represented 5.1% of the total diagnosis. This condition was cataracts, which affected 4 patients, with a prevalence of 8%.

The Fundus

Several diagnoses affecting the fundus were identified, representing 5.1% of the established diagnosis. These included retinal detachment, retinal atrophy, and retinal degeneration, each diagnosed in 1 patient, with a prevalence of 2% for each condition. Additionally, blindness was diagnosed in 1 patient, also with a prevalence of 2%. This patient exhibited concurrent facial paralysis and dorsal strabismus, with all symptoms exclusively affecting the left eye.

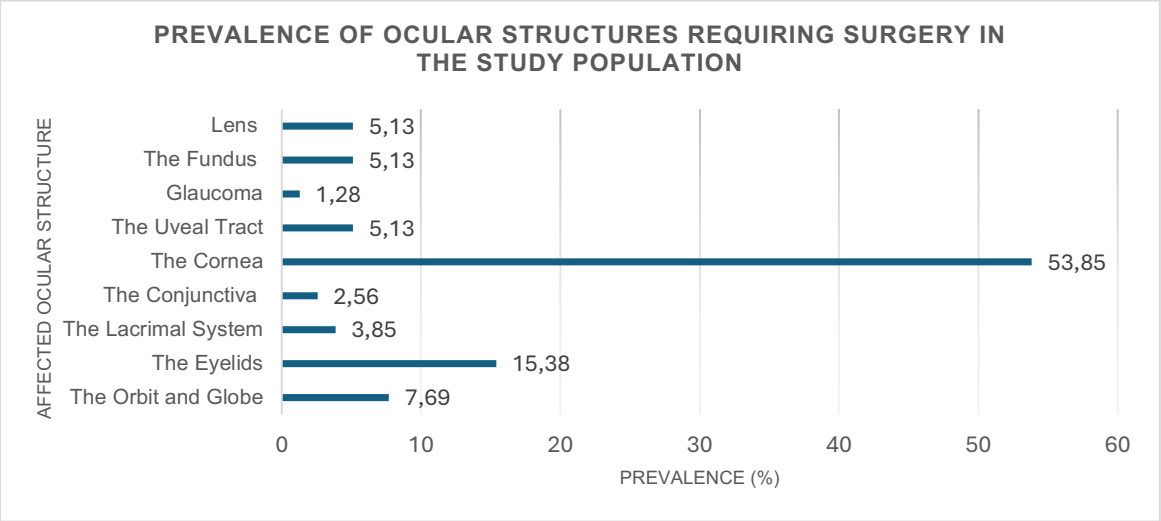
4.7. Treatment Options

Out of the 50 patients seen at the ophthalmology specialist consultation, a total of 28 patients (56%) underwent surgical intervention, while the remaining 22 (44%) patients did not receive any surgical treatment.

Furthermore, all 28 patients that underwent surgical intervention also received concurrent medical treatment.

Further analysis of the most frequent ocular diseases requiring surgical treatment revealed that, of the 28 patients that underwent surgery, 75% (21/28) were treated for corneal sequestrum, 32.1% (9/28) for entropion, and 3.6% (1/28) each for cataract, ruptured cornea, corneal laceration/puncture, corneal perforation, and diffuse ocular melanosis. The distribution of the prevalence of ocular structures requiring surgery in the study population was evaluated, and results are summarized in graphic 7.

Graphic 7: Bar graphic illustrating the ocular structures requiring surgery in the study population.

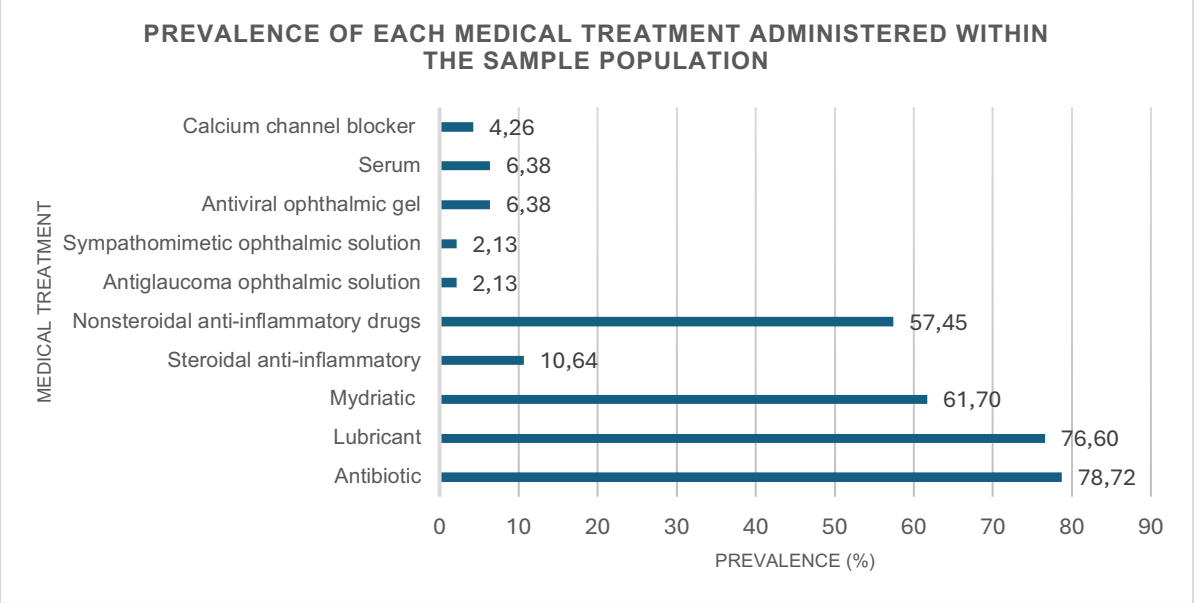


Of the sample population, 47 patients (94%) received medical treatment, while the remaining 3 patients (6%) did not undergo any form of treatment. The patients that did not receive either medical or surgical treatment were diagnosed with retinal detachment, retinal atrophy and retinal degeneration.

The medical treatments applied to the patients varied depending on the diagnosis and comorbidities. These treatments were either systemic, such as tablets or capsules, or topical, such as eye drops or ointments.

Graphic 8 provides an overview of the prevalence of each medical treatment administered within the sample population.

Graphic 8: Bar graphic illustrating the prevalence of each medical treatment administered within the sample population.



The Eyelids

Entropion

Out of the 11 patients diagnosed with entropion, 72.7% (8/11) were also diagnosed with corneal sequestrum. These patients underwent surgical treatment to correct the entropion at the same time as the surgical removal of the corneal sequestrum. The surgical technique used for entropion correction in every case was blepharoplasty with Hotz-Celsus. Another patient was diagnosed exclusively with entropion. This patient also received surgical treatment, where the same technique used on the other patients was applied. Finally, there were 2 other patients diagnosed with entropion; however, despite the ophthalmologist's recommendation for surgery as the optimal treatment, their guardians opted not to pursue surgical correction, leaving the condition untreated.

Hence, results showed that 81.8% (9/11) of the patients diagnosed with entropion received surgical treatment, while 22.2% (2/11) were treated exclusively medically.

The Cornea

Corneal Sequestrum

A surgical approach was implemented in 23 out of the 24 patients diagnosed with corneal sequestrum, representing 95.8% of the cases. These patients received surgical treatment in conjunction with medical management. In the remaining case, despite the ophthalmologist's recommendation that surgery was the most appropriate treatment option, the patient's guardian opted not to pursue surgical intervention, leaving the condition untreated. The surgical procedure performed for corneal sequestrum was consistent across all cases. It involved a keratectomy, placement of an amniotic membrane graft, application of a bandage contact lens, and completion with a temporary tarsorrhaphy. The only exception was a patient with perforated corneal sequestrum, in which the keratectomy was excluded, and the sequestrum was not treated, however all other steps of the procedure were completed. Figure 16 illustrates a case of corneal sequestrum prior to surgery, while figure 17 shows the same case during surgery after the amniotic membrane graft was placed.

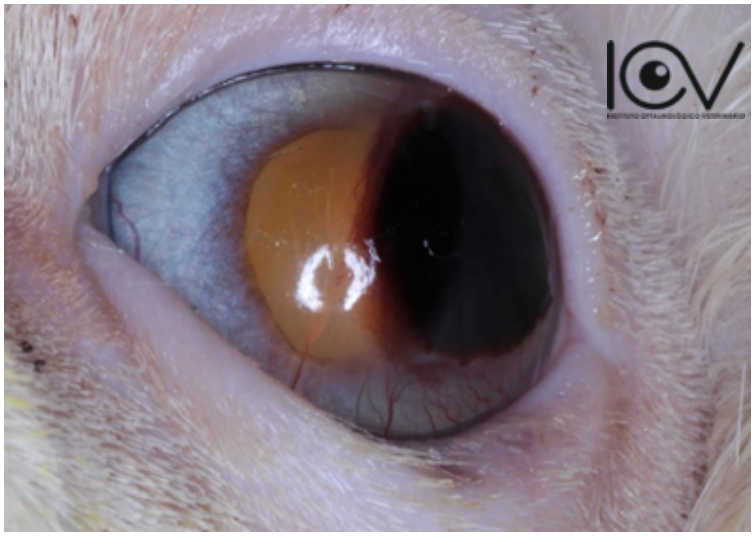


Figure 16: Pre-Surgical Presentation of the Left Eye with a black, dorso-lateral corneal sequestrum, occupying nearly 2/3 of the corneal surface, with signs of corneal neovascularization – image kindly provided by Dr Rui Oliveira.

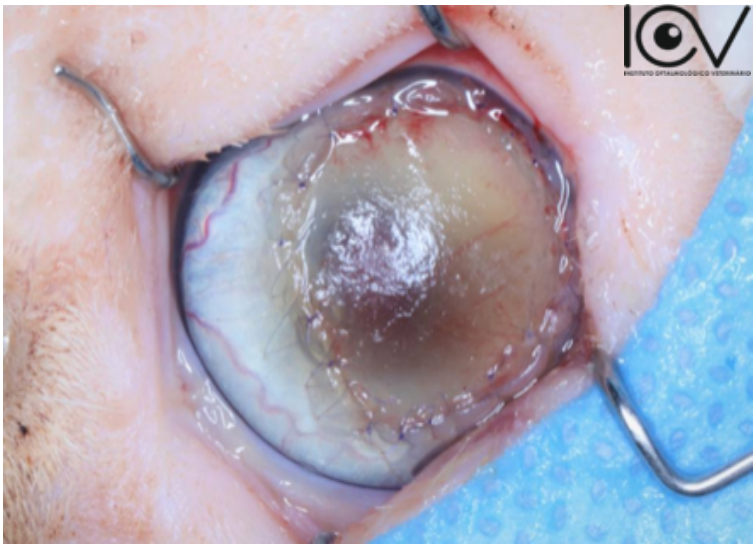


Figure 17: Intraoperative View of the Left Eye with Amniotic Membrane Graft Sutured, before performing Temporary Tarsorrhaphy – image kindly provided by Dr Rui Oliveira.

Corneal Ulceration

All 8 patients diagnosed with corneal ulceration received some form of medical treatment. Of these, 5 patients were treated with a combination of different regimens.

Additionally, one patient with a perforated corneal ulcer affecting the full thickness of the cornea, accompanied by leakage and secondary infection, not only received medical treatment but also underwent surgery. The surgical intervention included the placement of an amniotic membrane graft, the application of a bandage contact lens, and the performance of

a tarsorrhaphy. Thus, 100% (8/8) of the patients diagnosed with corneal ulceration received medical treatment, while only 12.5% (1/8) underwent surgical treatment.

The Lens

Cataracts

Of the 4 patients diagnosed with cataract, only 1 underwent surgical treatment using the phacoemulsification technique. Although the ophthalmologist recommended surgery for all patients diagnosed with cataract, the guardians of the remaining 3 patients chose to manage the condition medically. All patients diagnosed with cataract, including the one who underwent surgery, received similar medical treatment; however, the patient who was also treated surgically was prescribed additional ocular medications.

4.8. Inferential Analysis

Inferential analysis was performed in order to test the two previously mentioned hypothesis. When analyzing if there is a correlation between the presence of corneal sequestrum and the Persian breed, results obtained from the qui-squared test showed a p-value of 0.2568. The correlation between the presence of entropion in cases of corneal sequestrum revealed a p-value of 0.2549.

Additionally, a inferential analysis was performed on the three most prevalent ocular diseases diagnosed in the sample population – entropion, corneal sequestrum, and corneal ulceration – to determine the prevalence of each disease across the different breeds included in the study.

Entropion

When examining the prevalence of entropion within each breed in the study population, it was found that among the 11 patients diagnosed with entropion, no cases were recorded in the Himalayan breed (0%), while 7 were Persian (63.3%), 2 were British Blue (18.2%), and 2 were Scottish Fold (18.2%).

Corneal Sequestrum

Upon further analysis of the prevalence of corneal sequestrum within each breed in the study population, it was observed that among the 24 patients diagnosed with the condition, 13 were Persian, accounting for 54.2%, 5 were Scottish Fold (20.8%), 4 were Himalayan (16.7%), and 2 were British Blue (8.3%).

Corneal Ulceration

When analyzing the breeds affected by corneal ulceration, it was found that out of the 8 patients diagnosed with this condition, there were no cases among the Scottish Fold or Himalayan breeds; however, 7 were Persian (87.5%), and 1 was British Blue (12.5%).

5. Discussion

5.1. Demographics of the Study Population

When looking at the gender distribution in the sample population, the proportions were relatively balanced, with 27 females and 23 males. This implies that any observed differences in the incidence and prevalence of ocular conditions are unlikely to be influenced by gender disparities within the sample.

Similarly, the mean age of the patients, calculated as 5.6 ± 4.0 years, did not indicate a specific age group that appeared more predisposed to ocular conditions. The fact that the range of the age varied between 1.6 years to 9.6 years, suggests that the identified ocular conditions are not considered to affect older cats, affecting mainly young to middle aged cats. However, it is reasonable to hypothesize that ocular abnormalities leading to chronic exposure of the corneal surface, such as entropion, may contribute to the gradual development of ocular surface diseases over time. Conditions like entropion, which cause chronic irritation through the persistent contact of eyelashes with the corneal surface, could predispose these cats to progressive abnormalities, including corneal ulcers, as the lesions accumulate over the years.

When analyzing the distribution of brachycephalic and non-brachycephalic patients in ophthalmology referral consultations, the results revealed a significant difference in representation. Non-brachycephalic breeds accounted for 74.1% of the cases, while brachycephalic breeds represented only 25.9%, which indicates that brachycephalic breeds are underrepresented in the general ophthalmology patient population. Consequently, the results and statistics derived from this study should be considered specific to brachycephalic breeds and are not generalizable to all feline breeds. However, these breeds accounted for a quarter of the cases that went to the ophthalmology consultation in this cat clinic.

The fact that the sample population in this study includes only four brachycephalic feline breeds (Persian, Scottish Fold, Himalayan and British Blue) may limit the representativeness of the results regarding the most frequently diagnosed ocular conditions in cat brachycephalic breeds. Certain ocular conditions might be more prevalent in brachycephalic breeds that were not represented in the sample population, potentially leading to an underrepresentation of these conditions in the findings. Despite this limitation, the study provides valuable insights

into the most prevalent ocular conditions observed in the selected brachycephalic breeds. However, to draw more accurate and representative conclusions about ocular conditions across all brachycephalic feline breeds, further research involving a broader range of breeds is necessary.

When looking at the living conditions of the patients in the sample population, it was found that all patients were indoor. This implies that unlike outdoor cats, these patients were not often exposed to several external factors such as trauma, viruses, bacteria, as well as sand and dirt, that could possibly increase their susceptibility to certain conditions such as traumatic lesions and conjunctivitis (Conjunctivitis | Cornell University College of Veterinary Medicine). Nevertheless, this does not imply that because they are all indoor patients, they cannot be affected by these conditions. This is because one of the most common causes of conjunctivitis is FHV-1infection, which is usually passed on from the mother to the kittens during birth (La Croix). Hence, even if the patients are exclusively indoor, they can still be affected by ocular conditions that would be more common in outdoor patients.

The fact that 78% of patients in this study were referred cases, while 22% were first-opinion cases, suggests that only more complex ophthalmologic conditions were referred to the specialist, with simpler cases being managed by the primary veterinarian. This has implications for the study of the most prevalent ocular conditions in brachycephalic breeds, which is the primary aim of this research. Specifically, the results may not accurately represent the overall prevalence of these conditions in brachycephalic cats but rather reflect those that tend to present in more complicated or advanced forms. As a result of a higher prevalence of referred cases, simpler cases such as conjunctivitis may be underrepresented in the sample population because they were treated by the primary veterinarian and were not referred to the ophthalmology specialist, hence, not included in this study.

This referral bias impacts the interpretation of the study's statistics, as it implies that less severe conditions, such as non-complicated conjunctivitis, may be underrepresented in the sample population. Conversely, more serious conditions requiring specialist intervention, such as corneal sequestrum and cataracts, could be overrepresented.

On a positive note, these statistics also suggest that veterinarians are aware of the predisposition of brachycephalic breeds to ocular conditions, which could justify the early referral to an ophthalmologist for more specialized care.

5.2. Iatrotropic Stimulus

Considering the anatomical differences between brachycephalic and non-brachycephalic breeds, it is expected that the cornea and nasolacrimal system would be the most affected

parts of the eye. These differences are attributed to the increased corneal exposure seen in brachycephalic breeds (Bott and Chahory 2022) and their inefficient nasolacrimal drainage system (Schlueter et al. 2009).

In line with this, and as expected, results of this study showed that the sections of the eye most commonly exhibiting clinical signs were the eyelids and lacrimal system, each accounting for 29.6% of the clinical signs, followed by the cornea, which accounted for 22.3%.

The results also indicated that all patients exhibited two or more clinical signs, sometimes presenting multiple signs within the same section of the eye (e.g., corneal ulcer and dark or brown central or paracentral plaque due to a corneal sequestrum) (62%), and, at other times, showing signs in different sections (e.g., dark or brown central or paracentral plaque due to a corneal sequestrum and inward rolling of the eyelid) (38%). This reinforces the complexity of brachycephalic syndrome, as these breeds are frequently affected by more than one ocular condition. Due to their predisposition to one condition, such as inward rolling of the eyelid, they are often predisposed to secondary conditions, like corneal ulcers and the presence of plaques due to a corneal sequestrum.

As anticipated, the study revealed that the most common complaints prompting pet owners to seek ophthalmologic consultation were related to these areas of the eye. Epiphora was observed in 80% of patients, blepharospasm in 78%, and dark or brown central or paracentral plaque due to a corneal sequestrum in 48%. These findings support the previously suggested hypothesis by several authors regarding increased corneal exposure and an inefficient tear drainage system in brachycephalic breeds. This explains the high prevalence of epiphora due to inadequate tear drainage. Furthermore, blepharospasm is an indicator of discomfort often associated with corneal disease, and some authors have linked this clinical sign to the development of corneal sequestrum (Herrera 2005).

The findings of this study revealed that 26% of patients presented with complaints of ocular discharge at the time of consultation. The discharge varied in terms of color, consistency, and laterality. When comparing these results to those reported by Andrews et al., whose study found that a significant majority (75%) of brachycephalic dog owners identified ocular discharge as a primary concern, the prevalence observed in our study is notably lower. This discrepancy suggests the need for further research to determine whether brachycephalic breeds have a predisposition to ocular discharge. Such a predisposition could potentially be attributed to their increased susceptibility to entropion and other conformational ocular abnormalities (Andrews et al. 2023).

Although the study by Andrews et al. focused on brachycephalic dogs, it can be hypothesized that similar findings may apply to brachycephalic cats. This assumption is supported by the

anatomical similarities between the species, as brachycephalic cats are also predisposed to entropion due to the conformational abnormalities associated with brachycephalic syndrome. However, further studies specifically targeting brachycephalic cats are necessary to confirm whether they exhibit similar prevalence rates of ocular discharge.

5.3. Comorbidities

Although 30% of the patients in the sample population had comorbidities, no clear pattern emerged indicating that any particular comorbidity predisposed patients to specific ocular conditions. In fact, a highly likely link between comorbidity and ocular disease was only observed in three cases. These included a patient with a large cell lymphoma and an intraocular mass and secondary glaucoma, another patient with hypertension and retinal atrophy, and a patient with an active herpesvirus infection which led to keratitis.

5.4. Ophthalmologic Examination Findings

Alterations in visual reflexes were observed in nine patients, including the absence of PLR, menace response, and dazzle reflex. These changes were associated with conditions such as retinal detachment, intraocular masses, suspected periocular neoplasia, chorioretinitis, retinal degeneration, and retinal atrophy.

A study conducted by Alhaddad et al. suggested that Persian cats are genetically predisposed to PRA. While this brachycephalic breed is predisposed to the condition, non-brachycephalic breeds such as the Abyssinian have also been identified as being at risk for PRA. The primary identified difference between retinal atrophy in these breeds lies in the age of onset: it is typically early-onset in Persian cats and late-onset in Abyssinians (Alhaddad et al. 2014). Therefore, although certain brachycephalic breeds are predisposed to retinal atrophy, this condition is unlikely to be associated with the anatomical implications of the brachycephalic syndrome and is instead influenced by genetic factors.

There were two patients with intraocular masses: one had large cell lymphoma, and the other had a malignant ocular mass presumably of nasal origin. Although any cat, brachycephalic and non-brachycephalic, may suffer from different types of neoplastic conditions, a study conducted by Almendros et al. in 2024 identified that in a sample of 444 cats, the most frequently diagnosed type of lymphoma was large cell lymphoma, and the Domestic Short Hair cat was the most affected breed. Hence, although in this study the large cell lymphoma was found in a British Blue, it does not necessarily mean that brachycephalic cats are more likely to develop this condition (Almendros et al. 2024).

Although ophthalmologic examination findings showed that three patients did not show any PLRs, menace response, or dazzle reflex – among which there was a patient diagnosed with retinal detachment, another with retinal degeneration, and another with suspected periocular neoplasia or chorioretinitis – these conditions are not influenced by the brachycephalic syndrome and may affect any patient, brachycephalic or not.

Similarly, three other patients did not exhibit PLRs or menace response. However, as their diagnoses were corneal ulcer, corneal sequestrum, and bullous keratitis – conditions that do not typically explain these findings – this absence was likely attributed to stress during the consultation, which can reduce PLRs and menace response in stressed cats of any breed (Stiles and Kimmitt 2016).

Concerning tonometry readings, the normal range of IOP in cats is between 10 and 25 mmHg; however, various ocular disorders can influence these values. A study conducted on 1000 dogs of different breeds by Williams and Gimson found that healthy brachycephalic dogs without any ocular abnormalities exhibited higher IOP values compared to non-brachycephalic breeds. Although the mean IOP values for both brachycephalic and non-brachycephalic dogs remained within the normal range, the brachycephalic group showed higher readings (Williams and Gimson 2020 Apr 1). Although this study focused on dogs, similar results may be expected when comparing brachycephalic and non-brachycephalic cats, given the anatomical and physiological similarities in the brachycephalic syndrome between these two species. However, further studies are required in cats to confirm whether a comparable pattern exists.

Tonometry readings below the normal range were observed in two patients. One patient had retinal degeneration, which is not consistent with lower IOP, suggesting that the reduced readings may have been an error. The other patient had anterior uveitis, a condition commonly associated with low IOP, which aligns with the observed measurements (Thomasy 2024 Jul). On the other hand, higher values were observed in four patients.

A study conducted in dogs by Grahn et al. found that retinal detachment may lead to secondary glaucoma (Grahn et al. 2007). This mechanism could also be applicable to cats, as the pathophysiology of both retinal detachment and glaucoma is similar in both species, suggesting that retinal detachment in cats may result in similar consequences (McLellan and Miller 2011). This could explain the high IOP (65 mmHg) observed in a Himalayan with retinal detachment. This same patient also had a higher IOP value (29 mmHg) in the other eye, which had a cataract; however, cataracts are not commonly associated with changes in IOP, raising the possibility of an error in the reading. A Scottish Fold with corneal sequestrum also exhibited increased IOP (30 mmHg). While this is not a typical consequence of corneal sequestrum, it

was considered that this could represent either a misreading or that the corneal sequestrum may have caused secondary glaucoma, possibly due to alterations in the drainage structures. Higher IOP values were also recorded in two patients: one with an intraocular mass (IOP of 48 mmHg) and another with ocular melanoma (IOP of 34 mmHg). These conditions can lead to increased IOP due to potential obstruction of the iridocorneal angle (Hamor 2024 Mar).

Although the observed tonometry values were, in most cases, consistent with the diagnoses, none of the conditions were found to be more likely to affect brachycephalic breeds due to their anatomical differences. Therefore, it can be suggested that while these findings regarding tonometry readings align with the majority of the diagnoses, they are not exclusive to brachycephalic breeds and do not appear to be a direct consequence of brachycephalic syndrome.

Concerning Schirmer tear test results, abnormal values recorded in the Schirmer tear test were not directly caused by the primary diagnoses. Since these diagnosed conditions did not directly impact tear production, they may instead reflect the anatomical implications of brachycephalic syndrome. Due to their exophthalmos and large palpebral fissures, brachycephalic breeds have a more exposed cornea, leading to increased tear film evaporation and predisposing them to chronic corneal diseases (Matas Riera 2022).

A study conducted by Leis and Sandmeyer indicated that brachycephalic dogs have a lower tear film breakup time, which heightens their risk of developing conditions such as keratoconjunctivitis sicca (Hamor 2024 Mar). Additionally, findings from a study by Blocker and Van Der Woerdt demonstrated that brachycephalic dogs exhibit reduced central corneal sensitivity (Blocker and Van Der Woerdt 2001). Considering these findings collectively, it can be suggested that the combination of increased tear film evaporation, reduced tear film breakup time, and diminished corneal sensitivity cumulatively predisposes brachycephalic breeds to lower tear production values in the Schirmer tear test.

Although the implications of the brachycephalic syndrome on tear production and ocular health in cats remain unstudied and require further investigation, it can be hypothesized that due to anatomical similarities between brachycephalic cats and dogs, both species may exhibit comparable ocular consequences and manifestations associated with the syndrome.

Additionally, it is important to consider the role of FHV-1 infection in tear production, as this condition is often associated with reduced Schirmer tear test values. A study conducted by SE Andrew found that cats with FHV-1 infection have an increased predisposition to developing keratoconjunctivitis sicca (Andrew 2016). This predisposition is attributed to the chronic nature of the infection and the implications of its recurrence. When a patient is infected with FHV-1, the virus invaded the sensory nerve endings of the trigemini nerve and migrates to the

trigeminal ganglion where it remains latent until it is reactivated. The presence of keratoconjunctivitis sicca and instability of the tear film has been associated with FHV-1 infection however, it remains unclear whether the virus has a direct impact on the lacrimal gland or whether keratoconjunctivitis sicca is secondary to an inflammatory process that causes the closing of the lacrimal ductules (Gould 2011). However, there are no current studies suggesting that brachycephalic breeds are more predisposed to this ocular condition compared to non-brachycephalic cats. Nevertheless, FHV-1 infection should be considered a potential cause of low Schirmer tear test values.

Finally, stress could also play a significant role in Schirmer tear test results, as tear production may decrease in cats experiencing stress.

5.5. Complementary Exams Performed

Various complementary exams were conducted on some patients within the sample population. The fluorescein stain test resulted in positive results in cases with diverse diagnoses, most of which involved corneal conditions, including corneal ulcer, corneal sequestrum, keratitis due to FHV-1 infection, corneal laceration or puncture, persistent pupillary membrane, and entropion.

Additionally, other complementary exams were performed on some patients; however, neither the clinical signs nor the diagnoses showed any association with brachycephalic syndrome.

5.6. Prevalence of the Diagnosed Ocular Diseases

This study's findings indicate that the most frequently diagnosed ocular diseases in the sample population were corneal sequestrum (48%), entropion (22%), and corneal ulceration (16%). Furthermore, analysis of the most affected ocular structures revealed that the cornea was significantly more impacted than other sections of the globe, accounting for more than half of the total diagnoses (53.8%). These results align with expectations, as brachycephalic breeds are known to have increased corneal exposure due to their anatomical characteristics, predisposing them to a higher incidence of corneal disease.

Further analysis of the most prevalent corneal diseases revealed that the three most frequently diagnosed conditions were corneal sequestrum, followed by corneal ulceration and keratitis. These findings are consistent with prior research conducted on brachycephalic breeds, which highlighted that brachycephalic cats, particularly Persian and Himalayan breeds, have a predisposition to developing corneal sequestrum (Schipper et al. 2022). This predisposition is linked to a higher incidence of entropion (the second most common diagnosis of this study) and other ocular abnormalities such as lagophthalmos and distichiasis, which cause chronic

irritation of the corneal surface. Consequently, chronic irritation not only increases the risk of corneal sequestrum formation but also contributes to a higher prevalence of corneal ulceration (Demir 2024).

Results of the patients with corneal sequestrum showed that 62.5% of patients diagnosed with corneal sequestrum were also diagnosed with other ocular abnormalities, among which corneal ulceration was one of them. A study conducted by Sandmeyer et al. (2015) showed that sequestrum cases are often accompanied by corneal ulceration of the epithelium that overlies the sequestrum. Additionally, this study also demonstrated that the most common color of sequestrum varies between dark brown and black, the shape might be oval or a more rounded shape, and the position in the cornea tends to be central or paracentral, all findings that are consistent with the ones found in the present study (Sandmeyer et al. 2015).

Additional factors may exacerbate the prevalence of corneal disease in brachycephalic breeds, including decreased corneal sensitivity, which increases the risk of ocular surface disease due to heightened irritation and an inadequate blinking rate. A study by Kafarnik et al. (2008) demonstrated that brachycephalic breeds, particularly Persians, exhibit lower nerve fiber density in the cornea, resulting in decreased corneal sensitivity (Kafarnik et al. 2008). This decreased sensitivity reduces their ability to perceive corneal stimuli that would typically trigger a protective reflexive blinking response. Consequently, these breeds are more vulnerable to ocular surface issues due to inadequate tear film distribution and improper debris removal from the corneal surface. This decreased sensitivity not only predisposes these cats to corneal sequestrum and ulceration but also increases their risk of exposure keratitis, as reflected in this study's findings.

Results also identified keratitis as the third most common corneal disease, which is consistent with expectations for brachycephalic breeds. This can be attributed to their ocular abnormalities and prominent globes. Exposure keratitis, in particular, may predispose patients to corneal sequestrum, establishing a connection between these conditions. The results of this study align with existing research, which demonstrates that exposure keratitis in brachycephalic breeds increases their susceptibility to corneal sequestrum and ulceration (Demir 2024).

Moreover, studies have highlighted a predisposition among brachycephalic feline breeds to eyelid abnormalities, particularly entropion. This finding aligns with the results of this study, which identified the eyelids as the second most affected ocular section, with 22% of the sample population diagnosed with entropion. Research by Ergin et al. (2025) further supports this, demonstrating that brachycephalic cats are significantly predisposed to developing entropion,

with the British Shorthair identified as the most susceptible brachycephalic breed (ERGİN et al. 2025 Jan).

While conditions such as corneal ulcer, corneal sequestrum, exposure keratitis, and entropion can occur in both brachycephalic and non-brachycephalic cats, research indicates that brachycephalic breeds are predisposed to corneal diseases due to their anatomical conformation. Their more exposed corneal surface increases the likelihood of developing these conditions (Szafran 2016 Nov 18), which can compromise the integrity of the ocular surface. Similarly, brachycephalic cats have a higher risk of entropion due to their facial anatomy. This predisposition often results in chronic trauma to the corneal surface caused by the eyelashes, further elevating the risk for corneal abnormalities, including ulcers and sequestrum (Williams and Kim 2009).

5.7. Treatment Options

None of the treatments administered to the patients in the sample population, whether surgical or medical, were specifically tailored to brachycephalic cats. Instead, the treatments applied were identical to those typically used for non-brachycephalic breeds.

Nevertheless, the results indicate that many patients received medical treatment with ocular lubricants. While this approach is also commonly used in non-brachycephalic cats, particularly those with corneal disease, its importance is especially pronounced in brachycephalic breeds. Due to their prominent eyes and predisposition to exposure keratitis and other corneal conditions, the use of ocular lubricants is crucial in their management. In these cases, lubricants play a vital role in protecting the corneal surface from increased environmental exposure, not only creating optimal conditions for healing but also preventing further damage.

In several cases in this study, the referral ophthalmologist prescribed lifelong lubrication for both eyes, even when ocular disease was present in only one. This preventive strategy aims to preserve the cornea, as brachycephalic breeds are particularly susceptible to corneal exposure due to their prominent eyes, decreased blink rate, and reduced reflex lacrimation.

Although no specific research has been conducted on the use of ocular lubricants for corneal diseases in brachycephalic cats, a 2021 study on dogs suggests that lubricants play a significant role in the management of corneal ulcers in brachycephalic breeds. Given the similarities in the underlying mechanisms that contribute to the increased prevalence of corneal disease in both brachycephalic dogs and cats, it is reasonable to consider a similar medical approach for brachycephalic cats (Costa et al. 2021).

When examining the sections of the globe most frequently treated with a surgical approach, it is evident that the cornea had the highest prevalence of surgical treatment, accounting for more than half of the surgeries (53.9%). The eyelids followed as the second most frequently treated ocular structure, with a prevalence of 15.4%.

The analysis of all surgical procedures revealed that corneal sequestrum was the most frequently ocular disease, with 75% of cases requiring surgical intervention. Entropion was the second most common condition treated surgically, accounting for 32.1% of cases.

Among the cases of entropion, 72.7% of affected patients were also diagnosed with corneal sequestrum. This correlation supports the hypothesis that brachycephalic breeds, due to their anatomical predispositions, are more susceptible to developing entropion, which may indirectly contribute to the higher prevalence of corneal sequestrum in these breeds. Notably, all patients requiring surgical intervention for both corneal sequestrum and entropion underwent both procedures concurrently. However, financial constraints and other factors influenced the decision of some pet guardians, resulting in two cases of entropion remaining untreated despite the ophthalmologist's recommendation for surgical correction. For those who underwent surgery for entropion, the technique used was blepharoplasty with Hotz-Celsus, which is widely recognized as the standard approach for treating this condition (Featherstone 2017 Apr 1).

Among patients diagnosed with corneal sequestrum, 95.8% underwent surgical correction. The surgical procedures varied and included keratectomy, placement of an amniotic membrane graft, application of a bandage contact lens, and completion with a temporary tarsorrhaphy. The keratectomy was performed to remove the sequestrum and varied in depth, depending on the corneal layers involved. An amniotic membrane graft and bandage contact lens were used to protect the surgical site and allow healing during the postoperative period. Additionally, a temporary tarsorrhaphy was performed to further protect the surgical site, particularly to prevent self-inflicted trauma, such as scratches (Szafran 2016 Nov 18).

Although 94% of patients received some form of medical treatment, the type of treatment varied significantly depending on the underlying condition, age, and comorbidities.

Patients diagnosed with ocular diseases affecting the fundus, such as retinal detachment, atrophy, degeneration, and blindness, did not receive either medical or surgical treatment, as these conditions are currently untreatable.

5.8. Statistical Findings

Contrary to expectations, this study found no statistically significant relationship between corneal sequestrum and the Persian breed or between entropion and corneal sequestrum, with p-values exceeding 0.05. This suggests no significant association between these variables within the study's sample.

Previous research has identified the Persian breed as predisposed to corneal sequestrum due to both anatomical features associated with brachycephalic syndrome and genetic factors (Schipper et al. 2022). The lack of statistical significance in this study may be attributed to its limited sample size, potentially leading to an underrepresentation of affected Persian cats.

Similarly, brachycephalic cats are known to be predisposed to entropion, which can either result from chronic discomfort leading to spastic entropion or contribute to corneal sequestrum due to persistent corneal trauma. However, because most affected patients in this study were diagnosed with both conditions simultaneously, it was not possible to establish a causal relationship. Given existing literature (Szafran 2016 Nov 18), a statistically significant association would have been expected.

Results also suggest that Persians have a higher prevalence of entropion, corneal sequestrum, and corneal ulceration than other breeds. However, this may be influenced by their overrepresentation in the sample, limiting the generalizability of these findings.

The study's sample size represents a key limitation that may have affected the results, potentially obscuring existing relationships in brachycephalic cats. Future studies with larger, more representative populations and balanced breed distributions are necessary to accurately assess the Persian breed’s predisposition to corneal sequestrum and the likelihood of entropion in affected brachycephalic cats.

Understanding these correlations would enhance awareness of ocular disease prevalence in brachycephalic cats and support a preventive approach. Early and thorough ocular health assessments could aid in the early detection of potential issues before they progress.

Further research should also investigate additional factors contributing to ocular disease susceptibility in brachycephalic breeds, particularly those affecting the cornea, such as tear film quality, degree of exophthalmos, corneal sensitivity, and palpebral fissure size. Identifying these risk factors would allow for timely intervention, including the use of artificial tears to protect the ocular surface and mitigate the impact of conformational abnormalities.

The anatomical features of brachycephalic cats – prominent globes, reduced corneal sensitivity, and lower blinking rates – increase their risk of conditions such as exposure

keratitis, corneal sequestrum, and corneal ulceration. A more selective breeding approach, favoring less extreme anatomical traits, could help reduce predisposition to these diseases.

Given the heightened risk of ocular conditions in brachycephalic breeds, regular ophthalmological examinations, ideally on an annual basis, are recommended for early detection and management. Timely diagnosis and surgical correction of entropion could prevent chronic corneal trauma, reducing the likelihood of ulceration and sequestrum formation. Additionally, preventive strategies, such as the early use of lubricating eye gels or drops, may help mitigate exposure keratitis and improve long-term ocular health in these breeds.

6. Conclusion

The findings of this study suggest that brachycephalic cat breeds, due to the ocular anatomical singularities associated with the brachycephalic syndrome, are predisposed to several ocular diseases. The most frequently diagnosed conditions in the sample population were corneal sequestrum, entropion, and corneal ulceration, in descending order of prevalence. Additionally, this study identified the cornea as the ocular structure most commonly affected in the presence of disease.

No statistically significant association between the presence of corneal sequestrum and the Persian breed, nor the presence of entropion in sequestrum cases was found in the sample population. However, given the study's limitations – such as breed distribution and representativeness within the sample – it is recommended that future research be conducted with a more balanced distribution of patients across breeds, a larger sample size, and, ideally, a broader range of brachycephalic cat breeds.

Moreover, the study confirmed that corneal sequestrum, corneal ulceration, and keratitis were the most frequently diagnosed corneal conditions, aligning with findings from previous research. These results further support the idea that brachycephalic breeds are predisposed to corneal disease due to various anatomical factors, including their increased susceptibility to entropion – a condition that leads to chronic corneal surface trauma caused by the eyelashes, thereby contributing to the development of corneal pathologies.

Considering all these findings, it is evident that the brachycephalic syndrome has a significant impact on the ocular health of brachycephalic cats. More severe degrees of brachycephaly are associated with greater and more pronounced anatomical alterations, which in turn increase the risk of developing various ocular conditions, particularly those affecting the

cornea. Therefore, it is essential for both veterinary professionals and cat owners to be fully aware of the ophthalmic consequences of the brachycephalic syndrome.

In light of this study's findings, it is evident that the anatomical characteristics of brachycephalic cat breeds – specifically their prominent globes, reduced corneal sensitivity, and lower blinking rate – collectively increase their susceptibility to ocular conditions such as exposure keratitis, corneal sequestrum, corneal ulceration, and other corneal diseases. Therefore, it is crucial to adopt a more selective breeding approach that favors exemplars with less pronounced anatomical traits, avoiding the use of individuals with more exaggerated features. To mitigate these health issues, more responsible breeding practices should be adopted to prevent the exacerbation of extreme anatomical traits that contribute to ocular disease. The implementation of selective breeding strategies that prioritize the health and well-being of these animals could help reduce the prevalence and severity of ocular conditions associated with brachycephaly. Nevertheless, even mild degrees of brachycephaly have been linked to ocular pathologies. As such, it is important to critically assess the ethical implications of breeding cats with anatomical abnormalities that, to some extent, will always be associated with discomfort and health complications. A reassessment of breeding standards that favor extreme conformation is warranted to ensure the long-term welfare of these animals.

Given the increased predisposition of brachycephalic breeds to develop corneal diseases and other ocular abnormalities, regular ophthalmological examinations, ideally on an annual basis, are recommended. This proactive approach enables early detection of ocular issues, allowing for timely intervention. For example, early diagnosis and surgical correction of conditions like entropion can prevent chronic corneal trauma caused by the eyelids, reducing the risk of corneal ulceration or sequestrum. Furthermore, early use of therapeutic strategies, such as eye gels or drops to hydrate the corneal surface, may help mitigate the effects of exposure keratitis in these breeds, improving ocular health and preventing the progression of related complications.

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APPENDICES

Appendix A: Results from systematic ophthalmologic examination of reflexes.

As part of the systematic ophthalmologic examination, reflex evaluations were conducted on 47 out of the 50 patients. Among these, abnormalities were identified in 9 patients. The findings are summarized as follows:

Patient 1: Demonstrated a positive palpebral reflex but was negative for menace response and pupillary light reflexes (PLRs) in the left eye, which was later diagnosed with an intraocular mass and secondary glaucoma.

Patient 2: Lacked menace response, PLRs, and dazzle response in the left eye, subsequently diagnosed with retinal detachment.

Patient 3: Maintained reflexes, although attenuated and less responsive in the left eye compared to the right. This patient was later diagnosed with retinal atrophy in both eyes.

Patient 4: Presented with sudden blindness and absent menace and dazzle responses as well as PLRs in both eyes. This was later attributed to an orbital mass in the right eye.

Patient 5: With a history of high blood pressure, bradycardia, and significant weight loss, this patient exhibited no menace or dazzle response, PLRs, palpebral reflex, or corneal reflex in the left eye. The diagnosis was facial paralysis and blindness in the left eye.

Patient 6: Had intact PLRs in both eyes but lacked menace and dazzle responses bilaterally. This patient was diagnosed with retinal degeneration, likely of toxic etiology.

Patient 7: Showed absent PLRs and menace response bilaterally, but dazzle response was normal. This patient was diagnosed with bullous keratitis in the left eye.

Patient 8: Displayed absent PLRs and menace response in both eyes, while dazzle response remained normal. The diagnosis was corneal sequestrum in the right eye.

Patient 9: Exhibited no PLRs, menace, or dazzle response in the left eye. This was later diagnosed as corneal ulceration.

Appendix B: Identified iatrotropic stimuli, categorized by the affected ocular structure, along with their incidence and prevalence.

Affected Ocular Structure	Iatrotropic Stimuli	Incidence (x/50 patients)	Prevalence (%)
The Orbit and Globe	Exophthalmos	1	2
	Strabismus	2	4
The Eyelids	Blepharospasm	39	78
	Entropion	10	20
	Proptosis	1	2

	Third eyelid prolapse	3	6
The Lacrimal System	Epiphora	40	80
	Ocular discharge	13	26
The Conjunctiva	Conjunctival hyperemia	9	18
The Cornea	Corneal sequestrum	24	48
	Corneal ulceration	7	14
	Corneal edema	4	8
	Corneal perforation	2	4
	Ruptured cornea	1	2
	Corneal scar	1	2
	Exposure keratitis	1	2
The Sclera, Episclera and Limbus	Scleral hyperemia	1	2
The Uveal Tract	Anisocoria	2	4
	Persistent pupillary membrane	1	2
	Acquired heterochromia	1	2
	Iris hemorrhage	1	2
	Miosis	1	2
	Mydriasis	1	2
	Melanosis/pigmentation	1	2
Glaucoma		2	4
The Lens	Lens opacity	4	8
The Fundus	Blindness	4	8

Appendix C: Presence and absence of ocular conditions affecting different ocular compartments across different breeds in the study population.

Ocular compartment	Breed	Disease present	Disease absent	Total
The Orbit and Globe	Persian	0.11	0.89	28
	Himalayan	0	1	6
	Scottish Fold	0	1	6

	British Blue	0.1	0.9	10
	TOTALS	0.08	0.92	50
The Eyelids	Persian	0.29	0.71	28
	Himalayan	0	1	6
	Scottish Fold	0.33	0.67	6
	British Blue	0.2	0.8	10
	TOTALS	0.24	0.76	50
The Lacrimal System	Persian	0.04	0.96	28
	Himalayan	0	1	6
	Scottish Fold	0	1	6
	British Blue	0.2	0.8	10
	TOTALS	0.06	0.94	50
The Conjunctiva	Persian	0	1	28
	Himalayan	0	1	6
	Scottish Fold	0	1	6
	British Blue	0.1	0.9	10
	TOTALS	0.02	0.98	50
The Cornea	Persian	0.89	0.11	28
	Himalayan	0.83	0.17	6
	Scottish Fold	1	0	6
	British Blue	0.5	0.5	10
	TOTALS	0.82	0.18	50
The Uveal Tract	Persian	0.07	0.93	28
	Himalayan	0.17	0.83	6
	Scottish Fold	0	1	6
	British Blue	0.1	0.9	10
	TOTALS	0.08	0.92	50
Glaucoma	Persian	0	1	28

	Himalayan	0	1	6
	Scottish Fold	0	1	6
	British Blue	0.1	0.9	10
	TOTALS	0.02	0.98	50
The Lens	Persian	0.11	0.89	28
	Himalayan	0.17	0.83	6
	Scottish Fold	0	1	6
	British Blue	0	1	10
	TOTALS	0.08	0.92	50
The Fundus	Persian	0.14	0.86	28
	Himalayan	0	1	6
	Scottish Fold	0	1	6
	British Blue	0	1	10
	TOTALS	0.08	0.92	50