UNIVERSIDADE DE LISBOA

FACULDADE DE MEDICINA VETERINÁRIA

OSTEOCHONDROSIS OF THE DISTAL ASPECT OF THE SAGITTAL RIDGE OF THE THIRD METACARPAL BONE IN HORSES: A CLINICAL, RADIOGRAPHIC AND ARTHROSCOPIC DESCRIPTION

MARIA DA CONCEIÇÃO LÍBANO MONTEIRO DA COSTA MACEDO

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2024

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OSTEOCONDROSE DO ASPETO DISTAL DA CRISTA SAGITAL DO TERCEIRO OSSO METACARPIANO EM EQUINOS: UMA DESCRIÇÃO CLÍNICA, RADIOGRÁFICA E ARTROSCÓPICA

RESUMO

A osteocondrose é uma doença ortopédica do desenvolvimento e é uma das doenças degenerativas articulares mais prevalentes nos animais domésticos. A osteocondrose caracteriza-se por um defeito na ossificação endocondral que geralmente é localizado, bilateral e situado em localizações específicas. Este defeito ocorre devido a uma interrupção no aporte sanguíneo à cartilagem de crescimento, o que leva à isquémia e necrose dos condrócitos. No entanto, as causas primárias do suprimento vascular ainda não são conhecidas na totalidade.

Nos equinos, o boleto é uma das articulações mais afetadas e as lesões podem estar presentes em qualquer parte da estrutura articular, contudo, as localizações mais comuns para as lesões são o aspecto dorsal da crista sagital e os côndilos do metacarpo/metatarso. Lesões no aspeto distal da crista sagital do metacarpo são escassamente documentadas em artigos científicos, e há apenas um único artigo que aborda a presença de lesões nesta localização. Assim, o principal objetivo desta dissertação é fornecer uma análise dos sinais clínicos, das alterações radiográficas e das características artroscópicas de seis cavalos com lesões de osteocondrose no aspeto distal da crista sagital do metacarpo.

É possível concluir, depois deste estudo, que as lesões de osteocondrose nesta localização de interesse foram mais comuns nos membros anteriores e a maioria delas apresentava uma forma macroscópica (em forma de placa) e radiológica (radiopacidades lineares) distinta. Os sinais clínicos mais comuns foram a efusão e a resposta positiva ao teste de flexão ativa. Quanto ao diagnóstico destas lesões, é importante ter em consideração que a melhor projeção para detecção é a lateromedial com o boleto em flexão. Tendo em conta que esta não é uma projeção *standard* do boleto e que estas lesões não são detetadas na projeção lateromedial em extensão, é possível que as lesões nesta localização estejam a ser, atualmente, subdiagnosticadas na clínica de equinos. Por fim, a artroscopia é a opção de tratamento recomendada na maioria dos casos, devido à sua alta taxa de sucesso e por permitir a visualização de toda a articulação, contribuindo para a deteção de lesões que podem passar despercebidas em radiografias.

Assim, esta dissertação é uma contribuição para a melhor compreensão das lesões de osteocondrose nesta localização anatómica ainda pouco estudada. Contudo, são necessários estudos futuros com uma amostra mais extensa de cavalos e lesões, de modo a obter conclusões mais sólidas e consistentes

Palavras-chave: Osteocondrose; Osteocondrite Dissecante; Crista Sagital; Boleto; Equino

OSTEOCHONDROSIS OF THE DISTAL ASPECT OF THE SAGITTAL RIDGE OF THE THIRD METACARPAL BONE IN HORSES: A CLINICAL, RADIOGRAPHIC AND ARTHROSCOPIC DESCRIPTION

ABSTRACT

Osteochondrosis is a developmental orthopedic disease and is one of the most prevalent degenerative articular diseases in domestic animals. Osteochondrosis is characterized by a defect in endochondral ossification that is usually localized, bilateral, and in predisposed sites. This defect occurs due to a failure in blood supply to growth cartilage, which leads to ischemic chondronecrosis, however, the primary causes of vascular failure are still not known to the full extent.

In horses, the fetlock joint is one of the most affected joints and lesions can be present anywhere within the articular structure, however, the most common lesion sites are the dorsal sagittal ridge and the condyles of the cannon bone. Lesions at the distal aspect of the sagittal ridge of the cannon bone are scarcely documented in scientific papers, and there is only a single article addressing lesions at this site. The main aim of this dissertation is therefore to provide an evaluation of the clinical signs, the radiographic changes, and the arthroscopic findings of six horses suffering from osteochondrosis lesions at the distal aspect of the sagittal ridge of the metacarpus.

It is possible to conclude with this study that osteochondrosis lesions at the distal aspect of the sagittal ridge were most common in the forelimbs and most of them had a distinct shape macroscopically (plate-like shape) and radiographically (linear radiopacities). The most common clinical signs were effusion and a positive response to the active flexion test. For the diagnosis of these lesions, it is crucial to realize that the best projection for detection is the flexed lateromedial of the fetlock. Considering that this is not a standard projection of the fetlock and that these lesions are not detected in extended lateromedial, lesions here might be currently underdiagnosed in equine practice. Ultimately, arthroscopy is the preferred treatment option in most cases due to its high success rate, and because it provides a clear visualization of the whole joint and enables the detection of lesions that might go unnoticed in radiographs.

This dissertation thus stands as a contribution to the understanding and exploration of osteochondrosis lesions in this understudied anatomical site. Nevertheless, further studies with a more extensive sample size are needed in order to fill a gap in the existing knowledge of this disease and reach more robust and consistent conclusions.

Keywords: Osteochondrosis; Osteochondritis Dissecans; Sagittal Ridge; Fetlock; Horse

OSTEOCONDROSE DO ASPETO DISTAL DA CRISTA SAGITAL DO TERCEIRO OSSO METACARPIANO EM EQUINOS: UMA DESCRIÇÃO CLÍNICA, RADIOGRÁFICA E ARTROSCÓPICA

RESUMO ALARGADO

A osteocondrose é uma das doenças ortopédicas de desenvolvimento mais comuns em animais domésticos, sendo caracterizada por um defeito na ossificação endocondral que geralmente se localiza em locais predispostos, de forma bilateral. Este defeito ocorre devido a uma falha no suprimento sanguíneo às artérias da cartilagem de crescimento, resultando em condro-necrose isquémica. Contudo, as causas primárias desta falha vascular ainda não são totalmente conhecidas.

Este estudo abrange uma avaliação dos sinais clínicos, alterações radiográficas e achados artroscópicos de seis cavalos com lesões de osteocondrose na porção distal da crista sagital do metacarpo.

Entre as várias articulações afetadas pela osteocondrose, a articulação metacarpofalângica/ metatarsofalângica é uma das mais frequentemente comprometidas. Em cavalos Puro-Sangue Lusitano a articulação mais frequentemente afetada é a tarsocrural, seguida pela metacarpofalângica/ metatarsofalângica e em terceiro lugar a patelo-femoral. A articulação metacarpo/tarso-falângica é composta pelo aspeto distal do metacarpo/ metatarso, pelo aspeto proximal da primeira falange e pelos sesamoides proximais. A crista sagital do metacarpo/ metatarso é composta por quatro aspetos: o aspeto proximal, aspeto medial, aspeto distal e aspeto palmar.

As lesões podem ocorrer em qualquer parte da articulação do boleto, sendo os locais mais comuns o aspeto dorsal da crista sagital e os côndilos do metacarpo e metatarso. Apesar da alta prevalência da osteocondrose no boleto, as lesões na porção distal da crista sagital do metacarpo/ metatarso são pouco documentadas na literatura científica, havendo apenas um único estudo de Wright e Minshall de 2014. Dada a informação limitada disponível, tornou-se evidente a necessidade de investigar mais detalhadamente as lesões de osteocondrose no aspeto distal da crista sagital do metacarpo.

No boleto, tal como noutras articulações, para além da cartilagem articular há outro tipo de cartilagem, onde ocorrem as lesões primárias de osteocondrose/ osteocondrite dissecante – a cartilagem de crescimento. Esta pode ser encontrada em dois locais dos ossos longos: sob a cartilagem articular, no aspeto superficial da epífise e na fise/ placa de crescimento metafisária. A cartilagem de crescimento é irrigada temporariamente por artérias terminais, ou seja, uma certa porção de tecido é irrigado por uma única artéria, não havendo anastomoses levando a um maior risco de isquémia dos tecidos. Estas artérias encontram-se nos canais cartilagíneos que regridem pelo processo de condrificação com a idade, levando ao cessar da irrigação após algumas semanas de vida.

A etiologia desta doença ainda não é conhecida na sua totalidade, mas sabe-se que tem uma etiologia multifatorial, e que se deve à interrupção do aporte sanguíneo à cartilagem de crescimento, que leva à condronecrose isquémica e a um defeito na ossificação endocondral. As teorias mais apoiadas cientificamente para a interrupção do aporte sanguíneo são 1) a incorporação dos vasos na junção osteocondral, 2) a adesão de bactérias e conseguente oclusão luminal dos vasos que irrigam a cartilagem de crescimento. Pensa-se que a hereditariedade, o trauma, a rápida taxa de crescimento e a nutrição podem também ter um papel importante no despoletar destas lesões. As lesões de osteocondrose têm um caráter dinâmico, isto é, podem regredir espontaneamente até uma certa idade. A idade é, por isso mesmo, um fator importante a ter em consideração aquando a decisão de intervencionar cirurgicamente ou não um cavalo. As lesões de osteocondrose na crista sagital do metacarpo/ metatarso podem ser caracterizadas em 3 tipos/ graus: tipo 1 em que se observa um aplanamento radiolucente da crista sagital; tipo 2 em que já se observa, para além do aplanamento, um "flap" osteocondral ainda aderente ao osso de origem; e o tipo 3 em que se deteta um aplanamento da crista, com ou sem flap e com um ou mais fragmentos soltos na articulação.

O estudo desta dissertação incluiu seis cavalos com um total de oito lesões de osteocondrose no aspeto distal da crista sagital do metacarpo. Todos estes cavalos foram submetidos a um exame de claudicação e radiográfico e três dos seis cavalos submetidos a artroscopia.

No geral, dos oito membros radiografados, todos apresentaram lesões na porção distal da crista sagital do metacarpo – cinco membros anteriores direitos e três membros anteriores esquerdos. Os graus atribuídos às lesões nesta localização (de 0 a 3) foram registados, sendo que cinco lesões foram consideradas grau 2 e três grau 3. Neste estudo, a maioria das lesões de osteocondrose apresentavam uma forma macroscópica (em forma de placa) e radiográfica (radiopacidades lineares) distinta dos típicos fragmentos osteocondrais redondos.

Relativamente aos sinais clínicos no momento em que as radiografias foram tiradas, entre os seis cavalos incluídos neste estudo, cinco exibiram sinais clínicos, enquanto o outro não apresentou qualquer sinal. Os dados obtidos neste estudo não são totalmente consistentes com a afirmação de que os sinais clínicos iniciais estão frequentemente associados a um aumento recente no treino, como sugerido na literatura científica - os cavalos mais velhos, já em fase de treino, neste estudo, foram aqueles com sinais clínicos mais subtis.

Quanto ao diagnóstico, para avaliar a presença de lesões no aspeto distal da crista sagital do metacarpo, a projeção radiográfica mais eficaz é a LM em flexão, seguida pela projeção DP. A projeção skyline, que permite uma melhor visualização da superfície articular da crista sagital e dos côndilos do MCIII, deveria ser mais considerada entre os veterinários de equinos. Ao avaliar as projeções DLPMO e DMPLO, a menor suspeita de uma possível radiolucência ao longo da crista sagital deve levar à aquisição de uma projeção LM em flexão para uma avaliação mais detalhada da presença de lesões. Por fim, a análise das projeções LM em extensão deve ser realizada com precaução, pois a ausência de uma lesão visível na crista sagital não garante a ausência de lesão. Consequentemente, as projeções LM em flexão deveriam ser realizadas rotineiramente, especialmente durante os exames pré-compra e de claudicação. Estes achados sugerem que, atualmente, estas lesões podem estar a ser subdiagnosticadas na prática equina, não apenas porque são raramente abordadas na literatura científica, mas também pelo facto de a projeção mais fiável para a sua deteção, LM em flexão, não ser realizada rotineiramente por muitos veterinários, uma vez que não é uma das projeções *standard* do boleto.

Por fim, a artroscopia é a opção de tratamento recomendada na maioria dos casos, devido à sua alta taxa de sucesso, rápida recuperação, e por permitir a visualização de toda a articulação, contribuindo para a deteção de lesões que podem passar despercebidas apenas com um exame radiográfico.

Os achados desta dissertação fornecem informações úteis acerca dos sinais clínicos, e do diagnóstico e tratamento de lesões de osteocondrose no aspeto distal da crista sagital do metacarpo. Dado o número limitado de artigos científicos que abordam estas lesões neste local específico (apenas um artigo de 2014 (Wright e Minshall 2014)), este estudo contribui para a compreensão e exploração das lesões de osteocondrose neste local anatómico pouco estudado, com o objetivo de preencher uma lacuna no conhecimento existente sobre esta doença.

A principal limitação desta dissertação foi o pequeno tamanho da amostra, composto por apenas seis cavalos, o que dificultou a obtenção de conclusões substanciais para toda a população equina. Além disso, a natureza retrospectiva do estudo apresentou desafios na clarificação de algumas informações nos relatórios e na obtenção de todas as projeções radiográficas para cada membro dos seis cavalos envolvidos.

Apesar destas limitações, esta dissertação proporciona uma base para futuros estudos. Seria interessante reunir uma amostra maior de cavalos com lesões no aspeto distal da crista, documentar os sinais clínicos, radiográficos, as intervenções terapêuticas, e evolução dos pós-operatória. Seria interessante explorar a possível associação entre o grau/padrão de claudicação e o grau de lesões de osteocondrose neste local. Dado a distinta apresentação dos fragmentos/flaps osteocondrais detetados durante este estudo, com radiopacidades lineares e formas macroscópicas semelhantes a placas, seria esclarecedor explorar mais profundamente as origens/ causas dessas lesões de osteocondrose neste local específico.

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AECC – Articular-Epiphyseal Cartilage Complex

CDET – Common Digital Extensor Tendon

CT – Computerized Tomography

CVSM – Cervical Vertebral Stenotic Myelopathy

DDFT – Deep Digital Flexor Tendon

DLPMO – Dorsolateral-palmaromedial oblique

DMPLO – Dorsomedial-palmarolateral oblique

DOD – Developmental Orthopaedic Disease

DP – Dorsopalmar

DPr-DDiO – Dorsoproximal-dorsodistal oblique

LDET – Lateral Digital Extensor Tendon

LF – Left Fore Limb

LH – Left Hind Limb

LM – Lateromedial

MC – Metacarpus

MCP – Metacarpophalangeal

MMP-1 – Matrix Metalloproteinase-1

MRI – Magnetic Resonance Imaging

MT – Metatarsus

MTP – Metatarsophalangeal

NEMS – Neuromuscular Electrical Stimulation

OC – Osteochondrosis

OCD – Osteochondritis Dissecans

P1 – First Phalanx

PT – Patellofemoral

RF – Right Fore Limb

RH – Right Hind Limb

SDFT – Superficial Digital Flexor Tendon

SR – Sagittal Ridge

TC – Tarsocrural

TENS – Transcutaneous Electrical Nerve Stimulation

INTRODUCTION

Osteochondrosis belongs to the group of developmental orthopedic diseases and is considered one of the most common articular degenerative diseases in domestic animals (Bourebaba et al. 2019). This disease is characterized by a defect in endochondral ossification that is usually localized, bilateral, and in predisposed sites (Ytrehus et al. 2007). The defect in endochondral ossification occurs due to a failure in blood supply to the arteries of the growth cartilage, which leads to ischemic chondronecrosis, however, the primary causes of vascular failure are still not fully understood (Olstad et al. 2015).

The metacarpophalangeal/metatarsophalangeal joint is one of the most affected joints by this disease (Ramos et al. 2022). Lesions can be present anywhere within the fetlock joint however, the most common lesion sites are the dorsal sagittal ridge (Ortved 2017) and the condyles of the metacarpus and metatarsus (Douglas 2011). Despite the high prevalence of osteochondrosis in the fetlock, lesions at the distal aspect of the sagittal ridge of the cannon bone are scarcely documented in scientific papers (Wright and Minshall 2014) and the only study to this day addressing lesions at this site is an article from Wright and Minshall 2014. Considering the limited information available, the necessity to investigate more thoroughly osteochondrosis lesions at this understudied site became apparent. Consequently, this dissertation study offers valuable insights into this condition affecting the distal aspect of the sagittal ridge. It specifically addresses clinical signs, radiographic changes, and arthroscopic findings.

The dissertation is structured into several sections and commences with this small introduction on osteochondrosis, which includes the aim of this work, the study's purpose, and what motivated it. It proceeds to the presentation of the internship report, followed by the literature review section. The literature review consists of an overview of the anatomy of the fetlock, followed by a concise summary of developmental orthopedic diseases. Subsequently, a review of osteochondrosis and osteochondritis dissecans in the context of the fetlock joint can be found. Lastly in the literature review section, there is a comprehensive summary of the existing literature on osteochondrosis at the distal aspect of the sagittal ridge of the metacarpus. Following the literature review, the focus turns to the study of this dissertation itself, titled "*Osteochondrosis of the distal aspect of the sagittal ridge of the third metacarpal bone in horses: a clinical, radiographic and arthroscopic description*". This chapter is further divided into five sections: aims of the study, materials and methods, results, discussion, and conclusion.

1. CHAPTER I: INTERNSHIP REPORT

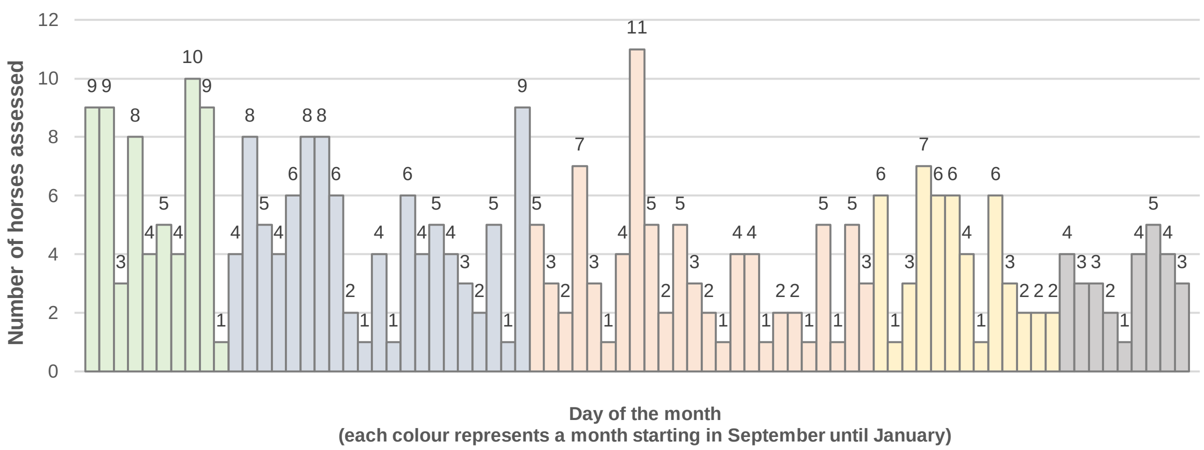
The internship took place in Évora, in Equimuralha – Hospital Veterinário da Muralha de Évora and lasted four months, from the 12th of September 2022 until the 13th of January 2023, under the supervision of Dr. Tomé Fino (DVM; FEI level 3 endurance official veterinarian), in an ambulatory regimen.

Equimuralha is an ambulatory equine clinic that assists equids in the vicinity of Alentejo as well as all over Portugal, from north to south. The clinic offers a 24-hour, 365 days a year service and is made up of 5 veterinarians with practice in equine medicine. The medical services provided by the clinic cover a wide range of areas, such as sports medicine/ orthopaedics, reproduction, internal medicine, dentistry, pre-purchase exams, field castration under general anaesthesia, prophylaxis and identification, assistance to emergencies (colic, wounds, etc.), among others.

The day shifts were approximately eight hours long and, having worked for a total of 77 days, the number of hours the author was involved in the internship was around 600. Every Monday morning the team of veterinarians and interns gathered to discuss all cases from the previous week and plan the week ahead. On Thursday mornings a journal club took place, in which one of the team members presented a recent article on some area of interest, with a theory component and occasionally a practical component as well. The author´s presentation consisted of a theoretical review followed by a practical demonstration on how to ultrasound the sexual gonads of a stallion and took part on the 17th of November 2022.

From the beginning to the end of the internship, a total of 318 horses were assessed, contributing to an average of 4 horses assessed per day, the maximum number of horses seen in one day being 11. The graph below (Chart 1) exhibits the number of horses assessed every day for the whole duration of the internship.

Chart 1 - Number of horses assessed per day during the internship



The author accompanied all five veterinarians throughout the internship. Out of the 318 cases, 109 were assessed with Dr. Tomé Fino, 128 with Dr. Beatriz Silva, 39 with Dr. Ana Galhós, 36 with Dr. Leonor Filipe, and 6 cases with Dr. Tiago Bugarim.

During the internship, exposure was provided to various areas of practice, such as sports medicine, dentistry, prophylaxis and identification, reproduction, internal medicine, emergencies, pre-purchase exams, and field castrations. The following paragraphs will describe thoroughly the number of cases assessed, the main activities and procedures executed, and the hands-on participation in the cases of each domain. At the end of this section, a graph representing the number of cases witnessed in each area can be found (Chart 2).

Overall, the examination of the musculoskeletal system was the area with the highest number of horses assessed: 91 horses were evaluated (29% of the cases approximately) throughout the four months of the internship. The management of cases in this field consisted of lameness examination, palpation of anatomical structures, flexion tests, nerve and intra-articular blocks, ultrasonography, and radiography of the musculoskeletal system in order to reach a diagnosis. Once a diagnosis was reached treatment options were discussed and, if possible, performed. Regenerative medicine, like Platelet Rich Plasma (PRP) and Pro-stride therapy, was carried out in 6 horses. Other treatment options after correct diagnosis consisted of intraarticular medication, administration of anti-inflammatory drugs, delineation of a rehabilitation plan according to the horse´s discipline and the time and financial availability of the owners, etc. Many bone and soft tissue disorders, laminitis, and hoof abscesses were managed throughout this time. The author´s hands-on involvement in these cases was mainly: horse restraint, asepsis, intra-muscular or intravenous injections, acquisition of radiographs, and discussion with the veterinarian on the degree of lameness of the horse being evaluated.

The area with the second highest number of cases was dentistry, in which 34 horses (11% of the cases) were assisted under sedation either to undergo a regular dental exam, to reduce sharp edges (through teeth floating), or to proceed to the extraction of one or more teeth. The direct involvement in these activities was horse restraint, sedation, and teeth floating under the supervision of one of the veterinarians.

Likewise, primary care was carried out in 34 horses, these cases included prophylaxis and identification of horses, especially foals, and wound care management. The author vaccinated and dewormed several horses, did limb bandages and wound disinfection.

Internal medicine cases followed with a total of 33 cases (contributing to 10% of 318 horses). This field included a vast variety of cases such as dermatological, respiratory, ophthalmologic, systemic, endocrine, gastrointestinal, urogenital, and behaviour disorders. The practical engagement in these cases was mostly horse restraint, blood collection, sedation, asepsis of the catheter site, intravenous and intramuscular injections, and oral drug administration.

The forthcoming field was reproduction with 31 cases (10%). The most frequent activities done were follow-up ultrasounds to pregnant mares or artificial insemination, semen collection and cryopreservation, uterine lavage, testis ultrasound, and palpation. The author got the opportunity to get my hands on ultrasounding mares, mare restraint during semen collection, foals restraint, palpation of the mares and stallions' reproductive tract, and was involved in the process of semen cryopreservation.

Rehabilitation of the locomotor system contributed to 30 cases of 318 (9%). The rehabilitation sessions consisted of a combination of laser therapy, TENS (Transcutaneous Electrical Nerve Stimulation) NEMS (Neuromuscular Electrical Stimulation), kinesiology taping, and physiotherapy sessions. An active role was played in laser and TENS sessions and in the discussion of a detailed rehabilitation plan tailored to each horse´s needs.

Over the course of the internship, 19 emergencies took place (6% of the total cases), out of which 11 were diagnosed as colic cases. The remaining emergencies involved various conditions, including wounds, chokes, suspected abortion, and others. The participation in these cases consisted of transrectal palpation, physical examinations, horse restraint, ultrasound of the thorax and abdomen, intravenous, intramuscular, and oral drugs administration, blood collection, nasogastric tubing, wound disinfection, limb bandages and assistance in euthanizing horses.

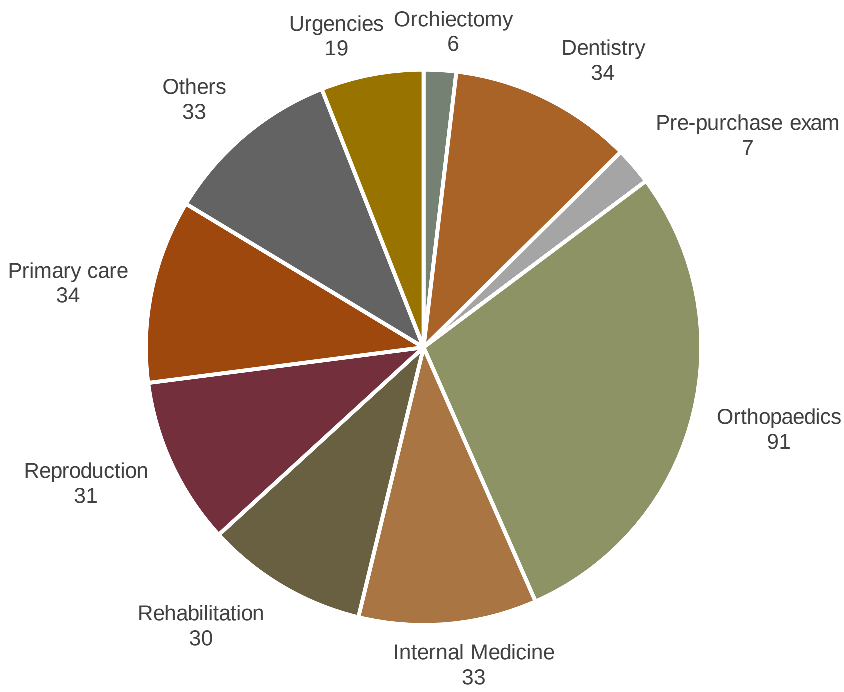
Pre-purchase exams were a common practice, especially for Dr. Tomé Fino. During the internship, I had the opportunity to participate in the examination of 7 horses with him. The exam procedure involved a statical examination, followed by a lameness exam, flexion tests, and acquisition of a standard set of radiographs that could be complemented with additional projections or ultrasound evaluation when needed. The practical input consisted mainly of discussion of the lameness degree of the horse being evaluated, execution of x-rays, and horse restraint.

Field castration was performed under general anaesthesia in 6 horses. Part of the author´s responsibilities, was overseeing the anaesthesia throughout the process, administration of pre-medication before castration, asepsis of the catheter site, and removal of the catheter at the end of the intervention and to observe the process of orchiectomy during the interventions.

Other single procedures contributed to approximately 10% (33 cases) of the total cases assessed. These procedures included sedation either to clip or to freeze brand a horse, necropsies, trimming the horses' hoofs, enteral and parenteral drug administration, blood collection, among others. My direct involvement in these activities consisted of sedating, administering drugs, trimming the horses´ hoofs, blood collection, and horse restraint.

Overall, the internship in Equimuralha provided a significant hands-on experience in a wide range of areas of practice and enriched the author´s clinical reasoning, which will be extremely useful the future career as a veterinarian.

Chart 2 - Number of cases assessed in each area



2. CHAPTER II: LITERATURE REVIEW

2.1. ANATOMY OF THE FETLOCK

The fetlock includes the metacarpophalangeal/metatarsophalangeal joint, composed of the distal aspect of the third metacarpal or metatarsal bone, the proximal aspect of the first phalange (P1) and the dorsal aspect of the proximal sesamoid bones. Due to the close similarity of this joint in the fore and hindlimbs, the terms metacarpal and palmar are used when referring to the forelimbs and hindlimbs (despite the correct terms for the latest being metatarsal and plantar).

The fetlock can be regarded as a condylar diarthrodial joint as it is composed of four structures: the hyaline cartilage covering the bones, the joint capsule which includes a fibrous external layer and an inner synovial membrane (Cauvin and Smith 2022), and the joint cavity filled with synovial fluid (Caola 2003). The fetlock is also considered a hinge joint, as bones are only capable of moving in one plane (flexion-extension) and therefore has very limited lateral range of motion (Konig et al. 2004). The forelimbs support 60 to 65% of the horse's weight so, consequentially, the distal forelimb is subject to greater stress than the distal hindlimb. Furthermore, the forelimbs typically experience a bouncing motion, while the hindlimbs tend to exhibit a sliding movement (Baxter et al. 2011).

The hyaline/articular cartilage is the tissue that covers the articular bone surfaces, and its function is absorbing mechanical loads and facilitating the movements of bones within the joint (Bourebaba et al. 2019). It is composed of chondrocytes and the extracellular matrix, which contains type II collagen fibres, hyaluronic acid, proteoglycans, and glycoproteins, the structural one being the condronectin (Junqueira and Carneiro 2013a). The cartilage is an avascular tissue, and it does not have any lymphatic vessels or nerves, meaning that its nutrition is made through the synovial fluid exclusively (van Weeren 2006). When located in articular bone surfaces, which is the case of the fetlock, the hyaline cartilage does not have perichondrium. The perichondrium is a thicker layer of cartilage, with dense connective tissue and an important source of nutrients, oxygen, and new chondrocytes for the cartilage. It is also responsible for the elimination of metabolic debris (Junqueira and Carneiro 2013a). Due to the absence of this layer in the articular cartilage, its regeneration is more difficult and often incomplete, and it tends to worsen over time (van Weeren 2006). As load is put upon the joint, water is forced out of the cartilage into the synovial fluid and the mechanism of electrostatic repulsion takes place within groups with the same electrical charge. Once the load is removed, the water returns to the hyaline cartilage. This motion of water, carrying in nutrients and dissolved gases is critical for the survival of the articular cartilage which depends exclusively on the synovial fluid for its nutrition and oxygenation (Junqueira and Carneiro 2013b).

The joint capsule, as referred above, consists of two layers, the external fibrous layer, and the inner synovial membrane layer. The fibrous layer is made up of dense connective tissue that receives very little blood supply, but it is very well innervated, therefore, when there is distention, there is pain associated with it (Konig and Liebich 2004). Its function consists of delimiting, cushioning, and protecting the articular space and bones. The inner part of the synovial membrane has multiple plicae and villi protruding into the synovial cavity. It is composed of two types of cells, one that is morphologically similar to fibroblasts, responsible for protein production, and one that is similar to macrophages, responsible for phagocytosis (Konig and Liebich 2004). This layer of the joint capsule is very well irrigated and innervated and its function is the secretion of synovial fluid into the joint space.

The synovial fluid is present in the joint cavity and has a high content of hyaluronic acid (Junqueira and Carneiro 2013b). It is transparent and viscous, and its function is to nourish and oxygenate the cartilage, reduce friction, and lubricate the joint.

There are two synovial pouches in the horse's fetlock, and they are located palmar and dorsal to the cannon bone. Laterally and medially to the joint there are the collateral ligaments, which tightly compress the joint abaxially, inhibiting the accumulation of synovial fluid here. Consequently, the only existing pouches are the palmar and the dorsal ones (Cauvin and Smith 2022). On its proximal aspect, the dorsal pouch has a small synovial fold made up by the folding of the joint capsule from proximal to distal. The palmar synovial recess is located between the metacarpus, the sesamoid bones, and the branches of the suspensory ligament. This palmar recess has a higher number of synovial folds, which are thicker and more vascularized than the dorsal one (Cauvin and Smith 2022). A small amount of synovial fluid is present in this pouch, although this amount can be higher than usual in perfectly sound horses (Cauvin and Smith 2022).

Besides the articular cartilage at the most superficial level of the epiphysis of the bone, there is another type of cartilage, where most primary lesions of osteochondrosis occur – the growth cartilage (Bjørnar Ytrehus et al. 2004). Growth cartilage can be found at two sites in long bones: in the superficial part of the epiphysis, right underneath the articular cartilage (epiphyseal growth plate or articular-epiphyseal cartilage complex), and in the physis (metaphyseal growth plate) (Wormstrand et al. 2021). This growth cartilage is temporarily irrigated by end arteries, during the first weeks of the foals´ life (Wormstrand et al. 2021), after which the blood supply ceases. It is responsible for the longitudinal growth of bones and for the shaping of long bone's endings (Ytrehus et al. 2007) until the growth plates ossify (van Weeren 2006).

The articular-epiphyseal cartilage complex (AECC) surrounds the secondary ossification center of the epiphysis on its superficial and abaxial aspects and the ossification front (or osteochondral junction) between these two structures is named epiphyseal ossification front. Besides this one, there is another ossification front, the metaphyseal-side ossification front of the physis (Wormstrand et al. 2021). The growth cartilage is organized in several zones. The AECC, from the most superficial to the deepest aspect, is composed by the resting zone, the proliferative zone, the hypertrophic zone, the mineralization zone, and finally, the ossification zone (Ytrehus et al. 2007) (Figure 1). Consequently, the endochondral ossification, in this location, occurs from the outermost layer towards the innermost layer, in the direction of the secondary ossification center.

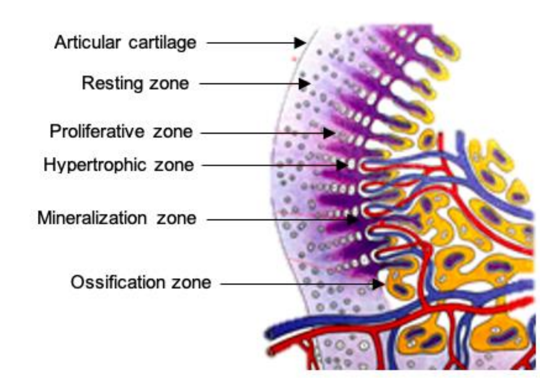


Figure 1 – Several zones of the AECC; Adapted from Abbasi 2021 Jun 18.

The growth cartilage of the physis is also divided into several zones, starting from the epiphyseal side onto the metaphysis is the resting zone, the proliferative zone, the hypertrophic zone, the mineralization zone, and the ossification zone, followed by the metaphyseal bone (Ytrehus et al. 2007). The endochondral ossification occurs from the epiphyseal side towards the metaphyseal side (Junqueira and Carneiro 2013b).

The temporary irrigation of the growth cartilage is done exclusively by end arteries (Wormstrand et al. 2021), meaning that there is a higher risk of tissue ischemia. These vessels are within the cartilage canals that regress by the process of chondrification, with age (Bjørnar Ytrehus et al. 2004). There are two different patterns of vessel branching, the dichotomous, characterized by many small vessels originating from a main one, and the monopodial, characterized by a single longer branch (Wormstrand et al. 2021). The AECC is irrigated by vessels with both patterns that course from the inner to the most superficial layers, turn 180º, and continue their course towards the deeper layers of the epiphysis (Wormstrand et al. 2021). In the physis, the epiphyseal side of the growth cartilage is irrigated exclusively by monopodial pattern branches, which course the full length of the growth plate, from the epiphyseal side to the metaphyseal side, turn 180º and follow back to the epiphysis. (Wormstrand et al. 2021). On the other hand, the metaphyseal side of the growth plate is supplied mainly by dichotomous pattern branches, making their way from the metaphysis onto the physis, which do not turn 180º and only reach half of the length of the physis. A study made by Wormstrand et al., on the left medial femoral condyle of foals, stated that at 15 days old all the branches from the metaphyseal side were non-existent and that the irrigation of the physis was made only through the epiphyseal side. It is known that the number of cartilage canals and, consequently, the number of vessels increase during the first days of the foals' life but diminish drastically afterwards (Wormstrand et al. 2021).

The three bone surfaces that compose the joint are the distal aspect of the cannon bone, the proximal aspect of the first phalanx, and the dorsal aspect of the proximal sesamoid bones. The metacarpus is a robust bone and has an oval shape in a transverse plane, whilst the metatarsus is relatively longer and rounder in cross-section (Dyce et al. 2010). The distal aspect of the cannon bone has a sagittal ridge axially, which fits into a depression in P1 (Kainer and Fails 2011). This sagittal ridge is composed of a proximal, a middle, a distal, and a palmar aspect, as it can be observed in the image below (Butler et al. 2017). The proximal facet of the first phalanx has got a concavity, the sagittal groove, axially, allowing it to accommodate the sagittal ridge (Dyce et al. 2010). The long pastern is wider on its proximal aspect than on its distal aspect and it has got tubercles latero-proximally where the collateral ligaments of the fetlock attach (Dyce et al. 2010). The proximal sesamoid bones have three facets: the dorsal / articular one, which faces the metacarpus; the palmar / flexor one which faces the flexor tendons (these slide over a fibrocartilage tissue that covers this surface called proximal scutum) (Cauvin and Smith 2022); and an abaxial one, that is the site of insertion for the suspensory ligament branches.

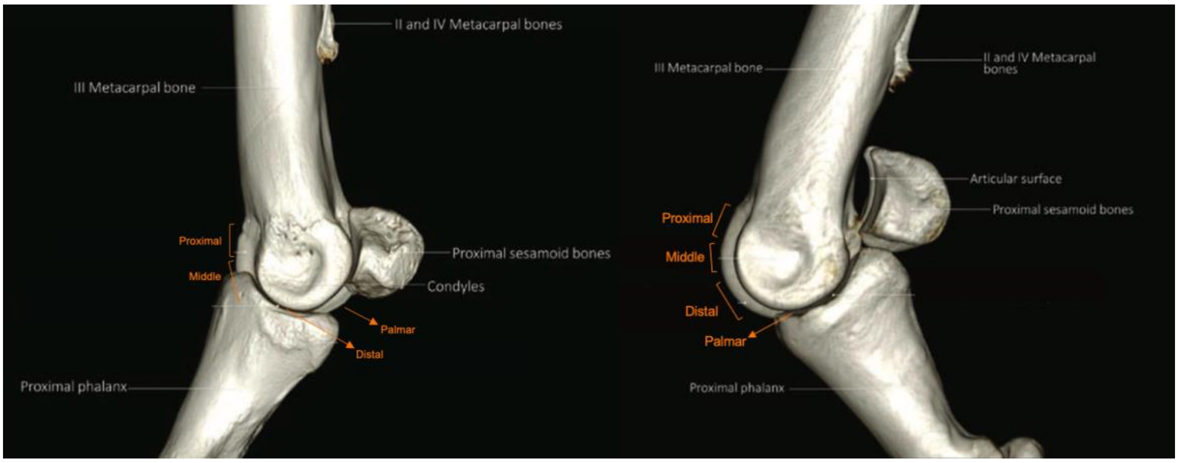


Figure 2 – Visual guide to the different aspects of the sagittal ridge with the fetlock in extension and flexion; Adapted from Manso-Díaz et al. 2018.

Regarding the fetlock's soft tissues, there is a series of tendons and ligaments that are involved, some of them intraarticular, and some others extraarticular. On the dorsal aspect of the fetlock, we can find axially the common digital extensor tendon (CDET), and between this tendon and the fetlock joint capsule the subtendinous bursa (Cauvin and Smith 2022), and more laterally, we can find the lateral digital extensor tendon (LDET) and its subtendinous bursa as well (Kainer and Fails 2011). Located on the palmar aspect of the fetlock, from the most dorsal structure to the most palmar there are: the palmar intersesamoidean ligament, the deep digital flexor tendon (DDFT) that is in contact with the proximal scutum, the superficial digital flexor tendon (SDFT) and the palmar annular ligament. This ligament attaches to the sides of the sesamoid bones, preventing both bones from spreading apart and holding the flexor tendons in place. The DDFT has got a subtendinous bursa that might hold a communication with the joint cavity in some horses (Kainer and Fails 2011). The straight, the oblique (lateral and medial), the short (lateral and medial), and the cruciate sesamoid ligaments can be found on the palmar aspect of the fetlock as well (Weaver et al. 1992). All of them, except from the cruciate ligaments, originate from the distal surfaces of the sesamoids, and their insertion is either on the second phalanx (straight sesamoidean ligament) or on the first phalanx (oblique and short sesamoidean ligaments) (Weaver et al. 1992). On the abaxial aspects of the fetlock joint of the horse many ligaments can be found. There are four collateral ligaments of the fetlock in each limb, two on each side of the joint which are the deep collateral ligament and the superficial collateral ligament of the fetlock. These two ligaments are X-shaped and blend with the joint capsule (Cauvin and Smith 2022). The lateral and medial collateral sesamoid ligaments insert into the deep lateral and deep medial collateral fetlock ligaments respectively (Cauvin and Smith 2022). Finally, the extensor branches of the suspensory ligament (medial and lateral) attach abaxially to the proximal sesamoid bones and dorso-distally to the common digital extensor tendon at the level of the middle phalanx.

2.2. DEVELOPMENTAL ORTHOPAEDIC DISEASES

There are many developmental orthopaedic diseases (DOD), all occurring at the horses' young age, either as foals or as growing horses (McIlwraith 2011). These are any acquired or congenital diseases that disrupt the typical growth, modelling, and remodelling of bones (Pool 1993).

The disturbances that are part of the group of developmental orthopaedic diseases are osteochondritis dissecans (OCD), angular and flexural limb deformities, physitis / physeal dysplasia, subchondral cystic lesions, juvenile arthritis, cervical vertebral malformation, and incomplete ossification of the cuboidal bones (McIlwraith 2011). The occurrence of more than one of these disturbances in a horse is possible, although rare. All these conditions, except flexural limb deformities, develop due to inadequate endochondral ossification (McIlwraith 2011).

Angular limb deformities consist of a lateral or medial deviation of the limb, viewing from a frontal plane (Witte and Hunt 2009). This is a quite common condition in foals (McIlwraith

2011) that many times requires corrective hoof trimming and shoeing, and sometimes surgical intervention, depending on the age of the horse and severity of the deviation (Witte and Hunt 2009).

Flexural limb deformities occur when tendons are contracted, or, more accurately, when the tendon's length is not long enough to accompany the bones' growth (Gaughan 2017). These deformities can be congenital (usually due to malpositioning or infection when in the uterus, or genetic factors) or acquired in horses with high growth rates, horses with an imbalanced diet (McIlwraith 2011) or secondary to injury (Gaughan 2017).

Physeal dysplasia, a more accurate term than physitis, consists of an inflammation of the growth plates in long bones, secondary to trauma due to an incapacity to receive the mechanical load of the body (Bramlage 2011) or nutritional imbalance (McIlwraith 2011).

Subchondral cystic lesions occur mostly on load-bearing bone surfaces as a consequence of trauma in the subchondral bone (Richardson 2011), or poor blood supply (Rechenberg et al. 1998). Subchondral cysts are considered by many as a manifestation of osteochondrosis (McIlwraith 2011). As most of the bone cysts are located in weight-bearing areas, the clinical presentation can be more delicate and precarious (McIlwraith 2011).

Juvenile arthritis is another DOD that usually appears after trauma over the articular cartilage or bone and rapid growth rate, leading to joint damage in the early stages of the horse's life (McIlwraith 2011).

Cervical vertebral stenotic myelopathy (CVSM), also named Wobbler's Syndrome is a DOD that leads to neurologic and abnormal gait in horses (Woodie et al. 2022). The neurologic gait is due to a compression of the spinal cord along the cervical vertebrae. This disease is the most common non-infectious cause of spinal ataxia in equines (Woodie et al. 2022).

Incomplete cuboidal bone ossification of the carpus or tarsus is mainly present in twin, premature or immature foals and is commonly associated with osteochondritis dissecans, and angular limb deformities (McIlwraith 2011). It takes place when the in-utero ossification, which should be completed 2 to 3 weeks before birth, is not concluded at birth and, consequently, the foal cannot bear its own weight (McIlwraith 2011).

Osteochondritis dissecans belongs to the group of developmental orthopaedic diseases, as well as the other diseases referred to above, and its thorough and detailed description can be found in the next section of the literature review.

2.3. OSTEOCHONDROSIS AND OSTEOCHONDRITIS DISSECANS

2.3.1. Introduction

Osteochondrosis (OC) is a disorder that affects several animals, more frequently pigs, horses, and dogs (Ytrehus et al. 2007), but it sparks special attention in the equine species, due to their athletic attribute and interest. The disease is characterized by a defect in endochondral ossification that is usually localized, bilateral, and in predisposed sites and typically does not result from a single traumatic external stimulus (Ytrehus et al. 2007). This disease negatively impacts the process by which cartilage is converted into bone tissue (Ytrehus et al. 2007). The condition is one of the most common causes of lameness, and, within the DOD, osteochondrosis is thought to be the most common disorder in need of surgery (McIlwraith 2011). The incidence of OC depends on the joint affected and the horse breed, but it is estimated to be around 20% to 25% (van Weeren 2006). The most affected joints are the tarsocrural (TC), the patellofemoral (PF), and the metacarpophalangeal /metatarsophalangeal (MCP / MTP). On a minor scale, the carpus, elbow, shoulder, and cervical joints are also affected (Ortved 2017). A recent study made with radiographs of 302 Lusitano Horses concluded that the most affected joint in this breed was the tarsocrural, followed by the MCP / MTP and the third most affected was the patellofemoral joint (Ramos et al. 2022).

A multifactorial etiology is behind the occurrence of osteochondrosis, therefore osteochondrosis does not occur due to a single factor, making the characterization of the disease difficult and challenging (van Weeren 2006).

There are and there have been several different definitions for this disease throughout the years, but there is still no unanimous consensus on what the most accurate would be. The exact pathogenesis of the disease and its primary lesions are also not known to the full extent, as most scientific studies were made at a stage at which the lesions were no longer clinically silent or were already seen in radiographs, meaning that the acute phase was no longer present. This led to the achievement of results related to the degenerative or regenerative phases, and not the initial phase of the disease (Ytrehus et al. 2007).

Osteochondrosis is widely used to refer to the initial phase of the disease when there is not yet an inflammatory response within the joint space (Ytrehus et al. 2007) or to refer to the disease itself (McIlwraith 2011). Less used is the term dyschondroplasia which refers to the same stage of the disease as osteochondrosis (Douglas 2011a). Osteochondritis refers to a phase of the disease at which the lesion has reached the articular surface and inflammation is present (Douglas 2011a). Finally, the term osteochondritis dissecans (OCD) is used when there is a loose intraarticular osteochondral fragment, usually present in the later stages of the disease (Douglas 2011a).

The term osteochondritis dissecans was first used by König in 1887 (König and König 1887) to refer to a pathological condition affecting the cartilage of the epiphysis making it susceptible to fragment and form intraarticular loose bodies, without external trauma or stimuli, mostly in young individuals (Ytrehus et al. 2007). The first time the term was used in Veterinary Medicine, was in the 1960s. The first veterinary studies referred to canine shoulder joints and "leg weakness" in pigs (Ytrehus et al. 2007). After that, around the 1980s studies on osteochondrosis advanced to other species, including the equine species (Olstad et al. 2015).

2.3.2. Etiology

As a multifactorial disease, the causes of osteochondrosis are not known in its totality. There are many different theories on the etiology of this bone-cartilage disorder on the table. Despite its etiological uncertainty, it is known that all OC lesions have a local defect in endochondral ossification (Ytrehus et al. 2007).

Studies made in porcine species stated that these focal points of defects in endochondral ossification consisted of necrotic growth cartilage associated with necrosis of the cartilage blood vessels (Olstad et al. 2015). This initial stage of the lesion, impossible to detect by the naked eye, is characterized as *osteochondrosis latens* (Bjrarnar Ytrehus et al. 2004). A Bjrarnar Ytrehus et al. 2004 study proved that vascular failure and subsequent ischemic chondronecrosis (at an intermediate level of the epiphyseal growth cartilage) were the underlying causes of osteochondrosis in pigs. The term *osteochondrosis manifesta* refers to the stage at which the ossification and mineralization of the lesion site does not take place (as there is a defect in the endochondral ossification) (Olstad et al. 2015), and can be seen macroscopically as a site of retained necrotic growth cartilage (Bjrarnar Ytrehus et al. 2004), surrounded by bone tissue (Bjørnar Ytrehus et al. 2004). Due to the lack of solid trabecular bone tissue at the lesion site, an osteochondral fragment can detach and become an intraarticular loose fragment, at this stage the appropriate designation for the disease, as mentioned above, is *osteochondritis dissecans* (Bjørnar Ytrehus et al. 2004).

In equine species, the knowledge of the pathogenesis of osteochondrosis was not as advanced as in pigs, and until 2007, most of the studies made were on chronic lesions and older horses (Olstad et al. 2015). The first of several theories (around the 1980s and 1990s) on the etiology of OC lesions in horses was developed by *Bridges et al* and *Hurting et al*, which affirmed that deficiency in copper could be a cause of a poorer quality of collagen fibers, leading to a less protective cartilage tissue and the occurrence of OC lesions (Hurtig et al. 1993). Other authors, around the same time as the previous ones, associated OC lesions in horses with the inability of blood vessels to reach from the subchondral bone to the growth cartilage and with ischemic chondronecrosis, respectively (Olstad et al. 2015). In 1996, a study of intraarticular fragments in the fetlocks and hocks stated that, since there were no signs of inflammation nor degenerative processes in the joints affected, the most probable cause for the OC fragments would be aberrant accessory ossification centers (Grondahl et al. 1996). More recent studies made in week-old foals proved that the accessory, or separate centers of ossification, are a response to repair ischemic chondronecrosis, and not a cause for the occurrence of the disease (Olstad et al. 2013). In 1997, some authors stated that the disease was due to dyschondroplasia, i.e., the improper differentiation of chondrocytes. The causes leading to dyschondroplasia would be either hormonal or nutritional imbalances (Olstad et al. 2015). On the table, there was also the hypothesis that alterations in collagen fibers constituted the primary etiology of OC lesions, due to the reduction in weight-bearing capacity (Olstad et al. 2015). None of these theories were totally proven until then.

More recent studies, since 2007, have focused on investigating whether vascular failure and ischemic chondronecrosis were the causes of OC lesions in horses after it was proven for the porcine species. For this purpose, arterial perfusion studies were done in order to understand the epiphyseal growth cartilage irrigation. Physiologically, blood vessels are only present in the epiphyseal growth cartilage for a limited time, which varies concerning the joint. For instance, in the fetlock and hock, the irrigation of the epiphyseal cartilage ceases before it does in the stifle (Olstad et al. 2015). It is known that the number of vessels present decreases with aging, after a small increase during the first days (Wormstrand et al. 2021) and that the more proximal the joint, the longer the duration of the blood supply to its epiphyseal cartilage (Olstad et al. 2015). Studies on experimentally induced lesions were performed in a horse breed that has very little prevalence of osteochondrosis, the Fjord Pony (Olstad et al. 2013). This study consisted of the transection of the epiphyseal growth cartilage blood vessels of the lateral trochlear ridge of the distal femur and subsequent assessment through radiography, histological, and macroscopical examination. The results showed that there was necrosis of the chondrocytes and vessels as well as a focal delay in ossification after at least 21 days post-operation (Olstad et al. 2013). Currently, it is therefore proven that OC lesions in horses result from vascular dysfunction in the growth cartilage and ischemic chondronecrosis, followed by a failure in endochondral ossification at the lesion site (Olstad et al. 2015).

The primary causes of vascular failure and associated chondronecrosis are still being investigated. Most of the studies made until today were implemented in older horses, and as the blood irrigation to the growth cartilage is temporary and ceases around 10 weeks old (for the fetlock and hock joint), the conclusions were and are scarce. To have a better understanding of the underlying cause of vascular failure and ischemic chondronecrosis, studies should be made when irrigation is still present (Olstad et al. 2015). There are several theories for the cause of failure in the blood supply to the growth cartilage. The first theories proposed were premature chondrification due to trauma (Woodard et al. 1987) or exacerbated chondrification (Carlson et al. 1989), but were later considered as a rare and improbable cause

(Olstad et al. 2015). Another theory proposed, affirmed that the microfractures of trabecular bone could be one of the leading causes of vascular failure (Bjørnar Ytrehus et al. 2004), however, nowadays it is also considered an improbable cause (Olstad et al. 2015).

The most plausible and supported theory for blood irrigation failure (Olstad et al. 2015) is the incorporation of cartilage canal vessels into the ossification front during growth (Olstad et al. 2008). As explained in the anatomy chapter of this dissertation, cartilage canals are the structures that contain the temporary vessels that supply blood to the growth cartilage. As an individual ages, these cartilage canals gradually diminish through a process called chondrification, during which cartilage tissue replaces the contents of the canals (Bjørnar Ytrehus et al. 2004). In this process, the endothelial cells disintegrate and the cells adjacent to the vessel are transformed into chondrocytes able to produce matrix (Bjørnar Ytrehus et al. 2004). Chondrification is a natural process, but if the regression of the canals occurs prematurely, before the physiological time at which blood supply to the growth cartilage ceases, it can lead to the development of lesions of osteochondrosis (Bjørnar Ytrehus et al. 2004). The incorporation of cartilage canals occurs in the epiphyseal ossification front, compromising the irrigation, and the first osteochondrosis lesions occur at the adjacent resting zone of the epiphyseal growth cartilage, underneath the articular cartilage. The initial lesions of necrosis are only detected microscopically (*osteochondrosis latens*) and often develop into macroscopic lesions (*osteochondrosis manifesta*), as there is a failure in endochondral ossification, and finally, in more severe cases, osteochondral fragments can be detected (*osteochondritis dissecans*) (Bjørnar Ytrehus et al. 2004). The ossification front is, therefore, the location at which the cartilage canal vessels are especially prone to failure, leading to implications for the survival of the chondrocytes reliant on them (Olstad et al. 2008).

The second most common and research-supported theory, states that bacterial binding, leading to luminal occlusion can have a major role in the vascular failure of cartilage canal vessels (Denecke et al. 1986). Bacteremia and subsequent inflammatory response lead to an increase in the permeability to bacteria of the cartilage canal blood vessels of the AECC and of the physeal growth cartilage of foals (Wormstrand et al. 2018). The location at which bacteria are most commonly found is the distal aspect of the AECC end arteries (Wormstrand et al. 2021). The presence of discontinuities in these vessels has been described in chickens and swines (Wormstrand et al. 2018), and in foals by (Hellings et al. 2016) These discontinuities and fenestrations in the endothelium of blood vessels facilitate the adherence of bacteria and the formation of an inflammatory response, resulting in infection and a higher risk to the occurrence of OC lesions (Wormstrand et al. 2018). (Wormstrand et al. 2018) affirm that one should distinguish the acquired OC lesions (the ones caused by bacterial infection), from other OC lesions, and state that the term “Septic Osteochondrosis” should be used when referring to ischemic chondronecrosis caused by bacterial infection. In the article Wormstrand et al. 2018 the author highlights the importance of differentiating sepsis-related osteochondrosis from other forms of osteochondrosis, especially when considering the breeding aspect. Equines suffering from acquired sepsis-related osteochondrosis could still be used in reproduction, as they would not be contributing to a higher occurrence of heritable OCD.

There are some other theories proposed but not yet investigated, that could be of interest to explore to get a clearer understanding of the underlying causes of blood irrigation failure to growth cartilage. These are the reduced cross-linking, derived from copper deprivation, of elastin molecules in blood vessel walls and the association of disorders that lead to intravascular thrombosis and later obstruction, like hypercoagulability disorders, hemolytic anemia, and disseminated thrombosis (Olstad et al. 2015).

Some other etiological factors that can be involved in the development of osteochondrosis are hereditary predisposition, anatomic conformation, rapid growth rate, trauma, and imbalanced nutrition (Bjørnar Ytrehus et al. 2004). It is known that the number of affected animals within a species varies according to breeds, and bloodlines, suggesting that there is a certain hereditary factor responsible for the prevalence of OC lesions (Ytrehus et al. 2007). The heritability of osteochondrosis is a complex domain as it involves a polygenetic trait and the interaction between environmental and genetic factors (Ytrehus et al. 2007). One of the genetic factors most associated with OC lesions is anatomic limb conformation. If a limb has an abnormal conformation, the joint shape will most likely be abnormal as well, leading to the overload of a region within the joint, making it prone to develop OC lesions (Ytrehus et al. 2007). These two factors, heritability, and anatomic conformation, which often go hand in hand, are strongly corroborated by evidence to influence the development of osteochondrosis. The other factors mentioned above, like rapid growth rate, trauma, and imbalanced nutrition are not supported by conclusive and convincing data yet. With regards to trauma, studies affirm that trauma can have a role in the severity of the OC lesions and in the appearance of clinical signs, but it is not yet proven to have a role in the appearance of initial OC lesions (Ytrehus et al. 2007). Concerning rapid growth, a study made by Sandgren et al. 1993 stated that foals weighing more than usual at birth had more lesions of OC in the hock than foals with normal birthweight and that the opposite happened in foals with OC lesions in the fetlock, showing how variable and challenging the etiology and pathogenesis of OC can be.

In conclusion, what is known about the etiology of osteochondrosis in horses is that it occurs due to a failure in blood supply to growth cartilage’s end arteries, which leads to ischemic chondronecrosis of the epiphyseal growth cartilage. The causes of vascular failure are still not known to the full extent, although there are two main theories supported by research evidence. The first one refers to the incorporation of the cartilage canal vessels into the ossification front, and the second one to bacterial infection leading to an inflammatory response and luminal occlusion, responsible for the failure in irrigation of the growth plate and subsequent ischemic chondronecrosis. Osteochondrosis only develops when several etiological factors coexist, which makes it difficult to fully understand its pathogenesis. Future studies must be made for a better and clearer understanding, especially during the period at which blood supply is still present in the growth cartilage.

In addition, studies have concluded that some OC lesions can spontaneously regress and heal, without any treatment or intervention, within a certain age window which depends on the joint (Douglas 2011a). The younger the horse, the better the healing capacity of cartilage (van Weeren 2006). For example, for the hock joint, the age at which this spontaneous healing can occur is before 5 months of age. After that, the lesions visualized in imagiology will no longer heal by themselves, and treatment should be considered. For the stifle the "age of no return" is considered to be at 8 months of age (Douglas 2011a). According to van Weeren OC lesions can appear and disappear until the age of 9 to 10 months, hence a surgical intervention before that time should only be carried out in case clinical signs are recurrently present, otherwise surgery could turn out being unnecessary or have to be repeated in the future due to the emergence of other lesions (van Weeren 2006).

2.3.3. Clinical signs

The arising of the first clinical signs is usually related to the beginning or a recent increase in the intensity of training (van Weeren 2006) and is not necessarily coincident with the initiation of the OC lesion. Usually, there is a clinical presentation at the age of three to four years of age in warmblood horses, and an earlier clinical expression in racehorses, as their breaking phase has an earlier start (van Weeren 2006). Clinical signs can be present with or without any radiographic changes (only detected through arthroscopy) or absent when radiographic signs are already present (McIlwraith 2011). It is thought that the appearance of the first clinical signs occurs when the articular surface is affected and lesioned (McIlwraith 2011). The worse the OC lesion, the earlier the clinical signs appear, according to Bourebaba et al. 2019. A sudden and severe lameness in older horses is usually related to the loosening of the OC fragment from the lesion site (Richardson 2011).

The most common clinical sign is joint effusion, independently of the joint affected (McIlwraith 2011). The swelling may not be obvious to detect by the naked eye however, palpation of the joint might facilitate the detection of effusion.

The presence of lameness is very variable. Some cases display a very accentuated lameness of the affected limb, others a mild lameness, and some others no signs of a lame limb at all (van Weeren 2006). A positive response to the active flexion is commonly present, this is, the lameness is displayed or exacerbated after a flexion is performed to the affected limb, even if the limb is sound before the flexion (McIlwraith 2011).

Synovitis is detected during ultrasonography examination of the joint and is present when the detritus from the lesion detaches from it and is released into the articular space, promoting an inflammatory response (McIlwraith 2011). If synovitis is present, during an ultrasound of the articular space a thickening of the synovial layer can be seen, together with fluid in the joint. The fluid is usually slightly echogenic and grainy hyperechoic foci can be found (Cauvin and Smith 2022).

2.3.4. Diagnosis

Nowadays, the most common diagnostic method of osteochondrosis is via clinical signs and radiography (van Weeren 2006), which is easily available in the field. More recent research is focusing on biomarkers and more precise diagnostic imaging like magnetic resonance (MRI) (van Weeren 2006) and computed tomography (CT) (Olstad et al. 2008).

During lameness examination, if lameness is present in the affected limb, proper perineural, or intraarticular analgesia of the joint affected should cease or decrease the level of lameness (Richardson 2011).

Radiography, following a lameness examination, usually confirms the presence of OC lesions. If a lesion is found, the contralateral limb should also be radiographed, as these findings are commonly present in more than one limb (Richardson 2011). Usually, if an OCD fragment is detached from the bone, it can be detected through radiographs. The absence of radiographical changes does not rule out the presence of the disease, some OC lesions are only detected through arthroscopy or more advanced diagnostic imaging, especially during the initial stages (McIlwraith 2011). Radiographs might as well not show the severity of the lesions to the full extent, usually, in the patellofemoral joint the arthroscopic appearance is worse than the radiographic one (Ortved 2017), therefore, it is important to evaluate radiographs bearing in mind the clinical signs. The radiographic findings vary depending on the horse, the joint, and the location of the lesion within the articulation. The findings can be very subtle, like a slight flattening of the bone surface or subchondral bone opacity increase, or more problematic, like radiolucent areas and loose radiopaque fragments detached from the bone (Butler et al. 2017).

Diagnosis through biomarkers that help detect osteochondrosis is being studied, although most of the research on biomarkers of joint diseases has been focusing mainly on osteoarthritis, as its early lesions cannot be easily detected through radiography (van Weeren 2006). Some biomarkers like collagen serum markers proved to be effective in distinguishing severe lesions of OC from less severe lesions in young foals (Billinghurst et al. 2004). In two articles Laverty et al. 2000 and Laverty et al. 2002 proved that there was an alteration of collagen metabolism in synovial fluid and an excessive degradation of type II collagen in the articular cartilage of young horses suffering from osteochondrosis. Another study affirmed that matrix metalloproteinase-1 (MMP-1) was high in affected joints of young horses. All the biomarkers referred above relate to young horses only, meaning that in older horses there is a decrease in the metabolism of cartilage extra-cellular matrix, whether the horse is healthy or whether it suffers from OC. In mature horses inflammatory mediators are under research, after a Grauw et al. 2005 study proved that there were differences in the concentration of leukotriene B4 and prostaglandin E2 in synovial fluid of horses' joints affected by OC with clinical signs and non-affected joints. Another study described that there is a relation between osteocalcin in serum in a two week old foal and the probability of this foal developing osteochondrosis (van Weeren 2006). Biomarkers are a less specific diagnostic method to detect osteochondrosis than radiography, but despite this, in the future they might become more useful in early diagnosis, prevention, and risk assessment (van Weeren 2006).

More advanced diagnostic imaging provides a more detailed visualization of the bone and cartilage. For instance, MRI allows better visualization of the cartilage and has an important role in the detection of early OC lesions (van Weeren 2006). On the other hand, a recent study on OCD in the elbow joint of humans concluded that CT offers a better look into the aspect of the subchondral bone, detects more easily OCD (loose) fragments, and more advanced changes of the disease, like sclerosis, loose fragments, and the fragmentation of these (Müller et al. 2022). Both of these advanced imaging methods, MRI and CT, are superior to radiography, as they provide a more detailed visualization of the cartilage and bone (Müller et al. 2022). The negative aspects of these two modalities, besides the higher cost, are the restricted access to the equipment in the field, the need for general anaesthesia in some cases, and the difficulty to analyse more proximal joints in the horse species (van Weeren 2006).

2.3.5. Treatment

The decision on whether to treat or not a horse should be based on several factors, such as the age of the horse, the clinical status (presence of lameness, effusion, and other signs), the degree and location of the lesions after imagiology is performed, and the future use of the horse (potential sale, for example). As for the age of the horse, it is important to note that some lesions might regress and heal spontaneously within an age window that varies from joint to joint (Douglas 2011a). According to van Weeren 2006, surgery should only be performed after the age of 9 / 10 months due to the dynamic character of lesions. However, it is important to have in mind that a horse with recurrent clinical signs, like lameness and/or effusion, meets the criteria for surgery (van Weeren 2006). Horses that will potentially be sold in the future and horses with more severe lesions are also strong candidates for surgery (Richardson 2011).

There are two types of treatment: conservative and surgical (van Weeren 2006). The conservative or medical treatment consists of rest and restrictive exercise and if needed, systemic administration of nonsteroidal anti-inflammatory drugs and/or intraarticular administration of corticosteroids and/or hyaluronic acid (Ortved 2017), especially if synovitis is present (Bourebaba et al. 2019). The progression, or regression of lesions should be inspected via radiographs, as well as any clinical signs (Ortved 2017) in order to understand if there is any improvement and discuss the need for surgery or any changes to the treatment being administered. Special attention to the horse's nutrition is important during this time. A decrease in energy intake (and consequently body weight) and an appropriate diet level of proteins and minerals may help reduce the gravity of OC lesions, if these are not extremely severe (Pagan 2011). According to Semevolos 2017 study, the restriction of exercise at an early stage of the disease can prevent the progression of the OC lesions into osteochondral flaps or loose intraarticular OC fragments.

The use of regenerative medicine, like platelet-rich plasma (PRP), is becoming more usual in the management of OC lesions (Semevolos 2017) although more studies must be made for a better understanding of these methods and for a full knowledge of the process of cartilage regeneration (Bourebaba et al. 2019).

Surgical intervention via arthroscopy is the treatment of choice for OC(D) lesions nowadays, and it has replaced the traditional arthrotomy that used to be performed in the past (Ortved 2017). Arthroscopy is a minimally invasive procedure that enables the diagnosis and treatment of intraarticular lesions, and a clear and better visualization of the intraarticular structures (McIlwraith et al. 2015). Compared to imagiology, including MRI and CT, arthroscopy offers greater accuracy for the diagnosis of cartilage lesion degree (McIlwraith et al. 2015). The arthroscopy is done through two, or a few more, small incisions and the aims of this procedure are to reconstruct articular surfaces of bones, withdraw OCD fragments or flaps, debride lesions until healthy tissue is exposed to facilitate healing, and perform synovial lavages (W. McIlwraith, Nixon, and Ian Wright 2015). In foals with cartilage flaps without the involvement of subchondral bone, the placement of polydioxanone needles to attach the flap to the underlying subchondral bone can be done via arthroscopy (Bourebaba et al. 2019). In adults, the most common procedure to resolve OCD lesions is the debridement of the unhealthy intraarticular structures and removal of the osteochondral fragments from the joint (Ortved 2017). Despite its successful results and effectiveness, after the debridement of lesions, the characteristics of the articular surface will not be the same as the initial ones (Muttini et al. 2003). This is, the articular hyaline cartilage surface will not be covered in collagen type II fibers (as it happens physiologically), it will most likely be covered in fibrocartilage tissue in the best-case scenario (Muttini et al. 2003). As a minimally invasive technique, arthroscopy promotes a fast recovery, a rapid return to work and less performance loss, and it is, therefore, considered a crucial treatment option for articular disorders in the equine athlete (W. McIlwraith, Nixon, and Wright 2015).

2.3.6. Prognosis

The prognosis of OC lesions is variable and depends on several critical factors. Early detection of lesions followed by appropriate treatment is crucial and plays one of the most significant roles in achieving the best possible prognosis for osteochondrosis in equines, as it avoids cartilage deterioration and synovitis (Goldkuhl et al. 2023). The location and severity of lesions i.e., articular cartilage damage, and other arthroscopic findings, significantly impact the prognosis (Goldkuhl et al. 2023). Cartilage injury is related to future joint diseases like osteoarthritis (OA), as when injured, there is stimulation of the production of proteolytic and degenerative enzymes that leads to inflammation and further cartilage degeneration, with morphological changes in the joint cartilage (Goldkuhl et al. 2023). A recent study based on 823 arthroscopies of the MCP and MTP joints affirmed that there was no relationship between fragment size and cartilage injury, therefore, the prognosis of an OCD fragment does not depend on the fragment size (Goldkuhl et al. 2023). Other arthroscopic findings like a bigger extension of the lesions within the affected joint than the ones seen on radiographs contribute to a poorer prognosis (McIlwraith 2011). In addition, the discipline in which the horse is involved and the owners' expectations are important when it comes to establishing a prognosis (van Weeren 2006). In the racing discipline, for example, studies have proven that there is no difference in performance between a group previously affected with OC and a healthy group (van Weeren 2006). On the other hand, horses in the discipline of dressage, where the symmetry of movements and the aesthetic aspect have an important role, show a lower performance in the previously OC-affected group (van Weeren 2006). After surgical intervention the success rate varies according to the joint, the one with the higher success rate (of 90%) is the metacarpophalangeal / metatarsophalangeal joint, followed by the tarsocrural (over 80%), the patellofemoral (75%) and the joint with poorest prognosis after surgery (under 50%) is the shoulder joint, although still better than if treated conservatively (van Weeren 2006). To gain a full understanding of the different prognostic indicators and to optimize treatment options, further research must be made so that patients suffering from OC have a better quality of life and a better performance as athletes in their disciplines (van Weeren 2006).

2.4. OSTEOCHONDROSIS AND OSTEOCHONDRITIS DISSECANS IN THE FETLOCK

2.4.1. Introduction

Osteochondrosis lesions are very often present in the fetlock joint. In general, the fetlock is among the three most affected joints by OC, and in the Lusitano breed, a study by Ramos et al. 2022 concluded that the fetlock is the second most affected joint, subsequent to the tarsocrural and followed by the patellofemoral joints. Within the fetlock articulation, the most common lesion sites are the dorsal sagittal ridge (Ortved 2017) and the condyles of the metacarpus and metatarsus bone (Douglas 2011). Fragments on the proximal palmar/plantar aspect of the first phalanx are generally accidental findings and less common. There is no unanimous consensus on whether these fragments (usually embedded in the short sesamoid ligament and more common in the hindlimbs) are actually osteochondrosis lesions (Ortved 2017). Fragments in the dorsoproximal aspect of P1 can be found in routine X-rays, more commonly in racehorses (Goldkuhl et al. 2023), but they are considered traumatic in origin by most authors (Richardson 2011). These fragments are usually rounded (McIlwraith et al. 2015). The fragments located at this site are frequently surgically withdrawn as they can cause cartilage damage and surgery is relatively straightforward and simple (Richardson 2011).

Typically, lesions in the fetlock are formed before 7/8 months of age (Douglas 2011), and most lesions are first detected in weanlings to yearlings, many are accidental findings in routine presale radiographs (McIlwraith et al. 2015). As there is a quadrilateral involvement when it comes to osteochondrosis in the fetlock joints, it is advisable to evaluate all four fetlock joints, if an OC lesion is found in any of them (Richardson 2011). Lesions in the sagittal ridge, if not treated, can progress into greater and more significant lesions, affecting the condyles of the MC or MT (McIlwraith et al. 2015). In the cases of osteochondritis dissecans in the fetlock, the fragments are more frequently located in the medial aspect of the joint, believably due to the fact that the proximal medial surface of the first phalanx is higher than the proximal lateral surface.

A recent study analysing eight hundred and twenty-three MCP and MTP joints by Goldkuhl et al. 2023 came to several conclusions about osteochondral fragments in the fetlock joint. The study concluded that fragments of the dorsal aspect of the sagittal ridge and of the dorsoproximal P1 had a stronger association with cartilage injury than fragments on the palmar/plantar aspect of the fetlock joint (Goldkuhl et al. 2023). In fetlocks that presented cartilage damage, cartilage lesions in the dorsal aspect of the joint were found in 99,4% of joints with dorsal fragments and in 44,1% of joints with palmar/plantar fragments (Goldkuhl et al. 2023). On the other hand, cartilage lesions in the palmar/plantar aspect of the joint were found in 12,2% of joints with dorsal fragments and in 73,5% of joints with palmar/plantar fragments (Goldkuhl et al. 2023). This indicates that cartilage lesions do not exclusively correspond to the location of the fragment within the joint, as they can be found throughout the entire joint. The study reached other conclusions, one of them was that dorsal fragments were more likely to be associated with cartilage damage than palmar/plantar fragments, that fragment size did not influence the presence of cartilage injury, and that the age of the horse and the presence of lameness were associated with cartilage injury (Goldkuhl et al. 2023).

2.4.2. Clinical signs, diagnosis, treatment & prognosis

Clinical signs

In most cases lameness only starts becoming evident when the horse is put to work, therefore yearlings usually do not present any signs of lameness until their breaking phase (Richardson 2011). Effusion is the most common sign of osteochondrosis in a joint (Ortved 2017) and is usually the first (and many times the only) clinical sign. Effusion of the fetlock, contrary to other clinical signs, might be present previously to the breaking phase of the foal (Richardson 2011), or even before radiographic changes can be detected (McIlwraith et al. 2015). If a horse has an unstable OC lesion, it is probable that as soon as work starts clinical signs will arise. The lameness degree is very variable but a positive response to an active flexion test occurs in most cases (Ortved 2017). A study by Santos et al. 2022 found a positive correlation between lameness degree and the presence of fetlock effusion.

Some cases might be clinically silent, this is, there is a visible OC lesion in X-rays, but no lameness, effusion, or other signs are observed. In some of these cases, an active flexion test can unveil lameness in the affected limb (McIlwraith 2011). An abrupt display of lameness in an old horse is often related to the loosening of an osteochondral fragment from the parent bone (Richardson 2011). According to Goldkuhl et al. 2023 recent study, lameness is associated with cartilage injury and older horses, but it is not associated with fragment location or fragment size.

Diagnosis

In many cases, diagnosis of osteochondrosis lesions in the fetlock is accidentally reached during presale radiographs and in other cases, diagnosis is reached for clinical reasons (Richardson 2011). The most common diagnostic tool is radiography after a lameness examination is performed. More advanced imaging techniques, like MRI and CT can help in the diagnosis of lesions in the fetlock joint as well. Arthroscopy is generally used for treatment purposes, but it can also be a helpful and precise diagnostic method, as it allows a detailed examination of the cartilage and other structures of the fetlock (Muttini et al. 2003).

The lameness exam consists of evaluating the presence or degree and the pattern of lameness in different gaits, in a straight line, in circles, and in soft and hard surfaces. During the lameness examination, intraarticular (in the fetlock joint) and perineural anaesthesia can be performed in order to locate and confirm the origin of the pain, by ceasing or reducing the lameness of the affected limb (Richardson 2011).

According to McIlwraith et al. 2015, when examined radiographically, osteochondrosis lesions in the sagittal ridge consist of three degrees/types: flattening or defect in bone surfaces (Type I OCD / 1-degree OCD), a flattening or defect with a fragment associated with it (type II OCD / 2-degree OCD) or a flattening or defect with or without a fragment associated and with intraarticular loose bodies (type III OCD / 3-degree OCD). The figure below shows the different types of OCD in radiographs.

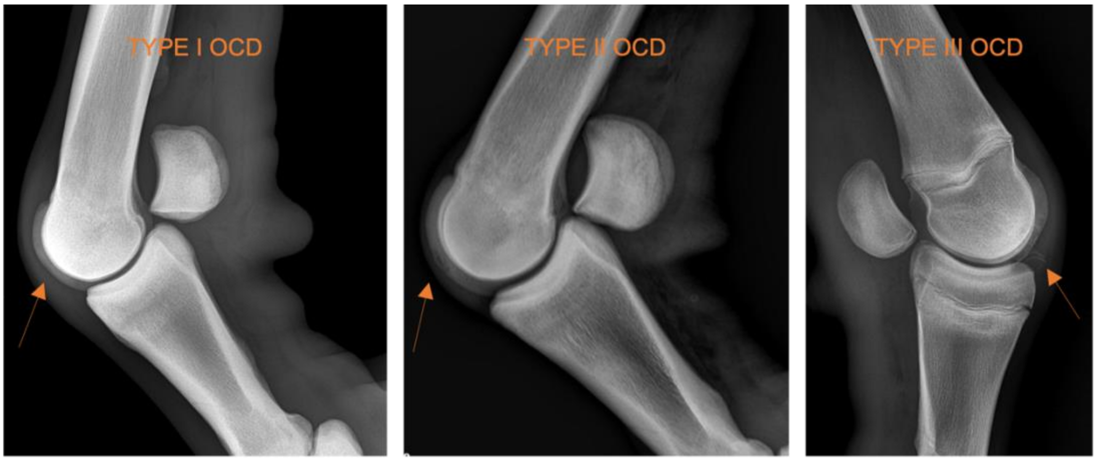


Figure 3 – Different types of OCD in the sagittal ridge; Original images.

The projections used to better visualize the fetlock joint are the latero-medial (LM), the dorsopalmar / dorsoplantar (DP), flexed LM, dorsolateral-palmaromedial oblique (DLPMO), and the dorsomedial-palmarolateral oblique (DMPLO). For assessing a lesion in the sagittal ridge (SR), the best projections are the DP, the LM, and the flexed LM (Butler et al. 2017) and all of them should either be perfectly exposed or slightly underexposed for a better image collection (Richardson 2011). For more distal lesions in the SR, the best projections will be described further on. For assessing lesions in condyles, the oblique projections are very important (McIlwraith et al. 2015). When it comes to palmar/plantar fragments in the fetlock, the best views are the dorsal 30º proximal 70º lateral-palmar distal medial oblique (D30ºPr70ºL-PaDiMO) and dorsal 30º proximal 70º medial-palmar distal lateral oblique (D30ºPr70ºM-PaDiLO) (Butler et al. 2017).

Treatment

The decision to treat and how to treat a fetlock OC(D) lesion should be based on multiple factors, like the age of the horse, the fragment or lesion location, and the clinical signs (Goldkuhl et al. 2023). The “age of no return” of the fetlock and other joints, i.e. the age at which lesions will no longer regress spontaneously, is considered to be around 10 months old (van Weeren 2006), hence surgery before this age could turn out to be unnecessary (either because lesions could heal by themselves or because more lesions after surgery could appear during this age window) (van Weeren 2006). Nevertheless, if a horse younger than 10 months old has an OC lesion accompanied by persistent clinical signs, like lameness and effusion, it is advised to consider surgery as treatment (van Weeren 2006). This is, a horse with recurrent clinical signs due to an OC lesion in any location is always indicated to undergo surgery (Goldkuhl et al. 2023). A study by Goldkuhl et al. 2023 concluded that fragments present in the dorsal aspect of the fetlock joint are more prone to cause cartilage damage than palmar/plantar ones, therefore early withdrawal via arthroscopy of these fragments is strongly advised, as cartilage injury is a factor that negatively influences the overall prognosis. This study also affirmed that fragment size is not related to cartilage damage, thus the decision to perform surgery should never be based exclusively on fragment size (Goldkuhl et al. 2023).

As for the treatment options for an osteochondrosis lesion in the fetlock, there are conservative and surgical treatments. For type I OC lesions (flattening or defect in the bone surface) conservative treatment is advised unless clinical signs are recurrently present, and the horse is 1 year or older (Ortved 2017). For type II and type III OC lesions the surgical approach is recommended (Ortved 2017), in order to reduce the risk of developing osteoarthritis or any other joint disease. During surgery attached and detached OC fragments are withdrawn along with the damaged tissue in the joint and the lesioned area is debrided. Before suturing the arthroscopic portals, a lavage to the dorsal and palmar/plantar pouch is performed (McIlwraith et al. 2015).

Prognosis

In osteochondrosis lesions, the prognosis varies according to several factors, like the arthroscopic findings, the type of OC lesion, and the age at which lesions are detected and treated (Declercq et al. 2011). In relation to lesions in the fetlock, McIlwraith 2011 stated that if there is an extension of the lesions throughout other bone or cartilage surfaces, usually detected during arthroscopy, the prognosis for that joint is poorer. For instance, if a lesion in the sagittal ridge extends onto the MC/MT condyles, the prognosis becomes less promising.

Arthroscopic findings will dictate most of the prognosis for the future athletic career of the patient, as the presence of wear lines, erosion of the cartilage, or subchondral bone exposure are related to the development of future joint degenerative disease like osteoarthritis, which will condition the sportive career (Santos et al. 2022).

The type and location of the lesion play an important role in the prognosis as well, for example, dorsal fragments are more commonly related to cartilage injury than palmar/ plantar fragments. As cartilage injury is related to a poorer prognosis, dorsal fragments might contribute to a worse result if not removed at an early age (Goldkuhl et al. 2023). According to Goldkuhl et al. 2023 in jumping horses with a lesion in the sagittal ridge, the prognosis is better for type II and type III lesions in hindlimbs, for joints not yet affected by any kind of degenerative disease, and if treated promptly via arthroscopy. According to Ortved 2017, the prognosis for the surgical removal of palmar/plantar fragments embedded in the short sesamoid ligaments is excellent.

Goldkuhl et al. 2023 concluded that older Warmblood horses (older than 7 years old) presented more cartilage injury than younger horses, therefore older animals usually had a poorer prognosis than younger patients (Goldkuhl et al. 2023).

In conclusion, the removal of OC fragments at an early age, particularly the OC fragments located in the dorsal aspect of the fetlock has a positive influence on the prognosis and sportive career of the horse (Goldkuhl et al. 2023).

2.5. OCD IN THE DISTAL ASPECT OF THE SAGITTAL RIDGE OF THE METACARPUS / METATARSUS

Osteochondrosis lesions of the metacarpus/metatarsus' sagittal ridge are common at its dorsoproximal and dorsomedial aspect, but not as common at its distal aspect (Butler et al. 2017) (the different aspects of the sagittal ridge are presented in Figure 2). Until the year of 2013, there were no articles published regarding osteochondrosis (dissecans) lesions at the distal site of the MC/MT sagittal ridge (Wright and Minshall 2014).

Despite the uncertainty of the aetiology of lesions in the fetlock joint, abnormalities at the sagittal ridge of the MT and MC are often seen as lesions of osteochondrosis. Wright and Minshall 2014, categorized OC lesions localized to the distal aspect of the sagittal ridge if these were not observable on extended lateromedial radiographs (with the affected limb in a weight-bearing position), but observable in flexed LM radiographs. On the contrary to OCD lesions in other sites of the sagittal ridge, lesions at the distal aspect of the SR are more common in the metacarpus than in the metatarsus (Wright and Minshall 2014). These are mainly of osteolytic nature and prone to fragmentation (McIlwraith et al. 2015).

The clinical signs displayed due to a lesion at this location are fetlock effusion, a positive response to the fetlock flexion test, and a variable degree of lameness (McIlwraith et al. 2015).

In Wright and Minshall 2014 study, out of the 16 horses with OC lesions at the distal aspect of the SR, all of them displayed lameness of the affected limb, and 13 presented fetlock effusion.

Diagnosis of osteochondrosis lesions at the distal aspect of the sagittal ridge is reached through radiography, although it requires specific projections, as most of these lesions are not detected in standard projections of the fetlock (McIlwraith et al. 2015). The best projections to detect any lesion at the distal aspect of the SR are flexed lateromedial and dorsopalmar of the fetlock (McIlwraith et al. 2015). Sometimes the lesion in the DP projection can have a similar appearance to a subchondral bone cyst, but if analyzed in the flexed LM projection it is clear that it is not a cyst, but a lesion of osteochondrosis (McIlwraith et al. 2015). In their study, Wright and Minshall 2014 could only detect the lesions in flexed LM and DP projections, and not in the remaining projections performed, which were extended lateromedial, dorsolateral-palmaromedial oblique, and dorsomedial-palmarolateral oblique. All 23 lesions could be detected in flexed LM projections, but the DP projection only allowed the detection of 21 out of 23 lesions (Wright and Minshall 2014). In a total of 16 horses 7 presented bilateral lesions and 9 unilateral lesions of the distal aspect of the sagittal ridge (Wright and Minshall 2014).

The treatment for lesions at this location consists of debridement and removal of fragments/flaps, if present, via arthroscopy (McIlwraith et al. 2015). The arthroscopic approach is made through the dorsal synovial pouch of the fetlock, but an adjusted technique to the standard approach is necessary to facilitate the visualization and operation of the distal lesions (Wright and Minshall 2014). During arthroscopy, the dorsal compartment of the metacarpophalangeal joint is distended, a portal is opened below the midpoint of the dorsal synovial pouch, and the arthroscope with a conical obturator is inserted (Wright and Minshall 2014). The joint is flexed to allow visualization of the distal aspect of the sagittal ridge. The instrument portals are usually made more axially and require going through the common digital extensor tendon, which seems to hold no future consequences (McIlwraith et al. 2015). Fragments and unhealthy tissue are then removed, the lesions are debrided, and lavage of both dorsal and palmar synovial pouches is performed before closing the portals (McIlwraith et al. 2015). Arthroscopies included in the Wright and Minshall 2014 study presented variable degrees of cartilage damage and irregularities of the distal sagittal ridge of the metacarpal bone. In all cases, there was either an osteochondral flap or a fragment. In nine out of twenty-three joints, a brown pigment resembling haemosiderin deposition was observable in the gaps between osteochondral fragments or flaps and the subchondral bone (Wright and Minshall 2014).

Lesions at the distal aspect of the sagittal ridge can lead to the loosening of an osteochondral fragment (McIlwraith et al. 2015) and later to the fragmentation of that fragment into several intraarticular loose fragments, which can have catastrophic consequences for the horse and its athletic career (Ramos et al. 2022).

The prognosis for lesions at the distal aspect of the sagittal ridge is poorer than that of lesions in a more proximal location of the sagittal ridge (Richardson 2011). However, according to Wright and Minshall 2014, if there are no degenerative alterations to the metacarpophalangeal joint, and arthroscopy is carried out smoothly, the prognosis for the future sportive career of the horse is positive.

3. CHAPTER III: OSTEOCHONDROSIS OF THE DISTAL ASPECT OF THE SAGITTAL RIDGE OF THE THIRD METACARPAL BONE IN HORSES: A CLINICAL, RADIOGRAPHIC AND ARTHROSCOPIC DESCRIPTION

3.1. AIMS OF THE STUDY

The aim of the present study was to characterize osteochondrosis lesions in the distal aspect of the sagittal ridge of the metacarpus, through a detailed description of 6 cases of horses with these lesions. A clinical, radiographic, and arthroscopic description of cases with these lesions will be given, in order to have a better understanding of all these aspects.

Lesions at this site may be underdiagnosed in equine practice, not only because they are scarcely addressed in the scientific literature, but also due to the fact that the most reliable projection for their detection, flexed lateromedial of the fetlock, may not be routinely performed by many veterinarians. One of the additional objectives of this study is, therefore, to raise awareness among individuals, particularly veterinarians, to detect and act as soon as possible when dealing with lesions at this site.

3.2. MATERIALS AND METHODS

3.2.1. Population of the study

For the purpose of this dissertation, horses with osteochondrosis lesions at the distal aspect of the metacarpal/tarsal sagittal ridges, diagnosed by radiography were selected from radiographic records of one equine first opinion practice and one equine referral hospital. Signalment details and relevant clinical signs of each case were recorded.

For each horse, a lameness examination was performed, followed by a radiographic exam of the affected limb. Half of the individuals (three horses) were later sent to arthroscopy in order to treat the OC lesions located at the distal aspect of the sagittal ridge.

3.2.2. Equipment used and data collection

The radiographs, clinical/lameness exams, and arthroscopies were all performed between the years of 2018 and 2023.

The clinical examination consisted of a static and a dynamic lameness examination. The following table represents the aspects evaluated during the clinical examination.

Table 1 - Aspects evaluated during the clinical examination

	Limb 1 (RF)	Limb 2 (LF)	Limb 3 (RH)	Limb 4 (LH)	
Lameness level					0-5 AAEP[1] Scale
Passive flexion					Positive / Negative
Active flexion					Positive / Negative
Effusion					Present / Absent
Synovitis					Present / Absent

Effusion was evaluated visually and by palpation of the dorsal and palmar aspects of the fetlock. The presence of synovitis was evaluated by ultrasonography and the equipment used was the Fujifilm SonoSite ultrasound machine.

The radiographic exam was performed by two people, using proper protective equipment against radiation, with the digital X-ray machines Examion and Viewpoint. Some horses, especially the unhandled ones, were sedated for this purpose with the proper dose of butorphanol and detomidine for their body weight. A total of eight limbs with lesions at the distal aspect of the sagittal ridge were radiographed in the field. The thirty-seven projections taken in the field consisted of 7 latero-medial (LM), 8 dorso-palmar/plantar (DP), 6 dorsolateral-palmaromedial oblique (DLPMO), 5 dorsomedial-palmarolateral oblique (DMPLO), 8 flexed LM, 3 dorsoproximal-dorsodistal oblique (DPr-DDiO / skyline). Some other X-ray projections were taken later at the hospital post-surgery, or for comparison matters. A quick on-the-field analysis of the obtained X-rays was made, followed by a second and more thorough analysis made later at the office. The images were analysed a third time for the special purpose of this dissertation, and for each one of them, a description of the radiographic findings was noted.

The arthroscopies were all performed in the Faculty of Veterinary Medicine of Lisbon University. The horses were given a proper dose of an anti-inflammatory and antibiotics as pre-surgical medication, sedated, and later anesthetised in the induction box. A report for each case, describing the procedure and lesions observed, was elaborated at the end of the surgery.

3.2.3. Characterization and description of the cases

For each horse, details referring to their age at diagnosis, sex, breed, discipline, and location of origin will be given.

There will be a description of their clinical presentation at diagnosis that includes which limbs were lame, lameness level of the affected limbs trotting on a hard surface in a straight line (scale of AAEP[1] was used), negative/positive response to passive flexion, negative/positive response to active flexion, presence/absence of fetlock effusion, and presence/absence of synovitis in the fetlock joint (Table **1**).

Radiographic findings were reported and reviewed for the purpose of this study if the clinical reports were considered to have insufficient specific information to characterise the findings. After the overall analysis, each lesion was given a degree, according to McIlwraith et al. 2015 scale, as follows: The scale of 0 to 3, where 0 is the absence of any defect; 1 is a defect or flattening on the sagittal ridge (type I OCD); 2 is a defect or flattening on the sagittal ridge with a fragment associated to it (type II OCD); 3 is a defect on the sagittal ridge associated or not with a fragment plus one or more loose bodies (type III OCD) (Figure 3).

Arthroscopic findings were also recorded namely: the precise location of any abnormalities or lesions and their visual characteristics using visual documentation captured during the surgical procedure.

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[1] **AAEP Scale:**

0: Lameness is not perceptible under any circumstances.

1: Lameness is difficult to observe and is not consistently apparent, regardless of circumstances (e.g., under saddle, circling, inclines, hard surface, etc.).

2: Lameness is difficult to observe at a walk or when trotting in a straight line but consistently apparent under certain circumstances (e.g., weight-carrying, circling, inclines, hard surface, etc.).

3: Lameness is consistently observable at a trot under all circumstances.

4: Lameness is obvious at a walk.

5: Lameness produces minimal weight bearing in motion and/or at rest or a complete inability to move.

3.3. RESULTS

3.3.1. Horse number 1

The first patient is a Lusitano (PSL) from Alto Alentejo, born in 2018, intended for use in dressage. At 4 and a half months old the foal was diagnosed with a lesion on the sagittal ridge of the metacarpus of the right forelimb. The foal was submitted to surgery a few days after in the Faculty of Veterinary Medicine in Lisbon. Clinical signs were present when radiographs were taken.

Clinical signs

The horse presented a 4 out of 5 right forelimb lameness trotting on a hard surface in a straight line and had a positive response to the passive flexion, as well as to the active flexion. Effusion of the fetlock was present, and, on the ultrasonography, synovitis of the fetlock was diagnosed. The table below resumes the clinical findings:

Table 2 - Clinical findings of horse number 1

	Limb 1 (RF)	**Limb 2 (LF)**	**Limb 3 (RH)**	**Limb 4 (LH)**	
Lameness level	4	0	0	0	**0-5** AAEP Scale
Passive flexion	1	-	-	-	**1** Positive / **2** Negative
Active flexion	1	-	-	-	**1** Positive / **2** Negative
Effusion	1	-	-	-	**1** Present / **2** Absent
Synovitis	1	-	-	-	**1** Present / **2** Absent

Radiographic findings

The limb that presented a lesion in the sagittal ridge of the cannon bone was the right forelimb.

A description of the lesion observed on different X-ray projections (Figure 4) before surgery will follow:

- RF LM: Radiolucency in the sagittal ridge as if there was a splint of bone still attached to it and linear radiodensities (at least 3) on the dorsal aspect of the joint.
- RF DP: Radiolucency in the distal aspect of the sagittal ridge.
- RF DLPMO: Radiolucency in the sagittal ridge
- RF DMPLO: Nothing to report
- RF Flexed LM: Radiolucency in the distal aspect of the sagittal ridge and linear radiodensities (at least 2) on the dorsal aspect of the joint
- RF Angled DLPMO: Radiolucency in the sagittal ridge and radiopaque loose fragment distal to the SR

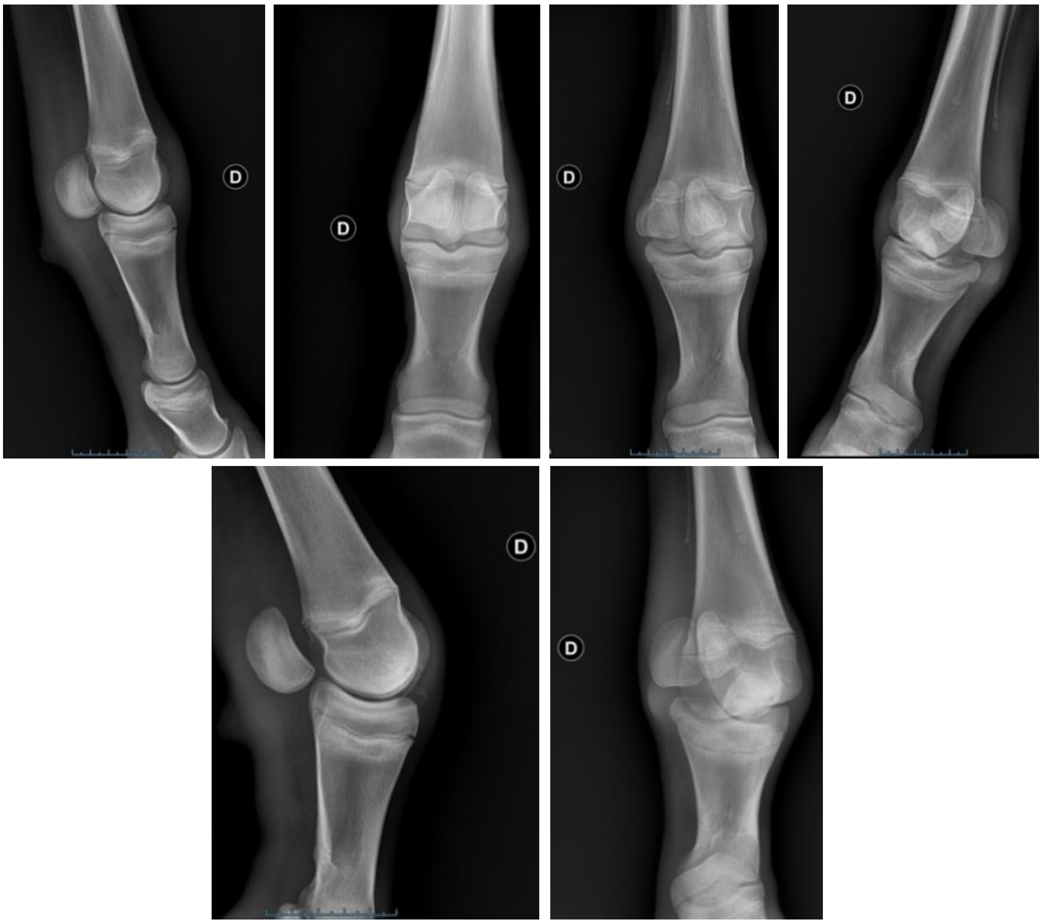

Figure 4 – Radiographs of the RF of horse number 1 before surgery

In conclusion, a radiolucent lesion in the distal aspect of the sagittal ridge of the metacarpus and several intraarticular radiopaque loose bodies can be found on the dorsal aspect of the fetlock joint of the right forelimb, which is equivalent to a 3-degree lesion on the scale from 0 to 3. In the clinical evaluation conducted at the hospital, radiographs were performed on the three remaining limbs. These radiographs revealed the presence of lesions in the sagittal ridge of all fetlock joints. However, it should be noted that due to the unavailability of radiographs for direct review, it is not possible to ascertain the exact location of the lesions within the sagittal ridge or assess the degree of these lesions.

Arthroscopic presentation

The right forelimb was submitted to surgery and a general inflammation of the fetlock joint was observed along with moderate synovitis. In the arthroscopy, two large fragments detached from the distal sagittal ridge and from the condyles of the MCIII, of approximately 1 cm in diameter, were identified and removed. These fragments corresponded to areas of cartilage and subchondral bone and were flattened and plate-shaped (Figure 5). The edges of the lesions were curetted until healthy subchondral bone and cartilage were visible (Figure 5).

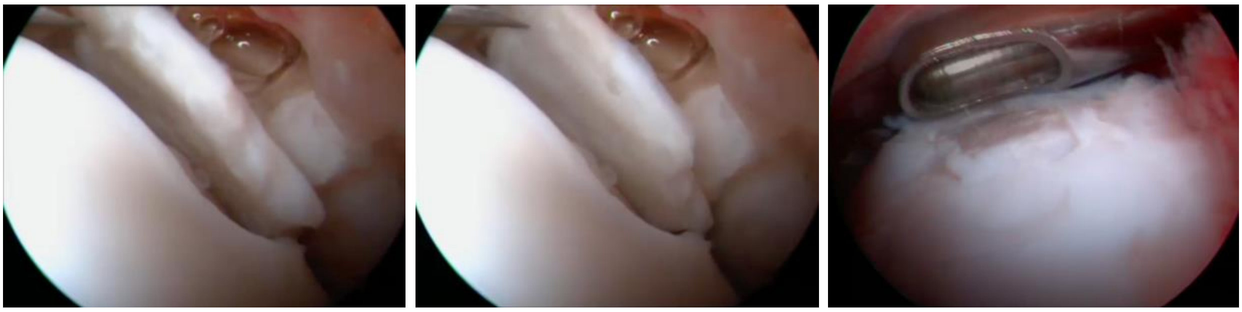

Figure 5 – Arthroscopic images of the RF of horse number 1

3.3.2. Horse number 2

The second horse is also a Lusitano stallion from Alto Alentejo, born in 2019, and bred to perform in dressage. The radiographs allowed the diagnosis of the lesion on the sagittal ridge of the metacarpus of both left and right forelimbs at the age of 1 year and 8 months, time at which the horse was not yet under training. The veterinarian conducted two visits a few days apart, and in both occasions, radiographs were taken to both forelimbs. The patient was submitted to surgery to both forelimbs a few days later, in the Faculty of Veterinary Medicine in Lisbon. Clinical signs were present when radiographs were taken.

Clinical signs

In both visits, the horse displayed 3 out of 5 left forelimb lameness, while the right forelimb was sound. There was effusion and the presence of synovitis in the fetlocks of both forelimbs. The active and passive flexions were positive in the left forelimb only. The table below resumes the clinical findings:

Table 3 - Clinical findings of horse number 2

	Limb 1 (RF)	Limb 2 (LF)	Limb 3 (RH)	Limb 4 (LH)	
Lameness level	0	3	0	0	**0-5** AAEP Scale
Passive flexion	2	1	-	-	**1** Positive / **2** Negative
Active flexion	2	1	-	-	**1** Positive / **2** Negative
Effusion	1	1	-	-	**1** Present / **2** Absent
Synovitis	1	1	-	-	**1** Present / **2** Absent

Radiographic findings

As mentioned above, both, left and right forelimbs presented a lesion on the sagittal ridge of the metacarpal bones.

A description of the lesions observed on different X-ray projections before surgery to both forelimbs (Figure 6 and Figure 7) will follow:

- LF LM: Nothing to report
- LF DP: Circular radiolucency in the distal aspect of the sagittal ridge
- LF DLPMO: Radiolucency in the distal aspect of the sagittal ridge

- LF DMPLO: Radiolucency in the distal aspect of the sagittal ridge
- LF Flexed LM: Irregular and lacy radiolucency along the distal aspect of the sagittal ridge, with splints of radiopaque fragments attached to it
- LF Skyline: Oval-shaped radiolucency in the sagittal ridge

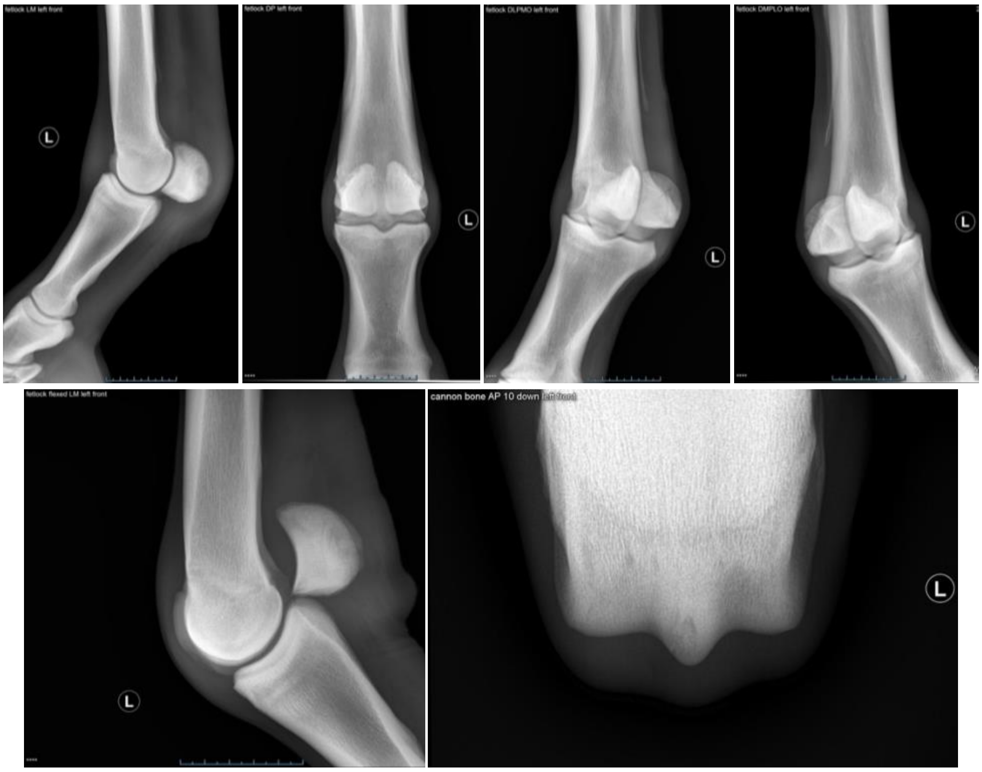

Figure 6 – Radiographs of the LF of horse number 2 before surgery

- RF LM: Nothing to report
- RF DP: Oval-shaped radiolucency in the distal aspect of the sagittal ridge
- RF Flexed LM: Irregular and lacy radiolucency along the distal aspect of the sagittal ridge, with splints of radiopaque fragments still attached to it
- RF Skyline: Oval-shaped radiolucency in the sagittal ridge

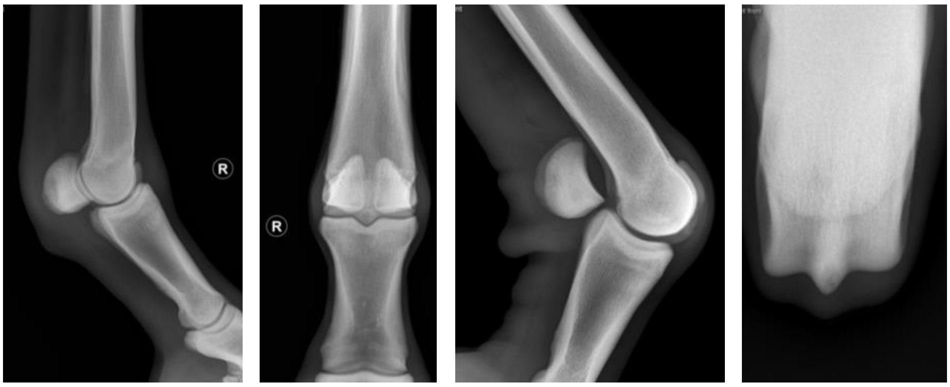

Figure 7 – Radiographs of the RF of horse number 2 before surgery

A description of the lesions observed on different X-ray projections two months after surgery to both forelimbs (Figure 8 and Figure 9) will follow:

- LF LM: Several radiopaque fragments dorsal to the joint
- LF DP: Radiolucency in the distal aspect of the sagittal ridge
- LF DLPMO: Radiopaque fragments dorsal to the fetlock joint and radiolucency of the sagittal ridge
- LF DMPLO: Radiolucency in the distal aspect of the sagittal ridge
- LF Flexed LM: Radiopaque fragments dorsal to the joint and radiolucency along the distal aspect of the sagittal ridge

Figure 8 – Radiographs of the LF of horse number 2 after surgery

- RF LM: Radiopaque fragments dorsal to the joint (proximally to the proximal aspect of the sagittal ridge)
- RF DP: Radiolucency in the distal aspect of the sagittal ridge
- RF DLPMO: Radiolucency in the distal aspect of the sagittal ridge and a radiopaque fragment dorsal to the joint
- RF DMPLO: Radiolucency in the distal aspect of the sagittal ridge
- RF Flexed LM: Loose radiopaque fragments dorsal to the joint and a radiolucency along the distal aspect of the sagittal ridge

Figure 9 – Radiographs of the RF of horse number 2 after surgery

In summary, the sets of X-rays taken before surgery, showed, in both forelimbs a radiolucent, irregular, and lacy lesion on the distal aspect of the sagittal ridge of the metacarpal bones with splints of radiopaque fragments still attached to it, which coincides with a 2-degree OCD lesion. Two months after surgery the radiographs show cleaner radiolucent bone surfaces of the sagittal ridges of both forelimbs and the presence of radiopaque fragments in the subcutaneous tissue (note that these are not intraarticular).

Arthroscopic presentation

In dorsal recumbency, the osteochondral flaps located in the distal sagittal ridge of both metacarpal bones were removed and the borders of the lesions were curetted until healthy subchondral bone and cartilage were exposed (Figure 10 and Figure 11). There are no reports of lesions in the condyles of the third metacarpal bones.

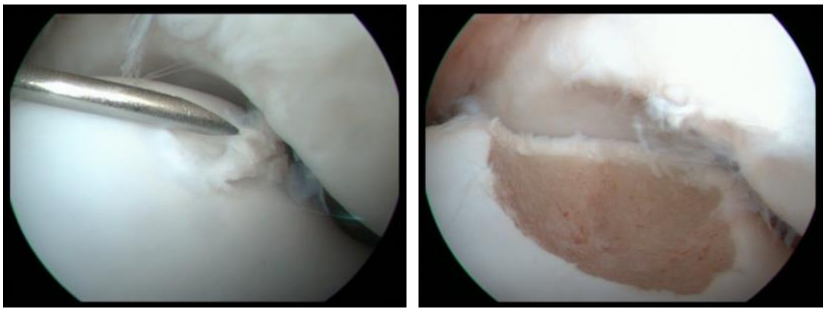

Figure 10 – Arthroscopic images of the RF of horse number 2 (sagittal ridge before and after)

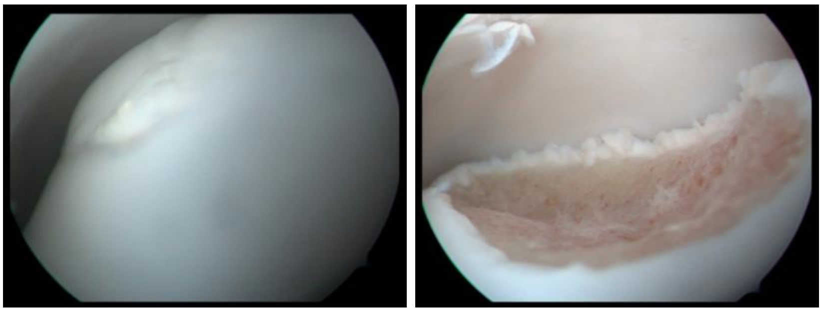

Figure 11 – Arthroscopic images of the LF of horse number 2 (sagittal ridge before and after)

3.3.3. Horse number 3

The third animal submitted to X-rays and later to surgery was a dressage Lusitano stallion from Alto Alentejo, born in 2019. The X-rays taken at the age of 2 years and 9 months old (still an untrained horse) diagnosed a lesion in the sagittal ridge of the metacarpus of the right forelimb and intraarticular loose fragments. Surgery was performed 12 days after in the Faculty of Veterinary Medicine in Lisbon. Post-operative radiographs were provided as well (six weeks after surgery). The clinical signs were present at the time of diagnosis.

Clinical signs

The right forelimb was 3 out of 5 lame, trotting on a hard surface in a straight line. There was a positive response to the passive and to the active flexion tests and there was effusion and signs of synovitis in the fetlock joint. The table below resumes the clinical findings:

Table 4 - Clinical findings of horse number 3

	Limb 1 (RF)	Limb 2 (LF)	Limb 3 (RH)	Limb 4 (LH)	
Lameness level	3	0	0	0	**0-5** AAEP Scale
Passive flexion	1	-	-	-	**1** Positive / **2** Negative
Active flexion	1	-	-	-	**1** Positive / **2** Negative
Effusion	1	-	-	-	**1** Present / **2** Absent
Synovitis	1	-	-	-	**1** Present / **2** Absent

Radiographic findings

The right forelimb presented a lesion on the sagittal ridge and a loose fragment on the dorsal aspect of the metacarpophalangeal joint.

A description of the lesions observed on different X-ray projections before surgery (Figure 12) will follow:

- RF LM: Loose rounded fragment on the dorsal aspect of the joint, proximal to the dorsoproximal aspect of the first phalanx (P1)
- RF DP: Slight radiolucency in the distal aspect of the sagittal ridge
- RF DLPMO: Very slight radiolucency in the distal aspect of the sagittal ridge
- RF DMPLO: Very slight radiolucency in the distal aspect of the sagittal ridge
- RF Flexed LM: Loose rounded fragment on the dorsal aspect of the joint, close to the dorsoproximal aspect of the P1, and two radiolucent areas on the sagittal ridge, one in distal aspect of the SR and one in the proximal aspect of the SR
- RF Skyline: Slight radiolucency in the distal aspect of the sagittal ridge

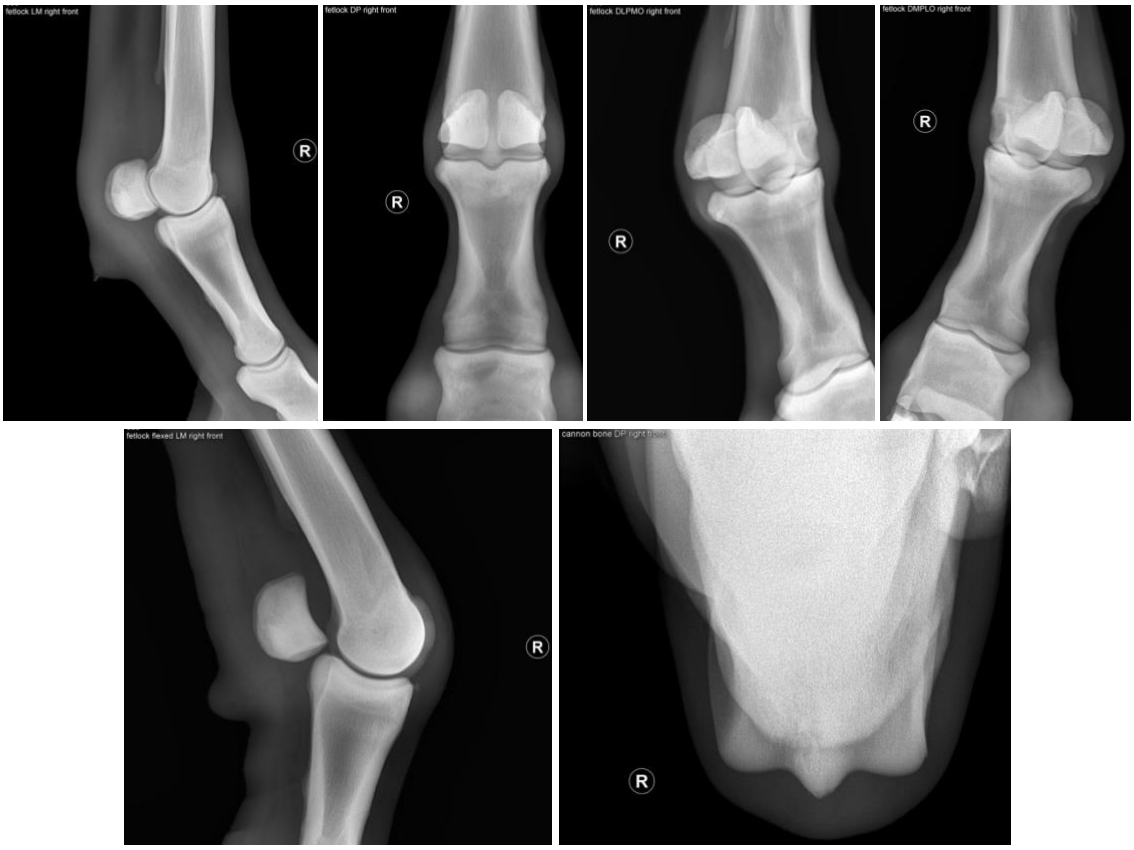

Figure 12 – Radiographs of the RF of horse number 3 before surgery

A description of the lesions observed on different X-ray projections 6 weeks after surgery (Figure 13) will follow:

- RF LM: Nothing to report
- RF DP: Extremely slight radiolucency in the sagittal ridge
- RF DLPMO: Nothing to report
- RF DMPLO: Nothing to report
- RF Flexed LM: No loose fragment, two radiolucent areas on the sagittal ridge, one in the distal aspect of the sagittal ridge and one in the proximal aspect of the SR

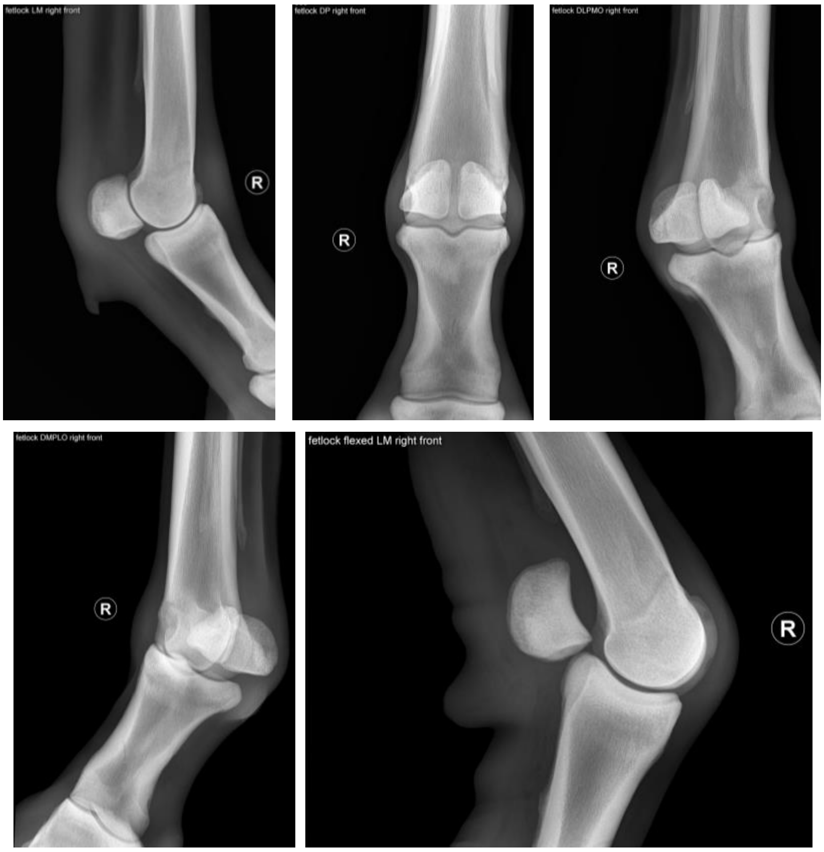

Figure 13 – Radiographs of the RF of horse number 3 after surgery

In conclusion, the right forelimb presented before surgery, a loose fragment on the dorsal aspect of the fetlock joint and two radiolucent areas on the sagittal ridge, one of them on the distal aspect and the other more proximally, consisting of a 3-degree lesion. After surgery, the right forelimb showed a 1-degree lesion, with two radiolucent areas on the sagittal ridge. Six weeks post-surgery, radiographs were also performed on the contralateral limb (left forelimb), revealing the presence of an extremely slight radiolucency in the distal aspect of the sagittal ridge. This finding suggests bilateral lesions in this horse; however, note that due to the absence of clinical signs, the very small size of the lesion, and the timing of its diagnosis (six weeks after surgery) this information will be solely utilized in this thesis to indicate bilateral involvement of OC lesions in the distal sagittal ridge in horse number 3.

Arthroscopic presentation

In dorsal recumbency, osteochondral fragments were removed from the dorsoproximal aspect of P1 and from the lateral aspect of the lateral condyle of the MCIII. The lesion located in the distal sagittal ridge was curetted until the exposure of healthy subchondral bone (Figure 14).

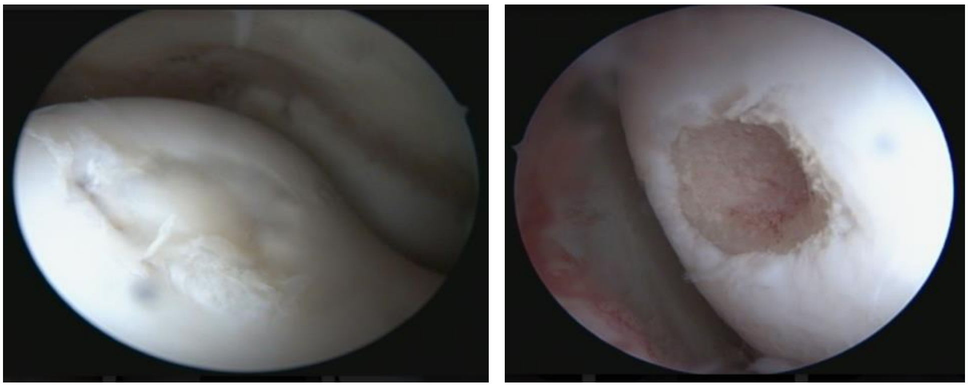

Figure 14 – Arthroscopic images of the RF of horse number 3 (sagittal ridge before and after)

3.3.4. Horse number 4

The fourth patient is a stallion, dressage Lusitano born in 2020 from Alto Alentejo as well. At three years old, not yet in breaking phase, a lesion in the sagittal ridge was detected after some routine X-rays were taken to both forelimbs. Surgical intervention was not undertaken on this equine due to the owner's preference. No clinical signs were present at the time radiographs were taken.

Clinical signs

The patient was sound in all four limbs at the time lesions were detected and did not display any other clinical signs. The table below resumes the clinical findings:

Table 5 - Clinical findings of horse number 4

	Limb 1 (RF)	Limb 2 (LF)	Limb 3 (RH)	Limb 4 (LH)	
Lameness level	0	0	0	0	**0-5** AAEP Scale
Passive flexion	2	2	-	-	**1** Positive / **2** Negative
Active flexion	2	2	-	-	**1** Positive / **2** Negative
Effusion	2	2	-	-	**1** Present / **2** Absent
Synovitis	2	2	-	-	**1** Present / **2** Absent

Radiographic findings

The horse presented lesions in the sagittal ridge of both metacarpal bones.

A description of the lesions observed on different X-ray projections (Figure 15 and Figure 16) will follow:

- RF LM: Nothing to report
- RF DP: Radiolucency in the distal aspect of the sagittal ridge
- RF DLPMO: Slight radiolucency in the distal aspect of the sagittal ridge
- RF DMPLO: Slight radiolucency in the distal aspect of the sagittal ridge
- RF Flexed LM: Radiolucency in the distal aspect of the sagittal ridge and a radiopaque splint of bone attached to it

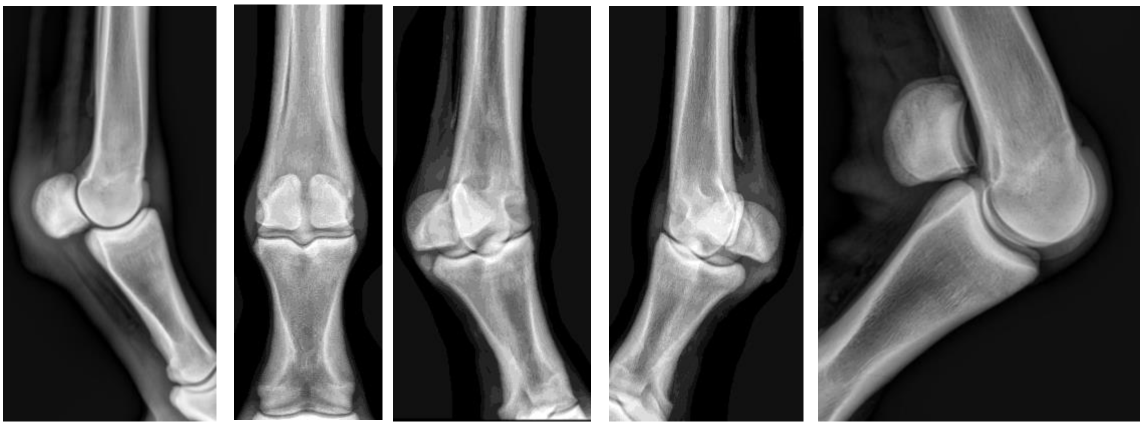

Figure 15 – Radiographs of the RF of horse number 4

- LF LM: Nothing to report
- LF DP: Radiolucency in the distal aspect of the sagittal ridge
- LF DLPMO: Slight radiolucency in the distal aspect of the sagittal ridge
- LF DMPLO: Slight radiolucency in the distal aspect of the sagittal ridge
- LF Flexed LM: Radiolucency in the distal aspect of the sagittal ridge and a radiopaque splint of bone attached to it

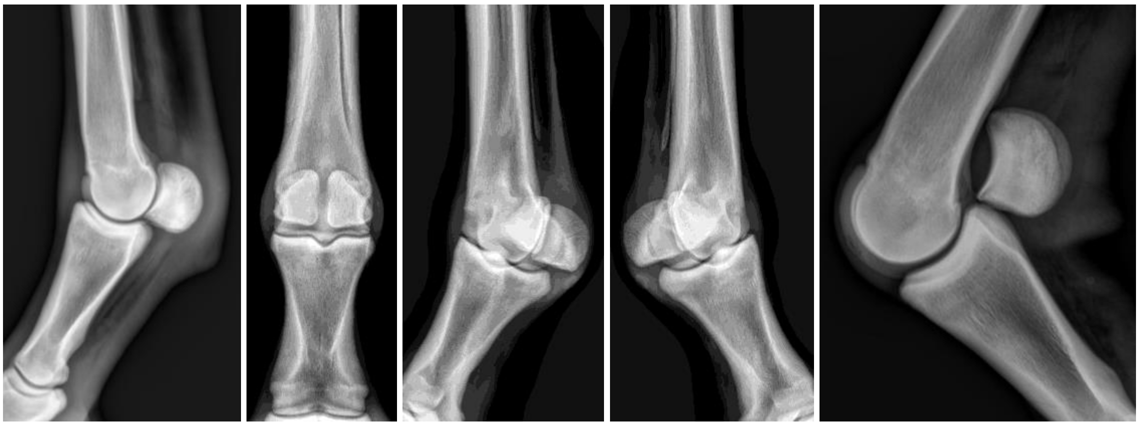

Figure 16 – Radiographs of the LF of horse number 4

Ultimately both right and left forelimbs presented a radiolucent area in the distal aspect of the sagittal ridge and an elongated osteophyte still attached to the sagittal ridge, being considered a 2-degree lesion on both limbs.

3.3.5. Horse number 5

Equine number 5 is a dressage Lusitano stallion from Alto Alentejo, born in 2019. The radiographs taken at 3 years and 5 months of age (when the horse was starting its training) for pre-purchase purposes, showed a lesion on the sagittal ridge of the right forelimb. Surgery was not performed in this horse, as the horse was not a patient of the veterinarian (the visit was solely due to pre-purchase purposes). There were almost none, or very mild clinical signs present at the time radiographs were taken.

Clinical signs

The horse did not display lameness on any limb. The only clinical signs present were a positive response to the active flexion test and a very slight effusion of the fetlock joint of the right forelimb. The table below resumes the clinical findings:

Table 6 - Clinical findings of horse number 5

	Limb 1 (RF)	Limb 2 (LF)	Limb 3 (RH)	Limb 4 (LH)	
Lameness level	0	0	0	0	**0-5** AAEP Scale
Passive flexion	2	-	-	-	**1** Positive / **2** Negative
Active flexion	1	-	-	-	**1** Positive / **2** Negative
Effusion	1	-	-	-	**1** Present / **2** Absent
Synovitis	2	-	-	-	**1** Present / **2** Absent

Radiographic findings

The limb that presented the lesion in the metacarpus was the right forelimb.

A description of the lesions observed on different X-ray projections (Figure 17) will follow:

- RF DP: Very slight radiolucency in the distal aspect of the sagittal ridge
- RF Flexed LM: Radiolucency in the distal aspect of the sagittal ridge and a radiopaque splint of bone attached to it

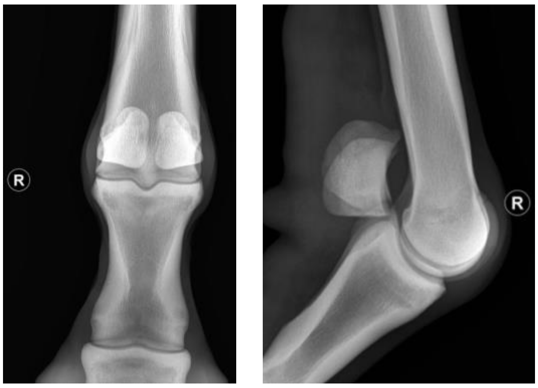

Figure 17 – Radiographs of the RF of horse number 5

In conclusion, a lesion on the distal aspect of the sagittal ridge of the right forelimb and a radiopaque splint of bone attached to the sagittal ridge can be observed on the X-rays, it is, therefore, a 2-degree alteration.

3.3.6. Horse number 6

The last patient is a Lusitano stallion from Ribatejo, Santarém, born in the year 2018, with the intended use for dressage. At the age of four years and three months, during a pre-purchase exam, radiographs taken showed lesions on the sagittal ridge of the left metacarpus. Surgery was not performed on this horse (the veterinarian's visit was solely due to pre-purchase purposes). Very mild clinical signs were present at the time X-rays were taken. When the lesion was diagnosed, the horse was at the initial stages of its training.

Clinical signs

The only clinical signs displayed by the horse were a positive response to the active flexion and a slight effusion of the fetlock joint of the left forelimb. The table below resumes the clinical findings:

Table 7 - Clinical findings of horse number 6

	Limb 1 (RF)	Limb 2 (LF)	Limb 3 (RH)	Limb 4 (LH)	
Lameness level	0	0	0	0	**0-5** AAEP Scale
Passive flexion	-	2	-	-	**1** Positive / **2** Negative
Active flexion	-	1	-	-	**1** Positive / **2** Negative
Effusion	-	1	-	-	**1** Present / **2** Absent
Synovitis	-	2	-	-	**1** Present / **2** Absent

Radiographic findings

The left forelimb showed, on the X-ray images, lesions on the sagittal ridge of the metacarpus.

A description of the lesions observed on different X-rays (Figure 18) will follow:

- LF LM: Small linear radiopaque fragment on the palmar aspect of the joint (palmar to the proximal extremity of P1 and distal to the sesamoid bones)
- LF DP: Very slight radiolucency in the distal aspect of the sagittal ridge
- LF Flexed LM: Radiolucency in the distal aspect of the sagittal ridge and a radiopaque linear fragment on the palmar aspect of the joint (palmar to the proximal extremity of P1 and distal to the sesamoid bones)

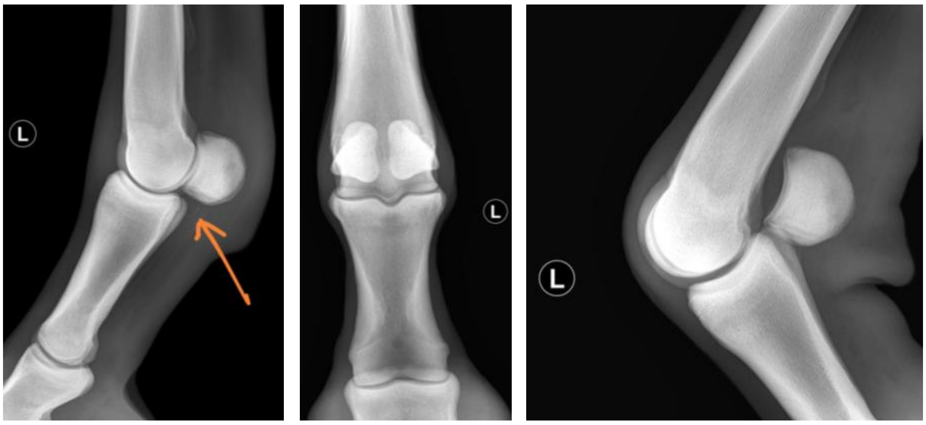

Figure 18 – Radiographs of the LF of horse number 6

In conclusion, a radiopaque linear fragment on the palmar aspect of the metacarpophalangeal joint and a radiolucent area at the distal aspect of the sagittal ridge can be found on the left forelimb, which consists of a 3-degree lesion.

3.3.7. General results

Overall, of the 8 limbs radiographed, all of them showed lesions in the distal aspect of the sagittal ridge of the metacarpus – five right forelimbs and three left forelimbs. The degrees given to the lesions at this location (from 0 to 3) were registered, according to the radiographic presentation at diagnosis, and are presented in the table below.

Table 8 – Distribution of radiographic lesion degree among affected limbs

Lesion degree (0 - 3)	Number of limbs
0 – No lesion detected	0
1 – Flattening or defect in bone surfaces	0
2 – Flattening or defect with a fragment associated	5
3 – Flattening or defect with or without a fragment associated and intraarticular loose bodies	3
Total	**8**

Regarding clinical signs at the time radiographs were taken, among the six horses included in this study, five exhibited clinical signs, while the remaining one did not display any sign. The table below provides information about the occurrence of clinical signs and the degree of the OC lesion at the distal aspect of the metacarpal bone in each limb.

Table 9 - Summary of clinical signs and radiographic OC lesion degree for each limb

Limb	Clinical signs	Lameness level (0-5)	Lesion degree (0-3)
Horse 1 RF	Lame, effusion, active flexion, passive flexion	4	3
Horse 2 RF	Effusion	0	2
Horse 2 LF	Lame, effusion, active flexion, passive flexion	3	2
Horse 3 RF	Lame, effusion, active flexion, passive flexion	3	3
Horse 4 RF	None	0	2
Horse 4 LF	None	0	2
Horse 5 RF	Effusion, active flexion	0	2
Horse 6 LF	Effusion, active flexion	0	3

The ages of the horses involved in the study ranged from four months old to four years old, four of the horses were not yet under training and two of them were initiating their training protocol. Regarding the age at which the horses displayed their first clinical signs, horses number 1, 2, and 3 were under or three years old and were not yet under training. Horses number 5 and 6 were over three years old and were initiating their training program/ breaking phase. The table below resumes the information about the age at which horses first exhibited clinical signs, and whether the horses were already in training.

Table 10 - Age of Onset of Clinical Signs and Training Status of Horses

Horse	Age 1st signs/ at diagnosis	Training / Not training	Notes
1	4 months and a half	Not training	-
2	1 year and 8 months	Not training	-
3	2 years and 9 months	Not training	-
4	3 years	Not training	Did not display any clinical signs
5	3 years and 5 months	Initiating training	-
6	4 years and 3 months	Initiating training	-

Concerning the radiographs taken exclusively at the time of diagnosis (excluding those taken post-surgery), a total of 37 radiographs were captured. Various projections of the fetlock were utilized, and an evaluation of their effectiveness in diagnosing lesions at this specific anatomical site was conducted. Of these radiographs, 19 were diagnostically useful, indicating the presence of the lesion. Seven were not diagnostically useful, as these did not reveal the lesion, and 11 were categorized as suspicious. Suspicious radiographs were not conclusively diagnostic, yet they alerted to the possibility of an abnormality, suggesting the need for additional projections to achieve a diagnosis. The following table summarizes this assessment.

Table 11 - Radiographs Assessment

Projection	Nº	Diagnostic	Not Diagnostic	Suspicious
LM	**7**	1	6	0
DP	**8**	6	0	2
DLPMO	**6**	0	0	6
DMPLO	**5**	1	1	3
Flexed LM	**8**	8	0	0
Skyline	**3**	3	0	0
Total	**37**	**19**	**7**	**11**

Out of the six horses, three of them received surgical treatment, with one horse undergoing surgery on both forelimbs, resulting in a total of four operated limbs. Horses number 1 and 3 exhibited fragments associated with the condyles of the third metacarpal bone (detected and removed during surgery), while horse number 2 did not present any lesions or fragments associated with the condyles of the MCIII in either of the forelimbs.

3.4. DISCUSSION

The principal aim of this study was to provide a comprehensive description of osteochondrosis lesions occurring in the distal aspect of the sagittal ridge (SR) of the metacarpal bone, given the limited available literature and studies concerning this pathological condition in this specific anatomical location. In the course of the literature review for this dissertation, only a single article addressing osteochondrosis lesions at this anatomical site was identified. This study was conducted by Wright and Minshall 2014 and involved 16 horses.

The small number of horses included in this dissertation study (six horses) restricts the ability to draw substantial conclusions, representing one of the study's main limitations. However, it does contribute to summarizing existing knowledge regarding osteochondrosis and, specifically, osteochondrosis in this understudied anatomical location. The comprehensive description of the cases, including clinical, radiographic, and arthroscopic details, was feasible for only three of the horses, half of the population involved. The other three horses did not undergo surgery, resulting in a limited description consisting solely of clinical and radiographic findings. The retrospective nature of the study presents a challenge in collecting essential information as further collection of data is no longer possible. For instance, the X-ray projections vary among individual horses, and not all of them exhibit projections of all four limbs or even both forelimbs, which constrains some conclusions of the current study.

The presentation of these osteochondrosis lesions at the distal aspect of the sagittal ridge, whether viewed radiographically or arthroscopically, has sparked interest, as these lesions appear to have a more plate-like shape and, in radiographic images, often appear as linear radiopacities and not round OC fragments. Out of the six horses included in this study, the radiographs of five of them showed linear radiopacities (OC fragments or flaps), with a resemblance to “splints of bone”, horse number 3 was the only patient with a round-shaped fragment. In the case of horse number 1 arthroscopy evidently revealed flat and plate-shaped fragments (Figure 5). Given this different presentation, it would be of interest to explore further the origins of these OC lesions at this particular location, in order to comprehend the factors contributing to their distinct shape. According to McIlwraith et al. 2015, OC lesions at the distal aspect of the sagittal ridge are predominantly of osteolytic nature and often associated with fragmentation, which could have devastating consequences in the sports career of the horse as fragments become loose within the joint potentially causing extensive damage to the articular surface. Therefore, it could be particularly interesting to investigate how trauma (major and minor) may play a special role in their etiology, especially given the significant weight-bearing role of the distal aspect of the sagittal ridge. Additionally, given that 5 out of 6 horses involved in the study were from the same geographic region, Alto Alentejo, it could be worth investigating whether the soil consistency, nutritional factors, and horse management practices in that region might impact the prevalence of these lesions.

Wright and Minshall 2014 affirm that OC lesions at the distal aspect of the sagittal ridge are more common in the metacarpus than in the metatarsus, this aligns with the findings of this dissertation, which observed injuries exclusively in the third metacarpal bone and not in the third metatarsal bone. Baxter et al. 2011 affirm that the forelimbs bear 60 to 65% of the horse’s weight and that the distal structures of the forelimbs are under greater stress due to weight-bearing forces than the distal structures of the hindlimbs, additionally, forelimbs have a bouncing motion whilst the hindlimbs tend to slide. This may account for the higher occurrence of these lesions in the distal aspect of the sagittal ridge of the metacarpus, as this site endures more stress than the distal aspect of the sagittal ridge of the metatarsal bone. For lesions in a more dorsal location of the sagittal ridge the opposite is noted, as the prevalence of lesions is higher in the hindlimbs than in the forelimbs, according to the studies of Ramos et al. 2022 and Goldkuhl et al. 2023.

Osteochondrosis is characterized by a defect in endochondral ossification that is usually localized and bilateral (Ytrehus et al. 2007), on the other hand, according to Richardson 2011 there is a quadrilateral involvement of osteochondrosis in the fetlock joint. However, concerning the distal aspect of the sagittal ridge, where OC lesions are more frequent in the metacarpus (Wright and Minshall 2014), it is plausible that this condition may exhibit a bilateral predisposition rather than a predisposition involving all four fetlock joints. In their study, Wright and Minshall 2014, found that among 16 horses with lesions at the distal aspect of the sagittal ridge, 7 of them presented bilateral lesions and 9 of them unilateral lesions. In this dissertation study, horse number 1 had an OC lesion at the distal aspect of the SR, and there were also recorded observations indicating lesions in the SR of all fetlocks, although the specific locations of these lesions within the SR were not specified (radiographs were not available). Horses number 2, 3, and 4 had bilateral lesions at the distal aspect of the SR, radiographs of the hindlimbs were not available. Horses number 5 and 6 had lesions at the distal aspect of the SR in the right forelimb and left forelimb respectively, the radiographs of the contralateral and hind limbs were not available for analysis. In summary, all horses with radiographs of both forelimbs (a total of three horses) had bilateral lesions at the distal aspect of the sagittal ridges.

In terms of clinical signs, according to the literature, the most frequently observed sign of osteochondrosis is joint effusion, and a positive response to the active flexion test is also commonly noted (McIlwraith 2011). In this study, among the horses displaying clinical signs, which accounted for 5 out of 6 cases, all of them exhibited effusion of the fetlock and displayed a positive response to the active flexion test (except horse 2, in which only one of the limbs responded positively to the flexion test). Both of these signs were the most common clinical signs. Among the horses studied, only one, horse number 4, did not exhibit any clinical signs, despite having a 2-degree lesion in both forelimbs. Notably, horse number 2 displayed all clinical indicators, including lameness, positive results in active and passive flexion tests, and fetlock effusion, in the left forelimb. In contrast, the right forelimb, despite also having a 2-degree osteochondrosis lesion, only displayed mild fetlock effusion.

The occurrence of lameness and its degree varied considerably. Limbs with identical lesion severity exhibited very different levels of lameness (Table 9). During the literature review for this dissertation, no studies were found that examined the association between the degree and pattern of lameness and the severity and location of lesions within the fetlock or other joints. Therefore, it could be worth exploring an association of lameness degree/pattern with an OC lesion in particular anatomical locations, for that, a bigger sample size would be needed.

The absence of clinical signs does not necessarily indicate the absence of osteochondrosis in the distal aspect of the cannon bone, hence, conducting routine radiographs is essential. This way, early lesion detection facilitates prompt treatment allowing to plan cautiously the horse's athletic career and reproductive life.

Studies affirm that the first display of clinical signs is often related to a recent increase in training (van Weeren 2006). Under training, horses are more manipulated which facilitates the detection of clinical signs. In this study, three horses (horses 1, 2, and 3) displayed their first clinical signs before reaching three years of age and prior to initiating their breaking phase. Two other horses (horses 5 and 6) showed their first clinical signs after turning three years old, coinciding with the beginning of their training, although these signs were subtle, manifesting as only fetlock effusion and a positive response to active flexion tests. Horse number 4 was diagnosed at three years old, not yet under training, and did not display any clinical signs at all. According to Ortved 2017 it is probable that as soon as this horse is put into work, clinical signs will arise. The former data is not fully consistent with the affirmation that initial clinical signs are frequently associated with a recent increase in training, as suggested by studies. As seen in the table below (Table 12) the older horses, already under training, are the ones with more subtle clinical signs. It is important to note that a more extensive sample size would be required to reach a more robust and thorough conclusion on this topic.

Table 12 - Assessment of clinical signs concerning the age and training status of the horses

Horse	Age at diagnosis	Training status	Clinical signs (absent vs subtle vs obvious)
1	4 months and a half	Not training	Obvious
2	1 year and 8 months	Not training	Obvious (although subtle in the RF)
3	2 years and 9 months	Not training	Obvious
4	3 years	Not training	Absent
5	3 years and 5 months	Initiating training	Subtle
6	4 years and 3 months	Initiating training	Subtle

Note: Subtle = only 1 or 2 clinical signs displayed; Obvious = more than 2 clinical signs displayed

Radiography was the diagnostic method used in this study to detect the lesions at the distal aspect of the sagittal ridge. In their study, Wright and Minshall 2014 categorized lesions at the distal aspect of the sagittal ridge using radiography. The authors determined that lesions are considered to be restricted to this site if they cannot be seen on the extended latero-medial (LM) radiographic projections of the fetlock joints (and visible on the flexed LM projection). In this dissertation, this was true for all detected lesions, except for the one in horse number 1, which was visible in both flexed and extended LM projections (Figure 4). This is due to its extensive coverage along the sagittal ridge, which extends beyond the length of the other lesions found, encompassing both the distal and intermediate aspects of the sagittal ridge. This particular lesion was included in this study despite being visible on the extended LM projection, as it covers the distal aspect of the sagittal ridge as well. This choice was determined due to the fact that the lesion's extension is more pronounced in the flexed projection compared to the extended projection.

In the study by Wright and Minshall 2014 a total of 23 OC lesions located at the distal aspect of the SR were radiographed. Five distinct projections were captured for each lesion, including LM, DP, DLPMO, DMPLO, and Flexed LM. All 23 lesions were successfully identified in the flexed LM projection, while 21 of them were detected in the DP projection. None of the 23 lesions was identifiable through any other radiographic projections. In the course of this dissertation's investigation, focusing solely on radiographs taken at the time of diagnosis (excluding post-surgery images), a total of 37 radiographs were examined. Among these, 19 were considered diagnostically conclusive, indicating the clear detection of the lesion, seven were considered nondiagnostic, meaning that the lesion could not be detected in this projection, and 11 were classified as suspicious, indicating that they were not definitively diagnostic but did raise concerns about the potential presence of an abnormality. As Table 11 shows, all 8 flexed LM projections were diagnostically conclusive, meaning that all lesions could be detected on this specific projection. As mentioned above, out of 7 extended LM projections taken, 6 were non-diagnostic and 1 was diagnostic. Out of 8 DP projections taken, 6 were diagnostic and 2 were suspicious, requiring the flexed LM projection to confirm the presence of the OC lesion at the distal site of the sagittal ridge. All 6 DLPMO projections taken were considered suspicious (in these cases due to a slight radiolucency in the SR) and from the 5 DMPLO projections performed, one was diagnostic, another one was non-diagnostic and the remaining three were classified as suspicious (due to a slight radiolucency in the SR). Finally, all 3 skyline (DPr-DDiO) projections were considered diagnostic. Contrasting with the findings in Wright and Minshall 2014, in this thesis investigation, the diagnostic reliability of the extended LM, flexed LM, and DP projections exhibited similar outcomes. On the other hand, the diagnostic reliability of the DLPMO and DMPLO projections diverged from the authors' assertions, as these projections, while not definitively confirming the presence of lesions, indicated the possibility of their potential existence. Ultimately, the skyline projection, not previously documented in Wright and Minshall 2014 study, potentially introduces a new diagnostic radiographic projection for lesions at the distal aspect of the sagittal ridge.

In summary, for evaluating the presence of lesions at the distal aspect of the sagittal ridge in the metacarpus, the most effective radiographic projection is the flexed LM, followed by the DP projection. The skyline projection, allowing better visualization of the articular surface of the sagittal ridge and condyles of MCIII, deserves greater consideration among equine veterinarians. When assessing DLPMO and DMPLO projections, even the slightest suspicion of radiolucency along the sagittal ridge should prompt the acquisition of a flexed LM projection for a more thorough investigation of lesion presence. Lastly, the examination of extended LM projections should be exercised with caution, as the absence of a visible lesion in the SR does not guarantee the absence of a lesion there. Consequently, flexed LM projections should be routinely conducted, especially during pre-purchase and lameness examinations. These findings suggest that currently, these lesions may be being underdiagnosed in equine practice, not only because they are scarcely addressed in scientific literature, but also due to the fact that the most reliable projection for their detection, flexed LM, may not be routinely performed by many veterinarians, as it is not one of the standard fetlock projections.

The horses involved in this study contributed to a total of eight lesions detected (plus another extremely small lesion detected in horse number 3, six weeks after surgery in the non-operated limb – left forelimb). Out of these eight lesions, none of them was a 1-degree lesion, five of them were considered a 2-degree lesion, and three of them were accounted as a 3-degree lesion (OCD lesion), according to McIlwraith et al. 2015 radiographic classification of these lesions (Table 13). Special caution should be taken when dealing with OCD (type 3) lesions, as the loose fragments, especially the dorsal ones, which is the case of horses number 1 and 3, might break into several intraarticular loose bodies, potentially damaging the cartilage, compromising the sportive career and well-being of the horse (Goldkuhl et al. 2023).

Table 13 - Radiographic lesion degree of each affected limb

Limb	Lesion degree (0-3)
Horse 1 RF	3
Horse 2 RF	2
Horse 2 LF	2
Horse 3 RF	3
Horse 4 RF	2
Horse 4 LF	2
Horse 5 RF	2
Horse 6 LF	3

It is important to remember that radiographs may not reveal the severity of lesions to the full extent (Ortved 2017), therefore it is crucial to always evaluate a lesion together with the clinical signs displayed by the patient and to not underestimate slight changes detected during radiographs assessment, especially if clinical signs are present.

The decision to opt for surgery as treatment for osteochondrosis lesions at the distal aspect of the sagittal ridge of the metacarpus should be based on several factors including the clinical status and the age of the horse, the degree of lesion observed via radiographs, and the location of the intraarticular loose fragment, in the context of 3-degree lesions (OCD). According to McIlwraith et al. 2015, surgery is always recommended to patients with persistent clinical signs related to the osteochondrosis lesion. In the current study, all horses that underwent surgery had recurrent clinical signs in the affected limbs. This recurrence played a significant role in the decision to proceed with surgical treatment. Van Weeren 2006, in his study, concluded that the age at which the dynamic character of osteochondrosis lesions ceases is around 10 months old, therefore, until then, surgery is not recommended, unless clinical signs are present. Performing surgery before this age is not encouraged, as lesions have the potential to self-heal, or additional lesions may arise during this age window following the surgery. In this study, only horse number 1 underwent surgery before reaching 10 months of age due to the presence of severe clinical signs. Horses number 2 and 3 were older, one being 1 year and 8 months old, and the other 2 years and 9 months old, at the time of surgery.

As stated by Ortved 2017, arthroscopy is always recommended for type II and type III OC lesions, after the age of one year. Horses number 1, 2, and 3 had type III, type II, and type III lesions respectively, which influenced the decision to perform surgery on the affected limbs as well. In the case of an OCD (type III) lesion, the location of the loose fragment(s) within the joint should influence the decision-making as well. In accordance with Goldkuhl et al. 2023, intraarticular loose fragments present in the dorsal pouch of the fetlock joint are more prone to cause cartilage damage than palmar/plantar ones, hence early removal via arthroscopy of these fragments is strongly advised, as cartilage injury is a factor that negatively influences the prognosis. In this dissertation study, horse number 1 and number 3, both with type III lesions, presented dorsal osteochondral fragments. This condition prompted the reference veterinarian on the field to consider the urgent need for surgery, which was performed a few days later.

The use of arthroscopy for the surgical treatment of osteochondrosis lesions offers several benefits. Firstly, being a minimally invasive intervention, it promotes a rapid and effective recovery, furthermore, it allows a broad and detailed view of all joint structures, which may not be fully visible through radiography.

As McIlwraith et al. 2015 affirmed, lesions in the proximal sagittal ridge might extend onto the condyles of the metacarpus/metatarsus, leading to a poorer prognosis. In this dissertation investigation, two horses with lesions in the distal aspect of the sagittal ridge of the metacarpus (horses number 1 and 3), also presented lesions in the metacarpus' condyles, which were only detected during arthroscopy, and not in radiographs. This might suggest a potential association between lesions in the distal aspect of the sagittal ridge and lesions in the condyles. Wright and Minshall 2014 detected an irregularity in the medial MC III condyle (via radiographs) in only one joint out of 23 suffering from a lesion at the distal sagittal ridge. Further research examining the simultaneous presence of lesions in both anatomical sites is necessary to draw more robust and conclusive findings on this subject. In their study, Goldkuhl et al. 2023 affirm that intraarticular loose fragments can damage the cartilage surface wherever regardless of their location within the joint. For instance, dorsal fragments have been associated with dorsal and palmar cartilage injury, and palmar fragments have been associated with injuries on both dorsal and palmar cartilage as well. In such cases, arthroscopy plays an important role, as it provides a clear visualization of the whole joint, facilitating the assessment of cartilage damage on all articular surfaces.

Overall, it is vital to acknowledge the crucial role of arthroscopy, not only to resolve the lesion visualized and remove OC fragments but also to explore condyle, cartilage, and other structures involvement, which may only become apparent during arthroscopy and go unnoticed in radiographs.

3.5. CONCLUSION

The main aim of this work was to provide an evaluation of the clinical signs, the radiographic changes, and the arthroscopic findings of six horses suffering from osteochondrosis lesions at the distal aspect of the sagittal ridge of the metacarpus.

The most significant constraint of this study was the small sample size, consisting of only six horses, which made it challenging to draw some substantial conclusions for the whole equine population. Additionally, the retrospective nature of the study posed challenges in clarifying some information in the reports and in obtaining all radiograph projections for each limb of the six horses involved.

Despite these limitations, this study has opened the door to future research. It would be interesting to gather a more extensive sample size of horses manifesting lesions at the distal aspect of the sagittal ridge and document their clinical manifestations, the radiographic changes, therapeutic interventions as well as their post-operative recovery and performance outcomes. A lameness assessment of the affected limbs should be performed in order to understand if there is any association between lameness degree/pattern and OC lesions at this site. Given the distinct presentation of the osteochondral fragments/flaps detected during this study, with linear radiopacities in radiographs and macroscopic plate-like shapes, it would be enlightening to explore further the origins of these OC lesions at this particular location. In order to comprehend the factors contributing to their distinct shape one should investigate how trauma may play a special role in their etiology, as well as soil consistency, nutritional factors, and horse management practices. Furthermore, research examining the simultaneous presence of lesions in the distal aspect of the sagittal ridge and the metacarpal condyles would be interesting in order to analyze a possible association between lesions in both sites. These studies would allow a better understanding of the causes and consequences of these lesions and provide valuable insights for veterinarians and horse owners about their impact.

In summary, according to the literature and the data obtained in this study, it is possible to conclude that osteochondrosis lesions at the distal aspect of the sagittal ridge are more commonly found in the forelimbs than in the hindlimbs and can have a distinct shape macroscopically (plate-like shape) and radiographically (linear radiopacities). The most common clinical signs are effusion and a positive response to the active flexion test, although clinical signs may be completely absent as well. The time at which the first clinical signs of osteochondrosis are displayed is usually at the beginning of the breaking phase, although this was not a consistent finding in this study, as three horses displayed their clinical signs before beginning their training protocol. For the diagnosis of lesions at the distal aspect of the sagittal ridge, it is important to have in mind that the best projection to detect these lesions is the flexed LM of the fetlock and that skyline and DP might be useful as well. Considering that this is not a standard projection of the fetlock and that these lesions are not detected in extended LM, lesions at this location might be currently underdiagnosed in equine practice. Finally, arthroscopy is the recommended treatment option in most cases, as it has a high success rate, provides a clear visualization of the whole joint, and enables the detection of lesions that can go unnoticed in radiographs.

These dissertation findings provide valuable insights into the clinical signs, diagnosis, and treatment of osteochondral lesions at the distal aspect of the sagittal ridge. Given the limited number of scientific papers addressing these lesions at this specific site (only one article from 2014 (Wright and Minshall 2014)), this study thus stands as a contribution to the understanding and exploration of osteochondrosis lesions in this understudied anatomical site, aiming to fill a gap in the existing knowledge of this disease.

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