Mestrado Integrado em Medicina Veterinária

Ciências Veterinárias

Radiographic Study of Bone Spavin in Lusitano Horses

– Versão Final –

Maria João Balas dos Santos Rosa

Orientador: Professor Doutor Mário Pedro Gonçalves Cotovio

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"You are a great champion. When you ran, the ground shook, the sky opened and mere mortals parted. Parted the way to victory, where you'll meet me in the winner's circle, where I'll put a blanket of flowers on your back."

In Dreamer: Inspired by a true story

Abstract

Osteoarthritis (OA) of the distal tarsal joints (commonly known as bone spavin) is a common skeleton disease of equine athletes, particularly dressage, jumping and racing horses. The most commonly affected joints are the distal intertarsal and tarsometatarsal joints. In many cases, the inflammatory process is painful resulting in a lameness that is progressively more evident. Sooner or later, this osteoarthritis affects the horses' performance and sporting longevity.

The Lusitano horse in one of the most versatile breeds of the world. Its growing popularity, particularly as a classical dressage horse has contributed for the growing numbers of its population worldwide.

The present work aimed the study of osteoarthritis of the distal tarsal joints on the Puro Sangue Lusitano (PSL) breed. Its use in horse riding modalities that require a great capacity of collection such as dressage, working equitation and bullfighting, and the typical tarsal conformation with small angles in this breed are possible contributing factors for the development of bone spavin in these horses. And despite veterinarians may diagnose it as a common cause of hindlimb lameness in these horses, bone spavin hasn't been properly studied in the breed.

Were included in the study all PSL horses that were examined in ambulatory clinical practice and underwent radiographic exam of the hock region between January 2010 and August 2016. The majority of the horses were from the geographic regions of Alentejo and Ribatejo (Portugal). For each animal, at least two radiographic views of each tarsus were obtained. The final sample included in the present study comprised a total of 104 horses, being 76 males and 28 females, aged between 1 and 19 years old. Of these, 41% were radiographed in context of lameness exam and 37% were radiographed as part of check-up exams (a component of the normal stud control already implemented in several stud farms). The remaining animals (22%) were radiographed during pre-purchase exams.

Of the 104 animals studied, 53 presented radiographic signs compatible with OA of the distal tarsal joints. In the group of horses submitted to pre-purchase exam, only 6 of the 25 animals presented radiographic signs of OA and none of the animals presented hindlimb lameness.

Although without significant statistical differences, were identified radiographic signs of OA more frequently in the left hock, and the disease had a higher prevalence in the female group. The great majority of the diagnosed OA were classified as mild. As expected, the most commonly affect joints were the distal intertarsal and the tarsometatarsal joints. Finally, of the five radiographic signs evaluated, the most commonly found in this study were “Joint space narrowing” and “Osteophyte/new bone formation”.

This study shows the importance of bone spavin in the PSL breed. Its high prevalence in the studied sample, and the possibility of existence of genetic predisposition for the disease in the breed display that it is necessary the implementation of an effective control program of the disease in breeding sires and dams.

Keywords: Lusitano horse, bone spavin, hock, degenerative joint disease, dressage

Resumo

A Osteoartrite (OA) das articulações distais do tarso (também conhecido como esparavão ósseo) é uma doença esquelética comum de cavalos de desporto, em particular cavalos de dressage, obstáculos e corrida. As articulações mais comumente afetadas são as articulações intertársica distal e tarsometatársica. Em muitos casos, o processo inflamatório é doloroso, o que resulta numa claudicação que é progressivamente mais evidente. Mais tarde ou mais cedo, esta osteoartrite acaba por afetar a performance e longevidade desportiva do cavalo.

O cavalo Lusitano é um dos cavalos mais versáteis do mundo. A sua popularidade crescente, em particular como cavalo de dressage tem contribuído para o crescimento da sua população a nível mundial.

O presente trabalho teve como objetivo o estudo da osteoartrite das articulações distais do tarso no cavalo de raça Puro Sangue Lusitano (PSL). O uso desta raça em modalidades equestres que exigem grande capacidade de concentração, como a dressage, equitação de trabalho e toureio, e a conformação tarsal com ângulos pequenos, típica nesta raça são factores que podem contribuir para o desenvolvimento de esparavão ósseo nestes cavalos. Além disto, apesar de ser frequentemente diagnosticado pelos veterinários como uma causa comum de claudicação de membros posteriores nestes cavalos, o esparavão ósseo não está estudado nesta raça.

Foram incluídos neste estudo todos os cavalos PSL que foram examinados em regime de clínica ambulatória e foram submetidos a exame radiográfico dos curvilhões entre Janeiro de 2010 e Agosto de 2016. A maioria dos cavalos eram provenientes das regiões do Alentejo e Ribatejo (Portugal). A amostra final incluída neste estudo era composta por um total de 104 cavalos, 76 machos e 28 fêmeas, com idades compreendidas entre 1 e 19 anos de idade. Destes animais, 41% foram radiografados em contexto de exame de claudicação e 37% foram examinados como parte dos controlos já implementados em várias coudelarias para exame dos animais aí criados. Os restantes (22%) foram radiografados em contexto de exame em ato de compra.

Dos 104 animais estudados, 53 apresentavam sinais radiográficos compatíveis com OA das articulações distais do tarso. No grupo de cavalos submetidos a exame em ato de compra, apenas 6 dos 25 animais tinham sinais radiográficos de OA e nenhum apresentava claudicação dos membros posteriores.

Embora sem diferenças estatisticamente significativas, foram identificados com maior frequência sinais radiográficos de OA no curvilhão esquerdo e a doença apresentou maior prevalência no grupo de fêmeas. A grande maioria das osteoartrites diagnosticadas foram classificadas como ligeiras. Como já era previsto, as articulações mais frequentemente afetadas foram a intertársica distal e tarsometatársica. Por fim, dos cinco sinais radiográficos avaliados, a “Diminuição do espaço articular” e a “Osteofitose/neoformações ósseas” foram os mais frequentes.

Este estudo revela a importância do esparavão óssea na raça PSL. A sua alta prevalência na amostra estudada e a possibilidade de existir predisposição genética para a doença na raça demonstram que é necessário implementar um programa de controlo efetivo da doença em garanhões e éguas reprodutores da raça.

Palavras-chave: cavalo Lusitano, esparavão ósseo, curvilhão, doença articular degenerativa, dressage

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Abbreviations

- BID = Twice a day
- BS = Bone Spavin
- CT = Computed Tomography
- DIT = Distal Intertarsal
- DJD = Degenerative Joint Disease
- DLPMO = Dorsolateral – plantaromedial oblique
- DMPLO = Dorsomedial – plantarolateral oblique
- DP = Dorsoplantar
- ESWT = Extracorporeal shock wave therapy
- IM = Intramuscular
- IV = Intravenous
- LM = Lateromedial
- MMP = Metalloproteinases
- MRI = Magnetic Resonance Imaging
- OA = Osteoarthritis
- PIT = Proximal Intertarsal
- PSL = Puro Sangue Lusitano
- SID = Once a day
- TMT = Tarsometatarsal
- W/ = With
- W/O = Without

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I. Literature Review

a. The Lusitano Horse Breed

Known for its elegance and graciousness, the Lusitano horse is in the genesis of many modern horse breeds worldwide. Although considered the most important native equine breed in Portugal, its official Studbook was established only in 1967 (Lopes *et* al. 2005; Vicente *et al.* 2012; Vicente *et al*. 2014b). Until that, the Lusitano and the Pura Raza Española were jointly designated as Andalusian, Iberian or Peninsular horses (Vicente *et al.* 2012).

There are many causes pointed out for the small number of founder animals and limited gene pool by the time the studbook was stablished, such as wars, foreign invasions and uncontrolled crossbreeding. Despite these constraints, the breed survived and the number of registered animals has been increasing since the 1980s (Vicente *et al.* 2012). Nowadays, the Lusitano is the main equine breed in Portugal (Vicente *et al*. 2014b). In 2009, about 5000 mares were registered in the PSL's studbook as official broodmares, and the stud farms with bigger groups of breeding animals were located in Portugal, Brazil and France (Vicente *et al.* 2013).

The breed was selected mainly based on aesthetical and functional traits. Its use in bullfighting, herd management and cavalry was a key aspect to maintain its functionality and versatility. Nowadays the Lusitano breed has increased its popularity as a leisure and sports horse, being successful in many equestrian disciplines such as dressage, driving and working equitation (Vicente *et al* 2012; Solé *et al.* 2013; Vicente *et al*. 2014a). Classical dressage is the equestrian discipline where the breed has achieved greater prominence (Solé *et al*. 2013).

Since 1989, only offspring of approved stallions and mares is registered in the studbook. To be registered has a breeding stallion or mare, the animal is submitted to a morpho-functional test, where it is evaluated on gaits and conformation by a jury comprising three experts. The stallions are presented ridden and the mares are presented by hand (Vicente *et al.* 2012; 2014a; 2014b).

The Lusitano is a medium size horse of well-proportioned and rounded shapes, with agile and elevated gaits. Its head has a slightly convex profile, the neck and withers are strong and well-developed, and the chest is wide. The back, loin and croup form a continuous and harmonious line and the limbs are strong and muscled. The hindlimbs have relatively small angles (APSL 2010).

b. Dressage

Classical dressage is an equestrian discipline whose main purposes are the harmonious development of the horse and the perfect understanding between the horse and its rider (FEI 2016). The dressage horse should be calm and well balanced, combining elegance, athleticism, power and trainability (Dyson 2002).

A good dressage horse performs the exercises with elegance, balance, suppleness and power. Most of all, dressage requires that the horse moves naturally regardless the difficulty of the exercises performed (Dyson 2002; Solé *et al*. 2013).

At higher levels of dressage training, the center of gravity of both horse and rider is placed further caudally. While this gives freedom to the front limbs to execute more uphill movements it also results in an increased degree of flexion and loading over the hind limbs. This, ultimately, leads to a great storage of strain energy in the pelvis and hock joints (Dyson 2002). The required collection to execute the exercises and consequent increased tarsal loading and joint compression may be predisposing factors to tarsal injury in dressage horses (Murray *et al*. 2010).

Equine athletes competing in different sports or competing in the same sports at different levels have different types and locations of lesions. This is most likely to be related with specific features of the management of the horses and the type of exercises they perform (Murray *et al*. 2010). Yet, dressage horses competing at low levels have similar lesions as show jumpers and leisure horses. Despite that, these injuries may result in lameness earlier since these horses probably work more on circles (Dyson 2002).

In a survey that has taken place in the United Kingdom (UK), lameness was pointed out as the most common cause of injury or disease of dressage horses and there was no difference in the lameness frequency in elite and non-elite horses. Nonetheless, elite horses tend to be off work for longer periods of time, which can be related to the severity of the lameness or with the capacity of the rider to detect or mask that lameness (Murray *et al*. 2010).

The most common causes of lameness and/or reduced performance of a dressage horse include suspensory ligament desmitis and degenerative joint disease (DJD) of the distal tarsal joints (distal intertarsal and tarsometatarsal joints) in the hind limbs, synovitis of the distal interphalangeal joints and middle carpal joint in the front limbs (Dyson 2002; Murray *et al*. 2006).

This is consistent with other survey performed in the UK, in which the hind limb suspensory ligament and tarsal injuries were reported to have high incidence in these equine athletes. Tarsal injuries were the second cause of hindlimb lameness in elite dressage horses (Murray *et al.* 2006; Murray *et al*. 2010).

Studies have shown that some specific conformation particularities and body dimensions have a positive effect on the athletic performance of the horses, particularly in the equestrian discipline of dressage. For example, it has been studied that elite dressage horses have a less vertical scapula and have a greater tarsus angle than non-elite dressage horses. It has also been showed that both large and small tarsus angles are considered a handicap when the horses are submitted to morphological tests (Solé *et al*. 2013).

The Lusitano horse has a small tarsus angle (144.96º ± 3.58º), which has been pointed as a cause of loss of elasticity and amplitude, having a negative effect in the development of high gait quality (Solé *et al*. 2013).

c. The Equine Hock

The tarsus is the region of the hindlimb most commonly associated with lameness. Being a very complex region imaging it for diagnostic purposes is a real challenge (Vanderperren *et al*. 2009a; Vanderperren *et al*. 2009b).

i. Anatomy and Biomechanics

The equine tarsus has an external round shape, with a protuberance proximally in its plantar region which corresponds to the calcaneus (Judy 2013). It is composed of ten bones, four joints and various ligaments, tendons and bursae (Vanderperren *et al*. 2009b). The bones are organized in three rows. The proximal one is formed by the talus (which articulates with the coclea of the tibia) and the calcaneus bone. The *sustentaculum tali* (part of the calcaneus bone) articulates with the fourth tarsal bone (Björnsdóttir 2005; Budras and Jahrmärker 2009).

The middle row comprises only the central tarsal bone and the distal row consists of the four tarsal bones (I – IV from medial to lateral) (Figure 1). The first and second tarsal bones are fused. The fourth tarsal bone is larger than the other bones in its row and articulates with both the Proximal Intertarsal (PIT) and Tarsometatarsal (TMT) joints (Jackman 2006; Budras and Jahrmärker 2009).

The tarsal bones, together with the distal extremity of the tibia and proximal end of the metatarsal bones, form a composite joint known as *articulation tarsi*. This comprises the Tarsocrural (or Tibiotarsal), Proximal Intertarsal (or Talocalcaneal-centroquartal), Distal

Intertarsal (or Centrodistal) and Tarsometatarsal joints. Each joint is in a different level (Björnsdóttir 2005; Budras and Jahrmärker 2009).

The four joints are surrounded by a common fibrous joint capsule which extends from the tibia to the metatarsal bones and encloses four separated synovial sacs/cavities. This joint capsule is steadily attached to the tarsal bones in several points (Budras and Jahrmärker 2009).

The joint capsule is stabilized by lateral and medial collateral ligaments, proximal and distal tarsal ligaments and tarsometatarsal ligaments. The collateral ligaments arise from the *malleoli* of the tibia, attach to some of the tarsal bones and insert proximally in the II and IV metatarsal bones (Björnsdóttir 2005; Budras and Jahrmärker 2009).

The long plantar ligament origins in the calcaneus bone and inserts on the proximoplantar surface of the metatarsal bones. It also attaches to the tarsal bones (Budras and Jahrmärker 2009). The tendon of the *tibialis cranialis* muscle, also designated as the "tendon of spavin", runs obliquely over the medial aspect of the tarsus and over the cunean bursa (Björnsdóttir 2005).

The accessory ligament of the suspensory ligament originates from the plantar aspect of the fourth tarsal bone and the calcaneus. This anatomical relationship between the suspensory ligament and the tarsus is a possible explanation of why distal hock joint pain and suspensory injury may coexist and why horses with suspensory desmitis show a positive response to tarsal flexion (Dyson and Ross 2011).

The hock joint is surrounded by other important structures such as tendons and tendons' sheaths as demonstrated in Figure 1 (Budras and Jahrmärker 2009).

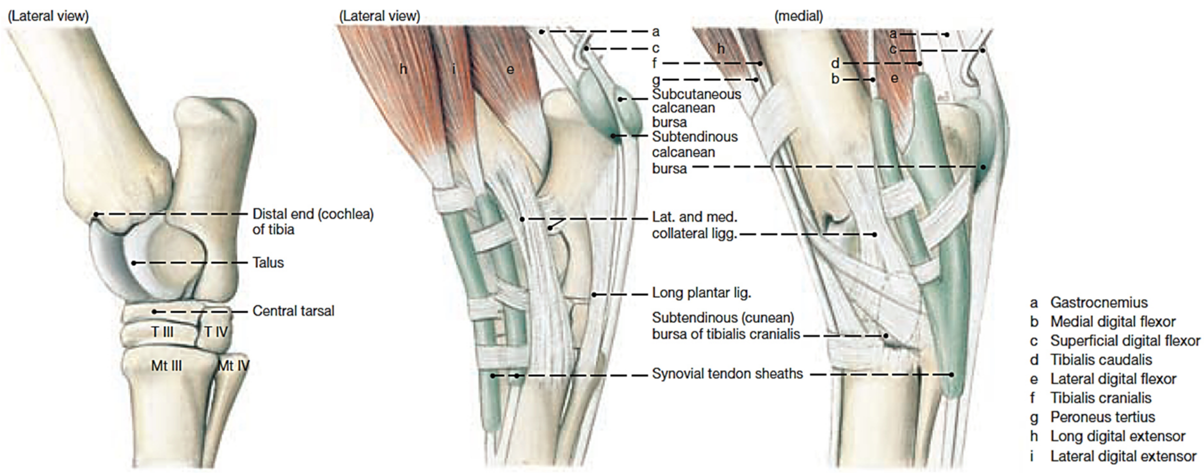


Figure 1 – The anatomy of the tarsal region of horse (Budras and Jahrmärker 2009).

The tibiotarsal and talocalcaneal – centroquartal joints communicate. The distal intertarsal (centrodistal) joint doesn´t communicate with the proximal intertarsal (talocalcaneal – centroquartal) joint but, in some cases, may communicate with the tarsometatarsal joint (Shelley and Dyson 1986; Jackman 2006). Apparently, this ccommunication happens between the third and the fused first and second tarsal bones and/or the tarsal canal (Jackman 2006).

The most proximal joint is the largest hock joint and the responsible for the majority of the movement of the tarsal region. The three distal joints are known as "lower-motion" joints because they have flat surfaces which limits motion (Björnsdóttir 2005; Gutierrez-Nibeyro 2016). Their area of maximal weight bearing is practically stationary during locomotion. These joints have minimal flexion-extension motion and they are under greater compression, rotational and shear forces than high-motion joints. Therefore they are more susceptible of suffering overloading and metabolic disturbances (Björnsdóttir 2005; Jackman 2006).

The distal medial aspect of the tibia and the proximal lateral aspect of the third metatarsal bone are under great compression. In scintigraphy studies, normal mature horses have a mildly higher isotope uptake dorsally and laterally in the distal aspect of the tarsus (Jackman 2006; Dyson and Ross 2011). This is suggestive of an increased adaptive bone remodeling in response to the higher load in the lateral aspect of the bones. This meets the findings in biomechanical studies that suggest that the compressive load is transferred from medial to lateral through the tarsus (Dyson and Ross 2011).

The lower tarsal joints functions are to absorb energy in the beginning of the stance phase and contribute to propulsion in the end of the stance phase. Tarsal conformation greatly influences its function. Small (< 155,5º) and intermediate tarsal angles allow more flexion and energy absorption then large (> 165,5º) tarsal angles. Horses with larger tarsal angles can generate less vertical impulse with their hind limbs, which may result in less propulsion and absorption of concussion, affecting both athletic performance and soundness. On the contrary, horses with smaller hock angles have greater flexion during the stance phase, which may result in compression of the dorsal aspect of the tarsal bones (Dyson and Ross 2011).

Abnormal tarsal conformation may be in the origin of tarsal lameness due to distal hock joint pain. Horses with sickle hocks (hocks with small angles) frequently develop osteoarthritis of the distal hock joints, curb and soft tissue injuries in the plantarodistal aspect of the hock. These horses may also be prone to suffer fractures of the central and third tarsal bones (Dyson and Ross 2011).

ii. Imagiology of the tarsal region

Because of its complexity, imaging the equine tarsus requires a very good knowledge of the anatomy of the involved structures, the normal appearance and the possible alterations that may be detected with the different imaging tools (Vanderperren *et al*. 2009b; Puchalski 2012). Another key aspect for an accurate diagnosis is to evaluate and compare both hindlimbs (Vanderperren *et al*. 2009b).

Presently, the most used imaging techniques for evaluation and diagnosis of tarsal injuries are radiography and ultrasonography, which usually are used in association (Vanderperren *et al*. 2009a).

Radiography is an imaging technique commonly used for routine evaluation and screening of the tarsus, as a component of the lameness exam or during a pre-purchase exam (Puchalski 2012; Judy 2013). It is also indicated whenever the veterinarian suspects the tarsal region is the origin of the lameness or to confirm the correct placement of a needle during a intra-articular anaesthesia (Jackman 2006; Weaver and Barakzai 2010).

It is an effective diagnostic tool to evaluate bony structures, but the projection of a three-dimensional structure onto a two-dimension image causes superimposition of the bones and lack of differentiation of soft tissues (Vanderperren *et al*. 2009b). Therefore, a complete radiographic exam, with high quality and properly centered projections is crucial for its diagnostic value (Puchalski 2012).

It is possible to access all sides of the limb for evaluation of the different aspects of the bony structures (Judy 2013). Weight-bearing lateromedial (LM), dorsoplantar (DP), dorsolateral – plantaromedial oblique (DLPMO) and dorsomedial – plantarolateral oblique (DMPLO) views (represented in Image 2) are the most commonly used and enough to reach a diagnosis (Weaver and Barakzai 2010; Puchalski 2012; Judy 2013). The radiographies can be centered in the tarsocrural or in the distal hock joints depending on which part of the tarsal bones we want to evaluate with more detail (Weaver and Barakzai 2010).

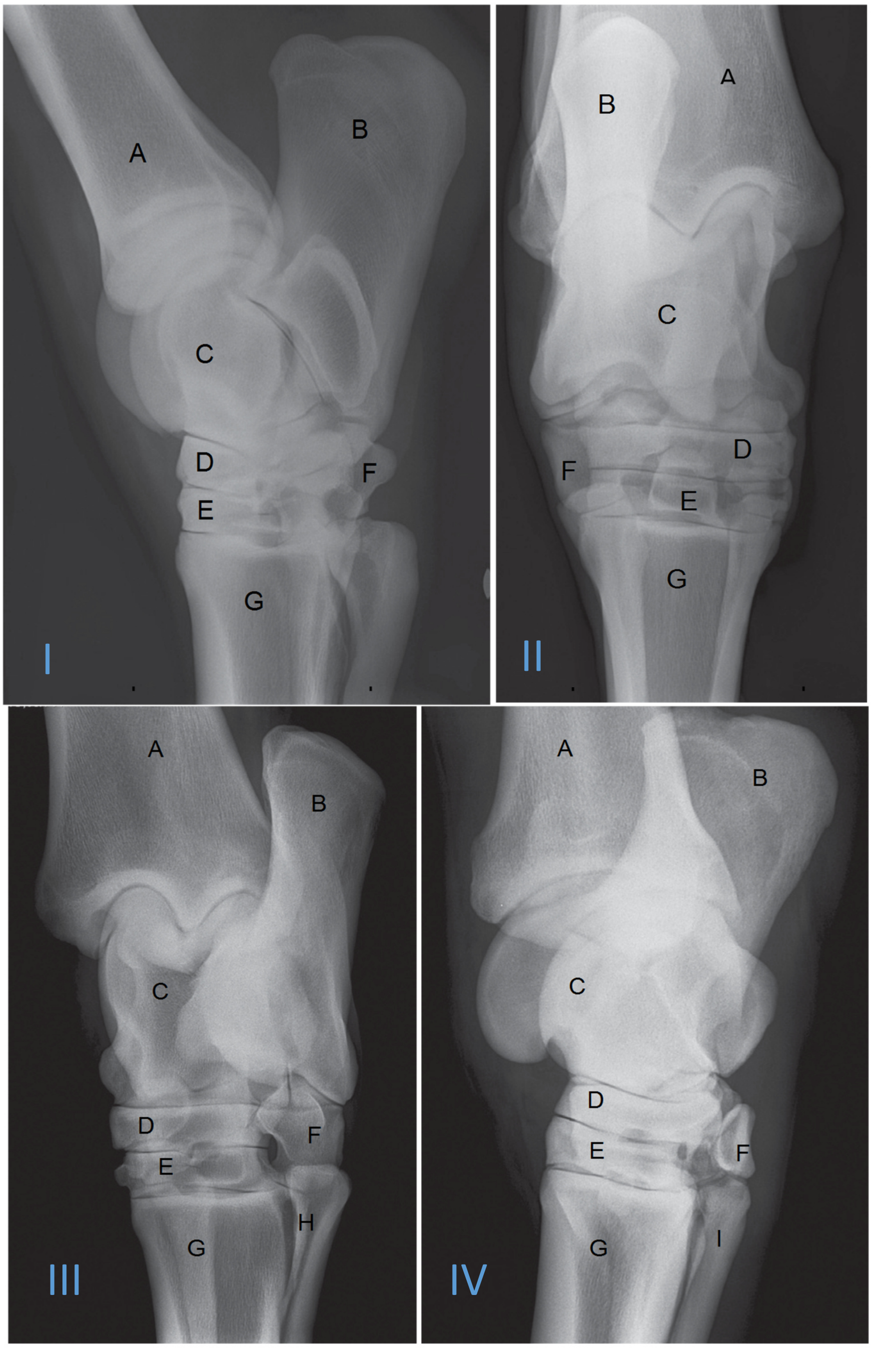


Figure 2 - Most common Most Common Radiographic Views of the Tarsus – Lateromedial (I), Dorsoplantar (II), Dorsolateral – plantaromedial oblique (III) and Dorsomedial – plantarolateral oblique (IV). We can observe and evaluate the distal extremity of the Tibia (A), the Cacaneus bone (B), Talus (C), Central tarsal bone (D), Third tarsal bone (E), Fourth tarsal bone (F), and the proximal extremity of the Third (G), Fourth (H) and Second (I) metatarsal bones (adapted from Weaver and Barakzai 2010).

It is possible to identify subtle changes in trabecular detail and cortical thickness. However, this imaging technique can be insensitive to the early stages of bone inflammation and a decrease in bone density inferior to 30% isn´t visible on radiography. Despite its limitations, it is still the most accessible and commonly used imaging technique for diagnosing of tarsal bone injuries such as osteochondrosis, osteoarthritis and fractures (Vanderperren *et al*. 2009a; Garrett 2011).

The hock has a complex anatomy, so in order to be able to detect abnormalities, it is essential to understand the normal radiographic appearance of this region, which depends on the age (in younger animals, the joint spaces are wider because there is proportionally more cartilage than in adult horses) and type of horse (heavier animals have a rougher bony conformation). Usually, these variations are bilateral, and that is one more reason that makes it so important to evaluate both hind limbs (Shelley and Dyson 1986).

In some adult horses, the first and second tarsal bones aren´t fused, either in one or both hind limbs. The contour of the tarsal bones is variable – the central and third tarsal bones may have prominences and the bony ridges may seem like sclerosis areas. The superimposition of the third tarsal bone with the proximal diaphysis of the second and fourth metatarsal bones results in areas of variable radiodensity (Shelley and Dyson 1986).

The intertarsal joints are better seen when the limb is in a weight bearing position. The surface curvature of the central and third tarsal bones causes superimposition of the intertarsal joint spaces. The non-articular concavities on the opposing surfaces of the talus, central and third tarsal bones and the third metatarsal bone show as radiolucent areas centrally in the DIT and TMT joints (Shelley and Dyson 1986).

Ultrasonography is a complementary technique used to assess the articular and periarticular soft tissues (such as the proximal region of the suspensory ligament, collateral ligaments of the tarsal region, flexor tendons and tarsal sheaths), the bone surface and evaluate the synovial fluid and synovial membrane of the tarsal joints (Vanderperren *et al*. 2009b; Garret 2011; Puchalski 2012).

It is possible to detect effusion and/or edema and identify with precision the affected synovial structure (joint, sheath or bursa). As in the radiographic exam, it is also important to evaluate and compare both limbs (Garrett 2011).

Skeletal scintigraphy, computed tomography (CT) and magnetic resonance imaging (MRI) are much less used. Scintigraphy provides information about the bone functional or physiological state. With it, we can check for abnormal bone activity and evaluate the significance of bony abnormalities found in the radiographic exam (Vanderperren *et al*. 2009b; Puchalski 2012). It is also useful to detect exercise (stress) induced bone remodeling in racehorses, fractures of the cuboidal bones and the talus that may occur without radiographic abnormalities, and injuries at ligament-bone interfaces (Garrett 2011; Puchalski 2012).

Both computed tomography and magnetic resonance imaging provide three-dimensional images without superimposition of the structures and allow visualization of hard and soft tissues (Vanderperren *et al*. 2009b; Garrett 2011).

CT delivers a highest degree of bony detail. However, only provides information about the osseous components and can be used to diagnose fractures, subchondral osseous cyst-like lesions, osseous trauma and joint disease. MRI provides detailed information and may allow the identification of tarsal bone sclerosis, bone bruising, fractures, osteoarthritis, osteochondrosis, cartilage damage and soft tissue injuries (Garrett 2011; Puchalski 2012).

Besides these non-invasive imaging procedures, in some cases, arthroscopy is used for intra-articular visualization of the tarsocrural and, only in adult horses, talocalcaneal – centroquartal joints to reach a specific diagnosis (Vanderperren *et al*. 2009b).

d. Bone Spavin (Degenerative Joint Disease)

There are two types of spavin, bog spavin and bone spavin. Bog spavin is the excessive accumulation of fluid in the tarsocrural joint, which results in slight to severe enlargement of the region. It is more common in younger horses and can be due to trauma, osteochondrosis, severe osteoarthritis or septic arthritis. It can affect just one or both hocks (Ross 2012; Carson and Ricketts 2013).

Bone spavin is the non-septic, degenerative osteoarthritis of the smaller (distal) hock joints, most commonly the distal intertarsal and tarsometatarsal joints. Being a degenerative condition, it is more common in older performance and leisure horses and can be unilateral or bilateral (Carson and Ricketts 2013). It is considered to be widespread in the general equine population and particularly common in racing, jumping, dressage and Western performance horses (Björnsdóttir *et al*. 2000; Latimer 2004; Gutierrez-Nibeyro 2016).

i. Definition

Osteoarthritis or degenerative joint disease (DJD) is a chronic disorder of synovial joints that is characterized by progressive deterioration of the articular cartilage and changes in the bone and soft tissues of the joint (Björnsdóttir 2005).

A series of mechanical and biological processes leads to the progressive degradation and destruction of the articular cartilage. The loss of articular cartilage is the result of its incapacity of withstanding trauma (caused mainly by athletic activity), loss of stability and joint congruence changes. These factors cause abnormal stress over the normal cartilage triggering pathologic changes and degradation of the cartilage, remodeling of the underlying subchondral bone, loss of joint space and new bone proliferation on joints' surfaces and margins (Carmona and Prades 2009; McIlwraith 2009; Caron 2011).

Commonly known as bone spavin (BS), the distal tarsal degenerative joint disease is a common cause of hindlimb lameness and the primary cause of tarsal lameness. It is often bilateral and usually involves the two lowest hock joints (centrodistal and tarsometatarsal joints) but also may involve the talocalcaneal – centroquartal joint (Edwards 1982; Shelley and Dyson 1986; Dyson and Ross 2011). The involvement of the PIT joint is associated with a poorer prognosis (Shelley and Dyson 1986).

Any chronic osteoarthritis such as tarsal DJD is characterized by articular cartilage damage, joint capsule fibrosis, periarticular osteophytes, subchondral bone lysis and sclerosis, joint space narrowing and ankylosis (Gutierrez-Nibeyro 2016). The periarticular soft tissue components of the joint may be affected due to sliding and shear forces (Ross 2012).

Studies in different sports breeds have shown high prevalence of radiographic signs and histological abnormalities compatible with the disease (Björnsdóttir 2005). Radiographs are frequently negative or inconclusive in the earlier stages of the disease, particularly in young racehorses. On the contrary, in sports horses radiographs are often positive and, in some cases inactive changes may lead to a false positive diagnosis (Ross 2012).

ii. Etiology and Pathophysiology of the Osteoarthritis

The articular cartilage is responsible for distributing loads and allowing the articular surfaces to glide over one another almost without friction, even when under significant loads. In cases of joint trauma or osteoarthritis, the normal structure and function of the hyaline cartilage change. This results in biochemical, structural and biomechanical alterations that will lead to joint destruction if the original trauma isn't corrected (Caron 2011).

Although cartilage is designed to bear compressive stress, its capacity to absorb shocks is limited. Several mechanisms and anatomical features contribute to make this possible, such as the distribution of forces to surrounding tissues (periarticular soft tissues, muscles and the underlying subchondral bone), the incongruity of the articular surfaces, and the capacity of elastic deformation under compressive stress (compliance) of the cartilage and subchondral bone (Caron 2011).

When the subchondral bone isn´t able to bear the loading forces, repetitive subchondral deformation causes trabecular microfractures, which may or may not be accompanied by changes in the articular cartilage. When occurring at an acceptable rate, this trabecular microfractures are repaired and that causes an adaptation of the orientation of the subchondral bone that provides improved strength and shock absorption capacity (Caron 2011).

The causing factor that triggers the degenerative process is unclear, however several factors such as repeated trauma, subchondral bone overload, joint instability, synovitis – capsulitis, hypoxia and neovascularization are associated with it (Carmona and Prades 2009; Caron 2011).

A defective cartilage with abnormal biomechanical properties (instability and lack of mechanical integrity) fails to bear and absorb normal loads (Carmona and Prades 2009; Caron 2011). The defective properties can be congenital or caused by increased ligament laxity, a tear or strain in a periarticular ligament or poor conditioning of the muscles that affect the joint. For example, overtraining can increase joint laxity while the horse is fatigue (Carmona and Prades 2009).

Joint instability can also be caused by intense synovitis because it generates excessive amounts of synovial fluid. That increases the pressure within the joint and may produce direct mechanical cartilage damage and anomalous overload forces of subchondral bone regions (Carmona and Prades 2009).

Repeated microtrauma is considered the most important pathogenic factor in equine OA (Caron 2011). So, a different explanation also involves mechanical stress over the subchondral bone (Carmona and Prades 2009; Caron 2011). As mentioned earlier, normal mechanical stress causes microfractures of the subchondral and epiphyseal trabecular bone. However, when this occurs at an excessive rate, and surpasses the capacity of optimal healing and remodeling of the subchondral trabeculae, bone accretion due to healing of these microfractures increases the density of the subchondral plate and trabeculae (subchondral esclerosis) (Caron 2011). This leads to an increase in bone stiffness reducing its ability of dissipating energy, and capacity of absorbing repetitive physiological loads and to deform under normal stress (elasticity) (Carmona and Prades 2009; Caron 2011).

Furthermore, the injured tissue fails to heal due to rigorous training programs, inadequate warm-ups, fatigue and inadequate rest intervals (Carmona and Prades 2009). Consequently, the articular cartilage undergoes supraphysiological stress, which results in mechanical damage (Caron 2011).

Additionally, mechanical forces can also damage healthy cartilage and directly origin OA. Cartilage is very resistant to shear forces but is quite vulnerable to repetitive impact trauma. The resulting injuries cause changes in the chondrocytes metabolism, leading to the release of proteolytic enzymes that destroy the cartilage (Caron 2011). Thus, repetitive trauma causes cartilage damage through a direct physical effect and an indirect influence in the metabolism of chondrocytes by enhancing the concentration of arachidonic acid in their cellular membrane (Jansson 1996).

In healthy joints, chondrocytes are responsible for maintaining the balance between matrix degradation and repair. However, when this cells suffer metabolic changes, as in OA, this balance is lost and the catabolic processes predominate. This leads to matrix depletion and progressive loss of cartilage. Since the viscoelastic properties of the remaining tissue are insufficient to bear normal loads, the remaining cartilage eventually suffers fissuring and fragmentation (Caron 2011).

Besides the direct and predominant involvement of cartilage and subchondral bone in the progression of the OA, the development of the disease is associated with a cascade of biochemical events mediated by cytokines, proteolytic enzymes and inflammatory mediators (such as prostaglandins, leukotrienes and nitric oxide) (Carmona and Prades 2009; Caron 2011). Therefore, synovitis (inflammation of the synovial membrane) can be a primary phenomenon or a consequence of joint trauma or articular overload, and plays a central role in the pathways of cartilage degeneration through the release of these inflammatory mediators into the synovial fluid (Jansson 1996; Carmona and Prades 2009; Caron 2011).

Synoviocytes and chondrocytes are rich in mediators and enzymes, particularly inflammatory mediators and degradative enzymes implicated in the cartilaginous degeneration, such as prostaglandins, cytokines, matrix metalloproteinases (MMP) and other proteolytic enzymes (Jansson 1996; Caron 2011). Some of these mediators, in particular catabolic cytokines and enzymes degrade cartilage and subchondral bone matrix (Carmona and Prades 2009). They are also involved in the osteolysis, subchondral bone sclerosis, osteophytosis, articular cartilage erosion and synovial membrane thickening (Carmona and Prades 2009).

These molecules and oxygen-derived free radicals are considered the major mediators of matrix depletion, being the matrix metalloproteinases (cartilaginous matrix degradative enzymes) and related enzymes the most active in osteoarthritis (Jansson 1996; Caron 2011). A healthy articular cartilage contains inhibitors of the MMP, which, in normal conditions, help to keep a normal rate of proteoglycan and collagen turnover in the cartilage matrix. Synovitis disturbs this balance by stimulating the chondrocytes to produce more MMP, enhancing cartilage degradation (Jansson 1996).

Synovial macrophages are also important contributors to the inflammatory and degradative responses in affected joints through the combined effect of interleukine-1 (IL-1) and tumor necrosis factor-α (TNF-α) (Caron 2011).

Fluctuations in the synovial fluid oxygen tension during exercise may generate continuous ischemia-reperfusion cycles, which generate oxygen-derived free radicals in the joint. These molecules react directly with cartilage components, causing its degradation. It is also possible that they influence the activity of the cyclo-oxigenase, and therefore interfere with prostaglandin synthesis (Jansson 1996).

All the mediators and enzymes mentioned above attract inflammatory cells such as neutrophils and mononuclear cells. These infiltrate the synovial membrane and fluid, and release lysosomal enzymes and more oxygen-derived free radicals, which apparently degrade cartilage components, and stimulate even more the synoviocytes, chondrocytes and macrophages to synthetize and release more inflammatory mediators and degradative enzymes (Jansson 1996).

iii. Pathophysiology of the Distal Tarsal Osteoarthritis

It is assumed that the disease begins and affects more commonly the medial aspect of the small tarsal joints but the abnormalities can extend dorsally (Edwards 1982). However, the radiographic signs are frequently identified first on the dorsolateral aspect of the distal joints, a region that is under high compressive strain (Edwards 1982; Dyson and Ross 2011). Therefore, it is expected that mild periarticular osteophytosis is best seen on the dorsomedial – plantarolateral oblique view of the hock (Ross 2012).

As mentioned earlier, the OA also involves increased trabecular thickness and reduced trabecular spaces in the subchondral bone, which reduces its capacity of absorbing repetitive loads and causing the bone-cartilage unit to fail in deforming under stress. Therefore, these horses may have subchondral bone pain due to increased intraosseous pressure (Branch *et al*. 2007; Dyson 2008). So, in horses with distal tarsal DJD, persistent lameness may be due to subchondral bone pain or to early changes in more than one joint (Butler *et al*. 2008).

There is also formation of cysts in the subchondral bone, which often open into the joint surfaces. Later these lesions lead to an irregular atrophy of the subchondral bone, apparently widening the joint space (Edwards 1982). Besides subchondral bone, the trabecular bone and articular cartilage can also suffer pathological changes (Dyson 2008). For example, excessive cartilage compression may lead to narrowing of joint space, compression and erosion of the lower tarsal bones surface (Dick Vet Equine Practice 2016).

In response to subchondral bone changes, periosteal reaction occurs, resulting in new bone proliferation in the affected joints. In some cases, this new bone is enough to promote complete ankylosis of the affected joint(s), which eliminates tarsal lameness (Edwards 1982).

Progressive joint fusion may occur associated or not with destructive and proliferative changes. In DJD "end stage", spontaneous ankylosis of the intertarsal and tarsometatarsal joints occurs, though it may never be a complete ankylosis (Shelley and Dyson 1986; Verschooten and Schramme 1994). There is great joint space reduction and none or minimal bone destruction associated. The new bone production is either minimal or forms bridges that cause external ankylosis of the affected joints (Shelley and Dyson 1986).

The progression of the disease is variable and can´t be predicted (Butler *et al*. 2008).

iv. Causes and Predisposing Factors

The etiology of the disease is considered multifactorial. The most studied factors are inherited poor tarsal conformation, type of exercises performed, incomplete ossification of the tarsal bones in foals, trauma of the region and genetic predisposition (Latimer 2004; Björnsdóttir 2005).

From a clinical standpoint, horses with distal tarsal DJD can be divided into two categories: middle-aged and older horses which developed distal tarsal OA secondary to excessive joint wear and tear due to the type of exercises they perform, and young horses that have worked very little and have developed distal tarsal OA secondary to malformation or collapse of the tarsal cuboid bones (Baxter 2004).

Poor hock conformation such as "straight-legged", "sickle hocks", "cow hocks" and angular deformities (tarsal valgus or varus) are some of the contributing factors for the development of bone spavin. (Latimer 2004; Dyson and Ross 2011; Sullins 2011). Usually, these deviations are developmental but there are cases of tarsal valgus or varus due to trauma or overload secondary to an injury in the opposite limb (Bramlage 2006).

Mild angular deviations don't interfere with the athletic performance of the horse, but severe deviations can affect its soundness. In both cases, the existing asymmetries of the tarsal bones lead to accelerated wear and tear of the articular surfaces of the tarsal joints (Bramlage 2006).

These types of conformation may be associated with increased forces acting on the medial aspect of the tarsus (Sprackman *et al*. 2015). Therefore, they can cause uneven loading with excessive compression of the cartilage and bone on one side and strain in the joint capsule and supporting ligaments on the opposite side (Dick Vet Equine Practice 2016).

It has also been suggested that the shape of the central and third tarsal bones, particularly the “wedging” (inclination) of their dorsal aspect, may predispose to the development of distal tarsal OA. In many horses, the dorsal height of these bones is different from the plantar height and that is thought to be secondary to the collapse of the tarsal bones, which may be caused by a faulty endochondral ossification of the affected bones in the foals. However it is unclear if this inclination reflects a normal anatomic variation or not (Sprackman *et al*. 2015).

Besides these conformational defects, poor trimming and shoeing are all causes of uneven distribution of the load on the joints (Sullins 2011; Dick Vet Equine Practice 2016).

The type of exercise and workload are also important aspects. Classical dressage, show jumping and racing are examples of equestrian disciplines that require much hock flexion and may involve excessive concussive forces acting over the tarsal joints, which also leads to repeated and, sometimes, uneven loading and strain of the lower tarsal joints (Latimer 2004). Repeated compression, torsion, rotation and shear strain of the small tarsal bones and joints may be the trigger factors of the inflammatory cascade that results in DJD (Latimer 2004; Sullins 2011; Gutierrez-Nibeyro 2016).

Since mechanical loading is a factor associated with joint degeneration, comprehending the osteochondral tissues adaptive changes associated with different types and intensity of exercise is important in order to understand the relationship between exercise and joint degeneration. The osteochondral tissues suffer changes in order to adapt to the strains they are submitted to, which vary with different type and intensity of the exercises that the horse performs. This adaptation translates in different patterns of subchondral bone thickness (Murray *et al*. 2007).

Horses performing at an elite level of competition, in particular dressage and show jumping horses, are more likely to experience more intensive training and suffer greater compressive strain in the hock. Gaits such as passage, piaffe and pirouettes performed in elite classical dressage require more flexion by the tarsus and takeoffs, landings and sharp turns performed by jumpers cause tarsal compression and may alter the normal pattern of loading (Murray *et al*. 2006).

Finally, the occurrence of bone spavin in horses younger than 2 years old (known as "juvenile spavin") may be caused by osteochondrosis lesions or distortion forces applied on the cuboidal tarsal bones in premature or dysmature horses (Dyson and Ross 2011). The heritability of the disease has been studied in the Icelandic horse and other European breeds such as German and Dutch warmblood horses (Björnsdóttir 2005).

v. Epidemiology

As previously said, DJD of the distal tarsal joints is a common cause of lameness in sports horses, including dressage horses, jumpers and racers. However, despite its impact in the sporting longevity and success of equine athletes, little is known about its real prevalence in the different breeds. The disease has been studied mainly in the Icelandic breed, Warmblood riding horses and Thoroughbred racing horses.

Bone spavin has been described as a common cause of hindlimb lameness in Icelandic horses, affecting the sporting longevity of some animals (Björnsdóttir *et al*. 2000). Histological and radiographic studies support that BS has a progressive nature, starting at a young age, and seems to have a very slow progression in the majority of the horses (Björnsdottir *et al*. 2004; Björnsdóttir 2005).

In this breed, a strong correlation between prevalence of the disease, and age and hock conformation has been described (Björnsdóttir *et al*. 2000; Axelsson *et al*. 2001). In these horses, the radiographic signs are more common in the centrodistal joint or in both the centrodistal and tarsometatarsal joints (Björnsdóttir *et al*. 2000).

The heritability of the disease has been estimated to be 0,33 (Árnason and Björnsdóttir 2003). Therefore, in order to decrease the prevalence of bone spavin in the breed, stallions and mares are subjected to a radiographic examination of the distal tarsal region (FEIF 2016).

In a study with Hanoverian Warmblood horses, distal hock OA was diagnosed in 12,0% of the animals included in the study. The estimated heritability for bone spavin ranged between 0,02 and 0,17 and was considered moderate by the authors. It falls into a wide range of heritability estimates previously reported for bone spavin (0,02 – 0,65). The diagnosis was exclusively radiological (Stock and Distl 2006).

In a study realized in the early 90's, the prevalence of juvenile spavin in a group of horses with less than two years old was estimated to be 20%. The abnormalities were suggestive of osteochondrosis being a possible cause of bone spavin in juvenile horses (Watrous *et al.* 1991; Dyson and Ross 2011).

More recently, some studies have also been done in young performance horses, mainly Thoroughbred yearlings, to evaluate the prevalence of specific radiographic signs of distal tarsal OA in these animals. For example, in these horses, the prevalence of osteophytes in the dorsal aspect of the PIT, DIT and TMT joints ranged between 20,1 a 25%. The radiolucency of the DIT and TMT joints and wedging of the central and the third tarsal bones were much less prevalent, being identified in 7,3% and 0,6 – 1,6% of the horses, respectively (Santschi 2013).

In young performing Quarter horses, the prevalence of dorsal osteophytes in the PIT, DIT and TMT joints was estimated in 47,9% and the prevalence of wedging of the central and third tarsal bones was of 6,9% (Santschi 2013).

vi. Clinical Signs

Osteoarthritis of the TMT and DIT joints is a common cause of decreased performance in equine athletes, having an important impact in the sporting longevity of these animals (Bell *et al*. 1993).

Tarsal osteoarthritis can affect horses either in the beginning or in a later phase of their athletic careers (Latimer 2004). However, clinical signs are more common in mature horses in hard work (Björnsdóttir 2005). The lameness can range from mild to severe (Ross 2012).

Initial signs include a sporadic and mild hind limb lameness, which may appear to be only an intermittent “stiffness” that usually gets better as the horse begins to work and warms-up. The main complaints are that the horse seems uncomfortable on one lead and walking downhill, tends to be disunited in canter, is reluctant in using properly its hind limbs or even refuses to jump (Dyson and Ross 2011; Sullins 2011).

Frequently, horses with bone spavin get worse when forced to maintain a collected posture and work forcefully with their hind limbs, which is the most part of the groundwork of a dressage horse and is also very important in a jumping horse during the approach to the obstacles (Latimer 2004).

Over time, usually the lameness exacerbates, gradually becoming obvious and consistent. (Sullins 2011). Chronically affected horses may refuse some movements such as maintaining a certain leg lead or jumping. They may also show discomfort by energetically wagging the tail (Latimer 2004). Generally, the lameness is bilateral but worse in one of the limbs (Dyson and Ross 2011; Ross 2012; Dick Vet Equine Practice 2016).

Horses with bone spavin frequently move with a reduced arc of the foot flight and reduced flexion of the hock, which is also described as a “short – striding choppy gait” or “stab” movement (Björnsdóttir 2005; Sullins 2011; Ross 2012). However, this characteristic gait isn’t pathognomonic of tarsal pain (Dyson and Ross 2011; Ross 2012, Schramme 2016). Since the horse avoids to flex the tarsal region because it is painful and that results in dragging the toes, one or both hind hoofs become squared due to uneven wearing. (Sullins 2011; Ross 2012). Usually, the lateral aspect of the toe and the lateral branch of the shoe suffer greater wear (Schramme 2016).

They may also have bone swelling on the affected hock(s), which is more common on the medial aspect of the region, particularly in the lower region of the hock of the affected limb(s) (Sullins 2011). Besides, these horses may also have painful epaxial muscles in the lumbar region and sometimes also the caudal gluteal muscle due to their abnormal gait (Dyson and Ross 2011; Hague 2012). That is why back pain is a common finding associated with bone spavin (Sullins 2011).

vii. Diagnosis

A correct diagnosis is a key aspect for a targeted and more effective treatment that will have a better chance to allow the horse to return to work (Garrett 2011).

The diagnosis is based in the combination of history of hindlimb lameness, clinical examination, radiographic evaluation and perineural and intra-articular anesthesia (Árnason and Björnsdóttir 2003). During the evaluation, the veterinarian must take into account that the clinical signs are quite variable and there is a poor relationship between pain manifestation and existence of radiographic signs (Björnsdóttir 2005; Dyson and Ross 2011; Hague 2012).

The clinical examination includes a static and a dynamic evaluation of the horse. The veterinarian should examine and palpate the front limbs, hind limbs and back of the horse. In some cases, it is possible to notice proximal suspensory pain in the front, which may be due to the fact that a horse with distal tarsal pain tends to put more pressure on the front limbs. As mentioned before, we may also detect back pain in some horses, which is a common secondary effect of hind limb lameness (Jackman 2006; Dyson and Ross 2011)

During a thorough inspection and palpation of the hind limbs, the veterinarian may find some abnormalities such as a firm subcutaneous swelling or indistinct margins of the distal tarsal joints (Björnsdóttir *et al*. 2000; Jackman 2006). The palpation of this enlargement on the medial aspect of the distal aspect of the tarsus is known as the “Churchill test”. If the horse demonstrates pain, it’s a positive response to the test (Baxter 2004; Bathe 2012; Ross 2012).

Effusion of the TMT and DIT joints is difficult or even impossible to detect (Garrett 2011). In the majority of the cases it isn't noticeable (Dyson and Ross 2011). However, tarsal conformational abnormalities such as "sickle-hocks" or "cow-hocks", which are predisposing factors for the development of the disease, should be noted (Jackman 2006).

In the course of the dynamic part of the lameness exam, the horse is evaluated walking and trotting in a soft and a hard surface, both in straight line and circles, and galloping in circles in a soft surface. The veterinarian should observe the horse from its front, behind and both sides. (Jackman 2006; Dyson and Ross 2011; Carson and Ricketts 2013). In some cases, it may also be helpful to examine the horse when ridden (Jackman 2006).

Suspensory pain is a differential to take into account during the lameness exam. Tarsal pathology and suspensory desmitis are common causes of hindlimb lameness and poor performance. Due to the anatomical proximity of these structures, the differentiation can be difficult. Besides anesthetic blocks, radiography and ultrasonography, the lameness pattern observed during the dynamic part of the lameness exam can be helpful to differentiate hock and suspensory pain. Usually, horses with distal tarsal pain show a more pronounced lameness on hard surfaces, while horses with suspensory pain show more obvious lameness in soft ground (Bathe 2012).

Gait abnormalities such as asymmetrical movement of the *tubera coxae* and *tubera sacrale*, reduced arc of foot flight, toe dragging, shortening of the cranial phase of the stride and reduced extension of the fetlock may be detected. The affected limb may also swing medially during protraction and slide laterally during the stance phase (Dyson and Ross 2011; Schramme 2016). The lameness may be exacerbated on circle, in some cases with the lame limb on the outside and in other horses with it on the inside (Dyson and Ross 2011).

Then, flexion tests are performed in both frontlimbs and hindlimbs (Carson and Ricketts 2013). In some horses with distal tarsal joint pain, flexion tests are useful in exacerbating lameness. It may be preferable to flex first the least affected hind limb. To perform the test, the limb is held for 60 to 90 seconds with the metatarsal region parallel to the ground and then the horse is trotted in straight line. It's considered a positive response of the least affected limb when the gait becomes more balanced (Dyson and Ross 2011; Sullins 2011).

However, the flexion test of the hindlimb isn't specific for the hock region. Although horses with tarsal pain usually have a more pronounced positive response to this test, horses with stifle or hip problems may also have a positive response (Ross 2012).

At this point of the examination we may already have a presumptive diagnosis, however, a conclusive diagnosis requires perineural and joint anesthetic blocks on the affected hindlimb and radiographic exam of both hocks (Jackman 2006). Perineural and intra-articular anaesthesia are useful to define the significance of the radiographic findings and to determine the source of pain when there are no detectable abnormalities in the radiographic exam (Butler *et al*. 2008).

Diagnostic analgesia is crucial to get a correct diagnosis (Ross 2012). Radiography is considered to have low sensitivity in detecting the presence of early DJD. Therefore, in these cases, the disease is diagnosed by identifying the origin of the pain through intra-articular anesthesia (Björnsdóttir *et al*. 2000).

The anesthetic blocks generally used during evaluation of tarsal pain are perineural blocks of the tibial and peroneal (deep fibular) nerves or intra-articular blocks of the tarsocrural, tarsometatarsal or intertarsal joints (Latimer 2004; Dyson and Ross 2011).

Since pain may arise from different structures simultaneously, it is paramount to exclude the possibility of existing other source(s) of pain contributing for the lameness. In order to do that, the veterinarian should execute perineural blocks starting distally in the limb and then progress proximally towards the tarsus. For example, it is essential to differentiate genuine tarsal pain from proximal plantar metatarsal pain and suspensory pain (Ross 2012).

High plantar perineural blocks (blocks of the plantar nerves and plantar metatarsal nerves) should be used to evaluate if there is pain arising from the metatarsal region (Ross 2012). In particular, the block of the lateral plantar nerve or of its deep branch is important to evaluate if the source of the pain is the suspensory ligament, which is the main cause of metatarsal pain (Bathe 2012; Ross 2012).

The perineural analgesia of the peroneal and tibial nerves isn't specific for distal tarsal pain but is helpful to confirm it after excluding other sources of pain distally in the limb (Dyson and Ross 2011). If other nearby structure, such as the tarsal sheath or other synovial compartment, is suspected as the source of pain it should also be properly anesthetized (Garrett 2011).

A joint block is a very effective and specific way of confirming that a joint is painful. However, when there is extensive subchondral bone damage we may obtain a negative response to the intra-articular analgesia, and it can be a mistake to rule out the possibility of distal hock joint pain (Dyson and Ross 2011; Sullins 2011). It is common that horses with subchondral bone pain present a better response to perineural analgesia than to intra-articular analgesia (Dyson 2008).

Besides, when evaluating the responses, the veterinarian must take into account that the intra-articular anesthesia of the intertarsal and tarsometatarsal joints isn´t always specific since they may communicate (Latimer 2004; Dyson and Ross 2011). Several different studies indicate a variable frequency of communication between these two joints (Bell *et al*. 1993). Regardless that, the TMT and DIT joints should be blocked separately (Ross 2012).

Furthermore, in the case of the tarsometatarsal joint the distal pouches of the joint are immediately adjacent to the suspensory ligament. If this ligament is the origin of the pain and the anesthetic diffuses to it, we may get a false positive response to the intra-articular anesthesia (Latimer 2004; Dyson and Ross 2011; Latimer 2004). That is why low volumes of anesthetic should be used in these joints (Bathe 2012).

Arthrocentesis of the TMT joint is an easy procedure, usually done by the plantarolateral approach, proximally to the head of the fourth metatarsal bone. On the contrary, the access to the DIT joint is technically more difficult and more dangerous for the veterinarian due to its medial approach (Bell *et al*. 1993; Ross 2012). The same techniques are used for both diagnostic and therapeutic purposes (Bell *et al*. 1993).

For these procedures, adequate amounts of anesthetic should be used to guarantee proper anesthesia, avoiding false negatives due to insufficient quantity of anesthetic or false positives due to leakage from the joints, for example from the tarsometatarsal joints to the suspensory ligament as mentioned above (Bathe 2012; Ross 2012). It is also important to wait at least 10 minutes after arthrocentesis and 30 minutes after a perineural block to evaluate the response (Ross 2012).

Perineural and intra-articular analgesia is particularly useful to evaluate young horses that work with excessive strain placed on their hocks such as race, dressage and jumping horses. These animals may not present radiographic alterations but already have tarsal pain presumably because in the earlier stages of the disease it may only affect the articular cartilage and periarticular soft tissues (Latimer 2004).

It is considered a positive response when the lameness suffers an improvement of 50% or more (Dyson and Ross 2011).

Radiography is the most used imaging tool for DJD assess and diagnosis, for which it is essential (Björnsdóttir 2005). Since the condition is frequently bilateral, both hocks should be evaluated, even when the lameness is unilateral (Dyson and Ross 2011).

A complete radiographic exam should include the four views mentioned earlier – lateromedial, dorsoplantar, dorsolateral-plantaromedial oblique and dorsomedial-plantarolateral oblique. The horse should be square with the limbs in a proper weight bearing position (Jackman 2006; Butler *et al*. 2008). The x-ray beam should be centered on the distal tarsal joints (Sullins 2011).

Since the lesions usually begin in the dorsomedial aspect of the affected joints, the lateromedial and dorsolateral-plantaromedial oblique projections are the most important

(Latimer 2004; Vanderperren *et al*. 2009a). On the dorsomedial – plantarolateral oblique view, we should pay attention particularly to the dorsolateral margin of the PIT, DIT and TMT joints and search for evidences of osteoarthritis of these joints. On the lateromedial projection, we should evaluate the dorsal aspect of the same joints mentioned above. Here we may also find signs of OA and enthesophytes in the dorsoproximal border of the third metatarsal bone (Santschi 2013).

Despite the lesions tend to develop first in the dorsomedial aspect of the joints, as mentioned before, the radiographic signs are frequently identified first on the dorsolateral aspect of the distal joints (Dyson and Ross 2011). Besides, in some horses, particularly Icelandic horses, DJD commonly affects the dorsolateral aspect of the joints. Therefore, in these cases, the dorsomedial-plantarolateral oblique view is the most suitable for diagnosis (Vanderperren *et al*. 2009a).

A comprehensive radiographic evaluation is very important, particularly in the early stages of the disease, when lesions may only be seen in one view. Even in some advanced cases abnormalities are only visible in one of the four standard views (Jackman 2006; Garrett 2011).

In many cases there isn´t a good correlation between the clinical presentation and the radiological findings – hock lameness can be seen without associated radiographic findings in the tarsal region and extensive abnormalities can exist without detectable lameness (Shelley and Dyson 1986; Dyson and Ross 2011; Bathe 2012). For example, mild irregularity of the joint spaces can be found in both sound and lame horses and single subchondral cysts (particularly cysts that don’t communicate with the joint space) may be clinically silent (Verschooten and Schramme 1994).

Radiographic findings associated with bone spavin (summarized in Table 1) include irregular radiolucent areas in the articular margins, irregularity of the articular space, narrowing or collapse (ankylosis) of the joint space (Figure 3), subchondral bone lysis (rarefaction) (Figure 4) and/or sclerosis, decreased corticomedullary differentiation (sclerosis of the third and/or central tarsal bones), enthesiophytosis of the interosseous foramen, periarticular osteophytes (also described as “lipping”, bone exostosis, periarticular bone proliferation or spurs) (Figures 5 and 6) and/or enthesiophytes (Butler *et al*. 2008; Dyson and Ross 2011; Sullins 2011).

Table 1 - Summary table of the main radiological findings compatible with osteoarthritis (adapted from Caron 2011).

Most frequent Radiological Findings compatible with Osteoarthritis

Radiological Finding	**Pathogenic Mechanism**
Periarticular osteophytosis	Endochondral ossification occurring at bony margins of unknown cause. Possible repair attempt modulated by cytokines present in the joint environment.
(Asymmetrical) joint space thinning	Cartilage degeneration and loss, usually in areas of weight bearing or high stress.
Subchondral increased radiopacity (sclerosis)	Deposition of new bone as a response to changes in force transmission and from healing of trabecular microfractures. Corresponds to areas of maximum stress. Clinically significant sclerosis often corresponds to full-thickness cartilage loss.
Subchondral radiolucency (lysis)	Less common change of uncertain pathogenesis. Possibly caused by pressure necrosis from synovial fluid that access to the subchondral plate through fissures, or by pressure necrosis from trauma to the bone.
Osteochondral bodies	Disintegration of joint surfaces or fractured osteophytes.
Advanced remodeling/ankylosis	Articular response to advanced degeneration.

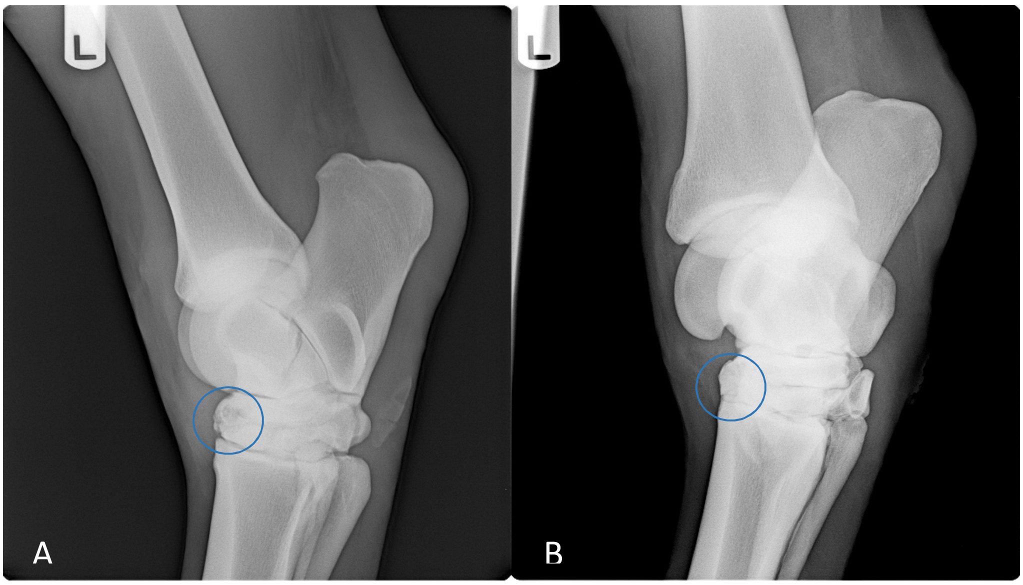


Figure 3 – Lateromedial view (A) and Dorsomedial-plantarolateral oblique view (B) of a left hock, where it is visible the severe narrowing of the joint space in the dorsal half of the DIT joint. There are also bone remodeling and irregularity of the articular margins.

The radiographs should be evaluated wisely because small osteophytes and periosteal new bone may be missed since they are less radiopaque than "normal" bone. Besides, their significance must be interpreted with care - osteophytes may reflect DJD but may also be associated with other problems, such as articular fracture, or may be entheseophytes associated with ligament insertions (Butler *et al*. 2008).

Localized reductions in bone density are pathological. However, bone demineralization has to be quite advanced to be seen in radiographs. Articular margin irregularity (roughened appearance of the joints margins) progresses to marginal demineralization (marginal radiolucency) and joint space destruction. There can also be bone erosions that look like cysts in the subchondral regions of the affected joints, particularly the distal intertarsal joint. Sometimes, this type of injuries may occur in the talus and central tarsal bones (proximal intertarsal joint) (Shelley and Dyson 1986).

Reduction on joint width is a sign of intra-articular degeneration and may evolve to partial or complete ankylosis. There are cases of complete ankylosis of the distal intertarsal and/or the tarsometatarsal joints without associated subchondral bone lysis, bone surface roughness or lameness (Shelley and Dyson 1986).

Bony spurs are common in the central and third tarsal bones and the third metatarsal bone (distal intertarsal and tarsometatarsal joints). Although their clinical significance is related with their proximity to the articular margins and presence of other abnormalities, their presence usually indicates significant intra-articular damage.

Figure 4 - DLPMO view of a left tarsus with OA of the DIT joint. There is subchondral radiolucency on the medial aspect of the joint (arrow). Adapted from Dyson and Ross (2011).

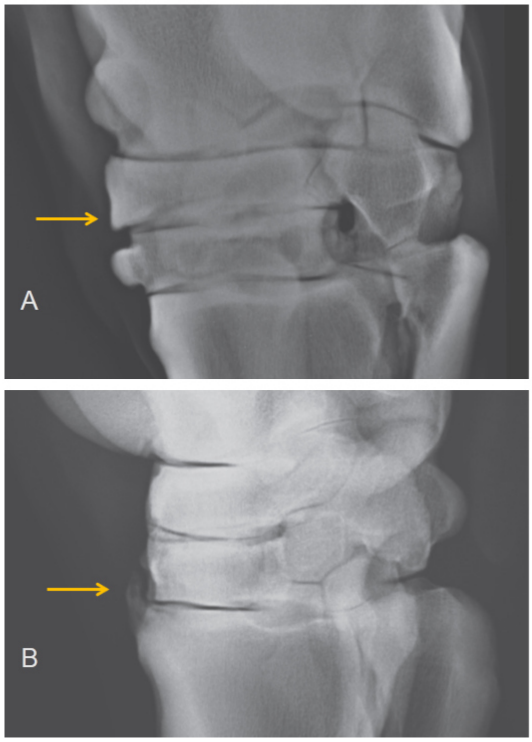


Figure 5 – A: DLPMO view of a left tarsus with mild periarticular ostheophytosis (arrow) on the distal dorsomedial aspect of the central tarsal bone and increased radiopacity of the adjacent trabecular bone. B: LM view of a left tarsus with large periarticular osteophytosis on the dorsoproximal aspect of the third metatarsal bone (arrow) in the TMT joint. Adapted from Dyson and Ross (2011).

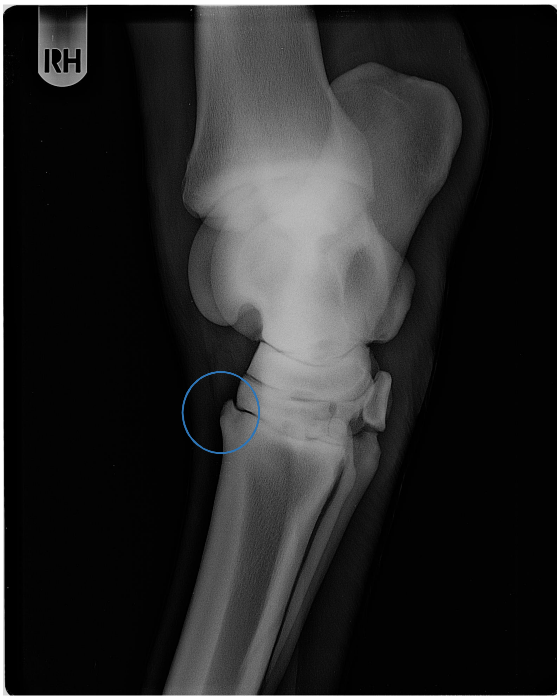


Figure 6 - DMPLO view of a right tarsus with OA of the TMT joint. There is mild periarticular bone neoformation ("lipping") on the dorsoproximal aspect of the third metatarsal bone.

For example, the complete obliteration of the tarsal canal by new bone is usually associated with severe intra-articular damage and extensive periarticular proliferation. If associated with subchondral radiolucency, new bone proliferation looks irregular and active (Shelley and Dyson 1986).

Finally, the shape of the central and third tarsal bones should be evaluated to detect cases of osteoarthritis secondary to tarsal bone collapse (Butler *et al*. 2008).

Currently, there is none standard system to evaluate and classify radiographic signs of bone spavin. However, Byam-Cook and Singer (2009) created their own classification system to evaluate 3 radiographic signs – "Subchondral bone sclerosis", "Subchondral bone lysis" and "Periarticular modelling" – and classify them as non-existent (0) mild (1), moderate (2) or marked (3). By summing up the values of each sign, it is obtained the classification of the osteoarthritis of the studied joints (0 – 4 = mild; 5 – 8 = moderate; 9 – 12 = severe).

Ultrasonography has a limited diagnostic value. The distal tarsal joints have a narrow width that limits the evaluation of the joint capsule, articular cartilage and intertarsal ligaments (Jackman 2006). However, in the accessible areas it is possible to assess cartilage degeneration, thinning of the articular surface in loaded areas, osteophyte and/or enthesiophyte formation, joint space thickening and, in more chronic cases, synovial chondromas (Vanderperren *et al*. 2009a). It is also possible to evaluate both the long and short components of the medial and lateral collateral ligaments (Jackman 2006).

Scintigraphy and MRI can be used to detect more subtle changes in cases with uncommon presentation or inconclusive radiographs and responses to perineural analgesia tests (Jackman 2006; Dyson 2008; Vanderperren *et al*. 2009a). MRI and TC have more sensitivity to detect subchondral bone pathology than radiography because they provide information about osseous activity (Dyson 2008).

For example, in a scintigraphy exam, an inflamed distal tarsal joint without radiographic abnormalities commonly has increased uptake of the isotope used (Latimer 2004).

viii. Treatment options

Bony changes aren´t reversible. Consequently, the treatment goals are to reduce pain associated with motion and compression of the arthritic joints (through reduction of inflammation or reduction of joint motion), slow down the progression of the disease and make it possible for the horse a progressive return to work (Latimer 2004; Jackman 2006; Carson and Ricketts 2013). In athletic horses with mild to moderate lameness, the treatment aims a return to soundness and to the prior level of performance (Garrett 2011). Therefore, in this cases, pain management should allow adequate joint movement, loading and flexion (Latimer 2004).

In the past, the most common therapeutic options included rest, cunean tenotomy, modified cunean tenotomy, firing and corrective shoeing (Edwards 1982).

Nowadays, there are several medical and surgical treatment options available, which include corrective trimming and shoeing, intra-articular injections of corticosteroids, administration of glucosamine and chondroitin supplements, adaptation of work program, extracorporeal shock wave therapy (ESWT), interleukin-1 receptor antagonist protein (IRAP) therapy, surgical fusion of the small tarsal joints (arthrodesis), surgical stabilization of the joints and neurectomy of the tibial and peroneal nerves (Baxter 2004; Dyson and Ross 2011). While medical treatment aims to minimize inflammation, surgical options are used to stabilize the affected joints preventing their movement, which is the cause of pain (Latimer 2004).

The treatment selection depends on several aspects such as the degree of lameness, type and extent of radiographic abnormalities, type of work performed and workload, and previous treatments and response to them (Dyson and Ross 2011). The initial treatment depends on the radiographic signs found. Horses with no to minimum radiographic abnormalities usually respond positively to exercise restriction, corrective trimming and shoeing and intra-articular medication. (Sullins 2011).

With medical management it is possible to keep most of the horses in training and performing (Gutierrez-Nibeyro 2016).

Non-steroidal anti-inflammatory drugs (NSAIDs) are used for pain management. Phenylbutazone (2,2 – 4,4 mg/kg SID or BID) may be used for 2 – 3 weeks as an attempt to reduce pain and inflammation while maintaining the horse’s workload (Latimer 2004; Sullins 2011).

The intra-articular administration of corticosteroids into the affected joints such as methylprednisolone, betamethasone and triamcinolone is a common treatment used to limit joint inflammation. The goals are to manage lameness and keep the horse on work, what is an important advantage when treating horses in seasonal competitions (Latimer 2004).

Most horses benefit from this type of treatment. In horses with advanced OA of the distal tarsal joints, the negative effects of the corticosteroids on the articular cartilage are negligible because there is no more chance of restoring the cartilage of the affected joints (Baxter 2004).

Corticosteroids may be used alone or in association with hyaluronic acid (in the form of sodium hyaluronate), which is a chondroprotective agent with anti-inflammatory properties and that helps reestablishing the joint environment (Jackman 2006; Sullins 2011).

The most commonly used drugs for intra-articular administration of the distal tarsal joints (DIT and TMT joints) are methylprednisolone (60 – 80mg/joint) and the association of triamcinolone (4 – 6 mg/joint) with sodium hyaluronate (Dyson and Ross 2011; Sullins 2011). These three pharmaceuticals can also be used together, for example, administrating 10 mg of hyaluronic acid, 3 mg of triamcinolone and 40 mg of methylprednisolone to each joint (Hague 2012).

After an intra-articular administration of corticosteroids, it is recommended to administrate systemic medication, such as phenylbutazone (2,2mg/kg SID), for a week to help decrease any post injection joint flair that may occur (Dyson and Ross 2011; Sullins 2011). A period of about 1 – 2 weeks of reduced exercise after the injection is also advised to improve the response to the intra-articular medication and to allow the treated joints to recover from any soft tissue damage and haemorrhage that may be caused during the arthrocentesis (Latimer 2004; Sullins 2011).

The duration of pain relief is quite variable, but usually ranges from 4 to 6 months (Latimer 2004; Jackman 2006; Hague 2012). In some horses, after multiple injections, their efficacy and duration of pain relief tend to diminish (Hague 2012).

The majority of the horses can be successfully managed throughout their athletic careers with periodic intra-articular administration of corticosteroids on the DIT and TMT joints (Latimer 2004; Jackman 2006). However, since bone spavin usually includes narrowing of joint space, it is progressively harder to make the intra-articular administrations (Gutierrez-Nibeyro 2016).

Besides, horses that have had repeated intra-articular injections and horses with advanced osteoarthritis may not respond as well as less affected horses. One possible explanation is that the repeated use of corticosteroids enhances the articular cartilage catabolism, accelerating the degenerative changes of it (Latimer 2004). Other explanation is that keeping the horse at work continues to cause repetitive strain on the arthritic joints, leading to further progression of the disease (Jackman 2006).

The tarsometatarsal and the distal intertarsal joints are the most frequently medicated, coinciding with the fact that these are the most affected joints by this disease. Since we don't know if the joints communicate, they should be treated separately when both of them have radiographic signs of OA (Latimer 2004; Dyson and Ross 2011; Baxter 2004). Although some studies suggest that therapeutic concentrations are achieved in the DIT joint by injecting only the TMT joint, higher doses are obtained by medicating both joints (Dyson and Ross 2011).

Other commonly used drug in equine osteoarthritis is Tiludronate. Its main pharmacological action is to inhibit bone resorption by osteoclasts. That slows down bone remodeling and helps in recuperating a normal balance between bone resorption and formation. By decreasing the resorptive process it alleviates the pain associated with abnormal bone lysis (Jackman 2006; Gutierrez-Nibeyro 2016).

It has also anti-inflammatory properties: decreases the amount of nitric oxide and cytokines released from activated macrophages (promoters of early inflammation responses) and prevents the secretion of cartilage-degrading enzymes induced by interleukin – 1 (Gutierrez-Nibeyro 2016).

Besides corticosteroids and Tiludronate, other frequently used drugs include chondroprotective agents such as hyaluronic acid (IV) and polysulfated glycosaminoglycans (IM) and oral nutraceuticals with chondroitin sulfate and glucosamine (Latimer 2004; Sullins 2011).

The pharmacological treatment must be combined with a proper exercise plan and shoeing. It is better to decrease the intensity of workload but never stop it completely – light exercise is much preferable than no exercise or just leave the horse in a paddock (Baxter 2004; Sullins 2011). Some horses improve with a decrease in their workload and adaptation of the type of exercise that they have to perform (Baxter 2004).

Correct trimming and shoeing is important to correct unbalanced loading and strain (caused by rotation and shear forces) over the affected joints, ensuring a correct mediolateral balance. Shoes with a rolled or squared toe that facilitate the breakover phase of the stride are good options. That will help to reduce the arc of flight and concussion of the joint surfaces during high-speed or collected work (Latimer 2004; Dyson and Ross 2011; Sullins 2011).

The use of heel was thought to be helpful to support maintaining a straight pastern axis. However, heel calks (and toe grabs) may increase shear stress on the distal hock joints. Thus it may be preferable to use flat shoes (Dyson and Ross 2011).

Lateral extensions can also be used in the shoe to avoid excessive twisting of the limb, which will cause symptomatic relief. However, they are contraindicated in horses that have to stop and turn quickly because they may dig and stop abruptly the toe, generating a twisting force over the more distal joints of the limb (Dyson and Ross 2011).

Extracorporeal shock wave therapy (ESWT) is a recent medical therapy used for pain management in many musculoskeletal injuries in horses. It consists in using direct pressure waves to the specific area of the body that is being treated. These waves cause a compressive force as they cross from a region of low impedance to a region of high impedance, such as in a bone – soft tissue interface (McCarroll and McClure 2000; Gutierrez-Nibeyro 2016).

The focused shock waves are thought to stimulate bone remodeling, increase blood flow, stimulate cellular metabolism and provide short term analgesia (Baxter 2004). It is assumed that the analgesic effect is due an altered pain perception by the central nervous system, altered intraosseous pressure, strengthening of periarticular soft tissues or decreased subchondral bone edema (Gutierrez-Nibeyro 2016).

The analgesic effects have been evaluated only on subjective assessments. In some horses the lameness decreases for a few months after treatment, while in others there isn´t improvement (Jackman 2006; Gutierrez-Nibeyro 2016).

Surgical treatments are the last therapeutical options to be taken into consideration, and only when the previously presented conservative options don't have the expected results. There are several techniques developed for surgical arthrodesis or to accelerate the normal process of ankylosis that most likely will occur in the arthritic joints over time. Once these joints are stable, the lameness will stop in most of the cases (Sullins 2011; Dick Vet Equine Practice 2016).

Surgical options include subchondral forage/fenestration to reduce intraosseus pressure, internal fixation with bone screws and plates (surgical arthrodesis), cunean tenotomy, neurectomy of the tibial and deep peroneal nerves, osteophyte removal (through small arthrotomy), and drilling the articular surfaces (e.g. 3-drill tract technique) and surgery with diode laser to promote facilitated arthrodesis (Latimer 2004; Jackman 2006; Dyson and Ross 2011).

The last two techniques are used to remove the articular cartilage and expose subchondral bone surface beneath it. That promotes the adhesion between the adjacent bone surfaces and stabilizes the joint (Latimer 2004; Jackman 2006; Dyson and Ross 2011). The laser surgery may be preferable because the heat can also damage nerve endings, reducing pain perception. The combined use of both techniques may be beneficial. While the drilling stimulates more bone production and fusion, the laser reduces post-operative pain (Jackman 2006).

Subchondral forage/fenestration consists in drilling tracts across the subchondral bone in order to reduce subchondral pressure, which is secondary to bone sclerosis (Jackman 2006; Dyson and Ross 2011). During surgery the articular cartilage is removed but the periarticular ligaments are kept to stabilize the joints (Gutierrez-Nibeyro 2016).

Cunean tenotomy causes a pressure reduction over the medial aspect of the distal tarsus and cunean bursa. Since the cunean tendon has an oblique path over the dorsomedial aspect of the distal tarsus, the tenotomy may diminish the rotational and shearing forces over these joints during the contraction of the *tibialis cranialis* muscle (Eastman *et al*. 1997; Jackman 2006; Dyson and Ross 2011).

Besides surgical arthrodesis, ankylosis can be promoted using some drugs (chemical arthrodesis), such as sodium monoiodoacetate and 70% ethyl alcohol (Jackman 2006; Carmalt *et al*. 2010; Dyson and Ross 2011). For example, sodium monoiodoacetate is a caustic and chondrotoxic substance used to promote chemical fusion of the treated joint (Latimer 2004). Some veterinarians use methylprednisolone to accelerate or promote joint ankylosis by promoting cartilage destruction with high doses of corticosteroids (Hague 2012; Gutierrez-Nibeyro 2016). However, this may never lead to radiographic evidences of bony fusion (Hague 2012).

These techniques require contrast arthrography to make sure that the needle is correctly placed in the affected joints. It is also necessary to confirm that there is no communication between the affected joins and the other tarsal joints. Otherwise, some of the chemical may diffuse to the healthy proximal joints and cause arthritis (Baxter 2004; Jackman 2006; Dyson and Ross 2011). However, even with no obvious communication between the distal and proximal tarsal joints, there were cases in which the chemical compound used reached the PIT and TT joints (Baxter 2004; Jackman 2006; Dyson and Ross 2011).

Intra-articular administration of ethyl alcohol in horses with distal tarsal arthritis results in a rapid improvement of the lameness and promotes joint space collapse. However, it may never lead to complete ankylosis (Carmalt *et al*. 2010).

Arthritis of the proximal intertarsal and tibiotarsal joints, severe lameness, persistent swelling and skin sloughing are some of the possible secondary effects of the administration of sodium monoiodoacetate or ethyl alcohol (Jackman 2006).

ix. Prognosis

The outcome depends on several aspects, such as the number and which joints are affected, severity of the abnormalities found, progression of the disease and type of exercise that the horse is used for (Byam-Cook and Singer 2009; Dick Vet Equine Practice 2016). It also depends on the type of treatment used. More aggressive therapies are correlated with poorer prognosis for athletic function. However, most horses still have a positive result (Jackman 2006).

The results of a study performed in Liverpool suggest that there isn't correlation between the duration and degree of lameness, the response to intra-articular anaesthesia and radiographic findings. However, horses that responded well to treatment are more likely to have a milder form of osteoarthritis of the TMT joints (Byam-Cook and Singer 2009).

The prognosis for athletic performance is good for the majority of the horses. However, horses with advanced DJD of the distal tarsal joints at an early age have a guarded prognosis for maintenance of soundness only with medical therapy. In these cases, surgical therapies may offer a better option to keep the animals working and competing (Latimer 2004). Horses with osteoarthritis of the PIT joint and extensive radiolucent defects of subchondral bone also have a more guarded prognosis (Dyson and Ross 2011).

II. Objectives

The present project aims the radiographic study of distal tarsal osteoarthritis in a population of Puro Sangue Lusitano horses.

Since there is very little studied about the disease in this particular breed, it is intended to:

a. Estimate the prevalence of the disease in a population of Lusitano horses;
b. Estimate and compare the prevalence of bone spavin according with gender;
c. Evaluate the correlation of the presence of radiographic signs of bone spavin with the presence of clinical signs of the disease (hindlimb lameness);
d. Estimate and compare the prevalence of distal tarsal OA in the left and right *tarsi*;
e. Identify the most commonly affected joints;
f. Identify the most common radiographic signs of BS and characterize them regarding their frequency, type and severity;
g. To study the Juvenile Bone Spavin in a population of Lusitano horses within the corresponding age range:
    i. Estimate the prevalence of Juvenile Bone Spavin;
    ii. Identify the most affected joints in these animals;
    iii. Identify the most common radiographic signs of BS and characterize them regarding their frequency, type and severity;
h. Compare our values with the ones published for other equine breeds.

III. Materials and Methods

a. Animals included in the Study

They were admitted to this study all Puro Sangue Lusitano horses subjected to radiographic examination of the tarsal region of the hind limbs during ambulatory clinical activity from January of 2010 to August of 2016.

Where accepted in this study only horses with radiographic projections of both *tarsi.* While otherwise it is advisable, no restrictions were placed regarding a minimum number of radiographic projections of each hock.

The horses were examined in the context of follow-up evaluations (horses at work and/or competing), screening of broodmares and yearlings, and pre-purchase exams. Animals less than 12 months old weren't included in the study.

The anonymity of the animals' data was guaranteed.

b. Sample Data

All the animals accepted in the present study were registered in the Puro Sangue Lusitano studbook. For each horse the following data were collected: date of the exam, age at the time of the exam and gender.

For the animals that were evaluated in the context of pre-purchase exam, the presence of hind limb lameness was also registered. For the remaining animals, particularly broodmares, colts and fillies, this type of information wasn't available, therefore wasn't collected.

c. Radiographic Evaluation

Whenever possible, the four standard views (LM, DP, DLPMO and DMPLO) of the left and right tarsus were used for evaluation. However, all horses with at least one radiographic view of both hocks were accepted in the study.

Every horse with one or more radiographic signs compatible with OA of the tarsal region was considered positive for the disease. Since there is no standardized evaluation system for the radiographic signs of the disease, a classification system was adapted for this study based on the criteria used by Byam-Cook and Singer (2009) and Branch *et al*. (2007), mentioned in the literature review. Thereby, the radiographic signs “joint space narrowing”, “subchondral bone sclerosis”, “subchondral bone lysis”, “irregularity of the articular margin” and “osteophyte/new bone formation” were graded in a scale of 0 – 3 (0 = none; 1 = mild; 2 = moderate; 3 = marked) for each joint. Then, an overall grade of the severity of the radiographic signs was assigned to each joint by summing up the scores of the five radiographic signs evaluated (0 to 5 = mild; 6 to 10 = moderate; 11 to 15 = severe).

All radiographic images were acquired with an imaging system of digital indirect radiography. It was used a *Fuji Capsula CR* scanner to reveal the digital images, which were then processed to optimize definition, brightness and contrast with the *Fuji Computed Radiography* program. The radiographic images were obtained and evaluated by the veterinarian surgeons working at the practice at the time. For the purpose of the present study, all radiographic images were re-evaluated by two of the authors of this work.

d. Formation of Groups

In order to characterize the population and the disease, the animals were grouped according to gender (males and females) and age (animals less than 2 years old were included in the “Juvenile Bone Spavin” group; and the remaining in the “Adult” group).

The horses that were radiographed in context of pre-purchase exam were evaluated aside to estimate the relationship between presence of radiographic signs and clinical manifestation (hindlimb lameness).

The prevalence of distal tarsal osteoarthritis was also evaluated separately in left hocks and right hocks, in order to test if there was a significant difference between them.

e. Statistical Analysis

The statistical study of the data was carried out using specialized software of statistical processing. The organization, edition and coding of the collected data were done with the Microsoft® Office 365 ProPlus Excel software. The statistical analysis was made with the SPSS® Statistics software, version 24.0.

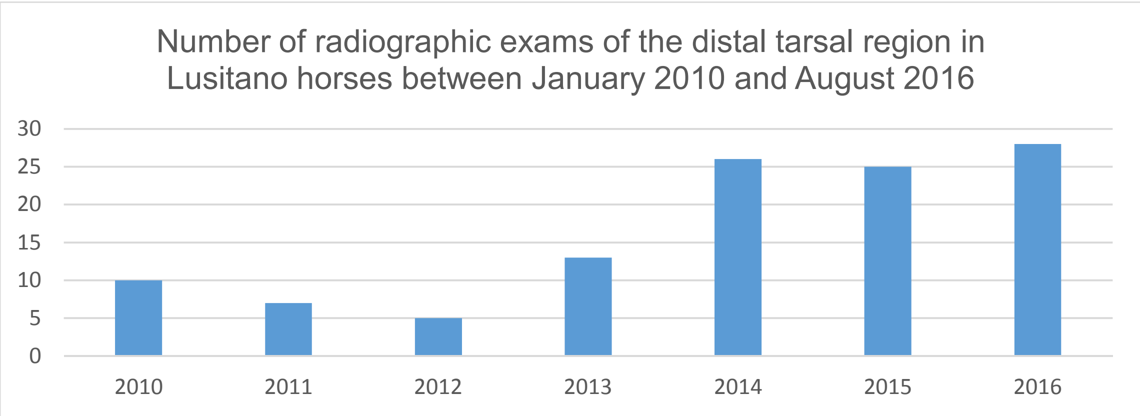
The descriptive statistical analysis included the calculation of the arithmetic mean and standard deviation of the age of the animals in the entire population and in the “Juvenile Bone Spavin” group; and the calculation of the frequency of osteoarthritis and of the different radiographic signs evaluated in each joint.

In the entire population and in the “Juvenile Bone Spavin” group that entered the present study, a Qui-Square test was performed to evaluate the BS prevalence distribution according with gender (male or female) and side (left or right tarsus). The significance level for the obtained results was set at $p < 0{,}05$.

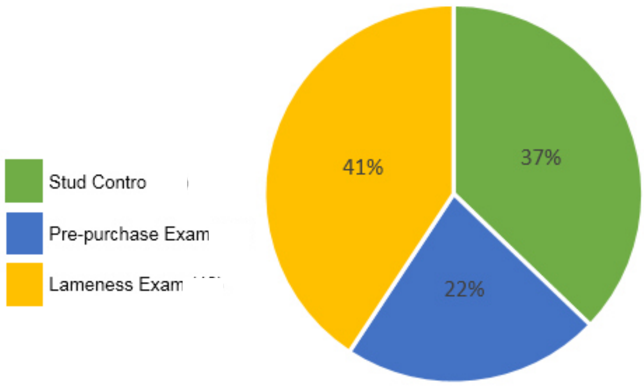
IV. Results

Were included in the present study 104 Lusitano horses, being 76 males (73,1%) and 28 females (26,9%). The horses were aged between 12 months and 19 years old and the medium age was 5,2 years (± 3,5 years). The animals were from several breeding studs and individual owners mainly located in the Alentejo and Ribatejo regions (Portugal).

Over the period of time covered by the present study, the number of Lusitano horses that were submitted to radiographic evaluation of the tarsal region tended to increase, as demonstrated in Graphic 1. As represented in Graphic 2, of these exams, 25 were performed during pre-purchase exams and 42 exams were done as check-up exams of broodmares and yearlings in stud farms. The remaining 46 exams were performed during lameness exams.



Graphic 1 - Number of radiographic exams of the distal tarsal region performed in Lusitano horses between January 2010 and August 2016.



Graphic 2 - The radiographic evaluations were performed in context of checkup exams of stud animals (broodmares and their progeny), pre-purchase exams and lameness exams.

As mentioned before, were accepted in the present study all PSL horses that underwent radiographic exam of the tarsal region. Of 104 (100%) horses, 21 (20,2 %) had all four radiographic projections of both hocks, 14 (13,5%) horses had 3 radiographs of each hock, 60 (57,7%) horses had only 2 radiographic projections of each hock. For the remaining 9 (8,7 %) horses was obtained only one radiograph of each hock.

As summarized in Table 2, of the 104 animals, 53 (51,0%) horses presented radiographic signs of BS, being 16/53 females (30,2% of the horses with bone spavin) and 37/53 males (69,8% of the positive horses). The remaining 51 (49,0%) horses didn't present radiographic signs of distal tarsal osteoarthritis.

Of the 53 positive horses, 36 horses (67,9% of the positive population) presented radiographic alterations in both hocks and 17 (32,1%) showed radiographic changes of the tarsal region in one of the hindlimbs. Of these, 5/53 horses (9,4%) had signs in the right tarsus and 12/53 (22,6%) had it in the left tarsus.

Table 2 – Sum up of the horses with positive and negative radiographic diagnosis of Bone Spavin.

	Total Horses	**By Gender/ Affected Hock(s)**	**Number of Horses**	**% in the positive horses**	**% in all the population**
W/ Bone Spavin	53	Males	37	69,8	35,6
		Females	16	30,2	15,4
		Only Right	5	9,4	4,8
		Only Left	12	22,6	11,5
		Both Hocks	36	67,9	34,6
W/ Bone Spavin	51	----------		----------	49,0

The prevalence of distal tarsal osteoarthritis was also estimated by gender. The results are presented in Table 3. Of the 76 male horses that entered this study, 37 (48,7%) were diagnosed with bone spavin. Of the 28 female horses that entered this study, 16 (57,1%) had a positive diagnosis, without significant statistical differences.

Table 3 - Prevalence of Bone Spavin by gender.

	♂		♀	
	Number of Males	**% in the Group of Males**	**Number of Females**	**% in the Group of Females**
W/ Bone Spavin	37	48,7	16	57,1
W/O Bone Spavin	39	51,3	12	42,9
Total	76	100	28	100

Besides the radiographic evaluation required for this study, for the animals examined in the context of pre-purchase exam, it was also studied if there was an association between the presence of hindlimb lameness and the presence of radiographic signs of bone spavin. The results are presented in Table 4.

Of the 25 horses submitted to pre-purchase exam, 6 (24,0%) horses presented radiographic signs of OA of the distal tarsal joints. Only one of the horses had signs of moderate osteoarthritis in one joint. The remaining 5 horses were diagnosed with mild osteoarthritis of one or more joints.

None of the horses submitted to pre-purchase exam presented hindlimb lameness. Therefore, it wasn't possible to stablish a correlation between the presence of radiographic signs and presence of hindlimb lameness.

Table 4 - Prevalence of Bone Spavin and Hindlimb Lameness in the horses submitted to pre-purchase exam.

Pre-purchase Exam		**W/ Bone Spavin**		**W/O Bone Spavin**	
		Nº	Prevalence in this group	Nº	Prevalence in this group
Bone Spavin	Mild	5	20,0%	19	76,0%
	Moderate	1	4,0 %		
	Severe	0	0,0%		
Hindlimb Lameness	Positive	0	0,0%	0	0
	Negative	6	24,0%	20	76,0%
			Total horses		25

The prevalence of bone spavin was also calculated in each *tarsi* (Table 5). Since this study included 104 horses, we have a total of 208 hocks (104 left and 104 right hocks). As shown, there were more arthritic left hocks (total of 48/208 hocks - 23,1%) than right hocks (41/208 - 19,7%), without significant statistical differences.

Table 5 - Prevalence of Bone Spavin - left hock *versus* right hock.

		Left Tarsus	**Right Tarsus**
Arthritic	Number	48	41
	% (n = 104)	46,2	39,4
	% (n = 208)	23,1	19,7
Normal	Number	56	63
	% (n = 104)	53,8	60,6
	% (n = 208)	26,9	30,3
Total *Tarsi*		104	104
		208	

Besides the calculation of the prevalence in the population, by gender and by left and right *tarsi*, it was recorded the type of OA (mild, moderate or severe) diagnosed in each type of studied joints (PIT, DIT and TMT). The results are presented below.

As indicated in Table 6, it was evaluated a total of 318 tarsal joints in the horses with positive radiographic diagnosis of bone spavin (53 horses x 2 hocks x 3 joints).

In these 53 horses, were found radiographic lesions in 129 joints. The other 189 tarsal joints didn't show radiographic alterations compatible with osteoarthritis. Of the positive joints, 73 (56,6% of the 129 affected joints) were left tarsal joints and 56 (43,4%) were right tarsal joints. The great majority of the OA (122 of the 129 diagnosed OA) were classified as mild.

The most affected joints were the tarsometatarsal joints, with 42 (32,6%) of the total affected joints on the left and 37 (38,7%) arthritic joints on the right.

Table 6 - Distribution of the left and right joints evaluated, total of joints diagnosed with bone spavin and classification of the osteoarthritis as mild, moderate or severe, in the 53 positive horses.

		Radiographic Exam					
		Left Hindlimb			Right Hindlimb		
		PIT	**DIT**	**TMT**	**PIT**	**DIT**	**TMT**
Total joints (53 horses)		53	53	53	53	53	53
Mild OA		3	26	41	1	15	36
Moderate OA		0	1	1	0	1	1
Severe OA		0	1	0	0	2	0
Total joints of each	Number (%) (n = 129 arthritic joints)	3 (2,3)	28 (21,7)	42 (32,6)	1 (0,8)	18 (14)	37 (28,7)
Total joints	Number (%) (n = 129 arthritic joints)	73 (56,6)			56 (43,4)		
Total joints evaluated		159			159		
Total affected joints		129					
Total of joints evaluated		318					
Total of positive animals		53					

They were also accounted all the radiographic signs found in all the studied joints of the unsound animals.

The most common radiographic signs of osteoarthritis were "Joint space narrowing", which was present in 80/129 joints (58,4% of the arthritic joints) and "Osteophytosis/new bone formation", which was identified in 83/129 joints (60,6% of the arthritic joints). The less common radiographic sign was "Subchondral bone sclerosis" with a total of 7 joints (5,1% of the unsound joints).

The sum prevalence of all lesions surpasses 100% because the majority of the affected joints presented more than one radiographic sign of distal tarsal osteoarthritis. These results are all presented in Table 7.

Table 7 - Summary of all the radiographic signs identified and their prevalence.

	Total of affected joints		
Total of Lesions	Number of joints that presented the lesion	Prevalence of each lesion in all the arthritic joints (n = 129)	Prevalence of each lesion in all the studied joints of the positive horses (n = 318)
Joint space narrowing	80	58,4%	25,2%
Subchondral bone sclerosis	7	5,1%	2,2%
Subchondral bone lysis	18	13,1%	5,7%
Irregularity of the articular margins/lines	69	50,4%	21,7%
Osteophyte/new bone formation	83	60,6%	26,1%

Lastly, were accounted all the radiographic signs found in the 3 types of joints (PIT, DIT and TMT joints) that can be affected by bone spavin.

As presented in Table 8, the proximal intertarsal joints with osteoarthritis (n=4, being 3 left PIT joints and 1 right PIT joint) showed a relatively small number of radiographic signs of bone spavin. None of the radiographic signs in these joints were classified as severe or as moderate (the totality of the lesions was classified as mild).

The most common radiographic sign was “Irregularity of the articular margins/lines”, which was found in all 4 (100%) PIT joints diagnosed with osteoarthritis. “Subchondral bone sclerosis” wasn’t present in any joint.

Table 8 – List of all the radiographic signs of Bone Spavin identified and classified in the PIT positive joints (n=4).

Lesion	Severity	Arthritic joints that show the sign		
		Number	Number	% (n = 4)
Joint space narrowing	Mild	2	2	50
	Moderate	0		
	Severe	0		
Subchondral bone sclerosis	Mild	0	0	0
	Moderate	0		
	Severe	0		
Subchondral bone lysis	Mild	1	1	25
	Moderate	0		
	Severe	0		
Irregularity of the articular margins/lines	Mild	4	4	100
	Moderate	0		
	Severe	0		
Osteophyte/new bone formation	Mild	2	2	50
	Moderate	0		
	Severe	0		
		Total	9	

A total of 46 DIT (28 left and 18 right) joints was diagnosed with osteoarthritis. These distal intertarsal joints showed a total of 84 radiographic signs of osteoarthritis. Only 3 of the radiographic signs in these joints were classified as severe. The majority of the lesions found was mild, with exception for the “Subchondral bone sclerosis” and “Subchondral bone lysis” – a bigger number of these lesions was classified as moderate.

The most recurrent radiographic sign was “Joint space narrowing”, which was present in 34 joints (73,9% of the DIT arthritic joints). “Subchondral bone sclerosis” was the less frequent sign, being present in only 6 joints (13,0% of the DIT arthritic joints). These findings are summarized in Table 9.

Table 9 – List of all the radiographic signs of Bone Spavin identified and classified in the DIT positive joints (n=46).

Lesion	Severity	Arthritic joints that show the sign		
		Number	Number	% (n = 46)
Joint space narrowing	Mild	29	34	73,9
	Moderate	4		
	Severe	1		
Subchondral bone sclerosis	Mild	1	6	13,0
	Moderate	4		
	Severe	1		
Subchondral bone lysis	Mild	4	9	19,6
	Moderate	4		
	Severe	1		
Irregularity of the articular margins/lines	Mild	17	20	43,5
	Moderate	0		
	Severe	3		
Osteophyte/new bone formation	Mild	15	15	32,6
	Moderate	0		
	Severe	0		
		Total	84	

The radiographic signs found in the tarsometatarsal joints are listed in the table below (Table 10). We have a total of 79 TMT joints diagnosed with osteoarthritis. In these, were identified 164 radiographic alterations, which is more than the radiographic signs of osteoarthritis found in the proximal intertarsal and distal intertarsal joints.

As well as in the proximal intertarsal joints, none of the radiographic signs in the TMT joints were classified as severe. A large majority of the lesions found was considered mild. The most common radiographic sign was “Osteophyte/new bone formation”, which was identified in 66 TMT arthritic joints (% of the 79 TMT unsound joints). The less common radiographic sign was “Subchondral bone sclerosis”, which was found in only 1 joint (1,3%).

Table 10 – List of all the radiographic signs of Bone Spavin identified and classified in the TMT positive joints (n=79).

Lesion	**Severity**	**Arthritic joints that show the sign**		
		Number	Number	% (n = 79)
Joint space narrowing	Mild	43	44	55,7
	Moderate	1		
	Severe	0		
Subchondral bone sclerosis	Mild	1	1	1,3
	Moderate	0		
	Severe	0		
Subchondral bone lysis	Mild	6	8	10,1
	Moderate	2		
	Severe	0		
Irregularity of the articular margins/lines	Mild	43	45	57,0
	Moderate	2		
	Severe	0		
Osteophyte/new bone formation	Mild	61	66	83,6
	Moderate	5		
	Severe	0		
		Total	164	

The results of the separate evaluation of the data of the "Juvenile Bone Spavin Group" are presented in Tables 11 to 15. This group was composed of 9 males and 6 females, with mean age of 1,3 years (± 0,5 years). Of the total 15 animals, 11 (73,3%) presented radiographic signs of bone spavin. Of the positive animals, 8/15 were colts (53,3% of the entire group) and 3/15 were fillies (20,0%).

Table 11 - Prevalence of distal tarsal osteoarthritis in the "Juvenile Bone Spavin" group (n=15).

	Number of Horses	**% in the Group (n=15)**	**By Gender**		**% in the Group (n=15)**
W/ Bone Spavin	11	73,3	♂	8	53,3
			♀	3	20,0
W/O Bone Spavin	4	26,7	♂	1	6,7
			♀	3	20,0
Total	15	100	15		

Since the “Juvenile Bone Spavin” group includes 15 animals, a total of 30 hocks was evaluated. As shown in Table 12, 17 *tarsi* (56,7% of the hocks of the 15 animals in this group) had a positive radiographic diagnosis of bone spavin. The left *tarsi* were the most affected in this group of animals, with a total of 10 (66,7%) left hocks with radiographic signs of OA, whereas the right *tarsi* were least affected, without significant statistical differences.

Table 12 - Prevalence of bone spavin by hock in the “Juvenile Bone Spavin” group (n=30).

		Left Tarsus	Right Tarsus
Arthritic	Number	10	7
	% (n = 15)	66,7	46,7
	% (n = 30)	33,3	23,3
	Number (%) (n = 30)	17 (56,7%)	
Normal	Number	5	8
	% (n = 15)	33,3	53,3
	% (n = 30)	16,7	26,7
Total *Tarsi*		15	15
		30	

As indicated in Table 13, none of the horses in the “Juvenile Bone Spavin” group present signs of osteoarthritis in the Proximal Intertarsal joints. The majority of the arthritic joints were left joints (60,9%). Of the 33 right joints evaluated in positive animals, only 9 (39,1%) presented radiographic signs of bone spavin.

The most affected joints were the left TMT joints (43,4% of the unsound joints) and the right TMT joints (26,1%).

Table 13 - Distribution of the left and right joints evaluated, total of joints diagnosed with Bone Spavin and classification of the osteoarthritis as mild, moderate or severe in the "Juvenile Bone Spavin" group.

		Radiographic Exam					
		Left Hindlimb			Right Hindlimb		
		PIT	**DIT**	**TMT**	**PIT**	**DIT**	**TMT**
Total joints (of the positive horses)		11	11	11	11	11	11
Mild OA		0	4	10	0	3	6
Moderate OA		0	0	0	0	0	0
Severe OA		0	0	0	0	0	0
Total affected joints of each	Number % (n = 23 arthritic joints)	0 (0)	4 (17,4)	10 (43,4)	0 (0)	3 (13)	6 (26,1)
Total affected joints	Number % (n = 23 arthritic joints)	14 (60,9)			9 (39,1)		
Total joints evaluated		33			33		
Total affected joints		23					
Total of joints (in the positive animals)		66					
Total of positive animals		11					

Just like in the general population, in this group, the majority of the lesions were found in the tarsometatarsal joints (76,3% of all the lesions). The most common radiographic signs were "Joint space narrowing" and "Osteophytes/new bone formation" (42,1% of all the radiographic signs each). None of the evaluated joints presented "Subchondral bone sclerosis" or "Subchondral bone lysis".

The most common radiographic sign in the DIT joints was “Joint space narrowing”, which was present in 6 of these joints (15,8% of all the lesions). The most frequent radiographic signs in the TMT joints was “Osteophytes/new bone formation”, which was detected in 13 TMT joints. All these results are presented in Table 14.

Table 14 - Prevalence of the radiographic signs of Bone Spavin found in the positive animals of the "Juvenile Bone Spavin" group.

		DIT joint		TMT joint		DIT + TMT joints	
		Number	% (n = 38)	Number	% (n = 38)	Number	% (n = 38)
Joint space narrowing	Mild	6	15,8	10	26,3	16	42,1
	Moderate	0	0	0	0		
	Severe	0	0	0	0		
Subchondral bone sclerosis	Mild	0	0	0	0	0	0
	Moderate	0	0	0	0		
	Severe	0	0	0	0		
Subchondral bone lysis	Mild	0	0	0	0	0	0
	Moderate	0	0	0	0		
	Severe	0	0	0	0		
Irregularity of the articular margins/lines	Mild	0	0	6	15,8	6	15,8
	Moderate	0	0	0	0		
	Severe	0	0	0	0		
Osteophytes/new bone formation	Mild	3	7,9	11	26,9	16	42,1
	Moderate	0	0	2	5,3		
	Severe	0	0	0	0		
Sum up of the lesions found		9	23,7	29	76,3	38	100
		38					

V. Discussion

The number of horses submitted to radiographic exam of the tarsal region tended to grow over the years covered by this study. That can be indicative of a growing concern of the breeders and owners of keeping track of the soundness of their animals.

It can also be associated with the fact that the veterinarians became more aware of the disease over time – for example, some pre-purchase exams of the first years comprised in this study weren't included in it because the radiographic exam didn't always include the evaluation of the tarsal region of the horses, while nowadays it is always included (at least, with 2 projections of each hock when it isn't possible to take all the four recommendable views).

As expected, the majority of the horses were males. This can be explained by the fact that more stallions and geldings are used in equestrian sports than mares – good mares usually are removed from competition for breeding purposes (Murray, 2014). Besides, usually broodmares aren't subjected to a conventional pre-purchase exam focused in the musculoskeletal system.

In the studied population of Puro Sangue Lusitano horses, 53 animals (51,0% of the population) presented radiographic alterations of the tarsal joints compatible with osteoarthritis. This value is much higher than the value estimated for the prevalence of Degenerative Joint Disease by Silva *et al* (2010) in her Master thesis. In that study, with a population of Lusitano horses submitted to pre-purchase exam, only 13,5% of the horses presented radiographic signs of osteoarthritis. Even though we can make a direct comparison between prevalence values (Silva and collaborators estimated the total prevalence of DJD in fetlock, hock and stifle altogether), such different indicate that our value of prevalence is indeed higher.

Our value of prevalence of bone spavin is also much higher than the prevalence estimated in Hanoverian warmblood horses (12%) by Stock and Distl (2006). The main reason is that the majority of the horses of our population were evaluated in context of a lameness exam. In that situation, usually radiographic projections are obtained in the regions that the veterinarian suspects to be the source of the lameness, so it is expectable to detect radiographic findings in there.

In the groups of animals separated by gender, the prevalence of Bone Spavin was superior in the females group. However, the difference between the prevalence in males (48,7%) and females (57,1%) was not significant. These results aren't in agreement with the findings of Bjornsdóttir and collaborators (2000). In the population of Icelandic horses that this team studied, females had a lower prevalence of radiographic signs. However, the difference also didn't have statistical significance.

One possible reason for the higher prevalence of Bone Spavin in our females is that the majority of them were older broodmares. As previously said, BS is a degenerative condition, so it is expectable to have higher prevalence in older animals.

The prevalence of bone spavin estimated in the group of 26 horses that were submitted to pre-purchase exam (24,0%) may be a value much closer to the real prevalence of the disease in the Lusitano breed because it includes clinically sound animals.

In this group, it was also intended to study the association between presence of hindlimb lameness (clinical manifestation of tarsal pain) and presence of radiographic signs. Since none of the 26 horses submitted to pre-purchase exam presented hindlimb lameness, it wasn't possible to stablish a correlation between these two factors.

This is most likely due to the fact that, for this disease, there isn't a good correlation between presence of clinical signs (lameness) and presence of radiographic signs. As mentioned above, it is very common to examine a horse with hindlimb lameness that doesn't present identifiable alterations in the radiographic evaluation of its *tarsi* or to find radiographic signs of distal tarsal OA in an animal that is clinically sound (Shelley and Dyson 1986; Dyson and Ross 2011; Bathe 2012).

In our population, the majority of the horses presented radiographic signs in both hocks. Björnsdóttir and collaborators (2000) had similar results in a population of Icelandic horses. These results meet what is described in literature – Bone Spavin if often a bilateral condition (Dyson and Ross 2011).

In our study, the prevalence of Bone Spavin in left and right hocks was also estimated and evaluated. More left hocks were diagnosed with distal tarsal OA – 48 left hocks against 41 right hocks diagnosed with BS. However, the difference isn't statistically significant. Björnsdóttir *et al* (2000) had similar results, also without significant difference.

In the Lusitano horses sample studied, the most commonly affected joints were the tarsometatarsal joints, followed by the distal intertarsal joints and the least affected were the proximal intertarsal joints. This meets the fact that usually Bone Spavin is described as affecting more frequently the two lowest hock joints, the DIT and TMT joints (Shelley and Dyson 1986; Dyson and Ross 2011).

The majority of the positive joints were considered to have mild osteoarthritis in our study. This can be explained by the fact that the studied population had a relatively young medium age (5,2 years). On the contrary, in a population of Icelandic horses (mean age of 7,9 years), the majority of the OA found were classified as moderate or severe (Björnsdóttir *et al.* 2000).

Since distal tarsal OA is a degenerative and chronic condition (Carson and Ricketts 2013; Björnsdóttir 2005) (which means it has tendency to aggravate with the aging of animals), it is expectable that a young population will present mild or initial signs of the disease.

Regarding the individual study of the three types of joints (PIT, DIT and TMT joints) and of the radiographic signs, we found that the most common radiographic signs were "Osteophyte/new bone formation" and "Joint space narrowing" and the least common radiographic signs were "Subchondral bone sclerosis" and "Subchondral bone lysis". This distribution of the prevalence of each radiographic sign can be explain either by the pathophysiology of the disease or by the limitations of radiography as diagnostic mean. Since we don´t have all the radiographic views of all *tarsi*, it is also possible that we missed some information.

Repetitive compressive stress over the articular cartilage is commonly identified as one of the trigger factors of OA, that may cause loss of the articular cartilage in weight bearing areas. In radiographs, the loss of this cartilage translates in reduction/asymmetry of joint space (Caron 2011). Being one of the trigger factors of OA, it is normal that the resulting radiographic sign is very common in unsound joints.

New bone proliferation can be a response modulated by inflammatory cytokines (Caron 2011) or a result of the periosteal reaction to subchondral changes (Edwards 1982). Since it can be triggered by the inflammatory environment present in the acute phase of osteoarthritis, it is expectable to find osteophytes as an early radiographic sign of OA.

Subchondral bone changes can also begin to occur early in the progression of the OA (mainly due to repeated microtrauma) (Carmona and Prades 2009; Caron 2011). However, since radiography can be insensitive in the detection of early stages of bone inflammation (Vanderperren *et al*. 2009a; Garrett 2011), milder changes in trabecular detail and cortical thickness may go unnoticed. Therefore, due to these limitations of radiography, subchondral bone sclerosis and lysis can be underdiagnosed, resulting in a smaller prevalence of these changes, when compared with radiographic signs that are more easily diagnosed.

At last, in the “Juvenile Bone Spavin” group, 11 animals (73,3% of the population) presented radiographic alterations compatible with distal tarsal osteoarthritis. As in the entire population, this value is also much higher than the prevalence estimated by other authors – in the decade of 90, the prevalence was estimated to be 20% (Watrous *et al.* 1991; Dyson and Ross 2011). One possible explanation is that those young horses were observed and submitted to radiographic exam of the *tarsi* because their progenitors had Bone Spavin (and, therefore, there was a bigger concern of the owners in following these foals) or because there already were suspicions of some problem in the *tarsi*.

There is no available data about the prevalence of Bone Spavin in young horses according with gender and bilateralism of the lesions. In this group, as in the general population, more left *tarsi* were affected. Contrariwise, differing of the general population, a bigger number of males presented radiographic signs of osteoarthritis. This may reflect a bigger concern in monitoring the musculoskeletal system of colts (rather than fillies) due to their sporting potential.

In the present study, in the “Juvenile Bone Spavin” group all distal tarsal OA diagnosed were classified as mild. Once again, this can be related with the fact that this is a young population (mean age of 1,3 years) and Bone Spavin is a degenerative disease, that progresses with the age (Björnsdóttir 2005; Carson and Ricketts 2013).

While in our population, none of the colts and fillies presented radiographic signs of osteoarthritis of the PIT joints, in a few studies in young performance Thoroughbred and Quarter Horses were found dorsal osteophytes in these joints (Santschi 2013).

In our group of young horses, the most frequent radiographic signs were “Joint space narrowing” and “Osteophytes/new bone formation”, which were present in 42,1% of the joints. This is in agreement with the studies performed with young Thoroughbred and Quarter Horses, in which dorsal osteophytes were also the most prevalent radiographic sign (Santschi 2013). However, while none of our young horses presented “Subchondral bone sclerosis” or “Subchondral bone lysis”, in one of the studies performed in Thourogbred young horses, was diagnosed lucency of the DIT and TMT joints in a few cases (Santschi 2013). All these differences between our results and the results obtained by other authors suggest that, in our horses, distal tarsal OA may have a slower progression.

An important aspect that wasn’t object of study of the present work is the hypothetical heritability of Bone Spavin in the Puro Sangue Lusitano breed. If proven to be true, it could also be one of the contributing factors for the high prevalence of Bone Spavin and Juvenile Bone Spavin estimated in this study, since a great amount of the horses were somehow related.

Other important aspect that wasn't object of study of the present work was the evaluation of a possible correlation between the tarsal conformation in this breed and prevalence and severity of lesions of the distal tarsal joints. The Lusitano horses' hindlimbs have to a certain extent small angles (APSL 2010) and, as mentioned earlier, poor hock conformation can be one of the contributing factors for the development of BS (Latimer 2004; Dyson and Ross 2011; Sullins 2011). Besides, it is pointed out that smaller tarsal angles have a negative effect in gait quality in dressage horses.

Therefore, an improvement in tarsal conformation in this breed would most likely have a beneficial impact in the sporting performance of Lusitano horses.

Finally, it would also be interesting to evaluate the correlation between type of exercises performed and prevalence and severity of BS in the Puro Sangue Lusitano breed. It has been studied that one of the most common causes of hindlimb lameness in dressage horses is the distal tarsal OA (Dyson 2002; Murray *et al*., 2006). Since Lusitano horses are widely used not only in classical dressage but also in working equitation and bullfighting (all equestrian disciplines that require a great capacity of collection, which results in an increased tarsal loading and compression), it is expected that the prevalence of distal tarsal OA will be greater in these horses.

Lastly, not getting the four recommended radiographic views to evaluate each hock was a major constrain of this study. That may have result in an incomplete assess to all the sides of the tarsal joints, which limited a proper identification and localization of all the alterations that may exist in the affected joints. Therefore, we can't ensure that in this study were identified all the lesions existent in the tarsal joints evaluated. In addition, the lack of radiographic studies of the distal tarsal osteoarthritis in this and in other breeds limited the comparison of the majority of our results with the existing data about Bone Spavin in Icelandic horses.

Besides, there are many factors that influenced the number of animals included in the study. In result, the population of horses studied and the results obtained and presented is this study may not be representative of the general population of Lusitano horses.

VI. Final Considerations

The presented work shows the importance of the osteoarthritis of the distal tarsal joints in the Lusitano breed. However, it is still necessary to perform more studies of the disease, with a bigger and random sample of horses, not only to determine more precisely the prevalence of bone spavin in the PSL horses population but also to investigate the possibility of a genetic predisposition for the disease in the PSL breed.

If in the future, the existence of a genetic predisposition for the disease in the breed is confirmed, it will mandatory the implementation of a control program of the disease in breeding sires and dams. That program should be executed by means of a radiographic examination of animals whose owners want to approve as breeding mares or stallions. It may also include the radiographic control of the offspring of approved animals.

In order to implement a successful control program, it will be essential to educate the breeders for its importance and for the harmful impact that the disease has in the sporting longevity and welfare of the horses and the negative influence it may have in the reputation of the breed worldwide.

The existence of such program will also result in the gathering of a representative and standard radiographic database of all studs. That will allow a continuous evaluation of the disease and control of the success of the program.

VII. Conclusions

Considering the early objectives of this study, the information collected during the literature review and the results obtained, we conclude that:

Bone Spavin had a high prevalence in **this** Puro Sangue Lusitano population;

The majority of the cases presented bilateral Bone Spavin;

In this study, Bone Spavin prevalence was not influenced by gender or side (left or right);

Radiographic signs of Bone Spavin can be present in animals without clinical evidence of pain;

The majority of the diagnosed OA were classified as mild;

The most affected joints were the tarsometatarsal joints and distal intertarsal joint;

The majority of the animals presented more than one radiographic sign of OA in each affected joint;

The most common radiographic signs were “Joint space narrowing” and “Osteophyte/new bone formation”;

“Juvenile Bone Spavin” had a very high prevalence the this Lusitano population. As in the total population, the most affected joints were the tarsometatarsal joints and the most common radiographic signs were “Joint space narrowing” and “Osteophyte/new bone formation”.

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