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Radiographic and ultrasonographic alterations in the metacarpophalangeal joints in older horses do not necessariliy correlate to lameness

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Summary: Information regarding the behavior of different diseases in geriatric equines is scarce, including the ones related to the locomotor system, which is essential to the animal's performance. The objective of this study was to evaluate the different types of alterations in the metacarpophalangeal joint (fetlock) in the thoracic limbs of geriatric equines and the frequency of which they occur. Furthermore, it was aimed to evaluate the scores of such lesions and their correlation to clinical manifestations. In this study, 39 mixed-breed equines were evaluated, all at a minimum age of 15 years (18,9 ± 2,86 years old). Of those, 21 were females (53,8%) and 18 were geldings (46,2%). A clinical examination specific to the locomotor system was performed, followed by ultrasonographic and radiographic imaging of the metacarpophalangeal joint of the thoracic limb. For every image obtained, a scoring system was applied in accordance to the severity of the found lesion, such as in the radiographic image (0–4) and in the ultrasonographic image of the soft tissue (0–6) and bone (0–4). Thirteen equines (35%) presented lameness, out of which three (10%) were sourced in the metacarpophalangeal joint and 10 (25%) in other painful sites. All animals (39/39) showed alterations in the metacarpophalangeal joint through ultrasound evaluation and 35 (90%) and 38 (98%) in radiographic evaluation. Considering the injury scoring system for soft tissue, 46 of 78 forelimbs (46/78; 59%) were scored 0; 5/78 (6%) were scored 1; 4/78 (5%) were scored 2; scores 3 and 4 were not observed within the group; 21/78 (26%) were scored 5 and 3/78 (4%) were scored 6. For the scoring system for ultrasonographic alteration in bones, 22/78 (27,5%) were scored 0; 19/78 (23,8%) were scored 1; 32/78 (40%) were scored 2; 6/78 (7,5%) were scored 3 and 1/78 (1,3%) were scored 4. As for the radiographic evaluation, considering both limbs 2/78 (2,5%) were scored 0; 19/78 (23,8%) were scored 1; 13/78 (16,2%) were scored 2, 43/78 (53,8%) were scored 3 and 3/78 (3,7%) were scored 4. The main alterations observed in the study were related to degenerative chronic joint diseases. There was no relationship between the presence of lameness and the scores based on the image´s analysis. The absence of clinical manifestations in geriatric horses that were not being submitted to intense exercises does not exclude the presence of alterations in ultrasonographic and radiographic images of the metacarpophalangeal joint.

Keywords: fetlock, radiography, ultrasonography, osteoarthritis,. degenerative joint disease

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Introduction

Musculoskeletal is one of the most affected systems in geriatric equines, mainly due to degenerative changes in soft and bone tissues (*Brosnahan* et al. 2003, *Bramlage* 2009). Metacarpophalangeal joints (fetlocks) are more likely to be injured due to the movement they make, especially in forelimbs as they support most of the weight of animals (*Denoix* et al. 1997). Aging, combined with poor handling conditions, favours the development of lesions (*Jarvis* 2009, *Secombe* et al. 2009). In this context, general health of the musculoskeletal system is essential for animals to perform their activities properly and have their productive life extended.

Demand for veterinary care for older horses has currently increased both to keep them active for longer and for emotional reasons. However, the physiology and behaviour of such disorders are poorly understood. Depending on injury chronicity, clinical manifestations may not be clear, thus hindering the identification (*Brosnahan* et al. 2003, *Ireland* et al. 2011).

Clinical evaluation of the locomotor system is extremely important, as it helps in the treatment of disorders and prevents their progression. Lameness examination may identify pain and its most likely origin. This practice is also important to define the clinical relevance of the pain. Furthermore, through additional imaging tests such as radiography (XR) and ultrasonography (US), lesions and their extensions can be accurately identified (*Seignour* et al. 2012, *Davidson* 2018, *Wulster* 2018). In general, a disorder can also be characterized as acute or chronic for further indication of its course of treatment and prognosis (*Bubeck* et al. 2018).

Given the above, this study aimed to evaluate the different types of bone, ligament, and tendon disorders in the metacarpophalangeal joint (fetlock) and their rate of occurrence in geriatric horses.

Material and methods

Animals

A group of 39 mixed-breed horses (crossing between different breeds: Crioulo Horse, Quarter Horse, Thoroughbred) was evaluated, among which 21 (53.8%) females and 18 (46.2%) geldings, with a minimum age of 15 and maximum of 25 years old, which was confirmed by teeth evaluation (Table 1). The animals were provided by Amigo do Carroceiro Extension Program (CAV/UDESC), Lages Environmental Center and private owners. All owners were aware of the nature of the study and signed an Informed Consent Term.

The medical history of each animal was provided by its owners; however, they did not know much information regarding the horse's entire life, only the most recent history. According to the information provided, no animal had lameness as a known medical problem or problems with the locomotor system in general. Regarding activities, 45% (18/39) of the animals were used for pulling cart, 13% (4/39) for riding, and 43% (17/39) had unknown activities.

Clinical Examination

All horses were submitted to lameness examination, including a comprehensive medical history and evaluations resting and exercising, which consisted of walking and trotting along a straight line or in circles to both sides on a firm surface. The lameness score system used ranged from 0 to 5 (*Anon* 1991). Palpation was focused on the metacarpophalangeal joint of the thoracic limbs to identify swellings, consistency changes, heat, and pain. The palpation was performed in both weight-bearing and non-weight-bearing positions. All animals were tested for a range of flexion and extension of the joints and underwent perineural anaesthesia (lidocaine 2% without vasoconstrictor) when lameness was detected (*Moyer* et al. 2007, *Baxter* et al. 2011). However, due to the logistical issues of the permanence of the horses at the University Animal Hospital and interferences of anaesthetic with ultrasound and radiographic images (*Kirberger* et al. 1996, *Zekas* et al. 2003), the animals that showed known changes in other regions of the body and positive for the flexion test in other joints were not submitted to local anaesthetic nerve block.

Radiographic and Ultrasonographic Imaging

All animals in the study, regardless of the lameness in the fetlock joint, were submitted to ultrasonographic (US) and radiographic (XR) imaging. The horses that due to behaviour did not allow preparation for the exams or imaging itself were sedated with detomidine hydrochloride (10 to 20μg/kg, IV). All animals were positioned on a firm surface for imaging and,

Table 1 Data referring to the evaluated animals, including breed, gender, age and activity carried out in the last six months (retired horses there is no exact history of the activities carried out). | *Angaben zu den bewerteten Tieren, einschließlich Rasse, Geschlecht, Alter und ausgeführter Tätigkeit in den letzten sechs Monaten (für Pferde im Ruhestand, gibt es keine genaue Angabe der ausgeführten Tätigkeiten).*

Nr.	Breed	Gender	Age	Activity
1	Mixed - breed	M	24	Pulling cart
2	Mixed - breed	F	25	Pasture
3	Mixed - breed	M	25	Pulling cart
4	Mixed - breed	M	20	Pulling cart
5	Mixed - breed	M	20	Pulling cart
6	Mixed - breed	M	18	Pulling cart
7	Mixed - breed	F	20	Pulling cart
8	Mixed - breed	M	20	Pasture
9	Mixed - breed	M	25	Pulling cart
10	Crioula	F	16	Pulling cart
11	Mixed - breed	F	20	Pulling cart
12	Mixed - breed	M	15	Pulling cart
13	Mixed - breed	M	19	Pulling cart
14	Mixed - breed	F	M	Pasture
15	Mixed - breed	M	15	Pulling cart
16	Mixed - breed	M	20	Pasture
17	Mixed - breed	F	20	Pasture
18	Mixed - breed	M	16	Pulling cart
19	Mixed - breed	F	20	Pasture
20	Mixed - breed	F	15	Pulling cart
21	Crioula	F	16	Pasture
22	Mixed - breed	F	20	Pasture
23	Mixed - breed	F	20	Pasture
24	Mixed - breed	F	15	Pulling cart
25	Mixed - breed	M	20	Pasture
26	Mixed - breed	F	15	Pulling cart
27	Mixed - breed	M	25	Pasture
28	Mixed - breed	M	16	Pasture
29	Mixed - breed	M	15	Pasture
30	Mixed - breed	M	20	Pasture
31	Mixed - breed	F	15	Pasture
32	Mixed - breed	F	25	Pasture
33	Mixed - breed	M	20	Pulling cart
34	Mixed - breed	M	20	Pasture
35	Mixed - breed	F	18	Pasture
36	Mixed - breed	M	16	Pasture
37	Mixed - breed	F	16	Pasture
38	Mixed - breed	F	20	Pasture
39	Mixed - breed	F	20	Pasture

for the radiographic images, wooden supports were placed on both forelimbs to stand the animal in an upright position.

Ultrasonographic imaging was performed by a portable ultrasound device (Sonoscape A6 Vet) equipped with a 5–12 MHz multi-frequency transducer. The limb skin was trichotomized, cleaned with water, soap and 70% alcohol solution, and then the coupling gel was applied. The examination was performed on the longitudinal and transverse planes of the dorsal, palmar, medial, and lateral aspects of the metacarpophalangeal joint (*Cauvin* et al. 2014). All images were recorded and saved for further evaluation by the Movies Microsoft® software. The equines were categorized under different scoring systems according to changes in soft and bone tissues, ranging from 0–6 and 0–4 respectively (Tables 2 and 3) (*Silva* 2014, *De Bastiani* et al. 2017). The presence of one or more signs of a certain score was set as inclusion criteria (*Silva* 2014, *De Bastiani* et al. 2017). All ultrasonographic images were obtained by only one professional.

Table 2 Categories for the scoring system of lesions in the metacarpophalangeal joint of the thoracic limbs in geriatric horses, ranging from 0 to 4 for bone alterations found in ultrasonographic imaging. *Kategorien für das Bewertungssystem von Läsionen im Metakarpophalangealgelenk der Vordergliedmaßen bei geriatrischen Pferden, von 0 bis 4 für Knochenveränderungen, die bei der Ultraschalluntersuchung gefunden wurden.*

0	– No bone alterations.
1	– Mild irregularity and roughness of subchondral bone margin. – Mild narrowing of the joint space occupied by the articular cartilage.
2	– Moderate irregularity of subchondral bone surface with peripheral osteophyte formation. – Narrowing of the joint space occupied by the articular cartilage, with bone surface presenting roughness and discontinuity.
3	– Severe irregularity of the subchondral bone surface, associated with areas of bone flattening and well-defined peripheral osteophyte formation. – Narrowing or ill-defined narrowing of the joint space occupied by the articular cartilage.
4	– Severe and diffuse irregularity of subchondral bone, undefined joint space with large and fragmented osteophytes. – Non-existent space occupied by the articular cartilage.

Table 3 Categories for the scoring system of lesions in the metacarpophalangeal joint of the thoracic limbs in geriatric horses, ranging from 0 to 4 for soft tissue alterations found in ultrasonographic imaging. | *Kategorien für das Bewertungssystem für Läsionen im Metakarpophalangealgelenk der Vordergliedmaßen bei geriatrischen Pferden, von 0 bis 4 für Weichteilveränderungen, die bei der Ultraschalluntersuchung festgestellt wurden.*

0	– No soft tissue alterations.
1	– Heterogenous periarticular ligaments with hypoechogenic areas. – Irregularities in the ligament origin/insertion.
2	– Heterogenous periarticular ligament with hyperechogenic areas. – Mild bony proliferation in the ligament origin/insertion.
3	– Extensive lesion in the periarticular ligament. – Evident bony proliferation in the ligament origin/insertion.
4	– Periarticular ligaments with extensive lesion or rupture. – Evident and fragmented bony proliferation in the ligament origin/insertion.
5	– Thickened ligament.
6	– Synovial effusion, synovial proliferation.

For radiographic imaging, digital equipment was used (ULTRA 100 ECORAY®) for the 30-degree dorsoproximal palmarodistal, lateromedial, dorsolateral-palmaromedial oblique views and dorsomedial-palmarolateral oblique projections (*Butler* et al. 2008). The images were saved on an external hard drive for posterior analysis. The analysis was performed in a blind fashion, with all animals gathered in a single group identified only by numbers, without any additional information or previous examinations. The lesions were categorized based on a scoring system ranging from 0 to 4 (Table 4) (*Silva* 2014, Verwilghen et al. 2009), setting the presence of one or more signs of a certain score as inclusion criteria. All radiographic images were obtained by only one professional.

Statistical Analysis

A descriptive statistical analysis was conducted by calculating absolute frequencies and percentage of tissue changes. Correlation between presence of lameness and lesion score from ultrasonographic and radiographic imaging was determined by the Chi-square test ($P < 0.05$).

Results

Lameness was evident in 35.8% (13/39) of the horses, three of which were in the right thoracic limb (RTL) and 10 in the left thoracic limb (LTL). However, only 23% (3/13) showed lameness in the metacarpophalangeal joint, two in the RTL and one in the LTL. The animal identified as horse number (n°) 8 presented lameness score 1 (LTL); horse n° 32 score 3 (RTL) and horse n° 37 score 4 (RTL); according to *Anon* (1991). The remaining animals (10/39) showed lameness as a source of pain in other areas.

All animals (39/39) showed alterations in the imaging examinations. In the ultrasound, 90% (35/39) showed some sort of alteration, the main ones were narrowing or absence of joint space occupied by articular cartilage, enthesophytes formation, irregularities in the subchondral bone, and thickening of the annular ligament.
All animals were categorized under different scoring systems according to the lesion found, separated by soft (0–6) and bone (0–4) tissues, each of those to both thoracic limbs (left and right), totalling 78 limbs. Considering the lesion scores obtained by US imaging, 47/78 (59%) scored 0; 4/78 (5%) 1; 4/78 (5%) 2; none scored 3 or 4; 21/78 (26%) scored 5; and 3/78 (4%). The results obtained by US imaging of the bones showed that 22/78 (27.5%) scored 0; 19/78 (23.8%) 1; 32/78 (40%) 2; and 6/78 (7.5%) 3.

In the US evaluation of the soft tissue, lesions prevailed in the LTL. According to the scoring system, 23 animals scored 0;

one 1; two 2; none scored 3 and 4; 11 scored 5; and two scored 6. In the US imaging of the bones, the LTL also showed a prevalence in lesion incidence and, according to the scoring system, nine horses scored 0; 10 scored 1; 17 scored 2; and three scored 3.

In the radiographic evaluation, 98% (38/39) of the horses showed some sort of alteration. The main changes were osteophyte formation, irregularities in bone shape, and sclerosis. The lesion scoring system applied to both limbs showed that 2/78 (2.5%) scored 0; 19/78 (23.8%) scored 1; 13/78 (16.2%) scored 2; 43/48 (53.8%) scored 3; and 2/78 (3.7%) scored 4. The levels of incidence of lesions in the RTL and LTL were the same.

The presence of lameness was then correlated to lesion scores from the US imaging and radiographic imaging of soft and bone tissues. No correlation was found between lesion score and lameness in the metacarpophalangeal joint ($p < 0.05$).

The three animals showing lameness in the metacarpophalangeal joint had different scores both for the radiographic and ultrasonographic imaging (Table 5).

The main ultrasonographic alterations in laming horses was irregularity of the subchondral bone, narrowing of the articular space, thickening of the collateral ligament, deep and superficial collateral ligaments with hypoechoic areas, and thickening of the annular ligament (Figure 1). In the radiographic imaging, the main findings were bone proliferation, peripheric osteophyte formation, areas of sclerosis, bone fragments, and irregularities in the shape of sesamoid bones (Figure 2).

Proximal sesamoid bone changes were observed in 25% (10/39) of the horses, five in the RTL (four lateral and one medial) and five in the LTL (three lateral and two medial), respectively. These alterations were characterized by visible and irregular vascularity, bone proliferation, bone shape irregularity, and trabecular pattern changes. One animal had a bone

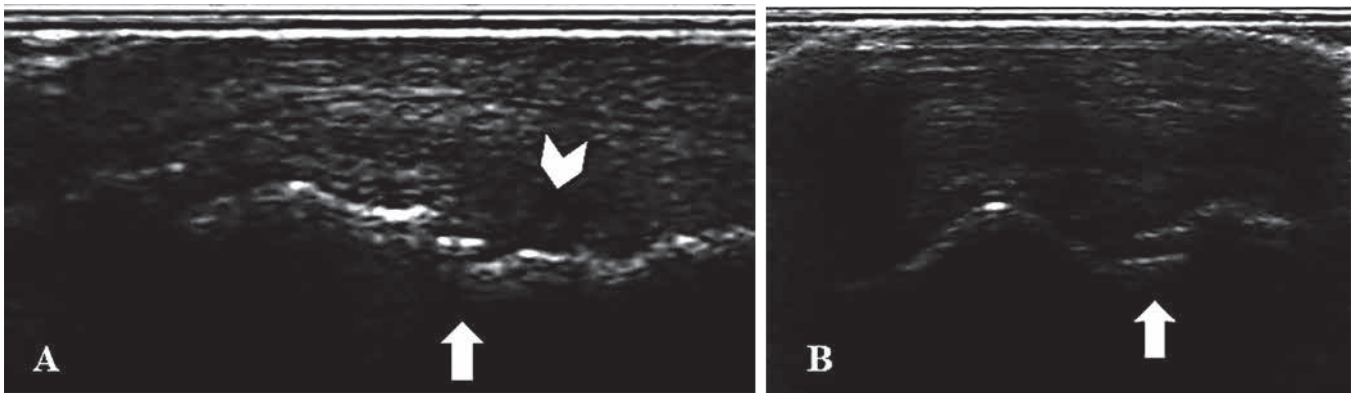

Fig. 1 (A) Longitudinal ultrasonographic imaging of dorsolateral side of metacarpophalangeal joint (MCP) in the right thoracic limb, Horse n° 32, presenting irregularity in the subchondral area of the third metacarpal bone (arrow), heterogeneous echogenicity of the synovial fluid and absence of the joint space occupied by articular cartilage (point of arrow). (B) Transversal image of the same area observed in (A), showing discontinuity of the subchondral bone surface of the lateral condyle of third metacarpal bone (MCIII) (arrow). | *(A) Longitudinale Ultraschallaufnahme der dorsolateralen Seite des Metacarpophalangealgelenks (MCP) in der rechten Vordergliedmaße von Pferd Nr. 32 zeigt Unregelmäßigkeiten im subchondralen Bereich des dritten Mittelfußknochens (Pfeil), heterogene Echogenität der Synovialflüssigkeit und Fehlen des Gelenkraums, der vom Gelenkknorpel besetzt ist (Pfeilpunkt). (B) Das Transversalbild der Stelle aus Abb. A, zeigt Diskontinuität der subchondralen Knochenoberfläche des lateralen Kondylus (MCIII) (Pfeil).*

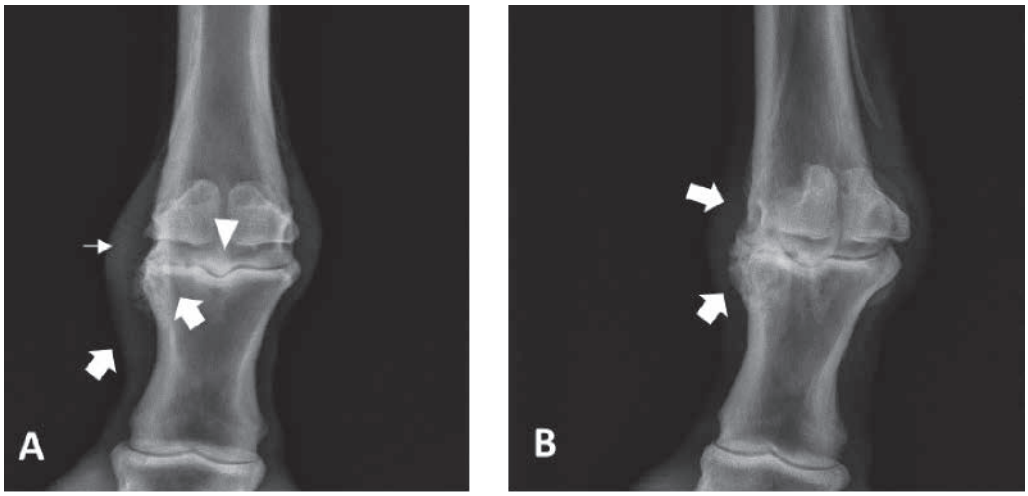

Fig. 2 (A) Dorsopalmar radiographic projection of the metacarpophalangeal joint (MCP) in the right thoracic limb, Horse n° 32, showing absence of medial joint space, with bone proliferation (arrows). Area of sclerosis in the subchondral area of the third distal metacarpal bone and first proximal phalanx (point of arrow), soft tissue with increased opacity (thin arrow). (B) Dorsomedial-palmarolateral oblique radiographic projection of the same limb, evidentiating the absence of joint space and lateral bone proliferation (arrows). | *(A) Dorsopalmare Röntgenaufnahme des Metacarpophalangeal-Gelenks (MCP) in der rechten Vordergliedmaße von Pferd Nr. 32 zeigt das Fehlen von medialem Gelenkraum, mit Knochenproliferation (Pfeile), den Bereich der Sklerose im subchondralen Bereich des Metacarpus und des ersten proximalen Phalanx (Pfeilspitze), und Weichgewebe mit erhöhter Trübung (dünner Pfeil). (B) Dorsomedial-palmarolaterale schräge Röntgenaufnahme der gleichen Extremität, die das Fehlen von Gelenkraum und laterale Knochenproliferation (Pfeile) zeigt.*

cyst in the proximal lateral sesamoid bone (Figure 3A), but no sign of lameness. Another animal showed extensive bone proliferation in the proximal medial sesamoid bone (Figure 3B), without pain when palpated. Three equines demonstrated periarticular soft tissue mineralisation in the palmar region, all were used for pulling cart.

The thickening of the proximal annular ligament was observed in 30% (12/39) of the animals, of which 42% (5/12) was bilateral and 58% (7/12) in just one limb. Out of those which showed bilateral alteration, 71% (5/7) was in the RTL and 29% (2/7) in the LTL (Figure 4). Of all the collateral ligaments, 28% (11/39) had alterations, of which 18% (2/11) were in both thoracic limbs and 82% (9/11) in just one of them. Five animals showed lesions in the deep layer of the fetlock joint collateral ligaments in the RTL, two in the medial and three in the lateral. Three animals showed lesions in the superficial layer of the fetlock joint collateral ligaments, two in the medial and one in the lateral. Four animals had lesions in the deep layer of the collateral ligaments in the LTL, three in the medial and one in the lateral collateral ligament. Three showed alterations in the superficial layer of the collateral ligaments, one in the medial and two in the lateral. One horse displayed thickening of the intersesamoidean ligament in the LTL, and another had clinical signs of aseptic tenosynovitis, characterized by an increase in anechoic fluid in the tendon sheath.

The main alterations observed in the imaging examinations were degenerative, with osteoarthritis being the most relevant. In the US evaluation, 70% (28/39) showed osteophyte formation, of which 36% (10/28) were bilateral and 64% (18/28) unilateral, 44% (8/18) in the RTL and 56% (10/18) in the LTL (Figure 5A). In the XR imaging, 70% (28/39) of the horses showed osteophyte formation, of which 64% (18/28) bilateral and 36% (10/28) unilateral. Out of those which were bilateral, 40% (4/10) were in the RTL and 60% (6/10) in the LTL (Figure 5B). Narrowing of the joint space occupied by the articular cartilage were seen in 30% (12/39) of the cases, of which 33% (4/12) on both thoracic limbs. Among those with narrowing only in the RTL, one had lateral and three medial narrowing. Of those with narrowing only in the LTL, all four were medial. Narrowing in just one of the limbs was detected

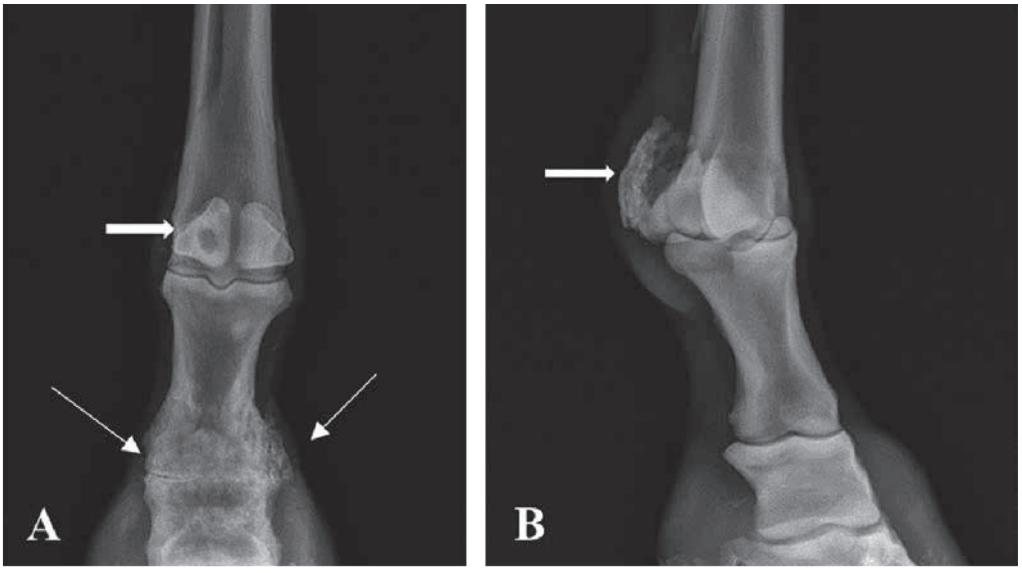

Fig. 3 (A) Dorsoproximal radiographic projection of metacarpophalangeal joint in right thoracic limb, Horse n° 39, demonstrating the presence of an oval radiolucent area in the lateral sesamoid bone, compatible with cystic lesion (arrow), and advanced degenerative process in proximal interphalangeal joint (thin arrows). (B) Dorsomedial palmarolateral radiographic projection of metacarpophalangeal joint in left thoracic limb, Horse n° 37, showing extensive bone proliferation in proximal medial sesamoid bone (arrow). | *(A) Dorsoproximale Röntgenaufnahme der Metacarpophalangealgelenks in der rechten Vordergliedmaße, Pferd Nr. 39, die das Vorhandensein eines ovalen radioluzenzen Bereichs im lateralen Sesamoidknochen zeigt, der mit der zystischen Läsion vereinbar ist (Pfeil), und einen fortgeschrittenen degenerativen Prozess im proximalen Interphalangealgelenk (dünne Pfeile). (B) Die dorsomedial palmarolaterale Röntgenaufnahme des Metacarpophalangealgelenkes in der linken Vordergliedmaße, Pferd Nr 37, zeigt umfangreiche Knochenproliferation am proximalen medialen Sesamoidknochen (Pfeil).* |

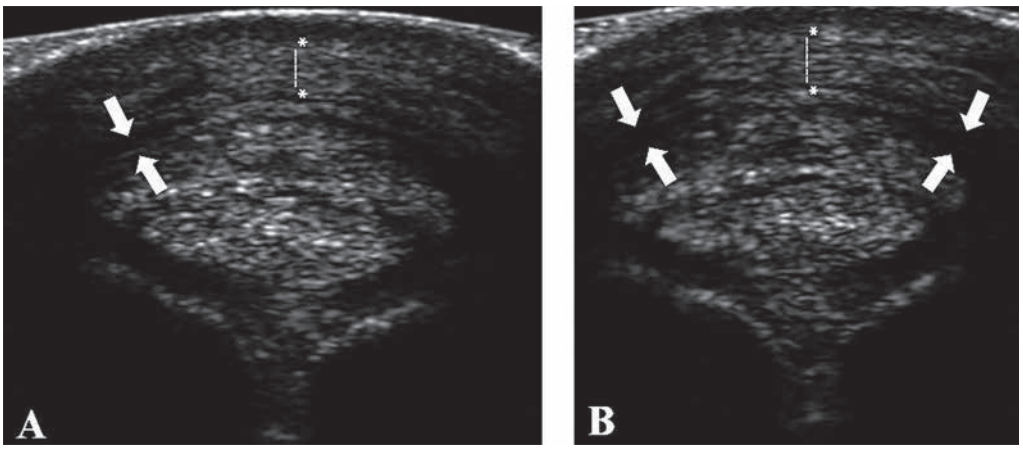

Fig. 4 (A) Ultrasonographic image of the medial surface of the metacarpophalangeal joint of the right thoracic limb, horse n° 7, presenting two osteophyte formations marginally (arrows). (B) Palmaromedial dorsolateral radiographic projection of the same animal, with osteophyte formation in dorsomedial area of first phalanx (arrow). | *(A) Ultraschallbild der medialen Oberfläche des Metacarpophalangealgelenks der rechten Vordergliedmaße, Pferd Nr. 7, mit zwei Osteophytenformationen marginal (Pfeile). (B) Palmaromedial dorsolaterale Röntgenprojektion des gleichen Tieres, mit Osteophytenbildung im dorsomedial Bereich der ersten Phalanx (Pfeil).*

in 67% (8/12), of which two in the RTL, one lateral and one medial; and six in the LTL, one lateral and five medial.

Discussion

All animal owners claimed to not have noticed the presence of lameness, which can be attributed to lack of knowledge on the subject, difficulty in recognizing the clinical manifestation (*Dyson* et al. 2011) or even because some alterations did not cause any manifestations at all. An increase in the size of the fetlock joint was observed in all horses that showed pain in the affected area. The small coverage of the area with soft tissue allows easy detection of effusion, thickening, and oedema (*Kawcak* et al. 2016).

Lameness examination provides important information along with manifestation of pain. However, this tool is subjective since it depends on the perception and experience of the person evaluating the animal. The horses showing pain to palpation in the metacarpophalangeal joint also demonstrated visible lameness during a walk or jog in a straight line and circles on a firm surface. Horse n° 8 had lameness score 1 (LTL), n° 32 scored 3 (RTL), and n° 37 scored 4 (RTL). In these cases, a flexion test was performed to confirm the lesion area, in addition to inspection at rest and palpation. The flexion test can provide a false-positive result because of the amount of pressure and time applied (*Keg* et al. 1997), reinforcing the importance of all exams being performed by only one professional, as in this study.

The fetlock joint flexion test was positive in all three horses with pain in this area. This test is more accurate when performed on the metacarpophalangeal joint than on more distal portions. Moreover, the positive results are supposed to confirm the area of pain, and the absence of a clear result may also decrease the probability of the fetlock joint be the source of lameness (*Meijer* et al. 2001, *Kearney* et al. 2010).

The metacarpophalangeal joint of the thoracic limbs was most likely the source of pain in just 10% (3/39) of the examined horses. For being geriatric horses, a high incidence of lameness sourced in this area was expected, as older animals are more prone to degenerative musculoskeletal diseases. This joint is also more prone to lesions due to its high mobility, small area of transversal section, and small soft tissue coverage. When considering ground reaction force and muscle strength, the fetlock joint receives pressure from five to seven times the animal's body weight.

The low lameness prevalence in the studied horses might be explained by the activity to which they were subjected. A higher incidence of fetlock joint alterations has been described in racehorses due to the pressure applied to this area. In our study, most horses were used for pulling and other lighter activities at lower speed, which could explain the lower incidence of injuries showing lameness in this region (*Maranhão* et al. 2006). But this hypothesis cannot be confirmed given the lack of previous medical history for most animals and because they are used to pull and come from other previous activities. Horses used for pulling, dressage, and reining usually show lameness focused in the pelvic limbs, due to higher pressure in that part of the body. When examining wild horses, the metacarpophalangeal joint showed signs of osteoarthritis; therefore, joint alterations may occur naturally with ageing, regardless of any professional athletic activities (*Cantley* et al. 1999).

The evaluation of the metacarpophalangeal joint in horses used for pulling showed that 41.4% had alterations, but most of them did not have lameness. Therefore, the severity of radiographic findings had no correlation with clinical manifestations of lameness (*Maranhão* et al. 2006), as described in this study.

Imaging examinations complement both the clinical judgement and diagnosis of lameness of musculoskeletal origin, as they allow to directly visualize structures that make up the affected part and conclude their exact location, extension, and severity (*Parks* 2003). Currently, several imaging examinations are available, such as magnetic resonance, scintigraphy, computed tomography, radiography, and ultrasonography. The last two are the most used due to accessibility, and that is why they were used in this study.

All horses evaluated showed some level of alteration in the imaging examinations, as their older age makes them more prone to musculoskeletal alterations (*Davidson* 2018). The ultrasonographic evaluation of the fetlock joint showed a high frequency of lesions (100%) in geriatric horses.

Given the specificity of each type of examination, US for soft tissue evaluation and bone contour and XR for bone tissue, both should be performed in all animals to increase diagnostic accuracy, as the techniques complement each other

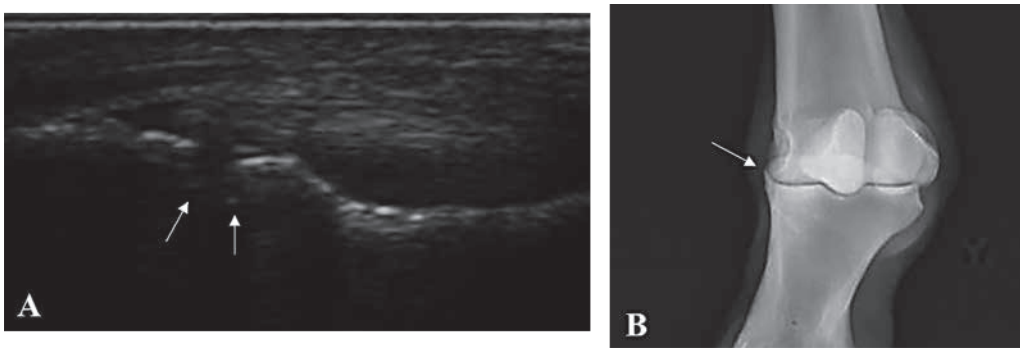

Fig. 5 (A) Ultrasonographic image of the medial surface of the metacarpophalangeal joint of the right thoracic limb, horse n° 7 (22 years old, mixed-breed, pulling cart), presenting two osteophyte formations marginally (arrows). (B) Palmaromedial dorsolateral radiographic projection of the same animal, with osteophyte formation in dorsomedial area of first phalanx (arrow). | *(A) Ultraschallbild der medialen Oberfläche des Metacarpophalangealgelenks der rechten Vordergliedmaße, Pferd Nr. 7 (22 Jahre alt, gemischtrassig, Zugpferd), mit zwei Osteophytenformationen am Rande (Pfeile). (B) Palmaromediale dorsolaterale Röntgenprojektion desselben Tieres mit Osteophytenbildung im dorsomediellen Bereich der ersten Phalanx (Pfeil).*

(*Seignour* et al. 2012). A higher number of animals showing lesions in the radiographic imaging is explained because US has limitations when it comes to producing images of some areas of the body, such as the proximal joint surface of the first phalanx and palmar/plantar joint surface of the third metacarpal/metatarsal bone, while XR allows more complete visualization of the joint (*Denoix* et al. 2001).

Table 4 Categories for the scoring system of lesions in the metacarpophalangeal joint of the thoracic limbs in geriatric horses, ranging from 0 to 4 for alterations found in radiographic imaging. | *Kategorien für das Bewertungssystem für Läsionen im Metakarpophalangealgelenk der Vordergliedmaßen bei geriatrischen Pferden, von 0 bis 4 für die bei der Röntgenuntersuchung gefundenen Veränderungen.*

0	– No alterations.
1	– Mild irregularity in the distal end of third metacarpal bone, with prominent condyle margins. – Mild remodelling of the dorsoproximal margin of the first phalanx bone. – Small bony projection in one of the bone surfaces. – Suspected soft tissue mineralisation. – Mild alteration in joint congruence between the third metacarpal bone and first phalanx. – Sclerosis: area of a mild increase in bone density. – Mild localized rounding in soft tissue.
2	– Moderate irregularity or flattening in the distal end of the third metacarpal bone. – Moderate remodelling of first phalanx bone in dorsoproximal margin. – Osteophyte formation in proximal sesamoid bones with increased vascularity. – Area of mineralisation in soft tissue seen as small stripe formations. – Altered joint congruence between the third metacarpal bone and first phalanx, mild narrowing or widening of joint space, either symmetric or asymmetric. – Subtle bony projections between bone surfaces. – Presence of small fragment (1-2mm) in dorsoproximal margin of the first phalanx. – Sclerosis: localized. – Mild and diffuse rounding in soft tissue.
3	– Severe irregularity in the distal end of the third metacarpal bone with palmar supracondylar lysis. – Osteophyte formation in the dorsoproximal margin of the first phalanx. – Radiolucent areas in proximal sesamoid bones. – Dorsal or palmar fragments. – Altered joint congruence between the third metacarpal bone and first phalanx, moderate narrowing or widening of joint space, either symmetric or asymmetric. – Marked and localized bone proliferation. – Well-organized and localized bony projection in the enthesis. – Sclerosis: moderate and heterogeneous. – Mineralisation of soft tissue localized and with increased density. – Moderate localized rounding in soft tissue.
4	– Dorsal supracondylar lysis. – Fragment on the margin of the condyle and sagittal border. – Fragmentation of palmar process in the first phalanx. – Joint collapse or severely increased joint width. – Prominent bone proliferation, seen in more than one radiographic projection. – Evident and irregular bony projection in enthesis of the ligament. – Sclerosis: evident and homogeneous. – Diffuse and high-density mineralisation of soft tissues. – Accentuated and diffuse rounding in soft tissue.

There was no correlation between the presence of lameness and the score of the lesion in the metacarpophalangeal bone. This fact reaffirms the individual variability of each animal in terms of demonstrated pain levels, as well as the small number of horses with lameness in this joint. Moreover, when lesions are in initial stages and affect only one articular cartilage, due to its lack of vascularity and innervation, there are no clinical manifestations. Some lesions may not cause pain as expected because of periarticular fibrosis. Degeneration of joint capsule neurons can also be added, which reduces pain levels (*Caron* 2011). Other studies have demonstrated similar results, such as the evaluation of the distal joints in the limb, which includes the metacarpophalangeal joint, horses with lower lesion scores did not show lameness. The presence of pain is poorly correlated with radiographic findings; therefore, the presence of alterations does not incur clinical manifestations of joint disease, and the correlation between disease manifestation and severity is small (*McIlwraith* 1996, *Caron* 2011, *Frisbie* 2012).

The imaging findings were compatible with chronic arthropathies characterized by narrowing of the joint space, increase in the radiopacity of the subchondral bone (sclerosis), and osteophyte formation. In more severe cases, there could be subchondral radiolucent defects (lysis), osteochondral fragmentation, and eventually ankylosis (*Caron* 2011). In the radiographic imaging, 98% (38/39) of the horses showed alterations compatible with degenerative processes, and 90% (33/39) in the ultrasonographic imaging were compatible with osteoarthritis. Osteoarthritis does not affect only the joint cartilage, but also the subchondral bone, ligament, joint capsule, synovial membrane, and periarticular tissue (*McIlwraith* 2016). Its occurrence is described more in beginner athlete horses than in elderly animals (*Kawcak* et al. 2008, van *Weeren* et al. 2016).

To be seen on radiographic screening, bone density changes should be at least 30 to 40%, whereas cartilage defects are not visible until there is extensive loss or narrowing of the joint space (*Baccarin* et al. 2012). In early stages, US screening may show lesion signs before XR. In this study, bone US measurements showed that 10 thoracic limbs had osteoarthritis-related alterations, with a score higher than XR observation. Radiologically evident changes tend to be less severe and appear later with disease progression in metacarpophalangeal and metatarsophalangeal joints when compared to other areas (*Caron* 2011). Some of the animals examined showed lesions in both imaging exams (27 RTLs and 30 LTLs), indicating their chronicity.

Table 5 Lesion scores in three geriatric horses with lameness in the metacarpophalangeal joint, according to the affected limb. | *Läsions-Scores bei drei geriatrischen Pferden mit Lahmheit im Metakarpophalangealgelenk, entsprechend der betroffenen Extremität.*

		Scores		
	Limb	XR	USs	USb
Horse n° 8	LT	1	0	1
Horse n° 32	RT	3	1	4
Horse n° 37	RT	0	5	3

Proximal sesamoid bone changes were recorded in 25% of the horses assessed in this study. Such percentage is low when compared to racehorses (66%) (*Plevin* et al. 2016), probably due to the activity. Vascularization is not indicative of injury if the animal has linear margins and a maximum width of 2 mm. When they increase in size, with irregular and non-parallel margins, animal performance can be compromised (*Spike*-Pierce et al. 2003).

US imaging showed that 28% (11/39) of the animals had collateral ligament alterations. Collateral and other ligaments are responsible for joint stability (*Kawcak* et al. 2016), and trauma is often the cause of injuries. The presence of hypoechoic areas with heterogeneous echotexture increased size, loss of fibre pattern, and periligamentous oedema are the main alterations seen in acute lesions. Chronic lesions have hyperechoic areas and potential presence of enthesophytes (*Vanderperren* et al. 2009, *Cauvin* et al. 2014). Lameness is the main manifestation of lesions in the collateral ligament of the metacarpophalangeal joint (*Richardson* et al. 2011). Even so, among the animals examined, only one horse showed signs of lameness.

Annular ligament thickening was observed in 30% (12/36) of horses without and 33% (1/3) of horses with signs of lameness, in which lesion originated in the fetlock joint and scored 4. Palmar annular ligament is a fibrous structure less than 1 mm thick. It is located between the subcutaneous tissue and superficial digital flexor tendon, which is connected to the sheath by a mesotendon (*Seignour* 2012). Animal aging is correlated with the incidence of annular ligament injuries. This is due to age-related weakness or loss of elasticity due to degenerative changes in dense ligamentous connective tissue (*Dik* et al. 1995).

US screening showed ligament thickening, subcutaneous tissue thickening, and flexor tendon sheath injuries. Such changes can be found individually or together. In our study, three horses had subcutaneous tissue with palmar annular ligament thickening simultaneously; the latter can be associated with lameness (*Owen* et al. 2008). In our study, only one animal had lameness focused on the fetlock joint, as well as changes in annular ligament and subcutaneous tissue; the other animals with alterations had no signs of lameness before or after the flexion test. Different from what has been described by *Owen* et al. (2008) in Cob horses and ponies, 96% of the horses had lameness associated with annular ligament alteration, together or not with alterations in the superficial digital flexor tendon and/or subcutaneous tissue. Of them, 94% of the horses responded positively to the flexion test of the fetlock joint (*Schramme* et al. 2003).

US imaging revealed no clear association between horses with palmar annular ligament thickening and tenosynovitis alterations. Such cases are described as primary thickening of the annular palmar ligament or desmitis of the annular palmar ligament, characterized by a thickened ligament without alterations in the tendon sheath. It can be associated with the thickening of subcutaneous tissue as seen in our study, and it frequently affects the thoracic limbs. This occurs due to the hyperextension of the fetlock joint or trauma (*Schramme* et al. 2003, *McGhee* et al. 2005, *Owen* et al. 2008, *Smith* et al. 2014).

Mineralisation of the deep digital flexor tendon in the fetlock joint was observed in only three horses (8%). Conversely, another study has described an incidence of 37% in Thoroughbred, Arab, Cleveland Bay, Warmblood, Cob (*O'Brien* et al. 2018). The lesion is characterized by hyperechoic areas associated with acoustic shadowing (*Smith* et al. 2014). Such an alteration can be accidental since some horses may have it, but without any association with lameness or other concomitant lesions (*O'Brien* et al. 2018), as seen in our study. In the metacarpophalangeal joint, compression of the deep digital flexor tendon on the proximal scutum favours mineralisation and may be a response to excessive compressive loads (*Butler* 2008, *O'Brien* et al. 2018).

Conclusion

The evaluation of older horses allowed identifying that a small number of animals presented lameness, even the majority of them with some degree of radiographic and ultrasonographic lesion in the fetlock joint of forelimbs, with degenerative alterations being the most frequent. The severity of the injuries was not associated with the presence of claudication, regardless of the degrees of alterations presented, the signs of pain were not corresponding. The absence of claudication does not exclude the presence of a lesion, which may evolve and cause clinical signs. There is no correlation between lesion score from imaging examination and presence of lameness in the fetlock joint of geriatric horses.

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