Case Report

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Simultaneous ruptures of the palmar carpal ligament and superficial digital flexor tendon in a traction horse

Rupturas simultâneas do ligamento palmar do carpo e do tendão flexor digital superficial em um cavalo de tração

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Abstract

This report described the clinical case of a gelding, approximately 13 years old, mixed breed, with concomitant ruptures in the forelimbs, including the left palmar carpal ligament and the right superficial digital flexor tendon. After the clinical examination, it was observed severe hyperextension in the carpal joint and swelling, heat and intense pain in both thoracic limbs, in addition to reluctance to move and severe degree of lameness. In the radiographic examination, the right forelimb showed hyperextension of the radiocarpal joint with 225° and the presence of lateral subluxation of the carpal-ulnar bone and the left forelimb had hyperextension of the same joint with an angle of 235°. After euthanasia, partial multifocal tearing of the carpal palmar ligament was observed in the left thoracic limb and total tearing of the superficial digital flexor tendon in the right forelimb. This study presented the case and discussed the possible causes of the occurrence of concurrent ruptures. Also, the report explored equine carpal hyperextension, a rare condition with limited recovery records following palmar carpal ligament rupture injuries. It emphasizes the biomechanical role of this ligament, and its synergy with the superficial digital flexor tendon in preventing hyperextension. Although tendon ruptures have treatment options, complete rupture of the palmar carpal ligament often leads to euthanasia due to irreparable joint damage.

Resumo

Este relato descreveu o caso clínico de um cavalo castrado, com aproximadamente 13 anos de idade, sem raça definida, com rupturas concomitantes nos membros torácicos, incluindo ligamento carpal palmar esquerdo e tendão flexor digital superficial direito. Após o exame clínico, observou-se intensa hiperextensão na articulação do carpo e edema, calor e dor intensa em ambos os membros torácicos, além de relutância em movimentar-se e grave grau de claudicação. No exame radiográfico, o membro torácico direito apresentava hiperextensão da articulação radiocárpica com 225° e presença de subluxação lateral do osso carpo-ulnar e o membro torácico esquerdo apresentava hiperextensão da mesma articulação com ângulo de 235°. Após a eutanásia, foi observada ruptura multifocal parcial do ligamento palmar do carpo no membro torácico esquerdo e ruptura total do tendão flexor digital superficial no membro torácico direito. Este estudo apresentou o caso e discutiu as possíveis causas da ocorrência de rupturas concorrentes. Além disso, o relato explorou a hiperextensão do carpo equino, uma condição rara com registros de recuperação limitados após lesões por ruptura do ligamento carpal palmar. Enfatiza o papel biomecânico deste ligamento e sua sinergia com o tendão flexor digital superficial na prevenção da hiperextensão. Embora as rupturas de tendões tenham opções de tratamento, a ruptura completa do ligamento palmar do carpo muitas vezes leva à eutanásia devido a danos articulares irreparáveis.
Palavras-chave: ortopedia equina; casos clínicos; sistema locomotor; membros torácicos.

1 | Introduction

The tendons and ligaments of the distal region of the thoracic limbs of horses are resistant anatomical structures, which support high loads and tensions, both in static and dynamic positions, capable of absorbing the impact and storing energy, acting as propellants during locomotion and thus reducing expenditure energy (Biewener, 1998; Smith et al., 2011; Patterson-Kane and Rich, 2014). Tendon and ligament injuries, including ruptures, are major contributors to musculoskeletal disorders in horses, with significant clinical and economic repercussions (Bonilla-Gutiérrez et al., 2019). Such injuries often stem from acute overloading or cumulative microtrauma, disrupting the balance between extracellular matrix degeneration and repair (Dahlgren, 2007). Lam (2013) highlighted tendon injuries, particularly in the superficial digital flexor tendon, as a leading cause of wastage in performance horses, noting that age-related risks indicate these overstrain injuries are linked to accumulated degeneration.

One of these fundamental structures is the palmar carpal ligament (PCL), formed by the thickening of the palmar surface of the joint capsule in this region, which, together with the flexor retinaculum, extends from the palmar surface of the accessory carpal bone to the palmar medial aspect of the carpal joints. Together, the PCL and the flexor retinaculum form the annular carpal palmar ligament, which involves the superficial and deep digital flexor tendons (Denoix, 1994, Pepe et al., 2013). In addition, the PCL is also the origin of the accessory ligament of the deep digital flexor muscle tendon. Together, these ligament structures ensure the alignment of carpal bones and prevent hyperextension (Engiles et al., 2017).

Horses are animals used for different purposes throughout human history. In urbanized centres, although there are many animals of high zootechnical value, individuals destined for the traction of carts by low-income families are also found (Segat et al., 2016). However, many of these horses do not receive proper handling practices and care for their health, including the lack of trim and shoeing. In the inadequate management of these essential practices for biomechanical balance, added to the repetitive stress of animal traction, musculoskeletal injuries develop (Schade et al., 2013). In this context, the objective of this report was to describe the case of rupture of the palmar carpal ligament of the left thoracic limb with simultaneous rupture of the superficial digital flexor tendon of the contralateral limb on a cart-traction horse. Furthermore, to discuss injuries in different structures, warning about similar clinical biomechanics.

2 | Case Description

A gelding male horse, approximately 13 years old, of mixed breed, weighing 234,57kg, used for traction and with a history of presenting alterations in both thoracic limbs, after a day of work, was received at the Veterinary Clinic Hospital of the Federal University of Pelotas (Rio Grande do Sul, Brazil). The animal's owner, a horse-drawn cart worker, reported transporting a load with the horse over the weekend, stating that he hadn't added much weight but that the distance was longer than usual. After the weekend, he observed alterations in the conformation of the carpi and reluctance to move in the morning. One day later, he took the horse to the hospital for further evaluation.

On general clinical examination, the animal presented tachycardia and tachypnoea, with heart and respiratory rates moderately elevated at 60bpm and 44rpm, respectively. The other clinical parameters, such as gastrointestinal motility, mucous membranes, capillary refill time, and rectal temperature, were within the physiological standards established for the species (Evans, 2007). During the locomotor system evaluation, on static assessment, the horse manifested severe hyperextension in the carpal region, with increase in temperature and intense pain in both thoracic limbs. In the left thoracic limb, there was a diffuse increase in volume evidenced from the humerus-radioulnar region, passing through the palmarolateral carpal face to the metacarpophalangeal joint, with the loss of anatomical silhouettes of the musculoskeletal structures when compared to the contralateral limb (Figure 1).

In the dynamic assessment, reluctance to locomotion was observed, with grade 5 of lameness, according to the American Association of Equine Practitioners (AAEP) scale, due to "minimal weight bearing in motion and/or at rest or a complete inability to move". Another important observation was the shortening of the caudal phase of the stance, in both thoracic limbs and an asymmetrical walk pattern, characterized by the typical movement of

antebrachiocarpal subluxation during the ground-bearing phase on the left thoracic limb, against only hyperextension of the right thoracic limb. In addition to bilateral carpal hyperextension, the carpo-metacarpal and proximal interphalangeal joints were also hyperextended, in addition to flexion of the distal interphalangeal joint in both thoracic limbs. No relevant biomechanical changes were observed in the pelvic limbs.

Figure 1. Static physical examination. Horse showing bilateral hyperextension of the carpal region of both thoracic limbs. (A) Left thoracic limb. (B) Right thoracic limb.

After the clinical examination, radiographic assessments of dorsal-palmar and lateromedial projections on the thoracic limbs were made. In the right thoracic limb, hyperextension of the radio-carpal joint (225°) (Figure 2B) and the presence of lateral subluxation of the carpal-ulnar bone (<10°) (Figure 2A) were observed. In the lateromedial projection, of the carpal region of the left thoracic limb, hyperextension of the antebrachiocarpal joint with an angle of 235° was observed (Figure 2C), with impairment of the dynamics of joint movement in a very similar way to the opposite limb.

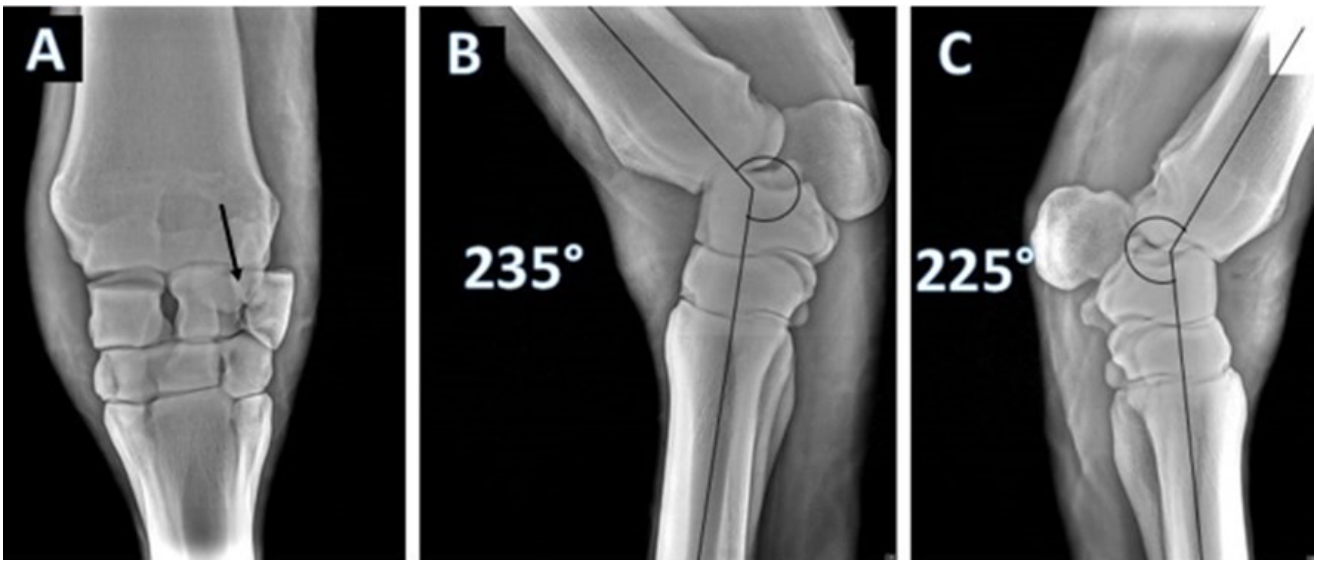

Figure 2. (A) Dorsopalmar radiographic projection of the carpal region of the left thoracic limb, with the presence of lateral subluxation of the carpal-ulnar bone (arrow). (B) Lateromedial radiographic projection of the carpal region on the left thoracic limb. (C) Mediolateral projection of the carpal region on the left thoracic limb.

Due to the severity of the clinical conditions, the severe pain, the grave prognosis and considering the animal welfare (FAWC, 2017), euthanasia was chosen according to Amaral et al. (2011) with the consent of the tutor. Afterwards, necropsy was performed to observe the pathological findings. Evidence of edema was observed in the left thoracic limb, due to the presence of abundant extracellular fluid in the subcutaneous and perimuscular tissues and the palmaromedial and palmarolateral recesses of the tendon sheath of the deep digital flexor (Figure 3 A, B, C). Multiple erosive lesions were identified in the articular cartilage on surfaces of the humerus-radio-ulnar, antebrachiocarpal and metacarpophalangeal joints, in which a focus of subchondral haemorrhagic lesion was also found in the lateral condyle surface of the third metacarpal bone (Figure 3 D, E, F).

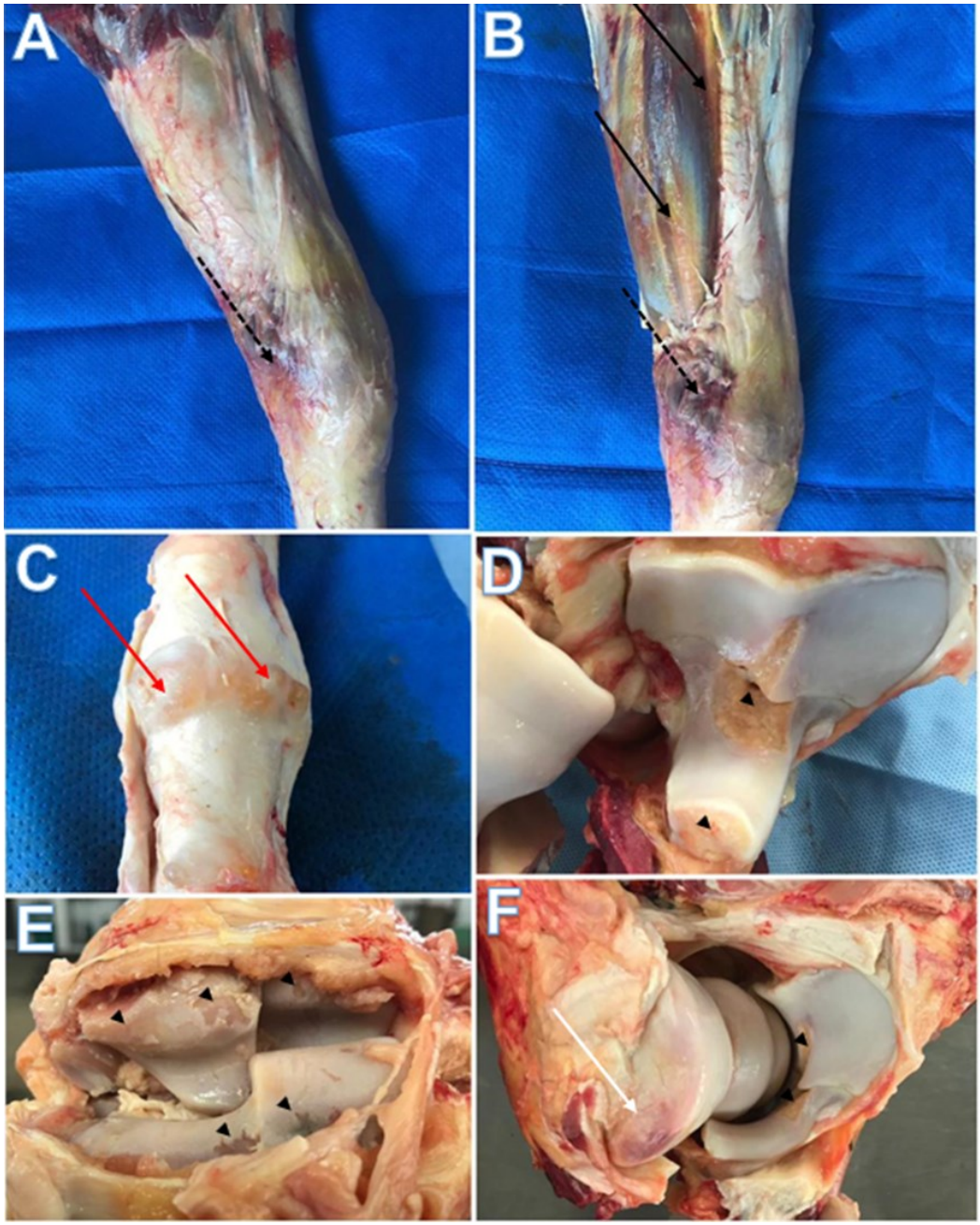

Figure 3. Macroscopic images of the left thoracic limb affected by the rupture of the carpal palmar ligament. (A, B) Presence of edema in the subcutaneous and perimuscular tissues (black arrows), with focal haemorrhage in the carpal tunnel region (dotted arrows). (C) Synovial effusion in the palmar-distal superficial digital flexor tendon recesses (red arrows). (D, E) Macroscopic images of the humerus-radio-ulnar and antebrachiocarpal joints with the presence of multiple erosive lesions of the articular cartilage with exposure of the subchondral bone (arrowheads). (F) Macroscopic image of the metacarpophalangeal joint showing multiple erosive lesions of the articular cartilage with exposure of the subchondral bone (arrowheads) and subchondral haemorrhagic lesion in the lateral condylar aspect of the III metacarpal bone (white arrow).

In the left thoracic limb, a partial multifocal tear of the palmar ligament of the carpus was observed in its middle third, associated with ecchymosis zones in the tendons of the superficial and deep digital flexor muscles (Figure 4A). In the contralateral limb (right thoracic), a total rupture of the tendon portion of the superficial digital flexor muscle was evidenced, with the presence of haemorrhagic petechiae in the ruptured stumps, at the height of the proximal third of the metacarpal region (Figure 4B), a lesion that has already been referenced (Carazzato, 1994), without involvement of the palmar ligament of the carpus. Integrity of the palmar ligament in the right thoracic limb and the tendon portion of the superficial digital flexor muscle in the left thoracic limb can be verified, with distinct evidence of injuries to the thoracic limbs (Figure 4A, B).

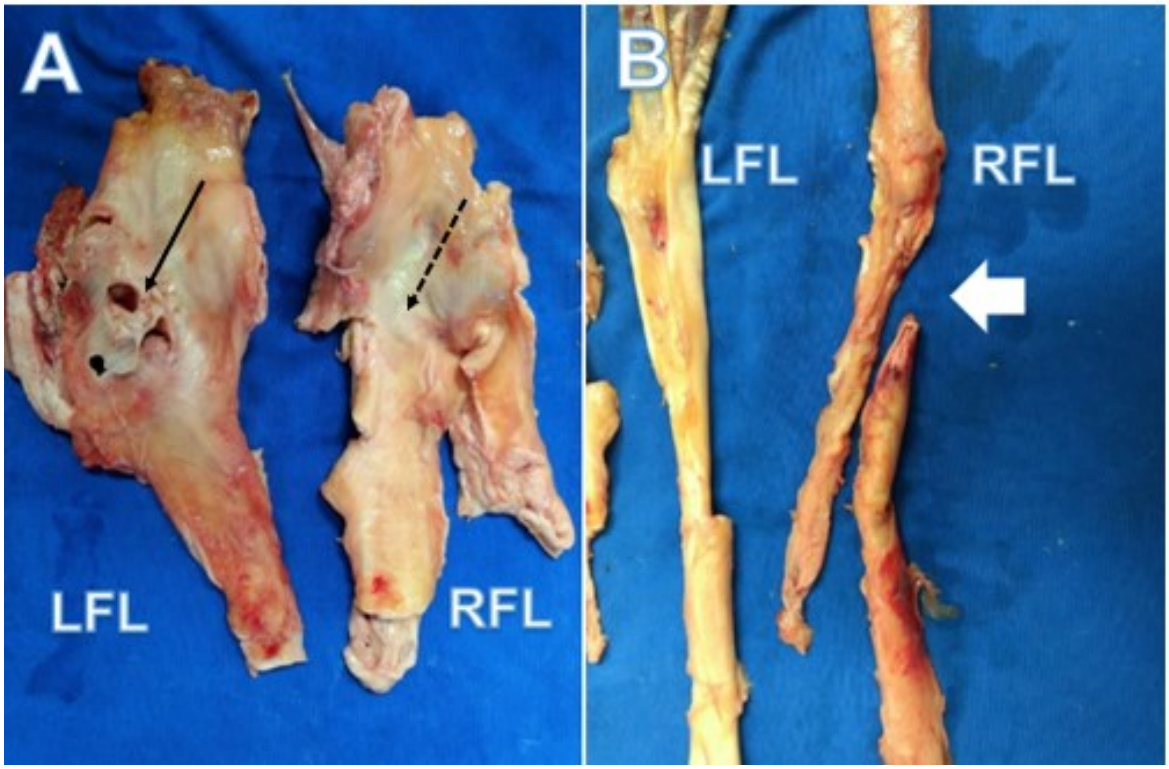

Figure 4. Dissection of the structures of the palmar ligaments of the carpus and the superficial digital flexor muscle in both the right and left thoracic limbs. (A) Ruptured palmar carpal ligament – left thoracic limb (LFL) (black arrow) and intact carpal palmar ligament – right thoracic limb (RFL) (dotted arrow). (B) Intact superficial digital flexor tendon – left thoracic limb (LFL and ruptured superficial digital flexor tendon (white arrow) of the right thoracic limb (RFL).

3 | Discussion

Carpal hyperextension is a rare condition in the horse and so far, there are no scientific clinical records showing recovery and return to sports activities when there is a ruptured injury to the carpal palmar ligament (Barba et al., 2014). Carpal hyperextension has been cited in several studies (Barr, 1994; Burn et al., 2006; Whitlock et al., 2012) but, as far as it is known, the biomechanical interaction between the palmar ligament and other small carpal ligaments (e. g. dorsal intercarpal ligaments) in preventing hyperextension in this region have not been well established in biomechanical studies (Barba et al., 2014; Nagy and Dyson, 2014).

During thoracic limb extension, the carpal region absorbs vertical ground reaction forces (GRF) generated by body weight and limb-ground contact during the support phase (Serra Bragança et al., 2021). In a healthy locomotor system, this kinetic energy is distributed longitudinally along the limb, both distally and proximally (Back et al., 1993). However, when alignment instability or injury occurs, such as the ligament ruptures diagnosed in this case (palmar carpal ligament and superficial digital flexor tendon), GRF is redistributed, overloading bones, joints, tendons, and ligaments, increasing the strain on the contralateral limb, and sometimes affecting pelvic limbs for additional support (Clayton et al., 2000). In the present case, despite thoracic limb instability due to conformational changes, no

alterations were observed in the pelvic limbs. Although morphologically distinct, the palmar carpal ligament and superficial digital flexor tendon have similar synergistic actions in the palmar region of the equine carpus, limiting extension and flexion in the sagittal plane (Palmer et al., 1987). Maximum extension occurs during the stance phase, when thoracic limb retraction is limited by tension from the flexor tendons, collateral ligaments, carpal intermediaries, and the palmar carpal ligament, a dense connective tissue structure (about 91.3 nm in adults) with obliquely organized type I collagen fibres (Dyce et al., 1987; Davankar et al., 1996; Pepe et al., 2013). Originating at the transverse palmar crest of the radius, this ligament connects to the carpal bones, forming the smooth dorsal wall of the carpal canal and continuing distally as the accessory ligament of the deep digital flexor tendon (Figure 5) (Getty, 1975). Denoix (2014) emphasized the role of the digital flexor muscles, particularly the superficial flexor, in flexing the carpus and digits, maintaining eccentric contraction during limb extension to store kinetic energy and prevent carpal hyperextension. Thus, the palmar carpal ligament and flexor tendons in the carpal tunnel contribute to radiocarpal joint stability, preventing hyperextension. Based on clinical observations, including static, dynamic, and radiographic examinations of both thoracic limbs in this case, it is notable that macroscopic lesions were found in distinct anatomical segments. Rupture of the palmar carpal ligament is a rare injury in equine orthopaedics, with limited detailed descriptions in previous studies, particularly regarding contralateral involvement of the superficial digital flexor muscle. Pepe et al. (2013) reported a case of severe carpal hyperextension in which the rupture of the palmar carpal ligament was identified as the cause of this characteristic posture. The findings in this case align with those described by the aforementioned authors regarding injury to the left thoracic limb but differ in that hyperextension of the right thoracic limb occurred with the same clinical and dynamic complexity, yet without rupture of the palmar carpal ligament. Instead, a lesion was found in the superficial digital flexor tendon. Although palmar carpal ligament lesions are rarely reported in horses, humans and small animals (i. e. in canine species) the occurrence is already more prevalent and better described (De Filippo et al., 2006; Piermattei et al., 2006). However, the main cause of this injury, regardless of the species, is of traumatic origin, and it is also the main etiological factor of the tendon rupture of the superficial digital flexor muscle in the equine species. Smith and Mair (2007) defined tendon rupture as a possibly catastrophic disease, with manifestation most commonly in the region comprising the middle third of the third metacarpal bone, coursing with possible hyperextension of the carpal segment and hyperflexion of the metacarpophalangeal joint, contrasting observed signs in the clinical inspection of both affected thoracic limbs in the horse of this report, which showed bilateral hyperextension of the metacarpal and proximal interphalangeal joints, with flexion only in the distal interphalangeal joints. It was not possible to establish which was the primary injury to the tendon or ligament, as the horse, at the first inspection, was bilaterally affected. It is believed, due to the greater hyperextension of the left thoracic limb and subluxation of the antebrachiocarpal joint, that the sagittal forces exceeded the limit of eccentric contraction of the fibre bundles of the superficial digital flexor tendon of the contralateral limb, secondarily triggering its rupture in the proximal third of the metacarpal region, causing both carpal regions to collapse.

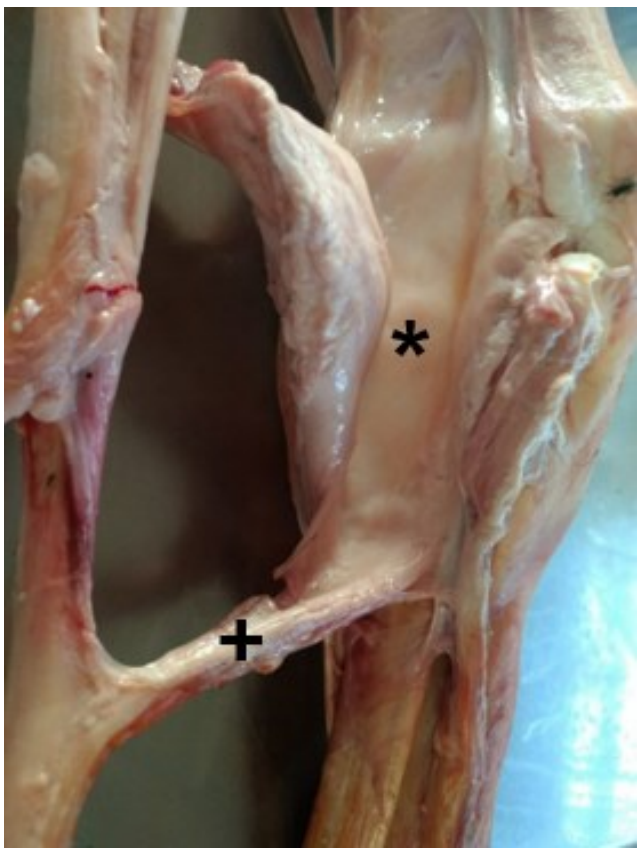

Figure 5. Palmar carpal ligament on the palmar surface of the carpal region (*) and accessory ligament of the tendon of the deep digital flexor muscle (+).

In the radiographic analysis of the case, subluxation of the ulnar carpal bone in the left thoracic limb resulted from the rupture of the intercarpal ligament between the intermediate and ulnar carpal bones, due to pressure exerted by the radius in a proximal-distal direction, secondary to the rupture of the palmar carpal ligament. Although both limbs were similar, this misalignment was observed only in the left thoracic limb, while the right limb showed intact joint lines in the transverse plane. Whitton and Rose (1997) highlighted that the palmar carpal ligament helps limit dorsopalmar displacement of the carpal bones, though less than the intercarpal ligaments. The collateral ligaments are key in containing bone displacement along the laterolateral axis, while dorsal intercarpal ligaments stabilize the intercarpal joints (Nagy and Dyson, 2014). Hyperextension of the antebrachiocarpal joints was clear in the lateromedial projections, showing a 'transcurved' angle of 225° in the right limb, due to superficial digital flexor tendon rupture, and 235° in the left limb, affected by palmar carpal ligament tear. The ligament rupture reduced carpal stability in the left limb, promoting subluxation and increased friction on the dorsoproximal surfaces of the carpal bones. Partial or total ruptures of the tendon structure of the digital flexors present clinical treatment alternatives and can even promote a return to sporting activities when treated surgically and with immobilization (Jorgensen and Genovese, 2003; Smith and Mair, 2007). However, there are no effective treatments for total palmar carpal ligament rupture, justifying the euthanasia of animals affected with this injury, due to the progression of the cascade of events, not limited to just one injury or joint, but multiple joint injuries in a degree of irreversibility, as observed in this report and cited in other studies (Pepe et al., 2013; Barba et al., 2014). It is believed that the biomechanical and conformational instability brought about by the rupture of the palmar carpal ligament is the key point to imbalances in mechanical forces on the hyaline cartilage and to the triggering of a perennial cycle of joint catabolism, with a notorious unfavourable evolution to the maintenance of the quality of life of horses affected with palmar carpal ligament rupture.

This parallel between published studies and the scarcity of reports about the findings in the present case reported, denote the importance of deepening histological and biomechanical studies to more accurately determine the importance of the palmar carpal ligament and surrounding structures, with regard to the biomechanics of extension of the carpus and the prevention of injuries in this region, as well as the implementation of therapeutic techniques that enable not only athletic performance, but also the life and well-being of affected animals.

4 | Conclusion

The rupture of the palmar carpal ligament in the left thoracic limb caused hyperextension of the carpal joint, causing subluxation of the ulnar carpal bone, creating stress on other supporting structures of the limb, such as the superficial and deep digital flexor tendons.

The rupture in the tendon portion of the superficial digital flexor on the right thoracic limb caused hyperextension of the carpus, presenting clinical alterations similar to the rupture of the palmar ligament of the carpus.

More in-depth studies about the specific biomechanics of musculoskeletal structures are needed, as their maximum load capacity during different types of gaits.

5 | Conflict of Interest Statement

The authors declare no conflict of interest.

6 | References

Amaral, L.A.; Rabassa, V.; Marchiori, M.; Meirelles, M.; Amado, M.; Nogueira, C.E.W. Use of lidocaine hydrochloride 2% intrathecally associated with prior anesthesia with thiopental as a method of euthanasia in horses. **Ars Veterinaria**, 27(1): 011-016, 2011.

Back, W.; Barneveld, A.; Van Weeren, P.R.; Van Den Bogert, A.J. Kinematic gait analysis in equine carpal lameness. **Acta Anatomica (Basel)**, 146: 86–89, 1993.

Barba, M.; McMaster, M.; Albanese, V.; Cole, R.; Caldwell, F.; Schumacher, J. Carpal hyperextension in a Percheron mare caused by a palmar carpal ligament tear. **Equine Veterinary Education**, 26(7): 347-352, 2014.

Barr, A.R. Carpal conformation in relation to carpal chip fracture. **Veterinary Record**, 134: 646-650, 1994.

Biewener, A.A. Muscle-tendon stresses and elastic energy storage during locomotion in the horse. **Comparative Biochemistry & Physiology Part B: Biochemical and Molecular Biology**, 120(1): 73–87, 1998.

Bonilla-Gutiérrez, A.F.; López, C.; Carmona, J.U. Regenerative therapies for the treatment of tenodesmic injuries in horses. **Journal of Equine Veterinary Science**, 73: 139-147, 2019.

Burn, J.F.; Portus, B.; Brockington, C. The effect of speed and gradient on hyperextension of the equine carpus. **The Veterinary Journal**, 171: 169-171, 2006.

Carazzato, J.G. Lesões musculotendíneas e seu tratamento. **Revista Brasileira de Ortopedia**, 29(10): 723-728, 1994.

Clayton, H.M.; Schamhardt, H.C.; Willemen, M.A.; Lanovaz, J.L.; Colborne, G.R. Kinematics and ground reaction forces in horses with superficial digital flexor tendinitis. **American Journal of Veterinary Research**, 61: 191–196, 2000.

Dahlgren, L.A. Pathobiology of tendon and ligament injuries. **Clinical Techniques in Equine Practice**, 6(3): 168-173, 2007.

Davankar, S.P.; Deane, N.J.; Davies, A.S.; Firth, E.C.; Hodge, H.; Parry, D.A.D. Collagen fibril diameter distributions in ligaments and tendons of the carpal region of the horse. **Connective Tissue Research**, 34(1): 11-21, 1996.

De Filippo, M.; Sudberry, J. J.; Lombardo, E.; Corradi, M.; Pogliacomi, F.; Ferrari, F. S.; Bocchi, C.; Zompatori, M. Pathogenesis and evolution of carpal instability: imaging and topography. **Acta Biomedica**, 77(3): 168-180, 2006.

Denoix, J.M. Functional anatomy of tendon and ligaments in the distal limbs (manus and pes). **The Veterinary Clinics of North America: Equine Practice**, 10(2) 273-322, 1994.

Denoix, J.M. **Biomechanics and physical training of the horse**. 1st ed. Boca Raton: CRC Press, 2014. 192p.

Dyce, K.M.; Sack, W.O.; Wensing, C.J.G. **Textbook of veterinary anatomy.** Philadelphia: W. B. Saunders Company, 1987. p.554-567.

Engiles, J.B.; Stewart, H.; Janes, J.; Kennedy, L.A. A diagnostic pathologist's guide to carpal disease in racehorses. **Journal of Veterinary Diagnostic Investigation**, 29(4): 414-430, 2017.

Evans, D.L. Physiology of equine performance and associated tests of function. **Equine Veterinary Journal**, 39(4): 373-383, 2007.

FAWC. Farm Animal Welfare Committee. **Opinion on the welfare of animals killed on-farm.** 2017. Available at: <www.gov.uk/government/collections/fawc-advice-to-government>. Accessed on: 24 jan. 2022.

Getty, R. **Sisson and Grossman's The Anatomy of the domestic animals**. Vol 1. 5th ed. Philadelphia: Saunders, 1975. 1286p.

Jorgensen, J.S.; Genovese, R.L. Superficial digital flexor tendonitis. In: Ross, M.W.; Dyson, S.J. (Eds). **Diagnosis and management of lameness in the horse**. 1st ed. St Louis: W.B. Saunders, 2003. p.628-642.

Lam, K.K.H. Comparative epidemiology of tendon injuries in different racing disciplines. **The Veterinary Journal**, 195(3): 265-266, 2012.

Nagy, A.; Dyson, S. The challenge of diagnosing soft tissue injuries in the palmar aspect of the carpus. **Equine Veterinary Education**, 26(7): 353-356, 2014.

Palmer, S.; Barlow, D.; Ji-Chun, X. Kinematics of the Equine Carpus. In: Gillespie, J.R.; Robinson, N.E. (Eds). **Equine Exercise Physiology 2**. Davis, CA: ICEEP Publications, 1987. p.599-606.

Patterson-Kane, J.C.; Rich, T. Achilles tendon injuries in elite athletes: lessons in pathophysiology from their equine counterparts. **ILAR Journal**, 55(1): 86-99, 2014.

Pepe, M.; Beccati, F.; Gialletti, R.; Moriconi, F. Bilateral rupture of the palmar carpal ligament in a horse suffering from acute diaphragmatic hernia. **Journal of Equine Veterinary Science**, 33(1): 57-61, 2013.

Piermattei, D.L.; Flo, G.L.; DeCamp, C E. Fractures and other orthopedic conditions of the carpus, metacarpus, and phalanges. In: ____. **Brinker, Piermattei and Flo's handbook of small animal orthopedics and fracture repair**. 4th ed. St. Louis, Missouri: Saunders Elsevier, 2006. p.382-428.

Schade, J.; Baldissera, R.; Paolini, E.; Fonteque, J.H. Biometria do equilíbrio podal em equinos de tração pertencentes ao Programa de Extensão "Amigo do Carroceiro" do Centro de Ciências Agroveterinárias da Universidade do Estado de Santa Catarina no município de Lages/SC, Brasil. **Ciência Rural**, 43(3): 456-461, 2013.

Segat, H.J.; Braga, D.N.; Samoel, G.V.A.; Porto, I.P.Ó.; Weiblen, C.; Rodrigues, F.S.; Vogel, F.S.F.; Pereira, D.I.B.; Sangioni, L.A.; Botton, S.A. Equinos Urbanos de Tração: Interação Social, Sanidade e Bem Estar Animal. **Investigação**, 15(4): 71-76, 2016.

Serra Bragança, F.M.; Hernlund, E.; Thomsen, M.H.; Waldern, N.M.; Rhodin, M.; Byström, A.; van Weeren, P.R.; Weishaupt, M.A. Adaptation strategies of horses with induced forelimb lameness walking on a treadmill. **Equine Veterinary Journal**, 53(3): 600-611, 2021.

Smith, L.J.; Mair, T.S. Rupture of the superficial flexor tendon in the forelimb in aged horses: a report of nine cases. **Equine Veterinary Education**, 19(4): 183-186, 2007.

Smith, M.A.; Dyson, S.J.; Murray, R.C. The appearance of the equine metacarpophalangeal region on high-field vs. standing low-field magnetic resonance imaging. **Veterinary Radiology & Ultrasound**, 52(1): 61-70, 2011.

Whitlock, D.; Garcia, T.C.; Vallance, S.A.; Stover, S.M. Possible role of carpal hyperextension in superficial digital flexor tendinopathy. **Equine Veterinary Journal**, 44: 559-563, 2012.

Whitton, R.C.; Rose, R.J. The intercarpal ligaments of the equine midcarpal joint, part 2: the role of the palmar intercarpal ligaments in the restraint of dorsal displacement of the proximal row of carpal bones. **Veterinary Surgery**, 26(5): 367-373, 1997.