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Diagnosis and management of tendon and ligament injuries of the equine foot

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Introduction
Distal interphalangeal joint (DIPJ) arthropathy and navicular disease (podotrochlear syndrome) are well known conditions as primary causes of chronic foot lameness. Biomechanical stresses and a lot of different conditions such as chronic hoof unbalance or long toe-low hoof angle can be responsible for these conditions. Ligament and deep digital flexor tendon (DDFT) injuries are often considered in the differential diagnosis of foot problems without radiographic findings. Now a real definitive diagnosis is possible with ultrasonography and Magnetic Resonance Imaging (MRI). Collateral ligament (CL) injuries have occasionally been reported in the literature. Injuries of other ligaments of the foot may induce lamenesses which can be confused with a DIPJ arthropathy or a podotrochlear syndrome.
The purposes of this paper are to demonstrate the interest of ultrasonography in the differential diagnosis of foot injuries, to present the accuracy of this technique in the diagnosis of numerous ligament and tendon injuries in the foot and to discuss the limitations of this technique comparatively to MRI, a modality now available in some referral centers.

Materials and methods
All the clinical cases were examined clinically and were investigated with radiography ultrasonography. The most difficult cases have also been investigated with nuclear scintigraphy and/or MRI.
Ultrasound examination of the DIPJ was performed using dorsal and collateral approaches of the coronet using longitudinal and transverse sections made with 7.5 or 10 MHz linear probes. In some cases, 7.5 MHz convex or sector probes were also used to examine the
distal insertion of injured collateral ligaments on the distal phalanx (P3). The hair of the coronet was clipped short and the skin was cleaned with hot water. Acoustic gel and a stand off pad were used to improve contact between the probe and coronet. On transverse sections, the probe was placed over the periopleum which represents a good acoustic window between the skin and hoof wall to obtain the best images.

Examination of the palmar aspect of the joint and podotrochlear apparatus (PTA: distal sesamoid bone-DSB and associated ligaments, DDFT and podotrochlear bursa) was performed with two approaches. The proximopalmar aspect of the joint was examined with a 7.5 MHz microconvex probe placed on the most distal part of the pastern. The hair of this area was clipped short and the skin was cleaned with hot water; no stand off pad was used. Images were done the toe being placed on the operator’s knee to induce extension of the DIPJ. Examination of the distopalmar aspect of the joint was performed with a 6MHz convex probe through the frog to image the PTA (DSB, distal impar sesamoidean ligament-DISL, DDFT) and distal surface of P3. To improve the contact with the frog, the most superficial part of the horn was cut to obtain a flat and clean surface over the body and dorsal part of central sulcus of the frog.

### Results

1 - Collateral ligaments injuries

Collateral desmopathy were found on the lateral side or medial side of the DIPJ in forelimbs and hindlimbs. A trauma (sliding, twisting, bad step) was observed prior to the examination in half of the patients.

On radiographs, most of the affected limbs presented enthesiophytes on P2 and/or P3. Osteolysis can be found at the distal attachment on P3 and/or at the proximal attachment of the CL on P2. Few cases presented an avulsion fracture at the distal insertion of the CL on the collateral fossa of P3. Periarticular osteophyte proliferation was observed in the longer standing cases.

In all horses, the 2 CL of the affected DIPJ have been examined ultrasonographically and compared to the CL of the opposite normal limb, in transverse and longitudinal sections. In all cases, the injured ligament appeared thickened and hypoechogenic compared to the opposite sound one of the same limb and the homologous one of the normal limb. Bone
changes at the insertion sites were also clearly seen with ultrasonography. They include osteolysis, enthesophyte production and avulsion fractures. Synovial fluid distension of the DIPJ dorsal and/or palmar recesses was also documented ultrasonographically in most of the horses. Management of the condition includes reduction of physical activity depending on the severity of the clinical manifestations, corrective shoeing, soft ground footing and reduction of turns. The objective of the corrective shoe is to reduce ligament tension using a wider support under the lesion and a bevel on the opposite side to reduce ligament stresses during turns opposite to the lesion.

2 - Other ligaments injuries
Injuries of other ligaments in relation with the DIPJ have been found in the coronet area. These lesions involved the chondrocoronal ligament, between the ungular cartilage and P2 and the chondrocompepal ligament, between the ungular cartilage and P1. Moreover, lesions have been diagnosed and documented in palmar ligaments participating to the podotrochlear apparatus including the collateral sesamoidean ligaments using a proximopalmar approach and the DISL using a distopalmar approach.

3 - Degenerative joint disease
Abnormal findings indicative of degenerative joint disease of the DIPJ can be demonstrated ultrasonographically. They include synovial distension of the dorsal and proximopalmar recesses of the DIPJ, bone remodeling at the dorsal and collateral aspects of P2. Periarticular osteophytes on the dorsal margins of P2 and extensor process of P3, on the palmar margins of P2 and DSB, as well as on the collateral aspects of the distal condyles of P2 (where there are very difficult to identify with radiography) are also seen in DIPJ degenerative joint disease. A full rolling motion shoe, soft ground footing and reduction of turns are essential for the management of this condition.

4 - Podotrochlear apparatus lesions
Many PTA injuries have been diagnosed with ultrasonography and MRI. They include: collateral sesamoidean desmopathies and enthesopathies, distal impar sesamoidean desmopathies and enthesopathies, suprassesamoidean and infrassesamoidean DDFT tendinopathies, DDFT enthesopathies on the flexor surface of P3, distal digital annular ligament injuries, chondrosesamoidean ligament desmopathies and enthesopathies, podotrochlear bursitis, flexor surface alteration and fractures of the DSB.
Distal impar sesamoidean enthesopathies can be seen on the distal border of the DSB and/or at the opposite insertion surface on P3. When this condition is present, the bone surface becomes irregular and the underlying bone is echogenic because of the osteolysis.

Asymmetric thickening of the 2 lobes of the DDFT and changes in echogenicity are indicative of a suprassesamoidean DDF tendinopathy. As the tendon is imaged obliquely in this location, it appears as a progressively hypoechogenic structure down to the level of the DSB. Recent tendinopathies and granulation tissue induce more hypoechogenic images than the rest of the tendon and diffuse or localised thickening. In chronic lesions, hyperechogenic spots are easily seen in the tendon because of its hypoechogenic appearance. A definitive diagnosis is made when the size of the 2 lobes is asymmetric, when changes in echogenicity and size can be documented in longitudinal as well as transverse sections and when comparison is made between the 2 front feet.

Infrassesamoidean DDF tendinopathies induce thickening and changes of echogenicity and architecture in the distal part of the tendon. Moreover, in DDFT enthesopathies, the flexor surface of P3 is irregular and the underlying bone becomes echogenic.

On MRI scans, DDFT lesions induce thickening of the injured part of the tendon and diffuse or focal areas with increased signal in T1 and T2 weighted sequences as well as in fat saturation images;

Management of DDF tendinopathies includes corrective shoeing, soft ground footing and reduction of turns. The objective of the corrective shoe is to reduce the DDFT tension during propulsion phase of the stride using a rolling toe and a wider support under the heels. Egg bar shoes with rolling toe or reverse shoe with a bevel at the dorsal aspect of the branches are indicated.

**Discussion and Conclusion**

A specific diagnosis of several foot conditions can be made on clinical cases with appropriate imaging techniques. Many ligament and tendon injuries of the foot can be diagnosed and documented with ultrasonography and MRI; these techniques were found particularly useful in horses presenting a foot lameness without significant radiographic finding.
Severe collateral desmopathy of the DIPJ was found in patients with a acute distal limb lameness. A differential diagnosis between this condition and other bone or ligament injuries in relation with the DIPJ can now be made. Acute as well as chronic tendinopathies of the DDFT have been diagnosed in a lot of patients. The use of MRI in some of them permitted improvement in the ultrasound technique and interpretation.

Ultrasonographic examination of the foot requires a deep knowledge of the descriptive and topographic anatomy of this area as well as adequate equipment and technique. In order to improve the sensitivity and specificity of the procedure in the examination of symmetrical structures (such as CL in every joints) a double square comparison must be done; it consists in comparing the injured structure with the symmetrical one of the same limb; comparing the injured structure with the equivalent one of the opposite limb; and this must be performed on longitudinal as well as transverse sections.

Limitations of ultrasonography in the evaluation of tendons and ligaments in the foot include mainly the lack of imaging of the collateral parts of the DISL and distal DDFT. These structures can be completely investigated with MRI which allows diagnosis of small and deep structures such as the chondrosamoidean ligaments. With these two modalities considerable progress has been made in the knowledge of equine foot injuries during the last years. A precise knowledge of the injured structure(s) help in prescribing the most appropriate corrective shoeing program for every horse.

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