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Ultrasonographic examination of the equine limbs: a live demonstration

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Introduction
Ultrasonography has become an essential procedure for the diagnosis of tendon and joint injuries. With this technique and the new equipments available, a non invasive assessment of the majority of the soft tissues of every joints in the limbs, back and pelvis is possible. Ultrasonography provides also useful information on many lesions of the articular surfaces. The objectives of the demonstration are:
1- to show how to image the most interesting anatomical structures being frequently injured;
2- to provide normal anatomical images to aid in the identification of the most frequent injuries seen in horses;
3- to present the main ultrasonographic abnormal findings of the different tendon and joint structures.

Palmar metacarpus: flexor tendons and suspensory ligament
The demonstration is focused on the proximal suspensory ligament (third interosseus muscle, TIOM). The flexor tendons are used to demonstrate the contrast enhancement technique (CET) consisting in highlighting the contrast between different structures or between the different tissues within the same structure, tilting the probe to make an oblique cross section of the anatomical structures being examined. This procedure is especially useful for examining the proximal TIOM on the weight bearing and on the flexed limb. When the probe is perpendicular to the TIOM, the tendon fasciculi and fat fasciculi have the same echogenic appearance; when the probe is placed obliquely, because of its anisotropy, the tendon become hypoechogenic and can easily be differentiated from the fat remaining echogenic. This procedure increases considerably the sensitivity of ultrasonography in diagnosing small lesions of the tendinous parts of the proximal TIOM.

Fetlock joint
The fetlock joint has a thick dorsal articular capsule. Except the suspensory apparatus (third interosseus muscle, proximal sesamoid bones and palmar ligament, sesamoidean ligaments) this joint presents two symmetrical collateral ligaments with 2 layers: a superficial and long one as well as a short and oblique layer.
This joint presents two main recesses: a dorsal recess with little synovial fluid in normal joints and a fibrous proximodorsal synovial fold, and a proximopalmar recess with numerous and high synovial villi.
The dorsal and collateral articular margins are easily accessible and smooth in normal joints. The articular cartilage and subchondral bone surface of the dorsal aspect of the metacarpal (metatarsal) condyle can be imaged on the weight bearing limb whereas imaging of he distal aspect of this articular surface requires flexion of the joint. The articular cartilage is thicker dorsally (approximately 0.8-1 mm) than distally (approximately 0.4-0.5 mm).
The palmar aspect of the joint is supported by the proximal scutum made of the two proximal sesamoid bones (PSB) and the palmar (or intersesamoidean) ligament. The two digital flexor tendons passe in the ‘fetlock canal’ closed by the palmar annular ligament attached on the palmar border on both PSB. Proximally to these bones, the deep digital flexor tendon (DDFT) passes in the manica flexoria of the superficial digital flexor tendon (SDFT).

**Pastern: flexor tendons and sesamoidean ligaments**

The demonstration is focused on the palmar aspect of the pastern. The objective is to demonstrate the ultrasonographic anatomy of the superficial digital flexor tendon (SDFT) progressively divided in two branches attaching on the middle scutum and the deep digital flexor tendon (DDFT) progressively divided in two lobes and passing between the two SDFT branches. A synovial plica attached on the SDFT branches covers the dorsal aspect of the DDFT at the middle of the proximal phalanx.

The straight sesamoidean ligament is sagittal and extends from the proximal scutum to the middle scutum attached on the palmar tuberculum of the second phalanx. On both sides of the pastern, the oblique sesamoidean ligament extends from the base of the corresponding PSB to the palmarocollateral aspect of the proximal phalanx. Its proximal part is best seen when the probe is placed on the lateral (or medial) aspect of the pastern, below the corresponding PSB. The cruciate sesamoidean ligament can be imaged proximally between the palmar eminences of the proximal phalanx. Imaging of the palmar ligaments of the proximal interphalangeal joint and of the scutocompedal ligament is performed on transverse section using a collateral (lateral or medial) approach.

**Distal interphalangeal joint (DIPJ) and podotrochlear apparatus (PTA)**

This joint presents 6 ligaments that can be imaged ultrasonographically: two short and strong collateral ligaments between the middle phalanx (P2) and the distal phalanx (P3), two long and oblique collateral sesamoidean ligaments (CSL) between the distal sesamoid bone (DSB) and P2 as well as the proximal phalanx (P1), a proximal sesamoidean ligament (PSL) inserted on the proximal border of the DSB and joining the CSL on both sides, and a short but wide distal (impar) sesamoidean ligament (DSL) between the DSB and P3. The DIPJ present two main recesses accessible with ultrasonography: a dorsal recess between the dorsal digital extensor tendon and P2 and a proximopalmar recess located proximal to the DSB.

The podotrochlear apparatus (PTA) is made of the distal sesamoid bone and associated structures: CSL, PSL, DSL, podotrochlear bursa, deep digital flexor tendon and distal digital annular ligament. Whatever the structure injured, the horse present a typical foot lameness with reduction of the propulsion phase of the stride, clinical expression of a podotrochlear syndrome (formely “navicular disease”)

**Carpal canal**

The objective of the demonstration is to image the carpal canal content and the flexor retinaculum. The content is made of tendon structures (the SDFT and its accessory ligament and the DDFT) as well as neurovascular structures such as the median artery, vein and nerve.

**Shoulder joint**

The scapulohumeral joint is closed by a thin articular capsule and does not present any ligament. This capsule is better seen with the lateral and caudolateral approaches than it is with a cranial approach to the joint. It is covered by the supraspinatus, infraspinatus and deltoideus muscles.

There is very little synovial fluid in the articular cavity in sound joints. When present, this fluid is seen on a caudolateral approach below the margin of the humeral head.
The articular margins are also more easily imaged with lateral and caudolateral approaches; the glenoid cavity has a sharp articular margin on longitudinal sections whereas the humeral head has very a smooth caudolateral articular margins. The articular surface of the scapula cannot be imaged ultrasonographically. The lateral and caudal parts of the humeral head are the only articular surfaces accessible with this technique. The exposed surface can be expended when the limb is protracted and adducted.

**Hock joint**

The **crurotarsal joint** has two strong and complex collateral ligaments (CL). Each of them is composed a long and single CL as well as a short CL with a calcanean and a talean parts. The talean part of the medial CL is divided into a superficial and a deep fasciculi. These different ligaments do not have the same orientation; therefore examination of each of them in longitudinal and transverse sections requires a specific orientation of the probe. The articular capsule can easily be imaged at the medial and dorsal aspects of the joint. The normal crurotarsal joint has a wide dorsomedial recess which is imaged below the medial malleolus of the tibia. The normal synovial fluid is totally anechogenic, and the synovial membrane present distinct villi floating in the synovial fluid. In normal horses, there is very little amount of fluid dorsally and laterally between the talus and the articular capsule or in the plantarolateral and plantaromedial recesses of the tarsocrural joint. The articular margins of the medial malleolus and the medial aspect of the talus are imaged with a medial approach. The dorsal aspect of the articular surface of the talus is widely exposed allowing an easy imaging of the medial and lateral trochlea ridges of this bone. On the flexed hock, the caudoproximal part of the talus trochlea can also be examined. The **distal tarsus** is surrounded by strong ligaments composed of the distal part of the CL, laterally and medially, the talometatarsal ligament dorsally and the distal plantar ligament caudally. Very little amount of synovial fluid can be seen at the medial aspect of the distal intertarsal joint or at the plantarolateral aspect of the tarsometatarsal joint. The articular margins of theses two joints are regular and sharp; the joint spaces with the articular cartilage appear as an anechogenic gaps in the hyperechogenic profile of the distal tarsal bones.

**Stifle joint**

The three patellar ligaments (PL) of the **femoropatellar joint** can be imaged on longitudinal and transverses sections. On transverse sections, the medial PL is triangular, the intermediate PL is round and the lateral PL is flat and wide, melted over the lateral ridge of the femoral trochlea in its proximal part. The distal part of these ligaments is extraarticular, as the infrapatellar fat pad is placed between them and the synovial membrane. The femoropatellar joint present three recesses with synovial fluid: one medial caudal to the medial PL, one lateral caudal to the lateral PL and one proximal between the femur and quadriceps femoris muscle. High and thick synovial villi are present in the medial femoropatellar recess. The distal articular margin of the patella is smooth. The articular surface of the femoral trochlea is widely exposed on the weight bearing limb. The medial trochlea ridge is thick and present a thin articular cartilage (between 1 and 2 mm thick); the lateral trochlea ridge is sharp and covered by a thick articular cartilage (between 2 and 4 mm thick); the femoral trochlea groove often present an irregular subchondral bone surface. The **femorotibial joint** present two menisci the body and horns of which can be examined on the weight bearing limb. On longitudinal section, the medial meniscus present a triangular radial section with a concave proximal border melted over the medial femoral
condyle. The body of the lateral meniscus has a trapezoidal shape whereas its cranial and caudal horns have a triangular radial section. The cranial attachment of each meniscus can be imaged on longitudinal and transverse sections on the flexed limb. The medial collateral ligament is applied on the medial meniscus whereas the lateral collateral ligament is separated from the lateral meniscus by the proximal tendon of the popliteus muscle. The insertion surfaces of the cruciate ligaments can be imaged on the flexed stifle with a cranial approach and on the weight bearing limb with a caudal approach, but because of their orientation, the cruciate ligaments themselves are hypoechogenic and difficult to differentiate from the surrounding structures. The femorotibial joint present two main synovial recesses. On sound joints, the medial femorotibial joint recess contains anechogenic synovial fluid and few or no synovial villi. On sound stifles, there is no synovial fluid in the subextensorius recess of the lateral femorotibial joint. The femoral and tibial articular margins of the femorotibial joint are smooth and regular. The distal articular surfaces of the femoral condyles can be imaged on parasagittal and transverse sections on the flexed limb. The caudal articular surfaces of these condyles can be imaged with a caudal approach to the joint.

Discussion
Ultrasonographic evaluation of tendons and joints is a very informative procedure for diagnosing many injuries with or without radiographic manifestations. As a primary step, knowledge of soft-tissue anatomy is essential as is regular training to gain knowledge of the normal ultrasonographic appearance of each joint structure. Because of their quite simple anatomy, the fetlock and stifle can be used as models for beginners in this diagnostic procedure. In all clinical cases, comparison with the same structure of the contralateral limb improves sensitivity (better identification of lesions) and specificity (limits false interpretation) of the ultrasonographic diagnosis.

Like every imaging technique, the ultrasonographic examination of joints has some limitations mainly related to anatomical particularities of the joints. For example, in the fetlock joint, the main limitation of ultrasonography is the lack of imaging of the proximal articular surface of PI and palmar (plantar) articular surface of the metacarpal (metatarsal) condyle. In the carpus and tarsus, the intraarticular ligaments and most of the articular surfaces cannot be imaged. In the stifle, the cruciate ligaments cannot be adequately represented and the articular surface of the patella is not accessible. Despite these limitations, ultrasonography provides many diagnostic informations through a non invasive approach of the joints. For the equine practitioner, there is much value in combining systematically radiography and ultrasonography. This complementary approach provides more information concerning the different anatomical components of the joint. It helps to interpret X-rays and fastens the gain of experience. Besides, with this combination, the limitations of each technique are better identified.