Review Article

Ultrasonographic examination of the palmar aspect of the pastern of the horse: Sesamoidean ligaments

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Summary
The suspensory apparatus is composed of the third interosseous muscle (TIOM) or suspensory ligament, the proximal sesamoid bones, palmar ligament and distal sesamoidean ligaments (DSL). Of these structures, the suspensory ligament is the most frequently implicated in conditions seen in race and sport horses; nevertheless, DSL lesions are not rare and often associated with other injuries that can modify patient prognosis and management. Ultrasonography has been shown to be valuable in the assessment of DSL desmitis. In contrast to the metacarpal area, the pastern region has been considered technically more difficult to scan because of the small and irregular contact surface and frequent artefacts. Advances in imaging techniques with adapted ultrasound probes and the use of magnetic resonance imaging (MRI) for equine lameness evaluation have revealed that distal sesamoidean ligament injuries are more frequently implicated in lameness than previously suspected.

Introduction and indications
The suspensory apparatus is composed of the third interosseous muscle (TIOM) or suspensory ligament, the proximal sesamoid bones, palmar ligament and distal sesamoidean ligaments (DSL). Of these structures, the suspensory ligament is the most frequently implicated in conditions seen in race and sport horses; nevertheless, DSL lesions are not rare and often associated with other injuries that can modify patient prognosis and management (Denoix et al. 1991; Dyson and Denoix 1995). Ultrasonography has been shown to be valuable in the assessment of DSL desmitis (Denoix et al. 1991; Denoix 1994a; Coudry and Denoix 2004). In contrast to the metacarpal area, the pastern region has been considered technically more difficult to scan because of the small and irregular contact surface and frequent artefacts (Redding 1996). Advances in imaging techniques with adapted ultrasound probes and the use of magnetic resonance imaging (MRI) for equine lameness evaluation have revealed that distal sesamoidean ligament injuries are more frequently implicated in lameness than previously suspected (Sampson et al. 2007; Smith et al. 2008b).

Indications for examining the DSL include:

- Positive response to diagnostic analgesia such as positive common digital and metacarpal nerves block (low 4 point nerve block), proximal digital (abaxial sesamoidean) nerve block, or intrasynovial analgesia of the metacarpo/metatarsophalangeal joint or the digital tendon sheath;
- Suspensory ligament injuries and/or lack of fetlock suspension;
- Abnormal findings of the pastern detected by other imaging techniques such as radiography or nuclear scintigraphy, to evaluate soft tissue integrity;
- Ruling out a magic angle artefact in MRI scans.

The purpose of this paper is to present the technique of the ultrasonographic examination of the DSL, then, the echoanatomy, reference and principal pathological images of the DSL.

Basic anatomy
The DSL act as a part of the suspensory apparatus and provide resistance to metacarpo/metatarsophalangeal hyperextension during the weightbearing phase of the stride. They include the straight sesamoidean ligament (SSL), oblique sesamoidean ligaments (OSLs), cruciate sesamoidean ligaments (CSLs) and short sesamoidean ligaments (SSLs) (Denoix 2000). All DSL originate proximally from the base of the proximal sesamoid bones and palmar (or intersesamoidean) ligament (Fig 1).

The SSL originates from the palmar ligament and the proximal sesamoid bones and courses distally in the sagittal plane towards the flexor tuberosity of the middle phalanx (P2). It inserts on this bone by means of a thick fibrocartilaginous structure, the scutum medium (middle scutum). It participates in sagittal stabilisation of the metacarpo/metatarsophalangeal and proximal interphalangeal joints. Each lateral and medial OSL mainly originates at the base of the corresponding proximal sesamoid bone and runs obliquely to the sagittal plane. The lateral and medial ligaments form a V-shape and insert together on the trigonum of the proximal phalanx (P1), at the palmar aspect of this bone. A sagittal fascicule originating from the palmar ligament ends with the OSLs on the distal apex of the trigonum of P1. Oblique sesamoidean ligaments limit extension, collateral motion and rotation of the metacarpo/metatarsophalangeal joint (Denoix 1994b).

Each CSL crosses the sagittal plane obliquely from the base of a proximal sesamoid bone to the axial margin of
the opposite palmar/plantar eminence of P1 and outline the distal palmar/plantar synovial recess of the metacarpo/metatarsophalangeal joint.

The ssLs extend from the dorsal aspect of the base of the proximal sesamoid bones to the proximopalmar/plantar margin of P1. They are closely related to the OSLs and difficult to differentiate from them, and covered by the synovial membrane of the metacarpo/metatarsophalangeal joint.

Cruciate and short sesamoidean ligaments are much smaller than straight and oblique ones and their role in fetlock suspension is limited.

**Equipment and technique**

The technique and images presented in this paper were performed with a 7.5–10 MHz linear transducer. Long T-shape or endorectal probes can be used for transversal scans but good quality images of longitudinal sections are difficult to obtain in short pastern horses due to the maladjustment to the shape of the pastern and consequent lack of contact with the skin surface.

The palmar/plantar and palmaro/plantarocollateral aspects of the pastern are closely clipped and soaked with warm water. An acoustic coupling gel is applied over the wet skin.

A stand-off pad is placed between the skin and probe to improve adaptation of the probe to the surface profiles mainly in the collateral approaches and transverse views. When several thicknesses of the stand-off pad are available, the optimal one must be selected in order to choose the best compromise between attenuation and the extent of the field of view to follow easily the anatomical structures.

Scanning is performed in a weightbearing position of the limb to avoid relaxation artefacts. Cutaneous sores or scratches, frequent at the palmar aspect of the pastern, may impede the acquisition of good quality images.

Using a palmar/plantar approach, transverse and longitudinal scans from the base of the proximal sesamoid bones to the proximal part of P2 are performed to evaluate straight, oblique and cruciate sesamoidean ligaments. In addition, palmaro/plantarocollateral approaches are performed to complete the evaluation of the proximal part of the OSLs.
As presented by Denoix et al. (1991), the pastern region can be divided into 4 anatomical levels (Fig 1) including the proximal third (A), intermediate third (B), distal third (C) of P1 and proximal interphalangeal joint coupled with the proximal part of P2 (D).

The SSL is examined in transverse and longitudinal sections using a palmar/plantar approach. The OSLs are examined in transverse section using an oblique palmaro/plantarocollateral approach at level A and a palmar/plantar approach at level B. Longitudinal sections are performed in an oblique palmaro/plantarocollateral plane. The CSLs are visualised on sagittal and transverse section at level A.

In clinical cases, comparison with the similar anatomical structures of the contralateral limb on longitudinal and transverse scans is strongly recommended to confirm or rule out ligament abnormalities.

**Normal images**

**Proximal P1: level A (Figs 2 and 5)**

**Palmar/plantar approach**

On transverse scan (Figs 2a,b), the SSL is triangular-shaped and homogeneously echogenic, deep to the deep digital flexor tendon (oval-shaped and hypoechochogenic, when the beam is directed to image the SSL). In a 550 kg horse, the SSL is about 5–7 mm thick × 19–22 mm wide at level A. Oblique sesamoidean ligaments are partly visualised on each side of the SSL. At the most proximal part [close to the metacarpal/metatarsalphalangeal joint] CSLs are visualised as a central echogenic horizontal band (intersection of the lateral and medial ligaments) in contact with the distopalmar/plantar recess of the fetlock joint. When the probe is lightly distally oriented this band separates into 2 oval echogenic structures, corresponding to the distal part of the CSLs.

On sagittal scan (Fig 3), the SSL fibre interfaces are parallel to the sharp palmar/plantar and dorsal borders of the ligament. The most proximal part of the ligament appears hypoechochogenic at the junction with the palmar/plantar ligament. Deep to it, the intersection of the CSLs is visualised at the distopalmar/plantar aspect of the sagittal ridge of the metacarpal/metatarsal condyle. In a 550 kg horse, the CSLs are less than 5 mm thick sagittally. At the most proximal level of P1, the SSL is separated from the bony surface by the distopalmar/plantar recess of the metacarpal/metatarsalphalangeal joint. Distally, on the weightbearing limb, it separates from the deep digital flexor tendon.
Palmar/plantarocollateral approach
On transverse scans, the OSL is oval and echogenic when the probe is proximally oriented. In a 550 kg horse, measurements of the OSL are about 10–15 mm × 10–15 mm. It is located between the collateral aspect of the palmar/plantar eminence of P1 and the SSL (Figs 4a,b). At the most proximal part, when the probe is slightly tilted in a more transverse plane, it looks hypoechoic with echogenic spots created by fat between fibre bundles.

For longitudinal scans, the probe must be placed in an oblique palmar/plantarocollateral plane. Oblique sesamoidean ligament fibres are visualised almost parallel to the skin (Fig 5). This view provides a clear image of the OSL proximal insertion at the base of the corresponding proximal sesamoid bone.

Middle P1: level B (Figs 6 and 7)
On transverse scans (Fig 6), the SSL conserves a triangular shape and becomes slightly thinner (5–6 mm) than at the proximal P1 level. The OSLs become progressively thinner (4–5 mm) and closer to the sagittal plane. In the front limbs, the isolated straight sagittal bundle originating with the SSL and ending with the OSL is imaged deep to the SSL. In the hindlimbs, some horses show flat isolated bundles originating from the plantar aspect of the OSL and ending with the SSL. To obtain a correct visualisation of each OSL, slightly palmaro/plantarocollateral scans can be performed. Both OSLs insert together as a common echogenic band on the trigonum of P1. Mild irregularities of this bony surface at the OSL distal insertion are frequently observed without clinical
manifestations. At this level, the SSL is about 5 mm thick × 13–15 mm wide, in a 550 kg horse.

In the sagittal plane (Fig 7), anechogenic synovial fluid of the digital flexor tendon sheath is observed between the SSL and the deep digital flexor tendon. It is crossed by an echogenic fibrous synovial plica attached on both distal branches of the superficial digital flexor tendon and covering the palmar/plantar aspect of the SSL.

**Distal P1: level C (Figs 8 and 9)**

At this level, on transverse scans (Fig 8), the OSLs have already finished and the oval-shaped SSL is separated from the palmar/plantar aspect of P1 by the palmar/plantar recess of the proximal interphalangeal joint. The SSL is narrower lateromedially but thicker dorsopalmarly/plantarly than in the upper level (approximately 6 mm thick × 11 mm wide).

On sagittal scans (Fig 9), dorsally to the deep digital flexor tendon, the SSL ends on the thick scutum medium, showing a more heterogeneous fibre pattern and a slight reduction of echogenicity. When present, anechogenic synovial fluid of the digital sheath enhances SSL and deep digital flexor tendon contours.

**Proximal interphalangeal joint and proximal P2: level D (Figs 9 and 10)**

The SSL inserts on the palmar/plantar flexor tuberosity of P2 by means of the scutum medium.

This fibrocartilaginous structure appears mildly heterogeneous with reduced echogenicity in the sagittal plane on sagittal (Fig 9) and transverse scans (Fig 10).

Injury assessment needs comparison with similar anatomical structures of the contralateral limb on longitudinal and transverse scans to avoid misinterpretation of individual anatomical variations.

**Abnormal findings and lesions**

Ultrasonographic findings indicative of sesamoidean desmopathies include modifications of size, shape, echogenicity and architecture, as well as insertional abnormalities.

**Straight sesamoidean ligament (SSL)**

Lesions of the SSL can be found at every level A, B and C. Core lesions are frequent (Figs 11 and 12) but asymmetry of the edges can also be observed. Acute injuries are characterised by thickening, hypoechoic aspect, fibre disruption and alteration of the architecture of the ligament on longitudinal scans. Fibrillation of the edges is less common.
chronic injuries, the ligament remains thicker with a heterogeneous echogenicity and local alteration of the fibre pattern. Chronic digital sheath inflammation may impede clear delineation of the ligament contour.

**Oblique sesamoidean ligaments (OSL)**

Injuries of the OSL usually involve the entire ligament or the proximal half of the ligament (Sampson et al. 2007; Smith et al. 2008b). In acute lesions, the ligament is thicker with hypoehogenic areas in its central part or at the palmar/plantar aspect with margin fibrillations (Fig 13). In chronic injuries, the ligament remains thickened and has a heterogeneous echogenicity with fibre pattern alteration on longitudinal section. Mineralisation (hyperechogenic spots casting acoustic shadows) can also be observed in the ligament (Denoix et al. 1990). Some have been considered as incidental findings without clinical significance (Reef and Genovese 2003). This finding must not be confused with the echogenic fat separating ligament fascicles.

Three types of proximal OSL enthesisopathies can be differentiated:

- Avulsion fracture at the base of the proximal sesamoid bones with or without injury of the OSL, frequently observed in acute traumatic cases;
- Moderate to severe bone remodelling of the proximal sesamoid bone base with a heterogeneous echogenicity of the OSL; signs of chronic injury;
- Osteochondral fragments originating from the palmar/plantar eminence of P1 included in a homogenously echogenic OSL.

Fig 11: Transverse ultrasound scans of both forelimb pasterns at level A using a palmar approach (medial is to the left). A straight sesamoidean ligament core lesion is observed in the right forelimb. A comparative image of the left forelimb is presented on the left. LF - left forelimb; RF - right forelimb. 1 - straight sesamoidean ligament; 2 - oblique sesamoidean ligaments; 4 - deep digital flexor tendon; 5 - superficial digital flexor tendon; 7 - palmar bone surface of P1; 10 - proximal digital annular ligament; 11 - skin.

Fig 12: Sagittal ultrasound scans of both forelimbs pasterns at level A using a palmar approach to image the same lesion as in Figure 11 (proximal is to the left). Straight sesamoidean ligament fibres are disrupted in the right forelimb. A comparative image of the left forelimb is presented on the left. LF - left forelimb; RF - right forelimb. 1 - straight sesamoidean ligament; 3 - cruciate sesamoidean ligament; 4 - deep digital flexor tendon; 5 - superficial digital flexor tendon; 7 - palmar bone surface of the P1; 8 - distopalmar recess of the metacarpophalangeal joint; 9 - digital sheath with synovial plica; 10 - proximal digital annular ligament; 11 - skin.
Distal enthesopathies are clearly specific to each OSL. Collateral remodelling of the collatero-palmar/plantar aspect of the proximal phalanx with enthesophyte production is an indication of OSL distal enthesopathy (Fig 14). Collateral enthesophytes on both sides of P1 are frequently observed in large horses. These are more frequently related to the proximal insertion of the distal digital annular ligament than to the OSL. Modelling of the most distal aspect of the P1 trigonum is often a nonclinically significant finding.

Sagittal avulsion fracture of the flexor tuberosity of P2 in fore- and hindlimbs can be considered as a type of distal enthesopathy of the SSL.

Previous descriptions of conditions of each ligament have considered them separately; nevertheless, concomitant injury of the SSL and OSL can also be observed (Sampson et al. 2007). Moreover, when sesamoidean desmopathies are observed, examination of the corresponding suspensory ligament is indicated.

**Discussion**

Injuries of the DSL are observed in all breeds and disciplines of horses: a higher incidence has been reported in long pastern horses (Reef and Genovese 2003). The OSLs are the most frequently injured, mainly in the hindlimbs of nonracing horses (Reef and Genovese 2003; Sampson et al. 2007; Smith et al. 2008b). Distribution for SSL desmopathies seems similar between fore- and hindlimbs (Schneider et al. 2003).

Distal sesamoidean ligament injuries can implicate isolated or multiple ligament lesions and can be concomitant to suspensory ligament desmitis, proximal sesamoid bone fractures, metacarpo/metatarsophalangeal and proximal interphalangeal arthropathies (Denoix et al. 1991; Dyson and Genovese 2003; Coudry and Denoix 2004; Sampson et al. 2007). In cases with simultaneous desmopathy of the suspensory ligament branch and the OSL, both injuries are usually located on the same side (lateral or medial), confirming collateromotion as being an essential aetiopathogenic factor (Denoix 1994a).

Although heat and palpable swelling of the palmar/plantar (palmaro/plantarocollateral) aspect of the pastern can be observed in some horses presenting sesamoidean ligament desmitis, others present no physical signs (Schneider et al. 2003; Sampson et al. 2007; Smith et al. 2008b). Acute and subacute injuries are frequently associated with moderate to severe lameness and the digital flexion test often increases the lameness grade.
In previous case reports (Schneider et al. 2003; Sampson et al. 2007), lameness was sometimes not improved by palmar/plantar propius digital nerve block, but completely abolished after the 4 point distal metacarpal/metatarsal block. In all cases where intra-synovial diagnostic analgesia of the metacarpophalangeal joint or digital tendon sheath was performed the lameness grade decreased (Sampson et al. 2007). On the other hand, ultrasonographic examination of the pastern must be considered when no abnormality is detected in the foot in spite of a positive distal digital nerve block, because proximal diffusion of local anaesthetic solution can eliminate palmar/plantar pastern soft tissue sensitivity.

Although bone abnormalities associated with chronic entheseopathies or avulsion fractures can be detected with radiography, ultrasonographic examination of the pastern must be systematically coupled to evaluate the surrounding soft tissues. Correlation between radiographic abnormalities and pastern ligament injuries was reported to be fair (Dyson and Denoix 1995).

Recent studies (Sampson et al. 2007; Smith et al. 2008b) using magnetic resonance imaging (MRI) have underlined the role of the DSL in the suspensory apparatus and their direct implication in lameness. With this imaging modality anatomical variations observed in dissection are well documented. Straight sesamoidean ligament size is directly correlated to the horse height; additionally, some horses present a larger OSL at the lateral side and this difference is also present in the opposite limb (Smith et al. 2008b).

As observed with ultrasound, the proximal part of the OSLs shows heterogeneous signal correlated with a different tissue composition, the proximal part of the OSLs is partially composed of fat tissue.

Standing MRI examination of the OSLs is highly susceptible to magic angle effect (Smith et al. 2008a,b). A proper technique and concomitant assessment with ultrasonography can limit misinterpretation of signal abnormalities. Although MR imaging has proved to have a higher sensitivity to detect DSL injuries, this imaging modality is still reserved to referring clinics and hospitals.

Good prognosis for DSL acute injuries was observed after 6 months of rest, a rehabilitation programme and digital flexor tendon sheath medication with steroids and hyaluronic acid (Schneider et al. 2003; Sampson et al. 2007). Corrective shoeing depends on the injured ligament. Thin branches and a wide toe is recommended for SSL and bilateral OSLs injuries (Denoix et al. 2005). For single OSL desmopathy, asymmetrical shoeing with a wider branch on the injured side is advised (Denoix et al. 2005). Ultrasoundographic examination of the DSL requests a good knowledge of the pastern anatomy, the scanning technique and normal images. In the authors’ opinion, a complete ultrasonographic examination of the pastern combining longitudinal and transverse comparative scans offers a good sensitivity for diagnosing DSL injuries and remains the technique of choice in field practice.

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