Review Article

Ultrasoundographic examination of the palmar aspect of the pastern of the horse: Digital flexor tendons and digital sheath

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Summary

Ultrasoundography is the technique of choice to identify and document tendon and ligament injuries and its interest in the diagnosis of pastern injuries has been largely demonstrated. Ultrasound examination is therefore part of routine examination in diagnostic work-up of lameness originating from the foot or pastern area. This paper describes the ultrasonographic technique and presents normal and abnormal ultrasound images of the palmar pastern. A comprehensive description of normal transverse and longitudinal ultrasound scans is made at 4 anatomical levels. Main ultrasonographic findings indicative of digital flexor tendon lesions are presented as well as digital sheath injuries.

Introduction

The technique and indications of ultrasonographic examination of the pastern have been previously described in the early 1990s (Denoix et al. 1990, 1991; Dyson and Denoix 1995). With improvements in imaging techniques, the use of magnetic resonance imaging (MRI) to examine the pastern has been widely developed (Denoix and Audigié 2004; Dyson and Murray 2007). However, ultrasonography remains the first choice as it is a rewarding and reliable field technique to identify precisely the structure(s) involved and nature of the lesion(s) in the pastern region (Denoix 1994a, 1998). Indications of ultrasound examination of the pastern include:

- Local physical signs: synovial sheath effusion, soft tissue swelling, thickening or deformations;
- Response to diagnostic analgesia compatible with a suspected lesion in the pastern: 1) negative distal digital nerve block and positive proximal digital or distal metacarpal/falcial nerve block or 2) possible proximal diffusion of local anaesthetic solution in a positive distal digital nerve block without lesions in the foot;
- Abnormal radiographic and/or scintigraphic findings of the pastern: to complete the survey of the area by evaluating the soft tissues structures;
- Suspensory ligament injuries: in order to complete the evaluation of the suspensory apparatus by examining the lesions of the potentially associated distal sesamoidean ligaments;
- Luxation or subluxation of the proximal or distal interphalangeal joints (Denoix et al. 1991).

This article describes the equipment and technique of ultrasonographic examination of the palmar/plantar aspect of the pastern and normal ultrasonographic images, and presents the common abnormal findings indicative of lesions of the flexor tendons and digital flexor tendon sheath. In this article, to avoid systematic repetition of palmar/plantar orientation terms, the following descriptions will consider the pastern of the foreleg and only differences present in the hindlimb will be noted.

Basic anatomy

Front and hindlimb flexor tendons present the same global anatomical organisation in the pastern area (Denoix 2000). The superficial digital flexor tendon (SDFT) is flat and wide at the proximal aspect of the proximal phalanx (P1), becomes thinner in the sagittal plane distally and covers the palmar and collateral aspects of the deep digital flexor tendon (DDFT). At the level of the middle of P1, the SDFT starts to divide into 2 branches on each side of the pastern, which become thicker and completely differentiated at the distal aspect of P1 (Barone 1989). The distal branches of the SDFT insert distally on the scutum medium: this strong and thick structure attaches on the flexor tuberosity of the middle phalanx (P2) and at the palmar aspect of the distal P1 (Denoix 2000).

The DDFT lies dorsal to the SDFT and covers the palmar aspect of the distal sesamoidean ligaments (DSL). It has an oval shape in the most proximal part of the pastern and divides progressively into 2 oval symmetrical lobes. At the distal aspect of P1, the DDFT runs over the fibrocartilaginous surface of the scutum medium. At the proximal aspect of P2 the dorsal layer of the DDFT is differentiated into a thick fibrocartilaginous pad.

The synovial cavity of the digital flexor tendon sheath (DFTS) surrounds the SDFT and DDFT from the distal third of the metacarpal/falcial area down to the middle of P2 (Barone 1989). In the proximal part of the pastern, the proximal digital annular ligament (PDAL), in continuity with the palmar annular ligament, constitutes the palmar fibrous wall of the DFTS (Denoix 1994a). At the level of the middle of P1, a thin synovial and fibrous fold of the DFTS is present at the dorsal aspect of the DDFT and attaches on both sides onto the SDFT branches. It is sometimes named the ‘distal manica’. In the distal part of the pastern, a mesotendon attaches sagittally on the palmar aspect of the DDFT which is covered by the distal digital annular ligament. In the hind pastern, the DDFT looks slightly bigger compared to the SDFT.
Equipment and technique

The ultrasound images of the pastern are routinely acquired with a 7.5–10 MHz linear transducer. Linear array transducers are recommended for the evaluation of superficial straight anatomical structures [Denoix 1994b, 1998]. Longitudinal scans performed with long T-shaped or endorectal probes may be difficult to obtain in horses with short pasterns because of inadequacy with the shape of the area and lack of contact.

The hair is clipped closely on the palmar and palmarocollateral aspects of the pastern to obtain good contact between the probe and skin. The area is soaked with warm water. Acoustic coupling gel is applied to the skin and probe. A stand-off pad is routinely placed between the skin and transducer to improve visualisation of superficial structures and contact with the area. Cutaneous sores or scratches, frequently found at the palmar aspect of the pastern, may impede the acquisition of good quality images.

Routine examination of the pastern is performed with the limb bearing weight. Transverse images made with palmar and palmarocollateral approaches, as well as sagittal and parasagittal images, are acquired from the base of the proximal sesamoid bones (PSB) to the proximal part of the P2. Ultrasonographic examination of the pastern was divided into 4 different anatomical levels by Denoix et al. (1991) (Fig 1): proximal third (A), intermediate third (B), distal third (C) of P1, proximal interphalangeal joint and proximal part of P2 (D). Dynamic examination of the flexor tendons in the DFTS is performed on the nonweightbearing limb while flexion and extension of the digit are slowly induced by an assistant.

The SDFT is examined on transverse and longitudinal sections and its branches visualised on each side of the pastern with a palmarocollateral approach. The DDFT is examined on transverse, sagittal and parasagittal sections. On transverse sections, a slightly palmarocollateral approach improves imaging of its lateral and medial borders.

For each clinical case, examination of the contralateral pastern should be performed to allow comparison of similar anatomical structures on longitudinal and transverse scans.

Normal images

Proximal P1: level A (Figs 2 and 3)

On transverse scan (Fig 2), the SDFT has a homogeneously echogenic crescentic shape and lies immediately under the PDAL. The DDFT has an oval shape and is separated from the DSL by the anechogenic synovial content of the DFTS. In a standard horse (550 kg), the SDFT is about 3 mm thick, the DDFT is approximately 5.5 mm thick and 22 mm wide and the PDAL is about 0.3–0.6 mm thick. On longitudinal scans (Fig 3) the SDFT becomes thinner distally in the sagittal plane, while the DDFT fibres run obliquely from a deep to a superficial position.

Middle P1: level B (Figs 3 and 4)

The SDFT becomes thinner in the sagittal plane and starts to separate into 2 branches (Fig 4). They are visualised as teardrop-shaped homogeneously echogenic structures. The PDAL is thin and difficult to differentiate from the subcutaneous tissue and superficial fibres of the SDFT in the sagittal plane. The DDFT become slightly thinner (5 mm) and tends to separate into 2 symmetrical oval echogenic lobes on transverse images. On longitudinal scans (Fig 3), its fibres run obliquely from a deep to a more superficial position distally. A thin echogenic synovial and fibrous fold of the DFTS (about 0.5 mm thick), surrounded by a small amount of anechogenic synovial fluid, is present at the dorsal aspect of the DDFT and attaches on both sides on the SDFT branches.

Distal P1: level C (Figs 5–8)

At this level, the DFTS is located just under the skin, only separated by a very thin palmar digital fascia. A small amount of anechogenic synovial fluid may therefore be visualised in this location when no pressure is applied on the probe. This fluid disappears when pressure increases.

The SDFT is not present in the sagittal plane because it is completely separated into 2 branches (Fig 5). Transverse palmarocollateral scans (Fig 6) are performed on each side of the pastern to visualise each branch (about 10–12 mm thick) down to its distal insertion on the scutum medium. Longitudinal views of the SDFT branches (Fig 7) are obtained with oblique collateralpalmar scans.

The DDFT is divided into 2 symmetrical oval lobes (about 5 mm thick) on transverse images. It is only separated from the skin by the DFTS and the palmar digital fascia. Each lobe is visualised as aligned fibres on longitudinal images (Fig 8).
Proximal interphalangeal joint and proximal P2: level D (Figs 8 and 9)
The 2 lobes of the DDFT lie immediately palmar to a thick echogenic fibrocartilaginous structure, the scutum medium, attached on the flexor tuberosity of P2 (Fig 8 and 9). In a standard horse, its thickness is about 8–10 mm. A thin distal digital annular ligament (about 0.5 mm thick) covers the DDFT; it is differentiated from the subcutaneous tissue thanks to the transverse orientation of its fibres.

Abnormal findings and lesions
As in the metacarpal/tarsal area, ultrasonographic findings indicative of injuries of the digital flexor tendons include modifications of size, shape echogenicity and architecture. In the pastern insertiona1 abnormalities of the SDFT can be seen.

Superficial digital flexor tendon (SDFT)
Injuries of SDFT in the pastern can involve the proximal part of the tendon at level A and/or the branches at levels B or C. Longitudinal tears and core lesions are found proximally in the SDFT, more often parasagittal, and can extend to the corresponding branch. Lesions of the branches (Fig 10) are characterised by thickening and alteration of echogenicity: a
hypoechogenic pattern in the acute stages, and a heterogeneous pattern in chronic cases. They are more frequently unilateral (Fig 10) but bilateral lesions are not rare. Although injuries of the medial branch are reported to be more frequent (Reef and Genovese 2003; Smith and Wright 2006), lesions of the medial and lateral branches have been found in the same proportion in our caseload and seem to be correlated to digital conformation.

Thickening and hypoechogenicity of the proximal digital annular ligament are often found in association with SDFT tenosynovitis. Peritendinous thickening, corresponding to diffuse oedema, is indicative of the acute stage of tenosynovitis.

**Deep digital flexor tendon (DDFT)**

Lesions of the DDFT are most frequently associated with DFTS tenosynovitis. Recent (acute or subacute) lesions often induce an asymmetric enlargement of the DDFT lobe(s) with core or variable distribution of hypoechogenicity and fibre pattern alteration. Heterogeneous echogenicity of one or both lobes, with global enlargement of the tendon, can be found in chronic tendinitis of the DDFT (Fig 11). In the proximal pastern (level A), lesions are often found at the dorsolateral aspect of the tendon (Fig 12) presenting local thickening, hypoechogenic or heterogeneous echogenicity and dorsal margin fibrillations. Palmar margin lesions can also be seen. Mineralisations, characterised by hyperechogenic spots casting an acoustic shadow (Fig 13), are indicative of chronic degenerative tendinopathy.

**Digital flexor tendon sheath (DFTS)**

In cases of digital sheath effusion, the amount of anechogenic synovial fluid is significantly increased, inducing distension of the collateral recesses of the DFTS between the DSL and SDFT branches. Fluid effusion is also seen at level C where the SDFT is separated into 2 branches and the DFTS is very superficially close to the skin. At levels A and C, the echogenic mesotendon, thickened in cases of chronic tenosynovitis, is enhanced by the surrounding anechogenic fluid at the palmar aspect of the SDFT (Fig 14). Free floating echogenic material, thickening of the synovial membrane and synovial fold (level B) can also be found. In chronic cases, masses of torn fibres or synovial thickening called, ‘granulomas’ can be found in contact with the DDFT or the SDFT. In septic tenosynovitis, several abnormal findings can be noted including diffuse enlargement of the soft tissues, peritendinous oedema and abnormal echogenicity of the fluid with echogenic fibrin clots after a few days.

**Discussion**

Ultrasonography was primarily developed to diagnose tendon injuries in the metacarpal/tarsal area and was rapidly applied to examination of the pastern and digital sheath. Therefore, this diagnostic modality has been previously widely described (Denoix et al. 1991; Denoix 1994a, 1998; Dyson and Denoix 1999) and is frequently used in practice. Indeed, ultrasonographic examination of the pastern does not require specific equipment and with basic anatomical knowledge this technique allows immediate diagnosis in the field. Moreover, ultrasonography of the flexor tendons in the pastern is recommended in cases of metacarpal tendonitis as lesions in
Radiography is essential to identify osteoarticular lesions but gives no diagnostic information about tendons and ligaments, except at insertional sites. Enthesopathic bone or avulsion fractures seen on radiographs at the insertion sites of the scutum medium can be found, but remain rare. In cases of chronic tenosynovitis of the DFTS, mineralisation of one tendon (more frequently the DDFT) can be seen on underexposed lateromedial radiographs of the digit.

Magnetic resonance imaging (MRI) was demonstrated to be of great value in the diagnosis of distal limb injuries in horses, allowing assessment of both soft tissue and bone lesions (Denoix and Audigié 2004; Dyson and Murray 2007). Considering the wide range of affections of tendons and ligaments in the foot and pastern, MRI is considered as a reference imaging technique, particularly in the podotrochlear area (Dyson and Murray 2007). For examination of the palmar aspect of the pastern, this modality offers imaging advantages such as 3D anatomical representation of the tendons and DFTS. On the other hand, ultrasonography allows dynamic evaluation of the SDFT and DDFT in the DFTS, which enables the identification of adhesions. Ultrasonography should remain the first diagnostic procedure to be employed whenever an injury of the pastern is suspected based upon clinical examination and local analgesia.

Reports of comparisons between ultrasonography and tenoscopy (Edinger et al. 2005; Smith and Wright 2006) have previously been published. Ultrasonography showed a good sensitivity, specificity and positive predictive values (71%) in detecting marginal tears of the DDFT and abnormal findings in the DFTS (90% sensitivity). Moreover, core lesions of the SDFT or DDFT not detected with tenoscopy can be seen with ultrasonography. Sensitivity and specificity of the ultrasonographic diagnosis are improved when comparison is made with the contralateral structures (Denoix 1994b), especially for evaluation of the size (thickness, cross-sectional area). Tenoscopy offers the advantage of treating the superficial lesions at the same time, but is an invasive and more expensive technique. Ultrasonography permits the detection of most lesions in the DFTS and is an important tool in the choice of surgical vs. conservative management. For example, as marginal tears of the DDFT were considered to carry a poorer prognosis for a return in competition (Smith and Wright 2006), ultrasonographic findings may represent important decision criteria for the owner. Therefore, ultrasonographic examination of the flexor tendons and DFTS is a mandatory preoperative diagnostic tool in cases of tenosynovitis.

Ultrasonography also plays an important role in the management of tendon lesions. Monitoring of the injury over time provides essential data to assess healing, stabilisation or deterioration of the condition. This information is critical for the accurate management of the horse regarding corrective shoeing, rehabilitation and prognosis.

As assessed tenoscopically, the most frequent lesions associated with DFTS tenosynovitis are tears of the DDFT, SDFT and manica flexoria (Wilderjans et al. 2003; Edinger et al. 2005). In a study performed on 76 cases of DFTS noninfected tenosynovitis (Smith and Wright 2006), only 15 cases had lesions in the pastern, with 10 short tears of the DDFT and 5 tears of the SDFT, including 4 of the medial branch. Granulomas were frequently found associated in those cases. Therefore, in cases of DFTS tenosynovitis, a complete and detailed ultrasonographic examination from the distal metacarpal/tarsal area down to the pastern is essential.
Conservative management of tendon injuries in the pastern is carried out in the same way than tendonitis in the metacarpal/tarsal area, and corrective shoeing plays an essential role. For DDFT injuries, an egg-bar-shoe or a reverse shoe is recommended to decrease distal interphalangeal extension (Denoix et al. 2005). Trimming of the toe and dorsal rolling are also essential to facilitate break over. Shoes with a wider toe and bevelled branches are indicated for the corrective shoeing of SDF tendonitis (Denoix et al. 2005). When asymmetrical injury of one SDFT branch is present, an asymmetrical shoe with a wider branch on the side of the lesion is recommended (Denoix 1999).

Ultrasoundography is a safe, noninvasive modality, easy to perform in field practice, providing accurate real-time diagnostic information about the flexor tendons and DFTS. Considering the anatomy of the palmar aspect of the pastern, ultrasoundography should be routinely employed as a first choice field technique in the diagnosis and management of digital flexor tendonitis and DFTS tenosynovitis.

Authors’ declaration of interests
No conflicts of interest have been declared.

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