Diagnosis of digital flexor tendon sheath conditions in the horse

Diagnosis of digital flexor tendon sheath conditions can be challenging, although they are a common occurrence in horses. Injuries can occur in either the fore- or hindlimbs and a thorough understanding of the complex anatomy of the digital flexor tendon sheath will help practitioners to gain confidence in their diagnostic ability of its pathologies. This article outlines the clinically relevant anatomy, approaches to and interpretation of diagnostic anaesthesia, as well as common stable-side imaging findings that may be expected for the main pathologies associated with the digital flexor tendon sheath. Tips and tricks to maximise diagnostic potential are also included throughout the article.

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Anatomy

The digital flexor tendon sheath (DFTS) is a synovial cavity occupying the distal third of the palmar metacarpus/plantar metatarsus and the palmar/plantar pastern, to the level of the middle phalanx. It contains the digital flexor tendons and helps to lubricate and stabilise their passage through the highly mobile fetlock canal and the pastern region. The proximal sheath is defined by a reflection of the sheath's synovial membrane at the junction between the middle and distal third of the metacarpus/tarsus. The dorsal sheath effaces the suspensory ligament branches, the proximal scutum and the distal sesamoidean ligaments. The distal sheath is defined by the T-ligament that borders the distal interphalangeal (DIP) joint dorsally and the navicular bursa palmarly/plantarly.

Proximal to the fetlock canal, the lateral and medial margins of the superficial digital flexor tendon (SDFT) are attached to a thin collar of tendinous tissue that wraps around the deep digital flexor tendon (DDFT), known as the manica flexoria (Findley et al, 2017) (*Figure 1*). The manica flexoria helps to stabilise the flexor tendons in alignment as they traverse this location. At the mid-proximal phalanx, the digital manica connects the branches of the SDFT, between the dorsal sheath wall and the DDFT (Jordana et al, 2017).

The intersesamoidean ligament, coupled with thick fibrocartilage covering the axial margins of the proximal sesamoid bones, forms the proximal scutum, which provides a smooth gliding surface for the flexor tendons as they cross the palmar/plantar aspect of the metacarpo/tarsophalangeal (MC/TP) joint within the fetlock canal. The palmar/plantar annular ligament (PAL), attached to the abaxial margin of the proximal sesamoid bones (*Figure 1*), helps to stabilise the passage of the flexor tendons. The proximal and distal digital annular ligaments (DAL), attached to the abaxial margins of the proximal phalanx, stabilise the DDFT as it courses distally in the pastern.

Throughout the sheath, there are a number of mesotenon and vinculum attachments between the flexor tendons and the sheath wall. Most notable of these are the medial and lateral mesotenons attached to the DDFT in the proximal sheath, just above the level of the manica flexoria; the palmar/plantar vinculum attached to the SDFT throughout the sheath's length that renders the palmar/plantar aspect of the SDFT body extra-synovial; and, a number of irregular vinculae between the DDFT and dorsal sheath wall, distal to the digital manica (Redding, 1994; McIlwraith et al, 2014).

Presenting signs

Pathologies of the DFTS are usually associated with effusion and lameness. Either sign can vary in its presentation, depending on the severity of injury. Acute pathology tends to be associated with acute onset and moderate-to-marked effusion. Lameness may initially be severe but often improves with rest. Chronic pathology may be accompanied by generalised thickening of the skin overlying the DFTS region, as well as thickening of the PAL, which may also be tender to palpate. Classically, a noticeable 'notch' is seen at the level of the PAL when there is moderate-to-marked effusion (*Figure 2*). Horses with chronic and severe effusion resulting from constriction of the PAL may struggle to fully bear weight through their heels.

While it is possible for any horse to suffer DFTS pathology, certain breeds and predilection sites are commonly associated with

Table 1. Approaches to the digital flexor tendon sheath for intrathecal injection or synoviocentesis

Approach	Technique
Proximolateral	• Horse standing or with metacarpo/tarsophalangeal joint slightly flexed (resting on floor or in a foot block) • Needle is inserted between the suspensory ligament branch and the deep digital flexor tendon, just proximal to the palmar/plantar annular ligament • Needle is directed from lateral to medial, parallel to the ground or slightly distal
Basisesamoid	• Horse standing or with metacarpo/tarsophalangeal joint slightly flexed (resting on floor or in a foot block) • Needle is inserted between the distal aspect of the palmar/plantar annular ligament and the proximal aspect of the proximal distal digital annular ligament, palmar/plantar to the neurovascular bundle • Needle is directed perpendicular to skin, either parallel to the ground or slightly proximal
Palmar/plantar axial sesamoid	• Leg lifted + metacarpo/tarsophalangeal joint flexed • Needle is inserted axial to the palpable palmar/plantar mid-border of the proximal sesamoid bone • Needle is directed 45° to the sagittal plane, towards the central intersesamoidean area Note, only one hand free to remain sterile
Palmar/plantar pastern	• Horse standing or with leg lifted • Needle is inserted on palmar/plantar midline between the proximal and distal digital annular ligaments • Needle is directed perpendicular to skin Note, there is possibility of contamination because of the proximity to floor if done standing, but only one hand free to remain sterile if the leg is lifted

specific lesions. For instance, ponies and cobs are more prone to manica flexoria tears than other breeds (Findley et al, 2012; Kent et al, 2020) whereas Thoroughbreds, Warmbloods and draft breeds are more likely to develop a DDFT injury (Kent et al, 2020). Injuries to the PAL tend to affect middle-aged to older horses, used for general purpose riding (Owen et al, 2008). Also, DDFT injuries occur more commonly in the forelimbs (Smith and Wright, 2006; Arensburg et al, 2011; Kent et al, 2020), whereas manica flexoria injuries (Smith and Wright, 2006; Findley et al, 2012; Kent et al, 2020) and PAL pathologies (Owen et al, 2008; Kent et al, 2020) more frequently affect the hindlimbs, the latter often being bilateral (Owen et al, 2008).

Diagnostic anaesthesia

There are four approaches to the DFTS for intrathecal injection or synoviocentesis (Jordana et al, 2012) (*Table 1*; *Figure 3*). For all techniques, a 20 or 22G, 2.5 cm needle can be used. When performing intra-synovial anaesthesia, a total of 10 ml local anaesthetic should be injected. Wrapping a cohesive bandage around the distal metacarpus/tarsus can sometimes push synovial fluid distally, making aspiration of a sample more likely from one of the more distal approaches (*Figure 4*). In the case of wounds or dermatitis on the lateral aspect of the limb, each approach can also be accessed from the medial side.

Figure 1. Photograph of the gross dissection of the digital flexor tendon sheath in a horse. The palmar/plantar annular ligament has been transected where it attaches to the abaxial margin of the proximal sesamoid bone (blue arrows) and the manica flexoria is seen wrapping around the deep digital flexor tendon (green star).

Figure 2. Photograph of a horse with hindlimb digital flexor tendon sheath effusion. Note the 'notch' created by the constrictive plantar annular ligament (green arrow), resulting in effusion bulging proximal and distal to this level.

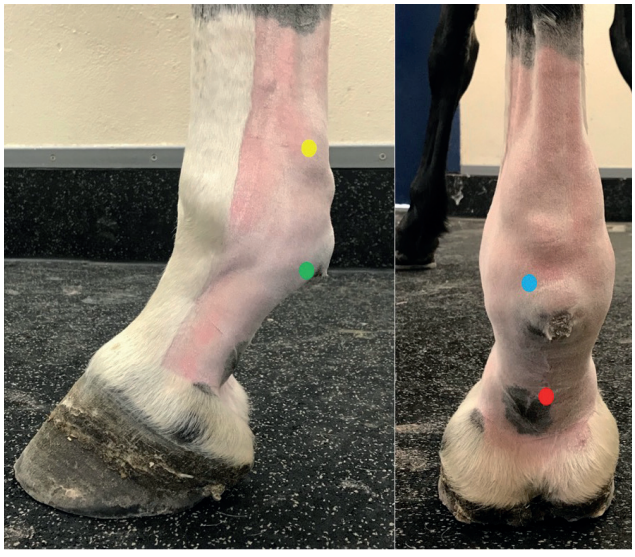

Figure 3. Photographs of the distal hindlimb of a horse highlighting the four approaches for intrathecal injection or synoviocentesis of the digital flexor tendon sheath-proximolateral (yellow dot), basisesamoid (green dot), plantar axial sesamoid (blue dot), plantar pastern (red dot).

Figure 4. Photograph of the same horse as in Figure 3 with cohesive bandage wrapped around the distal metatarsus, resulting in increased digital flexor tendon sheath effusion at the basisesamoid (red arrow) and plantar pastern (yellow arrow) injection sites.

Each approach has advantages and disadvantages, depending on whether you are trying to inject the sheath or aspirate fluid. When comparing all four approaches, the axial sesamoid and pastern approaches were best for successful injections but the former required more attempts (Jordana et al, 2012). In another study, there was no difference between the axial sesamoid and the basisesamoid approaches for injection (Rocconi and Sampson, 2013). When using the proximal approach, there was an increased likelihood of subcutaneous injection (Hassel et al, 2000) and a small chance of MC/TP joint penetration (Jordana et al, 2012), although Horne et al (2019) found that ultrasound-guidance increased the chances of a successful injection, as well as reducing the chance of penetrating other structures, compared with the basisesamoid approach.

When attempting to aspirate fluid, the basisesamoid approach has been demonstrated to be more successful, faster and required fewer attempts compared to the axial sesamoid approach (Rocconi and Sampson, 2013). Hassel et al, (2000) found that there was an increased chance of aspiration and fewer attempts required using the axial sesamoid approach compared with the proximal approach. In the case of investigating wounds that may have caused sepsis of the DFTS, the site for synoviocentesis will likely be influenced by the location of the wound and so it is pertinent to be familiar with all approaches.

Given the sheath's close proximity to other synovial structures and the palmar/plantar nerves, positive anaesthesia of the DFTS should be interpreted with caution. Jordana et al (2014) showed that anaesthesia of the palmar/plantar nerves can occur, presumably owing to leakage of mepivacaine from the puncture hole or local diffusion, resulting in loss of skin sensation at the heel bulbs. This most frequently occurred following injection of mepivacaine using a proximal approach. However, Jordana et al (2016) also demonstrated that although mepivacaine can diffuse to adjacent synovial structures, clinically significant concentrations of mepivacaine were not achieved within those structures. Finally, Harper et al (2007) found that anaesthesia of the DFTS did not alter experimental lameness associated with the DIP joint, navicular bursa or sole.

Anaesthesia of the DFTS can significantly improve lameness associated with the distal sesamoidean ligaments (Sampson et al, 2007), despite their extra-synovial location. Also, most cases of PAL desmitis will respond to DFTS anaesthesia, although some may require perineural anaesthesia of the palmar/plantar nerves to definitively localise the lameness. Practitioners should therefore combine the result of intrathecal anaesthesia with their other findings in order to reach their final diagnosis.

Diagnostic imaging

Ultrasonography

Ultrasonography is the main imaging modality used to assess the DFTS, but it is a complex region to assess and the acquisition of good quality images can be hampered by thick skin and/or skin folds (*Figure 5*). Standard preparation of the horse is employed, although it can sometimes help to clip, wash and apply ultrasound coupling gel to the skin overnight by wrapping the legs in clingfilm and applying stable bandages on top to encourage the gel to

Figure 5. Photograph of a horse with marked hindlimb digital flexor tendon sheath effusion and thick, corrugated skin which may inhibit acquisition of ultrasonographic images of diagnostic quality.

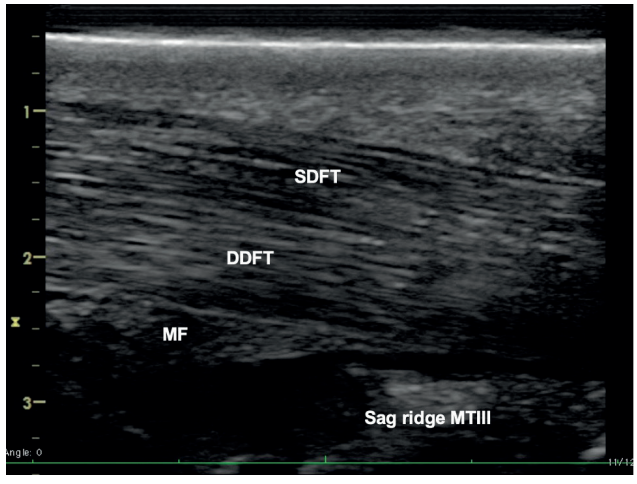

Figure 6. Longitudinal ultrasonographic image of the digital flexor tendon sheath at the level of the distal metatarsus. Proximal is to the left of the image. The normal superficial digital flexor tendon and deep digital flexor tendon are seen traversing distally. The normal manica flexoria is seen as a tapering structure with its most distal end extending to the level of the plantar sagittal ridge of the third metatarsal bone.

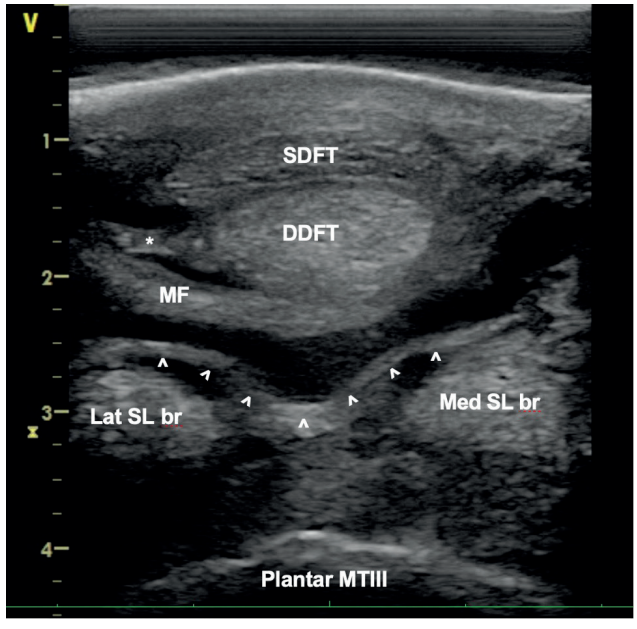

Figure 7. Transverse ultrasonographic image of the digital flexor tendon sheath at the level of the distal metatarsus. Lateral is to the left of the image. The manica flexoria is clearly seen attached to the medial aspect of the superficial digital flexor tendon, but it does not attach to the lateral aspect, indicative of a manica flexoria injury. The lateral mesotenon of the deep digital flexor tendon is also seen (asterisk) in this region. The dorsal sheath wall is clearly highlighted (arrowheads) due to the degree of digital flexor tendon sheath effusion present.

penetrate the skin. Images are typically obtained using a linear transducer, with or without the use of a standoff pad, depending on the area being assessed and the natural thickness of the skin. The ergot can obstruct image acquisition, but attempts should be made to push it to either side where possible. Despite the best efforts, it may still not be possible to obtain images of diagnostic quality in some horses. It is also worth remembering that multiple pathologies can occur together, the so-called "complex tenosynovitis" case, so a thorough examination is necessary to obtain a complete diagnosis.

As with ultrasonography at any other location, the integrity, margination, size and echogenicity of various soft tissue and osseous structures is assessed. In the hindlimb, it can be normal for the DDFT to have a well-circumscribed, hypoechoic region dorsally within the most proximal aspect of the DFTS, and this should not be mistaken for a pathological lesion (Smith, 2008). Mineralisation within the DDFT, most often in the proximal DFTS, has also been noted as an incidental finding and is not always associated with lameness (O'Brien and Smith, 2018). The various mesotenons and vinculae should not be confused with adhesions. It is important to note that the lateral DDFT mesotenon within the proximal sheath usually extends further distally than the medial mesotenon (McIlwraith et al, 2014).

The manica flexoria can be difficult to identify in the minimally-distended sheath. It may be most easily seen in the longitudinal plane as a tapering structure in tight apposition to the dorsal border of the DDFT, with its most distal end extending to the level of the sagittal ridge of the third metacarpal/tarsal bone (*Figure 6*). In the transverse plane, moving the transducer abaxially to examine the margins of the SDFT can help. Manica flexoria injuries frequently occur on the medial aspect of the sheath (Smith and Wright, 2006; Findley et al 2012). Usually the border of the manica flexoria is identified as being unattached to the SDFT (*Figure 7*) but if it cannot be visualised at all, it may have completely torn along its border with the SDFT and recoiled to the contralateral side of the sheath where it becomes adhered. Ultrasound is reported to have a 38% sensitivity and 92% specificity for detecting manica flexoria injuries (Smith and Wright, 2006).

Longitudinal DDFT injuries most commonly occur on the lateral border (Smith and Wright, 2006; Arensburg et al, 2011). They may be seen as disruption to the margination of the tendon, or

a hypoechoic defect at the border over a variable distance, with or without protrusion of tendinous fibres. Again, moving the transducer abaxially may further highlight subtle lesions. The sensitivity of ultrasound to detect DDFT tears is 71-76% (Smith and Wright, 2006; Arensburg et al, 2011), with a 71% specificity (Smith and Wright, 2006). Longitudinal SDFT lesions can also occur (Arensburg et al, 2011), but these are less common.

Desmitis of the PAL may be primary in origin (McGhee et al, 2005), or secondary to other DFTS injuries (Owen et al, 2008). A normal PAL thickness is less than 2mm (Verschooten and De Moor, 1978), thus desmitis can be diagnosed when this measurement is exceeded. In chronic cases, there is often accompanying subcutaneous thickening and fibrosis. Identification of the dorsal and palmar/plantar border of the PAL may be difficult because of the presence of the SDFT vinculum and/or subcutaneous thickening, but a number of techniques to aid its measurement can be used. First, the probe can be moved abaxially in the transverse plane to measure the PAL at its attachment to the proximal sesamoid bone (*Figure 8*). Secondly, the PAL can be measured along with the subcutaneous tissue, with any measurement over ~5 mm being considered abnormal (Dik et al, 1995). In cases of primary desmitis, the PAL may also have a heterogenous appearance (McGhee et al, 2005).

Where there is minimal DFTS effusion, intrathecal injection of contrast material (Redding, 1994) or saline (Daniel et al, 2019) may enhance ultrasonographic image acquisition by separating and highlighting the boundaries of individual structures. Injection of contrast may also help to highlight longitudinal DDFT injuries (Bertuglia et al, 2014). In addition, dynamic ultrasonography, involving flexion and extension of the fetlock in the non-weight-bearing limb, may help to determine whether there is PAL constriction and/or adhesion formation, if there is reduced gliding motion of the SDFT relative to the PAL (DiGiovanni et al, 2016). This imaging modality may also be used to determine the presence of a manica flexoria injury based on whether there is medial displacement of the SDFT relative to the DDFT, the appearance of an anechoic gap between the flexor tendons, or reduced SDFT sliding motion (Garcia de Fonseca et al, 2017).

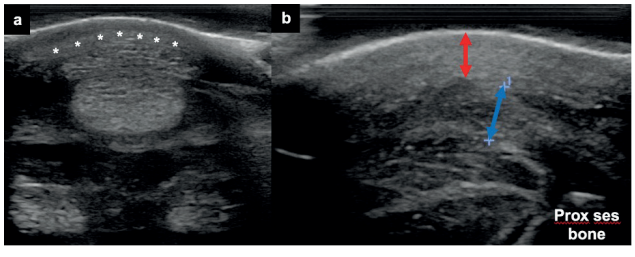

Figure 8. Transverse ultrasonographic images of the digital flexor tendon sheath at the level of the distal metatarsus (a) and fetlock canal (b). Lateral is to the left of the images. a) The plantar annular ligament is relatively visible (asterisks) compared to the superficial digital flexor tendon and subcutaneous tissue in this normal horse. b) The transducer has been moved medially to differentiate the thickened and heterogenous plantar annular ligament (blue arrow) from the thickened subcutaneous tissue (red arrow) as the plantar annular ligament attaches to the abaxial border of the proximal sesamoid bone. The plantar angular ligament measured 5.5 mm in this case of plantar annular ligament desmitis.

Contrast radiography

The use of contrast to delineate lesions of the manica flexoria and DDFT has been described (Fiske-Jackson et al, 2013) and a more recent study has further defined its use in determining PAL constriction (Kent et al, 2020). Briefly, 5–7 ml of radiographic contrast solution (sodium meglumine diatrozoate or iohexol) is injected into the DFTS at the same time as intrathecal anaesthesia, using the palmar/plantar pastern approach. The horse is walked for a few strides to distribute the solution within the sheath and then a lateromedial radiograph of the region, including the proximal and distal limits of the sheath, is obtained. It is important to use the palmar/plantar pastern injection approach to prevent contrast material that may have been inadvertently injected subcutaneously from masking the area of interest.

The normal manica flexoria is highlighted by two parallel lines of contrast material that taper to a natural point that lies level with, or just distal to, the apices of the proximal sesamoid bones (*Figure 9a*). Indications of a manica flexoria injury include proximal displacement and/or an abnormal contour of the distal point of the manica flexoria, focal accumulation of contrast material at the dorsal border of the DDFT at the level of the manica flexoria (*Figure 9b*), or an absence of the manica flexoria altogether. A DDFT injury may be highlighted by a thin line of contrast material coursing proximally and obliquely within the DDFT borders as they course palmar/plantar to the proximal sesamoid bones. Constriction of the PAL is seen as an unequal distribution of contrast material, proximal and distal to the proximal sesamoid bones, which may be coupled with an abnormal skin contour at the palmar/plantar aspect of the proximal sesamoid bones. Overall, contrast tenography is sensitive for detecting tears of the manica flexoria (sensitivity 92%; specificity 56%) and specific for diagnosing DDFT tears (sensitivity 54%; specificity 73%), but it is not as useful for identifying PAL constriction (sensitivity 71%; specificity 45%) (Kent et al, 2020).

Advanced imaging

The use of plain and contrast-enhanced computed tomographic (CT) anatomy of the DFTS has been described (Agass et al, 2018; Lacitignola et al, 2015), with the latter providing enhanced anatomical detail. However, there is no information available regarding the use of CT in detecting lesions in clinical cases. There is one anatomical study examining the use of magnetic resonance imaging (MRI) of the DFTS (Daniel et al, 2019) and a few studies describing the MRI findings of specific lesions such as distal sesamoidean ligament injuries (Sampson et al, 2007) and desmitis of the distal DAL (Cohen et al, 2008), although larger studies detailing the utility of MRI to detect specific DFTS lesions are currently lacking.

Tenoscopy

Despite advances in operator skills, imaging equipment and techniques, tenoscopic evaluation of the DFTS remains the gold-standard for both diagnostic and therapeutic purposes (*Figure 10*). While some horses with very mild pathology may respond to medical therapy the chance of complete resolution of clinical signs is limited, therefore tenoscopic evaluation should be considered,

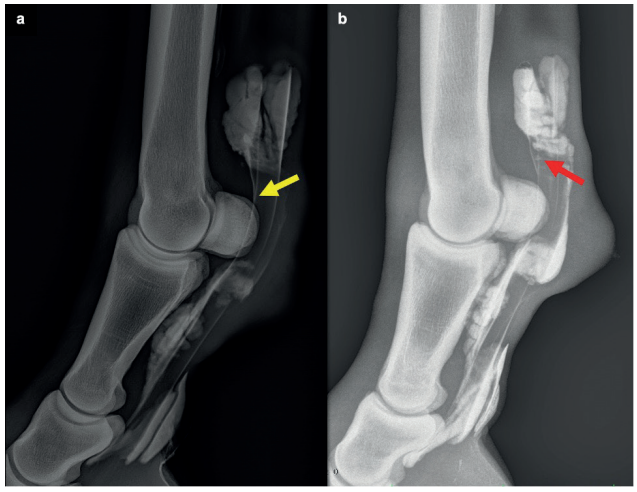

Figure 9. Contrast tenography of the digital flexor tendon sheath in the hindlimb of two horses. a) There is an intact manica flexoria depicted by two parallel lines of contrast tapering to a point (yellow arrow) which lies level with the apices of the proximal sesamoid bones. b) There is a focal accumulation of contrast material (red arrow) on the dorsal border of the deep digital flexor tendon at the level of the manica flexoria, which creates suspicion of a manica flexoria injury.

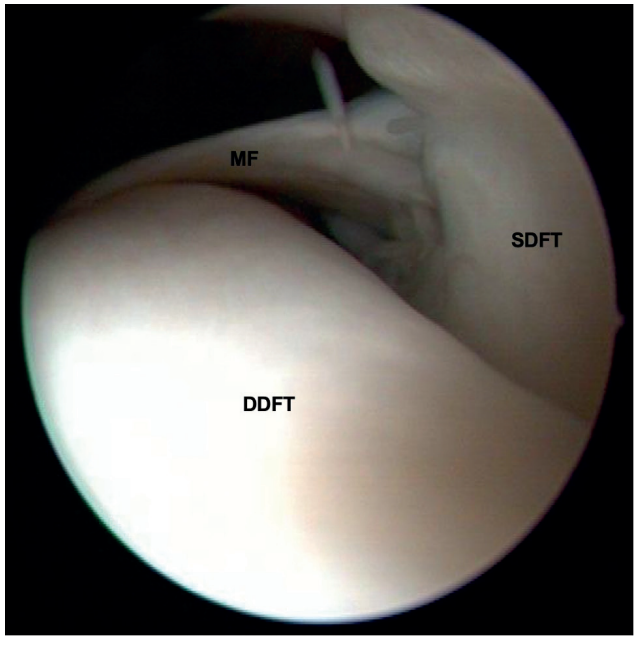

Figure 10. Tenoscopic image showing an injury to the lateral aspect of the manica flexoria where it joins the superficial digital flexor tendon. This view is obtained by looking proximally within the digital flexor tendon sheath from a basisesamoid tenoscopic portal.

preferably early in the course of disease, in order to maximise the prognosis for a full return to athletic exercise.

Conclusions

Despite being a complex and challenging structure to understand, there are multiple ways to diagnose DFTS pathology and this can be achieved stable-side using diagnostic anaesthesia, ultrasonography and contrast tenography. By expanding their knowledge of the clinically relevant anatomy and diagnostic techniques, practitioners can easily improve their confidence and ability in diagnosing common DFTS lesions. EQ

KEY POINTS

- The digital flexor tendon sheath is a complex structure and is commonly implicated in fore- and hindlimb lameness. Practitioners should aspire to expand their basic anatomical and clinical knowledge of this structure in order to finesse their diagnostic ability of its pathologies.
- There are multiple approaches to the digital flexor tendon sheath for performing intrathecal injection or synoviocentesis. Understanding the advantages, limitations and potential complications associated with each method will allow the practitioner to choose the most appropriate approach.
- Ultrasonography is the main imaging modality used to assess the digital flexor tendon sheath. A detailed understanding of the relevant clinical anatomy will greatly aid practitioners in reaching a diagnosis in horses with digital flexor tendon sheath pathology, while avoiding misidentification of normal anatomical structures as pathological lesions.
- Contrast tenography can complement ultrasonography in diagnosing deep digital flexor tendon, manica flexoria and palmar/plantar annular ligament injuries, although tenoscopy remains the gold standard for diagnostic, as well as therapeutic, purposes.

Conflict of interest

The author declares no conflicts of interest.

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