SECTION 1
MUSCULOSKELETAL
CHAPTER ONE

ULTRASONOGRAPHY OF THE FOOT AND PASTERN

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THE FOOT

Lameness associated with the foot is common and routinely evaluated using radiography. However, many causes of lameness are associated with soft tissue pathology where there are no or minimal radiographic changes. While magnetic resonance imaging (MRI) has become the imaging modality of choice for identifying such soft tissue causes, MRI is costly and not always available. Therefore, ultrasonography is a logical imaging modality to consider but its use is compromised by the presence of the hoof capsule, which precludes imaging through it. However, there are three ultrasonographic windows where images can be obtained of structures of the foot – proximal to the coronary band palmarly and dorsally, and transcuneally/transsolarly.

Ultrasonography Proximal to the Coronary Band

A number of structures within the foot extend proximal to the coronary band and so lend themselves to ultrasonographic examination.

Preparation

The hair should be clipped and cleaned as for other ultrasound examinations. Gel should be rubbed it the area and left for a few minutes to improve contact as this is often limiting.

Technique

For the palmar aspect of the foot a small footprint transducer (ideally a curvilinear probe) can be placed longitudinally between the bulbs of the heel, with the foot placed on a wooden wedge (as used for foot radiography – Figure 1.1) so as to have the fetlock partially flexed and the foot extended. This allows the assessment of the deep digital flexor tendon (DDFT), the palmar pouch of the distal interphalangeal (DIP) joint, the “T” ligament, and the navicular bursa down to the level of the proximal border of the navicular bone (Figure 1.2). However, the DDFT is off-incidence to the ultrasound beam and hence is hypoechoic, and the imaging window incorporates only the middle portion of the DDFT, making identification of DDFT tears, most commonly present in the lobes, difficult.

For the dorsal, medial, and lateral aspects, the transducer is positioned both transversely adjacent to the coronary band and longitudinally overlying the coronary band (Figure 1.3) and moved from the dorsal aspect to the dorsomedial and dorsolateral aspects where the dorsal joint capsule and collateral ligaments of the DIP joint (Figure 1.4) can be imaged immediately proximal to the coronary band. The collateral ligaments traverse the coronary band and so only the more proximal parts of the ligament are visible ultrasonographically. Care should be taken to ensure the transducer is on-incidence to the collateral ligament as it is easy to generate off-incidence artifacts in the ligaments that can resemble pathology (Figure 1.5). Further caudally lie the collateral cartilages, which are hypoechoic but can show areas of ossification (and therefore acoustic shadowing).

Ultrasonographic Abnormalities

Via the palmar window, only chronic DDFT pathology, where there is retained echogenicity and/or mineralization within the off-incidence hypoechoic DDFT, can
usually be visualized (Figure 1.6), limiting this view for comprehensive evaluation of the DDFT in this region of the foot. In some cases, DDFT pathology will extend sufficiently proximally to be visible in standard views within the distal pastern (see Pastern, later in this chapter).

Abnormalities of the distal interphalangeal joint can result in changes to the dorsal pouch which are visible ultrasonographically – both distension and synovial thickening (Figure 1.7) as well as osteophytosis in cases of osteoarthritis (Figure 1.8). Where ultrasonography of this region carries the most useful imaging is for collateral ligament desmitis, especially when there is palpable swelling in the region of the ligament (dorsomedially or dorsolaterally) at the level of the coronary band. Ultrasonographic abnormalities vary between enlargement and complete rupture (Figure 1.9).

**Transsolar and Transcuneal Ultrasonography**

The third phalanx (P3), distal sesamoid bone (navicular bone) (DSB), navicular bursa (NB), implantation of the deep digital flexor tendon (DDFT), distal sesamoid impar ligament (DSBIL), and other suprasolar structures can be evaluated ultrasonographically transcuneally (through the frog) and transsolarly (through the sole). A 7.5 MHz transducer, preferably curvilinear, should be used, although lower multi-frequency transducers such as a 3.5 MHz transducer used at 6 MHz can also give adequate images.
Figure 1.3  Linear transducer positioning to evaluate the dorsal and dorsolateral/dorsomedial aspects of the foot: (A) transverse, (B) longitudinal. Note the transducer spanning the coronary band in the longitudinal orientation.

Figure 1.4  Normal ultrasonographic appearance of the distal interphalangeal joint collateral ligaments. (A) Transverse image – note the oval-shaped collateral ligament (arrow) lying in a depression in the underlying bony surface of the second phalanx. (B) Longitudinal image (proximal to the left) – the longitudinal striations of the ligament are visible (arrow). Note the acoustic shadowing over the hoof capsule.

Figure 1.5  Hypoechoic region within the collateral ligament in a transverse image. There is no accompanying enlargement to the ligament and so such isolated hypoechoic areas should be interpreted with caution, as they can be generated artifactually by slight off-incidence orientations of the transducer.

Figure 1.6  Retained echogenicity in an off-incidence transverse image of the distal deep digital flexor tendon consistent with chronic tendinopathy and/or mineralization.
Preparation

Since the frog and sole are relatively impenetrable to ultrasound waves, and loose solar and frog keratin can trap air, it is important to prepare them to optimize the image. The sole and frog should be trimmed to get rid of loose scaly keratin and pared smooth. The foot should then be soaked in bandages/poultice for at least an hour in water. This may need to be prolonged to overnight soaking, if there is initially minimal softening of the sole or frog. Application of acoustic coupling gel (ACG) for 10–15 minutes prior to scanning also helps image visibility. Copious amounts of ACG that fill the collateral and central sulci of the frog also help to establish a clearer image with fewer artifacts and serve as a stand-off medium. A handler can hold the leg in a position so that the ultrasonographer can access the sole or the ultrasonographer may elect to hold the pastern between his/her knees with the sole facing upwards.

Scanning Procedure

For the navicular bone and associated structures (Figure 1.10), the area over the frog is scanned in both transverse and sagittal planes. The proximal aspect of the DSB is approximately at the middle of the frog and the insertion of the DDFT on P3 is just proximal to the apex of the frog (Figure 1.11). Using this technique, the hyperechoic collateral ligament of the DSB can be seen indistinctly on the proximal aspect of the DSB. The DSB flexor surface and distal aspect can be seen as a hyperechoic surface. Palmar/plantar to this is the hypoechoic DSB fibrocartilage, then the navicular bursa followed by the fibers of the DDFT, which, when followed distally, can be seen fanning out to implant on the facies flexoria of P3. Palmar/plantar and proximal to the DDFT and closely associated to it, is the very thin (hardly visible) distal digital annular ligament. From the distal aspect of the DSB the distal sesamoidean impar ligament (DSBIL) fibers can be seen extending distally to implant on P3 proximal to the facies flexoria. Between the DSBIL and the distal DSB is the hypo- to anechoic distal palmar recess of the distal interphalangeal joint (DIPJ). Between the DSBIL and the implantation of the DDFT is the distal recess of the navicular bursa, usually only a potential space. Between the DDFT and the sole is the inhomogeneously hyperechoic digital cushion (Figures 1.12, 1.13, 1.14, 1.15).

The entire solar surface of the distal two thirds of P3 can be evaluated if a small end-on footprint curvilinear transducer is used. Again the surface is evaluated both in the transverse and sagittal planes. The hyperechoic solar bone surface can be followed from centrally to its margin. A normal interruption can be seen at the tip of P3 if a crena is present. The overlying hypoechoic solar corium can be seen as well as the hyperechoic transitional line to the inhomogeneously hyperechoic keratinized epidermis of the sole (Figures 1.16, 1.17, 1.18, 1.19).
Figure 1.8  Distal interphalangeal joint osteoarthritis. Dorsal longitudinal ultrasonographic image (A – proximal to the right) showing irregular new bone on the dorsal surface of the second phalanx, as seen radiographically (B).

Figure 1.9  Ruptured collateral ligament of the distal interphalangeal joint. (A) and (B) show the transverse (A) and longitudinal (B) images of the normal contralateral medial collateral ligament. (C) and (D) show the corresponding ultrasonographic images of the ruptured ligament. Note the absence of any organized echogenic ligament tissue where the ligament should be. Images (E) and (F) show the “regeneration” of a new ligament after 2 months in a distal limb cast, indicating that these injuries, although seemingly severe, can heal satisfactorily when the joint is immobilized adequately.

Figure 1.10  Anatomical structures in a sagittal section of the distal digit. CL: collateral ligament of the DSB; DC: digital cushion; DDFT: deep digital flexor tendon; DSB: distal sesamoid bone; ff: facies flexoria; NB: navicular bursa; P2: second phalanx; P3: third/distal phalanx; * distal recess of the NB.

Figure 1.11  Diagrammatic illustration of the position of the DSB and P3 on a solar view of the foot. DSB: distal sesamoid bone; P3: third/distal phalanx.
Figure 1.12  Sagittal transcuneal ultrasound image of the hyperechoic flexor cortical surface of the DSB and the solar surface of P3. DC: digital cushion; DDFT: deep digital flexor tendon; DSB: distal sesamoid bone; DSBIL: distal sesamoidean impar ligament; ff = facies flexoria = DDFT insertion on P3; NB: navicular bursa; P3: third/distal phalanx. Proximal is to the left and the solar surface is at the top of the image. The stippled red box in this, and all subsequent images in this chapter, indicates the probe position.

Figure 1.13  Sagittal transcuneal ultrasound image of the hyperechoic flexor cortical surface of the proximal DSB. Note the loss of image proximal to the DSB where transducer contact is poor and the DDFT is obliquely oriented to the angle of incidence of the ultrasound beam. DC: digital cushion; DDFT: deep digital flexor tendon; DSB: distal sesamoid bone; NB: navicular bursa. Proximal is to the left and the solar surface is at the top of the image.
**Figure 1.14** Transverse transcuneal ultrasound image of the hyperechoic flexor cortical surface mid DSB. DC: digital cushion; DDFT: deep digital flexor tendon; DSB: distal sesamoid bone; NB: navicular bursa. The solar surface is at the top of the image.

**Figure 1.15** Transverse transcuneal ultrasound image of the DDFT and DSBIL immediately distal to the DSB. DC: digital cushion; DDFT: deep digital flexor tendon; DSB: distal sesamoid bone; P3: third/distal phalanx; *: palmar recess of the distal interphalangeal joint. The solar surface is at the top of the image.
**Figure 1.16** Transverse transsolar ultrasound image of P3 at the level of the frog apex. The solar corium is the hypoechoic structure above P3. DSB: distal sesamoid bone; P3: third/distal phalanx.

**Figure 1.17** Oblique transverse transsolar/cuneal ultrasound image of the hyperechoic marginal solar surface lateral P3 with the DSB seen obliquely in the far field at the distal third of the frog. DSB: distal sesamoid bone; P3: third/distal phalanx. Laterodorsal is to the left.

**Figure 1.18** Sagittal transsolar ultrasound image of the hyperechoic solar tip of P3. Note the hypoechoic corium immediately solar to P3 (*) and the corium–solar keratinized epidermis interface (arrow). DSB: distal sesamoid bone; P3: third/distal phalanx. Proximal is to the left.
Ultrasound-guided navicular bursocentesis can be quite easily performed by positioning the transducer in the sagittal plane over the DSB and placing the needle in the midline proximal to the bulbs of the heel and visualizing the tip of the needle when it reaches the proximal or flexor aspect of the DSB (Figure 1.20). Navicular bursa fluid can be aspirated or therapeutic or contrast agents can be deposited within the NB.

**Ultrasonographic Abnormalities**

Subsolar gas indicative of a solar abscess or penetrating foreign body will be seen as hyperechoic specks within the solar corium or at the corium–epidermis interface (Figure 1.21). Pedal osteitis changes (Figure 1.22) or marginal fractures of P3 (Figure 1.23) will be seen as an irregular P3 margin. In chronic laminitis (Figure 1.24), where capsular rotation of P3 or distal displacement of P3 relative to the hoof wall has taken place (sinking), the tip of P3 will be seen closer to the solar surface of P3 than normal (less than approximately 10.4 mm in the Thoroughbred). Abscessation or edema of the digital cushion will be seen as a change in its normal echogenicity.

Navicular bursitis with an effusion can be seen as an increase in fluid within the bursa and, depending on the nature of the fluid, will be more echoic if it is a modified transudate or exudate. Adhesions of the DDFT to the flexor surface of the DSB may be seen as increased echogenicity in this area and may be further evaluated dynamically while scanning by flexing and extending the tip of the foot while scanning in a longitudinal plane. If adhesions are present the normal gliding of the DDFT over the DSB will be impaired. Lesions of the DDFT can be seen as a thickening of the DDFT and, if acute or subacute (Figure 1.25), as a decreased echogenicity and loss of fiber alignment. A more chronic lesion will result in a more hyperechoic tendon. Rupture of the DDFT should be seen as an interruption of the normal fiber continuity, possibly with associated inhomogeneous echogenicities around and within it due to hemorrhage.

Doppler ultrasonography can indicate increased or decreased blood flow within the DDFT or DSBL. Fractures of the DSB and P3 can be seen as an interruption in the hyperechoic cortical line. Avulsion fractures of the DSB involving the DSBL may result in a subluxation of the DSB and visualization of the underlying distal aspect of the second phalanx (P2). (Figures 1.26, 1.27) Distal sesamoid impar ligament rupture also result in proximal displacement of the DSB, allowing visualization of the distal condyle of P2 as well as fiber disruption of the DSBL.
Figure 1.20 Ultrasound-guided injection of the navicular bursa. Sagittal image showing needle (red line) placement for NB arthrocentesis. Sagittal transcuneal ultrasound image showing the tip of the needle placement (*) to inject fluid into the NB. The distal recess of the bursa can be seen filled and distended with anechoic fluid depressing the DDFT solarly. Effusive navicular bursitis would appear similar with possible increase in echogenicity depending on nature of the fluid. DDFT: deep digital flexor tendon; DSB: distal sesamoid bone; NB: navicular bursa. Proximal is to the left.

Figure 1.21 Subsolar abscess. Sagittal transsolar ultrasound image showing a focal hyperechoic area (arrow) immediately solar to the hyperechoic tip of P3, indicating subsolar gas. The adjacent dermis appears slightly thicker than normal and bulging slightly. P3: third/distal phalanx. Proximal is to the left.
Figure 1.22  Septic pedal osteitis. Transverse ultrasound image of tip of P3; note the irregular hyperechoic areas (fragments – arrowheads) within the hypo- to anechoic fracture bed of the tip of P3. Dorsoproximal–palmarodistal radiograph of the tip of P3 of a clinical case of septic pedal osteitis. Note the irregularly margined W-shaped radiolucent concavities of the tip of P3; metallic opacity drawing pin present. P3: third/distal phalanx. (Source: Ultrasound images – Olivier-Carstens, A. (2004) [1]. Reproduced with permission of John Wiley & Sons Ltd.)

Figure 1.23  Pathological large marginal fracture of P3 secondary to a septic pedal osteitis. Transverse ultrasound image of tip of P3; note the irregular hyperechoic areas (fragments – arrowhead) within the hypo- to anechoic fracture bed of the tip of P3. Dorsoproximal–palmarodistal radiograph of tip of P3 of a clinical case with a pathological large marginal fracture of P3 secondary to chronic subsolar abscessation; note the irregular radiolucency at the tip of the distal phalanx and the bony opacities disassociated from the parent bone. The toe of the sole has been pared away. P3: third/distal phalanx. (Source: Ultrasound images – Olivier-Carstens, A. (2004) [1]. Reproduced with permission of John Wiley & Sons Ltd.)
Figure 1.24  Chronic laminitis with capsular rotation of P3. Sagittal ultrasound transsolar image of distal tip of P3 (below cursor); the distance from the tip of the distal phalanx to the sole is 2.4 mm, indicating a marked decrease of the distance of the tip of P3 from the solar hoof surface. The normal distance in the Thoroughbred should not be less than 10.4 mm. Lateromedial radiograph of P3, showing marked capsular rotation of P3; metallic linear marker indicates dorsum of hoof wall of the same case; the magnification corrected distance between the tip of the distal phalanx and the solar margin is 3 mm; metallic drawing pin indicates frog apex. P3: third/distal phalanx. (Source: Ultrasound images – Olivier-Carstens, A. (2004) [1]. Reproduced with permission of John Wiley & Sons Ltd.)

Figure 1.25  Implantational deep digital flexor tendinopathy. Sagittal transcuneal ultrasound image showing a thickening and bulging of the most distal aspect of the DDFT with decreased echogenicity and a decrease in the distinct fiber alignment as seen normally. There also appears to be an increase in the fluid within the distal recesses of the NB and DIPJ (*). DDFT: deep digital flexor tendon; DIPJ: distal interphalangeal joint; NB: navicular bursa; P3: third/distal phalanx. Proximal is to the left.
Figure 1.26  Distal sesamoid impar ligament rupture. Sagittal ultrasound image; note the hypoechogenic appearance of the DSBIL with fiber disruption, proximal displacement of the DSB, and a large pocket of synovial fluid (SF). The proximal displacement of the DSB allows visualization of the distal condyle of the second/middle phalanx (MP). The DDFT looks slightly less echogenic than normal but it is within the normal range of size. The architecture and variation in imaging representation is related to the orientation of the probe. LM radiograph of the right hind digit. Note several avulsion fracture fragments (white arrows) and the proximal displacement of the navicular bone as well as the dorsal periarticular remodeling of the DIPJ (arrowhead). The joint space is enlarged dorsally (black arrow) compared with the plantar aspect consistent with DIPJ instability. DC: digital cushion; DDFT: deep digital flexor tendon; DIPJ: distal interphalangeal joint; DP: third/distal phalanx; DSB: distal sesamoid bone; DSBIL: distal sesamoidean impar ligament; NB: navicular bursa. Proximal is to the right and the solar surface is to the bottom of the image. (Source: Ultrasound images – Heitzmann, A.G. & Denoix, J.-M. (2007) [2]. Reproduced with permission of John Wiley & Sons Ltd.)

Figure 1.27  The same case as in Figure 1.26. Transverse ultrasound image; proximal displacement of the DSB allows visualization of the distal condyle of the second/middle phalanx (MP) and of a large pocket of synovial fluid (SF). Note the hypoechogenic appearance of the DSBIL. The solar surface is to the bottom of the image. DC: digital cushion; DDFT: deep digital flexor tendon; DSIL/DSBIL: distal sesamoidean impar ligament. (Source: Ultrasound image – Heitzmann, A.G. & Denoix, J.-M. (2007) [2]. Reproduced with permission of John Wiley & Sons Ltd.)
THE PASTERN

The pastern is an area that, with a little practice, can be evaluated very satisfactorily using the ultrasound machines and probes available in general practice. The use of ultrasonography to investigate lesions in this region of the distal limb is particularly applicable as many injuries to the soft tissue structures on the palmar aspect of the limb result in non-specific subcutaneous fibrosis which prevents accurate digital palpation of the area. Certainly, with the advent of ultrasonography, it has become apparent that many cases previously diagnosed as distal sesamoidean ligament desmitis were probably tendinitis of the superficial digital flexor tendon branches or digital sheath abnormalities.

Ultrasonography is particularly useful for “superimposing” the soft tissue components onto the information obtained from radiographs. The fetlock and pastern regions are particularly complex in the arrangement of its soft tissue attachments and the tendons running over the palmar/plantar aspect. Many primarily soft tissue abnormalities will also have bony lesions in this region of the limb and vice versa. Therefore the combination of ultrasonographic and radiographic techniques is frequently indicated. The most diagnostic information is usually obtained by performing a radiological appraisal first, followed by ultrasonography.

A variety of transducers can be used to examine these areas. Both sector and linear probes are applicable – the linear probe offers superior longitudinal images, while the small curvilinear probe can scan further distally in the pastern region by placing it between the bulbs of the heels.

Preparation and Scanning Technique

The skin is prepared as for other areas and the transducer applied using couplant gel and a standoff pad. The latter is usually used, as many of the structures being assessed are superficial. However, appreciable subcutaneous edema or fibrosis, common in this region, will provide a “natural” standoff and a separate standoff pad will therefore not be needed.

The ultrasound examination is normally performed with the limb fully weightbearing and the horse standing square. Exceptions to this include placement of the limb further caudally to hyperextend the DIP joint to allow scanning further distally in the pastern region and placement of the foot on a block to improve access and maneuverability of a large transducer.

Because many injuries to this region involve the digital sheath, an ultrasonographic examination of this area should stretch from the proximal limit of the digital sheath (mid-metacarpal) to the bulbs of the heels.

The palmar/plantar pastern region is also divided into a number of levels (1–3) or zones (P1a–c; P2a–b). The distal two zones correspond to the more distal position that can be frequently achieved with a sector probe between the bulbs of the heels, although one of those levels can be obtained with a linear probe if the limb is placed caudally so as to hyperextend the DIP joint. A single longitudinal level is usually achievable with a linear transducer (although a rectal probe may require reversing so that the lead is positioned proximally and does not contact the heels, compromising the required probe orientation).

Because a number of structures pass obliquely across the first phalanx (oblique distal sesamoidean ligaments proximally; SDFT branches distally), oblique 45° views should be used to perform a complete examination. Hence the skin should be clipped to the medial and lateral limits of the pastern when preparing the limb.

A full examination should therefore include transverse and longitudinal images obtained from both the palmar/plantar and oblique probe positions. The contralateral limb should, as usual, be scanned as well, both for comparative purposes but also as many soft tissue injuries in this region can be bilateral.

Line drawings of the normal anatomy are shown in Figure 1.28.

In addition to the digital flexor tendons within the digital sheath (see Chapter 2), both the oblique (ODSL) and straight (SDSL) distal sesamoidean ligaments (DSLs) can be identified ultrasonographically. The straight distal sesamoidean ligament (SDSL) is the most echogenic structure within the pastern region. The ODSLs require oblique views to image them adequately. The short and cruciate DSLs cannot be distinguished but can sometimes be identified adjacent to the joint capsule in oblique views of the palmar/plantar aspect of the fetlock joint.

Beware of the insertion of the SDSL onto the middle scutum on the palmar/plantar aspect of the PIP joint. This area will frequently have a hypoechoic “core” or “sandwich” in the transverse views (P3 only) and a hypoechoic “wedge” with its apex directly proximally in the longitudinal view (Figure 1.29). The hypoechoic region does not usually extend further proximally than the distal limit of insertion of the ODSL. These are normal anatomic variations and should not be mistaken for pathology.

Both proximal and distal digital annular ligaments exist within the pastern; they cannot be easily
Figure 1.28 Diagrammatic representation of ultrasonographic anatomy of the pastern region. (Source: Smith, R.K.W. & Webbon, P.M. (1997) [3]. Reproduced with permission of Elsevier.)
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Figure 1.29  Appearance of the insertion site of the straight distal sesamoidean ligament (SDSL) via the middle scutum onto the proximal aspect of the middle phalanx. Note the normal hypoechoic area with the distal SDSL/middle scutum (arrows) which should not be mistaken for SDSL desmitis. This hypoechoic area should not extend further than the limit of insertion of the oblique distal sesamoidean ligaments indicated by at bony prominence on the palmar/plantar aspect of the proximal phalanx (dashed arrow).

Figure 1.30  Straight distal sesamoidean ligament desmitis. Note the hypoechoic area seen in both transverse and longitudinal images extending further proximally than the limit of insertion of the oblique distal sesamoidean ligaments (open arrow).

Ultrasonographic Abnormalities

Most soft tissue injuries to the pastern region are associated with the digital sheath so Chapter 2, relating to this structure, should be consulted in conjunction with this section.

Distal Sesamoidean Ligament Abnormalities

Injury to these ligaments is relatively rare but injuries to either the single straight distal sesamoidean ligament (SDSL) or the one of the paired oblique distal sesamoidean ligaments (ODSL) can be identified ultrasonographically. The changes identified ultrasonographically are similar to those seen in other strains involving tendons and ligaments (enlargement, alterations in echogenicity, shape, and loss of the normal striated pattern) (Figure 1.30). Enlargement of

visualized in the normal horse (they are usually less than 1 mm in thickness) but can be seen when enlarged. The proximal digital annular ligament can be identified proximal to the distal outpouching of the digital sheath, especially medially and laterally where they are more discrete structures grossly.
the SDSL is manifested by occlusion of the space between the palmar/plantar surface of the first phalanx/ODSL and the SDSL, and between the DDFT and the SDSL. Once again subcutaneous fibrosis is a common concurrent finding. Many SDSL injuries can tear into the adjacent digital sheath resulting in digital sheath distension and can benefit from tenoscopic debridement (Figure 1.31). Radiography can be helpful in these cases to assess any subluxation of the PIP joint, which can result from damage to the DSLs (or the branches of the superficial digital flexor tendon). Severe disruption of the DSLs can result in proximal displacement of the proximal sesamoid bones (cf. severe SL disruption giving distal displacement). Avulsion fractures can also be present and these will also be identifiable ultrasonographically where they can be linked to specific structures.

ODSL injury can be difficult to identify ultrasonographically, especially if the injury is restricted to its proximal limits; this requires oblique ultrasonographic views that are difficult to obtain devoid of artifacts. Injuries to these structures have been a relatively common diagnosis on magnetic resonance imaging (MRI), although care must be taken to avoid misinterpretation due to the magic angle artifact associated with the obliquity of these ligaments. Convincing changes on ultrasound include enlargement and heterogeneity, together with overlying subcutaneous fibrosis and enthesophytosis at the base of the proximal sesamoid bones (Figure 1.32).
Enthesophytosis associated with the insertion of the ODSL onto the palmar/plantar aspect of the proximal phalanx is characterized as an irregularity to the bone surface. Although this is most commonly identified at this site, it is rarely a cause of lameness.

**Digital Annular Ligaments**

They are poorly visible ultrasonographically and rarely a cause of lameness, but they have been implicated in constriction syndromes similar to the palmar/plantar digital annular ligament (PAL). In these situations, they appear as thickened structures in the subcutaneous space and can be traced to their attachments to the palmar/plantar aspect of the proximal phalanx. Like the PAL, the identification of such thickening does not confirm constriction, which ideally relies on tenoscopic confirmation. These ligaments may also enlarge secondarily to many soft tissue conditions of the pastern region.

A small number of cases have been seen where horses have been presented with acute lameness referable to the proximal pastern region. Both radiography and ultrasonography have shown the presence of avulsion fractures at the origin of the proximal digital annular ligament. As with many avulsion fractures, the ligaments themselves have been largely normal in appearance.

**Proximal Interphalangeal Joint Abnormalities**

Synovial effusion can be identified ultrasonographically during ultrasonographic evaluation of the distal pastern as an anechoic region deep to the straight distal sesamoidean ligament.

With degenerative joint disease of the PIP joint, osteophytes and enthesophytes can be visualized ultrasonographically around the periphery of a joint by a roughened bone surface echo. Osteophytes can be imaged on the palmar surface at the limits of the anechoic synovial cavity when scanning longitudinally over the pastern.

PIP joint disease can be related to ligamentous damage either of the collateral ligaments or the palmar ligaments (Figure 1.33). Acute injury to these ligaments can be identified by enlargement and hypoechogenicity of the ligaments and occasionally avulsions. More chronic pathology is manifest by osteoarthritis and enthesophytosis, which are best identified ultrasonographically when the transducer is oriented longitudinally and moved over the lateral and medial aspect of the PIP joint.

The articular cartilage of the PIP joint is very thin which makes accurate identification of cartilage lesions difficult. Osteochondrotic lesions are usually identifiable by their bony changes (visible radiographically) rather than the articular cartilage changes per se. Ultrasound can be useful to differentiate some of the bony fragments on the palmar/plantar aspect of the fetlock joint, some of which are considered to be osteochondrotic in origin, while others are fractures or ossification within the DSLs.
Desmitis of the palmar ligaments of the proximal interphalangeal (PIP) joint. Transverse ultrasound images obtained obliquely over the distal pastern region at the level of the proximal interphalangeal joint from the palmarolateral (A) and palmaromedial (B) aspects. The dashed arrow shows the subcutaneous fibrosis and the solid arrow the hypoechoic palmar ligaments of the PIP joint. This disruption extended into the palmar pouch of the PIP joint, seen arthroscopically (C). An arthroscopic probe could be inserted into the damaged ligament (D). Image E shows the arthroscopic appearance of the ligament after debridement.
**Recommended Reading**


**References**

