INTRODUCTION

Ultrasound can provide important diagnostic information on the soft tissue and bony structures of the foot, despite some inherent limitations of field of view and variations in image quality. A thorough history, physical examination and lameness examination should be performed prior to the ultrasound examination (or any diagnostic imaging modality) and serves as an aid to defining a region of interest and in interpretation of findings.

COFFIN JOINT AND COLLATERALS

The collateral ligaments of the coffin joint can be visualized with a 7.5 MHz or higher linear transducer. In particularly large horses or those with unusual conformation or swelling, a lower frequency and/or curvilinear probe is often necessary. The dorsomedial and dorsolateral aspects of the coronary band should be clipped from the level of the coronary band to about 2-3 centimeters in a proximal direction.

The collateral ligaments of the coffin joint arise proximally from the depressions on either side (medial, lateral) of P2 and insert deep to the hoof capsule in the depressions on either side of the extensor process of P3. Thus, only the proximal portion (1/2 to 2/3rds of the ligament) is accessible to sonographic visualization. Nonetheless, lesions can be identified and routine ultrasound of the collaterals is recommended when evaluating lameness referable to the foot. Visualization through the coronary band is possible. The collaterals are fairly dorsally located on the foot, at about 11 and 1 on a clock face, with dorsal being 12 o’clock. They can and should be evaluated in both short and long axis, and followed as far distal as the hoof capsule allows. They appear as dense, echoic structures which are round to oval in shape in short axis and have a typical ligamentous fiber alignment in long axis. Due to difficulties in maintaining a perpendicular angle of incidence, a central hypoechoic artifact can rather easily be created in the short axis view. Careful technique and use of the sagittal view should help establish whether the region represents a lesion or an artifact. Some normal variation in shape/symmetry may occur in without representing a pathological process. Critique technique and use of contralateral limb comparison (when contralateral limb is not clinical) may aid in determining whether an active lesion is present. Cross sectional area of the medial and lateral collateral ligaments has been reported to be .63+/- .05 cm² and .62+/- .04 cm² respectively (Sage and Turner, 2002).

The synovial outpouching of the coffin joint itself appears as a slightly inhomogeneous hypoechoic region at the level of the coronary band. It is much more prominent and easy to identify when effusion is present. It is typically best seen dorsally, dorsomedially and dorsolaterally rather than palmar medial or lateral. Coffin joint effusion, however, can be appreciated from the palmar window, as will be discussed in the next section.

It is worth noting that Dyson (2004) reported that in 62 horses with desmitis of the collateral ligament of the DIP diagnosed on MRI, only 20 of those (32%) had lesions detectable on ultrasound, indicating a high rate of false negatives for evaluation of this structure. This should be kept in mind during evaluation of the collateral ligaments and making subsequent recommendations. It is possible that the combination of ultrasound with other diagnostics results in improved sensitivity and that with improved image quality and feedback from modalities such as MRI we can improve our sensitivity.

HEEL BULB APPROACH

The more distal portion of the DDFT over P2, as well as the collateral sesamoidean ligament (suspensory ligament of the navicular bone), proximal margin of the navicular bone, proximal outpouching of the distal interphalangeal joint (coffin joint), navicular bursa and palmar/plantar aspect of P2 can be seen via the heel bulb approach. A small footprint curvilinear or convex probe is required to fit in the relatively short and narrow depression between the heel bulbs. The majority of the
examination is conducted with the probe oriented sagittally (easiest to initially identify structures). However, diagnostic transverse views are possible and should be attempted in all cases. Optimal visualization is obtained when the horse is standing with the forelimb slightly underneath/below him. Visualization and image quality will vary depending on conformation.

The DDFT will be the most prominent structure, and will be visible running distally on the palmar/plantar aspect of the limb, just deep to the skin, subcutaneous layer and portion of digital cushion. It has a reported thickness at this level of .84 cm (Sage and Turner, 2002). The dorsal margin of the navicular bone, when visible, will appear as a short linear hyperechoic echo with a shadow, oriented perpendicularly to the deep flexor tendon. The collateral or suspensory ligament of the navicular bone appears as a short echoic band which can be imaged extending from the region of the navicular bone proximally. It is wider at its base and narrower proximally, resulting in a slightly triangular appearance. It should be followed as far laterally and medially as possible within the window of visualization. It divides two small anechoic fluid pockets, the palmar/plantar being the navicular bursa and the dorsal being the DIP joint. Considerable variation in the normal shape and prominence of the collateral ligament exists between horses, and evaluation of the contralateral limb is recommended in all cases.

TRANSCLUNIAL/SOLAR VIEW

Transcuneal evaluation (i.e. through the frog) can be performed on most horses with proper patient preparation. The DDFT insertion, the plantar/palmar border of the navicular bone, impar ligament, navicular bursa, distal recess of the coffin joint and a portion of P3 can be identified.

To begin, the foot should be trimmed so any excess or redundant tissue is removed and the surface is made as flat and smooth as reasonably possible (excluding cleft) to maximize contact. The foot should then be cleaned with a hoof brush and soapy water, then soaked in water in a wrap or foot boot for 30 minutes to 12 hours, depending on situation. The wrap should not be removed until immediately prior to the ultrasound. Depending on foot shape and frog density and dryness, images can be obtained with a variety of probes from a 7.5 MHz linear probe to 3.5 MHz convex abdominal probe. In some horses, images can be obtained without prior foot soaking, but it is generally advisable to soak the foot in advance whenever possible; likewise, a few conformational types are not amenable to obtaining a diagnostic quality image. If one is able to depress the frog slightly with digital palpation then it should be amenable to sonographic imaging. If it feels rock hard or has unusually irregular conformation, imaging may be difficult to impossible. Preparation of both feet is recommended for purposes of contralateral limb comparison; bearing in mind however that many foot lamenesses are bilateral and considerable variation in foot conformation may exist, making comparison to a contralateral “control” more difficult.

Care should be taken with probe orientation to facilitate anatomical recognition. The structures are most recognizable when imaged in a sagittal plane initially, with the marker thus oriented toward the toe or the heel region. It can then be slid medially and laterally (parasagittal planes) as much as the frog allows. Transverse views should also be attempted. The probe should be slid dorsally and caudally along the frog, or otherwise manipulated as necessary, in order to center over the specific structure (navicular, impar ligament, DDFT insertion) being evaluated and minimize incidence artifacts.

The digital cushion is the most palmar structure, about 1-2 cm depth. It may be fairly uniformly mildly echoic or may present as having an echoic outer rim surrounding a more hypoechoic central region. The next most prominent structures are typically the navicular bone and P3. The navicular bone appears as the short, hyperechoic bony echo which is located superficially (palmarly) to the bony echo of P3. Extending from the shadow of the navicular bone will be the bony echo of P3, which will course superficially to a very shallow depth towards the toe.

The DDFT will be visible as a linear, hypoechoic structure deep to the digital cushion and overlying the navicular bone. It can be seen coursing over the navicular bone to its insertion on P3. Distinct fiber pattern is more visible towards its insertion on P3. Playing with the probe angle over the DDFT (to minimize a poor incidence angle) aids in identifying fiber pattern. In my experience there is some variation in the normally detected fiber pattern of the DDFT amongst horses, thus evaluation of the contralateral limb is advisable in most cases. Likewise, the palmar margin of the DDFT can appear...
hypoechoic in some horses, and contralateral limb evaluation is also advisable in these cases. Immediately over the navicular bone, the DDFT is more fibro cartilaginous and thus tends to appear more hypoechoic with less discernable fiber pattern. Combined thickness of the DDFT and distal digital annular ligament in clinically normal feet are reported to be 4.26 +/- .19 cm (Grewal and McClure, 2004). Width of the DDFT proximal to insertion has been reported by Sage and Turner, 2002 as .36 +/- .05 cm.

The impar ligament is visualized deep to the DDFT, in the roughly triangular region between the navicular bone and P3. If an increased volume of effusion is present in the navicular bursa, it is easier to identify. It should demonstrate a fiber pattern similar that of other ligaments. Thicknesses have been reported to be 2-3 mm (Busoni and Denoix, 2001) and 3.19 +/- .23 mm (Grewal and McClure, 2004) in a sagittal plane. The area has been reported as .22cm squared (Sage and Turner, 2002). Anechoic fluid dorsal to the deep flexor tendon represents effusion in the navicular bursa.

CONCLUSION

Grewal and McClure (2004) concluded in their study on normal horses and those clinically affected with navicular syndrome that ultrasound was a useful tool in diagnosing causes of caudal heel pain. We have found likewise in our clinical practice. Certainly, though, limitations exist and ultrasound is less sensitive than high strength MRI for evaluation of the foot. However, with experience, careful sonographic evaluation of the foot can provide important diagnostic information in many horses. It is this author’s opinion that it remains a reasonable imaging option, particularly in cases where finances, location, timing or other concerns prevent performing an MRI. Future studies correlating findings on ultrasound with MRI (as well as other modalities) should aid in improving our diagnostic skills and may help further define the role of ultrasound in this area.

REFERENCES

1. AM Sage and TA Turner, Ultrasonography of the soft tissue structures of the equine foot. Equine Veterinary Education/AE/August 2002