How to Maximize Image Quality for the Sonographic Evaluation of the Hind Proximal Suspensory Ligament

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1. Introduction

Lameness attributable to pathology of the proximal hind suspensory ligament is not uncommon and may affect horses of any performance discipline. Such lameness varies in severity, may be bilateral, and can be difficult to confirm with diagnostic analgesia. Radiography, nuclear scintigraphy, and ultrasonography have been used to investigate disorders of the hind suspensory ligament origin with variable results.1–4 Sonographic evaluation of the hind suspensory ligament can be daunting and frustrating because of the location of the overlying superficial and deep digital flexor tendons, the artifacts created by adjacent blood vessels, and the acoustic properties of the muscle and fat within the ligament.

Magnetic resonance imaging (MRI) is becoming increasingly available for equine imaging and has been shown to be of great value in elucidating the nature of proximal metatarsal injuries in the horse.5 In a previous study, images obtained with MR were found to be superior to those obtained with ultrasound compared with histologic sections of normal hind suspensory ligaments.6 A recent study of horses with lameness originating from the plantar tarsal region showed far better detection of abnormalities with MRI over ultrasonography in horses with proximal plantar metatarsal pain, including the ability to detect lesions of the suspensory origin. The conclusion of that study was that sonography was of “limited value for detection of proximal suspensory desmopathy.”7 However, some of the sonographic images published in these reports could be considered suboptimal because of either transducer positioning and/or transducer-frequency selection. Transducer selection and machine settings greatly impact image quality and can potentially result in reduced detection of abnormalities. Higher frequency transducers have become more widely used, and although ideal for imaging superficial structures such as the superficial digital flexor tendon and collateral ligaments, they may not be ideal for imaging deeper structures such as the suspensory origin and body. Additionally, factory-installed preset imaging applications are available on almost all units but often need to be modified by the operator. Although personal preference is a factor in selection of image-processing settings, knowledge of the effects of each processing function is important to achieve optimal image quality.
MRI may not be available to, or affordable for, a number of veterinarians or horse owners. General anesthesia for studies of the hind proximal suspensory ligament is required, and follow-up studies may not be affordable or practical. The ability to maximize the quality of sonographic images of the proximal hind suspensory would be an asset to both to the veterinarian and the horse owner. Ultrasonography may also provide a means to evaluate osseus abnormalities of the suspensory ligament attachment to the cortices of the third metatarsal and fourth tarsal bones, because it is superior to MRI for imaging bone margins. In the author’s experience, horses with proximal suspensory desmitis associated with an irregular, echolucent, pitted bone surface at the suspensory origin have a poor prognosis for resolution of lameness.

The purposes of this paper are to review appropriate transducer positioning, show the impact of machine settings on the appearance of lesions, and illustrate osseus abnormalities involving the origin of the hind suspensory ligament that may be detected with ultrasound. This may result in improved diagnostic utility of ultrasonography for the evaluation of hind suspensory ligament disease. The viewpoints on image quality shared in this paper may also be applied to other musculoskeletal, abdominal, fetal, and cardiothoracic ultrasound studies.

2. Procedure

Sedation with both detomidine and butorphanol is recommended for most horses, both for safety of the sonographer and to limit any patient motion that could prolong the study time. Clipping of the hair both facilitates the procedure and improves image quality in general. This is particularly true in the hindlimb because of the presence of cow licks, which can trap air and impede sliding and rocking of the head of the transducer over the area being imaged. Hair and dead skin are removed with an alcohol-soaked sponge, and ample coupling gel is applied both to the limb and the transducer. Images are obtained in short and long axis, with attention paid to the appearance not only of the ligament but of that of the associated bony attachments (Fig. 1). Care should be made not to interpret acoustic artifacts from overlying vasculature as lesions and to avoid mistaking any dorsally located vasculature as a lesion by following the course of the blood vessel or Doppler imaging, if necessary. If any abnormalities are detected, the contralateral limb should be examined to aid in the interpretation of the significance of the findings.

Transducer Selection

In the past, transducers with a frequency of 7 MHz or higher have been advocated for evaluation of the suspensory ligament. Increased availability of 12- to 13-MHz transducers over the past few years has resulted in the widespread use of these higher frequencies for musculoskeletal imaging in the equine, including that of the suspensory ligament. The higher resolution provides superior image quality of superficial structures such as the superficial digital flexor tendon; however, deeper structures such as the suspensory ligament may not be adequately imaged. Transducers now often have variable frequency options, enabling the use of lower frequencies with a 12- or 13-MHz transducer. However, use of a transducer with the appropriate center or optimal frequency for the structure being evaluated

Fig. 1. (A) Proximal suspensory injury in the hindlimb associated with an irregular surface to the third metatarsal bone (suspected avulsion; arrows) in a 2-yr-old Thoroughbred in training. Notice the thickened suspensory ligament and its hypoechoic dorsal half overlying the bone lesion. Lateral and proximal are to the right of each image. (B) Echolucent pitted bone surface (arrows) in an Irish Sport Horse with severe chronic suspensory desmopathy that failed to respond to surgical and intralesional therapies.
will result in a better image than one obtained by manipulating the frequency of a transducer that is not optimal for the region being studied.\textsuperscript{9} Variable-frequency transducer settings are also not exact and are not comparable between manufacturers or even within the same manufacturer. For example, a 12-MHz transducer set to a frequency of 10 MHz or even 8 MHz may not provide as adequate an image of the suspensory ligament as an 8-MHz transducer set to a frequency of 10 MHz or even 13 MHz. Also of interest, the calculated cross-sectional area of the same suspensory ligament may differ greatly depending on the transducer used (Fig. 2). Every brand of machine is different, and trial and error is necessary to determine the ideal transducer and best frequency options to use for imaging the suspensory ligament.

Transducer Position
The transducer should be positioned plantaromedially just distal to the chestnut and over the deep digital flexor tendon rather than the superficial flexor tendon.\textsuperscript{10} The transducer is held overhand, cupped in the palm of the hand, with the thumb and fingers of the scanning hand in contact with the limb to facilitate transducer control during the study (Fig. 3). A portion of the suspensory ligament also originates from the fourth tarsal bone; therefore, images should be obtained proximal to the third metatarsal bone, because injuries can occur in this location (Fig. 4). Off-angle imaging or imaging the ligament in a non-weight-bearing position may also

Fig. 2. (A and B) Images of the same abnormal suspensory ligament obtained with two different transducers using the same unit and image-processing options. (A) The image on the left was obtained with an 8-MHz transducer (set on 13 MHz), and the image on the right was obtained with a 12-MHz transducer (set on 10 MHz). Notice that the margins of the ligament, lesion, and bone are more clearly defined in the image on the left using the dedicated lower-frequency transducer, even at a higher-frequency setting. Also, notice the disparity in the calculation of the cross-sectional area of the ligament. The lower-frequency transducer yields a larger cross-sectional area. (B) Sonographic images of a localized hypoechoic lesion (arrows) in the dorsolateral corner of the suspensory origin in the same horse using different transducers (lateral is to the right of each image). The image on the left was obtained with a transducer with a center frequency of 8 MHz, whereas the image on the right was obtained with a transducer with a center frequency of 12 MHz. The frequency of each transducer was then adjusted to frequencies of 13 and 10 MHz, respectively, to result in a balance of optimum resolution and penetration for each image. Notice that the lesion and its margins are more clearly delineated in the image on the left, which was obtained with the lower-frequency 8-MHz transducer at a frequency option of 13 MHz.

Fig. 3. Transducer position and handling for imaging the proximal hind suspensory ligament (left limb shown). Notice the location of the transducer head just below the chestnut and the contact of the thumb and fingers with the limb.
help delineate muscular tissue from ligament fibers and can be incorporated into the examination. If dynamic range is set too low (more black and white), more subtle yet important lesions will be missed. The author will adjust the dynamic range to a setting at which bone is nearly white and fluid or blood is nearly black, while trying to maximize the shades of gray.

**Edge Enhancement**

Edge enhancement accentuates the interface between echoes or tissue layers. The author prefers no edge enhancement, because it may reduce the ability to detect hypoechoic lesions by effectively adding echoes to the area of interest (Fig. 6).

**Focal Zones**

The greater the number of focal zones, in general, the slower the frame rate. Low frame rates result in poor temporal resolution, simply resulting in a blurred still image.

Maximum lateral resolution (ability to distinguish points that are side by side) is achieved within the focal zone of the transducer. Although instrumentation allows for several focal zones to be placed throughout the image, the best resolution at a given depth is achieved by the use of one focal zone at the depth of interest. This requires that the operator actively adjusts the focal zone during the ultrasound study of structures at different depths, such as the superficial digital flexor tendon and suspensory origin.

**Power, Gain, and Reject**

The power should be set as low as possible to obtain the best resolution and limit artifacts. The gain and time-gain compensation controls can be increased to amplify returning echoes to enable a...
lower power setting. The reject control eliminates weaker echoes from all depths that may not contribute significantly to the image; however, a high reject setting may also result in loss of detail. Most sonographers prefer to use little or no reject.9,11

Frame Averaging
Frame averaging blends information from one frame into the next, resulting in a smoother appearance in real time. However, frame averaging results in loss of detail within each frame as well as creates a blurred still image. The author prefers not to use any frame averaging.

3. Discussion
Undoubtedly, MRI has increased the understanding of the ultrasound appearance of the normal and abnormal hind suspensory ligament. Its use in clinical practice has also enabled the discovery of lesions causing lameness unrelated to the suspensory origin.5,7 However, MRI is restricted by its availability, cost, and requirement for general anesthesia for most studies. These factors also impact the feasibility of follow-up examinations.

Also, the incidence of abnormalities of the hind suspensory origin as detected by MRI in successfully performing individuals and the appearance of quiescent healed or asymptomatic injuries is not yet known to the author’s knowledge. Experience has shown that an abnormal structure discovered during an ultrasound study may not be clinically important. The same conclusion will likely follow with increased application of MRI to the investigation of musculoskeletal disease in the horse: that an abnormal ligament (thickened or abnormal signal) does not necessarily mean that it is a source of lameness in a particular individual. The ability to detect fluid within a ligament or bone with MRI may be more clinically important. Sonographic detection of anechoic fluid within the hypoechoic muscle of the suspensory ligament is obviously more difficult. However, abnormalities of the surface of the bone at the suspensory origin can be appreciated fairly readily with ultrasonography. With attention to proper technique and image quality and in light of its affordability and practicality for follow-up studies, ultrasonography may not be so bad for imaging the hind suspensory origin after all.

References