Musculoskeletal Ultrasonography

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Since the early reports of its use in animals, ultrasonography has gained an important place in equine diagnostic imaging algorithms.1–25 Although several textbooks review the basic principles of musculoskeletal ultrasonography,26–28 veterinary ultrasonography systems include many recent advancements (e.g., contrast enhancement, three-dimensional imaging, tissue harmonics, broad-bandwidth transducers, extended-view scanning, cross-beam scanning). Historically, ultrasound machines for human medical use have been adapted for veterinary use. In veterinary medicine, ultrasound was initially used in small animals because their small size allowed effective correlation of abdominal and thoracic radiography with ultrasonographic findings. Adaptation of ultrasound imaging to horses has occurred more slowly, primarily because of their large size. Pregnancy evaluation of mares was the first equine application for ultrasonography because this modality offered a vast improvement over the palpation techniques traditionally used to evaluate the ovaries and conceptus. Shortly thereafter, ultrasound gained popularity in diagnosing tendon and ligament injuries in horses and then in evaluating thoracic, cardiac, and abdominal diseases. These techniques developed rapidly because they provided information that could not easily be obtained by other methods in horses.

This column focuses on diagnostic ultrasound applications that have been proven effective in the diagnosis and prognosis of several equine musculoskeletal injuries. Basic ultrasound imaging has not changed much since the early 1980s; however, experience, technologic advances, improved knowledge of anatomy, the development of classification systems for different injuries and their responses to treatment, and improved operator skills have greatly increased the accuracy of sonographic diagnoses. For example, historically, superficial digital flexor tendons that were swollen or painful were scanned, and a “hole” (anechoic area) was identified, leading to a diagnosis of a “bowed tendon.” This prompted first aid plus other empirical treatments that had been used for decades, including pin firing, blistering, and tendon splitting. Since then, the science underlying the treatment and evaluation of such injuries has advanced dramatically.

Other musculoskeletal applications of ultrasound include the evaluation of any soft tissue or joint injury. Ultrasonography has proven successful in assessing periarticular and intraarticular structures of many joints. Although the soft tissue sites and joints are too numerous to cover in this column, the examination principles are similar; the primary difference is the anatomy particular to the various joints and soft tissues. Before evaluating injuries in “new” areas, clinicians should prepare by reviewing anatomy texts and the veterinary literature. This column discusses the superficial digital flexor tendon, forelimb suspensory ligament, digital tendon sheath, stifle, and coxofemoral joint as examples of the importance of ultrasonography in diagnosing musculoskeletal injuries.

SKIN PREPARATION
Improved transducer and software features, including frequencies of 7 to 13 MHz, have greatly improved the quality of ultrasound images. Ideal image quality, however, still requires satisfactory contact between the transducer and skin. The hair should be clipped if
the tissue cannot be visualized with the highest detail. Well-groomed horses whose haircoats have been clipped can usually be scanned by first applying alcohol in the direction of the hair and then applying the gel over it. Standoff pads should be used if the tendon or ligament is close to the skin surface, which can make near-field focusing difficult. A depth of field should be selected to display the anatomy in a favorable size and position on the screen.

**SUPERFICIAL DIGITAL FLEXOR TENDON**

Recognizing significant clinical signs or subtle tendon or ligament abnormalities during training, racing, or showing is extremely important. Palmar metacarpal swelling should prompt clinical and ultrasonographic examinations. Ultrasound scans are made from the palmar aspect and lateral or medial tendon margins if lesions are eccentrically located. Early suspicion of injury often leads to early treatment and a successful return to racing or showing. Determining the tendon’s size, shape, position, and fiber pattern is necessary to confirm the diagnosis. Although an initial prognosis can be made during the first examination, a 4- to 6-week follow-up examination is necessary after aggressive therapy to reduce the swelling and inflammatory response. Rest and minimal hand walking are allowed until the follow-up assessment to aid in determining an accurate prognosis.

The classic finding in superficial digital flexor tendonitis in a Thoroughbred racehorse is an increase in tendon size with central core fluid (Figure 1). In the case pertaining to Figure 1, the tendon was about 1.5 cm² (normal: ~0.9 cm²) in the cross section at the initial examination, and fibers in the central core were separated by about 0.2 cm². Figure 2 is a three-dimensional image derived from a cross-sectional video clip. The video allows the clinician to scroll through multiple planes to evaluate the integrity of longitudinal fibers.
Figure 3 is an “extended longitudinal view” of a ruptured superficial digital flexor tendon in a Quarter Horse. This view allows nearly the entire tendon to be imaged. The tendon’s undulant appearance is due to the relaxation and tendon shortening that resulted from the rupture.
eral suspensory ligament margins can be identified only by scanning directly from medial or lateral windows, as scanning with a flat-face linear array transducer from the palmar metacarpal surface “cuts off” the ligament margins. The suspensory ligament branches must also be scanned directly overhead medially and laterally.

Suspensory branch injuries can be difficult to detect; however, there is usually noticeable swelling around the branch and pain on palpation. Size, shape, position, and fiber patterns must be evaluated. It is important to measure either the diameter or circumference of the branches; normal branches range from 7 to 10 mm in diameter, depending on the breed. Figure 7 shows an axial suspensory branch fiber disruption in cross section in a Warmblood jumper. It is important to examine the suspensory ligament distally to its sesamoid insertion sites. Figure 8 shows an enthesopathy of a suspensory ligament branch sesamoid insertion. Damage to the insertion of the ligament on the sesamoid often carries a guarded to unfavorable prognosis.

**DIGITAL TENDON SHEATH**

Digital tendon sheath inflammation is an obvious clinical diagnosis in most horses; however, the etiology is sometimes difficult to determine. Any structure that communicates with the digital sheath can cause sheath effusion. Superficial and deep digital flexor tendonitis are relatively common causes. The deep digital flexor tendon extends to its insertion on the distal phalanx, and damage to the deep digital flexor at any level within the sheath can affect the digital sheath. The superficial digital flexor communicates with the sheath proximal and distal to the metacarpophalangeal joint. Desmitis of the proximal and/or distal digital annular ligaments can also contribute to digital sheath effusion. Superficial digital flexor tendonitis and chronic thickening of the palmar tissue at the annular ligament level can be career limiting due to restrictive adhesions. Therefore, care must be taken to examine all of the structures that could contribute to digital tendon sheath effusion.

Figure 9 is a cross-sectional image obtained during an ultrasound examination of a lame show jumper that had digital tendon sheath effusion over a 5-month period. The palmar aspect of the metacarpophalangeal joint was enlarged. The superficial digital flexor tendon, annular ligament, and palmar extension of the digital tendon sheath were damaged, and the palmar surface of the superficial digital flexor tendon was incorporated into the reaction. Restrictive superficial digital flexor tendon adhesions were evident when the area was imaged dynamically during flexion and extension.
STIFLE (MEDIAL MENISCUS)
The stifle (and other) joints yield sonographic information that is diagnostically and prognostically significant. Care must be taken to examine all aspects of any joint that is scanned and to compare the findings to those from other imaging modalities. Depending on the joint, it may be beneficial to scan the joint and related structures while the horse is non-weight bearing. The contralateral joint is often used to confirm or refute suspected abnormalities identified during scanning sessions.

Figure 10. Scan performed transverse to the medial margin of the stifle joint. The femur is on the left and the tibia on the right. The arrowhead points to a femoral margin osteophyte. This portion of the medial meniscus (MM) is normal in appearance.

Figure 11. Scan of the medial femoral joint pouch. The lining is thickened and irregular (arrows). The arrowheads point to cellular debris in the joint fluid compatible with synovitis.

Figure 12. Scan made over the greater trochanter of the femur and the femoral neck. The brightly echogenic structure is a fracture fragment (FX; arrowhead) arising from the acetabular rim; which, along with the femoral head, cannot be seen because of the fragment.

Figure 10 is a cross section of a normal medial meniscus just cranial to the medial collateral ligament. There is a small osteophyte secondary to chronic synovitis of the medial femoral tibial joint (Figure 11). Although echogenic cellular debris was identified in the synovial fluid, no meniscal lesions were found.

COXOFEMORAL JOINT
The coxofemoral joint is difficult to image and requires transducers with frequencies of 3 to 5 MHz, depending on muscle thickness. Figure 12 is from a Quarter Horse with acute onset of hindlimb lameness after pasture turnout and suspected pelvic trauma. The image includes the proximal end of the femur and the femoral neck. The raised linear echogenic structure is a fragment arising from the acetabular rim; it obscures the round surface of a portion of the femoral head that is normally seen in this plane.

CONCLUSION
This brief overview stresses the importance of ultrasonography in the algorithms for diagnosing equine musculoskeletal abnormalities. Because ultrasonography is noninvasive and provides unique diagnostic information, it complements other diagnostic imaging modalities, including scintigraphy, radiography, magnetic resonance imaging, computed tomography, and thermography.
Imaging Is Believing

**Key Points**

- Ultrasonography is the preferred modality for imaging soft tissue in horses.
- Early diagnosis of tendon and ligament injuries by ultrasonography has prevented numerous racetrack breakdowns.
- Periarticular and articular joint abnormalities can be accurately diagnosed with ultrasonography.
- The use of ultrasound is becoming routine for guiding vertebral facet injections and tendon or ligament lesion stem cell treatments.

**REFERENCES**