Introduction

Strain-induced injury of the tendons and ligaments is the most common orthopedic injury in athletic animals, either equine or human. Injuries of the tendon and ligaments of the tarsus are quite common and are diagnosed with a combination of clinical examination, diagnostic analgesia and diagnostic imaging. While clinical examination can often suggest the tarsus as a clinical problem, intraarticular and/or regional anesthesia should be utilized to confirm and more accurately isolate the source of lameness. Once the lameness has been isolated to a specific area of the tarsus then diagnostic imaging should be focused on this area. Once an accurate diagnosis is accomplished and a directed treatment strategy and rehabilitation schedule of that specific problem(s) is developed, imaging of the tarsus should, at the very least, include radiographic and sonographic examination. When diagnostic ultrasound and radiographic examination fail to provide confirmation of the source of pain then a diagnosis requires the use of nuclear scintigraphy or MRI to find the source of pain. While MRI is considered the gold standard for imaging the distal limbs of the horse it is not without risk to the horse because it requires general anesthesia to place the limb in short bore high field strength magnetic systems.

This talk will emphasize soft tissue injuries of the tarsus but will include a description of the radiographic examination of this area. Ligament and tendon injury frequently occurs at the bone-soft tissue interfaces or insertions onto bone (enthesis) with the earliest change often being early bone production. In addition a complete radiographic examination can be effective at demonstrating other boney problems that often co-exist with many soft tissue injuries. Accurately diagnosing both bone and soft tissue injury can lead to a more accurate treatment strategy and can improve the chances for a successful return to function. While soft tissue swelling can be easily identified on radiographic examination defining the specific structures involved can be difficult to define. Diagnostic ultrasound with high frequency linear tendon probes is a very practical imaging technique that provides real time information about the soft tissues of the tarsal region as well as portions of the articular cartilage and subchondral bone surface. Diagnostic ultrasound has proven to be more sensitive than radiology for the identification of early periarticular remodeling and enthesis new bone formation. Diagnostic ultrasound and radiology are considered complementary and should be performed together when evaluating tarsal disease. Ultrasonographic examination of the plantar aspect of the tarsus, dorsomedial tibiotarsal joint synovium and collateral ligaments of the tarsus has previously been briefly described. The tarsus has a complex anatomic arrangement with the superimposition of many structures. In addition to the complex anatomy, most of the radiographic changes that develop in and around this joint with disease are chronic and take some time to develop.
Nuclear scintigraphy may be required when radiographic and sonographic examination fail to reveal significant change or better define the origin of pain. More recently MRI is being utilized for tarsal imaging due to short bore high field strength magnetic systems when these other imaging modalities are inconclusive. MRI of the tarsus has been useful in the diagnosis of abnormalities that could not be detected radiographically or ultrasonographically. These abnormalities have included subchondral bone injury of the talocalcaneal joint, bone bruising of the distal tibia, intertarsal ligament enthesopathy with associated bone edema, focal osteoarthritis in the plantar aspect of the distal intertarsal and talocalcaneal joints with localized loss of joint space and subchondral bone sclerosis, and soft tissue injuries of the collateral ligaments of the tarsocrural and the proximal intertarsal (talocentral) joints, as well as tendonitis of the deep digital flexor tendon at the level of the calcaneus.

Because the tarsus is such a complex joint the examiner should develop a keen understanding of the anatomy of this joint as well as the types of injuries that can occur in this region to most effectively direct the use of diagnostic analgesia techniques and diagnostic imaging. This paper reviews the normal anatomy of the tarsus, describes the normal radiographic, sonographic and MR examination as well as the clinical conditions that can affect this area.

Clinical Presentation & Diagnosis

An accurate diagnosis is critical to effectively manage injuries to the tarsus. Some injuries may involve multiple structures so developing a complete routine examination protocol of the entire joint should be developed. The clinical examination should attempt to isolate the source of lameness by utilizing sequential regional and/or intra-articular analgesia of the distal hind limb. A low plantar (6 point) nerve block should be performed to eliminate the distal limb as a cause of the lameness. This should be followed by intra-articular analgesia of the tarsometatarsal (TMT) and distal intertarsal (DIT) joints with negative or only slightly improved response. Analgesia of the deep branch of the lateral plantar nerve or perineural analgesia of the plantar metatarsal nerves at the sub-tarsal site should be performed to eliminate the proximal suspensory ligament desmitis (PSD) as a source of lameness. Lameness due to PSD should be substantially improved (65-70%). Inaccuracies in the diagnostic analgesia techniques can and do occur. For example, occasionally lameness of the proximal plantar region may improve following a low plantar (6-point) nerve block most likely due to proximal diffusion of the local anesthetic. In addition several recent studies have shown proximal diffusion of contrast media after deep plantar nerve block. (Contino et al 2014) In addition there was 37.5% of horses had contrast in the tarsal sheath and 25% had sufficient mepivicaine in the TMT joint to produce analgesia. Analgesia of the deep branch of the lateral plantar nerve can influence distal tarsal pain. (Dyson1994) Intra-articular analgesia of the TMT joint can abolish lameness in horses with PSD (8%). Therefore a comparison between the respective outcomes of intra-articular and perineural analgesia may be useful in horses without radiological or ultrasonographic abnormalities. If necessary, a tibial nerve block alone is extremely useful to distinguish between distal tarsal joint pain and PSD pain, as analgesia of the tibial nerve will result in analgesia of PSD without significantly influencing distal tarsal joint pain. Tibiotarsal (TT) joint pain which can be associated with a range of conditions should have local anesthetic injected directly into the joint but often requires
perineural analgesia of the tibial and fibular nerves to improved lameness. In one study evaluating horses with TT joint pain intraarticular analgesia of the TT improved lameness > 50% in 12/17 limbs (70.6%), whereas < 50% in 3/17 limbs (17.6%). (Fleck 2012) Intra-synovial injection of local anesthetic into the tarsal sheath may be useful to isolate a lateral deep digital flexor tendon (LDDFT) injury as the source of lameness. Anesthetizing the tibial and the deep and superficial peroneal nerves above the point of the hock desensitizes the entire distal portion of the limb. The horse may drag the toe of the desensitized limb when the tibial and superficial and deep peroneal nerves are anesthetized. The tibial nerve is a large nerve and some clinicians have expressed concern that it may take up to 45-60 minutes before enough diffusion has occurred before it provides complete analgesia. Moving to the stifle as the next level of diagnostic analgesia of a hind limb lameness before the tibial nerve is completely blocked could lead to a false positive. In addition, local diffusion from the tibial injection site may result in resolution of lameness associated with gastrocnemius tendonitis.

Some clinicians use a 6-point subtarsal nerve block to eliminate the proximal plantar region. However, subtarsal injection around the plantar metatarsal nerves (with/without the plantar nerves) demonstrated contrast medium within the tarsal sheath in 40% of limbs; no proximal diffusion was identified outside the tarsal sheath. Contrast medium was only seen in one TMT joint, suggesting that the likelihood of subtarsal analgesia influencing the tarsus is relatively small.

Radiographic Examination of the Tarsus

Routine radiographic examination of the tarsus consists of four views: lateromedial, dorsal 45° medial-plantarolateral, dorsal 10° lateral-plantaromedial oblique, and the dorsal 45° lateral-plantaromedial (LM, D0°Pr–PliDiO (D10°Pr–PliDiO), D45°L–PliMO PI-5°Di60°L–DPrMO). There are three special views that may be utilized: the skyline of the calcaneus (flexed Pl-75°Pr–PliDiO), flexed LM and a flexed DPl. On all standard views the joint spaces should be identifiable with little or no superimposition. On the lateromedial view and dorsomedial-plantar lateral oblique view the intermediate ridge of the distal tibia and both the trochlear ridges of the talus should be identifiable. In the dorsolateral-plantaromedial oblique view the medial malleolus of the tibia should be identified not superimposed over the talus. Some special views include the flexed lateral and the skyline view of the calcaneus.

Generally speaking, most abnormal radiographic findings are located at the dorsum of the tarsus, pathologic abnormalities of the tarsus tend to be in specific anatomical areas and soft tissue swelling is a helpful to localize abnormalities. (O’Brien 2002). The diagnoses of abnormalities of the tarsus identified with radiography can be classified as soft tissue swelling without bony change, secondary joint disease, fractures, osteochondrosis and developmental disorders. The most common clinical condition requiring radiographic examination of tarsus is bone spavin. This condition manifests a variety of changes including osteophytes at the joint margins of the distal tarsal joints, loss of joint space, and presence of sclerotic tarsal bones, particularly the central tarsal bone. Another common clinical condition requiring radiographic examination is osteochondrosis of the tarsocrural joint. Osteochondrosis of the tarsocrural joint manifests as osteochondral fragmentation of the distal intermediate ridge of the tibia, the medial
and lateral trochlear ridges, and the medial and lateral malleoli with associated subchondral lucencies.

**Sonographic Examination of the Tarsus**

Diagnostic ultrasound provides an excellent means to image the soft tissues not seen with radiographs as well as providing detailed information about cartilage and subchondral bone. Most structures of interest in the tarsus lie superficial, just under the skin and subcutaneous tissue necessitating a variable focus high frequency linear probe such as a 12-18 MHz and a standoff. Sonographic examination of the tarsus requires examining the dorsal, medial, lateral and plantar aspects of the joint.

The plantar aspect should examine the gastrocnemius tendon attachment and the superficial and deep digital flexor tendons as well as the proximal suspensory. When the examiner is evaluating the articular surfaces of the dorsal and plantar tarsus it is important to utilize the normal range of flexion and extension in an attempt to evaluate the weight bearing and non-weightbearing surfaces of the articular cartilage of the joint. This technique can also be utilized when evaluating the accessibility and mobility of osteochondral fragments of the dorsal and palmar/plantar aspect of the joint.

The long collateral ligament of the lateral is well defined and oval in cross section. This ligament originates from the caudal aspect of the lateral malleolus caudal to the groove for the lateral digital extensor tendon. Two tendons, one medially (flexor) and one laterally (extensor) are located in close vicinity to the corresponding long tarsal CLs. The lateral digital extensor tendon is closely associated with the dorsal aspect of the long lateral tarsal collateral ligament. The tendon of the medial head of the DDFT (flexor digitalis medialis muscle) runs parallel a short distance to the plantar aspect of the long medial tarsal CL. The lateral digital extensor tendon produces a consistent landmark on the lateral aspect of the tarsus as it passes through the long lateral collateral ligament just distal to the malleolus. Fibers from the long lateral collateral ligament extend several millimeters proximally on the tibia and extend distally to attach on the lateral tarsus and lateral metatarsus. Fibers along the caudal edge of the long lateral collateral ligament can blend with the plantar ligament. The medial and lateral collateral ligaments are divided into the superficial or straight and the deep branches which incline to their insertions at different angles. This different orientation requires that each structure be examined independently. These structures should also be evaluated in through a range of motion by flexing and extending the joint.

Structures in close proximity that have similar sonographic density can be difficult to separate. The extensor retinaculae and the superficial and deep lateral branches of the peroneus tertius on the dorsal aspect of the tarsus can be difficult to accurately define. It was also difficult to discern the demarcation between the overlying skin and the thin LDE tendon and the smaller branches of the collateral ligaments were difficult to discern.

The plantar aspect of the tarsus is a difficult area to image from the plantar midline position. The probe should be placed more medially with the sound beam directed more obliquely from planteromedial to dorsolateral to more completely define the origin of the suspensory ligament. One of the most common clinical conditions affecting this area is proximal suspensory desmitis and the anatomic position as well as the presence of several structures overlying it make it more difficult to clearly discern. It
has been well documented that the proximal suspensory ligament produces a heterogeneous image due to the presence of muscle fibers and fat in between the ligamentous fibers. This can present a diagnostic challenge in cases of suspected desmitis. The most methodical approach is to compare size and appearance with the contralateral limb. Radiographic changes can occur in horses with proximal suspensory desmitis and include sclerosis of the proximal third metatarsal bone. Ultrasonographically, a roughening of the hyperechoic surface of the third metatarsal bone on the plantar aspect may be visualized. Avulsion fractures may occur, and are usually seen as a discontinuity of the bone surface.

Scintigraphic Examination of the Tarsus

Nuclear scintigraphy has become routinely utilized in the horse for detection of orthopedic disease. A radiopharmaceutical is injected into the intravenous system and is distributed throughout the body. Technetium pertechnetate is bound to a pharmaceutical called methylene diphosphonate (MDP). Methylene diphosphonate binds to osteoblasts that are actively remodeling bone. By doing this, the radioactive technetium is deposited at the site of osteoblastic activity and as the radioactive material decays, it emits a gamma ray. This gamma radiation escapes the body for external detection and measurement by a scintillation camera. The camera detects the gamma radiation and a dedicated computer creates an image of radiation distribution. This makes scintigraphy an especially valuable tool to diagnose early orthopedic injury. Musculoskeletal scans are divided into vascular phase, pool phase and bone phase (first pass, soft tissue and osseous). An area of increased uptake of radiopharmaceutical can indicate active inflammation in pool phase images and bone modeling in bone phase images. The metabolic rate of bone significantly influences the uptake of the radiopharmaceutical during the osseous phase making younger animals in training ideal candidates for scintigraphy. Older mature animals that have minimal bone turnover and are not actively training are poor candidates. In the appropriate candidate nuclear imaging of bone disease is very sensitive at detecting bone modeling but is less specific at defining the specific site of involvement. To assist with localization of lesion(s) the scans should be acquired in two planes (lateral and dorsopalmar) and should be compared to the paired opposite tarsus. The main drawback to nuclear medicine is that the images generated are very sensitive for disease, but not very specific. It is difficult to know the clinical importance of the lesions identified or whether these lesions are acute or chronic. Active bone remodeling after an incomplete stress fracture can persist for up to 2-3 years after the injury. Also, perineural and intra-articular anesthesia can cause increased vascularity to the regions injected and provide false positive results for several days after the procedure.

Scintigraphy examinations must always be combined with radiographic and ultrasonographic evaluation. The indications for nuclear scintigraphy in the horse with hock lameness include: when there is localization of pain to the hock region but no radiographic or ultrasonographic evidence of a problem; an acute onset of lameness thought due to a fracture but without radiographic evidence of a fracture; intermittent lameness that cannot be reproduced to perform anesthesia of the hock region; lameness in several limbs making local anesthesia interpretation difficult and finally in the assessment of the significance of equivocal radiographic abnormalities. Again, increased radionuclide uptake does not always equate with clinical significance emphasizing that
interpretation of nuclear scintigraphic images without reference to the clinical examination and other imaging results can be potentially misleading

**Magnetic Resonance of the Tarsal Region**

MRI can be useful for evaluation of distal tarsal pain because there is a lack of correlation between the presence and severity of radiographic changes on the one hand and lameness on the other. Protocols for MRI of the tarsus have been suggested and equine tarsal MRI anatomy has been described using both low- and high-field systems. In the normal tarsus, articular cartilage of the distal tarsal joints is very thin, which does not allow for distinction of proximal and distal cartilage layers in these joint spaces. Subchondral bone plates of the distal tarsal bones and the MTIII have homogeneous, low signal intensity with a regular osteochondral junction and a smooth but undulating deep border. In competition horses that undergo high intensity training, subchondral bone thickness is greater medially in the distal intertarsal joint and laterally in the tarsometatarsal joint. This repeatable thickness pattern of subchondral bone is lost in horses with distal tarsal lameness.

There are no reports on the incidence of MRI diagnoses in the tarsus of live horses. In 1 cadaver study, MRI was more sensitive and specific than radiography for detection of all types of pathology of the distal tarsal joints, including intertarsal ligament pathology, cartilage erosion, osseous cyst-like lesions, and subchondral bone irregularity. In live horses with lameness associated with the tarsal region, the presence of abnormal STIR signal hyperintensity compatible with the presence of bone bruising was reported in the central and third tarsal bones, talus, and tibia.

In the authors’ clinic, MRI of the tarsus has been helpful in the diagnosis of abnormalities that could not be detected radiographically or ultrasonographically. These abnormalities have included subchondral bone injury of the talocalcaneal joint, bone bruising of the distal tibia, intertarsal ligament enthesopathy with associated bone edema, focal osteoarthritis in the plantar aspect of the distal intertarsal and talocalcaneal joints with localized loss of joint space and subchondral bone sclerosis, desmitis of the collateral ligaments (CL) of the tibiotalar (TT) and the proximal intertarsal (PIT) joints and tendinitis of the DDFT at the level of the calcaneus.

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