Ultrasound of the tarsus, like other joints in the horse, provides valuable information to document and characterize soft tissue and osseous injury. The collateral ligaments, superficial digital flexor tendon, long digital extensor tendon, gastrocnemius tendon, and peroneus tertius are most commonly affected, but injuries to all tendons and ligaments can be seen. The frequency of wounds makes the tarsus a prime target for septic arthritis, tenosynovitis, and bursitis. Ultrasound can be used to show involvement of synovial structures in many cases of sepsis. Author’s address: Department of Surgical & Radiological Sciences, School of Veterinary Medicine, University of California at Davis, Davis, CA 95616; e-mail: mbwhitcomb@ucdavis.edu. © 2006 AAEP.

1. Introduction
Ultrasonographic imaging of equine joints is generally well accepted as a valuable diagnostic modality for tendon, ligament, and other soft tissue injuries. Compared with other joints such as the shoulder and stifle, tarsal ultrasound may easily be considered the most challenging. The complex anatomy of the tarsus, including several tendons and ligaments coursing in multiple directions and numerous synovial structures, contributes to this difficulty. A solid understanding of tarsal anatomy is critical to performing a successful ultrasound examination. Radiography has traditionally been the primary imaging modality for hock disease, but it provides little to no information on tendon or ligament injury or the appearance of synovial structures. Ultrasound remains the most cost effective imaging modality to diagnose soft tissue injuries and can be performed by motivated practitioners with basic ultrasound skills and equipment. Similar to other regions in the horse, the information gained from tarsal ultrasound often provides a diagnosis when physical-exam findings and radiographic evaluation have failed to reveal the source of lameness and/or clinical signs. Although computed tomography and magnetic resonance imaging of the tarsus have been described, the use of these imaging modalities is not yet practical in most cases. Common indications for tarsal ultrasound include distention of synovial structures, hock swelling, and/or wounds and lacerations. Ultrasound is very useful to elucidate the cause of tarsal swelling by differentiating between cellulitis, effusion of synovial structure(s), and/or tendon or ligament injury. The equine tarsus is a common site for puncture wounds and lacerations that often involve synovial structures, tendons, and/or ligaments. Communication with these structures is often difficult to determine by palpation alone. Contrast radiography can be helpful for this purpose, but it gives little information on associated soft tissue injury. Ultrasound is well suited to document wound communication with synovial structures and/or bone and to assess the degree of soft tissue injury. Ultrasound can also help to differentiate between septic and non-septic synovitis/tenosynovitis and can identify the best location to obtain synovial fluid samples for...
analysis. Ultrasound should also be performed in horses with radiographic evidence of fracture(s) suspicious for collateral ligament avulsion and in horses with evidence of osteomyelitis in close proximity to synovial structures. Less common indications include nuclear scintigraphic findings of increased radiopharmaceutical uptake in the hock region and lameness localized to the tarsus.

The purpose of this paper is to review the sonographic anatomy of the tarsus, describe techniques used to image the dorsal, medial, lateral, and plantar structures of the tarsus, and review the distribution of tendon, ligament, bone, and synovial injuries during the 6.5-yr study period (1999–2005) from the Large Animal Ultrasound Service at the University of California, Davis, Veterinary Medical Teaching Hospital (UCD-VMTH). Although the ultrasonographic appearance and clinical findings of many soft tissue injuries of the tarsus have been previously described in the veterinary literature, the distribution of injuries from a large patient population has not been reported.

2. Ultrasonographic Technique

Ultrasonographic evaluation of the equine tarsus is best divided into four regions (dorsal, medial, lateral, and plantar) because of the large number of tendons, ligaments, and synovial structures. Structures evaluated from the dorsum include the peroneus tertius (PT), cranial tibial tendons of attachment (primarily cunean tendon), long digital extensor (long DE) tendon/tendon sheath, and tibiotalar (TT) joint capsule. The joint capsules of the proximal intertarsal (PIT), distal intertarsal (DIT), and tarsometatarsal (TMT) joints can also be evaluated from the dorsum but are not typically seen in most horses. Medial structures include the superficial and deep components of the medial collateral ligament (MCL). The cunean tendon is also imaged medially. Lateral structures include the lateral digital extensor (lat DE), tendon/tendon sheath, and superficial and deep components of the lateral collateral ligament (LCL). Structures evaluated from the plantar aspect of the tarsus include the long plantar ligament (LPL), superficial digital flexor tendon (SDFT) and its retinacular calcaneal attachments, gastrocnemius (GN) tendon, deep digital flexor tendon (DDFT), and small medial DDFT. Plantar synovial structures include the subcutaneous bursa, calcaneal bursa, GN bursa, tarsal sheath, and plantar pouches of the TT joint.

Horses should be sedated with either detomidine HCl (0.005–0.01 mg/kg IV) or xylazine HCl (0.3–0.4 mg/kg IV). Butorphanol tartrate (0.01–0.02 mg/kg IV) should be used with intractable horses or those with severe pain or lameness. When available, horses should be restrained in stocks for equipment and operator safety. As usual, the best images are obtained by clipping the hair of the hock region with #40 blades, washing the skin with soap and water, and applying ultrasound coupling gel. Alcohol saturation can be used, but horses can become irritated by alcohol running down their legs. Evaluation of all structures can be accomplished using standard ultrasound equipment available in most equine practices. A high-frequency (7–14 MHz) linear transducer used for most musculoskeletal imaging is also well suited for tarsal ultrasound. A tendon-format transducer (commonly known as a “T” probe) is ideal; however, a rectal-format transducer will also produce diagnostic images. A scanning depth of 4–6 cm is appropriate for most structures. Whenever possible, a program designed for musculoskeletal imaging should be selected. A standoff pad is not necessary but may be useful when evaluating bony prominences.

3. Dorsal Structures

Peroneus Tertius

The PT can be followed from its origin at the extensor fossa of the distal femur throughout the length of the tibia to its insertions on the distal tarsal bones and proximal metatarsus (Fig. 1). The tendon is quite large in the proximal and midtibia regions where it is located deep to the long DE muscle belly. The PT becomes smaller and more superficially located in the distal tibia region (Fig. 2) and bifurcates into two primary tendons of insertion at the level of the talus. The tendons of insertion are often chal-
lenging to differentiate from the dorsal tendon of insertion of the cranial tibial muscle. PT abnormalities are primarily limited to ruptures that can occur secondary to falls, limb entrapment, or full-limb casting. Ruptures are most common in the mid and distal tendon regions but can also occur at the origin. The affected tendon is usually markedly enlarged with a diffusely hypoechoic and mottled appearance in the region of the rupture with an absence of linear fibers on longitudinal views (Fig. 3). Relaxation artifact of the proximal portion of the tendon may also be present in cases of rupture.

Cranial Tibial/Cunean Tendon
The cranial tibial muscle belly is located deep to the PT tendon in the mid/distal tibia region and has two tendons of attachment. These include the cunean tendon (medial tendon of attachment) and the dorsal tendon that inserts onto the dorsal surfaces of the third tarsal and third metatarsal bones. Compared with the dorsal tendon, the cunean tendon is readily imaged. The tendon begins to form in the distal tibia/proximal talus region deep to and between the PT lobulations that form immediately proximal to the PT bifurcation (Fig. 4, A and B). From this location, the cunean tendon quickly courses medially in a transverse direction toward its insertion onto the fused first and second tarsal bones. Linear fibers are easily seen deep to the skin surface on longitudinal views (Fig. 4C). The cunean bursa is located deep to the tendon in the midtendon region and is usually not visible in normal horses. Injuries to the cunean tendon and bursa are uncommon but can occur secondary to trauma or lacerations.

Long DE Tendon/Sheath
The long DE tendon is dorsolaterally located throughout the tarsal region. The long DE muscle...
is found superficial to the PT in the proximal and midtibia regions and can be followed to its musculo-tendinous junction in the mid/distal tibia region. At the level of the talus, the long DE tendon is located immediately lateral to the PT and shows an oval echogenic shape with a linear fiber pattern (Fig. 5). The tendon is easily followed throughout the tarsus and metatarsus where it becomes more dorsally located. Injury to the long DE tendon occurs frequently in horses with dorsal lacerations, but injuries can occur without external trauma and may result in distention of the long DE tendon sheath. The tendon sheath is typically not visible in normal horses, although some horses will show a small anechoic rim of fluid surrounding or partially surrounding the tendon. Although severe tenosynovitis of the long DE tendon sheath can be differentiated from other synovial structures by location and palpation, ultrasound should be performed to rule out tendon damage as a cause of distention (Fig. 6).

Tibiotarsal Joint Capsule
Distention of the dorsal TT joint capsule is a common physical exam finding. Ultrasound can determine the relative degree of effusion versus synovial thickening that contributes to the external appearance of distention, especially in severe cases. The dorsal joint capsule is easily imaged in most horses at the dorsomedial aspect of the tarsus between the PT and cranial tibial tendons of insertion and the MCL. Synovial fluid is typically anechoic (Fig. 7).

![Fig. 4. Sequential ultrasound images of Cu from dorsal (A and B) to medial (C). (A) Transverse image showing formation of PT tendons of insertion at the level of the distal tibia/talus. The Cu (arrows) appears “off beam” deep to and between the PT tendons. (B) Same image as A, but Cu is now “on beam” and the PT tendons are “off beam.” (C) Longitudinal image of Cu (arrows) as it extends medially toward its insertion. (Technique: 10-MHz linear, 3.1-cm scanning depth.)](image1)

![Fig. 5. Transverse (left) and longitudinal (right) ultrasound image of a normal long digital extensor tendon (arrows) at the level of the distal tibia. Note the flattened oval shape deep to the skin surface with a clear linear fiber pattern on longitudinal views. (Technique: 10-MHz linear, 3.1-cm scanning depth.)](image2)
Hypoechoic- or cellular-appearing fluid may be seen in cases of sepsis or hemarthrosis. Horses with septic arthritis often show severe synovial thickening without significant effusion (Fig. 8); however, synovial thickening/proliferation is also a common feature in horses with non-septic TT synovitis (Fig. 9). Arthrocentesis should be performed in suspect cases to rule out a septic component. The plantaromedial and plantarolateral joint capsules will be addressed later with other plantar structures.

4. Lateral Structures

Lateral Digital Extensor Tendon/Sheath

The lat DE tendon is located on the lateral aspect of the limb from the midtibia through the tarsal region (Fig. 10). The tendon becomes dorsolaterally located in the proximal metatarsal region as it nears its junction with the long DE tendon. The lat DE tendon shows a smaller but similar appearance to the long DE tendon (Fig. 11). Similar to the long DE tendon, lacerations...
may involve the lat DE tendon. Injury and associated distention of the lat DE tendon sheath can occur without trauma. Lat DE abnormalities seem to be less frequent than long DE injuries (Fig. 12).

Lateral Collateral Ligaments

The anatomy of the collateral ligaments of the tarsus is well described by Updike, including detailed descriptions of its four components (one long and three short) and their respective origins and insertions. The focus of this paper will be on those components, origins, and insertions most easily identified with ultrasound. The superficial or long component of the LCL originates from the caudolateral aspect of the distal tibia/lateral malleolus. Its primary insertion onto the distolateral aspect of the calcaneus is easily seen on ultrasound. Additional fibers extend to the fourth tarsal and fourth metatarsal bones; however, these are less readily visible (Fig. 10, B-D). The superficial (long) LCL is located plantar and adjacent to the lat DE tendon. Similar to collateral ligaments of other joints, the LCL is easiest to identify on longitudinal views. Injuries of the superficial LCL can occur at any location along the length of the ligament. Similar to other ligament injuries, the injured LCL is typically enlarged with hypoechoic areas and a disrupted fiber pattern (Fig. 14). Previous reports on LCL injuries have focused on horses with lateral malleolar fractures or with evidence of enthesiopathy, but LCL injuries can occur without either clinical finding. Compared with the superficial LCL, the deep (short) component of the LCL is somewhat challenging to evaluate, because it curves over the bony prominences of the talus. Its primary origin is located dorsal to the superficial LCL origin on the distal tibia. The deep LCL then courses in a

Fig. 9. Longitudinal ultrasound image of non-septic effusion and synovitis of the dorsal TT joint capsule (arrowheads) in an 8-yr-old Selle Frances gelding with a recent history of lameness after kicking in his stall. Prominent synovial thickening is present. Hypoechoic strands throughout the joint capsule are consistent with synovial inflammation and/or fibrin accumulation caused by trauma. Ultrasound revealed moderate injury to the medial and lateral CLs in this horse. (Technique: 13-MHz linear, 5.2-cm scanning depth.)

Fig. 10. Anatomy of lateral tarsus at multiple levels of dissection. (A) Skin and SC tissues removed. Note close association of lateral digital extensor tendon (LA) and superficial (long) LCL. (B) Extensor tendons removed to reveal association of superficial (long) and deep (short) LCL components. (C) Window removed from superficial (long) LCL to reveal the nearly transverse orientation of the deep (short) LCLs. (D) Bone specimen showing origins and insertions of superficial (long) and deep (short) LCL components. S, superficial digital flexor tendon; SL, lateral attachment of SDFT onto calcaneus; P, long plantar ligament; Cs, superficial (long) component of lateral collateral ligament; CD, deep (short) components of lateral collateral ligament; Lo, long digital extensor tendon; GN, gastrocnemius tendon.
nearly transverse direction to its insertion onto the mid portion of the calcaneus (Fig 10, C-D). Injuries of the deep LCL are not commonly seen.

5. Medial Structures: Medial Collateral Ligaments

Similar to the LCL, the MCL also has four components, briefly described as one long and three short ligaments (Fig. 15). Although the superficial ligament can easily be described as long, the primary short component is also quite long compared with its lateral counterpart and is probably better described as a deep long component (Fig. 15C). The other deep (short) MCLs are challenging to visualize on ultrasound because of their small size and will not be addressed. The superficial (long) MCL originates from the mid portion of the medial malleolus and has several areas of insertion (Fig. 16). Its primary insertion onto the distal tuberosity of the talus is well visualized with ultrasound. Additional fibers continue distally toward their insertions onto the central tarsal, third tarsal, and third metatarsal bones. The deep (long) MCL originates slightly cranial and distal to the superficial MCL origin on the medial malleolus and courses in a slightly transverse orientation toward its primary insertion onto the distomedial surface of the sustentaculum tali of the calcaneus (Fig. 17). Similar to the LCL, imaging of the two MCLs cannot be performed simultaneously because of their differing orientations. Imaging of each MCL is most easily accomplished by first locating their linear fibers on longitudinal axis and then following each ligament from its origin to insertion before transverse imaging. Both ligaments show a dense linear fiber pattern with the exception of the origin of the superficial MCL where a slightly irregular fiber pattern is commonly seen. Injuries can involve one or both components. Disruption of linear fiber pattern is easiest to identify in affected horses (Fig. 18). Hypoechoic areas on transverse views with enlargement of the ligament are also present. Although infre-
quently reported, MCL injuries do occur. Similar to LCL injuries, affected horses may not have associated avulsion fractures or enthesiopathy.

6. Plantar Structures

SDFT

The SDFT is the most plantar/superficial structure in the tarsal region; however, it is located deep to the GN in the proximal and midtibia regions. From this deep location, the SDFT rotates medially around the GN toward its superficial location in the distal tibia and tarsal region. The tendon has a flattened, crescent shape as it approaches the calcaneal tuber where retinacular attachments secure the tendon onto the medial and lateral surfaces of the calcaneus. The tendon then continues distally through the tarsus and metatarsus along plantar midline. Lacerations to the plantar tarsus frequently involve the SDFT. Injury can also occur without external trauma. Affected horses may show localized swelling that can be misinterpreted as “curb.” Ultrasound is necessary in cases of “curb” to differentiate between injuries to the SDFT or LPL, calcaneal bursitis, or SC swelling. Disruption of either SDFT retinacular attachment to the calcaneus can occur in horses with or without skin laceration. The resultant luxation of the SDFT

Fig. 13. Longitudinal ultrasound image of the normal superficial (long) LCL (arrows) showing its origin on the lateral malleolus of the distal tibia and its primary insertion onto the distolateral aspect of the calcaneus. Note the dense linear fiber pattern of the LCL. The deep (short) LCL components cannot be visualized in this image because of their nearly transverse orientation to the superficial (long) LCL component. (Technique: 10-MHz linear, 4-cm scanning depth.)

Fig. 14. Ultrasound image of severe desmitis of the superficial (long) component of the LCL (arrows) in a 3-yr-old Thoroughbred gelding with severe lameness. The LCL is enlarged on transverse views (left image) with a large hypoechoic area along its plantar border. Disruption in fiber pattern is readily apparent distally on the longitudinal view (right image). Periligamentous swelling is also present superficial to the LCL. A small lateral wound indicated previous trauma and communicated with an osteomyelitic lesion of the fourth tarsal bone (not visible in this image). (Technique: 13-MHz linear, 5.2-cm scanning depth.)
may be obscured in acute cases by the severe swelling that usually accompanies this injury. Ultrasound can easily be used to document this condition. Medial retinacular disruption with lateral SDFT displacement is most common, but lateral disruption with medial luxation can occur.

Gastrocnemius Tendon
As stated above, the GN is located superficial to the SDFT in the midtibia region. The GN rotates laterally around the SDFT toward its location deep to the SDFT in the distal tibia region. The GN tendon becomes quite large at this level as it...
nears its insertion onto the calcaneal tuber. The tendon can measure up to 3–4 cm² in normal horses and often shows hypoechoic areas of varying number and distribution (Fig. 19). Longitudinal imaging may reveal relaxation artifact of the tendon proximal to its insertion in normal horses and should not be mistaken for injury. For these reasons, comparison to the contralateral limb is often required in suspect cases. Similar to other tarsal structures, plantar lacerations may involve the GN tendon (Fig. 20). GN tendonitis has also been reported without evidence of external trauma.\(^\text{3,8,9,18}\)

**DDFT**

The DDFT is located plantaromedially throughout the tarsal region as it courses through the tarsal sheath medial to the calcaneus. The tendon has a large oval shape with a homogeneously hypoechoic appearance. Injuries of the DDFT within the tarsal sheath are not commonly reported.\(^\text{5,16}\) However, the DDFT should always be evaluated in horses with tarsal sheath effusion. The DDFT is often difficult to evaluate at the level of the sustentaculum tali where surface fibrillations may easily be missed on ultrasound. Endoscopy can reveal the presence of surface tears in such cases and should be considered in horses with persistent tarsal sheath effusion and associated lameness.

The medial DDFT is located dorsal to the primary DDFT and is not located within the tarsal sheath. The medial DDFT is surrounded by a separate tendon sheath that sometimes communicates with the tarsal sheath. The medial tendon inserts into the primary DDFT at the proximal/mid metatarsus and should not be mistaken for the inferior check-ligament remnant. Injuries to this tendon are uncommon.

**Long Plantar Ligament**

The LPL is located along the plantarolateral aspect of the tarsus. The ligament originates from the plantar surface of the proximal calcaneus and inserts onto the fourth tarsal and fourth metatarsal bones. The proximal LPL is seen deep to the SDFT. Two portions of the LPL are often visualized on transverse views in the midligament region. The
insertions of the LPL are best evaluated on longitudinal views. Injuries to the LPL create plantarolateral swelling that is commonly referred to as “curb.” As stated above, other injuries may also create this appearance, and ultrasound is required to define the source of swelling.\textsuperscript{5,16} LPL injuries seem to be more common in the Standardbred racehorse, but they may be seen in other breeds and uses.\textsuperscript{4,16}

7. Plantar Synovial Structures

Multiple synovial structures are located in close proximity in the plantar tarsal region, including the plantar pouches of the TT joint, tarsal sheath, GN bursa, and calcaneal bursa (from dorsal to plantar; Fig. 21). The anatomy of these structures is best viewed by contrast radiography (Fig. 21). Medial or lateral distention can occur in the distal tibia/proximal tarsal region within any of these structures. Distinguishing between synovial structures is often challenging if swelling or cellulitis is present. Ultrasound can be used to identify the distended structure and establish the relative degree of synovitis versus effusion. The frequency of plantar tarsal wounds in the horse creates the high potential for extension into one or more synovial structures.\textsuperscript{19} Injection of radiographic contrast agents into wounds or draining tracts may reveal communication but may not be successful if the wound has sealed off. Ultrasound can be used in such cases to document communication, aid in synovial-fluid collection, and assist in planning for surgical intervention.
Subcutaneous Bursa

Effusion within the SC bursa is commonly referred to as capped hock. This “bursa” is located between the skin and the SDFT at the calcaneal tuber; however, the presence of a true bursa is somewhat debatable. Distention is often secondary to creation of a false bursa from trauma. Horses with acute swelling at the point of the hock and associated lameness should be closely evaluated for the presence of wounds that extend into the bursa. Sepsis may also be present without evidence of a wound. Ultrasound usually reveals thickening of the bursa capsule with a large accumulation of fluid that may appear cellular. In horses with chronic non-septic bursitis, evaluation may be difficult because of severe thickening of the skin. Fluid is typically anechoic, and horses are generally asymptomatic.

Calcaneal Bursa

The calcaneal bursa is located between the SDF and GN tendons in the distal tibia region. The bursa continues deep to the SDFT to its distal extent in the midtarsal region (Fig. 21C). The calcaneal bursa frequently communicates with the GN bursa. Bursal distention is best recognized medial and lateral to the SDFT and GN tendons proximal to the calcaneal tuber. Distal distention is usually less apparent on physical exam. Moderate to severe non-septic bursitis can occur secondary to trauma, SDF/GN tendon injury, or osseous lesions of the calcaneus. Ultrasound will reveal anechoic fluid bulging medial and lateral to the SDFT and GN tendons proximal to the calcaneal tuber. Distal to the calcaneal tuber, fluid is seen medial and lateral to the SDFT (Fig. 22). Septic calcaneal bursitis is a common sequela of plantar tarsal wounds. Affected horses often show echogenic fluid within the bursa with increased synovial thickening (Fig. 23). Distention of the bursa is infrequent in normal horses, although a small amount of anechoic fluid may be seen.

Gastrocnemius Bursa

The GN bursa is a relatively small bursa located dorsal to the GN tendon at the level of its insertion
onto the calcaneus. The GN bursa often communicates with the calcaneal bursa (Fig. 21C). \(^{19}\) Distention of the bursa is not commonly identified as a sole entity and is often secondary to calcaneal bursitis (Fig. 24). \(^{8}\)

**Tarsal Sheath**

The tarsal sheath surrounds the DDFT from the distal tibia region through the tarsal canal and into the proximal metatarsus (Fig. 21B). Tarsal sheath distention is commonly referred to as “thoroughpin,” although distention of other synovial structures may be mistaken for thoroughpin. Proximal distention is most apparent on physical exam in affected horses and may extend medially and laterally. Distention of the distal tarsal sheath is less apparent and may be recognized as generalized fullness in the region of the chestnut. Most reports of tarsal sheath tenosynovitis have focused on abnormalities of the sustentaculum tali, \(^{21–23}\) but tenosynovitis may also be present in horses without osseous abnormalities. \(^{5,24,25}\) In cases of moderate to severe effusion, ultrasound should be performed to rule out associated DDFT injury. Sonographically, tarsal sheath effusion is easiest to identify in the proximal metatarsus where anechoic fluid is seen surrounding the DDFT (Fig. 25). In the distal tibia region, outpouching of fluid can be seen adjacent to the DDFT.

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**Fig. 23.** Composite transverse ultrasound image of septic calcaneal bursitis in a 6-mo-old Quarter Horse colt with a small wound to the point of the hock after kicking his stall. The CB is severely distended with echogenic fluid medial and lateral to the SDFT and GN. The wound was located in close proximity to the bursa, but a definite tract could not be identified. Cytologic analysis of bursa fluid confirmed sepsis (total protein concentration = 5.7 g/dL, nucleated cell count = 230,900 with 99% neutrophils). Culture yielded growth of *S. aureus*. (Technique: 10-MHz linear, 4-cm scanning depth.)

**Fig. 24.** Ultrasound image of gastrocnemius bursitis in a horse with extension of a plantar laceration into the calcaneal bursa. The transverse (left) image shows a normal appearance of the SDFT and GN at 4 cm proximal to the point of the hock. The GN bursa (arrows) is seen on the longitudinal (right) image deep to the GN tendon and immediately proximal to its insertion onto the calcaneus (arrowheads). (Technique: 8.5-MHz linear, 5.2-cm scanning depth.)

**Fig. 25.** Transverse ultrasound image of moderate non-septic tarsal sheath effusion in the proximal metatarsus (16-cm DPOH). The anechoic fluid surrounds the medial DDFT (DM) and partially surrounds the DDFT. (Technique: 13-MHz linear, 5.2-cm scanning depth.)
Septic tenosynovitis should be considered in horses with wounds along the length of the sheath. Similar to other septic synovial structures, hypoechoic cellular fluid can be seen in addition to pronounced thickening of synovial membranes (Fig. 27).

### 8. Results

Records were reviewed of all horses presenting to the UCD-VMTH Large Animal Ultrasound Service from July 1999 through December 2005 (a 6.5-yr study period). Ultrasonographic evaluation of the tarsal region was performed in 128 horses for a total of 168 examinations, including 133 primary exams and 35 recheck exams. Both limbs were evaluated in three horses. Two horses presented for a new problem in the same tarsus. Right (69) and left (64) tarsal exams were evenly distributed.

#### Signalment

Ages ranged from 2 mo-27 yr with a mean age of 8.7 yr. Foals constituted a small percentage of cases and included three foals under 6 mo and 7 yearlings. There was no apparent sex predilection. Breed distribution was similar to our hospital population and included Thoroughbred (36), Quarter Horse breeds (33), Warmblood (29), Arabian (12), Morgan (4), mule (3), draft breeds (3), Tennessee Walking Horse (2), American Saddlebred (1), Peruvian Paso Fino (1), Standardbred (1), Mustang (1), Friesian (1), and Missouri Fox Trotter (1). As expected from the breed distribution, a variety of uses were represented, including English show (39), pleasure/trail (26), Western performance (14), race (10), breeding (5), and endurance (4). Use was not recorded in 30 horses.

#### Clinical Data

Lameness was present in the affected limb in 83% of cases. Mean lameness grade was 2.8 using the American Association of Equine Practitioners (AAEP) grading scale of 0–5. Lameness was acute in onset in 81 horses and chronic in 31 horses. Lameness was not present in 18 horses. Swelling was present in 77 horses (58%) and was considered cellulitic in an additional 7 horses. Thirty-four horses (26%) had wounds involving the plantar, 19 had wounds involving the dorsal, 8 had wounds involving the medial, and three had wounds involving...
the lateral surfaces of the tarsus. Horses with wounds presented to the VMTH an average of 24.9 days post-injury (range 0–120 days). Fifty percent of cases presented within 2 wk of injury. Distention of synovial structures was present in 43 horses and was localized to the TT joint (25), tarsal sheath (9), long DE tendon sheath (6), and calcaneal bursa (3). Synovial distention was likely present in additional horses, but severe tarsal swelling precluded identification of the affected joint capsule, tendon sheath, or bursa on physical exam in many cases.

Radiographic Findings
A total of 110 radiographic studies were performed in 107 horses. Degenerative joint disease was the most common finding in 65% of tarsi (72 of 110), affecting the TMT (67), DIT (57), PIT (17), or TT joints (3). Fractures were seen in 27 horses (25%), including single fractures in 19 horses and multiple fractures in 8 horses. Fractures were located throughout the tarsus without any predilection site. Additional radiographic findings included osteitis (14), osteomyelitis (7), suspect osteomyelitis (3), osteochondrosis lesions (6), soft-tissue mineralization (4), and suspect septic arthritis (3). Abnormalities of the sustentaculum tali (osteitis) were only seen in two horses.

Ultrasonographic Findings
Ultrasonographic abnormalities were detected in the majority of studies performed (96%, 128 of 133 primary exams). Tendon and/or ligament injuries were most common and were diagnosed in 67 of 133 tarsi (50%). A summary of the distribution and severity of tendon and ligament injuries and their association with wounds and fractures is shown in Table 1.

CL injuries were identified in 23 horses. A total of 18 MCL injuries and 8 LCL injuries were identified. Three horses sustained medial and lateral injuries. Injuries to the superficial (long) MCL were most common in 17 horses and included two horses with concurrent injury to the deep MCL. Injury was associated with fracture in only three horses. Two horses with medial malleolar fractures had injury to both MCL components. Another horse with a fracture of the distal tuberosity of the talus had associated insertional injury of the superficial (long) MCL. The only horse with a sole injury to the deep MCL was graded as mild. Of the eight horses with LCL injuries, the superficial and deep components were injured in six and two horses, respectively. Concurrent injury to both LCL components was not seen. Injuries were associated with a lateral malleolar fracture and a suspect fourth metatarsal fracture in one horse each. Collateral ligament injury was associated with an overlying wound in only one horse.

Long DE tendonitis was the most common dorsal tendon abnormality. Tendonitis was associated with moderate to severe tenosynovitis in 6 of 10 horses. Peroneus tertius injuries (6) were the second most common dorsal abnormality and included five ruptures. The site of rupture was located in the mid to distal tibia region in all cases. Rupture was caused by falls (2), slipping (1), full-limb cast (1), and unknown injury (1). Mild calcific tendonitis was seen in the remaining horse. Cunean tendon and bursa abnormalities were rare but were the primary source of lameness in one horse with septic bursitis post-intra-articular injection of the distal

<table>
<thead>
<tr>
<th>Table 1. Distribution and Severity of Tendon and Ligament Injuries in the Tarsal Region, Including Association With Fractures and Wounds (n = 133 exams)</th>
<th>Total</th>
<th>Mild</th>
<th>Mod</th>
<th>Sev (Rupture)</th>
<th>Fracture</th>
<th>Wound</th>
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<tbody>
<tr>
<td>Dorsal structures</td>
<td></td>
<td></td>
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<tr>
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<td>1</td>
<td>0</td>
<td>5 (5)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Long digital extensor tendon</td>
<td>10</td>
<td>2</td>
<td>4</td>
<td>4 (3)</td>
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<tr>
<td>Lateral collateral ligament</td>
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<td>6</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Superficial (long) component</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Deep (short) component</td>
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<td>1</td>
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<tr>
<td>Medial collateral ligament</td>
<td>18</td>
<td>17</td>
<td>6</td>
<td>8</td>
<td>3 (1)</td>
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</tr>
<tr>
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<td>6</td>
<td>8</td>
<td>3 (1)</td>
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</tr>
<tr>
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<td>2 (1)</td>
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<tr>
<td>Deep digital flexor tendon</td>
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<td>2</td>
<td>1</td>
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Mod, moderate; Sev, severe.
Additional abnormalities of dorsal structures not listed in Table 1 include dorsal-intertarsal ligament desmitis (1) and cranial-tibial muscle tearing (1). The SDFT was the most frequently injured planatar tendinous or ligamentous structure, and it sustained the most severe injuries in 7 of 12 horses, including 5 horses with lacerations that severed the tendon. Four horses had retinacular tears that resulted in SDFT luxation. Lateral luxation caused by medial retinacular rupture was seen in three horses, and medial luxation caused by lateral-retinacular rupture was found in one horse. GN tenosynovitis was secondary to extension of lacerations through the SDFT in two horses with severe injury. The remaining six cases were not associated with wounds. Injuries to the LPL were only seen in four horses. DDFT injuries in the tarsal region were infrequently identified (4 horses) and included only one horse with associated bony remodeling of the sustentaculum tali. Severe DDFT injury was caused by extension of a laceration through the SDFT and tarsal sheath in one horse. Two horses with TT hemarthrosis were also seen. Calcaneal bursitis was seen in 8 horses with SDFT or GN injuries.

Wounds were noted to extend directly to bone in seven horses. Evidence of osteomyelitis was seen in all seven cases, including proliferative bone with overlying fluid and/or granulation tissue. Additional findings included primary cellulitis (12), SC abscesses (4), complete septic thrombophlebitis of the cranial tibial vein (1), and septic lymphangitis (1).

Synoviocentesis
Synoviocentesis was performed in 38 horses for a total of 43 samples obtained from the TT joint (23), tarsal sheath (11), SC bursa (4), calcaneal bursa (2), cunean bursa (1), TMT joint (1), and unknown location (1). Cytologic analysis was consistent with sepsis in 10 horses, suspicious for sepsis in 5 horses, and non-septic in 28 horses. Of the 26 samples submitted for culture, only 4 produced bacterial growth, including Staphylococcus aureus from the TT joint, tarsal sheath, and calcaneal bursa in one horse each and Streptococcus equisimilis from the SC bursa in another horse.
respectively) and involved the superficial (long) MCL in 74% of horses with collateral injury. These results suggest that MCL injury is more frequent than has been reported in the veterinary literature. Other reports have focused on the association of fracture and/or enthesitis with LCL injury. Osseous abnormalities were infrequently identified in association with injury to either collateral ligament in our study. Therefore, the absence of localizing osseous abnormalities on radiographs should not deter ultrasonographic evaluation.

Severe tendon or ligament injuries were seen in a relatively large percentage of horses (40%, 35 of 86) and included 16 complete ruptures. Although severe injuries were distributed throughout the tarsus, ruptures most commonly involved the PT and the DDFT. As expected, none of the PT ruptures were caused by lacerations, but all SDFT ruptures were caused by lacerations.

The use of ultrasound was very important to document and characterize abnormalities of tarsal synovial structures. Diffuse tarsal swelling with lameness was a common presenting complaint in the study population. Ultrasound was often requested to determine the presence of synovial abnormalities and if present, to determine the best location for synoviocentesis to avoid cellulitic regions wherever possible. The large number of horses with effusion and synovitis of the TT joint (45%) was not surprising. Tarsal sheath tenosynovitis was also relatively frequent among our population, but associated abnormalities of the sustentaculum tali were only seen in 1 of 30 horses. This is in contrast to prior reports of tarsal sheath tenosynovitis where the majority of horses had sustentaculum tali abnormalities. The occurrence of calcaneal bursitis in our study is similar to previous studies. Non-septic bursitis was often caused by SDFT or GN tenosynovitis, and septic bursitis was commonly caused by plantar wounds.

Wounds extended to synovial structures, bone, tendons, or ligaments in 23 of 34 (67%) horses with wounds. Septic synovial structures were identified in another three cases where direct communication was not apparent. Wounds extended to more than one synovial structure in six horses. In many cases, communication was not able to be determined on physical exam. Ultrasonographic evidence of communication provided an early diagnosis at the time of contamination before deep-seated infection could be established. Appropriate treatment with systemic antimicrobials and/or lavage of synovial structures could be instituted to increase the likelihood of a successful outcome and prevent extension into previously normal structures. Synovial structures were also determined to be septic in eight horses without wounds. Sepsis was due to recent intra-articular injection in two horses, but the remaining horses had no history of recent intra-articular injection to suggest sepsis. Ultrasound helped to differentiate between primary cellulitis and septic arthritis in these horses that typically presented with similar clinical signs of severe lameness, heat, and swelling.

Not surprisingly, lacerations or wounds to the plantar aspect of the tarsus occurred frequently in our study population. Although many plantar wounds are treated without sequelae in the ambulatory setting, practitioners should consider ultrasound and/or referral in horses with worsening clinical signs or if leakage of synovial fluid is present. Unfortunately, the proximal to distal extents of synovial structures are often underestimated. This creates a dangerous situation where practitioners can falsely believe that a wound lacks the potential for extension into a synovial structure. Undiagnosed cases may go unnoticed until extensive infection causes more severe clinical signs. Ultrasound may also be useful in cases with tendon or ligament defects visible or palpable through lacerations. Injury is often more extensive than is apparent on physical exam and may extend into other structures. This was illustrated by several cases in our study where SDFT injuries were visible through the wound, but significant DDFT or GN injuries were not apparent until ultrasound was performed.

In summary, tarsal ultrasound should be performed in horses with tarsal wounds, distention of tarsal synovial structures, or tarsal swelling that cannot be explained by radiographic findings. Although tarsal ultrasound can be challenging, its importance should not be overlooked, because soft-tissue injuries are a common source of lameness in the horse. Armed with a strong knowledge of anatomy, including relationships between structures, tarsal ultrasound can be successfully performed.

References and Footnotes

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