


Ultrasound Examination of the Ligament Complex Within the Medial Aspect of the Ankle and Foot

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Abbreviations

A, artery; AC, anterior colliculus; AH, abductor hallucis; ASTL, anterior superficial tibiotalar ligament; ATL, anterior tibiotalar fascicle; dATL, deep anterior tibiotalar ligament; DL, deltoid ligament; dPTL, deep posterior tibiotalar ligament; FDL, flexor digitorum longus; FHL, flexor hallucis longus; IG, intercollicular groove; MCLC, medial collateral ligament complex; MTL, medial talocalcaneal ligament; PC, posterior colliculus; PTN, posterior tibial nerve; SCL, superomedial calcaneonavicular ligament; sPTL, superficial posterior tibiotalar ligament; ST, sustentaculum tali; TA, tibialis anterior; TCL, tibio calcaneal ligament; TNL, tibionavicular ligament; TP, tibialis posterior; TSL, tibiospring ligament; US, ultrasound; V, veins

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To properly diagnose and treat injuries to the ankle or foot, the physician must have good anatomical knowledge of the ligaments involved. The bundles can be distinguished and identified by ultrasound examination of the medial aspect, but this may be a challenging task. In the present illustrated study, we discuss how a detailed ultrasound examination can be made of the different ligaments within the medial aspect of the ankle and foot.

Key Words—anterior tibiotalar ligament; deltoid ligament; medial talocalcaneal ligament; superomedial calcaneonavicular ligament

The medial collateral ligament complex (MCLC) or deltoid ligament (DL) forms a strong composite structure that stabilizes the tibiotalar and subtalar joints and helps prevent excessive eversion of the hindfoot, controlling the valgus, the external rotation, and the anterior translation of the talus.¹⁻⁶ Although DL injuries account for only 5 to 10% of those affecting the ankle ligaments of the active population,² they are related to processes such as hyperpronation,¹ damage to the articular cartilage of the talus,^{6,7} and the chronic mechanical instability associated with DL laxity after injury.⁶

The structure of the DL has long been the subject of controversy, but the criteria proposed by Milner and Soames⁸ are currently taken as a good frame of reference. According to these authors, the DL is composed of 6 bands, 3 of which are constant: the tibionavicular ligament (TNL), the tibioligamentous fascicle or tibiospring ligament (TSL), and the deep posterior tibiotalar ligament (dPTL). In addition, there are 3 nonconstant fascicles: the deep anterior tibiotalar ligament (dATL), the tibio calcaneal ligament (TCL), and the superficial posterior tibiotalar ligament (sPTL). Four of the bands (TNL, TSL, TCL, sPTL) are arranged in a superficial layer and 2 (dATL, dPTL) lie within a deep layer, separated by fatty tissue.⁸⁻¹⁰

Although they do not form part of the DL, in the present study, we also refer to other ligaments that are related to the medial aspect of the foot and ankle, namely the anterior tibiotalar fascicle (ATL), the medial talocalcaneal ligament (MTL), and the superomedial calcaneonavicular ligament (SCL), which forms part of the spring ligament complex.

The fascicles of the DL emerge from the tibia, connecting it with the talus, calcaneus, navicular, and SCL. Among the non-DL ligaments, the ATL connects the tibia with the talus on the anterior

Figure 1. Ligaments of the medial aspect of the ankle. **A**, Superficial layer. Deltoid ligament (DL) (tibionavicular ligament [TNL], blue; anterior superficial tibiotalar ligament [ASTL], green; tibiospring ligament [TSL], yellow; tibiocalcaneal ligament [TCL], purple; superficial posterior tibiotalar ligament [sPTL], aquamarine), and non-DL ligaments (anterior tibiotalar fascicle [ATL] pink; superomedial calcaneonavicular ligament [SCL], fluorescent green; medial talocalcaneal ligament [MTL], orange). **B**, Deep layer. Deep anterior tibiotalar ligament (dATL) (inconsistently present), green; deep posterior tibiotalar ligament (dPTL), red. **C**, Medial malleolus. AC, anterior colliculus; IG, intercollicular groove; PC, posterior colliculus.



aspect of the ankle, the MTL connects the talus with the calcaneus medially, and the SCL ligament connects the calcaneus with the navicular (Figure 1).

The aim of this study is to use ultrasound (US) examination to describe the sonoanatomy of the ligamentous fascicles within the medial aspect of the ankle and foot. Assessing the DL is a complex task, due to its fatty tissue cover and because the posterior tibial tendon overlies the posterior and medial portions⁵ of the long flexor muscles of the toes, including the great toe. These structures restrict the image and generate artifacts such as anisotropy due to the superposition and the varied directions of the different bundles. All ligaments were examined with high-resolution gray scale US and with B-mode, Logiq S8 (General Electric, Wauwatosa, WI). The probes used in this study were ML6-15-D (4–15 MHz) and L8-18I-D (8–18 MHz).

Superficial Layer

In this section, we consider the superficial layer of the DL, the ATL, and the MTL. The various bands within the DL (TNL, TSL, TCL, sPTL, and anterior superficial tibiotalar ligament [ASTL])^{3,10} emerge from the periosteum of the medial malleolus, divide, and then attached the navicular, the talus, the SCL, the calcaneus (sustentaculum tali), and the posterior talus¹¹ after crossing 2 joints, except the ASTL that the fascicles attach to the navicular, those of the ankle and the subtalar^{8–10,12} (Figure 1A). The superficial components maintain the alignment of the talus and

the medial malleolus,¹³ providing resistance against the valgus and external rotation of the talus³ by limiting hindfoot eversion.^{2,7} In acute ankle injuries, the absence of any of these components might compromise joint stability.¹⁴

Anterior Tibiotalar Fascicle

The ATL occupies the anteromedial space of the ankle joint, reinforcing the anterior capsule.^{1,10} It is proximally anchored in the medial malleolus and its fibers emerge in an oblique lateral direction toward the neck of the talus.

During an US examination, the patient must plantar flex the foot to expose the anterior aspect of the ankle. The operator then places the proximal end of the probe against the anterior aspect of the apex of the medial malleolus and moves it obliquely, distally and laterally toward the neck of the talus (Figure 2A).

The US image reveals a thin, elongated, hyperechoic fibrillar pattern extending over the anterior ankle joint, with a broad base, both proximally on the tibia and also at its distal junction in the neck of the talus. At a superficial level, and distal to the ligament, the fibers of the tibialis anterior tendon can be seen on the transverse axis (Figure 2B).

Tibionavicular Ligament

Within the DL, the TNL is the longest¹⁵ and thinnest bundle,¹⁴ which can lead to confusion with the joint

Figure 2. Ultrasound image of the anterior tibiotalar fascicle. **A**, Position of the patient and the probe. **B**, Ligament fibers (arrows) extend through the anterior ankle joint. The section of the tibialis anterior (TA) tendon can be seen at a superficial level and distal to this joint.

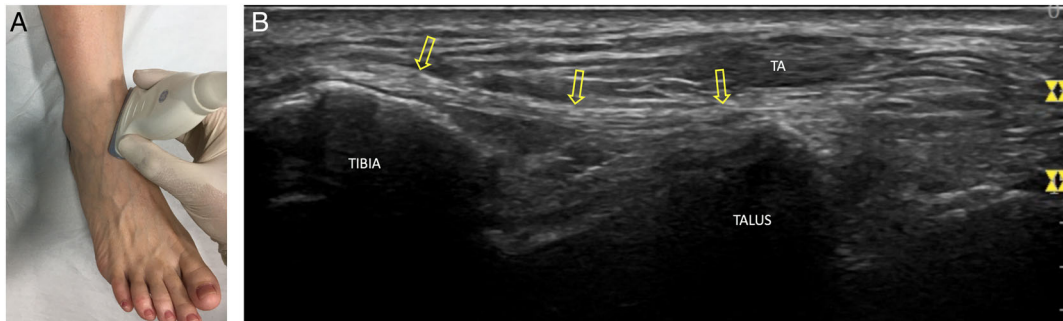
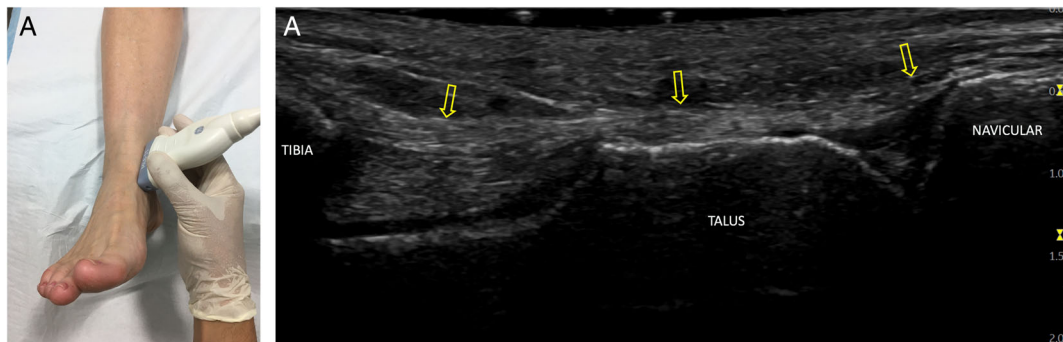


Figure 3. Ultrasound image of the tibionavicular ligament. **A**, Position of the patient and the probe. **B**, The long hyperechoic fibers (arrows) extend above the talus, crossing the ankle joint and the talonavicular joint.



capsule. It extends from the anterior border of the anterior colliculus of the tibia to the dorsomedial aspect of the navicular. The TNL is always present^{8–11} and is the component that most commonly presents a complete tear in DL lesions.¹⁶

To visualize the TNL, the probe is aligned with the longitudinal axis of the foot, and traces a path from the tibial malleolus toward the tip of the great toe, locating the fibers on the dorsal surface of the navicular (Figure 3A). This examination reveals the long fibers of the TNL, which are the most extensive within the DL and have a well-defined hyperechoic fibrillar pattern, which is concave and distally inserted into the dorsomedial aspect of the navicular (Figure 3B).

Anterior Superficial Tibiotalar Fascicle

There is some controversy regarding the ASTL. Some researchers consider it an independent ligament,¹⁰

while others refer to it as a group of fibers with no specific ligament entity, which can emerge from the TNL to join the talus.⁸ Its fibers have a common origin with the TNL (anterior border of the anterior colliculus), although at a deeper level and following a short, differentiated path to the neck of the talus.^{1,10}

For US study, the transducer is placed in the same position as that used in the TNL exploration. (Figure 3A). The US image shows that, from the tibia, the ASTL fibers emerge from the same origin and depth as the TNL, and extend toward the talus, in a tract with low echogenicity (Figure 4).

Tibiospring Ligament (Tibioliamentous Fascicle)

The TSL is constant^{8–11,16} and is the most superficial bundle, extending from the anterior colliculus of the

Figure 4. Ultrasound image of the anterior superficial tibiotalar ligament. The fibers (yellow arrows) emerge from the tibia beneath the tibionavicular ligament (TNL; white arrows) and extend to the dorsal aspect of the neck of the talus.

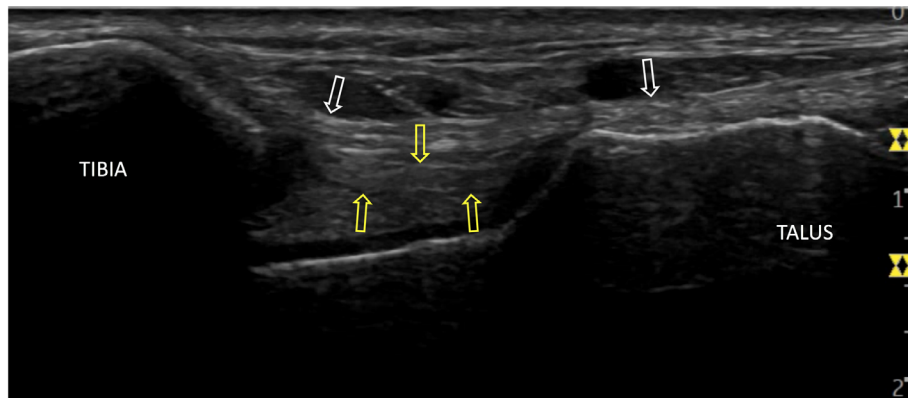


Figure 5. Ultrasound image of the tibiospring ligament. **A**, Position of the patient and the probe. **B**, Examination of the tibiospring ligament (TSL; yellow arrows) reveals the longitudinal path of its fibers, joining the tibia to the superomedial calcaneonavicular ligament (SCL). Superficially, it is related to the tibialis posterior (TP) tendon.



medial malleolus of the tibia to the upper border of the SCL (part of the spring ligament complex).⁶

For the operator to visualize the DL beams, the patient must externally rotate the hip, presenting the medial aspect of the foot and ankle.¹⁷ To assess the TSL, the foot is then placed in a neutral position, and the probe is located in the frontal plane, with its proximal pole against the anterior colliculus of the tibia and the distal pole against the SCL, in the space between the navicular and the calcaneus (sustentaculum tali)^{1,10} (Figure 5A).

The US image shows that the TSL fibers form a concave arch with a well-defined fibrillar pattern, from the tibia to the upper border of the SCL (Figure 5B).

Tibiocalcaneal Ligament

The TCL, considered to be a continuation of the TSL,^{1,10} is not a constant bundle. It emerges from the

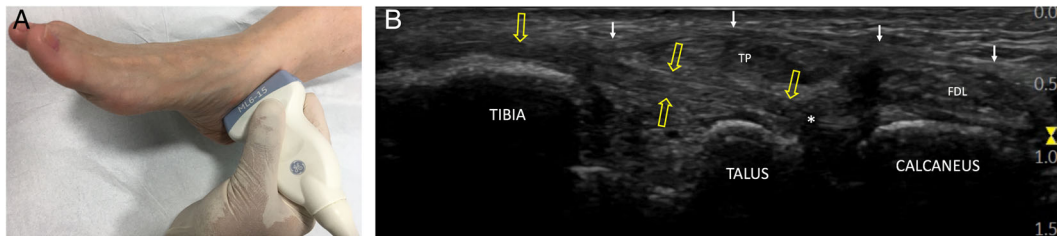
anterior colliculus of the medial malleolus and extends vertically⁶ to enter the posterolateral half and the posterior margin of the sustentaculum tali, where the SCL originates.¹⁵ If the TCL is not identified, some variants may be present, either as a deep band of the TCL, located posterior to the sustentaculum tali,¹ or as a band between the SCL and the sustentaculum tali.¹⁶

In DL injuries, the TCL is usually the second most frequently affected ligament (after the TNL) to suffer a complete tear, reducing the stability of the tibiotalar and subtalar joints.¹⁶

To obtain a good US image, from the initial examination position of the TSL, the probe should be moved slightly toward the rear of the foot, passing over the anterior colliculus of the tibia and toward the sustentaculum tali (Figure 6A).

The US examination reveals a group of fibers, banded rectilinearly, emerging from the surface of the tibia, extending beneath the tibialis posterior tendon

Figure 6. Ultrasound image of the tibiocalcaneal ligament. **A**, Position of the patient and the probe. **B**, Longitudinal examination revealing fibers with well-defined edges (yellow arrows) extending between the tibia and the sustentaculum tali, through the joint space, and containing a small anisotropic area (*). The flexor digitorum longus (FDL) tendon, the tibialis posterior (TP) tendon, and the flexor retinaculum (white arrows) can be seen on the surface.



and ending at the calcaneus (sustentaculum tali) (Figure 6B).

Superficial Posterior Tibiotalar Ligament

The sPTL, the fourth and last component of the superficial layer of the DL, originates from the posterior half of the anterior colliculus and attaches to the superficial anterior part of the medial tubercle of the posterior apophysis of the talus, although some of its fibers may extend toward the flexor longus tunnel of the great toe.^{1,10} The sPTL has an anatomical prevalence of 88%,¹⁶ and is either independent or combines continuously with the TCL to create a fan-shaped structure after which the DL is named.

For the US examination, the foot should be dorsiflexed. The proximal end of the probe is placed between the posterior segment of the anterior colliculus and the posterior colliculus; it is then pivoted on this point, distally toward the rear of the foot (Figure 7A).

The resulting US image enables us to observe the fibers of the ligament above the dPTL, extending posterodistally, usually entering the posteromedial tubercle of the talus, but sometimes continuing past the talus to reach the flexor hallucis longus (FHL) tendon (Figure 7B).

Superomedial Calcaneonavicular Ligament

The SCL is one of the fascicles that make up the spring ligament complex, occupying the medial

interval that extends from the subtalar joint and superomedial portion of the sustentaculum tali to the superomedial surface of the navicular.⁶ Some authors do not consider it a component of the DL,² while others consider it a functional component.⁶ It is of major significance, intervening in the control of pronation and in maintaining the internal longitudinal arch of the foot, the structural and functional failure of which is one of the main causes of flat feet.

The US examination is performed as follows. With the foot in a neutral position, the probe is placed between the sustentaculum tali and the navicular. The image thus achieved can be corroborated by reference to the deep-lying presence of the joint cartilage of the head of the talus, together with the superficial presence of the posterior tibial tendon, with the fibers arranged longitudinally or tangentially (Figure 8A).

The US image shows that the bundle extends from the sustentaculum tali to the navicular, covering the head of the talus and always remaining below the fibers of the tibialis posterior tendon. With US, the fibrocartilage structure has a marked hyperechoic appearance, clearly differentiated from the normal ligament pattern (Figure 8, B and C).

Medial Talocalcaneal Ligament

The MTL is not commonly studied. It has a short, robust structure, connecting the medial aspect of the talus and the calcaneus.

For the US examination, the foot should be placed in a neutral position to facilitate the localization of the short fibers comprising the bundle. The

Figure 7. Ultrasound image of the superficial posterior tibiotalar ligament. **A**, Position of the patient and the probe. **B**, The thin tract of the ligament (yellow arrows) extends from the tibia to the posteromedial tubercle of the talus, partial overlap to the deep posterior tibiotalar ligament (dPTL). It can be seen that the fibers reach the channel of the flexor hallucis longus (FHL) tendon on which the artery (A), veins (V), and posterior tibial nerve (PTN) are located. Superficial to the ligament are the tibialis posterior (TP) tendon, the flexor digitorum longus (FDL) tendon, and the flexor retinaculum (white arrows).

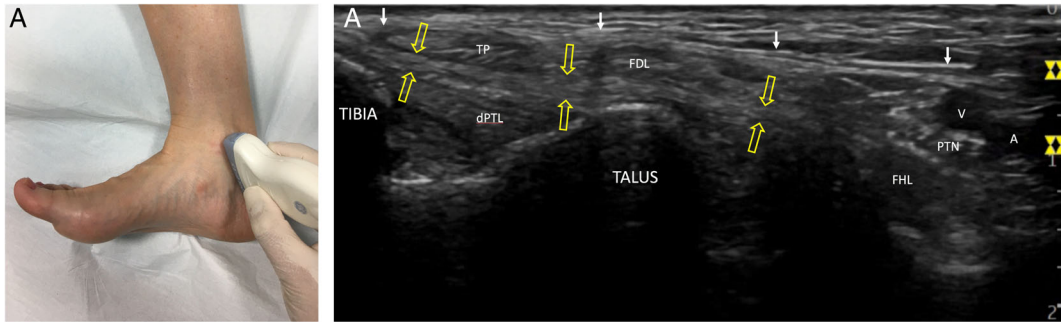
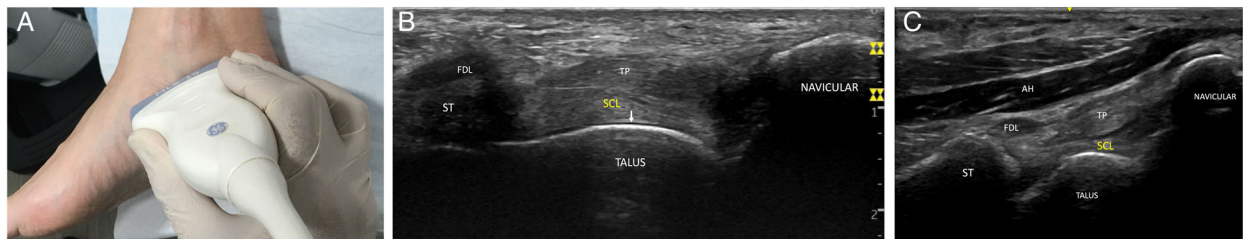


Figure 8. Ultrasound image of the superomedial calcaneonavicular ligament. **A**, Position of the patient and the probe. **B**, Longitudinal examination in the transverse plane reveals the orientation of the superomedial calcaneonavicular ligament (SCL), extending from the sustentaculum tali (ST) to the navicular, with its hyperechoic images of superficial and deep edges that differentiate it from the tibialis posterior (TP) tendon and from the articular cartilage of the head of the talus, respectively (white arrow). Proximally, the flexor digitorum longus (FDL) tendon, covering the sustentaculum tali (ST), is also visible. **C**, Longitudinal image from a medial and plantar perspective, showing the path of the superomedial calcaneonavicular ligament (SCL) from the ST to the navicular, related to the sections of the tibialis posterior (TP) tendon and the flexor digitorum longus (FDL) tendon, and also related to the muscular undersurface of the abductor hallucis (AH), located in the uppermost plane. The origin of the SCL fibers in the ST helps differentiate it from the midplantar portion of the spring ligament.



probe is held over the posteromedial tubercle of the talus and moved in an anteroinferior direction to the posterior edge of the sustentaculum tali (Figure 9A). US examination shows that the ligament contains a short, thick bundle composed of parallel echogenic fibers, extending in an anteroinferior direction from the talus to the posterior edge of the sustentaculum tali (Figure 9B).

Deep Ligaments

The deep lamina is composed of 2 short, strong ligaments that span only the ankle joint.^{2,3,8,10,12} The dATL and dPTL ligaments emerge from the deep

margin of the medial malleolus and extend to enter the medial fovea of the talus.¹⁸ These ligaments prevent lateral displacement, external rotation of the talus,^{2,3,13,18} and eversion of the talus¹⁸ (Figure 1B).

Deep Anterior Tibiotalar Ligament

The fibers of the dATL originate at the apex of the anterior colliculus and the rear of the intercollicular groove, and extend toward the medial aspect of the talus.^{1,10} This ligament is inconstant^{8–11} and often poorly differentiated. Some studies have situated it beneath the TNL, together with the capsule.¹⁵

Figure 9. Ultrasound image of the medial talocalcaneal ligament. **A**, Position of the patient and the probe. **B**, Connecting the talus to the sustentaculum tali (ST), the ligament (yellow arrows) forms a robust bundle revealing the echogenicity of its fibers, the surface of which is overlain by the flexor digitorum longus (FDL) tendon.

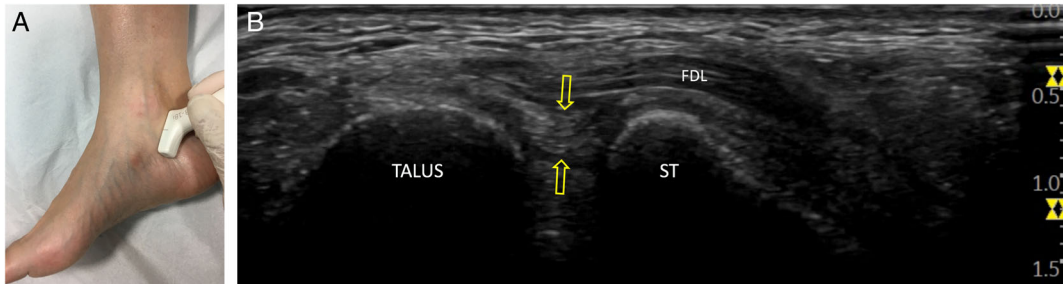
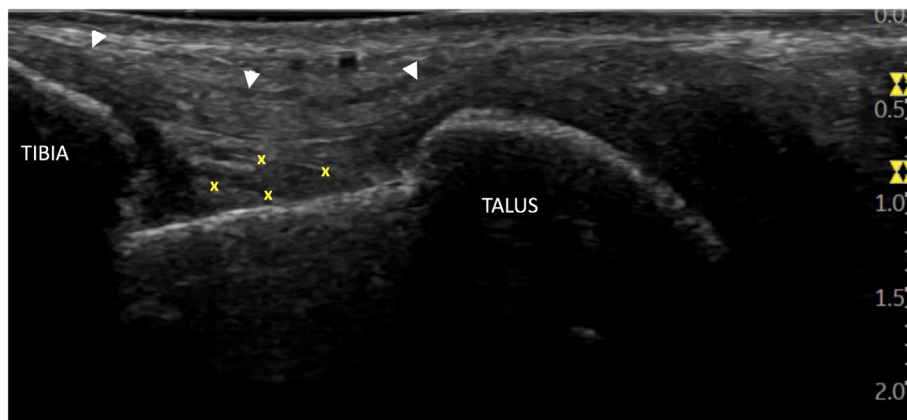


Figure 10. Ultrasound image of the deep anterior tibiotalar ligament. The ligament traces a short path (X) from the tibia to the talus beneath the concave fibers of the tibiospring ligament (TSL; arrowheads).



The US examination is performed seeking the proximal path of the TSL as a reference (Figure 5A), since it superficially covers the dATL, and then observing its insertion into the medial aspect of the talus. This fascicle traces a short rectilinear path, with a predominantly hypoechoic pattern (Figure 10).

Deep Posterior Tibiotalar Ligament

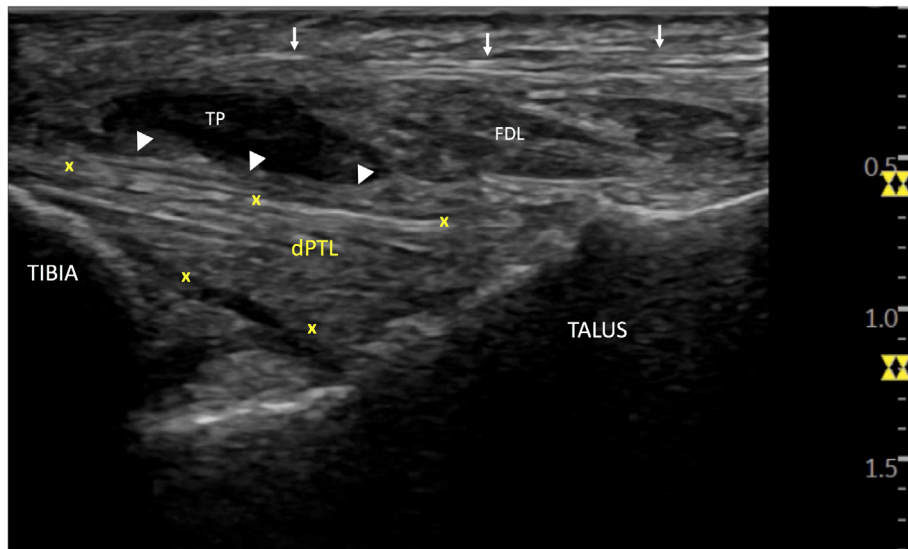
The dPTL is a constant bundle.^{8–11,14} It is extra-synovial but intra-articular, and is the strongest component of the DL.^{1,10} It originates in the posterior half of the anterior colliculus and in half or all of the posterior colliculus, and extends toward the posteromedial

tubercle of the talus. Medially rectangular and posteriorly triangular,¹⁵ the dPTL is variable in thickness and width, and may be compact or multifascicular in appearance.

To carry out the US study, the foot is placed in dorsiflexion, taking the sPTL as a reference for location. With the probe placed transversely between the posterior aspect of the anterior colliculus, the intercollicular fossa and the posterior colliculus, the operator then seeks the posterior area of the medial aspect of the talus (Figure 8A).

The US image reveals a conical ligament, with the main insertion area in the talus. Internally, there may be an area of parallel hyperechoic fibers, differentiated from other fibers that are hypoechoic and less well defined (Figure 11).

Figure 11. Ultrasound image of the deep posterior tibiotalar ligament (dPTL). The longitudinal study of the ligament (X) shows a robust ligament containing differentiated bundles. It is narrow at the tibial level and broad based in the talus. It is overlain by the superficial posterior tibiotalar ligament (sPTL; arrowheads), the tibialis posterior (TP) tendon (anechoic and dark, due to anisotropy), the flexor digitorum longus (FDL) tendon and the flexor retinaculum (arrows).



Discussion

In the literature on the DL, there is considerable controversy regarding the number of bundles, their constancy or otherwise, and the variations that may be observed. In 1998, however, Milner and Soames⁸ established criteria that have served as the foundation for most subsequent research, including this study, which was undertaken in response to the perceived dearth of comprehensive US studies of the ligaments of the medial aspect of the foot and ankle (including the DL).

US examination of the ligaments of the medial aspect of the foot and ankle is of special interest in cases of injury. To perform such an examination, it is advisable to evaluate the ligaments from anterior to posterior, evaluating both the superficial ATL, TNL, ASTL, TSL, TCL, sPTL, MTL, SCL) and the deep bundles (dATL, dPTL), and taking into account that some ligaments may be nonconstant. Another important consideration is that during the scan a difficult to image ligament may be due to either a significant injury or normal variation (ie, absence). The operator must try to resolve this by optimizing the imaging technique and if necessary, compare with the contralateral foot. Even though the anatomic studies are not used to contribute data linked to the different

prevalence of the distinct fascicles between same specie's feet, the operator must corroborate the fascicles of the other foot compare with the contralateral foot (recognizing all patients may not have symmetrical ligaments at baseline).

Conclusions

US imaging is a useful tool for identifying the ligaments in the medial aspect of the ankle and the foot, enabling the operator to differentiate normal from injured tissue. Recent technological advances, together with improved anatomical knowledge, are making it possible to discriminate constant bundles, additional ones and variations in the ligaments of the medial face, and to determine the pathology that may be present in any of these elements.

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