Ultrasound Evaluation of post traumatic ankle injuries

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Learning objectives

The ankle ligaments stabilize the bones of the hindfoot during motion.

Bones and ligaments, together with the joint capsule, are functionally linked to form the hindfoot joint complex. The ankle is frequently affected in trauma as well as in overuse disorders, and the lateral compartment is the most commonly affected site.

High-resolution ultrasonography (US) has become increasingly important in the assessment of ligaments around the ankle.

In this work we review the specific probe positions for an ankle US exam and we cover the normal sonographic appearances of tendons and ligaments. We highlight key techniques to allow optimal ultrasound assessment. The characteristic sonographic appearances of post traumatic injuries are also discussed.
Background

The complex anatomy of the ankle can make the clinical assessment of post traumatic injuries challenging. Ultrasound is an accessible, relatively inexpensive modality, and modern high-resolution probes allow eloquent demonstration of the main structures that are implicated.

A. General Principles of US Evaluation:

Proper execution of the examination and accurate interpretation of the results requires flawless knowledge of the anatomy of the joint, especially the tendons, capsule-ligament structures, nerves, vascular structures, and bones.

US can provide a detailed depiction of normal anatomic structures and is effective in evaluating ligament integrity, to detect abnormalities, such as tendinopathy, ganglia, bursitis, joint effusion with loose bodies, and neurovascular abnormalities. US allows performance of dynamic maneuvers, which may contribute to increased visibility of normal ligaments and improved detection of tears.

US of ankle ligaments should be performed with high-frequency linear transducers ranging from 10 to 18 MHz. Anisotropy is a common occurrence in clinical practice when examining tendons and ligaments, potentially, simulating a tear. The ultrasound beam must be directed as perpendicular as possible to the examined structure to avoid anisotropy.

Anatomic bone landmarks should be used to align the US probe along the course of the ligaments, which are usually scanned along their longer axis. Short-axis US can be helpful in the context of equivocal findings but is not routinely needed.

Damaged ligaments may manifest as different US patterns. Their normal thickness ranges from 2 to 5 mm, depending on the structure. Ligament thickening, loss of physiologic fibrillar echo texture, and presence of calcifications suggest chronic or degenerative abnormalities.

 Interruption or absence of fibers in the expected anatomic location is indicative of a ligament tear. Specific dynamic maneuvers can be performed to stress the joint and create tension in the ligaments.
For assessment of the normal anatomic structure, dynamic maneuvers may help straighten the ligament and, therefore, enable it to be more perpendicular to the US beam.

In addition, dynamic maneuvers may be used to increase the diagnostic accuracy of the detection of tears and to differentiate a partial from a complete

**B. Anatomy:**

The ankle can be divided into four compartments: medial, anterior, posterior, and lateral; each containing various anatomical structures (ligaments, tendons, retinacula, blood vessels, and nerves). We will look at the components of the joint that are affected by trauma and which can be explored sonographically and provide a brief description of the examination technique for each.

**1. Anterior compartment**

The study of the anterior ankle includes exploration of the tibialis anterior (TA), extensor hallucis longus (EHL), and extensor digitorum longus (EDL) tendons; the anterior retinaculum; the anterior tibial artery.

The anterior compartment is examined with the patient lying supine on the examination table, with the knee flexed and the sole of the foot resting on the surface of the table.

**Fig. 1** on page 10

**a) Tendons and retinacula:**

The tendons here are gliding tendons, which are surrounded by a synovial sheath. The tendons are derived from muscles located in the anterolateral portion of the leg.

- The TA tendon the most medial of the three constant tendons, follows an oblique, inferomedial course to its insertion on the medial aspect of the first cuneiform.

- The EHL tendon is thinner and lies lateral to TA. It runs along the dorsum of the foot and inserts into the base of the distal phalanx of the great toe.

- The EDL tendon is the most lateral of the three constant tendon. Its proximal segment is broad and thin. Just distal to the neck of the talus, the EDL divides to form four slips,
which insert on the dorsal aspects of the distal phalanges of the second, third, fourth, and fifth toes.

All of the extensor tendons run beneath the superior and inferior extensor retinacula, two fibrous bands that stretch horizontally across the anterior aspect of the ankle.

Both retinacula are approximately 1 mm thick, and they appear as echogenic bands on ultrasound.

b) The anterior inferior tibiofibular ligament (TFL):

The tibia and fibula are articulated at their distal end at the inferior tibiofibular joint. It is stabilized by two ligaments, one anterior and one posterior.

On the anterior aspect of the distal tibiofibular joint lies the strong, short anteroinferior tibiofibular ligament, which can be damaged during particularly severe ankle sprains. Fig. 2 on page 10

It is a stiff, flattened band lying anterior to and partially blended with the interosseous membrane. It extends obliquely downward and laterally from the anterior margin of the fibular tubercle of the tibia to the anterior border of the distal fibular shaft and the lateral malleolus.

The normal thickness of this ligament ranges between 2.6 and 4 mm.

2. Medial compartment:

The medial compartment contains the tibialis posterior (TP), the flexor digitorum longus (FDL), and the flexor hallucis longus (FHL) tendons; the neurovascular bundle; and the medial collateral tibiotalar-or deltoid-ligament).

The tendons and the neurovascular bundle run through the tarsal canal, an osseofibrous tunnel delimited deeply by the medial aspects of the distal tibia, the talus, and the calcaneus and superficially by the flexor retinaculum.

For examination of the medial compartment, the patient is placed in the supine position with the hip flexed and abducted, the knee flexed, and the outer aspect of the foot resting on the table.
a) Tendons and retinacula Fig. 3 on page 10

The three tendons, each of which is enclosed in a synovial sheath (each in its own sheath), are derived from muscles located deep in the posterior portion of the leg.

The TP is the largest and most anterior of the three tendons in this compartment. It runs through on the posterior aspect of the medial malleolus and then passes beneath the malleolus, encircling it inferiorly, superficial to the deltoid ligament.

Posterior to the TP tendon lies the FDL tendon, which is more slender.

The deepest and most posterior of the three tendons is that of the FHL. The tendon is reflected on the posterior aspect of the talus, between the medial and lateral tuberosities.

b) The medial collateral (deltoid) ligament:

The medial collateral (deltoid) ligament is actually a ligament complex with multiple components.

- A deep band, short and stumpy, which extends from the summit of the medial malleolus to the medial aspect of the talus

- A superficial delta shaped layer: the tibionavicular ligament, the tibiotalar ligament; and the tibiocalcaneal ligament.

- The robust medial collateral ligament is decidedly less vulnerable to sprains than the lateral collateral complex; it is generally injured as a result of eversion stress Fig. 4 on page 11

- The tibionavicular ligament originates from the anterior border of the anterior colliculus of the medial malleolus and inserts on the dorsomedial aspect of the navicular bone Fig. 5 on page 11

- The tibiospring ligament connects the anterior malleolar colliculus to the superior border of the superomedial portion of the spring ligament. Fig. 6 on page 12

- The tibiocalcaneal ligament originates from the medial aspect of the anterior colliculus of the medial malleolus, descends vertically, and inserts on the medial border of the sustentaculum tali.
b1. Mid foot Medial Ligaments:

The plantar calcaneonavicular ligament (CNL) is also known as the spring ligament complex.

It blends with the deltoid ligament and is one of the major stabilizers of the longitudinal arch of the foot. The spring ligament includes three portions that can be easily differentiated: the superomedial CNL, the medioplantar oblique CNL, and the inferoplantar longitudinal CNL.

3. Lateral compartment:

The lateral compartment contains the peroneus brevis (PB) and peroneus longus (PL) tendons, and the lateral collateral ligament.

This portion of the ankle is examined with the patient's thigh flexed and adducted, the knee flexed, and the inner aspect of the foot resting on the table.

Studies of the calcaneofibular ligament are facilitated if the foot is also dorsiflexed, while inversion is more useful during examination of the anterior talofibular ligament.

a) Tendons: Fig. 7 on page 13

The PL and PB tendons are derived from muscles located in the lateral portion of the leg. The spatial relationship between these two tendons varies. In the lateral supramalleolar plane, the PL lies lateral to the PB.

Behind the malleolus, the PL tendon runs posterior to that of the PB.

The peroneal tendons' contact with the underlying bone structures is maintained by the presence of two retinacula. The superior one, located in the external retromalleolar region, extends from the lateral malleolus to the outer surface of the calcaneus. The lower one, which is inframalleolar, stretches from the outer edge of the inferior extensor retinaculum to the outer surface of the calcaneus.

b) Lateral collateral ligament: Fig. 8 on page 13
The lateral collateral ligament complex includes three fasciculi:

- The anterior talofibular ligament (FTA): which extends from the anterior aspect of the lateral malleolus to the neck of the talus

- The calcaneofibular ligament (FC), which lies deep to the peroneal tendons and connects the summit of the lateral malleolus and the outer surface of the calcaneal body

- The posterior talofibular ligament (FTP) which runs from the posterior edge of the lateral malleolus to the posterior process of the talus, beneath the posteroinferior tibiofibular ligament.

The ligaments of the lateral complex can be injured during severe sprains (starting from the mostanterior to the most posterior): therefore, in general, damage to the FC ligament is usually associated with FTA ligament lesions. Lesions involving the FTP ligament are very rare.

(b1) Anterior Talofibular Ligament:

Fig. 9 on page 13

(b2) CFL:

Fig. 10 on page 14

The CFL has a concave course, which makes its evaluation particularly challenging.

Forced dorsiflexion of the foot tightens the CFL, making it straighter and more perpendicular to the US beam, thus allowing optimal visibility.

(b3) The posterior talofibular ligament

Fig. 11 on page 14

c) Midfoot lateral Ligaments:
The ligaments on the dorsal lateral side of the midfoot are the dorsal calcaneocuboid ligament and the dorsal talonavicular ligament. A third ligament, the bifurcate ligament (also known as the Chopart ligament), is the major stabilizer of the calcaneonavicular joint.

The bifurcate ligament extends in two strong bands from the anterior calcaneal tuberosity to the lateral side of the navicular and the dorsal surface of the cuboid.

- The calcaneocuboid ligament is a thickening of the dorsolateral surface of the fibrous capsule of the calcaneocuboid joint, rather than a real separated ligament. Fig. 12 on page 14

- The dorsal talonavicular ligament extends from the dorsal surfaces of the neck of the talus to the navicular. It is joined with the dorsal capsule of the talonavicular joint and is covered by extensor tendons. Fig. 13 on page 15

4. Posterior compartment:

The anatomic structures found in the posterior compartment are the Achilles' tendon, the tendon of the plantaris muscle, Kager's triangle (Figs. 17, 18, 19), and are examined with the patient lying prone and the toes resting on the surface of the examination table. This ensures maximal extension of the foot and maximal tension on the Achilles tendon.

The Achilles tendon is the strongest tendon in the human body: it is formed by the confluence of the soleus muscles (deep) and the gastrocnemius (superficially). It inserts into the posterior aspect of the calcaneus, distal to the posterosuperior tuberosity. The Achilles tendon does not have a synovial sheath as such, but it is surrounded by a band known as the paratenon. Fig. 14 on page 16
Fig. 1: Probe positioning on the anterior compartment and corresponding US image showing Tibialis anterior, extensor hallucis longus, and extensor digitorum longus (EDL) tendons.

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Fig. 2: Probe positioning on the anterior compartment and corresponding US image showing the normal aspect of anterior inferior tibio-fibular ligament (ATFL).

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**Fig. 3:** Probe positioning on the medial compartment and corresponding US image showing Tibialis posterior (TP), flexor hallucis longus (FHL), and flexor digitorum longus (FDL) tendons.

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**Fig. 4:** Drawing of the normal anatomy of the medial collateral ligaments of the ankle

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Fig. 5: Probe positioning on the medial anterior compartment and corresponding US image showing tibionavicular ligmanet. N= navicular, Ta= talus, Ti= tibia

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Fig. 6: Probe positioning on the medial anterior compartment and corresponding US image showing the tibiospring ligament. C= calcaneus, SL= spring ligament, Ti= tibia.

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Fig. 7: Probe positioning on the medial anterior compartment and corresponding US image showing the peroneus brevis (PB) and peroneus longus (PL) tendons.

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Fig. 8: Drawing of the normal anatomy of the lateral collateral ligament of the ankle

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Fig. 9: Probe positioning on the lateral compartment and corresponding US image showing the anterior talofibular ligament. F= Fibula, Ta= Talus

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Fig. 10: Probe positioning on the medial anterior compartment and corresponding US image showing calcaneofibular ligament. C= calcaneus F: fibula.

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Fig. 11: Probe positioning on the medial anterior compartment and corresponding US image showing the posterior talofibular ligament. C= calcaneus F: fibula.

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**Fig. 12:** Probe positioning on the medial anterior compartment and corresponding US image showing the calcaneocuboid ligament. C= calcaneus Cu: cuboid.

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**Fig. 13:** Probe positioning on the medial anterior compartment and corresponding US image showing the dorsal talonavicular ligament. C= calcaneus F: fibula.

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**Fig. 14:** Probe positioning on the medial anterior compartment and corresponding US image showing Achilles tendon. C= calcaneus F: fibula.

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Findings and procedure details

Patients were referred to us after clinical suspicion of ankle sprain. Images presented in this article were acquired with a 17-5-MHz linear probe. Use of a soft-gel spacer between the US probe and the skin may be helpful to optimize the surface of skin contact but will not improve image quality.

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Fig. 15: US image shows a focal disruption of the anterior inferior TFL with tibifibular joint widening. The Trauma dates back to 2 months. Ti= Tibia, F: Fibula

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**Fig. 16:** US image shows a fibrotic appearance of the anterior inferior TFL after previous trauma. The ligament is remarkably thickened and inhomogeneous. Ti= Tibia, F: Fibula

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**Fig. 17:** US image shows a fibrotic appearance of the dorsal talonavicular ligament after previous trauma. The ligament is markedly thickened and inhomogeneous (arrowheads). N = Navicula, Ta: talus.

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**Fig. 18:** US image shows a partial tear of the tibiocalcaneal ligament. The proximal portion of the ligament has normal fibrillar echostructure (arrowheads). More distally the ligament is diffusely inhomogeneous (arrow), with periligamentous fluid effusion. The distal insertion of the ligament is also inhomogeneous and hypoechoic.

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**Fig. 19:** US image shows a total rupture of the anterior inferior TFL. The tibial portion of the ligament is fibrillar, whereas the rest of the ligament is not distinguished and replaced by heterogeneous hematoma.

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**Fig. 20:** US image shows a partial tear of the calcaneofibular ligament. The ligament appears inhomogeneous and hypoechoic (arrowheads), with periligamentous effusion(*). PBT: peroneus brevis tendon, PLT: peroneus longus tendon, Ta: Talus, F: Fibula, Ta= talus, C=calcaneus

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**Fig. 21:** Wavy pattern with parallel fibers of the anterior talofibular ligament consistent with a lateral ankle sprain sequel

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**Fig. 22:** Axial US image showing a posttraumatic ganglion cyst of the ankle anterior compartment, lying inferiorly to extensor tendons.
**Fig. 23:** Tibialis anterior tear with tendon retraction: Sagittal and axial US image.
Conclusion

US has shown valuable results in the evaluation of the normal and post traumatic anatomic structures of the ankle and provides an imaging modality alternative to MR imaging and MR arthrography.

Use of a standardized imaging technique that allows dynamic imaging may play an important role in the assessment of the anatomic structure and main pathologic patterns of the ankle which can reveal the mechanisms underlying many lesions of the ankle (e.g., instability, impingement).

Its potential is enormous, but it cannot be fully exploited without thorough knowledge of the anatomy of the region.
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