Ankle and mid foot ligaments revisited: US and MRI with anatomic correlation: A pictorial essay

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Learning objectives

- To review the normal anatomy of the ankle and mid-foot ligaments.
- To review the ultrasound and MRI technique of ankle and mid-foot ligaments.
- To correlate the anatomy and the ultrasound and MRI appearance of these ligaments.

The following ligaments are included in this pictorial essay:

**Ankle ligaments**: Tibiofibular ligaments, Bassett ligament, Anterior talofibular ligament, Calcaneofibular ligament, Lateral talocalcaneal ligament, Medial ligament complex.

**Chopart ligaments**: Bifurcate ligament, talonavicular ligament and plantar ligament.

**Lisfranc ligaments**.

**Sinus tarsi ligaments**.

Background

Ankle and mid-foot ligaments play an important role in providing stability to the respective joints that they bind. Injuries of the ankle and foot can disrupt these structures and cause acute and chronic instability of the corresponding joints.

The anatomy of the ligaments around the ankle and foot is quite complex. A detailed knowledge of normal anatomy of these ligaments and their appearance on ultrasound and MRI can be useful in correct diagnosis of traumatic and non-traumatic ligamentous abnormalities.

Imaging findings OR Procedure Details

We have described the ligaments systematically on the basis of the joints they stabilize. Special anatomic features of these ligaments have been emphasized and illustrated with the help of images, wherever applicable.
General US features of ankle ligaments:

Ankle ligaments are basically bundles of collagen fibres. In general, on ultrasound images they appear as echogenic fibrillar structures similar to those elsewhere in the body. Any deviations from this appearance has been mentioned during the description of the respective ligament.

The ultrasound beam should be as perpendicular as possible to the ligament to avoid anisotropy.

High frequency linear transducers with frequencies ranging from 10-18 MHz should be used to evaluate ankle ligaments.

On ultrasound, ankle ligaments are usually scanned along their long axis. Short-axis US can be helpful in equivocal cases but are rarely needed.

Dynamic stress manoeuvres may help straighten the ligament and a better US imaging of the ligament. In pathological cases, they can help detect injury and differentiate partial and complete tears.

General MR features of ankle ligaments:

In general, ligaments appear as smoothly outlined hypointense bands on all sequences. Any deviation from this normal appearance has been mentioned during the description of the respective ligaments.

The following ligaments are included in this pictorial essay:

- **Ankle ligaments**: Tibiofibular ligaments, Bassett ligament, Anterior talofibular ligament, Calcaneofibular ligament, Lateral talocalcaneal ligament, Medial ligament complex.
- **Chopart ligaments**: Bifurcate ligament, talonavicular ligament and plantar ligament.
- **Sinus tarsi ligaments**.
- **Lisfranc ligaments**.

**Tibiofibular ligaments:**
The distal tibiofibular joint (tibiofibular syndesmosis) is reinforced by anterior tibiofibular ligament, Bassett ligament and posterior tibiofibular ligament.

**Anterior tibiofibular ligament:**

Anatomy: It is a stiff flattened band that originates from the anterior tubercle of the tibia, courses obliquely downward and laterally and inserts on the anterior border of distal fibular shaft and lateral malleolus (Fig. 1).

US: An excellent view of the ligament can be obtained on ultrasound with an oblique position of the probe and dorsiflexion of the ankle (Fig. 2).

MR: Anterior tibiofibular ligament has a multifibred structure and a striated appearance on MRI (Fig. 3).

**Bassett ligament:**

Anatomy: It is the most distal fascicle of the anterior tibiofibular ligament is separated from the rest of the ligament by a septum of fibrofatty tissue and lies somewhat deeper to the rest of the ligament (Fig. 4).

US: It can be visualised on transverse US just inferior to the anterior tibiofibular ligament (Fig. 5).

This ligament is implicated in anterolateral impingement. Laxity of the ankle joint secondary to anterior talofibular ligament injury or abnormal low insertion of anterior tibiofibular ligament lead to increased talar or distal fibular osseous contact with this ligament and a higher potential for impingement. Excision of Bassett ligament (arthroscopically or open surgery) would relieve the pain without causing compromise to ankle stability.

**Posterior tibiofibular ligament:**

Anatomy: (Fig. 6) It is stronger than anterior tibiofibular ligament. It has two components, superficial and deep.

The superficial component: It originates at the posterior edge of the lateral malleolus, courses superiorly and medially to insert into the medial tibial tubercle. The term posterior tibiofibular ligament is used to indicate this component.
The deep component: It is cone shaped. It originates in the proximal area of malleolar fossa and inserts on the posterior edge of tibia. This component is called the transverse ligament. It provides talocrural stability by preventing posterior talar translation.

US: It is not as well visualised on US as the anterior tibiofibular ligament. Since it is rarely involved in ankle sprains it is not a part of routine US examination. It can be visualized by placing the transducer almost horizontally and medially on the posterior aspect of the tip of lateral malleolus (Fig. 7). Dorsiflexion and eversion of the hindfoot can enhance its visualisation.

MR: It is best seen on coronal MR images (Fig. 8).

**Intermalleolar ligament:**

Anatomy: It is located posteriorly between the transverse ligament superiorly and the posterior talofibular ligament inferiorly (Fig. 6). The ligament may be divided into two or three bands. It spans the space between fibula and tibia. It runs obliquely upwards from lateral to medial side. Its prevalence in radiological and anatomical studies varies widely from 19% to 100%. The ligament has been implicated in the posterior soft tissue impingement of the ankle. It becomes taut in dorsiflexion of the ankle. Hence, forced dorsiflexion injury of the ankle can cause injury or rupture of the ligament or osteochondral avulsion. In plantar flexion of the ankle, it relaxes and can be trapped between tibia and talus and cause posterior impingement.

US: It can be seen on transverse US from posterior side spanning the space between the fibula and the tibia. The Achilles tendon can be used as a window to visualize it (Fig. 9).

MR: The intermalleolar ligament is shown on a coronal PD MR image in (Fig. 10).

**Lateral collateral ligament complex:**

It comprises of three distinct ligaments: the anterior talofibular ligament, the calcaneofibular ligament and the posterior talofibular ligament.

**Anterior talofibular ligament:**

Anatomy: It originates from the anterior margin of the lateral malleolus, runs anteromedially to its insertion on the talar body. The ligament is oriented horizontally to the ankle in neutral position. It is closely related to the joint capsule and typically composed of two distinct bands. It plays an important role in limiting anterior displacement of the talus and plantar flexion of the ankle. It is the most frequently injured ligament of the ankle (Fig. 4).
US: The examination is performed with patient supine on bed, knee flexed and foot sole placed flat on the examination table. Owing to the nearly horizontal orientation of the anterior talofibular ligament, this ligament is best evaluated with the transducer parallel to the examination table. (Fig. 11).

MR: Typically, it should be seen on two consecutive MR slices. If it is thinner, one of its two bundles may be torn (Fig. 12).

**Calcaneofibular ligament:**

Anatomy: (Fig. 13 and Fig. 14) It is the longest of the three ligaments. It is a strong cordlike structure with a vertical oblique course extending from the lateral malleolus to the lateral surface of the calcaneus. It is the only ligament bridging both talocrural and subtalar joints. In cross section, it is rounded with a diameter of 6-8 mm. It has a length of about 20 mm.

US: It can be seen on ultrasound by placing the probe obliquely and pointing it posteroinferiorly from the lateral malleolus with ankle in neutral position (Fig. 15). It can be seen better with dorsiflexion of the ankle which makes it taut with a nearly vertical orientation.

MR: It is best seen in coronal and transverse planes. It lies just deep to the peroneal tendons and forms a hammock for the peroneal tendons (Fig. 16).

**Lateral talocalcaneal ligament:**

Anatomy: (Fig. 17) It is a less well-known ligament and is not consistently present. It may be attached to the calcaneofibular ligament but diverging proximally or distally. In 23% of the cases, a lateral talocalcaneal ligament exists anteriorly and independent of the calcaneofibular ligament. In 42% of the cases, the lateral talocalcaneal is absent and is replaced by an anterior talocalcaneal ligament. In these cases, the calcaneofibular ligament acquires more functional significance in providing stability to the subtalar joint.

US: The relationship of calcaneofibular ligament and the lateral talocalcaneal ligament is shown in the US image in (Fig. 18).

**The posterior talofibular ligament:**

Anatomy: It is the strongest and deepest portion of the lateral collateral ligaments. It is intracapsular but extrasynovial and travels deeply between the posterior aspect of the lateral malleolus and the lateral tubercle of the posterior process of the talus. It has a horizontal course.
US: Because of its deep location, the posterior talofibular ligament cannot be assessed with US.

**Medial collateral ligament complex:**

Anatomy: It is also known as the deltoid ligament. It is stronger than the lateral collateral ligament. It has a triangular shape with its apex at the medial malleolus and fans out as it progresses downward. It is made of superficial and deep layers of fibres. (Fig. 19).

**Tibiotalar ligament:**

Anatomy: The deep layer of deltoid ligament courses from the medial malleolus to the talus.

US: It is made up of different fibre bundles and appears striated (Fig. 20).

MR: On fat saturated MR sequences, it may appear markedly hyperintense (in part due to striations) and this should not be mistaken as evidence of injury (Fig. 21).

The delta-shaped superficial layer of deltoid ligament typically has three components extending from the medial malleolus to the navicular (tibionavicular ligament), the spring ligament (tibiospring ligament), and to the calcaneus (tibiocalcaneal ligament). Some authors describe a fourth component of the superficial layer, called the superficial posterior tibiotalar ligament.

**Tibionavicular ligament:**

Anatomy: It is the most anterior portion of the superficial layer of deltoid ligament. It is a thin ligament with an oblique course. It originates from the anterior border of the anterior colliculus of the medial malleolus and inserts onto the dorsomedial aspect of the navicular. Due to the oblique course it may be difficult to depict it in its entirety on standard transverse or coronal planes.

**Tibiospring ligament:**

Anatomy: It is the intermediate component and the thickest part of the superficial layer of the deltoid ligament complex. It originates from the anterior colliculus of the medial malleolus and inserts on the superior aspect of the spring ligament complex (Fig. 22).
US: On US, along the long axis of the ligament, it can be seen inserting on the superior margin of the spring ligament. Between the deeper spring ligament and the more superficial posterior tibial tendon, a fibrocartilaginous nodule designated gliding zone may be seen (Fig. 23).

MR: It is always visible and best seen in the coronal plane (Fig. 24).

**Tibiocalcaneal ligament:**

It is the thinnest component of the superficial layer. It originates from the anterior colliculus of the medial malleolus, descends vertically, and inserts on the medial border of the sustentaculum tali.

MR: It is best visualized in the coronal plane (Fig. 25).

The main function of the deltoid ligament is to stabilize the medial aspect of the ankle joint. It also holds the calcaneus and navicular against the talus and reinforces the action of the spring ligament on which the head of the talus rests.

**Spring ligament:**

The spring ligament complex includes three ligaments extending the calcaneus and the navicular bones (Fig. 26):

**Superomedial Calcaneonavicular Ligament:**

Anatomy: It is the broadest and clinically most important part of the complex. It originates from the medial aspect of the sustentaculum tali and attaches broadly on the superomedial aspect of the navicular bone close to the talonavicular joint. Between the spring ligament and the posterior tibial tendon, a loose connective tissue nodule provides a gliding layer (Fig. 23 and Fig. 24).

US: The ligament is scanned along the long axis by placing one tip of the US probe inferior to the medial malleolus, over the sustentaculum tali, and tilting the other end slightly superiorly toward the superomedial aspect of the navicular bone (Fig. 27).

MR: The inner portion of the ligament articulates directly with the talar head and has a very smooth surface similar to an articular surface (Fig. 28).

**Medioplantar Oblique Calcaneonavicular Ligament:**

It originates just anterior to the middle articular facet of the calcaneus, has a medial oblique course and attaches at the medioplantar portion of the navicular bone. It is best seen in the transverse oblique plane on MR.
Inferoplantar Longitudinal Calcaneonavicular Ligament:

It originates from the coronoid fossa of the calcaneum, runs slightly obliquely to attach at the inferior beak of the navicular bone. It is well seen on transverse, sagittal, and coronal MR images.

Chopart ligaments:

Bifurcate ligament:

It is a short and stout Y shaped ligament with two components, calcaneocuboid and calcaneonavicular ligaments (Fig. 29, Fig. 30 and Fig. 31). It is intimate with the superior aspect of the calcaneocuboid joint and inferior aspect of the talonaviculare component of talocalcaneonavicular joint.

This ligament can be injured in inversion injuries of the ankle or foot.

Short and long plantar ligaments:

The short plantar ligament originates from the anterior calcaneal tubercle and attaches to the adjacent part of the plantar surface of the cuboid bone. It is short but strong and sustains the lateral plantar arch.

The long plantar ligament originates from the plantar surface of calcaneus, anterior to the calcaneal tuberosity and attaches to the plantar surface and tuberosity of cuboid bone. It lies on the lateral side of the short plantar ligament and is separated from it by a layer of loose areolar tissue. Some of its superficial fibres may attach to the bases of second to fifth metatarsals.

(Fig. 32, Fig. 33 and Fig. 34).

The dorsal talonaviculare ligament:

It extends from the dorsal surface of the neck of the talus to the navicular (Fig. 35). It is covered by extensor tendons. On MRI, it is best visualized in sagittal plane (Fig. 36). Dorsal talonaviculare ligament tears have been described after inversion injuries associated with forcible plantar strain (Fig. 37).

Sinus tarsi ligaments:

Sinus tarsi and canalis tarsi is a space located between the subtalar joint and the talocalcaneonavicular joint. It contains fat, blood vessels, nerve endings and ligaments.
The primary intrinsic ligaments of the sinus tarsi include cervical and interosseous ligaments. These ligaments limit inversion and maintain talocalcaneal alignment. Acute injury to these ligaments leads to subtalar sprain. Chronic injury causes sinus tarsi syndrome which causes lateral foot pain, tenderness and subtalar joint instability.

**Cervical ligament:** is located at the lateral border of the sinus tarsi (Fig. 38, Fig. 39, Fig. 40 and Fig. 41)). It originates from the superior surface of calcaneus and attaches at the inferolateral aspect of talar neck.

**Interosseous ligament:** is located medially in the canalis tarsi and extends from the sulcus tali to the sulcus calcanei (Fig. 42, Fig. 43, Fig. 44 and Fig. 45).

**Lisfranc Ligament:**

Lisfranc ligament is an oblique ligament between the medial cuneiform and the base of the second metatarsal. It is a complex ligament made up of three parts: a dorsal part, main central part and a plantar part. The plantar component may also extend to the base of the third metatarsal. As this ligament complex has a deep interosseous location, it cannot be seen with ultrasound. On MR, it can be identified on axial images (Fig. 46, Fig. 47 and Fig. 48).

**Tarsometatarsal joint ligaments (Fig. 49 and Fig. 50):**

At the Lisfranc joint, ligaments connecting the midtarsal bones to the bases of metatarsals and cuneiforms to the bases of metatarsals are present. Ultrasound and MR are well suited to evaluation of these ligaments.

**Images for this section:**
Fig. 1: Anatomical Specimen. Note multifibered anterior tibiofibular ligament
Fig. 2: Transverse US image of distal anterior tibio-fibular ligament. With an oblique position of the probe and ankle dorsiflexion an excellent view can be obtained of the anterior tibiofibular ligament
Fig. 3: Coronal PD weighted MR image. Note multifibered anterior tibiofibular ligament
Fig. 4: Anatomy specimen. Note anterior tibiofibular ligament (curved arrow), slightly lower Bassett ligament (arrowhead), and even lower anterior talofibular ligament (arrow).
**Fig. 5:** Transverse US. Bassett's ligament can be visualized just inferior to the anterior tibiofibular ligament (arrows). The talus comes in view when the probe is placed at the level of this ligament.
**Fig. 6:** Anatomy specimen. Posterior view: 1. Posterior tibiofibular ligament 2. Inferior transverse ligament 3. Intermalleolar ligament 4. Posterior talofibular ligament

**Fig. 7:** US image. Note posterior tibiofibular ligament (arrow).
Fig. 8: Coronal PD MR image. Note posterior tibiofibular ligament (arrow).
**Fig. 9:** US image. Note intermalleolar ligament spanning the space between fibula and tibia. This can be seen on a transverse US view from posterior. The Achilles (A) tendon can be used as a window. The ligament has been implicated in posterior impingement.
Fig. 10: Coronal PD MR image. Note intermalleolar ligament spanning the space between fibula and tibia. The ligament has been implicated in posterior impingement.

Fig. 11: Transverse US image. Arrows outline the anterior talofibular ligament.
**Fig. 12:** Transverse PD MR. Arrow outlines the anterior talofibular ligament. Typically it should be seen on two consecutive MR slices. If it is thinner one of its two bundles may be torn.

**Fig. 13:** Anatomy specimen transverse section. The calcaneofibular ligament (arrow) runs in a quite posterior direction deep to the peroneal tendons. It forms a hammock for the latter.
Fig. 14: Anatomy specimen coronal section. Note calcaneofibular ligament deep to peroneal tendons
**Fig. 15:** Oblique US. The calcaneofibular ligament (arrows) spans the space between fibula (F) and calcaneus (C). It forms a hammock for the peroneal tendons (P). With the foot in dorsiflexion it is taut. It can be much better seen from a posterior approach.
Fig. 16: Coronal PD MR. Arrow shows the calcaneofibular ligament which runs in a quite posterior direction deep to the peroneal tendons. It forms a hammock for the latter. On MR it may be seen in the coronal or transverse plane.
**Fig. 17:** Anatomy specimen. The lateral talocalcaneal (long arrow) ligament is less well known and not consistently present. It is located anterior to the calcaneofibular ligament. Note calcaneofibular ligament (short arrow) that is located more posteriorly.

**Fig. 18:** Long axis US. The lateral talocalcaneal (long arrow) ligament is less well known and not consistently present. It is located anterior to the calcaneofibular ligament. Note calcaneofibular ligament (short arrow) that is located more posteriorly.
Fig. 19: Anatomy specimen medial aspect. The 'deltoid' ligament is a complex structure spanning the entire medial aspect of the joint and is made up of different components: tibiotalar, tiocalcaneal, tibiospring, tibionavicular ligaments. Its anatomy is very variable with different components being larger than others in different patients. It is also more of a continuum of fibers as can be seen in the dissection than all clearly ‘separate’ ligaments.
Fig. 20: Coronal US. The tibiotalar ligament is made up of different fiber bundles and appears striated. This should not be mistaken as evidence of injury.
**Fig. 21:** Coronal MR image. The tibiotalar ligament is made up of different fiber bundles and appears striated. On fat saturated sequences it may appear markedly hyperintense (in part due to the striations) and this should not be mistaken as evidence of injury.
**Fig. 22:** Anatomy specimen coronal section. Note tibiospring ligament (arrows) in continuity with the spring ligament; Between the spring ligament and posterior tibial tendon (T) there is a fibrocartilaginous nodule designated gliding zone (G).

**Fig. 23:** US along long axis of tibiospring ligament (arrows). Note that the ligament terminates in spring ligament (S). Also note gliding zone (G) and adjacent posterior tibial tendon (T)
**Fig. 24:** PD MR image. Note tibiospring ligament (arrows) in continuity with the spring ligament; Between the spring ligament and posterior tibial tendon (T) there is a fibrocartilaginous nodule designated gliding zone (G).
Fig. 25: Coronal MR image. The arrow points to the tibiocalcaneal ligament spanning the space between medial malleolus and calcaneus.

Fig. 26: Anatomy specimen. Medial side. Spring ligament: 1. Superomedial 2. Inferomedial 3. Inferoplantar
Fig. 27: Transverse US. Long axis. Note posterior tibial tendon (T), adjacent to spring ligament (arrows). Note it misses the typical fibrillar aspect of ligaments and tendons.
Fig. 28: Transverse fat saturated MR image. Note spring ligament (arrow) just inferior to superomedial part. There is a joint space between the spring ligament and tarsal head.
Fig. 29: Anatomy specimen, lateral side. Observe calcaneocuboid component of bifurcate ligament (short arrow). The calcaneonavicular component is smaller and difficult to visualize on US and MR. It actually does not originate from the calcaneus but from the calcaneocuboid midportion.

Fig. 30: Long axis US of calcaneocuboid ligament. Note calcaneocuboid component of bifurcate ligament (arrow). Ca, calcaneus, E, extensor digitorum brevis.
**Fig. 31:** Transverse PD MR image. Note calcaneocuboid component of bifurcate ligament (arrow). E, extensor digitorum brevis.

**Fig. 32:** Anatomy specimen. Long arrow indicates long and short plantar ligaments Ca, calcaneus, Cu, cuboid, Peroneus longus tendon (short arrow).
**Fig. 33:** US image. Arrows indicate long and short plantar ligaments.
**Fig. 34:** Transverse PD MR. Note plantar ligament (arrows)

**Fig. 35:** Chopart ligaments: Sagittal ultrasound. Note dorsal talonavicular ligament (arrows).
Fig. 36: Chopart ligaments: Sagittal MR. Note dorsal talonavicular ligament (arrow).
**Fig. 37:** Chopart talonavicular ligament. Sagittal fat saturated MR image: Pathological appearance in strain of the dorsal talonavicular ligament (arrow)
**Fig. 38:** Anatomy specimen coronal section. This is a more anterior section compared to previous showing cervical ligament (arrow). The corresponding coronal MR image is seen in Fig. 41.

**Fig. 39:** Anatomy specimen sagittal section. A more lateral section through sinus tarsi shows the cervical ligament. The sinus tarsi ligaments are deeply seated and can not be seen with US.
**Fig. 40:** Coronal PD MR image. This is a more anterior section through sinus tarsi showing cervical ligament (arrow).

**Fig. 41:** Sagittal PD MR image. A more lateral section through sinus tarsi clearly shows the cervical ligament. The sinus tarsi ligaments are deeply seated and can not be seen with US.
Fig. 42: Anatomy specimen coronal section. This is a more posterior section through sinus tarsi showing interosseous ligament. Next image Fig. 39 is a more anterior section.
showing cervical ligament. Coronal MR images corresponding to Fig. 38 and Fig. 39 are seen in Fig. 40 and Fig. 41, respectively.

**Fig. 43:** Anatomy specimen sagittal section. This section is more medially placed through the canalis tarsi (arrow) containing a rudimentary ligament, the ligament of the canalis tarsi and vessels.
Fig. 44: Coronal PD MR image. This is a more posterior section through sinus tarsi showing interosseous ligament (arrow).
Fig. 45: Sagittal PD MR image. Arrow shows canalis tarsi containing a rudimentary ligament, the ligament of the canalis tarsi and vessels.
**Fig. 46:** Transverse PD MR. The Lisfranc ligament is a complex ligament made up of 3 parts, a dorsal component (arrow), the main central component and a plantar component. The ligaments connect the medial cuneiform with the base of the 2nd MT.
Fig. 47: Transverse PD MR. The Lisfranc ligament is a complex ligament made up of 3 parts, a dorsal component, the main central component (arrow) and a plantar component. The ligaments connect the medial cuneiform with the base of the 2nd MT.
**Fig. 48:** Transverse PD MR. The Lisfranc ligament is a complex ligament made up of 3 parts, a dorsal component, the main central component and a plantar component (arrow). The ligaments connect the medial cuneiform with the base of the 2nd MT, except the plantar component that also connects to the 3th MT.
**Fig. 49:** Sagittal anatomy specimen and US image. At the Lisfranc joints, ligaments (arrow) connect the midtarsal bones to the bases of the metatarsals. These ligaments can be assessed for tear or bone avulsion with US.

**Fig. 50:** Anatomy specimen transverse section and transverse US image: The ligaments connecting the cuneiforms and the bases of metatarsals at the Lisfranc joints can be evaluated with US.
Conclusion

Understanding the normal anatomy and normal US and MR imaging features of the ligaments of the ankle and midfoot joint is crucial to accurate diagnosis of pathologies involving these ligaments.

This pictorial essay correlating the anatomical, US and MR images of normal ankle and midfoot joints ligaments is directed towards serving this purpose.

References

A Few References:


Personal Information

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