Ultrasound and MRI Evaluation of the Lateral Ankle

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Lateral ankle pain is a common clinical complaint and may result from an acute traumatic event, chronic repetitive trauma, impingement syndromes or alignment abnormalities resulting in altered biomechanics. Additional etiologies of ankle pain include synovial proliferative processes, inflammatory arthropathies and crystalline deposition disease. While these articular-based processes typically result in diffuse ankle pain, they may result in localized symptoms and should also be considered in patients with lateral ankle pain. The purpose of this article is to review the common anatomy and pathology of the lateral ankle and to discuss the common imaging findings seen on ultrasound (US) and MRI.

Acute lateral ankle injuries are common and include fractures, ligamentous sprains, and tendinous injuries. Lateral malleolar fractures may occur in isolation or in the setting of bi- or trimalleolar injuries. Lateral ligamentous injuries at the ankle are the most common reason for missed athletic participation, and occur during inversion when the ankle is in the relatively unstable, plantarflexed position.1 Peroneal tendon injuries, including tenosynovitis, tears, or peroneal retinacular injuries may occur in isolation but are common in the setting of lateral ligamentous injuries. Entrapment of peroneal tendons between fracture fragments may occur; tendons should be closely interrogated in patients with ankle fractures. In the acute setting, peroneal tendon injuries may be overlooked and underdiagnosed, as pain and laxity from ankle sprain often dominates the clinical picture.2,3

Radiographs are the first line of imaging and should be obtained in weight-bearing, when possible, to evaluate alignment and integrity of the ankle mortise. While radiographs demonstrate most acute osseous injuries well, direct visualization of soft-tissue pathology often requires additional imaging. Both MRI and US can evaluate the ligaments and tendons of the lateral ankle. US has the advantage of assessing tendon motion during dynamic imaging and ligamentous integrity with applied stress; MRI is superior for the evaluation of intra-articular pathology and marrow signal abnormalities.

Osseous Anatomy of the Ankle

The ankle is composed of three main articulations: the tibiotalar (talocrural) joint, subtalar (talocalcaneal) joint, and the transverse tarsal (midtarsal joint) joint. The tibiotalar joint is a synovial hinge joint between the tibial plafond and talus, and bears most of the load during weight-bearing. Its primary function is dorsiflexion and plantarflexion of the foot, although it aids in inversion/eversion and abduction/adduction as well.4 The subtalar joint consists of three distinct calcaneal articulations and contributes to inversion and eversion of the foot. The transverse tarsal joint, also known as Chopart joint, is a compound joint that includes the talonavicular component of the talocalcaneonavicular joint as well as the calcaneocuboid joint, and assists with inversion and eversion. Collectively, the joints allow for complex motions such as supination (adduction, inversion and plantarflexion) and pronation (adduction, eversion and dorsiflexion) of the foot.4

Acute trauma may result in fractures of the malleoli or fifth metatarsal, which are typically well visualized on radiographs. Fractures of the body or anterior process of the calcaneus, lateral talar process, lateral calcaneus, talus, talar dome and lateral fibula from superior peroneal retinaculum avulsion injuries may be subtle or even occult on radiographs. Advanced imaging is performed in cases when there is a high clinical suspicion for occult fracture, or when more detailed evaluation of the soft tissues is clinically indicated.

Traumatic osteochondral injuries of the talar dome may result in a stable or unstable osteochondral lesion. Symptomatic osteochondral lesions often result in decreased range of motion and cause deep ankle pain with weight-bearing but patients may localize pain to the lateral ankle in the setting of lateral talar dome injuries. MRI is the modality of choice for evaluating osteochondral...
injuries as it can detect signs of instability, including a rim of fluid signal intensity surrounding the lesion, cysts underlyng the lesion, discontinuities in the subchondral bone plate, or displaced intra-articular fragments (Figure 1).5

Ligaments of the Lateral Ankle

The lateral ligaments of the ankle consist of the low ankle ligaments; the anterior talofibular, calcaneofibular and posterior talofibular ligaments; and the high ankle ligaments, the anterior and posterior tibiofibular, and interosseous ligaments (Figure 2). Lateral ankle ligament sprains account for 16% to 21% of sports-related injuries, with a predictable pattern of injury involving the weakest ligament, the anterior talofibular ligament (ATFL), followed by the calcaneo-fibular ligament (CFL), and finally the posterior talofibular ligament (PTFL).6

Low Ankle Ligaments

The ATFL extends from the lateral malleolus to the talus and functions to prevent anterior displacement as well as excessive inversion and internal rotation of the talus on the tibia.7 The ATFL is well visualized on MR as a hypointense band of tissue seen best on axial images (Figure 3A) and on US as a hypoechoic, linear structure seen best with the transducer in an oblique, short-axis plane (Figure 3B).

The CFL arises from the posterior aspect of the lateral malleolus, courses anteriorly on an oblique long axis, deep to the peroneal tendons, to insert on the lateral calcaneus. It functions to prevent excessive inversion and internal rotation as well as prevent excessive supination.7 The CFL is stressed most in dorsiflexion and is the second most injured ligament during ankle injuries. On MRI, evaluation of sequential coronal or axial imaging is required to visualize its oblique course from the tip of the lateral malleolus to the lateral calcaneus (Figure 4A). On US, the CFL is well visualized on a long axis with the transducer in an oblique, short-axis plane (Figure 4B).

The PTFL runs from the posterior aspect of the lateral malleolus, with
variable insertion on the posterolateral aspect of the talus, lateral talar process or os trigonum (if present) and protects the talocrural joint from excessive inversion and internal rotation. It is the least injured low ankle ligament. The PTFL is typically well visualized on axial MR images but can also be seen well in cross-section on sagittal MR images (Figure 5), which may be helpful in assessing the architecture of the ligament in cases of questionable injury on axial images. As the PTFL is injured infrequently, it is not routinely imaged by US, but in cases of clinical suspicion, it can be seen well with the transducer in the short-axis plane over the posterolateral ankle.

Lateral ankle ligament sprains are classified on a three-point grading scale with grade I representing a stretch injury without tear, grade II a partial tear, and grade III a complete tear. Some authors classify low ankle sprains on an anatomic basis, with grade I injuries resulting in partial disruption of the ATFL, grade II involving partial disruption of the ATFL and CFL, and grade III demonstrating complete disruption of the ATFL or CFL. With US or MR imaging, partial thickness injuries demonstrate heterogeneity and thickening of the ligament in the acute period, but are variable in appearance in the chronic setting, with thickening or thinning, ligamentous elongation, or wavy contour.

Complete tears of the ATFL result in a focal gap in the acute setting with

![Figure 3](image-url)

**Figure 3.** Normal appearance of the ATFL connecting the fibula to the talus, seen as a hypointense linear band of tissue on axial T1-weighted MRI (A, arrows) and a linear, fibrillar hypoechoic band of tissue on US (B, arrows).

![Figure 4](image-url)

**Figure 4.** Normal appearance of the CFL connecting the fibula to the calcaneus, seen as a hypointense linear band of tissue (arrows) deep to the peroneal tendons (asterisks) on axial T1-weighted MRI (A) and a linear, fibrillar hypoechoic band of tissue (arrows) deep to the peroneal tendons (asterisks) on US (B).
adjacent hyperemia, ligament redundancy and disorganization of fibers on both MR and US (Figure 6). If varus stress is applied to the ankle during the US examination, gapping of the lateral clear space can be visualized.

**High Ankle Ligaments**

The distal tibia and fibula form a syndesmotic joint, composed of three major ligaments: the anterior tibiofibular, posterior tibiofibular, and interosseous (or transverse) tibiofibular ligament, which stabilize the high ankle.\(^7\) Injuries to the high ankle ligaments occur in < 11% of ankle sprains.\(^8\)

The anterior tibiofibular ligament is trapezoidal in shape and runs from the anterior tubercle of the distal tibia obliquely to the anterior tubercle of the distal fibula. A thickened distal fascicle of the anterior tibiofibular ligament, termed the anterior inferior tibiofibular or Bassett’s ligament, is present in some individuals and can be visualized on MRI.\(^9,10\) Given its oblique orientation, the anterior tibiofibular ligament is difficult to visualize fully on a single MR image, but can be seen on axial MR at the level of the distal syndesmosis (Figure 7A). On US, the anterior tibiofibular ligament is easily visualized with the transducer in the short axis oblique position at the level of the distal syndesmosis (Figure 7B).

The posterior tibiofibular ligament is a triangular ligament that runs from the posterior tibial malleolus to the posterior tubercle of the fibula. It is extremely strong and formed by two independent components, superficial and deep, and has fibers that form a broad base at the tibial insertion.\(^7\) The posterior tibiofibular ligament is the least injured high ankle ligament and can be assessed on axial MR images at the level of the distal syndesmosis. The interosseous ligament is at the far inferior aspect of the distal interosseous membrane and is formed by a dense mass of short fibers, which span the tibia to the fibula. Its contribution to ankle stability is controversial, with some claiming it is insignificant and others claiming it is the primary stabilizing bond between the tibia and fibula.\(^11\)

On initial radiographs, widening of the ankle mortise or distal tibiofibular syndesmosis as well as the presence of Weber B or Weber C lateral malleolus fractures should raise concern for high ankle ligamentous injury, as syndesmotic tears occur in approximately 50% of Weber B and in all Weber C fractures.\(^8\) Injuries to the high ankle ligaments are also graded on the standard three-point scale with grade I representing a stretch injury without tear, grade II a partial tear, and grade III a complete tear. On US and MRI, focal discontinuity of the ligament is consistent with a grade III, or complete, tear (Figure 8). Ligamentous thickening, laxity or irregular contour suggests a less severe grade

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**FIGURE 5.** Normal appearance of the PTFL, seen as a hypointense linear band of tissue connecting the fibula with the talus on axial T1 image (A, arrows). The PTFL can also be seen in cross section on sagittal fat-saturated T2-weighted images (B, arrows). As the PTFL is infrequently injured, it is not often assessed on US.

**FIGURE 6.** Acute ATFL tear on US (A,B arrows) and axial T2 fat-saturated MRI (C, arrow) with ligamentous laxity, a focal defect at the talar insertion (asterisks), associated hyperemia on power Doppler US (B) and surrounding edema on MRI (B). [f = fibula]
II injury (Figure 9). Abnormal signal or echogenicity without structural abnormality is consistent with a grade I injury. Surrounding edema or hyperemia on Doppler US interrogation provides insight into acuity, as chronic injuries typically demonstrate irregular morphology without surrounding soft-tissue abnormalities.

**Tendons of the Lateral Ankle**

The peroneus longus muscle originates from the head of the fibula, and the peroneus brevis muscle originates from the mid-distal lateral fibula and the intermuscular septum. They both course distally in the lateral compartment of the lower leg. At the ankle, the tendons course through the retromalleolar groove of the fibula where they are both within a common peroneal tendon sheath and stabilized by the superior peroneal retinaculum (Figure 10). From there, the peroneus longus tendon courses inferomedially along the plantar foot to insert on the lateral plantar aspect of the first metatarsal base and stabilized by the superior peroneal retinaculum. The peroneus brevis courses anteriorly to insert on the lateral base of the fifth metatarsal.

**FIGURE 7.** Normal anterior and posterior tibiofibular ligaments on axial T1-weighted MRI (A, arrows), seen as linear hypointense bands of tissue at the distal tibiofibular syndesmosis. Normal anterior tibiofibular ligament on US (B, arrows), seen as a linear, fibrillar hypoechoic band of tissue at the distal tibiofibular syndesmosis.

**FIGURE 8.** Acute high ankle sprain with a grade III injury to the anterior tibiofibular ligament, seen on axial T1-weighted (A) and fat-saturated T2-weighted (B) axial MR images. The anterior tibiofibular ligament is focally disrupted at its fibular attachment (arrows) and there is surrounding edema on fat-saturated, T2 axial images. The posterior tibiofibular ligament is intact (interrupted arrows).

**FIGURE 9.** Acute high ankle sprain with grade II injury to the anterior tibiofibular ligament on US, seen as thickening of the ligament (arrows) with central architectural distortion and hypoechogenicity (asterisks), compatible with partial ligamentous disruption.
Pathology

Peroneal tendon pathology may result from acute injury or chronic repetitive trauma. Pathologic entities include tendinosis, tenosynovitis, tendon tears and injury to the superior peroneal retinaculum (SPR), which may predispose a patient to tendon subluxation or dislocation.\(^3\)

MR imaging has been described as the “gold standard” for imaging peroneal tendon pathology, and is a well-established technique to visualize fixed subluxation/dislocation of the peroneal tendons.\(^3,6,13,14\) Normally, peroneus longus is anterior and slightly lateral (or superficial) to the peroneus brevis, which is more posterior.
and medial, abutting the posterior cortex of the distal fibula. The supramalleolar tendons are relatively equal in size on axial MR and short-axis US (Figure 11). Normal peroneal tendons appear hypointense on MRI, as oval echogenic structures on short-axis US (Figure 12A), and demonstrate linear, fibrillar echotexture on long-axis US (Figure 12B).

Tenosynovitis is seen as T2-hyperintense material on MR or anechoic material on US contained within the tendon sheath, surrounding intact tendons (Figure 13). Tendinosis is seen
as thickening of the intact tendons, with intermediate T2 signal intensity on MRI and hypoechochogenicity and architectural distortion on US and can range from mild tendinosis (Figure 14) to severe tendinosis with early intrasubstance tearing (Figure 15). Longitudinal split tears, most commonly affecting the peroneus brevis tendon, are seen as an anechoic or hypoechoic linear defect paralleling the tendon fibers on long-axis imaging, or can be demonstrated by separating the tendon into two distinct components on short-axis imaging (Figure 16). The presence of three distinct tendons on short-axis US or axial MR images is diagnostic of a longitudinal split tear. Full thickness tears are much less common but may occur in tendons with longstanding or severe tendinosis. Occasionally, a full thickness tear of the peroneus longus tendon may be detected radiographically by noting proximal displacement of an os peroneum (Figure 17).

SPR tears and resultant peroneal tendon subluxation/dislocation are also well visualized by US. Peroneal tendon subluxation is most commonly found in athletes, resulting from disruption of the superior peroneal retinaculum (SPR), and is often associated with dorsiflexion of the ankle and concomitant eversion or inversion of the foot. Although the retinaculum is not directly visualized radiographically, an avulsion fracture of the lateral, distal fibular cortex may be identified, indicating SPR deficiency.
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**FIGURE 18.** Frontal (A) and oblique (B) radiographs demonstrating a superior peroneal retinaculum avulsion fracture of the lateral malleolar cortex (arrows), predisposing the patient to peroneal tendon pathology, including tendon subluxation/dislocation.

**FIGURE 19.** Short-axis US demonstrating dislocation of the peroneal tendons (PB, PL), which are positioned superficial and lateral to the distal fibular cortex (A). Even though the SPR is not directly visualized in this image, it is disrupted, allowing for the lateral and anterior displacement of the tendons. A normal short-axis image at this level is included (B) for direct comparison.

**FIGURE 20.** Multiple static sonographic images during ankle circumduction (A) demonstrating intrasheath subluxation of the peroneal tendons in which peroneus longus and brevis tendons reverse their normal positions in the common peroneal tendon sheath but remain within the retromalleolar groove. Normal tendon motion is demonstrated for comparison (B).

Peroneal tendon subluxation is relatively uncommon, occurring in 0.3% to 0.5% of traumatic ankle injuries, and is frequently masked by other ankle pathologies or misdiagnosed as an ankle sprain. However, accurate diagnosis of pathologic peroneal tendon subluxation is critical, as conservative measures are often inadequate and surgery is commonly required for complete return of function and symptom resolution.

MRI and US may directly demonstrate disruption of the superior peroneal retinaculum and resultant fixed subluxation/dislocation of the peroneal tendons. Transient, or dynamic, tendon subluxation or dislocation is more difficult to assess on MR, but US is ideal for assessing dynamic peroneal tendon subluxation, as the tendons can be visualized in real time. During
dynamic US evaluation, the patient performs provocation maneuvers such as ankle dorsiflexion and plantarflexion or circumduction, while the peroneal tendons are imaged in the short axis.\textsuperscript{15,16} Displacement of the peroneal tendons lateral to the fibular cortex is diagnostic.

A specific subtype of peroneal subluxation is intrasheath subluxation, during which the peroneus longus and brevis tendons reverse their normal position in the common peroneal tendon sheath but remain within the retromalleolar groove, with an intact retinaculum.\textsuperscript{15} (Figure 20) Patients with intrasheath subluxation may present with “popping” or “snapping” during ankle circumduction, as the tendons are displaced. It is unknown whether intrasheath peroneal tendon subluxation represents a pathologic entity or is a result of normal supramalleolar peroneal tendon motion. Therefore, it is important to note any symptom reproduction during the dynamic US examination.

**Anatomic Variants**

Aside from traumatic injuries, several anatomic variants of the lateral ankle may predispose a patient to peroneal tendon pathology. Lack of concavity of the distal posterior fibula of the retromalleolar groove may predispose a patient to peroneal tendon dislocation and subluxation.\textsuperscript{2,14,17} Additionally, a prominent peroneal tubercle on the lateral calcaneus may predispose a patient to peroneal tendon pathology. Anatomic variations in muscles, such as a peroneus quartus muscle or a low-lying peroneus brevis muscle belly may cause crowding of the tendons in the retromalleolar groove, leading to pathology.\textsuperscript{2,3,13}

**Other Pathology of the Lateral Ankle**

Anterolateral ankle impingement is a distinct entity, often seen in young, athletic patients, and is likely secondary to repetitive microtrauma and microinstability.\textsuperscript{18} Over time, microtrauma results in excessive hemorrhage, scar tissue formation and synovial hypertrophy in the lateral gutter of the ankle, eventually leading to impingement. The lateral gutter is defined by the tibia (posteromedially), fibula (laterally), tibiotalar joint capsule, ATFL and CFL (anterolaterally). As there is no associated high-grade ligamentous injury, these patients present with a stable ankle on examination, but
often have decreased dorsiflexion and a palpable soft-tissue mass at the anterolateral ankle.

Another subgroup of patients with anterolateral ankle impingement includes those with an accessory ligament or thickened distal fascicle of the anteroinferior tibiofibular ligament, a normal variant that may be present in 21% to 97% of ankles. In these patients, a prior lateral ankle sprain results in ligamentous instability, which allows for anterior extrusion of the talar dome and increased pressure at the anterolateral ankle during dorsiflexion.

Over time, this leads to synovial hypertrophy and impingement of soft tissues between the anterolateral talus and the accessory anteroinferior tibiofibular ligament. Both MRI and US can identify synovial/capsular hypertrophy in the anterolateral gutter, seen as heterogenous synovial mass on US and T1/T2 intermediate-to low-signal synovial hypertrophy and scar tissue in the anterolateral gutter on MRI (Figure 21).

Extra-articular soft-tissue and osseous impingement may also occur at the lateral ankle. Talocalcaneal and subfibular impingement may occur in the setting of pes planovalgus secondary to lateral shift of weight-bearing forces from the talar dome to the lateral talus and fibula (Figure 22). Eventually, progressive deformity leads to secondary osteoarthritis of the subtalar, talonavicular, and calcaneocuboid joints. MRI can provide detailed information about intra-articular pathology such as osteochondral lesions, osteoarthritis, and narrow edema-like signal in the setting of acute trauma and contusion.

Finally, articular-based processes such as synovial chondromatosis, pigmented villonodular synovitis, and inflammatory arthropathies, as well as crystalline deposition diseases such as gout and pseudogout, may be seen in the ankle. Although these often result in diffuse symptoms, they can present with lateral ankle pain if disease is asymmetric or focal.

Conclusion

Lateral ankle pain most commonly results from osseous, ligamentous or tendinous injury, but other etiologies should be considered in the nontraumatic setting. Although radiographs are an important first line of imaging, MRI and US can provide important diagnostic information regarding soft-tissue pathology around the ankle and should be considered in patients with lateral ankle pain.

REFERENCES