

Charcot neuroarthropathy

Anatomy & Pathophysiology

BONY ANATOMY

- The ankle mortise is formed by the tibial plafond, medial malleolus, and lateral malleolus [3].
- The ankle mortise articulates with the dome of the talar body [3].
- The talar dome is wider anteriorly and narrower posteriorly [3].
- The ankle mortise widens 1 to 1.5 mm during motion from plantar flexion to dorsiflexion [3].
- Medial and superior clear spaces appear wider with the foot in plantar flexion [3].
- The distal fibula has a convex medial surface that articulates with the concave incisura fibularis of the distal lateral tibia [3].
- The fibula rotates approximately 2 degrees within the incisura during ankle motion and ambulation [3].
- Ankle dorsiflexion results in external rotation and proximal translation of the fibula [3].
- The primary functions of the foot and ankle are to provide weight-bearing support and forward ambulation [3].

LIGAMENTOUS ANATOMY

- The lateral ankle ligaments function as restraints to varus and inversion forces at the ankle [3].
- The anterior talofibular ligament (ATFL) originates from the anteroinferior aspect of the lateral malleolus, 1 cm proximal to its tip, and extends to the lateral aspect of the talar neck [3].
- The calcaneofibular ligament (CFL) extends from the tip of the lateral malleolus to the lateral aspect of the calcaneus [3].
- The posterior talofibular ligament (PTFL) extends from the posterior lateral malleolus to the posterolateral talus [3].
- The ATFL is the weakest ankle ligament [3].
- The PTFL is the strongest ankle ligament [3].
- The distal tibiofibular joint (ankle syndesmosis) and fibula provide stability against lateral talar translation [3].

- The deltoid ligament complex is the primary ankle stabilizer during stance [3].
- The deep deltoid ligament extends from the apex of the medial malleolus to the medial talar body [3].
- The deep deltoid ligament functions primarily to resist lateral talar translation and external rotation [3].
- The posterior deep deltoid is the most important component of the deep deltoid ligament [3].
- The superficial deltoid ligament extends from the distal medial malleolus to the navicular bone, sustentaculum tali of the calcaneus, medial talus, and spring ligament [3].
- The superficial deltoid ligament functions primarily to resist valgus and eversion ankle forces [3].
- The deltoid ligament consists of superficial and deep layers, with at most six bands, of which only three are constant: the tibionavicular ligament, tibiospring ligament, and deep posterior tibiotalar ligament [8].
- The superficial layer of the deltoid ligament originates from the anterior malleolus and inserts into the navicular, neck of the talus, sustentaculum tali, and posteromedial talar tubercle [8].
- The tibiocalcaneal portion of the superficial deltoid ligament is the strongest component and resists eversion of the calcaneus [8].
- The deep portion of the deltoid ligament is organized into two short, thick, discrete bands: the anterior and posterior deep tibiotalar ligaments [8].
- The anterior and posterior deep tibiotalar ligaments are intra-articular but extrasynovial [8].
- The deep posterior band comprises the largest band of the deltoid complex [8].
- The anterior deep tibiotalar ligament arises from the anterior malleolus and attaches to the medial aspect of the talus [8].
- The posterior deep tibiotalar ligament originates from the posterior malleolus and inserts on the medial body of the talus [8].
- The deltoid ligament has a rich vascular supply from three extraosseous sources: the medial tarsal artery, posterior tibial artery, and tibialis anterior artery [8].
- The deltoid ligament also has an intraosseous vascular supply from either the talus or the medial malleolus [8].
- The deep deltoid ligament has the highest load to failure at $713.8 \text{ N} \pm 69.3$ compared with the lateral collateral ligaments [8].
- The dominant mode of failure for the deep deltoid ligament is an intrasubstance rupture near its talar insertion [8].
- The dominant mode of failure for the superficial deltoid ligament is at its insertion on the anterior malleolus [8].

BIOMECHANICS

- The ankle joint is responsible for most sagittal plane motion of the foot and ankle [3].
- Ankle plantar flexion ranges from 23 to 48 degrees [3].
- Ankle dorsiflexion ranges from 10 to 23 degrees [3].
- The ankle joint also contributes to inversion, eversion, and rotation [3].

- A simplified model of the ankle joint has a horizontal axis from anteromedial to posterolateral [3].
- A simplified model of the ankle joint has a coronal axis from superomedial directed distally and laterally to the tip of the fibula [3].
- The deltoid ligament, specifically the tibiocalcaneal ligament, primarily prohibits eversion and abduction [8].
- The deep deltoid ligament, primarily the deep posterior tibiotalar ligament, resists external rotation when the foot is dorsiflexed [8].
- The deep deltoid ligament is responsible for the greatest restraint against lateral translation [8].
- Valgus tilting of the talus within the mortise requires complete rupture of both the superficial and deep deltoid ligaments [8].

NEUROVASCULAR ANATOMY

- The superficial peroneal nerve penetrates the deep fascia and lies subcutaneously 8 to 10 cm proximal to the tip of the lateral malleolus, anterior to the subcutaneous border of the fibula shaft [6].
- The deep peroneal nerve accompanies the anterior tibial artery between the tendons of the anterior tibial and extensor digitorum longus muscles [6].
- The deep peroneal nerve lies just lateral to the anterior tibial artery and just lateral to the extensor hallucis longus tendon [6].
- The saphenous nerve is located just medial or posterior to the saphenous vein in a slightly deeper plane, 3 to 5 cm proximal to the tip of the medial malleolus [6].
- The anterior tibial artery can usually be palpated beneath the superior extensor retinaculum 4 to 5 cm proximal to the distal articular surface of the tibia [6].
- The peroneal tendons and superficial peroneal nerve are at the highest risk during intramedullary nailing of distal fibular fractures [11].
- An accessory incision for arthroscopic repair of the lateral ligament should not surpass 22 mm distance from the lateral malleolus in the anterior direction to avoid damaging the superficial peroneal nerve [11].

FRACTURE CLASSIFICATION

- The Danis–Weber Type A classification describes a transverse fracture of the fibula below the tibiofibular syndesmosis, sometimes associated with an oblique or vertical fracture of the medial malleolus [7].
- The Danis–Weber Type B classification describes an oblique fracture of the fibula in the sagittal plane at the level of the syndesmosis, often accompanied by an avulsion injury on the medial side [7].
- The Danis–Weber Type C classification describes a fracture above the level of the syndesmosis, indicating that the tibiofibular ligament and part of the interosseous membrane must have been torn [7].
- To achieve a reduced ankle, the fibula must be restored to its full length [7].
- To achieve a reduced ankle, the talus must sit squarely in the mortise with no tilt [7].
- To achieve a reduced ankle, the medial joint space must be restored to its normal width [7].

- To achieve a reduced ankle, there must be no tibiofibular diastasis [7].

Investigations

GENERAL IMAGING PRINCIPLES

- Advanced imaging is often helpful in diagnosis when combined with a thorough clinical examination [15].
- MRI is sensitive for all osteochondral lesions of the ankle, but the edema pattern frequently overestimates the severity of injury [12, 13].
- Linear fluid signal deep to subchondral bone on MRI indicates an unstable osteochondral injury [12, 13].
- MRI has a sensitivity of 92% for predicting stable versus unstable osteochondral lesions [12, 13].

OSTEOCHONDRAL LESIONS

- Osteochondral lesions are seen in up to 70% of ankle sprains and 75% of ankle fractures [12, 13].
- The most common location for osteochondral lesions is the medial talar dome [12, 13].
- Modern data prove that the most common location for medial talar dome osteochondral lesions is central [12, 13].
- Medial talar dome osteochondral lesions are larger and deeper than lateral lesions [12, 13].
- The most common location for lateral talar dome osteochondral lesions is central [12, 13].
- Lateral talar dome osteochondral lesions are more often unstable, displaced, or symptomatic than medial lesions [12, 13].
- AP, mortise, and lateral weight-bearing ankle x-rays may not demonstrate subtle osteochondral lesions [12, 13].
- CT scan is helpful for determining the integrity of subchondral bone and identifying cysts in osteochondral lesions [12, 13].

ANKLE FRACTURES AND SYNDESMOSIS

- MRI lacks additional diagnostic value for stability assessment of the ankle mortise in supination-external rotation-type ankle fractures [16].
- Preoperative computed tomography scans are used in operative planning for malleolar ankle fractures [16].
- Malreduction of the posterior malleolus is significantly more likely to lead to malreduction of the syndesmosis [16].

LIGAMENTOUS AND SOFT TISSUE PATHOLOGY

- MRI is used for the evaluation of posterior tibial tendon dysfunction with relevance to clinical staging [1].
- MRI is used for the evaluation of anterolateral soft tissue impingement of the ankle [1, 17].
- MRI is used for the evaluation of osteochondral lesions of the talus [1].

- MRI is used for the diagnosis of ligamentous and chondral pathology in the ankle [1].
- MRI and stress radiography are used in the evaluation of chronic lateral ankle instability [1].
- MRI is used for pre-operative evaluation of the anterior talofibular ligament in chronic ankle instability [1].
- MRI findings are associated with symptoms in patients with chronic ankle sprain [1].
- MRI is used for the imaging evaluation of traumatic ligamentous injuries of the ankle and foot [1].
- MRI is used for the musculotendinous imaging of the ankle [1].
- CT and MR imaging are used for the evaluation of the postoperative ankle and foot [1].
- MRI is used for the diagnosis of plantar plate injury with reference to intraoperative findings [1].
- MRI is compared to physical examination for the diagnosis of syndesmotic injury after lateral ankle sprain [2].
- Peroneal tendon abnormalities are identified on routine magnetic resonance imaging of the foot and ankle [14].

ENTRAPMENT NEUROPATHIES

- MR imaging is used for the evaluation of entrapment neuropathies of the lower extremity, including the knee, leg, ankle, and foot [18].
- Point-of-care ultrasonography is used in the diagnosis and management of superficial peroneal nerve entrapment [18].

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