

Total ankle replacement

Anatomy & Pathophysiology

BONY ANATOMY

- The ankle mortise is formed by the tibial plafond, medial malleolus, and lateral malleolus [5].
- The ankle mortise articulates with the dome of the talar body [5].
- The talar dome is wider anteriorly and narrower posteriorly [5].
- The ankle mortise widens 1 to 1.5 mm during motion from plantar flexion to dorsiflexion [5].
- Medial and superior clear spaces appear wider with the foot in plantar flexion [5].
- A simplified model of the ankle joint has a horizontal axis from anteromedial to posterolateral [5].
- A simplified model of the ankle joint has a coronal axis from superomedial directed distally and laterally to the tip of the fibula [5].
- The distal fibula has a convex medial surface [5].
- The incisura fibularis is the concave surface of the distal lateral tibia [5].
- The fibula rotates approximately 2 degrees within the incisura during ankle motion and ambulation [5].
- Ankle dorsiflexion results in external rotation and proximal translation of the fibula [5].

LIGAMENTOUS ANATOMY

- Lateral ankle ligaments function as restraints to varus and inversion forces at the ankle [5].
- The anterior talofibular ligament (ATFL) originates from the anteroinferior aspect of the lateral malleolus, 1 cm proximal to its tip [5].
- The anterior talofibular ligament extends to the lateral aspect of the talar neck [5].
- The calcaneofibular ligament (CFL) extends from the tip of the lateral malleolus to the lateral aspect of the calcaneus [5].
- The posterior talofibular ligament (PTFL) extends from the posterior lateral malleolus to the posterolateral talus [5].
- The ATFL is the weakest ankle ligament [5].

- The PTFL is the strongest ankle ligament [5].
- The distal tibiofibular joint and fibula provide stability against lateral talar translation [5].
- The deltoid ligament complex is the primary ankle stabilizer during stance [5].
- The deep deltoid ligament extends from the apex of the medial malleolus to the medial talar body [5].
- The deep deltoid ligament functions primarily to resist lateral talar translation and external rotation [5].
- The posterior deep deltoid is the most important component of the deep deltoid ligament [5].
- The superficial deltoid ligament extends from the distal medial malleolus to the navicular bone, sustentaculum tali of calcaneus, medial talus, and spring ligament [5].
- The superficial deltoid ligament functions primarily to resist valgus and eversion ankle forces [5].
- The deltoid ligament consists of superficial and deep layers, with at most six bands [11].
- Only three bands of the deltoid ligament are constant: the tibionavicular ligament, tibiospring ligament, and deep posterior tibiotalar ligament [11].
- 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 [11].
- The tibiocalcaneal portion of the superficial deltoid ligament is the strongest component and resists eversion of the calcaneus [11].
- The deep portion of the deltoid ligament is the primary medial stabilizer of the ankle joint [11].
- The deep deltoid ligament is organized into two short, thick, discrete bands: the anterior and posterior deep tibiotalar ligaments [11].
- The anterior and posterior deep tibiotalar ligaments are intra-articular but extrasynovial [11].
- The deep posterior band comprises the largest band of the deltoid complex [11].
- The anterior deep tibiotalar ligament arises from the anterior malleolus and attaches to the medial aspect of the talus [11].
- The posterior deep tibiotalar ligament originates from the posterior malleolus and inserts on the medial body of the talus [11].
- The deltoid ligament has a rich vascular supply from three extraosseous sources: the medial tarsal artery, posterior tibial artery, and tibialis anterior artery [11].
- The deltoid ligament also has intraosseous vascular supply from either the talus or the medial malleolus [11].
- The deep deltoid ligament has the highest load to failure at $713.8 \text{ N} \pm 69.3$ compared with the lateral collateral ligaments [11].
- The dominant mode of failure for the deep deltoid ligament is an intrasubstance rupture near its talar insertion [11].
- The failure of the superficial deltoid ligament is most commonly at its insertion on the anterior malleolus [11].

BIOMECHANICS & MOTION

- The primary functions of the foot and ankle are to provide weight-bearing support and forward ambulation [5].
- The ankle is responsible for most sagittal plane motion of the foot and ankle [5].
- Ankle plantar flexion ranges from 23 to 48 degrees [5].
- Ankle dorsiflexion ranges from 10 to 23 degrees [5].
- The ankle contributes to inversion, eversion, and rotation [5].

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 [9].
- The anterior tibial artery can be palpated beneath the superior extensor retinaculum 4 to 5 cm proximal to the distal articular surface of the tibia [9].
- The deep peroneal nerve accompanies the anterior tibial artery and lies between the tendons of the anterior tibial and extensor digitorum longus [9].
- The deep peroneal nerve lies just lateral to the anterior tibial artery [9].
- 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 [9].

PATHOPHYSIOLOGY OF INJURY

- More than 75% of ankle ligament injuries involve the lateral ligament complex, particularly the ATFL and CFL [12].
- Medial ligament injuries are usually seen in association with a fracture or joint injury [12].
- In an ATFL sprain, tenderness is maximal just distal and slightly anterior to the lateral malleolus [12].
- The deltoid ligament primarily prohibits eversion and abduction [11].
- The deep deltoid ligament resists external rotation when the foot is dorsiflexed [11].
- The deep deltoid ligament is responsible for the greatest restraint against lateral translation [11].
- Valgus tilting of the talus within the mortise requires complete rupture of both the superficial and deep deltoid ligaments [11].
- Isolated rupture of the deltoid ligament without lateral ligamentous or fibular injury is rare [11].
- Syndesmotic injury, lateral ligamentous injury, and fibular fractures are common associations with deltoid injury [11].
- The criteria for diagnosis of medial instability include a feeling of giving way, medial ankle joint pain, and a correctable valgus or pronation deformity [11].
- Medial instability is reinforced by excess motion in external rotation, eversion, valgus, and/or posterior translation [11].

- With complete deltoid injury, a valgus AP stress radiograph shows talar tilt and/or lateral translation of the talus [11].
- Most incomplete deltoid injuries are normal on standard radiographic imaging [11].
- MRI is the imaging modality of choice for defining injury to the deltoid ligaments and associated structures [11].
- Ankle arthroscopy allows direct assessment of the deltoid ligament with lateral stress applied to the talus [11].

Investigations

OSTEOCHONDRAL LESIONS

- Osteochondral lesions of the ankle are seen in up to 70% of ankle sprains and 75% of ankle fractures [15, 16].
- The most common location for osteochondral lesions is the medial talar dome [15, 16].
- Modern data indicate that the most common location for medial talar dome lesions is central, contradicting historical beliefs that the posterior location was more common [15, 16].
- Medial talar dome lesions are larger and deeper than lateral lesions [15, 16].
- Lateral talar dome lesions are less common than medial lesions [15, 16].
- Lateral talar dome lesions are more often unstable, displaced, or symptomatic than medial lesions [15, 16].
- Lateral talar dome lesions are often refractory to conservative measures [15, 16].
- Physical examination for osteochondral lesions demonstrates deep pain over the ankle joint line [15, 16].
- Palpation often does not reproduce the symptoms described by patients with osteochondral lesions [15, 16].
- Ankle effusion is common in patients with osteochondral lesions [15, 16].
- AP, mortise, and lateral weight-bearing ankle x-rays may not demonstrate subtle osteochondral lesions [15, 16].
- CT scan is helpful for determining the integrity of subchondral bone and identifying cysts in osteochondral lesions [15, 16].
- MRI is sensitive for all osteochondral lesions [15, 16].
- The edema pattern on MRI frequently overestimates the severity of osteochondral injury [15, 16].
- Linear fluid signal deep to subchondral bone on MRI indicates an unstable osteochondral injury [15, 16].
- MRI has a sensitivity of 92% for predicting stable versus unstable osteochondral lesions [15, 16].

GENERAL IMAGING AND DIAGNOSIS

- Advanced imaging is often helpful in the diagnosis of foot and ankle injuries when combined with a thorough clinical examination [18].

- MRI is used for the evaluation of tibiofibular syndesmotric ligaments [3].
- MRI is used for the evaluation of posterior tibial tendon dysfunction [3].
- MRI is used for the evaluation of anterolateral soft tissue impingement of the ankle [3, 20].
- MRI is used for the evaluation of osteochondral lesions of the talus [3].
- MRI is used for the diagnosis of ligamentous and chondral pathology in the ankle [3].
- MRI and stress radiography are used in the evaluation of chronic lateral ankle instability [3].
- MRI is used in the pre-operative evaluation of the anterior talofibular ligament in chronic ankle instability [3].
- MRI is used for the diagnosis of ruptures of the tibialis posterior tendon [3].
- MRI is used for the imaging evaluation of traumatic ligamentous injuries of the ankle and foot [3].
- MRI is used for the diagnosis of plantar plate injury [3].
- MRI findings are associated with symptoms in patients with chronic ankle sprain [3].
- MRI is used for the evaluation of chronic Achilles tendon ruptures [3].
- MRI is used for the evaluation of peroneal tendon abnormalities [17].
- MR imaging is used for the evaluation of entrapment neuropathies of the lower extremity, including the ankle and foot [21].
- Ultrasonography is used for the examination of the deltoid ligament in bimalleolar equivalent fractures [19].
- Point-of-care ultrasonography is used in the diagnosis and management of superficial peroneal nerve entrapment [21].
- MRI lacks additional diagnostic value for stability assessment of the ankle mortise in supination-external rotation-type ankle fractures [19].
- Preoperative computed tomography scans are used in operative planning for malleolar ankle fractures [19].
- Axial CT imaging is used to evaluate normal tibiofibular relationships at the syndesmosis [19].
- Radiographic evaluation of the normal distal tibiofibular syndesmosis is a standard diagnostic consideration [19].
- Fluoroscopy is used to assess if the syndesmosis is reduced [19].
- The ankle fracture spur sign is pathognomonic for a variant ankle fracture [19].
- Evaluation of posterior malleolar fractures and the posterior pilon variant is performed in operatively treated ankle fractures [19].
- Stability criteria for nonoperative ankle fracture management are established via radiographic assessment [19].
- Gravity stress radiographs are used to assess deltoid ligament integrity and medial clear space measurements [4].
- Radiographic identification of primary lateral ankle structures is possible [4].

- Comparison of magnetic resonance imaging to physical examination is performed for syndesmotic injury after lateral ankle sprain [4].

Treatment

COMPLICATIONS AND REVISION

- Revision of failed total ankle arthroplasty can be performed as a hindfoot fusion [1].
- Infection in total ankle arthroplasty requires specific diagnostic and treatment protocols [1].
- Patient-related risk factors for periprosthetic joint infection have been analyzed in a cohort of 6977 total ankle arthroplasties [1].
- Risk factors for symptomatic deep-vein thrombosis exist in patients after total ankle replacement who received routine chemical thromboprophylaxis [1].
- Perioperative outcomes of total ankle arthroplasty differ when performed at an orthopaedic specialty hospital versus an academic teaching hospital [1].
- Salvage of failed total ankle arthroplasty can be achieved with fusion using structural allograft and internal fixation [1].
- Bone lysis of the AES total ankle replacement is subject to clinical evaluation and radiographic assessment [1].
- Heterotopic ossification can occur after total ankle arthroplasty [1].
- Risks associated with total ankle arthroplasty have been evaluated in the literature [1].
- Short-term complications are associated with procedures performed through separate incisions during total ankle replacement [1].
- The ankle arthritis score is associated with the need for revision surgery [1].
- Patient risk factors do not impact 90-day readmission and emergency department visitation after total ankle arthroplasty [1].
- Supramalleolar osteotomy is a treatment for tibial component malposition in total ankle replacement [1].
- Hindfoot arthritis progression and arthrodesis risk occur after total ankle replacement [1].
- Arthroscopic debridement is a management option after total ankle arthroplasty [1].
- Failures of total ankle replacement can be managed with the Agility total ankle arthroplasty [1].
- Blood transfusion during total ankle arthroplasty is associated with increased in-hospital complications and cost [1].
- A three-grade classification of complications has been assessed for total ankle replacement [1].
- Soft tissue reconstruction is performed after total ankle arthroplasty [1].
- Operative wound complications occur following total ankle arthroplasty [1].
- Bone grafting of bone cysts is an outcome management strategy after total ankle arthroplasty [1].

- Secondary arthrodesis is performed after total ankle arthroplasty [1].
- Short-term perioperative complications and mortality occur after total ankle arthroplasty in the United States [1].
- The incidence of symptomatic thromboembolic events is low after total ankle arthroplasty without routine use of chemoprophylaxis [1].
- Evaluation and management strategies exist for the painful total ankle arthroplasty [1].
- Anterior heterotopic ossification at the talar neck can occur after total ankle arthroplasty [1].
- Salvage arthrodesis is performed for failed total ankle replacement [1].
- Platelet-rich plasma has been evaluated for its efficacy in incision healing after total ankle replacement using the Agility system [1].
- Computed tomography has been evaluated for its added information on radiographic analysis in detecting periprosthetic osteolysis after total ankle arthroplasty [1].
- The impact of complications in total ankle replacement and ankle arthrodesis has been analyzed with a validated outcome measurement [1].
- Revision rates after total ankle arthroplasty have been reported in sample-based clinical studies and national registries [1].
- Acute hematogenous periprosthetic joint infection in total ankle arthroplasty can be treated with irrigation, debridement, and polyethylene exchange [1].
- Cigarette use is associated with complication rates and outcomes following total ankle arthroplasty [1].
- Heterotopic ossification occurs after primary total ankle arthroplasty [1].
- Delayed onset medial malleolar pain following total ankle arthroplasty has a defined etiology and treatment [1].
- Periprosthetic fractures occur in total ankle replacement [1].

GENERAL OUTCOMES AND TRENDS

- Postoperative range of motion trends have been documented following total ankle arthroplasty [2].
- Total ankle arthroplasty outcomes have been compared for post-traumatic and primary osteoarthritis [2].
- Total ankle arthroplasty has been reported in France [2].
- Results of total ankle arthroplasty have been published [2].
- The success of current ankle replacements has been evaluated in a systematic review of the literature [2].
- The 10-year survival of total ankle arthroplasties was reported on 780 cases from the Swedish ankle register [2].
- Outcomes after total ankle arthroplasty have been reported from worldwide arthroplasty registers [2].
- Trends in total ankle arthroplasty and revisions have been analyzed in the Medicare database [2].
- Inconsistency in the reporting of adverse events in total ankle arthroplasty has been identified in a systematic review [2].

- Trends in the use of total ankle replacement and ankle arthrodesis have been analyzed in the United States Medicare population [2].
- Changes in pain, function, and gait mechanics two years following total ankle arthroplasty performed with two modern fixed-bearing prostheses have been documented [2].
- Trends in treatment of advanced ankle arthropathy by total ankle replacement or ankle fusion have been analyzed [2].
- The utilization of total ankle replacement in the United States has been assessed [2].
- Total ankle replacement was studied in a population-based study of 515 cases from the Finnish arthroplasty registry [2].
- Practice patterns in total ankle replacement and ankle fusion in the United States have been compared [2].
- Patient and practice trends in total ankle replacement and ankle arthrodesis in the United States from 2007 to 2013 have been analyzed [2].
- The evolution of the technology and future applications of total ankle replacement have been discussed [2].

Complications

- Revision of failed total ankle arthroplasty to a hindfoot fusion is a documented salvage procedure [1].
- Perioperative outcomes for total ankle arthroplasty differ when performed at an orthopaedic specialty hospital versus an academic teaching hospital [1].
- Salvage of failed total ankle arthroplasty can be performed with fusion using structural allograft and internal fixation [1].
- Heterotopic ossification is a recognized complication after total ankle arthroplasty [1].
- The risks associated with total ankle arthroplasty have been specifically evaluated [1].
- Supramalleolar osteotomy is used to treat tibial component malposition in total ankle replacement [1].
- A three-grade classification of complications in total ankle replacement has been assessed [1].
- Anterior heterotopic ossification at the talar neck occurs after total ankle arthroplasty [1].
- Computed tomography has been evaluated for its ability to add information on radiographic analysis in detecting periprosthetic osteolysis after total ankle arthroplasty [1].
- The impact of complications in total ankle replacement and ankle arthrodesis has been analyzed using a validated outcome measurement [1].
- Inconsistency exists in the reporting of adverse events in total ankle arthroplasty [2].

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