

Ankle arthrodesis

Overview

- Ankle arthrodesis has long been the gold standard for the surgical treatment of moderate to severe ankle arthritis [8].
- Circumstances in which ankle arthrodesis might be the best procedure include preexisting subtalar or other hindfoot arthritis [8].
- Circumstances in which ankle arthrodesis might be the best procedure include contralateral hindfoot or ankle arthritis [8].
- Circumstances in which ankle arthrodesis might be the best procedure include hip or knee impairment such that motion through the ankle joint may be beneficial to the overall limb and patient function [8].
- No level I studies have directly compared total ankle arthroplasty and ankle arthrodesis [8].
- Reports in the literature regarding the comparison of total ankle arthroplasty and ankle arthrodesis are contradictory [8].
- The most recent reports seem to favor total ankle arthroplasty with the latest-generation implants over arthrodesis, citing better functional outcomes, fewer complications, and better patient satisfaction [8].
- Some gait studies have noted no difference in gait patterns after arthroplasty and arthrodesis [8].
- Some gait studies report more nearly normal gait and better walking on uneven surfaces after arthroplasty [8].
- Gait appears to be improved by either total ankle arthroplasty or ankle arthrodesis [8].
- Daniels et al. found comparable clinical outcomes between arthrodesis and arthroplasty at a mean 5.5-year follow-up [8].
- Rates of reoperation and major complications were higher after ankle arthroplasty than after arthrodesis in the study by Daniels et al. [8].
- Norvell et al. found that ankle-specific adverse events were infrequent and only weakly associated with the operative procedure [8].
- Careful patient selection is mandatory for the success of either total ankle arthroplasty or ankle arthrodesis in the treatment of ankle arthritis [8].

- Nonunion rates after ankle arthrodesis vary widely in the literature, largely dependent on technique, underlying diagnosis, and patient selection [6].
- Factors that seem to improve results after ankle arthrodesis include arthroscopic or mini-incision technique [6].
- Factors that seem to improve results after ankle arthrodesis include the use of more than two screws or an adjunct plate (or fibular strut) [6].
- A diagnosis of primary osteoarthritis, as opposed to inflammatory, postinfectious, or posttraumatic arthritis, is a factor that seems to improve results after ankle arthrodesis [6].
- With modern techniques, attention to detail, and management of concurrent medical conditions, fusion rates of better than 90% should be expected in standard, uncomplicated ankle arthrodesis [6].
- Thevendran et al. determined a number of risk factors for nonunion after ankle arthrodesis, but clinical evidence is insufficient for most of these factors to be definitely implicated in the development of nonunion [6].
- There is fair evidence (grade B) to advocate the use of internal fixation for ankle arthrodesis [6].
- There is evolving grade B evidence suggesting that minimally invasive techniques may be equivalent to open procedures in selected patients for ankle arthrodesis [6].
- Physical findings of persistent swelling, pain at the fusion site, and difficulty with weight bearing should lead to careful scrutiny of plain radiographs to establish union [6].
- Bridging callus across the fusion site on more than one view usually confirms successful fusion [6].
- CT is sometimes necessary to establish that fusion has occurred or to evaluate the nonunion [6].
- There are no randomized level 1 studies that compare autograft to any commercially available product for use in ankle arthrodesis [6].
- Fourman et al. reported that more patients with rhBMP-2 had fusion (93%) than did those without rhBMP-2 (53%) in 82 patients with comorbidities who required complex ankle arthrodesis [6].
- Assessment of a patient with a delayed union or nonunion begins with an overall assessment for medical issues [6].
- Routine laboratory workup for delayed union or nonunion includes 25-hydroxyvitamin D levels, albumin, prealbumin, parathyroid hormone, thyroid stimulating hormone, calcium, C-reactive protein, erythrocyte sedimentation rate, and hemoglobin A1c levels [6].
- Satisfactory immobilization of a delayed union in a protected weight-bearing boot or cast is necessary [6].
- Saltzman et al. reported that the use of pulsed electronic magnetic field devices with immobilization and limited weight bearing was successful in only five of 19 delayed unions of foot and ankle arthrodeses [6].
- Better results have been reported with revision arthrodesis, with 75% to 94% successful fusion [6].
- Some patients with delayed union or nonunion will require reoperation with bone grafting and more stable fixation [6].

Anatomy & Pathophysiology

BONY ANATOMY

- The ankle mortise is formed by the tibial plafond, medial malleolus, and lateral malleolus [16].
- The ankle mortise articulates with the dome of the talar body [16].
- The talar dome is wider anteriorly and narrower posteriorly [16].
- The ankle mortise widens 1 to 1.5 mm during motion from plantar flexion to dorsiflexion [16].
- Medial and superior clear spaces appear wider with the foot in plantar flexion [16].
- A simplified model of the ankle joint has a horizontal axis from anteromedial to posterolateral [16].
- A simplified model of the ankle joint has a coronal axis from superomedial directed distally and laterally to the tip of the fibula [16].
- The distal fibula has a convex medial surface that articulates with the concave incisura fibularis of the distal lateral tibia [16].
- The fibula rotates approximately 2 degrees within the incisura during ankle motion and ambulation [16].
- Ankle dorsiflexion results in external rotation and proximal translation of the fibula [16].
- The talocrural angle is approximately 83 degrees and should be symmetrical with the contralateral ankle [23].
- The medial clear space should be less than 5 mm and no more than 2 mm greater than the tibiotalar clear space [23].
- The tibiofibular clear space, measured 10 mm above the joint line, is relatively constant with rotation and has an accepted normal parameter of >5 mm [23].
- The tibiofibular overlap, measured 10 mm above the joint line, is highly variable dependent on rotation, with accepted normal parameters of <5 mm on AP view and <1 mm on the mortise view [23].
- The “ball sign” is a confirmatory visual cue for fibular length where the articular margins of the distal fibula and the lateral process of the talus are parallel and equal to the tibiotalar joint space [23].
- Shortening of the fibula results in lateral and valgus subluxation of the talus [23].
- The size of the medial clear space more than doubles depending upon the rotational position of the limb [23].
- There is a significant increase in medial clear space with ankle plantarflexion [23].

LIGAMENTOUS ANATOMY

- The lateral ankle ligaments function as restraints to varus and inversion forces at the ankle [16].
- 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 [16].
- The calcaneofibular ligament (CFL) extends from the tip of the lateral malleolus to the lateral aspect of the calcaneus [16].

CQ HAND + UPPER LIMB

- The posterior talofibular ligament (PTFL) extends from the posterior lateral malleolus to the posterolateral talus [16].
- The ATFL is the weakest ankle ligament [16].
- The PTFL is the strongest ankle ligament [16].
- The distal tibiofibular joint and fibula provide stability against lateral talar translation [16].
- The deltoid ligament complex is the primary ankle stabilizer during stance [16].
- The deep deltoid ligament extends from the apex of the medial malleolus to the medial talar body [16].
- The deep deltoid ligament functions primarily to resist lateral talar translation and external rotation [16].
- The posterior deep deltoid is the most important component of the deep deltoid ligament [16].
- The superficial deltoid ligament extends from the distal medial malleolus to the navicular bone, sustentaculum tali of calcaneus, medial talus, and spring ligament [16].
- The superficial deltoid ligament functions primarily to resist valgus and eversion ankle forces [16].
- 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 [19].
- The tibiocalcaneal portion of the superficial deltoid ligament is the strongest component and resists eversion of the calcaneus [19].
- The deep portion of the deltoid ligament is organized into two short, thick, discrete bands: the anterior and posterior deep tibiotalar ligaments [19].
- The anterior and posterior deep tibiotalar ligaments are intra-articular but extrasynovial [19].
- The deep posterior band comprises the largest band of the deltoid complex [19].
- The deep deltoid ligament has the highest load to failure at $713.8 \text{ N} \pm 69.3$ compared with the lateral collateral ligaments [19].
- The dominant mode of failure for the deep deltoid ligament is an intrasubstance rupture near its talar insertion [19].
- The failure of the superficial deltoid ligament is most commonly at its insertion on the anterior malleolus [19].
- Valgus tilting of the talus within the mortise requires complete rupture of both the superficial and deep deltoid ligaments [19].

BIOMECHANICS & MOTION

- The primary functions of the foot and ankle are to provide weight-bearing support and forward ambulation [16].
- The ankle joint is responsible for most sagittal plane motion of the foot and ankle [16].
- Normal ankle range of motion includes 23 to 48 degrees of plantar flexion [16].
- Normal ankle range of motion includes 10 to 23 degrees of dorsiflexion [16].
- The ankle joint also contributes to inversion, eversion, and rotation [16].

- More than 75% of ankle ligament injuries involve the lateral ligament complex, particularly the ATFL and CFL [20].
- Medial ligament injuries are usually seen in association with a fracture or joint injury [20].

PATHOPHYSIOLOGY OF INSTABILITY

- Isolated rupture of the deltoid ligament without lateral ligamentous or fibular injury is rare [19].
- Criteria for diagnosis of medial instability include a feeling of giving way, medial ankle joint pain, and a valgus and/or pronation deformity that is correctable with posterior tibial muscle activation [19].
- Excess motion in external rotation, eversion, valgus, and/or posterior translation reinforces the diagnosis of medial instability [19].
- With complete deltoid injury, a valgus AP stress radiograph shows a talar tilt and/or lateral translation of the talus [19].
- Most incomplete deltoid injuries are often normal on standard radiographic imaging [19].
- Stress examination of the ankle should include anterior and posterior translation, medial and lateral translation, internal and external rotational instability, and varus/valgus instability [19].
- Ankle position does not influence the outcome of the stress examination [19].
- 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 [18].
- The deep peroneal nerve accompanies the anterior tibial artery between the tendons of the anterior tibial and extensor digitorum longus, just lateral to the extensor hallucis longus [18].
- 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 [18].

Clinical Presentation

- Assessment of an ankle fracture requires a detailed history, a thorough physical examination, and radiographic imaging [36].
- High-energy mechanisms in ankle injuries indicate the likelihood of additional soft tissue complications, compartment syndrome, the presence of the more complex pilon fracture, or other associated injuries [36].
- Diabetes indicates an increased likelihood of wound complications owing to immunologic and vascular impairment [36].
- Poorly controlled diabetics are at risk of peripheral neuropathy, which may influence postoperative weight-bearing decisions [36].
- A history of smoking, alcohol abuse, and psychiatric illness increases the likelihood of complications [36].
- Clinical examination begins with inspection for deformity, bruising, blistering, skin integrity, and color [36].

- Palpation of the limb starts at the fibular head and progresses sequentially down the lateral aspect of the leg to the lateral malleolus and the soft tissues anterior and posterior to it before moving medially across the ankle joint to the medial malleolus and its adjacent soft tissue structures [36].
- Palpation of the skeleton of the foot excludes commonly associated or missed injuries such as fractures of the metatarsals or lateral talar process, or disruption of the midtarsal (Lisfranc) articulation [36].
- Palpation of the Achilles tendon and the Simmonds or Thompson's test exclude rupture of this structure [36].
- A distal neurovascular assessment includes assessment of temperature and capillary refill [36].
- Skin marking of palpable dorsalis pedis and posterior tibial arterial pulsations at presentation is helpful in later assessment if the condition of the limb deteriorates [36].
- The Ottawa ankle rules provide assistance in determining the need for x-ray [36].
- The Ottawa ankle rules offer a highly sensitive and cost-effective method of identifying patients presenting with ankle injuries that are most likely to have sustained a fracture [36].
- Other authors have reported difficulties in disseminating the Ottawa ankle rules [36].
- The applicability of the Ottawa ankle rules in certain patient groups such as diabetics has been questioned [36].
- Pain exists near one or both of the malleoli plus one or more of the following: age >55 years old, inability to bear weight, or bone tenderness over the posterior edge or the tip of either malleolus [36].

Investigations

RADIOGRAPHY AND STRESS VIEWS

- AP, mortise, and lateral weight-bearing radiographs of the ankle are performed for the evaluation of chronic lateral ankle instability [26].
- Stress radiographs can be used to confirm instability in chronic lateral ankle instability [26].
- A lateral radiograph is obtained while performing the anterior drawer test to evaluate competency of the anterior talofibular ligament [26].
- A mortise radiograph is obtained while performing the talar tilt test to evaluate competency of the calcaneofibular ligament [26].
- Lateral radiographs may not show osteophytes in anterior ankle impingement [29].
- An anteromedial view is often helpful for visualizing osteophytes in anterior ankle impingement [29].
- Oblique radiographs have diagnostic value for the anterior ankle impingement syndrome [28, 30].
- Radiographic evaluation is used to assess the normal distal tibiofibular syndesmosis [25].
- Axial CT imaging is used to evaluate normal tibiofibular relationships at the syndesmosis [25].
- Preoperative computed tomography scans are used in operative planning for malleolar ankle fractures [25].

MAGNETIC RESONANCE IMAGING (MRI)

- MRI is useful in evaluating for associated pathology to the peroneal tendons or talar articular surface in chronic lateral ankle instability [26].
- MRI can confirm the abnormal appearance of affected ligaments, which may be thickened or indistinct, in chronic lateral ankle instability [26].
- MRI does not help determine functional instability in chronic lateral ankle instability [26].
- MRI can show osteophytes in anterior ankle impingement but is not very sensitive for soft-tissue impingement [29].
- MR arthrography or contrast-enhanced, fat-suppressed, three-dimensional (3D), fast-gradient recalled acquisition in the steady state with radiofrequency spoiling (CE 3D-FSPGR) MRI is more sensitive and specific for soft-tissue impingement than standard MRI [29].
- In one study, 58% of patients with anterior ankle impingement had an associated diagnosis that changed the surgical plan in 33% of cases [29].
- MRI is used to evaluate anterolateral soft tissue impingement of the ankle [9].
- MRI is used to evaluate osteochondral lesions of the talus [9].
- MRI is used for the pre-operative evaluation of the anterior talofibular ligament in chronic ankle instability [9].
- MRI is used to evaluate ruptures of the tibialis posterior tendon [9].
- MRI is used to evaluate posterior tibial tendon dysfunction with relevance to clinical staging [9].
- MRI is used to evaluate traumatic ligamentous injuries of the ankle and foot [9].
- MRI is used to evaluate chronic Achilles tendon ruptures [9].
- MRI is used to evaluate plantar plate injury with reference to intraoperative findings [9].
- MRI is used to evaluate tibiofibular syndesmotic ligaments with anatomic correlation [9].
- MRI is used for the evaluation of sports injuries involving the ankle [9].
- MRI is used for the evaluation of ligamentous and chondral pathology in the ankle [9].
- MRI findings are associated with symptoms in patients with chronic ankle sprain [9].
- MRI is used for the evaluation of the postoperative ankle and foot [9].
- MRI is used for the evaluation of musculotendinous structures of the ankle [9].
- MRI is used to evaluate the anterior tibial artery at the ankle joint [10].
- MRI is used to evaluate anterolateral impingement of the ankle [30].
- MR arthrography is used for the assessment of the anterolateral recess in anterolateral ankle impingement [30].
- MRI is used to compare with physical examination for syndesmotic injury after lateral ankle sprain [4].
- MRI is used to compare with clinical examination for the diagnosis of anterolateral ankle impingement [28, 30].
- MRI is used to compare with clinical

Treatment

INDICATIONS AND CONTRAINDICATIONS

- Ankle arthrodesis is indicated for patients with painful limited motion of the ankle who have failed conservative measures and have diagnoses including posttraumatic arthritis, osteoarthritis, arthritis from chronic instability, rheumatoid or autoimmune inflammatory arthritis, gout, postinfectious arthritis, Charcot neuroarthropathy, osteonecrosis of the talus, failure of total ankle arthroplasty, or instability from neuromuscular disorders [14].
- Absolute contraindications to ankle fusion include vascular impairment of the limb and infection of the skin through which the surgical approach is planned [14].
- Relative contraindications to ankle fusion include preexisting moderate-to-severe ipsilateral hindfoot arthritis and contralateral ankle arthritis likely to require surgical treatment in the foreseeable future [14].
- Ankle arthrodesis is not an optimal treatment for all patients due to the loss of joint motion and the possible development of degenerative adjacent joint arthritis [13].
- Arthrodesis may be the best procedure for patients with preexisting subtalar or other hindfoot arthritis, contralateral hindfoot or ankle arthritis, or hip or knee impairment where ankle motion is beneficial to overall limb function [8].

OPERATIVE TECHNIQUES AND FIXATION

- Ankle arthrodesis can be performed through open, mini-open, and arthroscopically assisted approaches [37].
- A comparison of anterior and transfibular approaches for ankle arthrodesis found no significant differences in AOFAS scores, though the anterior approach had a longer time to fusion and a slightly higher nonunion rate [37].
- If a transfibular approach is used for ankle arthrodesis, the fibula should be preserved to allow for potential future conversion to ankle replacement [37].
- In a study of 101 ankles undergoing arthroscopic ankle arthrodesis, 95% achieved fusion with the primary procedure [37].
- There is no conclusive evidence to recommend one hardware construct over another for ankle arthrodesis [37].
- A comparison of compression screws alone versus compression screws with anterior plate fixation showed nonunion rates of 15.4% for screws alone and 7.7% with plate augmentation, a difference that was not statistically significant [37].
- Factors that generally improve fusion results include arthroscopic or mini-incision technique, the use of more than two screws or an adjunct plate (or fibular strut), and a diagnosis of primary osteoarthritis [6].
- With modern techniques and management of concurrent medical conditions, fusion rates of better than 90% should be expected in standard, uncomplicated ankle arthrodesis [6].

- The presence of union is confirmed by bridging callus across the fusion site on more than one view on plain radiographs, with CT used when necessary to establish fusion or evaluate nonunion [6].

NONUNION MANAGEMENT

- Assessment of a patient with delayed union or nonunion includes laboratory evaluation for 25-hydroxyvitamin D, albumin, prealbumin, parathyroid hormone, thyroid stimulating hormone, calcium, C-reactive protein, erythrocyte sedimentation rate, and hemoglobin A1c [6].
- Satisfactory immobilization of a delayed union in a protected weight-bearing boot or cast is necessary for management [6].
- Pulsed electromagnetic field devices used with immobilization and limited weight bearing were successful in only 5 of 19 delayed unions of foot and ankle arthrodeses [6].
- Revision arthrodesis for nonunion has reported successful fusion rates of 75% to 94% [6].
- Nonunion after ankle arthrodesis is significantly more likely to occur with previous ipsilateral subtalar fusion and preoperative varus alignment [37].

ADJACENT JOINT PATHOLOGY

- In a study of 140 ankles with a minimum 5-year follow-up after ankle arthrodesis, 40% of adjacent subtalar joints and 34% of talonavicular joints showed progression of arthritic changes [15].
- In a study of 66 ankle fusions, significant radiologic progression of arthritis was reported in all adjacent joints [37].
- In a cohort with a mean follow-up of 22 years, 91% of subtalar joints and 57% of talonavicular joints developed moderate to severe arthritis following ankle arthrodesis [37].
- Sealey et al. reported 9.3 degrees of compensatory subtalar motion and 16.4 degrees of midfoot motion after ankle arthrodesis [15].

ALTERNATIVE PROCEDURES

- Arthroscopic or open debridement of the arthritic ankle is effective for removing anterior impingement osteophytes but provides only short-term relief in more advanced arthritis and is not recommended in most cases [13].
- Periarticular osteotomies of the tibia, fibula, or hindfoot are reasonable approaches for localized ankle arthritis, particularly when chondral loss is primarily in the medial or lateral gutter with minimal involvement of the superior talar surface [13].
- Opening wedge osteotomy of the tibia for varus deformity and medial joint arthrosis is an effective alternative to more invasive treatment [13].
- Joint distraction arthroplasty is based on the concept that mechanical unloading and intermittent flow of intraarticular synovial fluid encourage cartilage healing [7].
- In a randomized controlled trial, motion distraction resulted in earlier and consistently better outcomes than fixed distraction for ankle arthritis [7].

- Adverse events associated with ankle distraction arthroplasty include pin-track infections and neurapraxias [7].
- Contraindications for ankle distraction arthroplasty include active infection, advanced coronal plane deformity, significant loss of bone stock, and being a poor frame candidate [7].
- Relative contraindications for ankle distraction arthroplasty include uncontrolled diabetes, tobacco use, chronic edema of the lower limb, severe ankle deformity, and severe ankle ankylosis [7].
- Currently, there is not enough high-level evidence to support ankle joint distraction for generally accepted indications [7].

OUTCOMES AND COMPARISON WITH ARTHROPLASTY

- Ankle arthrodesis has the advantage of predictable pain relief and the disadvantage of limited motion [15].
- In a study of 114 ankle arthroplasties and 47 ankle arthrodeses, complication rates were 54% after arthroplasty and 26% after arthrodesis [15].
- A systematic review of 1262 arthrodeses and 852 arthroplasties identified revision rates of less than 10% and infection rates of less than 5% after both procedures [15].
- In a multicenter study of 321 patients, intermediate-term clinical outcomes of total ankle replacement and ankle arthrodesis were comparable, although reoperation and major complications were more frequent after ankle replacement [15].
- A multisite prospective cohort study of 517 patients found no statistically significant difference in adverse events at 1 year after either arthrodesis or arthroplasty [15].
- Gait analysis has shown that patients with total ankle replacement have a more normal gait pattern than those with arthrodesis [15].
- Sports participation is reported to be similar after both procedures, with approximately 76% of patients in both groups active in sports after surgery [15].
- Only 15% of patients undergoing either arthroplasty or arthrodesis experienced resolution of all symptoms and limitations [15].
- In a study of 72 ankle arthrodeses at a mean follow-up of 4.8 years, a 99% fusion rate was reported [37].
- In a study of 60 patients (66 ankles) with a mean follow-up of 9 years, the primary arthrodesis rate was 91%, with the remaining patients achieving fusion after a second procedure [37].

Complications

GENERAL COMPLICATION RATES AND COMPARISON WITH ARTHRODESIS

- In a study involving 114 ankle arthroplasties and 47 ankle arthrodeses, complication rates were 54% after arthroplasty and 26% after arthrodesis [15].
- A systematic review of 1262 arthrodeses and 852 arthroplasties identified infection rates of less than 5% after both procedures [15].

- In a multicenter study of 321 patients, reoperation and major complications were more frequent after total ankle replacement than after ankle arthrodesis [15].
- In a matched cohort study, in-hospital complications were higher following ankle arthroplasty than ankle arthrodesis [5].
- Trends in complication rates following ankle arthrodesis and total ankle replacement have been analyzed in comparative studies [5].
- A study of 2340 ankles across 95 academic centers reported an overall complication rate of 1.4%, with rates dropping to <0.5% after 2007 [38].
- The same study of 2340 ankles reported a readmission rate of 3% [38].
- A meta-analysis of mobile-bearing implants reported complication rates ranging from 2% to 15% [38].
- A systematic review of mobile and fixed-bearing implants reported a revision rate of 7% [38].
- A systematic review of mobile and fixed-bearing implants reported an overall failure rate at 10 years of 10% [38].
- A systematic review of mobile and fixed-bearing implants reported deep infection rates ranging from 0% to 5% [38].
- A study of 67 ankles with Salto Talaris implants reported that 15 patients (22%) experienced 23 complications [38].
- A study of 106 ankles with Mobility implants reported a 12% complication rate [38].
- A study of 50 ankles with Hinteagra implants identified osteolysis in 24 ankles (48%) [38].
- A study of 54 ankles with Hinteagra and Mobility implants found that ankle impingement syndrome was significantly more common with Hinteagra [38].
- The same study found that intraoperative malleolar fracture occurred only with the Mobility implant [38].

INFECTION

- Acute hematogenous periprosthetic joint infection in total ankle arthroplasty has been treated with irrigation, debridement, and polyethylene exchange [2].
- Patient-related risk factors for periprosthetic joint infection have been analyzed in a cohort of 6977 total ankle arthroplasties [2].
- Methods for diagnosing and treating infection in total ankle arthroplasty have been described [2].

WOUND AND SOFT TISSUE COMPLICATIONS

- Operative wound complications following total ankle arthroplasty have been reported [2].
- Soft tissue reconstruction after total ankle arthroplasty has been described [2].
- Association of short-term complications with procedures performed through separate incisions during total ankle replacement has been studied [2].
- The efficacy of platelet-rich plasma for incision healing after total ankle replacement using the Agility system has been evaluated [2].

- Association of cigarette use with complication rates and outcomes following total ankle arthroplasty has been reported [2].

THROMBOEMBOLIC EVENTS

- Risk factors for symptomatic deep-vein thrombosis in patients after total ankle replacement who received routine chemical thromboprophylaxis have been identified [2].
- The incidence of symptomatic thromboembolic events after total ankle arthroplasty without routine use of chemoprophylaxis has been reported as low [2].

HETEROTOPIC OSSIFICATION

- Heterotopic ossification after total ankle arthroplasty has been reported [2].
- Anterior heterotopic ossification at the talar neck after total ankle arthroplasty has been described [2].
- Heterotopic ossification after primary total ankle arthroplasty has been reported [2].

PERIPROSTHETIC OSTEOLYSIS AND BONE CYSTS

- Outcomes of bone grafting of bone cysts after total ankle arthroplasty have been reported [2].
- The role of computed tomography in detecting periprosthetic osteolysis after total ankle arthroplasty has been evaluated [2].
- Severe periprosthetic osteolytic lesions have been reported after Ankle Evolutive System total ankle replacement [3].

COMPONENT MALPOSITION AND FRACTURES

- Supramalleolar osteotomy has been used for tibial component malposition in total ankle replacement [2].
- Periprosthetic fractures in total ankle replacement have been reported [2].
- Delayed onset medial malleolar pain following total ankle arthroplasty has been described [2].

ADJACENT JOINT PATHOLOGY

- Hindfoot arthritis progression and arthrodesis risk after total ankle replacement have been studied [2].
- In a mid- to long-term outcome study, a moderate radiographic increase in adjacent subtalar and talonavicular arthritis was reported at a minimum of 5 years after arthrodesis [15].
- In 140 ankles averaging 6.5 years' follow-up, 40% of adjacent subtalar joints and 34% of talonavicular joints showed progression of arthritic changes using the modified Kellgren Lawrence scale [15].
- A study demonstrated that 30% of the clinical motion observed after ankle arthroplasty occurs through the subtalar and talonavicular joints [15].
- Compensatory subtalar motion of 9.3 degrees and midfoot motion of 16.4 degrees were reported after ankle arthrodesis [15].
- Compensatory subtalar motion of 6.7 degrees and midfoot motion of 16.5 degrees were reported after ankle arthroplasty [15].

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REVISION AND SALVAGE PROCEDURES

- Revision of failed total ankle arthroplasty to a hindfoot fusion has been described [2].
- Salvage of failed total ankle arthroplasty with fusion using structural allograft and internal fixation has been reported [2].
- Management of failures of total ankle replacement with the Agility total ankle arthroplasty has been described [2].
- Secondary arthrodesis after total ankle arthroplasty has been reported [2].
- Outcome after salvage arthrodesis for failed total ankle replacement has been studied [2].
- Arthroscopic debridement after total ankle arthroplasty has been described [2].
- Association of ankle arthritis score with the need for revision surgery has been analyzed [2].
- Revision rates after total ankle arthroplasty have been compared between sample-based clinical studies and national registries [2].
- A three-grade classification of complications in total ankle replacement has been assessed [2].
- An evidence-based classification of complications in total ankle arthroplasty has been proposed [3].

PERIOPERATIVE OUTCOMES AND MORTALITY

- Short-term perioperative complications and mortality after total ankle arthroplasty in the United States have been reported [2].
- Blood transfusion during total ankle arthroplasty is associated with increased in-hospital complications and cost [2].
- Patient risk factors were found not to impact 90-day readmission and emergency department visitation after total ankle arthroplasty [2].
- Impact of complications in total ankle replacement and ankle arthrodesis analyzed with a validated outcome measurement has been reported [2].
- Comparison of perioperative complications and hospitalization outcomes after ankle arthrodesis versus total ankle arthroplasty from 2002 to 2011 has been performed [5].
- Frequency and impact of adverse events in patients undergoing surgery for end-stage ankle arthritis have been analyzed [5].

DISTRACTION ARTHROPLASTY COMPLICATIONS

- Adverse events in a randomized controlled trial of ankle distraction included 43 pin-track infections and eight neurapraxias [7].
- In a randomized study, the rate of post-operative revision surgery was higher if distraction was not used compared to debridement and hinged distraction [7].

Recovery

- Campbell S Operative Orthopaedics 4 Volume Set includes a section titled “Reported Outcomes of Ankle Arthroplasty Compared With Ankle Arthrodesis” [1].
- The reference list for the “Reported Outcomes of Ankle Arthroplasty Compared With Ankle Arthrodesis” section in Campbell S Operative Orthopaedics 4 Volume Set includes Ajis A, Henriquez H, Myerson M: Postoperative range of motion trends following total ankle arthroplasty, *Foot Ankle Int* 34, 2013 [1].
- The reference list for the “Reported Outcomes of Ankle Arthroplasty Compared With Ankle Arthrodesis” section in Campbell S Operative Orthopaedics 4 Volume Set includes Bai LB, Lee KB, Song EK, et al.: Total ankle arthroplasty outcome comparison for post-traumatic and primary osteoarthritis, *Foot Ankle Int* 31:1048, 2010 [1].
- The reference list for the “Reported Outcomes of Ankle Arthroplasty Compared With Ankle Arthrodesis” section in Campbell S Operative Orthopaedics 4 Volume Set includes Besse JL, Colombier JA, Asencio J, et al.: Total ankle arthroplasty in France, *Orthop Traumatol Surg Res* 96:L291, 2010 [1].
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