This update summarizes recent research pertaining to the subspecialty of orthopaedic foot and ankle surgery that was published or presented between August 2013 and July 2014. The sources of these studies include The Journal of Bone & Joint Surgery and Foot & Ankle International. Additional recently published studies of high-quality design reviewed by the editorial staff of The Journal are also included in this update.

**Ankle Fractures and Syndesmosis**

Achieving the best possible articular reduction during surgery is the most important surgeon-controlled variable affecting clinical outcome and the development of ankle arthritis. Berkes et al. demonstrated inferior short-term clinical outcomes associated with postoperative articular incongruity of >2 mm in operatively treated supination-external rotation type-IV (SER IV) ankle fractures. Maisonneuve pronation-external rotation type-IV (PER IV) ankle fractures produce a proximal fibular fracture with syndesmotic disruption that is often treated with transsyndesmotic screw fixation only. Lambers et al. reported good to excellent long-term functional outcomes at a mean of twenty-one years following treatment of Maisonneuve-type PER IV ankle fractures with one or two syndesmotic screws. Although 49% of the patients showed radiographic signs of ankle arthritis, the most important predictor of long-term functional outcome was patient-reported pain rather than physician-reported function or radiographic evidence of arthritis.

Appropriate ankle fracture management includes proper recognition and accurate stabilization of associated syndesmotic instability. In a retrospective study comparing the outcomes of operatively treated PER IV ankle fractures with those of SER IV fractures, Schottel et al. found no significant differences in short-term clinical or radiographic outcomes. However, a significantly larger percentage of patients (PER IV, 40%; SER IV, 18%) were determined to have a syndesmotic malreduction as evident on postoperative computed tomography (CT). The operating surgeon must critically analyze the quality of syndesmotic reduction in PER fracture patterns.

Choi et al. retrospectively analyzed preoperative radiographic and CT findings for operatively treated SER-type ankle fractures to identify factors that could help to detect unstable syndesmotic injuries. Predictive cutoff values for unstable syndesmotic injuries on CT scans were a fracture height of >3 mm and a medial joint space of >4.9 mm, and on radiographs, a fracture height of >7 mm and a medial joint space of >4.5 mm.

Davidovitch et al. found the use of intraoperative three-dimensional CT imaging, compared with standard fluoroscopic techniques, to be ineffective in reducing the rate of syndesmotic malreduction in operative fixation of ankle fractures associated with syndesmotic instability. The surgeon should use several fluoroscopic parameters intraoperatively to assess accurate syndesmotic reduction and verify them against direct visual landmarks to prevent malreduction.

Cast immobilization remains a common practice during conservative or postoperative management of ankle fractures, despite its association with venous thromboembolism. Hickey et al. used Doppler ultrasound measurement of the popliteal vein to demonstrate a significant increase in venous return flow compared with resting baseline values with a program of exercises performed within an applied cast. Active toe dorsiflexion and plantar flexion as well as ankle dorsiflexion and plantar flexion with use of a cast all significantly increased the mean peak popliteal systolic velocity compared with resting baseline values and should be encouraged in patients who undergo cast immobilization.

McDowell et al. evaluated several commonly used methods to protect a cast from becoming wet. A standardized fiberglass cast was applied to a mannequin leg, which then underwent commonly employed methods of keeping the cast dry before submersion of the leg in water for two minutes. The quantity of...
water absorption was determined using the weight of the leg in the cast before and after submersion. The most effective methods for preventing a wet cast were found to be double plastic bags secured with duct tape and the CVS Pharmacy Reusable Cast & Wound Protector, both of which demonstrated 100% prevention of water saturation.

**Talar and Calcaneal Fractures**

Osteonecrosis is a well-known complication of talar neck fractures. Vallier et al. revisited the Hawkins classification system and subdivided the type-II fractures into those with a subluxated subtalar joint (type IIA) and those with a dislocated subtalar joint (type IIB) to determine if initial fracture displacement helps to predict the development of osteonecrosis. In their review of sixty-five talar neck fractures, osteonecrosis never occurred in patients with Hawkins type-I or IIA fractures, while patients with subtalar dislocation (type IIB) developed osteonecrosis 25% of the time and those with tibiotalar dislocation (Hawkins type III), 41% of the time. The degree of initial fracture displacement was associated with increasing rates of osteonecrosis. A delay in operative reduction and fixation did not elevate the risk of osteonecrosis.

Harnroongroj and Harnroongroj reported their long-term results of salvage of talar body osteonecrosis, comminuted talar fractures, and benign tumors of the talus with use of a talar body prosthesis. Twenty-eight of thirty-three prostheses survived greater than ten years, with the longest survival being at thirty-six years of follow-up. The mean AOFAS (American Orthopaedic Foot & Ankle Society) ankle-hindfoot score of the prostheses was 74, with satisfactory ankle range of motion and clinical function.

The risk of postoperative wound complications associated with the extensile lateral incision strongly influences use of this approach for the fixation of calcaneal fractures. Ding et al. reported a 17.8% overall wound complication rate in 490 cases of calcaneal fracture fixation using the extensile lateral approach. The authors found that an increased risk of wound complications was associated with a patient history of smoking, diabetes, increasing Sanders calcaneal fracture type, the number of residents and/or fellows present during the case, the duration of surgery, estimated blood loss, and a high number of people present in the operating room. Alternative, less invasive approaches to the calcaneus are being developed and investigated in order to decrease the risk of wound complications associated with operative fixation. Zhang et al. performed a prospective randomized study comparing the sinus tarsi approach with the minimally invasive longitudinal approach to the calcaneus. Outcomes were similar between the two approaches in the treatment of Sanders type-II and III calcaneal fractures, although significantly fewer wound-healing complications and shorter operative time were found for the minimally invasive longitudinal approach. Better outcomes were noted for Sanders type-IV calcaneal fractures when the sinus tarsi approach was used.

Surgical wound complications and the risks associated with the treatment of displaced intra-articular calcaneal fractures have challenged the role of surgery in the management of these fractures. A prospective, randomized, controlled multicenter trial by Ågren et al. compared outcomes of operative and nonoperative treatment of displaced intra-articular calcaneal fractures. No difference between treatment groups was found at one year of follow-up; however, a trend toward better pain scores and function in the operative group at eight to twelve years of follow-up was noted. Operative treatment increased the risk of complications but also reduced the prevalence of subtalar arthritis on follow-up radiographs. In another prospective randomized trial, Griffin et al. found no significant difference in pain or function at two years of follow-up between operative and nonoperative treatment of displaced intra-articular calcaneal fractures. The operative group had a higher risk of complications, prompting the authors to recommend against surgery for these fractures.

Operative treatment of intra-articular calcaneal fractures often relies on the sustentaculum tali to be a “constant fragment” against which to indirectly reduce the remainder of the fracture. Gitajn et al. identified sustentaculum tali fractures on CT in ninety-four (44.3%) of 212 patients with intra-articular calcaneal fractures. Eleven (11.7%) of the sustentacular fractures were displaced and ten (10.6%) were comminuted, while the sustentacular articulation with the talus was subluxated in forty-three of the 212 (20.3%) and dislocated in two (0.9%). The condition and location of the sustentacular fragment must therefore be confirmed preoperatively on CT scans prior to operative reduction and fixation. A guideline for optimal safe positioning of screws for fixation of the posterior facet in calcaneal fractures was defined by Phisitkul et al. The ideal starting point is 15 mm below the posterior facet, aiming toward the joint at an angle 20° less than perpendicular to the joint line, and 6° to 36° of anteversion parallel to the joint line, increasing from anterior to posterior.

The use of intraoperative three-dimensional CT imaging may help to identify intra-articular incongruence and implants that are not detected with standard fluoroscopy and, thereby, improve clinical outcomes. Franke et al. showed that intraoperative three-dimensional CT imaging effected an intraoperative revision to the surgery in 40.3% of cases, with the revision being a correction of a malreduced fracture in 19.6% of patients. CT scans are also helpful in identifying injuries associated with calcaneal fractures in the preoperative setting. In a review of 421 intra-articular calcaneal fractures, Toussaint et al. reported peroneal tendon subluxation or dislocation in 118 cases (28%). This under-recognized injury pattern was identified in only twelve (10.2%) of the cases in the radiology report and was addressed surgically in only seven (10.8%) of the sixty-five fractures with tendon displacement that were treated with internal fixation. Preoperative CT scans should be scrutinized for this injury pattern associated with intra-articular calcaneal fractures so that proper treatment can be rendered during surgery.
Ankle Instability

The consensus regarding management of acute inversion ankle sprains is conservative treatment with initiation of a functional rehabilitation program. In a prospective randomized study of the acute treatment of severe lateral ankle sprains, conducted by Prado et al., the use of a walking boot with restricted joint mobilization for three weeks followed by progression to a functional brace was compared with treatment with the immediate application of a functional brace. No difference was found between the groups in pain intensity scores or the development of mechanical instability; however, the group treated immediately with the functional brace demonstrated better functional scores and had a shorter recovery period. In a prospective randomized trial comparing neuromuscular training, bracing, and a combination of bracing with neuromuscular training for the management of lateral ankle sprains, Janssen et al. concluded that the bracing is the dominant secondary preventive intervention.

Surgical stabilization is indicated for ankle instability that does not improve through a conservative management program. Arthroscopic lateral ankle ligament repair has gained popularity, and Vega et al. reported encouraging results with the use of an all-inside technique of arthroscopic stabilization. Sixteen patients stabilized with an all-inside arthroscopic lateral ankle ligament repair reported subjective improvement of stability and showed significant improvement in mean AOFAS scores. In a cadaveric study, Clanton et al. dissected and isolated the anterior talofibular ligament, calcaneofibular ligament, posterior talofibular ligament, and cervical ligament in order to accurately determine the origins, insertions, footprint areas, orientations, and distances from known osseous landmarks. Consistent distances and footprint areas were identified and detailed to serve as a reference for more anatomically accurate lateral ankle ligament reconstruction.

Total Ankle Arthroplasty

Ankle arthrodesis continues to be the most frequently performed salvage operation for advanced ankle arthritis, although total ankle arthroplasty volume has increased dramatically over the past decade. One of the theoretical benefits of total ankle arthroplasty over arthrodesis is the presumed improvement in gait due to preservation of ankle motion. Two gait-analysis studies, by Singer et al. and Flavin et al., compared total ankle arthroplasty with ankle arthrodesis and found that both procedures resulted in improved gait postoperatively but failed to completely normalize the gait pattern. However, total ankle arthroplasty did restore a pattern that more closely resembled normal gait.

Clinically, the outcomes of total ankle replacement and ankle arthrodesis at intermediate-term follow-up were shown to be comparable in a retrospective comparative study by Daniels et al. However, the rates of reoperation and major complications were higher in the ankle replacement cohort. Clinical improvements in pain and function following total ankle arthroplasty were reported to be nearly equivalent between fixed and mobile-bearing devices in a study by Queen et al. Peak plantar flexion moment and Short Form-36 (SF-36) scores were better in the fixed-bearing group, while the mobile-bearing group had greater improvement in visual analog scale (VAS) pain scores. Total ankle replacement appears to effectively improve pain and function in all subtypes of ankle arthritis. Ramaskandhan et al. reported similar postoperative clinical improvements at two years of follow-up among patients treated with the three-component MOBILITY Total Ankle System (DePuy International, Leeds, United Kingdom), irrespective of ankle arthritis diagnosis (posttraumatic arthritis, osteoarthritis, or rheumatoid arthritis).

The sophisticated alignment guides of the newer generation of total ankle replacements have allowed for easier prosthetic implantation as well as greater accuracy and reproducibility in the placement of the implant components. Adams et al. compared extramedullary and intramedullary referencing for tibial component alignment in total ankle arthroplasty. The intramedullary referencing was more accurate for tibial component alignment in the sagittal plane, but no significant difference was found between the two techniques in coronal-plane alignment. Berlet et al. tested CT scan-derived, patient-specific guides on cadaver limbs to assess the repeatability of tibial and talar-guide placement and the deviation between the preoperative plan and actual implant placement. The patient-specific, custom guides allowed for successful, reliable, and reproducible implant positioning within 2° of that of the preoperative plan.

Veljkovic et al. described the lateral talus station (LTS) as a novel measure of the sagittal relationship of the talus to the tibial shaft, as demonstrated on weight-bearing lateral ankle radiographs. With good reliability found between observers, the LTS may help to better define the sagittal position of the talus following total ankle arthroplasty. Using a similar measurement of the sagittal position of the talus, Lee et al. found less sagittal malalignment of the talus following total ankle arthroplasty with the MOBILITY Total Ankle System than with the HINTEGRA total ankle system (Newdeal, Lyon, France; Integra, Plainsboro, New Jersey). Sagittal-plane malalignment of total ankle arthroplasty components can lead to earlier failure of the prosthesis; therefore, the authors have suggested paying particular attention to the sagittal alignment with the HINTEGRA system.

Excessive tibiotalar joint deformity in the coronal plane has been considered a relative contraindication for total ankle arthroplasty. Queen et al. reviewed their results of total ankle arthroplasty and subdivided the patients on the basis of preoperative tibiotalar alignment for a comparison of outcomes. Coronal-plane alignment was reliably restored to neutral in patients with coronal malalignment in excess of 15° of varus or valgus with the use of multiple adjunctive procedures, such as deltoid ligament release, lateral ligament reconstruction, and posterior soft-tissue releases. No significant difference was detected in clinical or functional outcomes on the basis of the severity of coronal-plane malalignment. A similar conclusion...
was reached for ankles with excessive coronal-plane varus deformity in a Level-I study by Trajkovski et al.\textsuperscript{35}. This prospective study demonstrated similar satisfactory results following total ankle arthroplasty for ankles with a preoperative coronal-plane varus deformity of $\geq 10^\circ$ compared with ankles with $< 10^\circ$ of varus deformity. Total ankle arthroplasty as well as supramalleolar osteotomy (SMOT) can be used to treat the varus osteoarthritic ankle. Colin et al. determined that total ankle arthroplasty more effectively corrected the talar position in all planes than SMOT when treating tibiotalar arthritis with varus malalignment\textsuperscript{36}.

The ability to achieve a balanced neutral ankle with adjunctive procedures has widened the scope of indications for total ankle arthroplasty to include ankles with substantial deformity. Lewis et al. reviewed their results of total ankle arthroplasty in patients who had a hindfoot arthrodesis consisting of either an isolated subtalar arthrodesis or triple arthrodesis before, during, or after the total ankle arthroplasty\textsuperscript{37}. Patients who underwent a total ankle replacement and a hindfoot arthrodesis experienced significant improvements in pain and function, although the outcomes were inferior to those of patients without a hindfoot arthrodesis. The hindfoot-arthrodesis group also had a significantly higher failure rate due to deep infection or aseptic loosening.

In a cadaveric study involving latex injection, Tennant et al. evaluated the effect of implantation of four types of contemporary total ankle arthroplasty prostheses on the vascular supply to the talus\textsuperscript{38}. Each of the four implants posed a risk to the extrasosseous talar blood supply, but the risk to specific arteries was unique to the specific implants. Knowledge of the risk to the talar blood supply that each implant poses may help to lower the risk of aseptic loosening due to talar osteonecrosis.

### Ankle and Hindfoot Arthrodesis

Tibiotalocalcaneal arthrodesis with use of a retrograde intramedullary nail is a useful technique for addressing severe ankle and hindfoot deformity and arthritis. Kane and Raikin reported successful results from the use of retrograde intramedullary nailing to treat tibial malunion or nonunion with concomitant hindfoot arthritis in a single-stage procedure\textsuperscript{39}. Two other studies, by Jeng et al. and Bussewitz et al., evaluated the use of retrograde intramedullary nails with bulk femoral-head allograft for the salvage of large bone defects\textsuperscript{40,41}. Successful fusion occurred in 50% and 48% of patients in the two studies, respectively, and the overall rate of a functional, braceable limb was 71% and 84%, respectively, if asymptomatic nonunions were included. The amputation rate was 19% and 16%, respectively, with a higher complication and nonunion rate noted among patients with diabetes.

CT can help to quantify the amount of osseous bridging following arthrodesis, but the extent of osseous bridging necessary for arthrodesis to be considered successful is unclear. Glazebrook et al. reviewed CT scans of isolated ankle and hindfoot fusions to compare the percentage of osseous bridging across the fusion site with the clinical outcomes\textsuperscript{42}. Osseous bridging of $>25\%$ to 49% at the fusion site was associated with clinically important improvement of outcomes scores.

Alternatives to autograft, to minimize donor-site morbidity and improve fusion rates, are continually being developed. In a multicenter, prospective, randomized, pilot clinical trial, Glazebrook et al. compared B2A-coated ceramic granules with autograft in foot and ankle arthrodesis\textsuperscript{43}. B2A-coated ceramic granules, serving as a bone-graft extender that augments osteodifferentiation, produced a 100% fusion rate compared with a 92% rate in the autograft group when fusion was assessed on CT scans.

### Osteochondral Lesions of the Talus and Osteonecrosis

Particulated juvenile cartilage (DeNovo NT Natural Tissue Graft; Zimmer, Warsaw, Indiana), a prepackaged allograft with viable human cartilage cells from donors younger than thirteen years of age, is being used for the treatment of moderate and large-sized talar osteochondral lesions to reproduce hyaline cartilage. Coetzee et al. reported good to excellent short-term outcomes in the majority of patients treated with particulated juvenile cartilage for talar osteochondral lesions of $>1$ cm in at least one dimension\textsuperscript{44}. Autologous osteochondral transplantation is another strategy for the management of talar osteochondral lesions; however, concerns exist regarding graft degeneration and poor integration of the chondral graft interface as well as postoperative subchondral cyst formation. Smyth et al. used a rabbit model to demonstrate improved integration of an osteochondral autograft transplant at the cartilage interface when the graft was soaked with platelet-rich plasma (PRP) prior to implantation in the defect site when compared with a control group\textsuperscript{45}. PRP helped to facilitate osteochondral graft integration in this in vivo rabbit model, which may suggest its potential in helping to prevent graft degeneration.

### Achilles Tendon

Young et al. compared weight-bearing with non-weight-bearing short-leg cast immobilization in equinus as part of the nonoperative management of acute Achilles tendon ruptures\textsuperscript{46}. Comparably low rerupture rates were noted, but the weight-bearing group had less subjective stiffness and no difference in outcome scores, patient satisfaction, or time to return to work or sports. In summary, weight-bearing cast immobilization produced outcomes that were equivalent to those of non-weight-bearing cast immobilization in the nonoperative management of acute Achilles tendon ruptures.

Numerous procedures for the lengthening of the gastrocnemius-soleus complex have been described for the treatment of equinus deformity. In a cadaveric study, Firth et al. evaluated the biomechanical characteristics of six common procedures for the lengthening of the gastrocnemius-soleus musculotendinous complex\textsuperscript{47}. Procedures in zone 1, from the femoral origins of the gastrocnemius to the distal extensions of the medial gastrocnemius muscle, allowed for a stable but limited amount of lengthening. Procedures in zone 2, from the end of the medial gastrocnemius muscle to the end of the soleus muscle, produced stable lengthening greater than that of zone 1. Procedures in zone 3, from the end of the soleus muscle to
the Achilles tendon insertion on the calcaneus, produced less
stable but significantly greater lengthening power than the zone
1 and zone 2 procedures.

Diabetes and Peripheral Neuropathy
Plantar foot ulcers from diabetic neuropathy are a risk factor
for subsequent plantar foot ulcers as well as lower-extremity
amputation. Ulbrecht et al. performed a multicenter, randomized
trial comparing standard-of-care orthoses with experimental
shape and pressure-based orthoses to assess the effective-
ness in the prevention of ulcer recurrence. The experimental
orthoses were found to significantly reduce subtetatarsal-head
plantar ulcer recurrence when compared with standard orthoses.
No difference between the orthoses was detected in the prevention
of nonulcerative plantar forefoot lesions. The operating surgeon
must also be aware of a patient’s diabetic control and neuropathic
status as a risk factor for adverse postoperative events.

A Level-I study by Wukich et al. demonstrated an ele-
vated risk of surgical site infection in diabetic patients with
complications associated with their diabetes, but diabetic pa-
ients without complications did not have higher infection
rates compared with nondiabetic patients. Interestingly, an
increased risk of surgical site infection was associated with
peripheral neuropathy, even in patients without diabetes. The
presence of peripheral neuropathy and a hemoglobin A1c level
of ≥28% were independent risk factors for surgical site infection.

Grear et al. reported on a series of patients with per-
ipheral neuropathy associated with rheumatoid arthritis who
developed Charcot arthropathy of the foot and ankle. The
relationship between rheumatoid arthritis and Charcot ar-
thropathy, to our knowledge, has not been previously reported,
and their review classifies the foot and ankle involvement ac-
ning to the Brodsky anatomic classification, thereby raising
awareness of this association.

Posterior Tibial Tendon Dysfunction
Flatfoot deformity is a complex, three-dimensional deformity
involving the osseous, tendinous, and ligamentous structures
supporting the entire foot and ankle. Haleem et al. demon-
strated the inability of weight-bearing radiographs to accu-
rately detect many radiographic parameters of the multilayer
deformity associated with posterior tibial tendon dysfunction
that were detected with three-dimensional CT-like multilayer
weight-bearing images. The most notable radiographic de-
formity in posterior tibial tendon dysfunction was evident at the
talonavicular joint in the sagittal plane.

Zanolli et al. evaluated the biomechanical effectiveness
of common surgical procedures used to correct a simulated
stage-IIB posterior tibial tendon-deficient flatfoot deformity in
a cadaver model. In the tested model, a medial displacement
calcaneal osteotomy and flexor digitorum longus transfer was
inferior to other evaluated treatments. Procedures incorpo-
rating a lateral column lengthening provided the most pow-
erful correction of sagittal and coronal deformity.

Bruce et al. showed that lateral calcaneal displacement
ostotomies significantly reduced the volume of the tarsal tun-
nel, while calcaneal osteotomies displaced medially did not
significantly alter tarsal tunnel volume. Therefore, patients
undergoing a lateral calcaneal displacement osteotomy may
benefit from prophylactic tarsal tunnel release to reduce the risk
of tibial nerve dysfunction. Ajis and Geary reported excellent
patient satisfaction and radiographic correction following nav-
iculocuneiform arthrodesis as the only arthrodesis procedure
for planovalgus foot deformity. Other adjunctive procedures were
performed; however, the naviculocuneiform arthrodesis was
performed in each patient on the basis of the results of weight-
bearing lateral radiography with the patient performing a reverse
Coleman block test to demonstrate the level of instability. The
level of instability is revealed with the reverse Coleman block test
and commonly involves the naviculocuneiform joint.

Charcot-Marie-Tooth Disease
Charcot-Marie-Tooth disease has many musculoskeletal effects
that manifest in the lower extremity, including dorsiflexion
weakness causing a clinical foot drop. Dreher et al. evaluated the
outcome of transfer of the posterior tibial tendon through the
interosseous membrane with split attachment to the tibialis ante-
rior and the peroneus brevis tendons at a mean follow-up of 28.8
months. Three-dimensional gait analysis revealed a significant
increase in dorsiflexion during the swing phase of gait but a re-
duction in active plantar flexion. Posterior tibial tendon transfer
was effective in correcting the foot-drop component of Charcot-
Marie-Tooth disease, with no acquired flatfoot deformity noted.

Upcoming Educational Events
The following are upcoming courses and events relevant to foot
and ankle surgery, sponsored or cosponsored by the AAOS
(American Academy of Orthopaedic Surgeons) and the
AOFAS.

- The AOFAS 31st Annual Meeting; July 16-18, 2015;
  Long Beach, California
- Foot & Ankle Masters Experience (Arthroscopy
  Association of North America); August 29-30, 2015;
  Rosemont, Illinois
- Surgical Complications of the Foot and Ankle;
  November 5-7, 2015; Tampa, Florida

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