What’s New in Foot and Ankle Surgery

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Abstract
This update summarizes recent research pertaining to the subspecialty of orthopaedic foot and ankle surgery that was published or presented between August 2009 and July 2010. The sources of these studies include The Journal of Bone and Joint Surgery (American and British Volumes), Foot & Ankle International, and the proceedings of Specialty Day at the annual meeting of the American Academy of Orthopaedic Surgeons (AAOS), held on March 13, 2010, in New Orleans, Louisiana, and the summer meeting of the American Orthopaedic Foot & Ankle Society (AOFAS), held on July 7 through 10, 2010, in National Harbor, Maryland.

Tibial Plafond Fractures
Surgical treatment of open tibial plafond fractures historically has been fraught with complications associated with the tenuous soft-tissue envelope surrounding the ankle. Boraiah et al. reported the outcomes of open reduction and internal fixation of open tibial plafond fractures with use of a treatment algorithm that includes early external fixation, meticulous soft-tissue management, and a staged approach to definitive fixation and soft-tissue coverage. Fifty-two of fifty-nine fractures healed, six patients required bone-grafting at the time of revision surgery for the treatment of nonunion, and one patient required an amputation following the failure of a free tissue transfer. Only two (3%) of fifty-nine patients developed a deep wound infection, three patients developed a superficial infection, and no cases of chronic osteomyelitis occurred. These results demonstrate that open reduction and internal fixation for the treatment of high-energy open tibial plafond injuries can be successful with use of a staged operative approach intended to minimize soft-tissue complications.

Ankle Fractures
The standard treatment of unstable ankle fractures is to hold the fracture reduction with rigid internal fixation. Ankle instability, however, can be difficult to determine, particularly in cases of isolated fibular fracture in which injury to the deep deltoid ligament is uncertain. Radiographic diagnosis of a deep deltoid ligament tear in these instances depends on an identifiable increase in the medial ankle joint “clear space.” Saldua et al. demonstrated the impact of ankle position during the radiographic measurement of the medial clear space.
Mortise-view radiographs were made for twenty-five healthy volunteers in four positions of ankle plantar flexion (0°, 15°, 30°, and 45°). With progressive ankle plantar flexion, the medial clear space progressively increased as the narrower posterior aspect of the talus occupied the mortise. This reached a significant level at 45° of plantar flexion, with an average increase in the medial clear space of 0.38 mm. Additionally, the prevalence of false-positive findings of deltoid injury increased with greater ankle plantar flexion when the ratio of the medial clear space to the superior clear space was used for diagnosis. These results underscore the impact of the position of ankle plantar flexion on the measured medial clear space, which can strongly influence the decision to proceed with operative or nonoperative treatment. The authors recommended making radiographs with the ankle in a neutral position to ensure accurate measurement of the medial clear space. Any ambiguity regarding the integrity of the deep deltoid ligament should be investigated further with use of a gravity stress test, a manual stress test, or magnetic resonance imaging (MRI) to appropriately guide management.

Intraoperative detection of syndesmotic disruption following the fixation of ankle fractures suggests the need for surgical stabilization of the distal tibiofibular joint. The exact criteria for the diagnosis of syndesmotic instability and the role of the intraoperative external rotation test and the lateral stress test remain unclear. Stoffel et al. performed a cadaveric study to determine the accuracy of these two stress tests for the identification of syndesmotic instability. The lateral stress test (involving the use of a bone hook to apply a lateralizing force to
the fibula) and measurement of the tibiofibular clear space proved to be the most useful for the detection of syndesmotic injury. The external rotation stress test was able to detect syndesmotic injury only with measurement of the medial clear space; however, this variable also increased in cases of isolated deltoid injury. The study suggested that a tibiofibular clear space of >5 mm as seen on an intraoperative lateral stress radiograph will most accurately diagnose syndesmotic disruption.

In order to determine the role of articular cartilage lesions in the development of posttraumatic osteoarthritis, Stufkens et al. investigated the long-term results of a study that originally presented arthroscopic documentation of intra-articular cartilage injury at the time of acute ankle fracture fixation. After a mean of 12.9 years, cartilage damage that was initially discovered arthroscopically was correlated with follow-up clinical outcomes as evaluated with American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot scores and radiographic outcomes with use of a modified Kianus osteoarthritis score. Initial cartilage damage that was seen arthroscopically at the time of ankle fracture fixation was found to be an independent predictor of the development of posttraumatic ankle osteoarthritis. More specifically, lesions on the anterior and lateral aspects of the talus and those on the medial malleolus correlated with lower clinical outcome scores. Deep lesions, defined as those exceeding 50% of the cartilage thickness, also correlated with worse long-term outcomes. These results provide evidence associating the development of posttraumatic ankle arthritis to the initial chondral damage sustained during an ankle fracture. Anatomic reduction of ankle fractures still remains the goal of operative fixation in order to optimize long-term results. The role of arthroscopy and its ability to alter the long-term effects of cartilage injury sustained during acute ankle fractures remain areas of future research.

The influence of injury as well as orthopaedic immobilization of the right leg on driving performance remains an uncertainty with both medical and legal implications. Tremblay et al. evaluated the isolated effect that different types of immobilization play on the braking performance of healthy volunteers under simulated driving conditions. The volunteers were tested under three conditions: (1) while wearing a running shoe, (2) while wearing a foam pneumatic walking boot (Aircast Walker; DJO, Vista, California), and (3) while wearing a short leg walking cast with an anti-skid sole (Cast Boot; DARCO, Huntington, West Virginia). Braking reaction time and total braking time during emergency braking conditions were significantly shorter in association with the running shoe than with either form of immobilization. Additionally, the maximum braking force was significantly lower for the walking cast than for the running shoe and walking boot, but the mean values were still far above the force previously shown to be required to adequately brake. Although that study demonstrated that orthopaedic immobilization has a demonstrable negative effect on driving performance, it did not prove that this effect is clinically relevant or that these types of immobilization are dangerous. Further investigation is necessary to clarify the effect that both orthopaedic immobilization and injury have on driving performance so that evidence-based recommendations can be designed and implemented.

**Calcaneal Fractures and Hindfoot Trauma**

Potter and Nunley reported the long-term results following the operative treatment of calcaneal fractures in the largest cohort of patient results reported to date. Validated outcomes measures, including adjusted AOFAS ankle-hindfoot scores, Foot Function Index scores, and a calcaneal fracture scoring system were used to clinically evaluate seventy-three patients at a median of 12.8 years after the injury. The average adjusted AOFAS ankle-hindfoot score was 65.4, the average Foot Function Index score was 20.5, and the average calcaneal fracture score was 69.3. These scores were found to be comparable with those previously reported in studies with smaller cohorts of patients. A worse long-term outcome was demonstrated for patients who sustained the calcaneal fracture as the result of a motor vehicle accident as compared with those who sustained the injury as the result of a fall. Interestingly, the outcomes for patients who were receiving Workers’ Compensation at the time of the initial surgical procedure did not differ significantly from those not receiving Workers’ Compensation. The worse short-term surgical results that were reported in earlier studies for patients receiving Workers’ Compensation were not found at the time of long-term follow-up in this cohort of patients. This discrepancy may have been due to either a relatively low number of patients receiving Workers’ Compensation in the study (twelve), a lower-energy mechanism of injury (falls), or the lack of incentive to overreport disability or limitation for secondary gain.

Subtalar dislocation is a relatively infrequent injury that most commonly occurs with an associated fracture. Jungbluth et al. combined data from two major university trauma centers over thirteen years to report the outcomes of twenty-three isolated subtalar dislocations in patients without osseous injury. The patients were evaluated on the basis of the AOFAS ankle-hindfoot scale, the joint range of motion, and radiographs at an average of 58.3 months of follow-up. Sixteen subtalar dislocations were medial, six were lateral, and one was posterior. If closed reduction was successful, the dislocation was treated with a short leg cast for six weeks, followed by aggressive physiotherapy and progressive weight-bearing. Seven open dislocations were irreducible with use of closed reduction. Each open dislocation was treated with open reduction and external fixator stabilization for six weeks, followed by physiotherapy with progressive weight-bearing. The average AOFAS ankle-hindfoot score was 82.3 points, and the average measured subtalar motion was 41.3°, with no difference related to the direction of the initial dislocation. Only six patients demonstrated minor radiographic changes. Patients
who were employed at the time of the injury ultimately were able to return to employment. All patients who participated in sports activities prior to the injury were able to resume athletics at the same level of performance without restriction. A computed tomography (CT) scan should be performed in all cases of subtalar dislocation to accurately characterize the nature of the subtalar dislocation. These results suggest that purely soft-tissue dislocations of the subtalar joint have a positive clinical and radiographic prognosis.

**Metatarsal Fractures**

Shock wave therapy is emerging as a safe and noninvasive alternative to surgery for the treatment of fracture nonunions. In a retrospective cohort study, Furia et al. compared intramedullary screw fixation and high-energy shock wave therapy for the treatment of established nonunions in the metaphyseal-diaphyseal region of the proximal aspect of the fifth metatarsal. Twenty of twenty-three nonunions healed by three months following one treatment with high-energy shock wave therapy (2000 to 4000 shocks; energy flux density per pulse, 0.35 mJ/mm²). Eighteen of twenty nonunions healed in the group that was treated with intramedullary screw fixation with use of either 6.5 or 4.5-mm partially threaded screws. Of the three persistent nonunions in the shock wave group, one united by six months whereas another healed following a second round of shock wave therapy. While the overall nonunion healing rates were similar for the two treatments, the associated complication rates differed. The shock wave therapy was generally well tolerated, and only one minor complication of transient petchiae was reported. In the intramedullary screw fixation group, eleven complications occurred, including nine cases of symptoms related to the implant, one refracture, and one case of superficial cellulitis. Shock wave therapy is an intriguing and evolving therapeutic option for fracture nonunions, although the mechanism by which this treatment modality promotes nonunion healing is unknown.

**Ankle Sprains and Instability**

The role and efficacy of prophylactic ankle bracing for the prevention of inversion ankle sprains remains unclear. In a prospective study, Frey et al. compared the incidence of inversion ankle sprains in high school volleyball players who wore braces during all athletic activities with that in a control group of players who did not wear braces. A total of 957 athletes were randomly assigned to treatment with a commercial ankle brace that was considered rigid, semi-rigid, or non-rigid and were followed for an entire playing season. Overall, the study failed to demonstrate a significant decrease in the incidence of inversion ankle sprains with prophylactic ankle bracing, irrespective of the type of brace device employed. However, when the group of athletes with a history of a previous ankle sprain was removed from analysis, the Active Ankle Trainer II (Active Ankle Systems, Louisville, Kentucky) and the Aircast Sports Stirrup (Aircast, Summit, New Jersey), considered a rigid and a semi-rigid brace, respectively, demonstrated a significant decrease in ankle sprains. Females wearing a nonrigid brace showed a significantly higher incidence of ankle sprains than did males wearing the same type of brace. Females wearing a nonrigid brace also showed a significantly higher incidence of ankle sprains compared with females wearing a semi-rigid or rigid brace. The results of that study suggest that a rigid or semi-rigid ankle brace may help to decrease the incidence of first-time ankle sprains.

**Osteochondral Lesions of the Talus**

Large-volume cystic osteochondral defects of the talus are extremely challenging to treat. Raikin reviewed the prospectively collected data on fifteen patients with symptomatic large-volume cystic osteochondral defects of the talus that were treated surgically with bulk fresh osteochondral allograft transplantation. The average volume of the talar defects was 6059 mm³, and the average duration of follow-up was fifty-four months. The average AOFAS ankle-hindfoot score improved from 38 points preoperatively to 83 points postoperatively, whereas the average visual analog scale (VAS) score improved from 8.5 preoperatively to 3.3 postoperatively. Radiographically, ten of the fifteen ankles demonstrated some evidence of collapse or resorption of the graft and nine ankles demonstrated some narrowing of the joint space overlying the graft. Two patients underwent arthrodesis of the ankle because of graft collapse or arthritis. Overall, eleven patients rated the outcome as good or excellent, and all fifteen were pleased that they had had the allograft procedure. Bulk fresh osteochondral allograft transplantation for the treatment of symptomatic large-volume cystic osteochondral defects of the talus appears to be a promising surgical alternative. The long-term survival of the grafts and patient outcomes are unknown.

Two similar studies evaluated the outcomes following fresh osteochondral allograft transplantation for the treatment of symptomatic osteochondral lesions of the talus. Hahn et al., in a study of thirteen patients who underwent fresh talar allograft transplantation, reported that the average AOFAS score increased from 45 preoperatively to 81 postoperatively and that the average Foot Function Index (FFI) improved from 5.56 preoperatively to 2.01 postoperatively. All patients were able to return to daily activities, although radiographs that were made at a mean of forty-eight months demonstrated osteoarthritic changes in all patients but one. Four of the thirteen patients required the removal of an impinging screw, and all allografts healed. Görtz et al., in a study of twelve ankles (eleven patients), reported that the mean Olerud-Molander Ankle Score (OMAS) improved from 28 to 71 points at a mean of thirty-eight months after fresh talar allograft transplantation. One patient required revision fresh talar allograft transplantation after the graft collapsed and fragmented, a second patient was managed with conversion to an ankle arthrodesis after developing persistent pain and
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large subchondral cysts, and a third patient underwent further arthroscopic debridement. Overall, only five of the eleven patients achieved a good or excellent result. These small series of fresh talar allograft transplantation demonstrate imperfect, yet acceptable, short-term results. Fresh talar allograft transplantation is a viable option for the replacement of talar hyaline cartilage and may be offered as a surgical alternative prior to ankle arthodesis or arthroplasty. Metallic focal resurfacing implants have been developed as an alternative to total joint replacement in the knee, hip, and shoulder. Anderson et al. evaluated the placement and effect of component position on joint contact mechanics with use of a metallic implant (HemiCAP; Arthrosurface, Franklin, Massachusetts) to resurface cadaveric talar osteochondral defects. The resurfacing implant restored 90% of the normal joint contact area after producing a 15-mm osteochondral defect on the talar dome. Peak contact stresses were found to be elevated after implantation of the metallic implant. Additionally, with the implant only 0.25 mm proud, the peak implant-on-cartilage contact stress was further elevated to 220% of the value for intact specimens. Metallic focal resurfacing may offer a potential solution to restore joint mechanics in ankles with talar osteochondral defects, but peak joint contact stresses are highly sensitive to implant positioning, which may in turn significantly affect clinical outcome.

Total Ankle Arthroplasty
Saltzman et al. performed a multicenter prospective study in which a three-part “mobile bearing” total ankle arthroplasty implant was compared with ankle arthrodesis for the treatment of end-stage ankle arthritis. The study was conducted following United States Food and Drug Administration (FDA) approval of an Investigational Device Exemption (IDE) permitting use of the Scandinavian Total Ankle Replacement (STAR; Link, Hamburg, Germany) in the United States. A total of 158 ankle replacements were available for comparison with sixty-six ankle fusions after a minimum of twenty-four months of follow-up. The ankle replacement group demonstrated higher functional scores and equivalent pain relief; however, major complications and the need for additional surgery were also more frequent. An additional 448 ankle replacements were followed clinically after enrollment in the direct comparison arm of the study was complete. The rates of secondary major and minor procedures decreased by half in the latter cohort of ankle replacements in comparison with the STAR prostheses that were initially implanted. The STAR ankle replacement met the criteria to be considered not inferior to ankle fusion in terms of overall patient success. On the basis of the results of this clinical trial, the Scandinavian Total Ankle Replacement received FDA approval in May of 2009 for use in the United States to treat painful ankle osteoarthritis, posttraumatic arthritis, or rheumatoid arthritis.

The design improvements associated with new generations of total ankle arthroplasty prostheses have been largely developed through critical analysis of clinical modes of failure of earlier implants. Relatively few biomechanical models have been used to evaluate potential modes of failure of ankle arthroplasty implants. Fukuda et al. evaluated the effect of talar component malrotation on ankle contact pressures and forces. Six cadaver ankles were implanted with a two-component prosthesis, the Agility Total Ankle System (DePuy, Warsaw, Indiana), in varying sequences of talar component rotation. Subsequent biomechanical testing and pressure recordings demonstrated reproducible patterns of increased contact pressure and rotational torque. Near the limit of the tested internal and external malrotation of the talar component, the total tibiotalar contact area decreased and a pattern of two-point contact developed. The orientation of the two-point contact opposed the direction of talar component malrotation and produced increased peak pressure, decreased contact area, and increased rotational torque that resisted the malrotation. These results provide insight into the effect of talar component malrotation on ankle contact pressures and forces that may contribute to premature polyethylene wear and prosthetic loosening. The importance of proper implant positioning during total ankle arthroplasty was underscored by Espinosa et al. in a finite-element model of two total ankle replacement prostheses. That study evaluated the two-component Agility Total Ankle System (DePuy) and the mobile-bearing Mobility Total Ankle System (DePuy) with computer-simulated tibial version misalignments, talar version, and relative component rotation of the two-component design. The finite-element model was validated in cadavers. The average joint-contact pressures for the Agility two-component prosthesis exceeded the yield stress of polyethylene when positioned in accordance with the manufacturer’s guidelines. The contact pressures predictably increased with progressive misalignment of the components from the manufacturer’s reference position. The Mobility three-component prosthesis produced lower contact pressures at baseline and was less sensitive to misalignment of the components. Deviation of component version of >5° in the Mobility prosthesis, however, increased average contact stresses to near the yield stress of polyethylene. To optimize ankle arthroplasty longevity, proper positioning of the tibial and talar components is necessary in order to reduce contact pressures. Three-component arthroplasty designs may reduce susceptibility to abnormal joint contact characteristics, and particular attention should be directed to version of the individual components.

Plantar Fasciitis
Scher et al. investigated the incidence and demographic characteristics of plantar fasciitis with use of the large-scale Defense Medical Epidemiology Database of the United States Military. The database was searched for the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code for plantar fasciitis for the years 1998 to 2006 and produced a total of 127,057 initial patient encounters with this diagnosis.
The overall incidence of plantar fasciitis was 10.5 per 1000 person-years. Several significant risk factors for the development of plantar fasciitis were identified, including female sex; black race; junior enlisted, senior enlisted, and senior officer military rank groups; military service in the Army or Marines; and increasing age. These results provide useful information on who may be susceptible to plantar fasciitis and who may benefit from preventive measures.

A dedicated Achilles and plantar fascia-specific stretching program remains the workhorse first-line treatment for plantar fasciitis, although recalcitrant chronic plantar fasciitis may respond to alternative therapies. Ibrahim et al. performed a prospective randomized study in which radial extracorporeal shock wave therapy was compared with placebo for the treatment of chronic plantar fasciitis that had failed to respond to standard nonoperative treatment\(^{16}\). The radial extracorporeal shock wave therapy was administered in only two sessions, one week apart, with 2000 impulses delivered per session. The radial extracorporeal shock wave therapy resulted in significant improvement in terms of pain in comparison with placebo as measured with a visual analog scale and on the basis of quality of life (evaluated with use of the Roles and Maudsley score) at each follow-up time point up to twenty-four weeks. Radial extracorporeal shock wave therapy may be an effective treatment for chronic plantar fasciitis with only two sessions performed one week apart instead of three sessions as previously reported.

In a prospective randomized pilot study, Lohrer et al. compared radial extracorporeal shock wave therapy with focused shock wave therapy for the treatment of chronic plantar fasciitis that had failed to respond to nonoperative treatment\(^{19}\). The shock wave treatments were administered in three sessions at one-week intervals, with 2000 impulses applied per session. Outcomes were measured on the basis of the Foot Function Index (FFI), neuromuscular performance, and a composite score from baseline to twelve weeks of follow-up. The overall result showed a trend toward superiority of the focused shock wave treatment that became stronger when adjusted for age. Additional studies are needed to support one form of shock wave therapy over another.

**Achilles Tendon**
Open repair of Achilles tendon ruptures carries an inherent risk of wound-healing complications and infection. Yepes et al. performed a digital vascular mapping study of the integument overlying the Achilles tendon in order to better understand the wound-healing capability of skin incisions used for the repair of Achilles tendon ruptures\(^{20}\). Ten cadaver legs underwent whole-body arterial perfusion with a lead oxide injectate. The legs were dissected free of the integument about the Achilles tendon, and the resultant angiograms were used for digital vascular mapping. Three vascular zones were identified. The medial vascular zone was located between the posteromedial border of the Achilles tendon and the posterior border of the medial malleolus. The posterior tibial artery provided the arterial supply to this zone and was significantly more dense than the posterior zone. The lateral vascular zone was located between the posterolateral border of the Achilles tendon and the posterior border of the lateral malleolus. The peroneal artery or its recurrent branch provided the arterial supply and was also significantly more dense than the posterior zone. A longitudinal hypovascular zone was identified over the posterior cutaneous midline covering the Achilles tendon. The blood supply of this posterior zone was derived from the perforating arteries from either side of the tendon as well as from small arterioles that communicated with the skin and subcutaneous tissue by the posterior paratenon of the Achilles tendon. The poor vascular supply to the integument immediately posterior to the Achilles tendon may help to explain the relatively high wound complication and infection rates reported in association with posteriorly based skin incisions.

**Tibialis Anterior Tendon**
Tendinosis of the Achilles tendon, posterior tibial tendon, and peroneal tendons have been recognized as degenerative disorders. Beischer et al. retrospectively evaluated twenty-nine patients (thirty-two feet) who were diagnosed with distal tibialis anterior tendinosis to further define and characterize the clinical presentation\(^{21}\). The typical presenting symptom was a burning or dull medial foot pain that was often worse at night and that occurred most frequently in women; twenty-seven of the twenty-nine patients were female. On examination, swelling was often present over the tendon and the symptoms were reproduced with passive plantar flexion of the foot combined with eversion, abduction, and pronation (the tibialis anterior passive stretch [TAPS] test). MRI features that were characteristic of tibialis anterior tendinosis were tendon thickening, increased signal within the tendon insertion, peritendon edema and synovitis, and longitudinal split tears. The natural history and treatment of this condition require further investigation.

Rupture of the tibialis anterior tendon is an infrequent injury but is associated with substantial morbidity, including pain, gait disturbance, and weak dorsiflexion strength. In a retrospective review, Ellington et al. reported their experience with the surgical reconstruction of fifteen tibialis anterior tendon ruptures in fourteen patients\(^{22}\). Five ruptures were treated with primary tendon repair, nine were treated an extensor hallucis longus tendon transfer, and one was treated with an extensor digitorum longus tendon transfer. The average postoperative AOFAS hindfoot score was 88.8, and the average Short Form-36 Health Survey (SF-36) score was 76.4. Seven patients were completely satisfied, six had minor reservations, and one had major reservations. The average dorsiflexion strength on the operatively repaired side was significantly lower than that on the contralateral side. These results add support to surgical repair or reconstruction for the treatment of tibialis anterior tendon ruptures.
Adult Acquired Flatfoot Deformity

Lateral column lengthening is a relatively common surgical adjunct for the correction of flatfoot deformity that specifically addresses the forefoot abduction aspect of the deformity. Ellis et al. investigated the association between lateral column lengthening and elevated plantar pressures by comparing patients with and without postoperative lateral plantar pain. The patients with complaints of lateral plantar pain had significantly lower SF-36 and Foot and Ankle Outcome Scores in comparison with those without discomfort. In addition, the symptomatic patients demonstrated increased plantar pressure values along the lateral aspect of the midfoot with plantar pressure measurement. Surgeons should be aware of the tendency to overload the lateral plantar border of the foot with lateral column lengthening and should make intraoperative adjustments to minimize the likelihood of this complication.

Hallux Valgus

A crossed-screw construct has traditionally been utilized for fixation during Lapidus (first metatarsocuneiform joint) arthrodesis procedures. Klos et al. performed a cadaver-based experiment in which the stability of the traditional crossed-screw technique was compared with that of a locking plate (X-locking plate 2.4/2.7; Synthes, Solothurn, Switzerland) with a single adjunct compression screw. For the crossed-screw technique, two 4.0-mm cannulated partially threaded stainless steel screws were used. For the locking plate arthrodesis, an adjacent 4.0-mm cannulated partially threaded stainless steel screw was used in addition to a medially applied locking plate. Biomechanical testing demonstrated no significant difference in terms of initial construct stiffness. Further cyclic testing revealed significantly less plantar gapping at the arthrodesis site for the plate and screw construct at all evaluated cycling stages. The number of cycles to failure was also significantly higher for the plate-and-screw construct.

The application of locking plate technology to small joint fusion procedures such as the Lapidus arthrodesis may provide a construct that is more resistant to cyclic loading and failure. It remains uncertain if the increased biomechanical strength of the plate-and-screw construct translates to a clinically relevant decrease in nonunion rates or to a shortened period of postoperative non-weight-bearing.

Numerous proximal and mid-diaphyseal osteotomies have been described for the correction of moderate to severe hallux valgus with metatarsus primus varus. Robinson et al., in a prospective comparative study of 115 sequential cases, compared the outcomes associated with two mid-diaphyseal osteotomies (the scarf and Ludloff osteotomies) that were used for the correction of moderate to severe metatarsus primus varus. At six and twelve months of follow-up, no significant difference was found in terms of subjective satisfaction, AOFAS score, improvement in functional activities, or range of movement. Significant improvement in terms of pain and the number of transfer lesions that resolved postoperatively favored the scarf osteotomy group. The radiographic correction of the intermetatarsal angle, the hallux valgus angle, the distal metatarsal articular angle, and sesamoid position were significantly better in the scarf osteotomy group at six and twelve months of follow-up. The authors recommended the scarf osteotomy over the Ludloff osteotomy for the correction of metatarsus primus varus.

Lesser-Toe Problems

Brachymetatarsia is a rare congenital shortening of the metatarsal bones that occurs most frequently in the fourth metatarsal. Lee et al. performed a retrospective review to assess the outcomes of lengthening for the treatment of fourth brachymetatarsia in 153 feet with use of three different surgical lengthening techniques. The surgical techniques included (1) intercalary bone-grafting with tricortical iliac-bone graft, (2) the application of an external fixator through a transverse osteotomy performed with a sagittal saw, and (3) the application of the same external fixator through an osteotomy performed with use of an osteotome through multiple drill-holes. The mean lengthening of the fourth metatarsal at the time of the latest follow-up was 13.9 mm in the bone-graft group, 17.8 mm in the saw group, and 16.8 mm in the predrilled osteotome group. There were no dissatisfied patients in the predrilled osteotome group, whereas 13.6% of the patients in the saw group and 11.1% of the patients in the bone-graft group reported dissatisfaction with the respective procedures. In eight patients in the saw group, bone failed to form postoperatively. Gradual distraction osteogenesis of the fourth metatarsal with an external fixator after a drill-hole or osteotome osteotomy may produce the most reliable results for the treatment of fourth brachymetatarsia. Ellington et al. reported the results associated with the use of an intramedullary fusion device to stabilize a proximal interphalangeal joint arthrodesis for the correction of hammertoes and clawtoes. That retrospective study evaluated thirty-eight toes that were treated with the StayFuse device (Nexa Orthopaedics, San Diego, California), which is a two-piece threaded implant that connects centrally. The union rate was 60.5% overall, 75% after primary procedures, and 53.8% after revision corrections. The alignment in the coronal and sagittal planes maintained adequate correction in the majority of patients; however, the overall complication rate, including nonunions, was 55.3%. Although alignment seems to be preserved with hammertoe and clawtoe corrections with use of this intramedullary device, longer follow-up will be required to determine if the high nonunion rate affects outcomes.

Diabetes

Diabetes and its associated complications are widely considered to be risk factors for postoperative infection. However, no study has evaluated the prevalence of postoperative infection following foot and ankle surgery in diabetic patients. Wukich et al., in a retrospective review of 1000 patients who underwent...
foot and ankle surgery, compared the postoperative infection rates in patients with and without diabetes mellitus. Diabetic patients represented 19% of the patients in the study and were significantly older than the patients without diabetes (mean age, 57.3 compared with 44.2 years). The overall infection rate was 4.8%, with the rate in the diabetic subgroup being significantly higher than that in the control subgroup (13.2% compared with 2.8%). Patients who were considered to have diabetes with end-organ medical complications had a tenfold greater risk of infection compared with patients without diabetes and had a sixfold greater risk compared with patients with uncomplicated diabetes. Patients with uncomplicated diabetes did not have an increased postoperative infection risk compared with those without diabetes. Younger et al. performed a retrospective study in which diabetic patients who had a successful transmetatarsal amputation were compared with those who had required revision to a transtibial amputation. In all cases, the primary transmetatarsal amputation was carried out in conjunction with a percutaneous heel cord lengthening to reduce postoperative forefoot pressures. Only two evaluated variables were significantly predictive of primary transmetatarsal amputation failure: (1) glycemic control as measured with hemoglobin A1c (HbA1c) levels and (2) the postoperative need for debridement of the amputation site because of delayed wound-healing or infection. A trend toward significance was found for the duration of ulceration prior to transmetatarsal amputation and tobacco dependence. Indicators of advanced systemic disease, such as renal dialysis, hemoglobin levels, and the duration of diabetes, were not different between the transmetatarsal amputations that were successful and those that failed. Glycemic control is an important determinant of operative success and should be strictly controlled both before and after any operation when feasible. HbA1c levels reflect glucose control over the preceding ninety days and cannot be expected to normalize prior to an emergency or limb-sparing operation.

**Gastrocnemius Recession/Tendo-Achilles Lengthening**

Isolated gastrocnemius contracture as diagnosed by the Silfverskiöld test has been postulated to be the root of numerous foot and ankle ailments. The resulting equinus deformity alters foot biomechanics and increases forefoot pressures, predisposing individuals to conditions such as metatarsalgia, plantar fasciitis, arch pain, posterior tibial tendon dysfunction, hallux valgus, and diabetic foot ulcers. Maskill et al. performed a retrospective review of twenty-nine patients (thirty-four feet) who underwent only gastrocnemius recession procedures for the treatment of foot pain without structural abnormality in the presence of a concomitant isolated gastrocnemius contracture. The diagnosis behind the nonstructural foot pain was plantar fasciitis in twenty-five cases, metatarsalgia in six cases, and arch pain in three feet. The average VAS score improved from 8 of 10 preoperatively to 2 of 10 postoperatively. Patients who underwent gastrocnemius recession for the treatment of plantar fasciitis and metatarsalgia demonstrated significant improvement in the VAS score. Although patients with arch pain showed a trend toward improvement, the difference was not significant. That study supports the controversial idea that an isolated tight gastrocnemius muscle-tendon is a cause of numerous foot and ankle conditions. Gastrocnemius recessions may indeed relieve pressures on the foot and ankle, although it is currently unclear when this procedure is indicated in isolation for the treatment of recalcitrant foot pain.

Chimera et al. performed a prospectively designed study to evaluate the effect of gastrocnemius recession on the function and strength of the limb. Patients with isolated gastrocnemius contracture were tested for ankle dorsiflexion, function, and plantar flexion strength both preoperatively and after a gastrocnemius recession. A significant decrease in passive ankle dorsiflexion and functional activities was found when patients with isolated gastrocnemius contracture were compared with controls. In the gastrocnemius recession group, the average passive ankle dorsiflexion significantly increased from 1° preoperatively to 13° at three months after surgery. Functional scores and peak isometric plantar flexion strength did not decrease at three months of follow-up after gastrocnemius recession.

Gastrocnemius recession and tendo-Achilles lengthening are commonly used procedures in foot and ankle surgery, yet little is known about how these procedures affect the underlying musculature. In a live rabbit model, Booth et al. compared the histologic effect of gastrocnemius recession, tendo-Achilles lengthening, or cast treatment alone on the gastrocnemius-soleus muscle. When compared with control specimens, the gastrocnemius recession group demonstrated a decrease of 22.6% in terms of the weight of the gastrocnemius-soleus complex; this difference was not significant. However, there was a significant (23.6%) decrease in volume and a significant (189.1%) increase in the percentage of fat in this group. When compared with control specimens, the tendo-Achilles lengthening group demonstrated a significant (39.4%) decrease in weight, a significant (37.7%) decrease in volume, and a significant (197.8%) increase in the percentage of fat. In comparison, the cast treatment did not significantly affect the gastrocnemius muscle. Of the two surgical procedures, gastrocnemius recession retained a significantly greater weight of the gastrocnemius-soleus complex than did tendo-Achilles lengthening, but there was no difference in terms of volume or the percentage of fat.

**Footdrop**

Rodriguez retrospectively reported the results of the use of the Brülle procedure for the treatment of dorsiflexion paralysis of the foot. Thirty-four patients underwent thirty-seven Bridle procedures for the restoration of foot dorsiflexion strength. Twenty-nine of the patients who had a grade-4 or 5 functional posterior tibial tendon muscle strength before surgery were all brace-free with satisfactory clinical dorsiflexion of the foot. Five
patients with functional grade-3 posterior tibial tendon muscle strength postoperatively had no active dorsiflexion following the Bridle procedure; however, the ankle was maintained in a neutral plantigrade position. The Bridle procedure can be a successful surgical technique for the restoration of dorsiflexion. That study underscores the importance of preoperative functional muscle grading of the posterior tibial tendon to optimize outcomes. The authors recommended a triple arthrodesis before the Bridle procedure if the posterior tibial tendon has grade-3 strength preoperatively.

**Surgical Techniques**

Intraoperative pedobarography has been validated as a method to statically measure and analyze force distribution of the foot with the patient in the supine position. Richter and Zech conducted a prospective randomized study to determine if the intraoperative use of this technology would equate to improved clinical outcomes. The authors, one of whom invented the intraoperative pedobarography device, enrolled 100 patients to receive arthrodesis of the foot or ankle with or without the use of intraoperative pedobarography. In the group of fifty-two patients who were randomized to the use of intraoperative pedobarography, analysis of the force distribution following the initial fixation caused the surgeon to modify the bone position and fixation 46% of the time. The modifications were most likely to be done in cases of midfoot corrections and forefoot corrections and were least likely to be done in cases of ankle and subtalar joint corrections. Use of the intraoperative pedobarography added an average of five minutes to the operation, and any modifications to the initial fixation as a result of the analysis added an average of fifteen minutes. After an average of two years of follow-up, the average AOFAS and SF-36 scores were higher in the intraoperative pedobarography group, especially in cases of arthrodesis of the midfoot and forefoot. These results suggest that intraoperative pedobarography can provide surgeons a manner in which to analyze foot pressures during surgery, which may lead to improved outcomes.

**Basic Science**

Two recent experiments have drawn attention to the toxic effect of intra-articular injections of local anesthetics on articular cartilage chondrocytes. Grishko et al. harvested articular cartilage from patients undergoing total knee arthroplasty in order to culture chondrocytes for exposure to 2%, 1%, and 0.5% lidocaine; 0.5% and 0.25% bupivacaine; and 0.5% and 0.2% ropivacaine. Exposure of the chondrocyte cultures to local anesthetic for one hour produced chondrotoxicity, with 2% lidocaine causing near complete loss of viable chondrocytes due to massive necrosis by twenty-four hours. A detectable but not significant decrease in viability occurred in association with 1% lidocaine and 0.5% bupivacaine after twenty-four hours. A significant decrease in chondrocyte viability was detected 120 hours after exposure, with an increase in apoptotic cells at all concentrations of local anesthetics except 0.2% ropivacaine.

Chu et al. evaluated the in vivo effects of single intra-articular injections of 0.5% bupivacaine on articular cartilage. In that study, 0.5% bupivacaine, 0.6% mono-iodoacetate, or saline solution were injected intra-articularly into forty-eight Sprague-Dawley rats with gross assessment of the articular surface and histologic and quantitative evaluation of the articular cartilage at one week, four weeks, twelve weeks, or six months following injection. The articular surface remained intact on gross and histologic evaluation after the injection of 0.5% bupivacaine; however, a significant reduction in chondrocyte density was discovered at six months. The 0.5% bupivacaine demonstrated up to a 50% reduction in chondrocyte density when compared with saline solution at the six-month time period. The 0.6% mono-iodoacetate demonstrated extensive chondrocyte necrosis and full-thickness pathologic changes beginning at one week. Those experiments demonstrated concerning detrimental effects of local anesthetics on articular cartilage. Those results may affect clinical decision-making as intra-articular injections of local anesthetics are commonly applied in the form of postoperative or in-office injections for pain relief as well as for selective diagnostic injections.

Iliac crest bone is the gold standard for autograft bone. However, the associated morbidity and postoperative pain associated with iliac crest bone harvest have caused surgeons to seek alternative sites to harvest autograft bone, such as the proximal part of the tibia. Chiodo et al. performed a study in which ten samples of iliac crest bone autograft were histologically compared with ten samples of autograft taken from the proximal part of the tibia. All of the iliac crest samples demonstrated active hematopoietic marrow, whereas the proximal tibial samples exhibited more fat and sparse hematopoietic marrow. Histologic grading with use of a scale from I to VI, indicating the percentage of bone surfaces adjacent to active hematopoietic marrow, showed that the iliac crest was classified as grade IV (41% to 60%) or higher whereas the proximal tibial samples were all classified as grade II (1% to 20%) or less. While proximal tibial bone graft may contribute osteoconductive trabecular bone, its cellular contribution and osteoinductivity remain questionable.

**Musculoskeletal Oncology**

Tumors in the foot and ankle are rare. A paucity of literature is available with regard to the incidence of bone and soft-tissue tumors in the foot and ankle. Chou et al. performed a retrospective review of 2660 tumors that were surgically treated in all anatomic sites at a tertiary referral center over a twenty-year period. One hundred and fifty-three patients (5.75%) with a mean age of 33.2 years were managed for bone and soft-tissue tumors of the foot or ankle. Overall, 39.2% of the foot and ankle tumors were considered to be malignant and 60.8% were considered to be benign. Eighty patients had soft-tissue tumors, of which giant-cell tumor of the tendon sheath and pigmented villonodular synovitis were the most common. Seventy-three
patients had bone tumors, of which giant-cell tumor was the most common. The practicing surgeon should maintain vigilance with regard to the types of tumors that occur in this region.

**Evidence-Based Orthopaedics**

The editorial staff of The Journal reviewed a large number of recently published research studies related to the musculoskeletal system that received a Level of Evidence grade of I or II. Over 100 medical journals were reviewed to identify these articles, which all have high-quality study design. In addition to articles published previously in this journal or cited already in the Update, one additional level-I study was identified that was relevant to foot and ankle surgery. We have provided a brief commentary about this article after the standard bibliography to help to guide your further reading, in an evidence-based fashion, in this subspecialty area.

**Upcoming Educational Events**

There are several upcoming courses and events relevant to foot and ankle surgery sponsored or cosponsored by the AAOS, AOFAS, and AANA (Arthroscopy Association of North America).

The AOFAS Annual Specialty Day will be held on February 19, 2011, at the San Diego Convention Center in San Diego, California.

The AOFAS Annual Summer Meeting will be held on July 13 through 16, 2011, at the Keystone Conference Center in Keystone, Colorado.

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**References**


What’s New in Foot and Ankle Surgery


30. Maskill JD, Bohay DR, Anderson JG. Gastrocnemius recession to treat isolated foot pain. Foot Ankle Int. 2010;31:19-23.


Evidence-Based Article Related to Foot and Ankle Surgery


This randomized multicenter clinical trial compared the use of manual physical therapy and therapeutic exercise with electrophysical agents such as ultrasound and iontophoresis combined with exercise for the treatment of plantar heel pain. Both treatment groups demonstrated benefits; however, the combination of manual physical therapy and exercise was superior to the combination of ultrasound, iontophoresis, and exercise. The treatment of plantar heel pain with some variation of manual therapy that emphasizes Achilles stretching and soft-tissue mobilization directed at the triceps surae and the origin of the plantar fascia at the medial calcaneal tubercle appears to be the superior treatment.