

**Does Ankle Aspiration for Acute Ankle Fractures Result in Pain Relief?
A Prospective Randomized Double-Blinded Placebo-Controlled Trial**

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Purpose: Aspiration of fracture hemothrosis has been previously recommended as a method of pain control following certain intraarticular fractures. This study is designed to determine if aspiration of the fracture hemothrosis in the setting of an acute ankle fracture results in pain relief and diminished need for narcotic pain medications.

Methods: After IRB approval, the investigators randomized 109 patients with an ankle fracture (OTA classification 44) who presented within 24 hours of injury to undergo either an ankle aspiration to remove the hemothrosis, or to receive a sham procedure where the needle was advanced to the level of the subcutaneous tissue above the capsule, but no fluid was removed. Both the patient and the investigators were blinded. No differences were seen between these study groups. Patients recorded their Numeric Rating Scale (NRS) pain scores and narcotic usage (oral morphine equivalents [OMEs]) for the first 72 hours or until a surgical procedure occurred, whichever was first. Secondary outcomes included limb volumes (as measured by the technique of fluid displacement), 6-month Olerud-Molander (OM) and SMFA (Short Musculoskeletal Function Assessment) scores, and complications.

Results: A total of 109 subjects (37 males, 72 females) were enrolled with an average age of 52 years. 56 patients were randomized to aspiration, removing an average of 5 mL of hemothrosis. 53 patients were randomized to and received the sham procedure (control). There were 9 OTA 44A, 78 OTA 44B, and 22 OTA 44C, occurring in even distribution between the aspiration and sham procedure groups. The NRS pain score between emergency department arrival and dismissal improved 2.9 in the aspiration group and 2.5 in the sham group ($P = 0.4$). The highest pain scores in the first 24 hours after injury were 7.3 in the aspiration group and 7.4 in the sham group ($P = 0.88$); hours 24-48 maximum scores were 5.7 in each group ($P = 0.97$); hours 48-72 maximum scores were 4.6 and 5.2 ($P = 0.33$). Pain medicine usage in the first 72 hours following injury showed a total of 89 mg OMEs in the aspiration group and 103 mg OMEs in the sham group ($P = 0.43$). Volumetric measurements at initial follow-up showed that the aspiration group had an average limb volume of 2296 mL on the injured side and 2032 mL on the uninjured side (13% difference), while the control group had volumes of 2248 mL on the injured side and 2012 mL on the uninjured side (12% difference, $P = 0.6$ between groups). OM scores at 6 months were 71.7 in the aspiration group and 78.4 in the sham group ($P = 0.67$). SMFA dysfunction index at 6 months was 15 in the aspiration group and 10.8 in the sham group ($P = 0.12$); bother index was 16.7 in the aspiration group and 10.7 in the sham group ($P = 0.09$). Two post-ORIF (open reduction and internal fixation) infections were seen in the aspiration group and none in the sham group ($P = 0.5$). There were no significant differences in any outcome measure between the aspiration group and the sham group.

Conclusion: Aspiration of acute ankle fractures did not result in decreased NRS pain scores or opioid usage following aspiration. No differences in secondary outcomes, including limb volume, 6-month SMFA and OM scores, or complications were seen. Aspiration of acute ankle fractures does not provide measurable clinical benefit.

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Continuous Popliteal Sciatic Nerve Block for Ankle Fractures Reduces Postoperative Opioid Requirements and Rebound Pain:

A Prospective Randomized Comparative Trial

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Purpose: Peripheral nerve blocks have been well studied in the literature with generally good results for controlling postoperative pain following orthopaedic surgery. However, patients often experience “rebound pain” occurring 12 to 24 hours postoperatively that is subjectively worse than in patients treated without regional blocks. The purpose of this study is to determine whether a continuous infusion of anesthetic will reduce rebound pain and the need for narcotic analgesia after operatively treated ankle fractures.

Methods: After IRB approval, 50 patients undergoing operative fixation of ankle fractures were randomized to receive either a popliteal sciatic nerve block as a single injection (SNB) or a continuous infusion via an On-Q pump. Pain medication (fentanyl and oxycodone/acetaminophen) and visual analog scale (1-10) pain levels were tracked in the post-anesthesia care unit (PACU). Patients were discharged with 5/325 mg oxycodone/acetaminophen for postoperative pain control. Additionally, pain scores, the number of pain medications taken, and any side effects were assessed at scheduled time points by blinded data collectors at 8, 12, 24, 48, and 72 hours postoperatively.

Results: While the On-Q group received significantly less fentanyl in the PACU than the SNB group (21 mcg vs. 71 mcg, $P = 0.006$), there was no difference in the number of oxycodone/acetaminophen pills taken in the PACU or in pain levels at discharge. For all time points after discharge, mean postoperative pain scores and pain pills taken were lower in the On-Q group versus the SNB group. Differences in pain scores were significant at the 12-hour postoperative time point ($P < 0.001$) and differences in pain pills taken were significant at the 12 to 24-hour ($P = 0.002$) and 24 to 48-hour ($P = 0.03$) postoperative intervals. By 72 hours postoperatively, the On-Q group had taken an average of 14.3 pills versus 23.8 pills in the SNB group ($P = 0.01$).

PAPER ABSTRACTS

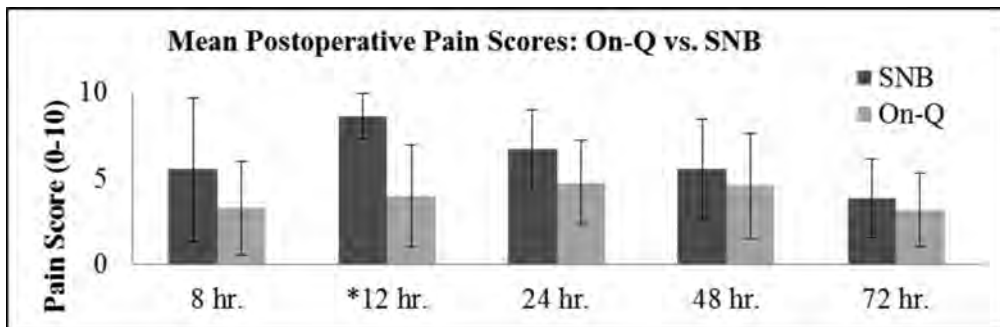


Figure 1. Average visual analog scale pain scores by hours postoperatively for SNB and On-Q groups with error bars representing ± 1 standard deviation from the mean. Statistically significant differences ($P < 0.05$) are represented by an asterisk.

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Conclusion: Use of continuously infused regional anesthetic for pain control in ankle fracture surgery significantly reduces “rebound pain” and the need for oral opioid analgesia compared to single-shot regional anesthetic after operatively treated ankle fractures over a 72-hour period.

Intraoperative O-Arm Evaluation on the Effect of Ankle Position on Accuracy of Syndesmotic Reduction

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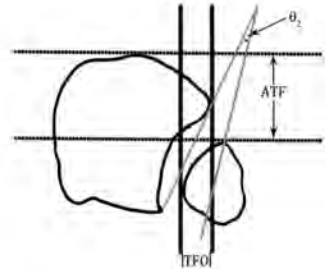
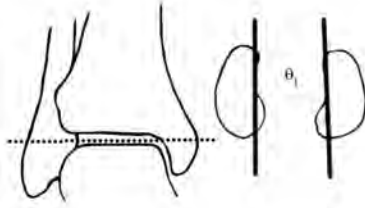
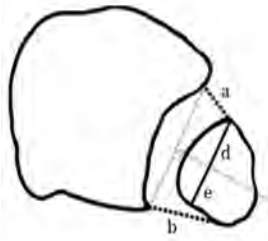
Purpose: This is a prospective study aimed at evaluating the effects of ankle position on the spatial relationships of the tibiofibular syndesmosis by utilizing intraoperative O-arm imaging. The differences in spatial relationships of the tibiofibular syndesmosis during intraoperative dorsiflexion and plantar flexion were observed by comparing each reduction with its contralateral, uninjured side (control). We hypothesize that dorsiflexion of the ankle will result in malreduction of the syndesmosis more frequently than plantar flexion due to the re-creation of the deforming force of external rotation, posterior translation, and proximal migration that occurs with dorsiflexion of the ankle.

Methods: 20 patients with obvious complete syndesmotic disruptions noted on static radiographs underwent O-arm scans after placement of a clamp across the syndesmosis but prior to definitive fixation. The clamp was placed at the level of the distal tibiofibular joint and at 0° with respect to the tibiofibular axis. O-arm images were then taken with the patient's ankle dorsiflexed to a neutral position and then in resting plantar flexion. The same procedure was repeated on the opposite, uninjured ankle for later comparison. All uninjured ankles had no history of previous injury. The same syndesmotic spatial measurements cited in Dikos et al and Nault et al were used for the measurement of all O-arm scans. Measurements from the injured side were then subtracted by the measurements taken in the same ankle position on the uninjured side. This difference was then compared to the difference in measurements when the ankle was placed in the other position. The significance of this comparison was then assessed.

Results: Out of the 14 different types of spatial measurements taken for each ankle position, a significant difference in measurement between ankle positions was found with 7 types of spatial measurements and ratios. These included tibiofibular overlap (TFO) ($P < 0.001$), anterior tibiofibular interval (ATF) ($P < 0.001$), q_1 ($P < 0.001$), q_2 ($P < 0.001$), a ($P = 0.04$), $a:b$ ($P < 0.001$), and $d:e$ ($P < 0.001$). While in dorsiflexion, ATF (mean = 2.4 mm), q_2 (mean = 7.3°), a (mean = 0.1 mm), $a:b$ (mean = 0.1), and $d:e$ (mean = 0.2) were measured to be most similar to their contralateral uninjured measurements when compared to plantar flexion. While in plantar flexion, TFO (mean = 0.5 mm) and q_1 (mean = 5.5°) were measured to be most similar when compared to dorsiflexion.

Conclusion: Seven out of the 14 measurements performed showed a significant difference in reduction depending on ankle position. Compared to the contralateral uninjured ankle, syndesmotic reduction was shown to be closest to anatomic alignment during dorsiflexion in 5 out of the 7 parameters measured. These findings could have implications with regards to the position of the ankle during placement of syndesmotic fixation.

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A Prospective Study to Compare Open Reduction and Ligament Repair Versus Percutaneous Screw Fixation of the Tibia Fibular Syndesmosis

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Background/Purpose: The outcome of high ankle fractures associated with syndesmotic disruption (Weber-C [OTA 44.C]) is determined by the quality of the reduction. Using fluoroscopic parameters (closed reduction) to gauge reduction has variable results. Open syndesmotic reduction can reduce malreduction rates from 40% to 15%. Current syndesmosis repair techniques include either open or closed reduction, combined with fixation between the distal tibia and fibula. In this study, we compare radiographic and functional outcomes between conventional closed reduction and screw fixation of the syndesmosis with open reduction of the syndesmosis, direct repair of the anterior inferior tibiofibular ligament (AiTFL) and screw fixation. The AiTFL is the first lateral ligamentous stabilizing structure compromised in rotational syndesmotic injury and is accessible for repair during open reduction. We hypothesize that restoration of the AiTFL combined with open reduction is more likely to provide an anatomic repair, and therefore a better outcome, compared to closed reduction and screw fixation.

Methods: 29 patients (19 male; average age, 37 years) with high ankle fractures and syndesmotic disruption were enrolled in this IRB-approved cohort study. Following fibular and/or malleolar fixation, a syndesmosis stress test was performed. Unstable ankles were treated with either an open or closed reduction and fixation of the syndesmosis. The anatomic repair technique (AR) involved direct reduction of the syndesmosis, repair of the AiTFL ligament using suture anchors, and placement of syndesmosis screws. The closed reduction technique (CR) included fluoroscopic assessment of reduction with the syndesmosis clamped, followed by placement of syndesmosis screws. 14 patients were treated by AR, 15 by CR. Rehabilitation was identical between the groups. Functional outcomes included the AOFAS (American Orthopaedic Foot & Ankle Society) Ankle-Hindfoot Score, Maryland Foot Score, and FAOS (Foot and Ankle Outcome Score). Radiographic reduction was measured from bilateral ankle CT scans performed 3 months following surgery; fibular translation and syndesmosis diastasis were compared between injured and noninjured ankles.

Results: *Radiographic:* The average difference in ankle translation and diastasis between injured and noninjured ankles was 0.47 ± 0.38 mm in the AR group (mean \pm standard deviation), compared with 1.09 ± 0.69 mm in the CR group ($P < 0.03$). 73% of the CR group and 11% of the AR group had 1 mm or greater side-to-side difference. 11% of the CR group and none of the AR group had 2-mm incongruity or diastasis. *Functional:* The Maryland pain subscore showed a statistically significant ($P < 0.05$) improvement in the AR group compared to the CR group. Improved functional outcome scores were noted using the AR technique compared with the CR technique, but did not reach statistical significance. To date, 5 patients required removal of hardware for irritation (4 CR; 1 AR). One in the CR group had failed reduction requiring revision.

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Conclusion: We have shown that an open anatomic repair of the syndesmosis results in better radiographic outcomes compared with percutaneous screw fixation. Pain at 6 months was significantly reduced in the AR group. Based on these results, 20 subjects per group would be required to demonstrate statistical significance in functional outcome scores. Efforts to achieve and maintain an anatomic syndesmosis reduction are important to improve patients' outcomes. Further study of the anatomic repair technique is warranted.

**Syndesmotic Fixation in Supination–External Rotation Ankle Fractures:
A Prospective Randomized Study at a Minimum of 4 Years of Follow-up**

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Background/Purpose: This study compared midterm functional and radiologic results of syndesmotic transfixation versus no fixation in supination–external rotation (SER) ankle fractures with intraoperatively confirmed syndesmosis disruption. We hypothesized that early-stage good functional results would remain and unfixed syndesmosis disruption in SER IV ankle fractures would not lead to an increased incidence of osteoarthritis.

Methods: This was a prospective study of 140 operatively treated patients with Lauge-Hansen SER IV (Weber B) ankle fractures. After bony fixation, the 7.5-Nm standardized external rotation stress test for both ankles was performed under fluoroscopy. A positive stress examination was defined as a difference of >2 mm side-to-side in the tibiotalar or tibiofibular clear spaces on mortise radiographs. 116 patients had a stable syndesmosis compared to the uninjured side. The other 24 patients were randomized to either syndesmotic screw fixation (13 patients) or no syndesmotic fixation (11 patients). After a minimum of 4 years of follow-up (mean, 58 months), ankle function and pain (Olerud-Molander, 100-mm visual analog scale [VAS] for ankle function and pain) and quality of life (RAND-36) of all 24 patients was assessed. Ankle joint congruity and osteoarthritis were assessed using mortise and lateral projection plain weight-bearing radiographs and 3-T MRI scans.

Results: Improvement in Olerud-Molander score, VAS, and RAND-36 showed no significant difference between groups during the follow-up. In the syndesmotic transfixation group, improvements in all functional parameters and pain measurements were not significant, whereas in the no syndesmotic fixation group Olerud-Molander score improved from 84 to 93 ($P = 0.007$) and pain (VAS) score from 11 to 4 ($P = 0.038$) from 1 year to last follow-up. Radiographs or MRI showed no difference between groups at the follow-up visit.

Conclusion: Syndesmosis transfixation in SER (Weber B)-type fracture patterns had no influence on the functional results or radiological findings after a minimum of 4 years follow-up compared to no syndesmosis fixation.

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Syndesmotic Malreduction Results in Poorer Clinical Outcomes in Supination and Pronation External Rotation IV Ankle Fractures

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Purpose: The purpose of this study was to compare the functional outcomes of postoperative supination and pronation external rotation (SER and PER) IV ankle fractures in patients with and without syndesmotic malreduction.

Methods: A prospectively created clinical registry of ankle fractures surgically treated from 2004 to 2010 was reviewed. Inclusion criteria included unilateral SER IV or PER IV ankle fractures (AO/OTA 44-B), patient age at time of surgery ≥ 18 years, preoperative ankle radiographs and MRI, postoperative bilateral ankle CT scans, and follow-up of 1 year including Foot and Ankle Outcome Score (FAOS). All patients with CT evidence of articular malreduction were excluded. 86 patients were ultimately included for analysis. Each ankle was assessed on axial CT scan for syndesmotic malreduction at a level approximately 1 cm proximal to the tibial plafond using a novel syndesmotic malreduction assessment method recently described by Davidovitch et al (Figure 1). Designation of syndesmotic malreduction was conferred if any one of the three measurements (anterior tibial incisura distance [AI], posterior tibial incisura distance [PI], or anterior translation distance [AT]) demonstrated a difference greater than 2 mm between the injured ankle and the uninjured ankle.

Results: 63 of the 86 patients (73%) demonstrated syndesmotic malreduction. These patients demonstrated a clinically significant reduction in the FAOS Sport subcategory (58 vs. 73; $P = 0.064$) compared to the 27% (23/86) with a reduced syndesmosis. No clinically or statistically significant differences were observed between patients with and without syndesmotic malreduction in the remaining FAOS subcategories. Demographic, medical comorbidity, injury severity, and postoperative complication comparison between the syndesmotic malreduction and reduction cohorts showed no statistically significant differences.

Conclusion: SER IV and PER IV ankle fractures with syndesmotic malreduction demonstrate poorer clinical outcomes than those without syndesmotic malreduction. However, the high syndesmotic malreduction rate and lack of a statistically significant difference between cohorts may represent an overestimation of malreduction utilizing this method. Regardless, we recommend exercising extreme care in performing open reduction and internal fixation of these ankle fractures to improve a surgeon-dependent variable influencing postoperative outcomes.

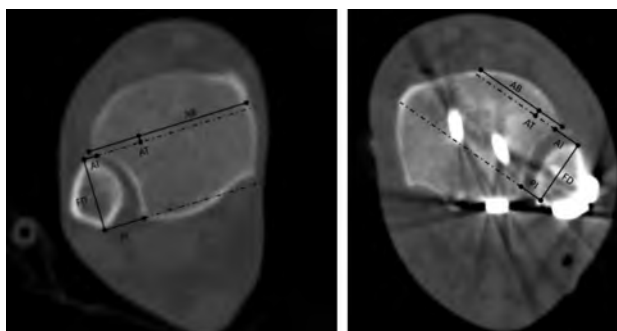


Figure 1. Syndesmotic malreduction assessment on axial CT utilizing a novel method.

**ΔOutcomes a Decade After Surgery for Unstable Ankle Fracture:
Functional Recovery Does Not Decay with Time**

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Purpose: Ankle fractures are among the most common injuries treated by orthopaedic surgeons; however, there is a dearth of evidence regarding long-term outcomes following surgery for an unstable ankle fracture. The purpose of this OTA-funded study is to examine long-term clinical and radiographic outcomes in a well-documented patient cohort.

Methods: Between January 2001 and January 2007, 500 patients who underwent surgical repair of an unstable ankle fracture (original cohort) were enrolled in a prospective database and followed out to 1 year. Trained interviewers recorded baseline characteristics at the time of injury, including patient demographics, American Society of Anesthesiologists (ASA) classification, and medical comorbidities. Short Musculoskeletal Function Assessment (SMFA) scores and American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot Scale scores were obtained at standard follow-up intervals. Patients were contacted by mail and telephone for long-term follow-up, which included radiographs and functional assessment with the use of the SMFA and AOFAS Ankle-Hindfoot Scale. Radiographs were evaluated for the presence of posttraumatic arthritis of the ankle. Multiple linear regression was used to identify predictors of functional recovery, binary logistic regression was used to identify predictors of radiographic osteoarthritis, and paired-samples *t*-tests were used to compare long-term functional outcome scores to scores at 1 year.

Results: Overall, 75 patients out of the 148 patients contacted (51%) returned for evaluation (follow-up cohort). The average length of follow up was 10.5 years (range, 7-13 years), and the mean age at follow up was 57 years (range, 27-85). The follow-up cohort was significantly older at the time of injury when compared to the original cohort ($P = 0.043$; mean 47.3 years vs. 43.2 years). There was no significant difference in the number of males and females in the original cohort compared to the follow-up cohort ($P = 0.547$). Based on follow-up radiographs, 23.2% of patients had no osteoarthritis, 46.4% of patients had mild osteoarthritis, 26.1% of patients had moderate osteoarthritis, and 4.3% of patients had severe osteoarthritis. Overall, 13% of patients had removal of ankle hardware, and 1 patient underwent a tibiotalar fusion secondary to symptomatic posttraumatic arthrosis. 86.2% of patients had none-to-mild ankle pain, and 89.2% of patients had no limitation of daily activities. According to the AOFAS Ankle-Hindfoot Scale, 86% of patients had $\geq 80\%$ long-term functional recovery and 58% had $\geq 90\%$ long-term functional recovery. Overall, male sex was a predictor of having radiographic osteoarthritis ($P < 0.05$). There were no other significant predictors for any severity of radiographic osteoarthritis. Overall, there was no difference in total SMFA scores at an average of 11 years compared to scores 1 year postoperatively. ASA class 1 or 2 was found to be a significant predictor of functional

Δ OTA Grant

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recovery based on long-term standardized total SMFA scores ($P < 0.05$). No other significant predictors of functional recovery were identified.

Conclusion: Over a decade after ankle fracture fixation, the majority of patients are doing well; despite the fact that 76% of patients have some form of radiographic arthritis, very few experience pain, and have few restrictions in function or daily activities. Patients' long-term functional outcomes are not significantly different than their outcomes at 1 year.

**Functional Outcome After Ankle Fractures and Ankle Fracture-Dislocations:
A Prospective Study**

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Purpose: The literature on patient and injury-specific factors that contribute to functional recovery and long-term results of ankle fracture-dislocations are limited. Further study specific to ankle fracture-dislocations may provide insight into patient and injury-specific factors contributing to poor outcomes or cause surgeons to explore alternative surgical methods to achieve improved outcomes. The long-term clinical and radiographic outcomes for patients sustaining ankle fracture-dislocations are poorer than those without dislocation.

Methods: After IRB approval, 80 patients with bimalleolar or trimalleolar ankle fractures (OTA 44A, B, and C type fractures) were prospectively enrolled in a prospective observational study. The study population included 40 patients with non-dislocated ankle fractures (AF) and 40 with ankle fracture-dislocations (AFD) treated operatively with standard fracture fixation techniques. Injury characteristics, radiographs, demographics, and medical comorbidities were collected at the time of injury. Postoperatively, patient-reported outcome scores were assessed using FAAM (Foot and Ankle Ability Measure) and SMFA (Short Musculoskeletal Function Assessment) questionnaires. Additional outcomes related to patient recovery and complications of surgical care were also tabulated.

Results: Demographic and injury characteristics for the two groups are comparable. Data at 6 months are available for 71 patients. 33 (82.5%) AF patients and 38 (95.0%) AFD patients' outcomes were collected at the 6-month follow-up. Interim results for patient-centered outcome scores collected at 6 months show a mean FAAM score of 72.8 for AF compared to 68.2 for AFD cohort ($P = 0.497$). Combined SMFA scores for the AF cohort were 36.8 compared to 37.5 in the AFD cohort ($P = 0.847$). Based on these results, we report no significant short-term differences in patient-reported outcome scores between these groups. Additionally, at the 6-month follow-up, there are no differences in complications (deep venous thrombosis, pulmonary embolism, neurovascular), time to full weight bearing, or time to full range of motion based on clinical follow-up data.

Conclusion: The comparison of the outcomes between patients sustaining ankle fractures and fracture-dislocations provides additional information for clinicians treating these injuries. Conventionally, ankle fracture-dislocations are considered a higher energy injury with increased soft-tissue stripping and propensity for concomitant soft-tissue and cartilagenous injury, putting patients at risk for increased complications and longer recovery. However, the initial results of our prospective study have shown no difference in FAAM and SMFA scores, complication rates, or time to full recovery when comparing AF and AFD groups.

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Correlation Between the Lauge-Hansen Classification and Ligament Injury in Ankle Fractures

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Purpose: The Lauge-Hansen classification system was intended to predict mechanisms and ligament injuries based on ankle fracture radiographs. Previous work has suggested that this classification has limitations in its ability to associate ligament injuries with ankle fracture patterns. The purpose of this study was to better define the ability of the Lauge-Hansen classification to predict ligament injury in ankle fractures using MRI and intraoperative findings.

Methods: We reviewed a prospectively collected database of patients who underwent operative treatment for ankle fractures from 2007-2013. All patients had injury radiographs, which were assigned a Lauge-Hansen classification by senior orthopaedic residents using the morphology of the fibula fracture and constellation of other fractures. Included patients all had preoperative MRI, and one of two experienced musculoskeletal MR radiologists evaluated the MR images for the integrity of the syndesmotic, talofibular, and deltoid ligaments. Operative treatment was performed by one senior attending trauma surgeon, who recorded a Lauge-Hansen classification for each patient based on intraoperative findings. The basis for the intraoperative classification included direct visualization of fractures and ligaments and the stability of the tibiotalar joint during intraoperative rotational stress tests. Comparisons were made between the predicted injuries based on the radiographic Lauge-Hansen classifications and the preoperative MRI analyses and intraoperative findings.

Results: 300 patients were included in the study, with an average patient age of 47.8 years (range, 15-88). On the basis of the Lauge-Hansen system, 228 (76%) were classified as supination-external rotation (SER), 42 (14%) were pronation-external rotation (PER), 11 (4%) were supination adduction, 2 (1%) were pronation abduction (PAB), and 17 (6%) were not classifiable. Of the 283 fractures that were classified into Lauge-Hansen categories, 254 (90%) had MRI readings of ligamentous injuries and fracture patterns consistent with the Lauge-Hansen predictions based on the sequential rotational mechanism. Intraoperative findings also highly correlated with the Lauge-Hansen class of ankle fracture, with nearly complete agreement. Comparing MRI and intraoperative findings revealed 37 (13%) of ankle fractures had different classifications by MRI than what was found intraoperatively, with 18 of these being classified as SER intraoperatively but unclassifiable by MRI. The stage of injury within the SER and PER classes had 88% agreement between injuries seen on MRI and findings intraoperatively.

Conclusion: Previous studies have reported mixed results regarding the reliability of the Lauge-Hansen system to predict ligament injuries associated with ankle fractures; however, these studies used limited numbers of patients with varying methods of assessing ligament injuries. In our large cohort of patients, comparing injury radiographs, preoperative MRI, and intraoperative findings suggested that the Lauge-Hansen system is an accurate predictor of ligamentous injuries. The predictions based on the Lauge-Hansen system can be useful for fracture reduction maneuvers as well as fixation planning.

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The Early and Medium-Term Results of Early Primary Open Reduction and Internal Fixation of AO43-B/C Tibial Pilon Fractures: A Prospective Cohort Study

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Purpose: Our hospital manages AO 43-B and C fractures with early open reduction and internal fixation (ORIF) whenever possible, rather than using staged management with delayed ORIF. Previous retrospective studies of early definitive ORIF for pilon fractures have reported complication rates that are comparable to delayed or staged ORIF. The purpose of this study was to report the results on the first assembled prospective cohort of pilon fracture cases aiming to (1) determine the early and late complication rates and (2) determine the medium-term functional and radiographic outcome of these fractures

Methods: 53 patients with 55 AO 43-B (n = 17) or 43-C (n = 38) distal tibial pilon fractures were prospectively enrolled. Patients were reviewed with radiographs and functional scores (Short Form-36 [SF-36], Foot and Ankle Outcome Scores [FAOS], and Short Musculoskeletal Function Assessment [SMFA]) at baseline, 6, 12, and 60 months postoperatively. Fracture reduction was graded using a strict intraoperative and radiographic method (modified Burwell). Osteoarthritis was graded at final follow-up (modified Resnick and Niwayama). Our outcome measures were (1) deep infection requiring reoperation; (2) ankle arthritis requiring reoperation; (3) functional scores at 6, 12, and 60 months; and (4) radiographic osteoarthritis at final follow-up.

Results: The mean age was 42 years (range, 19-70). Three patients (4 fractures) received external fixation in referring hospitals and were managed with delayed ORIF. Of the remaining 51 fractures, 57% underwent early definitive ORIF within 24 hours of injury, 79% by 48 hours, and 91% by 72 hours. *Infection:* The deep infection rate was 2/43 (4.7%) for closed fractures and 2/8 (25%) for open fractures treated with early definitive ORIF. Of the 3 patients (4 fractures) referred with a fixator, one patient sustained an open (IIIb) AO 43.C3 fracture with significant metaphyseal bone loss and underwent delayed definitive fixation with free flap 14 days after injury. This patient underwent a below-knee amputation 4 months following injury for deep infection. *Arthritis:* One patient (1/51) underwent ankle fusion following a deep infection. *Aseptic Nonunion:* Two patients had aseptic nonunion and underwent successful revision ORIF. *Radiographic Follow-up:* 50 patients had 1 year or greater radiographic follow-up. Using strict reduction assessment method, 34 had reduction graded as "anatomical" and 16 had reduction graded as "fair". Fair reductions were significantly more likely to develop moderate or severe arthritis than mild or no arthritis (c^2 ; $P = 0.009$). *Functional Scores:* Mean normalized SF-36 scores improved but remain abnormal at 5 years (statistically significant with difference >MCID [minimum clinically important difference]). Osteoarthritis was associated with significantly worse FAOS scores at 12 months and five years (t -test; $P < 0.05$).

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Table 1: SF-36 Scores by Time for All Patients (50 Represents the Normal Population Score)

	Physical Component Score*	Mental Component Score*
Baseline (n = 55)	55.84 (53.74-57.92)	53.02 (50.14-55.90)
6 months (n = 49)	37.17 (34.08-40.27) <i>P</i> < 0.0001	51.04 (47.37-54.70)
12 months (n = 47)	44.59 (41.33-47.86) <i>P</i> < 0.0001	47.89 (44.45-51.31) <i>P</i> < 0.005
5 years (n = 20)	45.21 (40.93-49.49) <i>P</i> < 0.0001	49.56 (44.67-54.44)

*With 95% confidence interval.

Conclusion: This is the first prospective cohort study to report the medium-term functional outcome of distal tibial pilon fractures. The acute fixation of pilon fractures is safe and results in rates of complications that are comparable to those in published series of delayed or staged fixation. Anatomical articular reduction appears to be associated with better short and medium-term functional outcomes as well as less radiographic osteoarthritis. Patients with pilon fractures show significant long-term morbidity, although this effect appears to plateau with time, which could inform prognosis.

Type C Tibial Pilon Fractures: Rate and Risk Factors for Complications Following Early Operative Intervention

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Purpose: The optimal treatment for tibial pilon fractures remains controversial, with advocates for both early fixation versus two-stage delayed fixation. It is acknowledged that further data are needed to document the outcome of these complex injuries. The aim of this study was to document the outcome following either early or delayed fixation for complex fractures of the tibial plafond.

Methods: We identified 112 skeletally mature patients from our trauma database over an 11-year period, which were managed acutely for a complex intra-articular fracture (type C) of the distal tibia. Demographic data, fracture classification, management, complications, and subsequent surgeries were recorded following retrospective clinical record review. A minimum follow-up of 3 months was used to detect any complications from surgery. Patients with incomplete data or inadequate follow-up were excluded. The primary outcome measure was the development of complications following the acute management of these injuries.

Results: There were 96 patients in the study cohort with a mean age of 42 years (range, 16-86) and 74% (n = 71) were male ($P < 0.001$). There were ≥ 1 comorbidities documented in 42 (43.8%) patients, with 40 (41.7%) smokers and 33 (34.4%) with a background of alcohol excess. High-energy injuries accounted for 79 (82.3%) of all fractures, with a fall from height (n = 66, 68.8%), motor vehicle collision (n = 8, 8.3%), and sports injuries (n = 7, 7.3%) most common. There were 22 (22.9%) patients with multiple injuries and 12 (12.5%) patients with an open fracture. The median time to definitive surgery was 2 days (range, 0-15). There were 71 (74%) patients who underwent primary open reduction and internal fixation (ORIF), 17 (17.7%) primary external fixation with delayed ORIF, 5 (5.2%) primary ORIF + external fixation, and 3 (3.1%) primary fusion. There were 33 complications recorded in 24 (25%) patients. There were 13 (13.5%) infections, with a deep wound infection in 7 (7.3%) patients and a superficial wound infection in 6 (6.3%). There were 9 (9.4%) patients who went onto a nonunion, of which 5 were infected nonunions. Other complications included a loss of reduction (n = 5, 5.2%), acute compartment syndrome (n = 1, 1%), and complex regional pain syndrome (n = 1, 1%). There were 34 (35.4%) patients who underwent ≥ 1 subsequent procedures, with 26 (27.1%) requiring removal of metalwork. The only risk factor identified for developing any complication was multiple comorbidities ($P = 0.033$). Risk factors for developing infection were multiple comorbidities ($P = 0.046$) and primary external fixation with delayed ORIF ($P = 0.035$), with an open fracture approaching significance ($P = 0.055$).

Conclusion: This is one of the largest series in the literature documenting the outcome following fixation for type C tibial pilon fractures. Despite the severity of these injuries, we

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have demonstrated a satisfactory outcome using primary early fixation in the vast majority of cases. The primary risk factor we identified for developing a complication was multiple comorbidities, with primary external fixation with delayed ORIF also a risk factor for infection.

Percutaneous Reduction and Screw Fixation in Displaced Intra-Articular Fractures of the Calcaneus

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Purpose: This study retrospectively reviewed patients with intra-articular calcaneal fractures who were treated with percutaneous reduction and fixation with screws alone and assessed their clinical outcomes and radiographs using a novel CT scoring system.

Methods: Between 2000 and 2011, 153 consecutive patients with 182 displaced intra-articular fractures of the calcaneus (Sanders type 2 in 17%, type 3 in 66%, and type 4 in 17%) were operatively reduced and fixed with screws alone using percutaneous techniques. During the study period, there were no patients treated with other operative techniques. All patients' records were assessed for early postoperative complications at 3 months from the injury and radiographs were measured for maintenance of reduction. Midterm clinical results for pain and late complications were assessed for patients seen at a minimum of 1 year after surgery (90 patients, 106 feet). This subgroup had a mean follow-up of 2.6 ± 1.7 years (range, 1-8.9 years). In patients who had both preoperative and postoperative CT scans (50 patients, 60 feet), the articular reduction was quantitatively analyzed by measuring the widest gap or step in the anterior talocalcaneal joint, posterior talocalcaneal joint, and calcaneocuboid joint in 3 scanning planes. Bohler angle, Gissane angle, talocalcaneal angle, calcaneal width, height, and length were measured by a nontreating surgeon on preoperative, immediate postoperative, and 3-month postoperative radiographs.

Results: At 3-month follow up, early complications were identified in 4 patients (2.6%). There were 2 superficial infections and 2 patients with screw irritation that required removal. The midterm complications in patients with a minimum 1-year follow-up were: screw irritation requiring removal in 10 feet (9.4%), subtalar osteoarthritis needed subtalar fusions in 6 feet (5.7%), 2 malunion (1.9%), 1 deep infection (0.9%), and 1 Achilles tendinopathy (0.9%). The clinical results in this subgroup were good-excellent in terms of pain, stiffness, and function at 54.5%, 52.2%, and 60%, respectively. Comparing preoperative and immediate postoperative radiographs, there was significant improvement in Bohler angle ($P < 0.0001$), calcaneal facet height ($P < 0.0001$), and calcaneal width ($P < 0.0001$). On radiographs after healing the reduction was maintained for all parameters except Bohler angle, which was significantly decreased compared to immediate postoperative films ($P = 0.0002$). Comparing the CT composite score of preoperative and postoperative CT showed significant improvement in posterior talocalcaneal joint ($P < 0.0001$) and calcaneocuboid joint ($P = 0.0303$). Of the patients with either subtalar fusion or late-stage arthritis, there was significant correlation between both the pre-operative and postoperative CT composite scores ($P = 0.05$ and 0.03 , respectively). The visual analog scale scores did not correlate with the preoperative CT scores ($P = 0.4$), although they showed a strong trend to correlate with postoperative scores ($P = 0.06$).

Conclusion: These radiographic measurements suggested that the shape of the calcaneus (height, width, and Bohler angle) could be significantly improved using percutaneous

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techniques and screw fixation alone and the improvements were largely maintained (average 4.3 screws per foot). The complication rate was low compared to other reported techniques. The posterior facet reduction on postoperative CT was significantly improved from the preoperative status. However, residual articular displacement and settling of Bohler angle were present. The clinical significance of these residual displacements is uncertain.

Evaluation of Vitamin D Levels and Outcomes After Ankle Fracture Fixation*Stephen Warner, MD, PhD; Matthew R. Garner, MD; Joseph Nguyen, MPH;**Dean G. Lorich, MD;**Hospital for Special Surgery, New York, New York, USA*

Purpose: Optimal vitamin D levels are critical for bone health and muscle function, and hypovitaminosis D is common in patients undergoing orthopaedic trauma surgery. While previous studies have shown that vitamin D levels correlate with functional outcome after hip fracture surgery, the significance of vitamin D levels on outcomes after surgery in other orthopaedic trauma patients is unknown. The purpose of this study was to determine if vitamin D levels correlated with outcomes in ankle fracture patients.

Methods: We reviewed a prospectively collected database of patients who underwent operative treatment for ankle fractures from 2003-2012. Preoperative serum 25-hydroxyvitamin D (25[OH]D) levels were measured, and the primary and secondary outcomes included Foot and Ankle Outcome Scores (FAOS) and ankle range of motion (ROM). Data were also collected on patient comorbidities, articular malreductions, and wound complications. Included patients had at least 12 months of clinical outcome data.

Results: 98 patients operatively treated for ankle fractures met our inclusion criteria. Mean patient age was 55.8 years (range, 18-91), and length of follow-up for outcome scores averaged 21 months (range, 12-77 months). Of these 98 patients, 36 (37%) were deficient in vitamin D (<20 ng/mL) and 31 (32%) had vitamin D insufficiency (<30 ng/mL, ≥20 ng/mL). Patients with vitamin D deficiency were similar with regard to age, gender, and comorbidities compared to patients with vitamin D levels ≥20. Univariate analysis revealed that patients with vitamin D deficiency had significantly worse FAOS with regard to symptoms ($P=0.031$) and worse average scores in the FAOS quality-of-life domain than patients with vitamin D levels ≥20. Multivariate regression analysis suggested that vitamin D deficiency was a factor in inferior FAOS with regard to symptoms, activities of daily living, and quality of life. Vitamin D levels were not significantly correlated with postoperative ROM, articular malreductions, or wound complications.

Conclusions: Several studies have demonstrated that patients with deficient vitamin D levels have increased fracture risks, yet the significance of vitamin D levels on postoperative outcomes is less known. In our group of patients with operatively treated ankle fractures, preoperative vitamin D deficiency correlated with inferior clinical outcomes at a minimum of 1-year follow-up. Our study suggests that deficient vitamin D levels may result in worse outcomes in orthopaedic trauma patients recovering from fracture fixation.

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