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Ankle Valgus after Hindfoot Arthrodesis: A Radiographic and Chart Comparison of the Medial Double and Triple Arthrodeses

Christopher F. Hyer, DPM, MS, FACFAS [1], Melissa M. Galli, DPM, MHA, AACFAS [2], Ryan T. Scott, DPM, AACFAS [3], Bradly Bussewitz, DPM, FACFAS [3], Gregory C. Berlet, MD [1]

[1] *Attending Physician, Orthopedic Foot and Ankle Center, Westerville, OH*
[2] *Resident, Ohio State University Medical Center, Columbus, OH*
[3] *Fellow, Orthopedic Foot and Ankle Center, Westerville, OH*

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A B S T R A C T

The medial double arthrodesis, comprised of subtalar and talonavicular joint fusions, has become a popular way to correct hindfoot deformity. There is potential concern for an increase in ankle valgus postoperatively owing to extended medial dissection and possible disruption of the deltoid ligament. Although this approach is often used to correct a valgus hindfoot, little attention has been paid to date on this procedure's effect on the tibiotalar joint. Although the medial double arthrodesis has been shown to produce reproducible outcomes without violating the lateral hindfoot structures, our hypothesis was that this approach would increase the ankle valgus deformity compared with its triple counterpart. The primary goal of the present retrospective study was to identify the frequency and severity of ankle valgus after the medial double arthrodesis compared with the triple arthrodesis. A total of 77 patients (78 feet) met our inclusion criteria. Their mean age was 61.3 ± 10.7 (range 27 to 79) years, and the follow-up period was 15.7 ± 9.9 (range 6 to 46) months. There were 16 and 61 patients (62 feet) in the medial double and triple arthrodesis groups, respectively. Overall, the preoperative ankle valgus was 1.24° ± 2.02° (range 0° to 6°), and there was no statistical difference of preoperative ankle valgus noted between groups ($p = .060$). Collectively, postoperative ankle valgus was 3.01° ± 3.54° (0° to 17°) with an increase in ankle valgus in 4 of 16 medial double and 34 of 62 triple arthrodesis patients. With a mean follow-up of 8.75 ± 4.02 (6 to 21) months, the medial double arthrodesis cohort's ankle valgus increased from 0.5° ± 1.55° (0° to 6°) to 1.5° ± 3.14° (1° to 10°) postoperatively. The triple arthrodesis group had a mean follow-up 17.53 ± 10.17 (6 to 46) months and ankle valgus increased from 1.44° ± 2.09° (0 to 6°) to 3.40° ± 3.56° (0° to 17°). Postoperative ankle valgus was statistically significant between groups ($U = 303.50$, $p = .013$). The odds of having an increase in the valgus ankle angle for patients in the triple group was 3.64 times that for patients in the double group, while holding all other variables in the model constant.

Triple arthrodesis has been considered the reference standard in the treatment of debilitating hindfoot deformities. In recent years, a strictly medial approach to hindfoot fusion has been popularized owing to concerns over lateral soft tissue and bony healing in the standard triple arthrodesis (1,2). The medial approach has been shown to allow for adequate joint preparation, to provide excellent deformity correction, and to provide good rates of fusion with fewer soft tissue complications (3–5).

Critical to the success of operative correction of advanced flat foot and arthritic deformity is the realignment of the hindfoot joints before fusion. However, the correction of the hindfoot etiology has the potential to uncover or create a secondary valgus deformity of the ankle. A part of the preoperative evaluation is to assess for ankle valgus during the clinical examination and using weightbearing ankle radiographs. Intraoperatively, the medial soft tissues are stressed to confirm stability and competence. Nevertheless, ankle valgus is sometimes observed in the postoperative period.

We theorized 2 potential mechanisms for the occurrence of ankle valgus postoperatively in what had appeared to be a stable medial ankle complex preoperatively and intraoperatively. First, in the case of triple arthrodesis, the fused hindfoot complex creates a much stronger lever arm against the medial soft tissue structures. When the joints are uncoupled, this valgus stress is dispersed among the mobile joints. In the fused hindfoot, this is no longer the case, and the medial soft tissues, including the deltoid ligament, ultimately fail. Second, in

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Address correspondence to: Christopher F. Hyer, DPM, MS, FACFAS, 300 Polaris Parkway, Suite 2000, Westerville, OH 43802.
E-mail address: ofacresearch@orthofootankle.com (C.F. Hyer).

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the case of medial double arthrodesis, portions of the deltoid ligament are transected to access the subtalar joint from the medial side. Although the ligament is repaired, it is possible that ankle valgus can occur from the now weakened deltoid complex. The deltoid ligament has been found to be the primary stabilizing factor of the loaded ankle in the ankle fracture model; however, its role in hindfoot fusion has not yet been established (6).

Patients and Methods

A radiographic review of consecutive patients who underwent triple arthrodesis and medial double hindfoot arthrodesis with a minimum of 6 months of follow-up was performed. The institutional review board approved the present retrospective clinical chart and radiograph review. Identification of potential subjects was done using the Common Procedural Terminology codes (subtalar joint arthrodesis, talonavicular joint arthrodesis, and calcaneocuboid joint [CCJ] arthrodesis) through our billing and clinical departments at the Orthopedic Foot and Ankle Center.

Chart Review

The patient charts were reviewed to determine that adequate inclusion criteria were met. Exclusion was noted if the clinical follow-up period was shorter than 6 months, if medical documentation was incomplete, if external fixation was used concurrently, and if the patients had undergone surgery for Charcot osteoarthropathy or revision, because these are known to affect the foot and ankle position (7,8). The study materials were de-identified of personal patient markers and recorded for the present study alone in accordance with institutional review board approval. The general patient parameters that were collected included age, gender, measured weight, measured height, and calculated body mass index. Additionally, the comorbidities and conditions that affect bone healing were collected. These included present and former tobacco usage, diabetes mellitus, liver disease, kidney disease, rheumatoid arthritis, immunocompromised state, chronic steroid use, and preoperatively documented osteopenia or osteoporosis.

Pre- and Postoperative Radiologic Review

All the radiographs were reviewed by 2 fellowship-trained foot and ankle surgeons who were unaware of the patient groups. Ankle varus or valgus was measured on the anteroposterior view of weightbearing radiographs of the ankle (Figs. 1 and 2). Parallel lines were drawn in accordance with the apex of Shenton's line and the articulating cartilage of the medial gutter of the tibia and the articulating cartilage of the talus. The angle formed by these 2 lines was then measured with a standard goniometer and recorded. In the case of measurement discrepancy, an average was obtained.

Fig. 1. Preoperative anteroposterior ankle radiograph of medial double arthrodesis patient.

Fig. 2. Postoperative anteroposterior ankle radiograph of same patient shown in Fig. 1.

Operative Technique

Equinus contracture was addressed according to surgeon preference before giving attention to the arthrodesis site. Under radiographic fluoroscopy, the ankle was stressed with varus and valgus to check for deltoid instability. A medial incision was created just inferior to the medial malleolus, extending along the course of the posterior tibial tendon to the navicular tuberosity. The dissection was carried deep to the sheath of the posterior tibial tendon for each of the involved joints.

In the triple arthrodesis patients, the lateral sinus tarsi incision was used for the planned subtalar joint and CCJ arthrodeses. The extensor digitorum brevis muscle belly was reflected superiorly, allowing for access into the sinus tarsi. The interosseus and calcaneofibular ligaments were released, allowing appropriate visualization of the roof and floor of the sinus tarsus. The distal aspect of this incision allowed access to the CCJ. The talonavicular joint was accessed through a medial incision overlying the course of the posterior tibial tendon from the neck of the talus to the distal navicular dorsomedially. The superficial deltoid was unharmed.

Both sides of the fusion site were then prepared according to standard surgical arthrodesis protocols. Each of the joints was denuded down to the level of the subchondral bone and fenestrated to augment fusion potential. The fixation techniques included the use of crossing screws with and without locking plate technology for the talonavicular joint. The subtalar joint arthrodesis was performed with 6.5 cannulated screws and the CCJ arthrodesis with locking plate technology. Standard postoperative protocols, including a period of non-weightbearing casting and protected weightbearing in a fracture boot, were followed until radiographic union was noted. Radiographs were obtained at regular intervals until union was radiographically and clinically identified.

Statistical Analysis

A biostatistician conducted all data analysis. Patient demographic data and outcomes were described using means, modes, standard deviations, and ranges for numeric variables and percentages for nominal variables. Because the demographic data was not normally distributed, the Mann-Whitney U Test (age, body mass index, follow-up) and Fisher's exact test (gender) were used to compare the data between cohorts. The primary analysis point was the radiographic position of the ankle—varus or valgus—preoperatively and at the last postoperative radiographs. Ankle valgus was compared using the Mann-Whitney U Test. A secondary analysis was conducted to determine whether any additional patient factors influenced the likelihood of ankle deformity. Multivariable logistic regression analysis techniques were used to find the clinically optimal association between the probability of having an increase in the valgus ankle score from pre- to postoperative measurements and multiple potential "predictor" variables (i.e., covariates).