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Lateral Column Lengthening for Revision Triple and Double Arthrodesis and Severe End-Stage Flatfoot Deformity

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ABSTRACT

Few options exist for the treatment of revision and severe cases of end-stage flatfoot deformity. Triple arthrodesis or medial-approach double arthrodesis have been the standard but often do not provide enough correction of the deformity. Lateral column lengthening is a powerful procedure performed either with an Evans calcaneal osteotomy or calcaneocuboid distraction arthrodesis that can be used as an adjunct in realigning the flatfoot. We performed a retrospective radiographic review and looked at 11 consecutive cases of patients who underwent hindfoot arthrodesis with a lateral column lengthening procedure. We matched these patients with 11 control patients who underwent isolated medial-approach double arthrodesis. For the patients who underwent a lateral column lengthening procedure, we found a significant improvement in calcaneal inclination angle ($p = .001$) and greater correction in talar declination angle, cuboid abduction angle, and talocalcaneal angle when compared with the control group. Lateral column lengthening is a useful adjunct to hindfoot arthrodesis in the correction of revision and severe end-stage flatfoot deformity.

Triple arthrodesis and medial double arthrodesis have been used successfully in the treatment of end-stage hindfoot deformities, including end-stage flatfoot deformity, post-traumatic arthritis, tarsal coalition, congenital and neuromuscular deformities, and inflammatory arthropathies (1,2). However, few options exist for cases of severe angular deformities of the hindfoot or in cases for revision of a misaligned or undercorrected flatfoot. Previous studies have mentioned the use of a medial displacement calcaneal osteotomy, Evans calcaneal osteotomy, laterally based opening wedge with graft, or medially based closing wedge to assist in correction of deformity (3). In their recent review article, Hunt and Farmer (4) described a systematic approach for correction beginning with correction of hindfoot valgus by medializing calcaneal osteotomy or revision subtalar joint fusion but did not report any outcomes. Haddad et al (5) reported on 33 patients who underwent surgical revision for failed triple arthrodesis. Their approach focused on opening, closing, and translational calcaneal osteotomies, many of which required bone block arthrodesis and reported adequate correction. However, calcaneal osteotomies have been known to only correct small degrees of valgus and may require additional midfoot procedures to maintain a plantar-grade forefoot (6).

Lateral column lengthening is a powerful technique that provides triplanar correction by correcting the abduction deformity of the midfoot and improve coverage of the talar head (7,8). Most commonly, this is performed with an Evans calcaneal osteotomy or a calcaneocuboid distraction arthrodesis (9,10). Traditionally, these procedures have been reserved for the treatment of stage IIB flatfoot deformity while preserving the rearfoot joints from fusion to correct transverse plane dominant deformities by adducting the foot over the talonavicular joint. Although it has been demonstrated that a lateral column lengthening procedure could increase calcaneocuboid joint pressures, no definitive evidence exists to show that this would lead to pain or joint degeneration (11). We believe that a lateral column lengthening procedure can correct difficult deformities even in the previously fused foot. No studies have looked at outcomes of rearfoot arthrodesis with a lateral column-lengthening procedure.

The purpose of this study was to measure radiographic outcomes of correction achieved with rearfoot arthrodesis in combination with lateral column lengthening in undercorrected flatfoot and end-stage flatfoot deformities. Our hypothesis was that lateral column lengthening provides additional correction as an adjunct to hindfoot arthrodesis in the correction of malaligned and severe flatfoot deformities.

Case Series

We performed a retrospective radiographic and chart review on patients who underwent surgery by a single surgeon (G.W.) between

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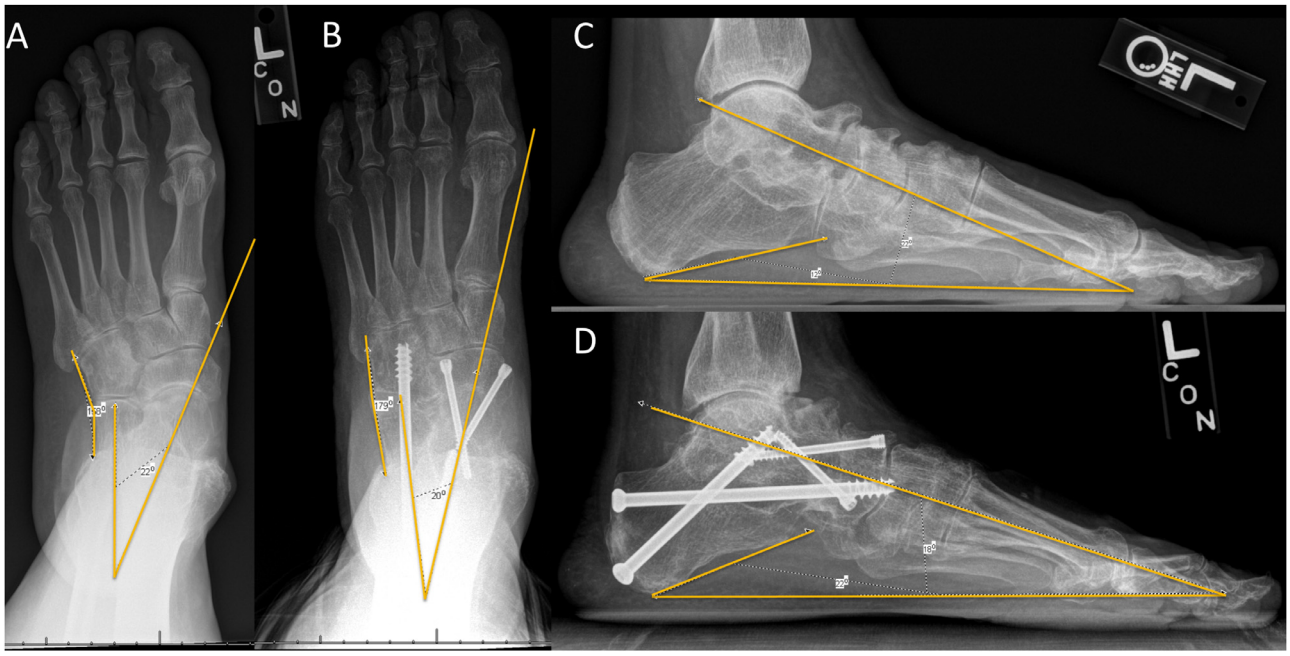

Fig. 1. A 63-year-old female with stage 3C posterior tibial tendon dysfunction corrected with subtalar and talonavicular joint arthrodesis with adjunctive calcaneocuboid joint distraction arthrodesis. Anteroposterior preoperative (*A*) and postoperative (*B*) radiographs show correction in the transverse plane. Lateral preoperative (*C*) and postoperative (*D*) radiographs show correction in the sagittal plane.

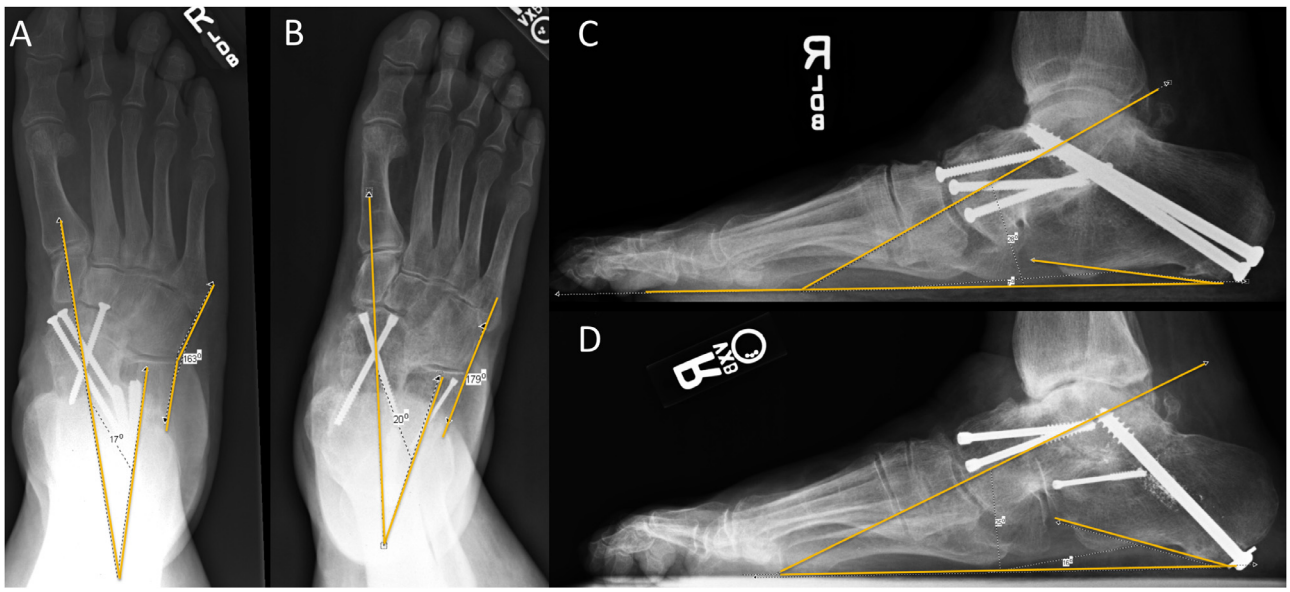

Fig. 2. A 53-year-old male with a history of double arthrodesis 3 years earlier with residual flatfoot deformity. The patient underwent revision subtalar and talonavicular joint arthrodesis with adjunctive Evans calcaneal osteotomy. Anteroposterior preoperative (*A*) and postoperative (*B*) radiographs show correction in the transverse plane. Lateral preoperative (*C*) and postoperative (*D*) radiographs show correction in the sagittal plane.

January 2013 and October 2017. Inclusion criteria included 11 consecutive patients who underwent any combination of rearfoot fusion (talonavicular or subtalar joint) in conjunction with a lateral column lengthening procedure (Evans calcaneal osteotomy or calcaneocuboid arthrodesis). Patients who underwent isolated talonavicular or isolated subtalar joint fusion were excluded. We matched these 11 patients with a control group of 11 consecutive patients who underwent medial double arthrodesis. Each patient needed a minimum 6-month radiographic follow-up to be included in the study. A single surgeon (E.S.) measured the preoperative and postoperative calcaneal inclination angle, talar declination angle, cuboid abduction angle, and anteroposterior talocalcaneal (Kite) angle using a picture archiving and communication system (Phillips Medical Systems, North Brabant, The Netherlands). All radiographic angles were measured with weightbearing radiographs taken at the 6-month postoperative visit (Figs. 1 and 2). Patient demographics collected included age, preoperative diagnosis, all surgical procedure performed at time of surgery, and complications. Data analysis was performed with single-factor analysis of variance test.

Table 1
Patient characteristics of a cohort of hindfoot fusion with lateral column lengthening (N = 11)

Case	Age/Sex	Diagnosis	Revision	Hindfoot Fusion	Lateral Column Lengthening	Posterior Lengthening
1	36 F	PTTD	Yes	STJ	Evans osteotomy	Gastrocnemius
2	31 M	Coalition	No	STJ	Evans osteotomy	TAL
3	44 M	PTTD	No	Triple	CCJ distraction arthrodesis	TAL
4	50 M	PTTD	No	STJ, TNJ	Evans osteotomy	TAL
5	21 F	Coalition	No	STJ	Evans osteotomy	TAL
6	29 M	PTTD	No	STJ, TNJ	Evans osteotomy	TAL
7	63 F	PTTD	Yes	Triple	CCJ distraction arthrodesis	TAL
8	74 M	PTTD	No	STJ, TNJ	Evans osteotomy	TAL
9	35 M	PTTD	No	STJ, TNJ	Evans osteotomy	TAL
10	23 F	Coalition	No	STJ	Evans osteotomy	TAL
11	53 M	PTTD	Yes	STJ, TNJ	Evans osteotomy	None

Abbreviations: CCJ, calcaneocuboid joint; F, female; M, male; PTTD, posterior tibial tendon dysfunction; STJ, subtalar joint; TAL, tendo-Achilles lengthening; TNJ, talonavicular joint.

Table 2
Radiographic outcomes (N = 11)

	Mean Preoperative Value ± SD	Mean Postoperative Value ± SD	Mean Improvement ± SD	*p* Value*
Calcaneal inclination angle				.001
Control group (n = 11)	13 ± 5.6	21 ± 5.0	6 ± 3.3	
With LCL (n = 11)	10 ± 5.2	24 ± 8.6	14 ± 5.8	
Talar declination angle				.09
Control group (n = 11)	30 ± 6.5	25 ± 6.5	6 ± 8.4	
With LCL (n = 11)	26 ± 7.2	15 ± 6.5	11 ± 5.6	
Cuboid abduction angle				.08
Control group (n = 11)	18 ± 10.4	2 ± 7.2	18 ± 10.4	
With LCL (n = 11)	26 ± 10.7	0	26 ± 10.7	
AP talocalcaneal (Kite) angle				.81
Control group (n = 11)	23 ± 11.9	14 ± 3.6	9 ± 12.1	
With LCL (n = 11)	23 ± 6.3	13 ± 5.5	10 ± 6.4	

Abbreviations: AP, anteroposterior; LCL, lateral column lengthening; SD, standard deviation.
* Statistical significance set at $p < .05$.

Operative Technique

Patients were positioned supine on the operating table using general anesthesia with thigh tourniquet. All patients first received a posterior muscle group lengthening when necessary, which was either a percutaneous, triple stab "Hoke" tendo-Achilles lengthening or a medial approach gastrocnemius recession performed in standard fashion. In revision cases, all prior hardware was removed and the prior arthrodesis was taken down, and the joints of interest were mobilized. The Evans calcaneal osteotomy was performed using standard technique, with the osteotomy made approximately 1 cm proximal to the calcaneocuboid joint, taking care to greenstick fracture the medial cortex. The graft size ranged between 0.6 and 1 cm, depending on how much correction was needed. The fusion sites were prepared using standard technique and fixation with partially threaded screws based on surgeon's choice. The calcaneocuboid distraction arthrodesis was performed in similar fashion by resecting the joint surfaces and selecting a tricortical allograft size between 0.6 and 1 cm, and fixation with partially threaded screws. The medial double arthrodesis was performed using standard technique as described in previous literature involving a single medial incision (2). All patients were placed in a splint after surgery and kept non-weightbearing in a short leg cast until radiographic fusion was achieved.

Result

Our treatment group was made of 11 consecutive patients who underwent rearfoot arthrodesis with an adjunctive lateral column procedure (Table 1). Ten of these patients required posterior lengthening. Mean age was 42 ± 16.8 years, with cases being 3 revision cases requiring hardware removal. This cohort was matched with a control group of 11 patients, all who underwent medial double arthrodesis with tendo-Achilles lengthening. The mean age of the control group was 59 ± 17.2 years.

The patients in the treatment group all had greater improvement in radiographic angles compared with the control group (Table 2). Calcaneal inclination angle improved from 6° ± 3.3° to 14° ± 5.8°, talar declination angle improved from 6° ± 8.4° to 11° ± 5.6°, cuboid abduction angle improved from 18° ± 10.4° to 26° ± 10.7°, and the anteroposterior talocalcaneal angle improved from 9° ± 12.1° to 10° ± 6.4° from the control group to the lateral column lengthening group, respectively. Statistical significance was found for calcaneal inclination angle at $p < .05$. There were no significant differences between patients who underwent Evans calcaneal osteotomy versus calcaneocuboid distraction arthrodesis. There were no complications noted for the 22 patients included in this study.

Discussion

Despite the power of triple arthrodesis and medial double arthrodesis to correct hindfoot deformities, there are cases of severe deformity that if left to arthrodesis alone would result in a foot fused in a pes planovalgus position. A foot fused in valgus will create stress on the deltoid ligament and degeneration of the ankle (12–14). A review of the literature on revision flatfoot surgery is limited to 2 review articles (3,6). Both articles discuss the undercorrected flatfoot with residual hindfoot valgus. This puts stress on the deltoid ligament leading to eventual rupture and ankle degeneration. There exists little scientific evidence to guide the foot and ankle surgeon. Treatment options discussed previously are limited to takedown revision arthrodesis with or without the use of medial displacement calcaneal osteotomy.

There are several limitations to our study. Our control group only consisted of medial double arthrodesis, and it can be argued that a medial double arthrodesis may not allow for as extensive correction as a triple arthrodesis would. Another limitation of this study is that there were no clear parameters for when a lateral column-lengthening procedure would be indicated. In our study, the decision for which patients received a lateral column lengthening was based on the primary surgeon's judgment. It can be argued, however, that this limitation can be present for any judgment a surgeon makes in the process of procedure selection, especially for flatfoot correction (15).

There is room for discussion when comparing the power of a triple arthrodesis versus a medial double arthrodesis. Prior studies have argued that a medial double arthrodesis provides the ability to expose the talonavicular joint complex to allow the resaddling of the talar head (2). The authors also argue that taking down the sustentaculum allows for ample calcaneal repositioning that is not available through a lateral approach arthrodesis. That being said, there have been no studies to our knowledge that quantify the degree of correction between a medial double arthrodesis and triple arthrodesis.

In conclusion, a revision of a failed flatfoot surgery is a challenging undertaking for the foot and ankle surgeon. However, a malaligned, in situ hindfoot fusion can be approached in the same way as an iatrogenic coalition, both with the same surgical goal of taking down the joints, aligning the foot in rectus position, and standard fixation. A foot and ankle surgeon has many tools when trying to realign the symptomatic flatfoot. Oftentimes, a triple arthrodesis or medial double arthrodesis can be sufficient to provide the desired amount of correction. However, in cases of severe and revision flatfoot deformities, lateral column lengthening is a well-known and effective procedure that can be a useful adjunct to provide additional correction.

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