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AOFAS AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY®

Foot & Ankle Orthopaedics
2023, Vol. 8(1) 1–5

DOI: 10.1177/24730114221146986
journals.sagepub.com/home/fao

Midterm Clinical and Radiographic Outcomes of the Calcaneal Z-Osteotomy for the Correction of Cavovarus Foot

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Abstract

Background: The Malerba calcaneal Z-osteotomy is an operative procedure to treat the hindfoot varus component of adult cavovarus deformity. Basic science studies support the corrective ability of this osteotomy. However, there have been no published midterm clinical and radiographic results. The purpose of this article is to describe the radiographic and clinical improvement in a series of patients treated with this osteotomy.

Methods: A retrospective chart review identified 14 feet in 12 patients from January 2013 to August 2018 who met minimal follow-up criteria. Preoperative visual analog scale (VAS) scores, Foot Function Index (FFI) scores, and American Orthopaedic Foot & Ankle Society (AOFAS) scores were compared with postoperative scores. Preoperative Meary angle, calcaneal pitch, and hindfoot alignment were also compared with postoperative measurements. Complications and radiographic union were recorded.

Results: At a mean of 80 months, VAS, FFI, and AOFAS scores improved from 7.86 to 1.64, 57.78% to 18.11%, and 39.57 to 80.71, respectively (all $P < .001$). At a mean of 15 months, Meary angle, calcaneal pitch, and hindfoot alignment improved from 11.14 to 6.64 degrees ($P < .001$), 30.93 to 27.43 degrees ($P = .005$), and 19.83 degrees varus to 8.50 degrees varus ($P < .001$). There was 1 nonunion and 1 postoperative sural nerve neuralgia, but both patients ultimately did well clinically. There were no instances of postoperative tarsal tunnel syndrome. All patients stated that they would have the procedure done again.

Conclusion: The calcaneal Z-osteotomy is an effective method to treat adult hindfoot cavovarus deformity. All patients had good clinical outcomes with minimal complications.

Level of Evidence: Level IV, case series.

Keywords: calcaneus, Z-osteotomy, Malerba, cavovarus, outcomes

Introduction

Adult hindfoot-driven cavovarus foot deformity is a painful condition with a variety of etiologies including neurologic, traumatic, congenital, and idiopathic causes.[11,12,24] Patients present with a spectrum of symptoms such as lateral column pain, ankle instability, peroneal tendinopathy, and eventually hindfoot arthritis. These manifestations of the underlying deformity often become debilitating and frequently necessitate operative intervention despite appropriate nonoperative treatment.

Calcaneal osteotomies are a common procedure performed during the operative management of adult hindfoot driven cavovarus deformity.[3,7,8,12] Numerous types of osteotomies exist, including the Dwyer lateral closing wedge osteotomy, lateralizing calcaneal slide osteotomy, and a combination of a closing wedge and a slide osteotomy, each with the goal of reducing the varus position of the heel.

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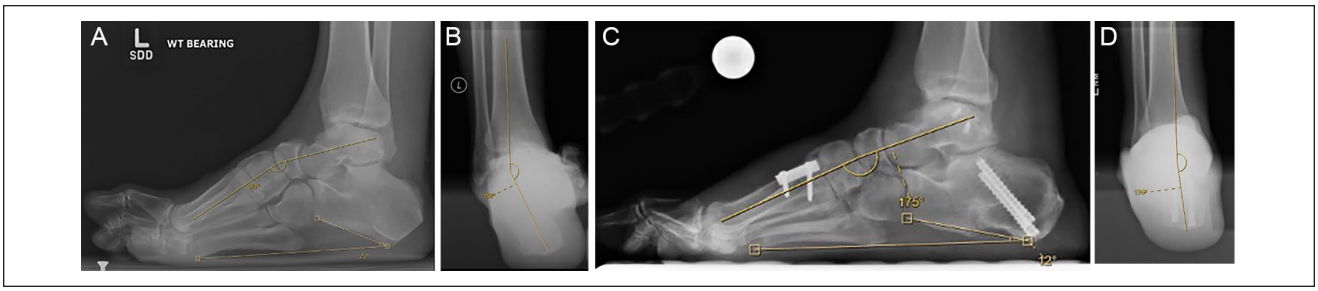

Figure 1. (A) Preoperative Meary angle and calcaneal pitch of 19 and 25 degrees, respectively, in a 59-year-old male on a lateral radiograph. (B) Preoperative hindfoot alignment of 24 degrees of varus on a hindfoot alignment view. (C) Postoperative Meary angle and calcaneal pitch of 5 and 12 degrees, respectively. (D) Postoperative hindfoot alignment of 6 degrees of varus.

The calcaneal lateral closing wedge Z-osteotomy was described by Malerba and De Marchi.[16] Pfeffer et al[19] demonstrated in a 3-dimensional printed model that the Malerba Z-osteotomy has a greater ability to correct coronal plane rotation compared to the Dwyer and oblique closing wedge osteotomies. The Malerba Z-osteotomy was later modified by Knupp et al[13] to add a slide component. The Z-osteotomy with a lateral heel slide was shown to be more effective at lateralizing the center of force at the ankle than an isolated Z-osteotomy or heel slide osteotomy in an anatomic model.[14]

Although these models support the corrective power of the Malerba Z-osteotomy, potential complications include neurovascular injury and tarsal tunnel syndrome.[6,13,23] Vermeulen et al[23] demonstrated risk to the medial neurovascular structures in a cadaveric model of the Z-osteotomy. In addition, although Knupp et al[13] described union of the osteotomy site in 18 consecutive patients, 4 of which had transient hypesthesia, he did not report clinical outcome scores or radiographic parameters. Thus, to date there have been minimal data describing the clinical and radiographic outcomes of the Malerba Z-osteotomy for the treatment of cavovarus foot deformity. Accordingly, the purpose of this article is to report midterm radiographic and clinical outcomes with the Malerba Z-osteotomy.

Materials and Methods

A retrospective analysis was performed on all patients with symptomatic cavovarus deformity operatively treated with a calcaneus Z-osteotomy from the dates of January 2013 to August 2018. Preoperative data gathered from the patient charts included age, gender, comorbidities, preoperative visual analog scale (VAS) score, and preoperative Foot Function Index (FFI) and American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot scale scores. The FFI is a validated scoring system previously used to measure pain and disability from hindfoot pathology.[4,5,9,15] Although not validated, the AOFAS score remains widely used.[22] For postoperative data, final VAS, FFI, and AOFAS hindfoot scores were collected via telephone surveys. A maximum of 3 attempts were made to contact the patients via telephone. Exclusion criteria included age <18 years, nonambulatory patients, patients with incomplete data, and patients whom we were unable to contact for the follow-up phone survey.

Preoperative and postoperative weightbearing foot radiographs were examined and measurements were made for lateral talus-first metatarsal angle (Meary angle), calcaneal pitch, hindfoot alignment, and evidence of radiographic union (Figure 1). Paired *t* test was used to test for significance between preoperative and postoperative outcome scores and radiographic measurements. Alpha was set to 0.05 for all statistical analyses.

The Z-osteotomy procedure was carried out as follows: A lateral oblique incision was made over the heel with care to protect the sural nerve and peroneal tendons. A Z-shaped osteotomy was made with a saw and a lateral-based wedge was removed roughly 5 to 10 mm in width depending on the amount of correction needed. A Hintermann compressor was applied over 2 pins inserted into each side of the osteotomy and the wedge was closed down to reduce the heel varus and slid laterally as necessary. The osteotomy was fixed with one or two 7.5-mm headless compression screws (Figure 1). Additional procedures were performed as necessary to achieve a well-aligned, plantigrade foot. Postoperatively, the patient was placed in a nonweightbearing cast for 6 weeks and gradually allowed to weightbear and resume activities after that period if healing was observed on radiographs.

Results

We first identified 18 patients who underwent the Z-osteotomy for correction of cavovarus hindfoot within the previously specified date range who met initial inclusion and exclusion criteria. Of these, we were able to contact 14. Two patients of those 14 did not wish to participate in our study. Two of the remaining 12 patients underwent bilateral correction. Thus, our final clinical analysis included 14 feet in 12 patients. All patients had presenting

Table 1. Concomitant Procedures Performed With the Malerba Calcaneal Z-Osteotomy.

Type Procedure	Number Performed
First metatarsal dorsiflexion osteotomy	11
Plantar fascia release	7
Lateral ligament reconstruction	4
Tibialis anterior tendon transfer	4
Peroneal tendon repair/debridement	3
Posterior tibial tendon transfer	2
Arthroscopic debridements/microfracture	2
Gastrocnemius recession	2
Naviculocuneiform fusion	1

symptoms of hindfoot pain with foot deformity and all had diagnosis of cavovarus deformity.

Mean clinical follow-up was 80 months (range 47-102). Average radiographic follow-up was 15 months (range 2-48). The mean age of our cohort was 51 years (range 18-73). There were 7 right feet and 7 left feet. There were 8 males and 4 females. The mean BMI was 31 (range 23-46). There were 2 former smokers, 1 current smoker, and 9 never smokers. Additional procedures included the following: 11 first metatarsal dorsiflexion osteotomies, 7 plantar fascia releases, 4 lateral ligament reconstructions, 4 tibialis anterior tendon transfers, 3 peroneal tendon repair/debridements, 2 tibialis posterior tendon transfers, 2 arthroscopic debridements/microfracture procedures, 2 gastrocnemius recessions, and 1 naviculocuneiform fusion (Table 1). All but 1 patient had at least 1 additional procedure.

VAS scores improved from a mean of 7.86 preoperatively to 1.64 postoperatively ($P < .001$). FFI scores improved from a mean of 57.78% preoperatively to 18.11% postoperatively ($P < .001$). AOFAS scores improved from a mean of 39.57 preoperatively to 80.71 postoperatively ($P < .001$). All 12 patients responded that they were satisfied with the surgery and would have the procedure again (Table 2).

Fourteen of 14 feet had both preoperative and postoperative lateral weightbearing radiographs. The mean Meary angle for these 14 feet improved from 11.14 to 6.64 degrees ($P < .001$). The mean calcaneal pitch improved from 30.93 to 27.43 degrees ($P = .005$). Twelve of 14 feet had both preoperative and postoperative weightbearing hindfoot alignment views. The mean alignment angle for these 12 feet improved from 19.83 to 8.50 degrees of varus ($P < .001$).

There was 1 nonunion. Despite this nonunion, the patient's final VAS, FFI, and AOFAS scores were 0, 2%, and 96, respectively, and he expressed satisfaction at his final outcome. One patient had postoperative sural nerve neuralgia and underwent a sural nerve neurolysis, after which he reported significant improvement of his symptoms. There were no other complications or reoperations related to the corrective procedure. Thus, the overall complication rate was 2 of 14 (14.28%).

Table 2. Clinical and Radiographic Results of the Calcaneal Z-Osteotomy.

	Preoperative	Postoperative	*P* Value
VAS scores	7.86	1.64	<.001
FFI scores	57.78	18.11	<.001
AOFAS hindfoot scores	39.57	80.71	<.001
Satisfied with procedure?	N/A	Yes; all patients would undergo again	NA
Mean Meary angle, degrees	11.14	6.64	<.001
Mean calcaneal pitch, degrees	30.93	27.43	.005
Mean alignment angle, degrees of varus	19.83	8.50	<.001

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; FFI, Foot Function Index; VAS, visual analog scale.

Discussion

The current study demonstrated that the modified Z calcaneus osteotomy provided significant pain relief, improvement in deformity, and improvement in patient-reported outcomes.

Of the numerous osteotomies that exist to treat pes cavovarus, the Dwyer[7,8] osteotomy may be the most historically used and referenced. Dwyer[8] reported on his own series of 170 pes cavus feet treated with calcaneal osteotomies and found that 109 of them had good or excellent results. Ayres et al[1] reported that 89% of 20 Dwyer osteotomies exhibited good to excellent results at minimum of 2 years' follow-up. Nayak and Cotterill[18] reported on 42 Dwyer osteotomies and found that 86% had good and excellent outcomes with a mean of 75% improvement.

The lateral calcaneal slide osteotomy is another popular osteotomy for the treatment of pes cavovarus. Barg et al[2] reported on 31 patients with cavovarus deformity treated with a lateral slide or wedge osteotomy. They demonstrated that VAS pain scores significantly improved from 6.3 to 1.1 and AOFAS scores improved from 33.1 to 78.0. Sammarco and Taylor[21] reported on 21 patients with combined superior and lateralizing calcaneal slide osteotomies and first metatarsal osteotomies. They found that 89% of patients had good to excellent outcomes along with a 9.1-degree reduction in hindfoot cavus and a 6.5-degree reduction in the talo–first metatarsal angle. Finally, Maskill et al[17] reported on 29 patients treated with a lateral calcaneal slide osteotomy and other concomitant procedures. At a mean of 4.4 years' follow-up, AOFAS scores improved from 45 to

90 points. Twenty of 23 patients expressed extreme satisfaction with their outcome. The talo–first metatarsal angle improved from 9.9 degrees preoperatively to 2.4 degrees postoperatively. Calcaneal inclination angle improved from 26.1 degrees preoperatively to 22.1 postoperatively. However, there were 10 patients who required hardware removal of the calcaneal screws.

Since its description by Malerba and De Marchi,[16] the calcaneal Z lateral closing wedge osteotomy has become popular as an alternative osteotomy that allows correction in multiple planes. Although the osteotomy described by Malerba has been modified by Knupp et al[13] to add a lateral slide component, all variations of it are still commonly referred to as the Malerba osteotomy. Knupp et al[13] reported on their series of 18 consecutive patients followed for a mean of 17 months. They reported that all patients showed union at 6 weeks postoperatively but did not disclose patient outcome scores or radiographic measurements. They did state that 1 patient had persistent symptoms and 4 had transient hypesthesia. Hamel[10] described in German his results of 20 patients treated with the calcaneal Z-osteotomy. However, there were no reports of clinical or radiographic outcomes in the English abstract.

To our knowledge, ours is the first English-language study that describes clinical and radiographic outcomes for the calcaneal Z-osteotomy to treat pes cavovarus deformity. In our study, we have shown tremendous improvement in clinical scores, with mean postoperative VAS, FFI, and AOFAS scores of 1.64, 18.11%, and 80.71, respectively. This is similar to the article by Barg et al[2] that reported a mean final VAS score of 1.1 in his series of patients treated with a slide or closing wedge osteotomy. In addition, our final AOFAS score is comparable to Barg et al[2] and Maskill et al[17] who reported final AOFAS scores of 78.0 and 90, respectively. We demonstrated a 4.5 degree reduction in Meary angle, similar to the 6.5-degree reduction by Sammarco and Taylor.[21] Our improvement in calcaneal pitch was 3.5 degrees, similar to the 4.0-degree improvement demonstrated by Maskhill et al.[17] Finally, we demonstrated 11.33 degrees of improvement in hindfoot alignment angle. Although we were unable to achieve neutral alignment in every patient, we believe this is due to the tremendous amount of preoperative varus in our patient cohort (mean of 19.83 degrees). This also suggests that obtaining a neutral or valgus alignment may not be necessary to achieve a satisfactory outcome, as it has been shown by Saltzman and El-Khoury[20] that the normal heel-ground contact point lies 3.2 mm medial to the longitudinal axis of the tibia.

We had just 1 case of postoperative neuralgia, which compares favorably to Knupp et al's[13] cohort, and zero cases of postoperative tarsal tunnel syndrome, a potential concern of all lateralizing calcaneal osteotomies. Cody et al[6] note that, irrespective of the calcaneus osteotomy technique chosen, lateralization reduces the tarsal tunnel volume and potentially predisposes to tarsal tunnel syndrome. In their cadaveric model study comparing Malerba with standard lateralizing calcaneus osteotomy, there was no significant difference between Malerba and standard lateralizing calcaneal osteotomies in magnitude of decrease in tarsal tunnel volume.[6] Therefore, preoperative patient education, careful intraoperative technique, and vigilant postoperative follow-up are essential in light of this known complication of all lateralizing calcaneus osteotomies, including the Malerba osteotomy. Also, we achieved union in 13 of 14 feet (92.9%). Finally, we had zero cases of hardware irritation necessitating removal as opposed to 43.5% of cases as reported by Maskill et al. This is likely because of our use of headless instead of headed compression screws.

Strengths of our study include the long period of clinical and radiographic follow-up in our cohort. This allows for the full course of postoperative recovery to take place and also for monitoring of postoperative recurrence of deformity. In addition, by using both FFI and AOFAS scoring systems, we were able to utilize both a validated system and also the most commonly used system.[22]

The main weakness of our study is the number of concomitant procedures performed, which make it difficult to isolate the effects of the calcaneal Z-osteotomy on our results. However, this is largely unavoidable as a successful cavovarus correction usually necessitates the use of multiple bony and soft tissue procedures.[12,17,21,24] Hence, outcome scores are descriptive of overall changes in patient function and cannot be used to describe a certain combination of procedures as significantly superior or inferior to others. In addition, we were unable to include data on 6 of 18 patients who underwent this procedure within our date range because of inability to contact them or patient refusal to participate. However, this is not particularly surprising given that we limited ourselves to 3 telephone call attempts to patients who had their surgery years ago. The small sample size of this series as well as the variable follow-up are important limitations of this study. Therefore, this represents an initial pilot study that can serve as a foundation for future comparative studies to determine the true clinical utility of this procedure. Finally, we do not have a comparison control group who underwent the Dwyer or slide osteotomy. Comparison of different types of osteotomies would help surgeons determine indications for each procedure. Moreover, comparing specific combinations of secondary procedures for each type of calcaneal osteotomy would provide useful information for clinical decision making. Future studies should prospectively compare the results of several osteotomies in a clinical setting in order to establish the most efficacious and safe type of osteotomy.

Conclusion

The Malerba Z-Osteotomy is a safe and effective osteotomy for the treatment of adult hindfoot-driven cavovarus foot

deformity. We demonstrated significant improvement in pain, patient-reported outcomes, and radiographic measures and a high union rate as well. Patients demonstrated good clinical outcomes at medium-term follow-up and all patients would have the procedure again.

Ethical Approval

Ethical approval for this study was obtained from Duke University Institutional Review Board (approval number 00103525).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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