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Displacement after Open vs Saw-Based Minimally Invasive Medial Displacement Calcaneal Osteotomy: A Cadaveric Study

Motasem Salameh, MD[1,2], Sereen Halayqeh, MD[3], Arielle Richey Levine, MS[2], Mostafa M. Abousayed, MD[1], Raymond Hsu, MD[1], and Brad Blankenhorn, MD[1]

Abstract

Background: Medial displacement calcaneal osteotomy (MDCO) is routinely used in hindfoot valgus realignment. Minimally invasive surgery (MIS) calcaneal osteotomies have been reported to be as safe and effective compared to open techniques. The aim of this cadaveric study was to compare the amount of medial tuberosity displacement obtained with fine-cut saw-based MIS vs open MDCO techniques.

Methods: Eight matched cadaveric specimens had one side randomly assigned to either open or MIS MDCO. The contralateral limb was then assigned to the alternative osteotomy. The amount of medial displacement provided by the osteotomy was measured manually using a flexible metric ruler and radiographically on standardized axial calcaneal radiographs.

Results: Manual measurements showed that a mean displacement of the MIS osteotomy was 7.9 mm compared with 8.7 mm for the open technique (*P* = .36). Radiograph measurement showed a mean displacement of the MIS osteotomy was 7.1 mm compared with 7.4 mm for the open technique (*P* = .83). No significant difference was found on manual and radiographic measurement of medial displacement between MIS and open MDCO.

Conclusion: In a cadaveric model, we found similar magnitude of calcaneal tuberosity displacement using fine-cut saw-based MIS and open techniques for medial displacement calcaneal osteotomies.

Level of Evidence: Level V, cadaveric study.

Keywords: cadavers, hindfoot valgus, medial displacement calcaneal osteotomy (mdco), minimally invasive

Introduction

Medial displacement calcaneal osteotomies (MDCOs) are routinely used in hindfoot valgus realignment.[4,7,8] Often the MDCO is completed in conjunction with other procedures to correct foot deformity. There can be concern for incision placement and wound healing especially when considering the addition of a lateral column lengthening, or Evans osteotomy. Traditionally, an MDCO was described through an open lateral heel oblique incision with soft tissue dissection and the use of sagittal saw to perform the osteotomy.[4] Recently, minimally invasive surgical (MIS) techniques have gained popularity among foot and ankle surgeons, with the proposed benefits of reduced wound complications and decreased postoperative pain and swelling.[1,2]

[1]Alpert Medical School at Brown University, Providence, RI, USA
[2]Yale School of Medicine, Yale University, New Haven, CT, USA
[3]Faculty of Medicine, University of Jordan, Amman, Jordan

Corresponding Author:
Brad Blankenhorn, Department of Orthopedic Surgery Alpert Medical School at Brown University, 1 Kettle Point Avenue, East, Providence, RI 02915, USA.
Email: bblankenhorn@universityorthopedics.com

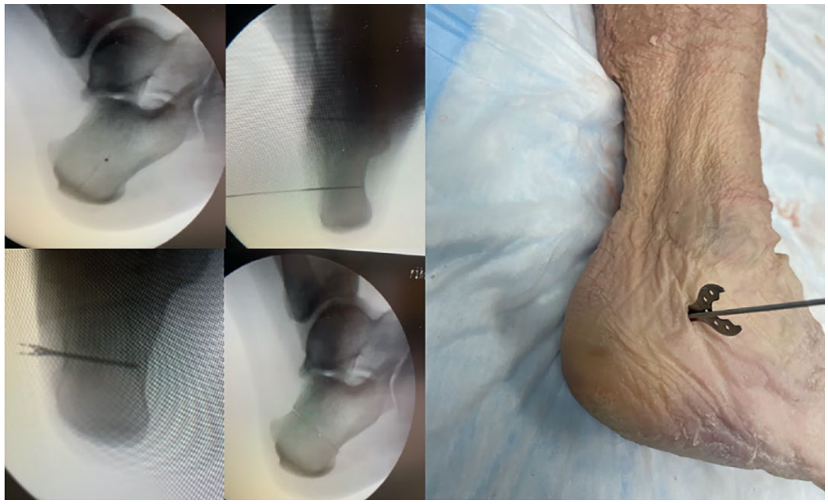

Figure 1. Minimally invasive osteotomy technique.

Minimally invasive calcaneal osteotomies have been reported in the literature to be as safe and effective compared to open techniques.[6,8] With the MIS technique, the soft tissues on the lateral "tension" side of the osteotomy are not released as much as the open technique. Due to less soft tissue release, the amount of displacement and hindfoot correction obtained with the MIS osteotomy may be limited.

There has not been a cadaveric study comparing the amount of medial displacement obtained with the MIS technique to the amount obtained with the traditional open osteotomy. The aim of this cadaveric study was to measure the amount of medial displacement obtained with a minimally invasive calcaneal osteotomy compared to an open calcaneal osteotomy. We hypothesized that the open MDCO would create a greater amount of medial displacement compared with the MIS MDCO.

Methodology

Eight matched foot and ankle cadaveric pairs were used for the study. All specimens were evaluated radiographically with nonweightbearing anteroposterior, lateral, and axial images for any gross deformities or prior surgeries.

For each pair, one foot was randomly assigned to either open or MIS MDCO. The contralateral specimen was then assigned to the alternative osteotomy. All osteotomies were done by a single surgeon.

This study was exempted from IRB review at our institution. All specimens were deidentified and personal information anonymized.

Open Osteotomy Technique

The open osteotomies were performed through an oblique incision over the lateral wall of the calcaneus made one fingerbreadth below the distal fibula. The incision was sharply dissected to the lateral wall of calcaneus and the lateral soft tissues were elevated off of the lateral wall of the calcaneus with a Cobb elevator. The osteotomy was completed using a sagittal saw. Further soft tissue release at the osteotomy was completed by distracting the osteotomy with a laminar spreader. After completion of the osteotomy, the calcaneal tuberosity was manually displaced medially to the maximal amount and fixed with a Kirschner (K)-wire.

MIS Osteotomy Technique

The MIS calcaneal osteotomies were done as previously described by Coleman et al[3] (Figure 1). The safe zone for the calcaneal osteotomy was identified under fluoroscopy on a true lateral of the ankle. A 1.6-mm K-wire was then inserted perpendicular to the calcaneus and checked on lateral and axial radiographs. A small skin incision was then made along the K-wire. A micorsagittal saw was then placed parallel to the wire, and the osteotomy was started. The osteotomy was then completed cranially and caudally using a microreceprocating saw. After completion of the osteotomy, the calcaneal tuberosity was manually displaced medially to the maximal amount and fixed with a K-wire. Moreover, no special techniques were used to maximize the displacement in the MIS arm. A laminar spreader was used to stretch the soft tissues after open osteotomy, which was done to mimic the traditional surgical technique.

Radiographic and manual measurements. An axial calcaneal radiograph was then taken for all specimens oriented parallel to the osteotomy. After radiographic evaluation, the osteotomy site was exposed in all the specimens for manual

Figure 2. Manual measurement for medial displacement.

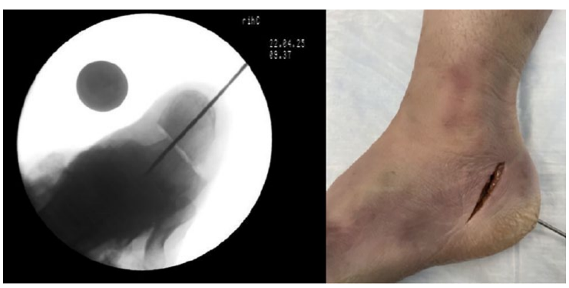

Figure 3. Post medial dispalcement osteotomy for the open technique.

displacement measurements. The displacement was measured manually using a flexible metric ruler on 3 different levels of the osteotomy (superior, middle, and inferior). The average displacement was then calculated (Figure 2).

Radiographic measurements were completed using an image processing software with standard scaling for magnification (ImageJ 1.35K, NIH, US). The measurements were completed by 3 foot and ankle–trained orthopaedic surgeons independently (Figures 3 and 4). The assessors were blinded to the technique used for the osteotomy. The mean measurement of the 3 radiographic measurements were calculated. Data were compared using the Wilcoxon-Mann-Whitney *U* test, with *P* values $<.05$ considered significant.

Figure 4. Post medial displacement osteotomy radiograph for MIS technique.

Table 1. Manual and Radiographic Measurements for Open and MIS Medializing Calcaneal Osteotomy.

Technique	Manual Measurement Mean (SD)/Median	Radiographic Measurement, Mean (SD)
MIS	7.9 (0.41) / 8.2	7.1 (0.20)
Open	8.7 (0.45) / 8.5	7.4 (0.36)
P value	.36	.83

Abbreviation: MIS, minimally invasive surgery.

Results

Five right and 3 left ankles underwent MIS osteotomy. Manual measurement of the medial displacement demonstrated a mean medial displacement of 7.9 mm (range 5.7-9.3 mm) for the MIS osteotomy and 8.7 mm (range 7-11 mm) for the open technique (*P* = .36). Radiographic measurements demonstrated a mean medial displacement of the MIS osteotomy of 7.1 mm compared with 7.4 mm for the open osteotomy (*P* = .83) (Table 1).

Discussion

In the current study, with both manual and radiographic measurements, there was no significant difference between the open and fine-cut saw-based MIS MDCO. Our findings are supported by several other clinical studies as the MIS technique has been shown to have good clinical outcomes.[1,2] Kendal et al[6] compared open and MIS calcaneal osteotomies in a retrospective case-controlled cohort study in which the authors reported a mean displacement of 9.4 mm in the MIS group compared with 10.2 mm in the open group measured from intraoperative fluoroscopic imaging. In this study, a 10-mm oscillating saw was used for the open-operative approach, whereas rasps, slow-speed high-torque burrs, and image-intensification guidance were used for the MIS approach. They also reported significantly fewer wound complications for the MIS compared to the open technique: 6.45% and 28%, respectively. Moreover, no cases of postoperative sural neuropathy were noted in the MIS group, whereas 6% of the open group had sural neuropathy postoperatively. In another study by Jowett et al,[5] the authors described that the posterior calcaneal fragment can be adequately displaced using an MIS technique based on both cadaveric and clinical retrospective study components. The cadaveric component measured shift and distance to important nerves. Only a minimally invasive approach was used in both the cadaveric and clinical approaches. A "nick and spread" technique was used for the approach, and a low-speed, high-torque burr was used under fluoroscopic guidance for the osteotomy and a Howarth elevator was used for displacement of the osteotomy for both components of this study. The average shift achieved was measured to be 16.7 ± 3.4 mm (range 12-21 mm), and no nerve damage or injury was reported. Measurements for displacement were obtained radiographically. The clinical component considered clinical outcomes of the restoration of neutral hindfoot after radiologic and clinical union among 35 patients. All patients reportedly had minimal swelling, no wound healing or neurovascular complications, and successful union with minimal adverse symptoms postoperatively. Only 4 patients required removal of headed screws, which was no longer reported in the second half of the series when headless screws began to be used. One patient experienced a delayed union (9 months) and 1 patient was found to have a pulmonary embolus.

Waizy et al[9] performed a prospective study comparing intraoperative parameters between minimally invasive vs open calcaneal osteotomies and showed no significant difference between the 2 methods in terms of the calcaneal shift irrespective of the direction. However, they emphasized the shorter operation time and length of the incision as a clear intraoperative advantage of the MIS technique. Also, they reported no significant difference between the radiation time, radiation dose, clinical outcome, and radiologic follow-up in the 2 groups.

To our knowledge, this is the first study quantifying medial displacement of a calcaneal osteotomy using an MIS technique completed without a side-cutting burr. The burr likely creates a kerf greater than the saw, which could lead to shortening of the calcaneus, less soft tissue tension, and the possibility of greater osteotomy displacement. We adopted the use of the saw for the MIS technique as the instruments were readily available and cost effective. We also felt the transition to this MIS technique was easier because the use of the saw directly translates from the open technique. Additionally, based on Dr Guyton's series, when adopting the MIS technique clinically, we were concerned for the higher potential for nonunion with the burr. Although the use of a burr may be considered a prerequisite for a technique to be considered minimally invasive, we feel that the subcentimeter incision used for this technique and the minimal soft tissue stripping justify the technique being considered minimally invasive.

The current study has limitations that need to considered when interpreting the results. The study was done on cadavers, and the amount of displacement that was quantified may not be the same seen clinically. This could be due to alteration in the soft tissues secondary to the freeze-thaw cycle as well as the transtibial harvest. The amount of correction obtained in both arms of this study, although at the lower amount of shift need to be effective, may be lower than the amount of displacement seen clinically. This discrepancy may be due to alteration of the cadaveric soft tissues from the freeze-thaw cycle. The surgical techniques utilized for study were meant to simulate normal operative conditions and no additional surgical tools were used to further displace the tuberosity.

The sample size is small and we did not perform a power analysis. However, the difference between displacements seen with the osteotomies is minimal and likely not clinically significant even if the sample size was increased to the point where a statistical difference was seen.

Conclusion

The current study demonstrated similar medial displacement of calcaneal osteotomies created using fine cut saw-based MIS and open techniques. This suggests that MIS calcaneal osteotomy completed with saws offers a reliable alternative to open techniques.

Ethical Approval

Ethical approval was not sought for the present study because it was a cadaveric study.

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. Disclosure forms for all authors are available online.

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ORCID iDs

Motasem Salameh, MD, https://orcid.org/0000-0002-1369-8837
Arielle Richey Levine, MS, https://orcid.org/0000-0001-7734-087X
Mostafa M. Abousayed, MD, https://orcid.org/0000-0002-8412-4275

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