

Minimally Invasive Open Reduction Internal Fixation of Calcaneal Fractures With Plate Fixation: A Five-Year Follow-Up Analysis

Brian Carpenter, DPM

Harold Cesar, DPM

Travis Motley, DPM, MS

INTRODUCTION

The calcaneus is a very complex osseous structure. It is the largest and the most fractured tarsal bone (1). Calcaneal fractures account for 60% of all tarsal injuries and only 2% of all fractures of the body (2). The calcaneus is composed of mostly cancellous bone and is surrounded by a thin cortical shell. Biomechanically, the calcaneus functions as a strong lever arm throughout the gait cycle through attachments of tendinous and ligamentous structures (3). The calcaneus articulates with the cuboid anteriorly and with the talus superiorly. The middle one-third of the calcaneus supports the posterior facet and the anterior one-third supports the middle and anterior facet of the subtalar joint. The posterior facet is the larger of the three facets and functions as the major weight-bearing surface while supporting the talus (4). The articulation between the talus and the calcaneus is considered to be the most important anatomic feature with respect to treatment as well as long-term prognosis after a calcaneal fracture (3).

The forces transmitted through the body of the calcaneus form traction and compression trabecular patterns. Compression trabeculae support the posterior and anterior articular facets while traction trabeculae supports the inferior cortex (5). Between those trabecular patterns is an area of sparse trabeculation known as the neutral triangle. The neutral triangle is considered to be the weakest area of the calcaneus and thus fractures are typically initiated in this area (6). The lateral aspect of the calcaneus is surrounded by a thin soft tissue envelope, which is supplied by the lateral calcaneal artery (7,8). This thin soft tissue coverage and the lack of subcutaneous tissue coverage to the lateral aspect of the calcaneus lead to wound healing complications after open reduction and internal fixation (ORIF) using the lateral extensile skin incision (3).

The most commonly used classification system for calcaneal fractures is the Sanders classification. The Sanders classification is based on coronal and axial reconstructed computed tomography (CT) images through the posterior facet of the subtalar joint. The Sanders classification is useful in the treatment as well as the prognosis of these fractures.

Type I fractures are nondisplaced. Type II fractures are two-part fractures of the posterior facet, and are subdivided into types A, B, or C, depending on the lateral to medial location of the fracture line. Type III fractures are three-part fractures that include an often additional depressed middle fragment. Like type II fractures, type III fractures are also subdivided into types, AB, AC, and BC depending on the location and position of the fracture lines. Type IV fractures are highly comminuted four-part fractures (7).

Calcaneal fractures result from high-energy trauma such as a fall from a height or motor vehicle collision. Approximately 75% of all calcaneal fractures are intraarticular (4). It is well accepted that displaced intraarticular fractures of the calcaneus in patients unaccompanied by local and systemic contraindications should be surgically treated and anatomically reduced (9). Calcaneal fractures with small step-offs of 1- to 2-mm in size in the posterior facet are linked with a load shift in cadaveric experiments and less than desirable functional results clinically (10,11).

In order to restore the posterior facet, the width, the height, the length, and any varus rotation of the calcaneus; an invasive lateral approach was traditionally described. The lateral approach provides the exposure needed for anatomic restoration of the calcaneus, but leads to wound complications. Wound complications have been reported to be as high as 16% (12-14). Wound complications are higher in patients with diabetes mellitus, smokers, and open fractures (15). Wound complications include hematoma formation, cellulitis, dehiscence, and infection. Because wound complications continue to be a major concern in surgically treated calcaneal fractures; a less invasive approach has been adapted in the past decade. A goal with a less invasive approach is a reduction in wound complications. The concern with this smaller incision is incomplete reduction of the posterior facet and restoring normal calcaneal anatomy. As stated previously, an incomplete reduction of the posterior facet leads to significant load in the subtalar joint and will lead to adverse effects in functional outcome and a rapid rate of arthritic changes in the subtalar joint (16).

Although ORIF of calcaneal fractures via the lateral

extensile approach is preferred by most surgeons, certain groups of patients may benefit from less invasive techniques including those with poorly control diabetes, patients with peripheral vascular disease, smokers, or those with severe polytrauma (17). Intra-articular calcaneal fractures that are minimally displaced such as a Sanders type II and certain Sanders type III may also benefit from less invasive reduction (17).

TECHNIQUE

The purpose of this study was to report the preliminary results of minimally invasive technique with open reduction and internal fixation of 56 displaced intra-articular calcaneus fractures in 50 patients (43 male and 7 female) using a variety of plating systems. There were 32 right-sided calcaneal fractures and 24 left-sided. We also report on wound complications, the morphology and the congruity of the posterior facet postoperatively.

All operations were performed by two surgeons (BC, TM). Perioperative antibiotics were applied prior to induction. Forty-four patients, those with unilateral injuries were treated in the lateral position with a bean bag for positional stabilization and a Seattle wedge pillow between the legs for positioning. The 6 patients with bilateral fractures were treated in the supine position to allow access to both fractures without repositioning. After exsanguination, a well-padded thigh tourniquet was inflated to 350 mm Hg.

A skin marker was used to mark out the distal fibula, the subtalar joint and the peroneal tendons. A 5-7 cm incision was used along the joint beginning at the distal tip of the fibula extending distally parallel to the peroneal tendons (Figure 1). Using sharp and dull dissection with Bovie



Figure 1. Lateral incision from tip of the fibula with visible peroneal tendons.

hemostasis, the incision was carried down to the level of the subtalar joint. Care was taken to identify and preserve the peroneal tendons and the sural nerve. The sinus tarsi was identified and evacuated of all fat and soft tissue via both blunt and sharp dissection. After debridement of the floor of the sinus tarsi, the entire posterior facet was easily visualized. A large threaded Steinmann pin was then inserted into the calcaneal tuberosity fragment from lateral or posterior for manipulation. Using a round blunt elevator, the soft tissues were mobilized along the lateral wall of the calcaneus. The lateral wall blowout fragment was also freed up at this time. The soft tissues were retracted laterally during this process and care was taken not to damage the peroneal tendons or the sural nerve.

Using a periosteal elevator or key elevator, the thalamic fracture fragments were mobilized. In severe cases if this is highly impacted and hard to disengage the impaction, a smooth laminar spreader was inserted into the fracture site to aid in mobilizing the fragments and dislodge them from within the calcaneal body to restore facet height and anatomic position. Multiple small gauge Kirschner wires (K-wires) were utilized as needed in reduction and stabilization of the fragments. This includes reduction of the anterior portion of the posterior fact to restore the angle of Gissane.

Once reduction was achieved it was held with K-wires as needed. The final step was traction and manipulation with the Steinmann pin to reduce varus, restore length, and restore Bohler's angle. A careful visual and fluoroscopic examination was then performed to assure anatomic reduction. The plate was then placed through the incision into the area along the lateral calcaneus (Figures 2-6). The posterior arm was inserted and then the plate was rotated inferiorly to insert the distal aspect of the plate.

Fluoroscopy was used to aid in plate placement. Temporary plate position was held with K-wires through the plate. Each plating system was slightly different but they were all similar in function and required technique. The distal arm parallels the sinus tarsi and the apex of the plate lies just inferior to the articular surface of the posterior facet.

Fluoroscopic examination was used to ensure that proper reduction of the sustentaculum fragment was achieved. A partially-threaded screw was then inserted to compress and stabilize the thalamic fragment. The anterior screws were then inserted through the incision. These can be either nonlocking or locking as needed. The posterior screws were then inserted through small percutaneous incisions. These also can be either nonlocking or locking. All K-wires and the Steinmann pin were then removed, and the incision was closed in layers with simple sutures in the deep tissues and horizontal mattress Allgower-Donati technique in the skin layer. All patients were placed in a well-padded posterior splint, which was maintained until the sutures



Figure 2. Arthrex plate.



Figure 3. Osteomed plate.



Figure 4. Synthes plate.



Figure 5. Tornier plate.

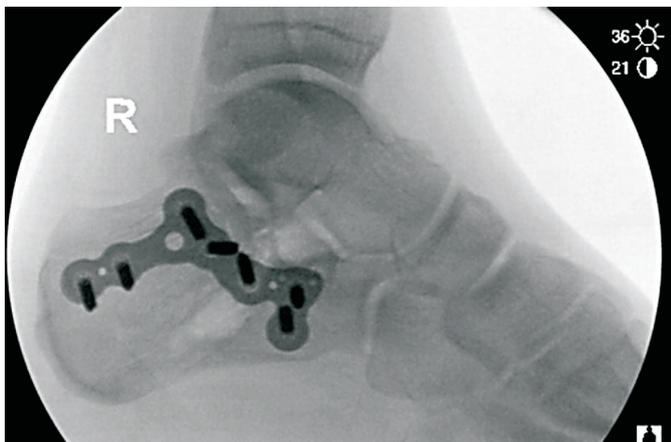


Figure 6. Biomet plate.

were removed between 14 and 21 days. At this time the patients were placed in a fracture boot to allow for removal during nonweight-bearing range of motion exercises of the hind foot and ankle. Follow-up radiographs were taken at 8 weeks and partial weight-bearing was begun on each patient when there was presence of osseous union.

In the treatment of these 56 fractures, there were 2 wound complications, all of which healed uneventfully with local wound care. All cases have maintained the reduction of the articular surface without collapse at last follow-up. Only one patient in this series (Sanders type 3 fracture) has undergone additional surgery with an in situ subtalar joint fusion secondary to painful post traumatic arthritis. All patients began partial weight-bearing by 10 weeks and advanced to full weight-bearing by 12. Anatomic reduction was obtained on 49 of the fractures, 1 of the Sanders type III had a loss of a 3 x 5 mm intra-articular segment that was anatomically reduced but with a defect. The other 6 (Saunders type IV) underwent reduction with primary arthrodesis. One patient had minimal irritation of the peroneal tendons over the plate just proximal to the calcaneal cuboid articulation but not enough to warrant plate removal at 46 months postoperative.

DISCUSSION

The patients who were treated with this small incision were those that had comorbidities that eliminated them from surgical reduction with the extensile lateral approach. These patients demonstrated good outcomes and less wound complications than were reported in several series that utilized an extensile lateral approach. We have now started treating healthier patients with comminuted calcaneal fractures with this small incision approach to plating calcaneal fractures. This approach provides several key benefits: it allows direct visualization of the joint to ensure anatomic reduction of the articular surface, the plates (due to their anatomic design) aid in restoration of calcaneal anatomy, there is less soft tissue disruption, and the incision and subsequent wound complications are fewer. Furthermore, the bone is not devitalized as with the traditional extensile lateral incision and with this small group size appears to heal faster than the traditional lateral extensile incision. In our study, minimally invasive techniques to repair fractures of the calcaneus have a lower risk of wound complications and require less time in the operating room.

REFERENCES

1. Eastwood DM, Greg PM, Atkins RM. Intra-articular fracture of the calcaneum. Part 1: pathological anatomy and classification. *J Bone Joint Surg Br* 1993;75:183-8.
2. Ruch JA, Taylor GC. Calcaneal fractures. In: ED McGlamry, AS Banks, MS Downey (Eds) *Comprehensive Textbook of Foot Surgery*, 2nd Edition. Williams & Wilkins: Baltimore; 1992. p. 1543.
3. Buddecke DE, Mandracha VJ. Calcaneal fractures. *Clin Pod Med Surg* 1999;16:769-91.
4. Sanders RW, Clare MP. Fracture of the calcaneus. In: Coughlin MJ, Mann RA, Saltzman CL (Eds) *Surgery of the Foot and Ankle*, 8th Edition: Mosby, Philadelphia; 2007. p. 2018.
5. Harty M. Anatomic considerations in injuries of the calcaneus. *Orthop Clin N Am* 1973;4:179-83.
6. Sabry FF, Ebraheim NA, Mehalik JN. Internal architecture of the calcaneus: implications for calcaneus fractures. *Foot Ankle Int* 2000;21:114-8.
7. Sanders R, Fortin P, Di Pasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures: results using a prognostic computed tomography scan classification. *Clin Orthop Rel Res* 1993;290:87-95.
8. Femino JE, Vaseenon T, Levin DA, Yian EH. Modification of the sinus tarsi approach for open reduction and plate fixation of intra-articular calcaneus fractures: the limits of proximal extension based upon the vascular anatomy of the lateral calcaneal artery. *Iowa Orthop J* 2010;30:161-7.
9. Rammelt S, Zwipp H. Calcaneus fractures. *Trauma* 2006;8:197-212.
10. Ananthakrishnan D, Tencer AF, Sangeorzan BJ. The effect of intra-articular displacement of calcaneus fractures on contact characteristics of the subtalar joint. *Orthop Trans* 1993;17:727.
11. Sangeorzan BJ, Ananthakrishnan D, Tencer AF. Contact characteristics of the subtalar joint after a simulated calcaneus fracture. *J Orthop Trauma* 1995;9:251-8.
12. Harvey EJ, Grujic L, Early JS. Morbidity associated with ORIF of intra-articular calcaneus fractures using a lateral approach. *Foot Ankle Int* 2001;22:868-73.
13. Howard JL, Buckley R, McCormack R, Pate G, Leighton R, Petrie D, et al. Complications following management of displaced intra-articular calcaneal fractures: a prospective randomized trial comparing open reduction internal fixation with nonoperative management. *J Orthop Trauma* 2003;17:241-9.
14. Benirschke SK, Kramer PA. Wound healing complications in closed and open calcaneal fractures. *J Orthop Trauma* 2004;18:1-6.
15. Folk JW, Starr AJ, Early JS. Early wound complications of operative treatment of calcaneus fractures: analysis of 190 fractures. *J Orthop Trauma* 1999;13:369-72.
16. Rammelt S, Amlang M, Barthel S, Zwipp H. Minimally-invasive treatment of calcaneal fractures. *Injury* 2004;35(Suppl 2):55-63.
17. Schuberth JM, Cobb MD, Talarico RH. Minimally invasive arthroscopic-assisted reduction with percutaneous fixation in the management of intra-articular calcaneal fractures: a review of 24 cases. *J Foot Ankle Surg* 2009;48:315-22.