Evaluation of anatomical alignment following percutaneous reduction with external fixation of calcaneal fractures: a retrospective case series

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Purpose
Our primary aim is to determine if anatomical alignment was achieved utilizing a percutaneous medial and lateral pin to bar external fixation technique for calcaneal fractures with joint depression. Understanding the correction provided by surgical reduction techniques provides surgeons with valuable information to base treatment method decisions.

Introduction
Calcaneal fractures make up 60% of all tarsal fractures and 2% of all fractures with approximately 25% of them being intra-articular.¹ If untreated, calcaneal fractures may result in chronic pain and degenerative changes in the subtalar joint with dysfunction of adjacent joints, structural malalignment and biomechanical stress. Intra-articular reduction and restoration of the spatial positioning of the calcaneus is required for proper biomechanical movements of the midfoot, rearfoot, and ankle. Thus, it is not surprise that most surgeons advocate for the reduction of these high energy fractures. However, the method by which to perform the reduction has been an area of debate in the literature.

Calcaneal fracture reduction is often accomplished with a lateral extensile incision with internal plate fixation. Although this method is favored by foot and ankle surgeons, there is evidence of increased infection and soft tissue complications when compared to less invasive reduction techniques. The inevitable soft tissue damage that accompanies the lateral extensile incision only adds to increased risk of complications with published rates of wound dehiscence and infection reaching between 14% and 33%.²,³,⁴ Furthermore, standard open reduction techniques recommend delaying immediate correction until soft tissues are able to recover from the initial trauma.³ Studies have shown that in cases with an average delay of 4.8 days before correction result in a 16.6% increase in risk of complications.²,³,⁴ Strikingly, the same study reported that when subjects are delayed 10 days, the risk for complications increases to 42.5%.³ With external reduction and fixation, trauma to surrounding tissues is very minimal. This translates into shorter periods of delay leading to surgery and proposes a decreased risk of complications.²,³ Furthermore, the external fixation method used in this study allows for ease of access to the posterior calcaneus for positioning and reducing pathological rearfoot varus that would otherwise lead to inappropriate biomechanical gait patterns.² Our study aims to further the body of literature regarding the use of minimally invasive external fixation for reduction of calcaneal fractures.

Patients and Methods
A consecutive series of patients treated between 2006 and 2015 using pin to bar external fixation following displaced joint depression type calcaneal fractures were identified. Preoperative and postoperative Bohler’s angles (BA) were measured and compared utilizing lateral projection radiographs. The measured BA’s were held to the accepted normal anatomical standard of 20-40°.¹ The authors measured 13 patients’ radiographs utilizing a straight edge forming a line from the most superior part of the calcaneal tuberosity to the highest point of the posterior facet, and a line from the latter to the highest point of the anterior process. A protractor was then used to manually measure the intersecting angle to allow for comparison of preoperative vs. postoperative BA’s. The authors found the mean, range, and standard deviation for quantitative evaluation of restored calcaneal anatomy within the normal accepted parameter.

Surgical Procedure
Medial and lateral pin to bar external fixators were utilized to achieve alignment and spatial orientation of the fractured calcaneus in three dimensions. The uninvolved calcaneus was imaged before the procedure to provide a road map for correction of the fracture site. Decompression of the posterior facet was achieved by correcting the pathological proximally migrated and varus rotated calcaneal fragments and renewed the length of the calcaneus using skeletal traction and external fixation. The medial fixator was applied first to assure varus position was corrected. Calcaneal length was then restored following application of the lateral frame using a series of progressive lengthening. Following decompression of the fractured calcaneus, the posterior facet fragments were oriented through a variety of both direct and indirect percutaneous techniques preventing any complex multplanar movements through skeletal traction devices. Following the reduction of the major fragments, the lesser fragments of the posterior facet could be manipulated and fixed. Without the essential decompression of the calcaneal fragments, it is nearly impossible to manipulate the posterior facet fragments into alignment. Postoperatively the patient is to be non-weightbearing for 8-12 weeks with permission to bathe at four days. The patients should be evaluated weekly with radiographs taken at 2-3 week intervals. External pin-to-bar fixation is removed within the 8-12 week time frame.²

Results
In the 13 patients selected there were no neurovascular or soft tissue complications. The patients were able to return to normal levels of activity. Average preoperative BA was 14° ranging from 0 to 23° with a standard deviation of 6.8. Postoperatively, BA was 34° with a standard deviation of 7.2 and a range of 18 to 42°. Table 1 shows individual BA results for each patient.

Discussion
Percutaneous reduction of calcaneal fractures by external fixation is an acceptable means for reduction of calcaneal fractures and offers several benefits including soft tissue preservation and expedited correction. One concern that has been raised relative to external fixation of calcaneal fractures is the ability to reduce the fragments to acceptable anatomical alignment. Previous studies have shown external fixation to have the ability to return the calcaneus to acceptable parameters in height, length, width, and axial alignment.⁵ The goal of this retrospective study was to determine if proper reduction was achieved in a series of cases using indirect reduction and external fixation. It was determined that Bohler’s angle was returned to an average of 33° compared to a preoperative average of 14°, significantly improving the calcaneal anatomy to within normal anatomical parameters.

When looking at percutaneous reduction and external fixation techniques, a key benefit is reduction of postoperative soft tissue complications. Previous studies have shown a relationship between the number of days between the inciting traumatic event and operative correction in open reduction internal fixation (ORIF). Abidi et al retrospectively studied 63 patients and found that those who underwent ORIF at 4.8 days had a lower wound healing complication rate (16.6 percent) compared to those with ORIF at 10 days (42.5 percent).⁶ The delay in operative time exhibits a direct correlation between successful wound healing, surgical approach, and time from injury to fixation. Delay of fixation to avoid the second hit phenomenon associated with ORIF procedures too close to the traumatic injury event has been recommended to reduce soft tissue complications. External fixation allows for earlier or immediate fixation of the calcaneal fracture without the second hit phenomenon to the injured soft tissue envelope, therefore sparing the soft tissues. Additionally, patients ability to return to function after external fixation calcaneal fractures is an important consideration. In a recent study comparing multiple fixation techniques, 100 percent of patients who received percutaneous external fixation were able to return to work and were able to perform the same activities as they had prior to injury. In comparison, 100 percent of patients receiving ORIF with plate fixation were able to return to work, however only 50 percent of those returned to the same activity, while the remainder had to alter activity due to a reduction in their abilities.⁷ Our findings are consistent with previous reports in which percutaneous fixation of calcaneal fractures returns the calcaneus to anatomic alignment, restores height, minimizes infection risk, minimizes postoperative wound complications, while allowing the patient to return to a similar level of activity experienced prior to injury.

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