An Update on Management of Fractures of the Os Calcis

John Scolaro, MD[1]
Samir Mehta, MD[1]

[1] Department of Orthopaedic Surgery, University of Pennsylvania, Philadelphia, PA

Calcaneal fractures can be difficult to manage, as the majority are intra-articular and can be challenging to reduce. In addition to a number of patient factors, the benefits of articular congruity in decreasing post-traumatic arthritis should be weighed against post-operative complications such as wound dehiscence when considering operative versus non-operative intervention. Recent evidence regarding the management of open calcaneal fractures, the use of minimally invasive techniques and bone substitutes/supplementation, and the role of subtalar and pantalar arthrodesis are discussed.

The treatment of calcaneal fractures has continued to evolve with increasing emphasis being placed on the soft tissue envelope, techniques in minimally invasive fracture reduction, and prevention of post-traumatic arthritis. Long term clinical and radiographic data comparing timing of treatment, treatment modalities, and predictors of outcome has changed calcaneal fracture management. Fractures of the os calcis continue to be a challenge to most orthopaedic surgeons as data continues to evolve regarding treatment and outcome.

Calcaneal fractures represent approximately 2% of all fractures; however, almost 70% of all fractures result in articular surface displacement[1]. Due to the atypical shape of the calcaneus, anatomic surgical reduction can be difficult. In addition to the difficulty of reduction and fixation, surgical treatment of calcaneal fractures has been associated with wound complications[2]. Depending on the severity of the fracture and the accuracy of the reduction by either open or closed means, post-traumatic arthritis can be a disabling complication of these fractures.

Operative Versus Non-Operative Management

Choosing between operative and non-operative management of a calcaneus fracture can be a difficult decision to make, particularly when using evidence-based principles. The goals of operative management are accurate articular reconstruction, stable fixation, restoration of Bohler's angle, heel alignment, calcaneal height, and talar tilt. Each of these goals has been shown to decrease the rate of subtalar arthrosis following fracture of the calcaneus[3]. Anatomic restoration of the articular surfaces is of great importance. Recent biomechanical studies show that as little as one to two millimeters of articular incongruity in the posterior facet can cause disturbances in load distribution and gait mechanics[4].

Multiple studies have shown excellent results following open reduction and internal fixation (ORIF) through a lateral extensile exposure, with fixation using a laterally-based, peri-articular plate (Figures 1-5)[5-7]. Buckley et al reported on a series of 424 patients with 471 displaced intra-articular calcaneal fractures. Initial results showed no difference in operative versus non-operative management, but once patients were stratified (excluding workers compensation injuries), those treated operatively had significantly better outcome[8]. Potter and Nunley reported recently on the long term functional outcomes (mean 12.8 years) of 81 intra-articular calcaneal fractures and found their results to parallel those of other studies which have supported operative care[9].

Operative management of these fractures is not without complication. Wound healing problems occur in anywhere from 16-25% of all patients after ORIF, with some series reporting even higher numbers[8,10]. Factors such as workers compensation also affect the outcome of patients who undergo ORIF. Folk et al reported 48 early wound complications in 179 operatively treated calcaneal fractures and identified smoking, diabetes, and open fractures as risk factors[11]. Deep infections can result in chronic wounds and/or osteomyelitis, multiple surgeries, and even amputation (Figure 6). Therefore, both surgeon and patient must understand the risks and benefits clearly.

Non-operative management is still preferred by some when the rates of wound infection, fixation failure, and potential post-traumatic arthritis are considered. Each patient must be evaluated individually to determine which course of treatment will be best for them. Bajammal et al, in a review of the current literature, determined that there was no difference between patients treated operatively and those treated non-operatively with regard to pain and functional outcome. There was a potential benefit of operative treatment in women and younger men, those not receiving worker's compensation, those with a high Bohler's angle, and those without a heavy workload. Elderly patients (age >50), those receiving workers compensation, and those with a heavy workload may benefit from non-

Corresponding Author:
Samir Mehta, MD
Department of Orthopaedics
University of Pennsylvania
3400 Spruce Street, 2 Silverstein
Philadelphia, PA 19104
Samir.Mehta@uphs.upenn.edu

Figure 1. Lateral radiograph revealing a nearly flat Bohler's angle with significant posterior facet depression and comminution.

Figure 2. Kirschner wire representing skin incision for an extensile lateral exposure to the calcaneus. The soft tissue has improved, and wrinkles are present, indicating an envelope ready for surgical manipulation.

Figure 3. Skin incision for the extensile lateral exposure to the calcaneus. The sural nerve is identified and protected through the dissection and plate application.

Figure 4: No touch technique for flap management during exposure. The flap is extremely tenuous and at high risk for necrosis and further wound complication. The Kirschner wires are used to retract the soft tissue. Visualization of the posterior facet and the majority of the calcaneus is possible through this exposure.

operative management[12]. Allmacher et al looked retrospectively at 19 displaced intra-articular calcaneal fractures in 15 patients who were treated non-operatively to determine their long-term functional outcome at an average of 22 years of follow-up. Their work indicated that the development of subtalar arthrosis, without auto-fusion, may predict a less satisfactory result and clinical deterioration (Figure 7)[13].

Open Calcaneal Fractures

The care of open calcaneal fractures focuses primarily on maintaining or achieving soft tissue coverage for the lower limb. Siebert et al reviewed the results of 36 open intra-articular calcaneal fractures and found a predominantly poor functional outcome at an average of 44 months follow-up. There were increased rates of osteomyelitis, amputation, and arthrodesis in this patient population when compared to those for closed fractures in the literature[14]. Meticulous soft tissue management can have a significant impact, as Berry et al reported in their series of 30 open calcaneal fractures as compared to controls. Fracture comminution and plantar wounds were identified as predictors of poor outcome[15]. Heier et al retrospectively analyzed 43 open calcaneal fractures with minimum two year follow-up. They had an overall wound site infection rate of 37% with 19% of all fractures developing osteomyelitis. They recommend that type I and II open fractures with a medial wound can be treated with ORIF. However, type II fractures with a plantar or lateral wound or type III fractures should not undergo early internal fixation but rather extensive debridement and soft tissue coverage[16]. General principles of open fracture care, including serial debridement and use of adjunctive wound care techniques such as vacuum assisted

Figure 5. Lateral post-operative radiograph nine months after fixation with a laterally-based locking calcaneal plate showing a healed fracture with no obvious signs of arthrosis or loss of reduction.

Figure 6. Lateral radiograph of a patient with osteomyelitis secondary to a wound complication after an extensile exposure to the calcaneus. The procedure was done acutely (within 24 hours of presentation) prior to allowing the soft tissue envelope to resolve.

A

B

Figure 7. Lateral (A) and axial heel (B) radiographs of a 49 year-old male with a history of smoking 2 packs per day who fell from scaffolding at work sustaining a comminuted calcaneus fracture. The patient was treated non-operatively and has significant functional limitations including pain, particularly over the peroneal tendons where the lateral wall blow-out is impinging on his tendons.

closure devices (if appropriate), provide the patient with the best opportunity for limb salvage and recovery.

Minimally Invasive Techniques

Increasing attention has focused on preservation of the soft tissues surrounding the calcaneus by utilizing percutaneous or minimally invasive techniques in initial or definitive fracture care. Magnan et al reported on their use of a mini external fixator in a series of 54 consecutive closed, displaced intra-articular calcaneal fractures. They had excellent or good clinical results (as measured by the Maryland Foot Score) in over 90% of patients. Transient local osteoporosis (18.5%) and superficial pin tract infections (5.6%) were the most common complications encountered. Their conclusions were that the results of minimally invasive external fixation were comparable to those obtained by open fixation without the risks of hardware failure or infection. The authors felt that external fixation should have a role beyond open or malunited fractures[17]. Emara and Alam described their use of the Ilizarov technique in 12 patients who had sustained Sanders type 3 fractures who were not good operative candidates because of severe soft tissue injury. They reported similar American Orthopaedic Foot and Ankle Society (AOFAS) scores as compared to a control group treated with internal fixation[18]. Both studies indicate that percutaneous external fixation

devices may perform as well as open internal fixation in severe intra-articular fractures (Figures 8 and 9).

In addition to percutaneous stabilization with external frames, simple reduction with Kirschner wires and cast immobilization has also been described in the treatment of some calcaneal fractures[19,20]. Percutaneous reduction also has a role in temporary fixation of calcaneal fractures. Gardner et al looked at all tongue-type fractures at their institution in a five year period and found that over 20% of all patients with this fracture type had compromise of the posterior skin. All patients who were treated with percutaneous reduction and splinting in a plantarflexed position were found to have no posterior soft tissue compromise. The authors recommend early minimally invasive reduction as their preferred initial treatment before a later definitive procedure (Figure 10)[21].

Recently, the arthroscopically-assisted open reduction and internal fixation has been reported, with the proposed benefits being a minimally invasive technique to assess articular congruity and calcaneal morphology[22]. This approach may be more time-consuming with those less experienced in such arthroscopic techniques, but its benefit is assessing reduction of intra-articular fractures as compared to fluoroscopy[23].

Bone Substitutes and Supplementation

The recent use of bone substitutes in the management of bone voids in calcaneal fractures is the result of the significant bone crush to the cancellous bone which occurs during these high energy injuries. Studies showing that displacement of the posterior facet of one to two millimeters can impact arthrosis have led surgeons to evaluate auto- and allogenic graft to support the cancellous bone. Cancellous bone graft and polymethylmethacrylate (PMMA) have been explored for this use but have not found widespread support[24,25]. Calcium phosphate has been used with promising results because it is osteoconductive, hardens in-situ, and has found use in other articular fractures (e.g., tibial plateau, pilon).

Johal et al prospectively randomized 52 closed displaced intra-articular calcaneal fractures to ORIF or ORIF with injectable calcium phosphate (alpha-BSM) and performed serial radiographs over one year to monitor for collapse of Bohler's angle. They also reported functional data at two years. There was a statistically significant benefit of alpha-BSM starting at 6 months with regard to maintenance of Bohler's angle, but at two years, there was no difference in the functional performance of the two groups[26]. Wee and Wong reported on the use of injectable calcium phosphate in addition to percutaneous reduction techniques with early weight bearing at one month. Serial radiographs in the early post operative period did not show loss of reduction and 6 month clinical assessments showed promising results.[27]

Figure 8. Lateral radiograph of a 34 year-old man who fell at work and sustained a comminuted calcaneus fracture. Due to his smoking history and his soft tissue envelope, acute percutaneous management was performed.

Figure 9. Lateral radiograph after percutaneous reduction and fixation of a comminuted calcaneus fracture four months after surgery showing a healed fracture with no loss of reduction and no soft tissue complications.

Figure 10. Lateral radiograph after percutaneous reduction and lag screw fixation of a calcaneal tuberosity fracture. Fractures of the calcaneal tuberosity must be addressed acutely due to the risk of posterior soft tissue complications.

Role of Fusion

The development of post-traumatic arthritis following calcaneal fractures has brought attention to the role that subtalar and pantalar arthrodesis play in the treatment of these patients. There is evidence to support that subtalar arthritis may develop regardless of the initial treatment provided[28,29]. Radnay et al hypothesized that patients who sustained a displaced intra-articular calcaneus fracture who were treated with ORIF at the time of injury would have better functional outcomes following subtalar fusion than those patients treated non-operatively and later needing a subtalar arthrodesis. At an average follow-up of 62.5 months, they found improved clinical results and fewer complications in those patients who were treated initially with internal fixation, leading them to recommend ORIF for such fractures[30]. Some authors have described a role for primary subtalar fusion a the time of injury based on the amount of comminution of the posterior facet[31]. There are no large series which support this and today, anatomic fixation of the calcaneus should be the goal if operative management is chosen.

Conclusion

Fractures of the os calcis can be difficult to manage and are often referred to surgeons with experience in treating such injuries. Although non-operative management was historically advocated for these fractures, there is evidence now that some patients may have significantly better outcomes if managed with ORIF. Ultimately, the soft tissue dictates timing of intervention. Recent evidence supports the potential role of minimally invasive or percutaneous methods for temporary or definitive fixation. In addition, certain biologic agents may provide additional support for the articular surface. In the treatment of fractures of the os calcis, our preference is to place the patient into a bulky soft-dressing until soft tissue swelling sufficiently resolves to the point of the presence of wrinkles (e.g., 7 to 21 days). An extensile lateral exposure is utilized to gain access to the articular facets and the calcaneocuboid joints. Once the articular surface and calcaneal height are restored, the resulting void is filled with crushed cancellous allograft. Fixation is performed with a laterally-based, pre-contoured calcaneal locking plate. The wound is closed meticulously over a drain, and the patient is placed into a bulky soft dressing. Two weeks later, the sutures are removed, and the patient is kept non-weightbearing for a total of 12 weeks. Ultimately, our understanding of this difficult injury pattern and its management continue to expand.

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