CHAPTER **46**

OPERATIVE MANAGEMENT OF CALCANEAL FRACTURES UTILIZING CIRCULAR RING EXTERNAL FIXATION WITH MINIMAL OPEN REDUCTION

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Most often seen following falls from a height or motor vehicle accident, calcaneal fractures often lead to displacement in all three cardinal planes with subtalar joint depression. The calcaneus impacts shear and tensile forces but is also subjected to axial loading.[1,2] This loading can result in compression and displacement of fracture fragments. In the adult population, calcaneal fractures are most often intraarticular, and most commonly involve the posterior facet of the subtalar joint.

There has been controversy in the podiatric literature regarding calcaneal fracture management. The generally accepted treatment for intra-articular calcaneal fractures is open reduction with internal fixation, followed by a minimum of six to eight weeks of non-weight bearing. This approach is considered technically difficult with limited ability to anatomically reproduce proper alignment of the subtalar joint. Open reduction with internal fixation is also limited to the degree of soft tissue quality and degree of comminution of bone. Alternatively, closed reduction with cast immobilization often leads to poor reduction, which can result in residual pain and chronically functional limitations.

The authors propose an alternative approach to surgical management of intracalcaneal fractures, by manipulating fracture fragments and stabilizing reduced fragments via transosseous tensioned wires secured to a circular external fixator often with only minimally invasive dissection. The goals of this approach to restore width, length, and height of the calcaneus via ligamentous taxis. Utilization of an external fixator allows for a stable restoration of fracture fragments and weight bearing from the beginning of postoperative care.

DISCUSSION

Anatomic reduction and restoration of function are two key aspects in a good outcome of calcaneal fractures. Traditional methods of surgical management can be contraindicated pending soft tissue and degree of bone comminution. Early range of motion is advocated in both internal and external fixation for calcaneal fractures. In regards to internal fixation, range of motion is often non-weightbearing. This commonly leads to residual plantar heel pain. The benefits of early weightbearing, as demonstrated by Paley and Fischgrund in six of seven patients who underwent anatomic restoration of the subtalar joint and heel with circular external fixation, can help to ensure an improved outcome. They found that, through early weight bearing, the plantar heel fat pad was desensitized thus preventing chronic heel pad pain and dystrophy.

Distraction of the subtalar joint via external fixator provides another advantage over traditional methods. Distraction eliminates excessive forces while weight bearing preventing disruption of a reduced posterior facet or early onset of joint stiffness that may lead to arthrosis. Soft tissue contraction is also minimized via distraction.

As stated previously, a major advantage of external fixation, is the prevention of muscular atrophy of the involved limb. Although the limb is stabilized to the fixator, the muscles are allowed to actively function as opposed to total immobilization therefore reducing joint stiffness and muscular atrophy. This in turn reduces the degree of physical therapy that may be needed to re-establish the reduced muscle as well as reduce the amount of time needed to return to preoperative condition.

External fixation applies the basic principles of closed fracture reduction and stabilization through the use of tensioned wires attached to a circular frame. The goals of the procedure are fracture reduction, restoration of length, width, and height of the calcaneus, minimally invasive open reduction when needed, and early weightbearing. This alternative approach to the management of intraarticular calcaneus fractures has proven to be safe, effective, and indicated in calcaneus fractures, including severely comminuted fractures with soft tissue disruption.

RADIOLOGY AND CLASSIFICATION

Many classification systems exist for assigning to a diagnosis the severity and specific nature of a calcaneal fracture. Utilization of these systems has been useful to clinicians in practice, both in communication for learning purposes, and for the ability to make a prognosis better understood to patients. Use of any single system has been historically controversial, as each intrinsically possesses satisfactory aspects, none necessarily better than the other.

Because of the complexity of these injuries, the clinician must be familiar with the anatomy of the calcaneus when diagnosing and classifying calcaneal fractures. The calcaneus is the largest bone in the foot and has a thin outer cortical layer surrounding cancellous bone. This cancellous bone contains traction trabeculae that support the posterior, middle, and anterior facets of the calcaneus.

Standard radiographic examination for calcaneal fractures should include the dorsoplantar, lateral, and axial projections of the foot. Additional ankle projections may also be utilized when appropriate. Advanced imagine modalities should also be employed, particularly instances of more complex fractures, depending on the classification assigned.

Visualization of various portions of the calcaneus should be achieved by standard radiographic evaluation. The lateral wall of the calcaneus, the body, and the articular surfaces are of particular interest. Additionally, the angular relationship of the lines in the rearfoot must also be assessed. The tuberosity joint angle was first described by Bohler in 1931 and is useful in determining the presence of joint depression in calcaneal fractures.[3] This angle, also known as the salient angle, is a quantification of the anatomical alignment of the calcaneus and the talus measured in the sagittal plane.

Bohler's angle is formed by a line drawn from the posterosuperior aspect of the calcaneal tuberosity to the superior aspect of the posterior facet, and by a line from the superior aspect of the posterior facet to the superior aspect of the anterior process.[3-6] This angle measures 25 to 40 degrees in correct anatomical alignment. Because of variations of this angle due to other unrelated foot structures, comparison is helpful with angles measured from the contralateral foot. In fractures involving subtalar joint depression, Bohlers angle is expected to decrease.

Another important angular relationship is the crucial angle of Gissane. This angle is also measured from the lateral radiograph and is created from the relationship of the subchondral bone of the posterior facet with that of the anterior and middle facets of the calcaneus. The angle ranges from 120 to 145 degrees in the normal foot. Again, comparison should be made with the contralateral foot.

OPERATIVE TECHNIQUE

Following medical as well as anesthesia clearance, the surgeon should assess severity of fracture via evaluation of plain and CT films. Since external fixation does not involve extensive tissue dissection, the condition of the soft tissue does not prevent delay of the procedure. General indications for surgical management include a greater than 2 mm displacement of the posterior facet with disruption of the width, length, and height of the calcaneus. Fibulo-calcaneal impingement may result if the width of the calcaneus is not addressed.

The extremity is prepped and draped to the knee. A pre-assembled circular Orhofix Sheffield fixator consisting of two leg rings and a foot plate are placed about the extremity. The authors have recently begun utilizing a low profile external fixator consisting of two leg rings and a half ring instead of a foot plate. This gives the patient a more cosmetically pleasing device about the extremity as well as allows greater ease of ambulation. Following application of the frame to the extremity a half pin is introduced into the posterior-plantar aspect of the calcaneus from a lateral to medial orientation. Care should be taken to avoid the critical neuro-vascular bundle on the medial aspect, as well as to allow of placement of the trans-osseous wires. The half pin is used for application of the skeletal traction device. The device consists of 30 lbs of weight which is placed and secured to the half pin transecting the calcaneus. The force of the fracture reduction should be directed according to the mechanism of the break. The goal of traction is to utilize the principles of ligamentous taxity to reestablish, anatomically and functionally, the length and height of the calcaneus. The width of the calcaneus is restored via manual side to side compression while the traction device is in place. Next utilizing intra-operative fluoroscopy, the angles of Gissiane and Bohlers are addressed. A Brodens view is obtained to assess the posterior facet. If necessary, a small incision is made inferior to the lateral malleolus into which a thin osteotome is utilized under fluoroscopic guidance to raise the posterior facet, thus facilitating a more anatomically correct position of the calcaneus.

The Orthofix circular frame is then attached to the extremity in the following manner. A frontal plane smooth wire is placed into the tibia at the level of the proximal ring. With the frame eccentrically positioned on the leg and foot, such that the frame is approximately two finger widths from the leg anteriorly, the wire is properly fixated to the ring and tensioned to 130kg. Another smooth wire is placed transversely into the calcaneus, properly fixated to the footplate and tensioned to 60kg. Three additional smooth tibial wires are added, as above, to secure the ring construct to the leg. The purpose of these transosseous wires is to maintain the foot in a 90 degree position to the leg. As needed, additional wires (including olive wires) are placed from opposing directions to further aid in reduction and maintenance of calcaneal width. Distraction of the subtalar joint is then accomplished by increasing the distance between the footplate and the distal tibial ring. This is achieved by loosening the frame hardware on the dorsal side of the ring and tightening the frame hardware on the plantar side. Fluoroscopic evaluation of the final fracture reduction is then made. If satisfactory reduction is appreciated, skeletal traction is then removed from the extremity.

CASE REPORTS

Case 1 (Patient A) suffered an acute intra-articular fracture secondary to a fall, which was fixated 3 weeks after the injury. Severe comminution with joint depression was noted on plain radiographs. Bohler's angle for this patient status post injury was measured at 12 degrees and was classified as Essex Lopresti Type B on plain film and as Sanders Type 3 on CT. Operative repair for this patient included subtalar joint arhtrodiastasis with application of the Orthofix 3-ring external fixation device.

Case 2 (Patient B) was 4 months status post open reduction with internal fixation of an intra-articular calcaneal fracture. This patient presented with malunion of the calcaneal fracture, severe calcaneal valgus deformity, and a fibrous talocalcaneal coalition. Bohler's angle had been restored to within a normal range from the previous surgical reduction and measured 30 degrees. Although radiographs prior to the initial operative management were not reviewed, the patient likely sustained an injury consistent with Essex Lopresti Type B fracture, or Sanders Type 4. This patient required removal of the existing internal hardware and fusion of the subtalar joint, as well as reduction of continued comminution of the calcaneus. The operative procedure for this patient, in addition to hardware removal, included resection of a talocalcaneal coalition, subtalar joint arthrodesis, percutaneous tendo-Achilles lengthening, as well as application of the Orthofix 3-ring external fixation device.

Case 3 (Patient C) also suffered a comminuted calcaneal fracture after a fall from a height of 10 feet. Though the fracture was intra-articular, depression of the joint was not appreciated. Bohler's angle measured 34 degrees, and the fracture was classified as Rowe Type IV by plain film and Sanders Type 3 on CT. Operative management for this patient included percutaneous restoration of the posterior facet of the subtalar joint, with application of the Orthofix 3-ring external fixation device.

Case 4 (Patient D) presented with a calcaneal fracture after a fall from a height of approximately 10 feet. Again, exteme comminution and displacement was noted along with joint depression. Clinically the patient was severely edematous and had multiple fracture blisters. Bohler's angle for this patient was measured at 18 degrees and was classified as Essex Lopresti Type B on lateral radiographs and Sanders Type 4 on CT. Operative repair for this patient included percutaneous reduction of the severely depressed facets of the subtalar joint and application of the Orthofix 3-ring external fixator.

Case 5 (Patient E) presented with a comminuted, intra-articular calcaneal fracture with severe joint depression after a fall from only 1 foot. Pre-existing pedal orthopedic pathology was suspected in this otherwise healthy, 45 year old male. Bohler's angle was measured at 18 degrees and was assigned according to Essex Lopresti Type B and Sanders Type 4. Surgical reduction of this patient's injury included percutaneous repair of joint depression from the posterior facet of the subtalar joint with application of the Orthofix 3-ring external fixation device.

RESULTS

All patients were able to be at least partially weight bearing during the treatment period. All patients utilized crutches at some point of the postoperative recovery. Treatment time ranged from six to nine weeks with a mean duration of eight weeks.

Subjective and objective clinical evaluation was performed on all patients using the Maryland Foot Score, according to which results are categorized as excellent (90-100), good (75-89), fair (50-74), and poor (<50). Therefore, one of the five fractures rated as excellent. In this patient, subtalar range of motion was greater that 50% and only mild pain was experienced that diminished over time. Three fractures rated as good. Subtalar joint range of motion was also greater than 50% but pain was more persistent, non-diminishing but tolerable. One fracture rated as fair. This patient's subtalar joint range of motion was 50% of norm with chronic pain.

There was no failure of hardware throughout the study, nor premature removal of the external fixator. Three patients developed superficial skin infections at the level of the wires. No wires were removed and all infections were managed via oral antibiotics. No evidence of fibulo-calcaneal impingement was noted. To date, none of the patients has required further surgical intervention. All are ambulating in normal shoegear with no limitations of daily activities.

Figure 1. CT scans frontal and lateral views depicting intra-articular calcaneal fractures

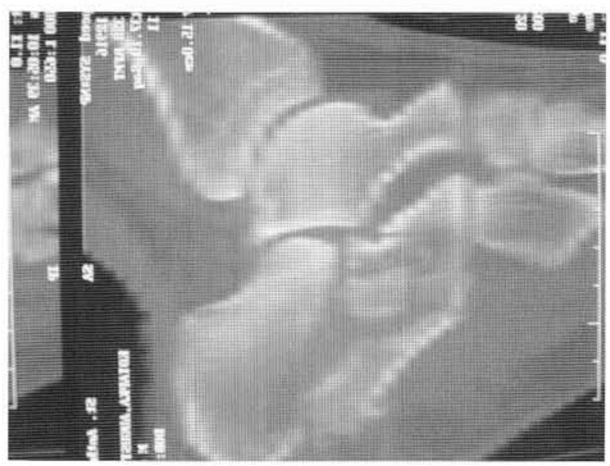

Figure 2. CT scan.

Figure 3. CT scan.

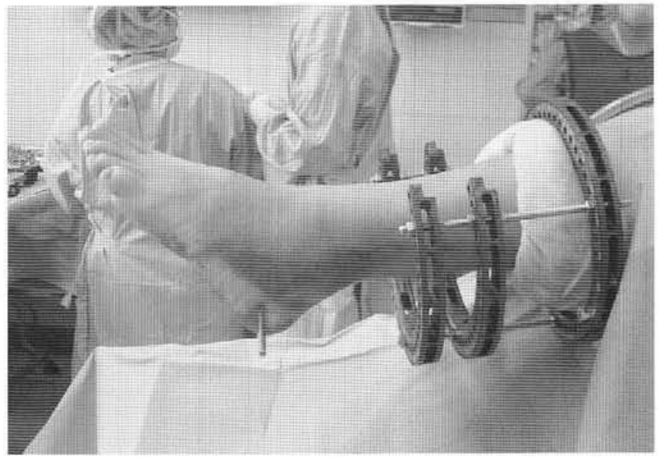

Figure 4. Application of Steimann pin through posterior aspect of calcaneus for application of distraction device

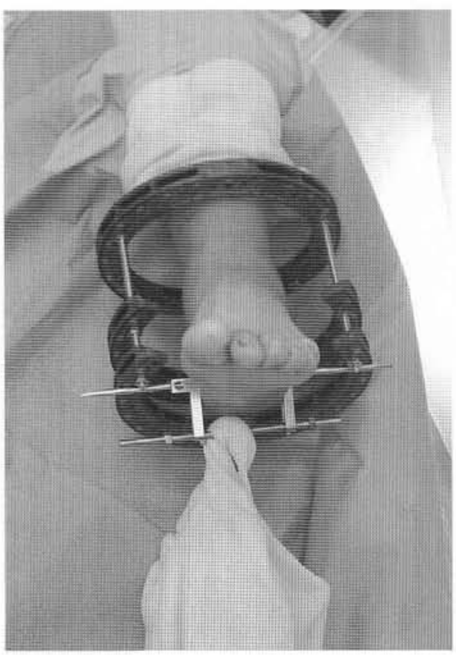

Figure 5. Application of distraction apparatus with external weight

Figure 6. Application of distraction apparatus.

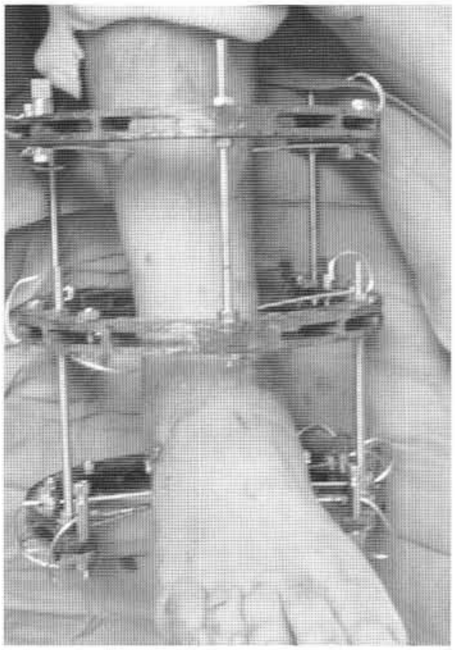

Figure 7. Application of Orthofix 3 Ring Shefield Low Profile External Fixator.

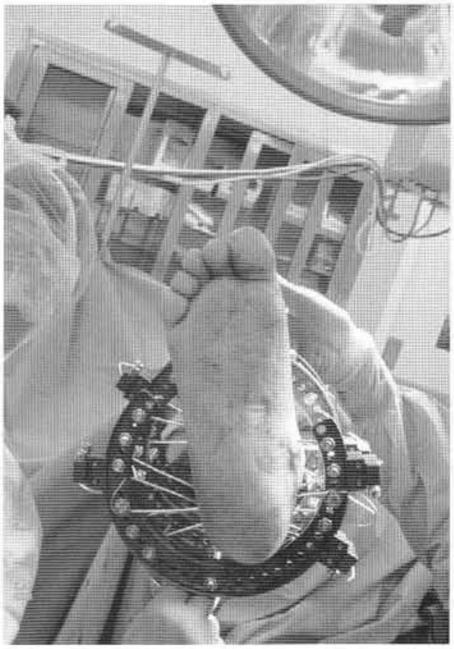

Figure 8. Intra-operative view of fixator secured to lower extremity.

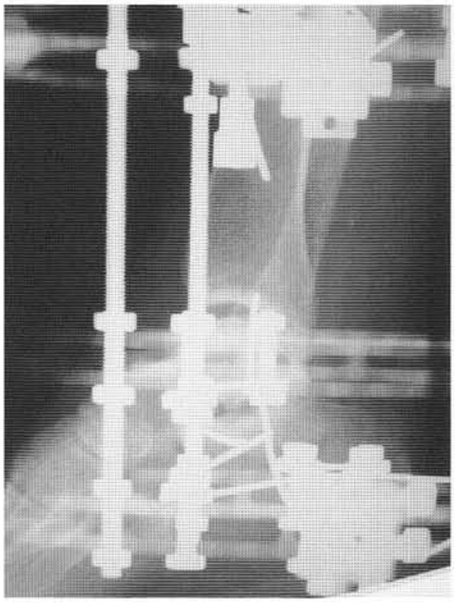

Figure 9. Postoperative radiographs depicting reduction of fracture fragments with external fixator apparatus.

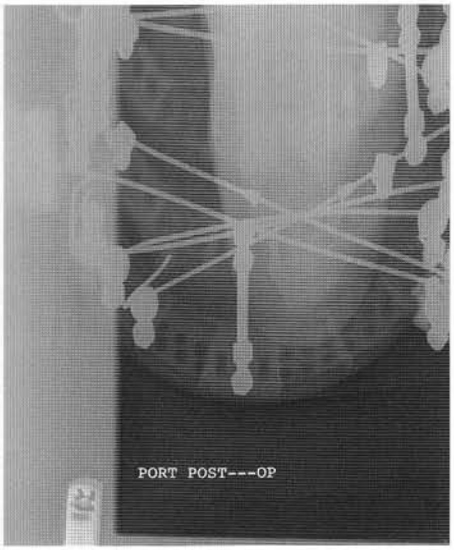

Figure 10. Postoperative radiograph.

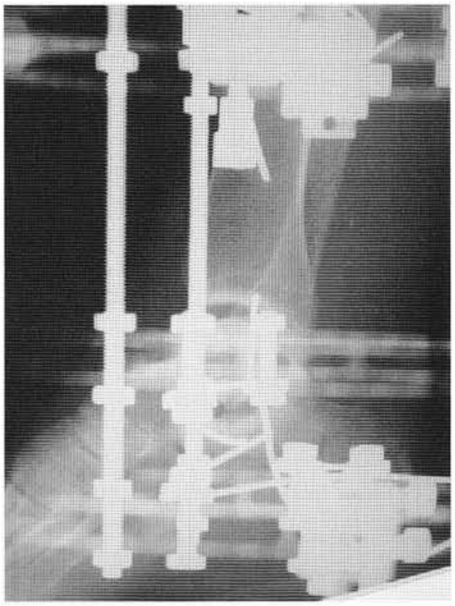

Figure 11. Postoperative radiograph.

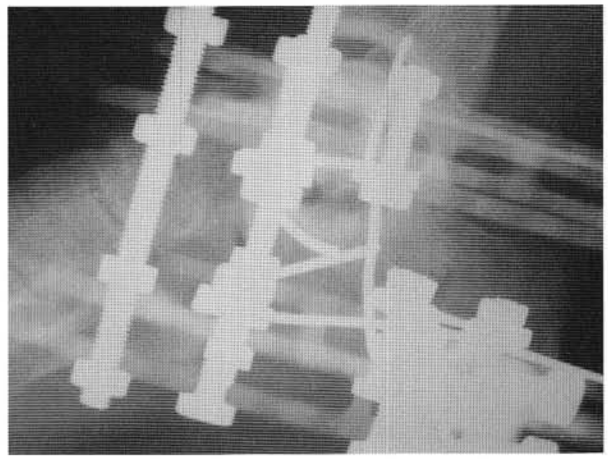

Figure 12. Postoperative radiograph.

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