FOOT & ANKLE INTERNATIONAL

Calcaneal Fractures: Indirect Reduction and External Fixation

William C. McGarvey, M.D.; Michael W. Burris, M.D.; Thomas O. Clanton, M.D.; Emmanuel G. Melissinos, M.D.
Houston, TX

ABSTRACT

Background: **The current treatment of displaced intra-articular calcaneal fractures has been surgical fixation. The objective of this study was to evaluate the use of indirect reduction with Ilizarov external fixation as a viable alternative in the surgical treatment of certain calcaneal fractures.** ***Methods:*** **Thirty-one patients with 33 fractures of the calcaneus (Sanders types II, III, and IV) were treated using small wire circular external fixation. A limited percutaneous plantar skin incision was used to improve reduction of the posterior facet. Fractures were evaluated by preoperative CT scans and classified by an independent observer. Patients were evaluated by physical examination as well as by the AOFAS hindfoot score questionnaire. Followup ranged from 6 months to 4 years.** ***Results:*** **The average AOFAS score for 18 patients available for examination was 66 (42 to 92). The average score increased to 74 for patients with more than 10 months followup and to 77 for patients with isolated calcaneal fractures. Open fractures also had early debridement and soft-tissue coverage; no deep infections were seen in this subgroup. There were 11 complications, including nine superficial pin track infections, one superficial skin necrosis under an area of fracture blister, and one deep infection in a diabetic smoker with severe hemorrhagic fracture blisters. All superficial infections responded to local pin or wound care and oral antibiotics. No secondary reconstructive procedures, including osteotomies, subtalar fusions, or amputations, have been done. All open fractures healed and maintained soft-tissue coverage.** ***Conclusions:*** **Indirect reduction and external fixation is a viable surgical alternative for intra-articular calcaneal fractures. Particularly favorable results were obtained in open fractures when soft-tissue reconstruction also was done. Advantages include shorter time to surgery, immediate weightbearing, minimal invasiveness, few serious wound problems, and no residual hardware. Disadvantages include technical difficulty, incomplete reduction of fracture fragments, and the need for secondary surgery (fixator removal).**

Corresponding Author:
Michael W. Burris, M.D.
6431 Fannin Street, Suite #6.144
Houston, TX 77030
E-mail: Michael.W.Burris@uth.tmc.edu

Key Words: Calcaneus; External Fixation; Fractures; Ilizarov

INTRODUCTION

Calcaneal fractures comprise 2% of all fractures and 60% of fractures that involve the tarsal bones of the foot. Approximately 75% of these are extra-articular, and most of these can be treated conservatively. However, for the 25% that involve the articular surface, there has been considerable debate about appropriate treatment and how to minimize potential complications. Untreated calcaneal fractures with alteration of the bone morphology and articular surface lead to substantial alterations in biomechanics.[12] Specifically, this results in shorter stance time and more rapid unloading on the injured extremity, leading to an abnormal gait pattern in which the subtalar joint is less adaptable to uneven surfaces. As a result, open reduction and internal fixation (ORIF) have been used to provide appropriate bone morphology and correct the subtalar joint mechanics to allow better accommodation of uneven surfaces. The complications of calcaneal fractures are well established and include but are not limited to:[4,14,16–18,21] subtalar pain, arthritis, peroneal tendinitis, fibular abutment, calcaneocuboid arthritis, heel pad damage, tarsal tunnel syndrome, stiff forefoot and toes, weak gastrocsoleus complex, a fixed flatfoot, infection, and regional pain syndromes. The current trend toward ORIF is an attempt to avoid these important and potentially disabling complications.[4,12,17–19,21] However, ORIF is not without complications, the most common of which are wound dehiscence and infection.[1,4,7,21] Wound complications have been reported to be as high as 33%.[1] Persistent subtalar joint stiffness also has been one of the main disadvantages. Other problems include symptomatic hardware, peroneal tendinitis, persistent plantar heel pain, prolonged nonweightbearing leading to weakness, and the potential for posttraumatic arthritis even in an anatomically repaired subtalar joint. In an attempt to reduce the invasive nature of ORIF, as well as to provide rigid fixation and potentially a better bone morphology, Schwartzman (personal communication) applied the concepts of Ilizarov to fractures of the calcaneus. Currently, there are no uniformly recognized protocols or

criteria for the use of circular small-wire fixation in the treatment of calcaneal fractures. Some proposed indications are open fractures, fractures with soft-tissue compromise, such as burns or large areas of fracture blistering, and combined fractures that include calcaneal and ankle or mid-foot fractures.[2,10,20] This method also is thought to provide an alternative to arthrodesis as has been recommended for Sanders IV type fractures.[18,19]

MATERIALS AND METHODS

Surgical Technique

The decision-making and preoperative planning are similar to those for ORIF, and, in fact, CT scan is potentially more useful in guiding the indirect reduction of the articular fragment.

A small traction pin was placed through the tuberosity fragment, and a Kirschner traction bow was applied. The patient was then positioned in skeletal traction similar to that used for a tibial shaft fracture reduction. The heel was distracted and the initial reduction verified fluoroscopically. A small stab wound was made through the plantar surface of the heel, and an elevator or other such device was introduced to manipulate the posterior facet fragment into a satisfactorily reduced position. The posterior facet fragment was then usually provisionally fixed with an olive wire, and the fixator frame was built around the foot (Figure 1).

Open fractures were treated with initial debridement as soon as the patient was stable enough to tolerate anesthesia. Irrigation and debridement of open wounds were done every 48 to 72 hours until all debris and nonviable and necrotic tissue were removed. Intravenous antibiotic therapy was instituted on arrival at the emergency department. Routine prophylaxis included Cefazolin (1 gram every 8 hours) and gentamicin (3.4 mg/kg/day) until soft-tissue coverage was obtained.[8] Stabilization was done as soon as possible and reasonable, preferably on the first operating room visit. Soft-tissue coverage was evaluated immediately and ultimately determined by the reconstructive plastic surgery service. This is best done simultaneously with or after application of the external fixation device (Figure 2).

Postoperatively, patients were asked to begin immediate touch-down weightbearing and to advance weightbearing as tolerated. Further distraction of approximately 5 mm was considered throughout the treatment phase to maintain the position of the articular and extra-articular fragments. The fixator was maintained for approximately 12 weeks. Clinical and radiographic healing parameters were the main determinants of timing of removal.

Patient Population

A subset of patients was collected prospectively between October of 1998 and January of 2003. All fractures of the calcaneus were treated at our institution by one surgeon (WCM). Thirty-three fractures in 31 patients were treated with indirect reduction and external fixation. The average age of the 24 men and seven women at the time of injury was 41.5 (19 to 64) years. Mechanisms of injury in the 31 patients were 15 motor vehicle accidents, 10 falls, two motor cross accidents, and four other high-energy traumas. Eleven fractures were open and four additional fractures had substantial (defined as dictating a delay in traditional ORIF) fracture blisters. There were eight isolated and four bilateral calcaneal fractures. Thirty-three patients sustained multiple orthopaedic injuries, as well as systemic injuries, including two spinal fractures, two tibial plateau fractures, five pilon fractures, three femoral fractures, six other foot and ankle fractures, and two closed head injuries. Comorbidities included smoking in eight patients and diabetes mellitus in one. Fractures were classified independent of the primary surgeon according to the method described by Sanders et al.[17,18] for all available CT scans. CT scans were not available for six fractures. Ten fractures were type II, eight were type III and nine were type IV. Average time to external fixation was 7.7 (range 1 to 21) days. Eleven patients were treated in 4 days or less. Average time to external fixator removal was just under 3 months. Patients were followed while in the hospital, then at a 2-week post-discharge visit, and monthly thereafter until the external fixator was removed. They were then seen quarterly. Average followup was 25 months, ranging from 6 to 55 months. Questionnaires were issued to patients, and they were evaluated by physical examinations. Each patient was assigned an AOFAS hindfoot score by an independent observer trained in foot and ankle surgery.[10]

RESULTS

Current AOFAS scores were obtained for 18 of the 31 patients at the time of review; the average score was 66 (range 42 to 92) points. The average score was increased to 74 when only the 11 patients with followup of 10 months or more were considered. Five patients with isolated, closed calcaneal fractures scored an average of 77. Range of motion was specifically recorded of the subtalar joint for 20 patients and the ankle joint for 21 patients. According to the motion criteria of the AOFAS scoring system, nine patients had marked restriction of subtalar motion, eight had moderate restriction, and three had normal or mild restriction. Fourteen patients had normal ankle motion or mild restriction, four had moderate restriction, and three had severe restriction of motion.

No secondary reconstructions or osteotomies and no fusions have been done in any of the 31 patients.

Eleven open fractures treated with this technique also had early flap coverage by a single plastic surgeon with experience in musculoskeletal reconstructive procedures. Eight patients had free myocutaneous flaps, two had local

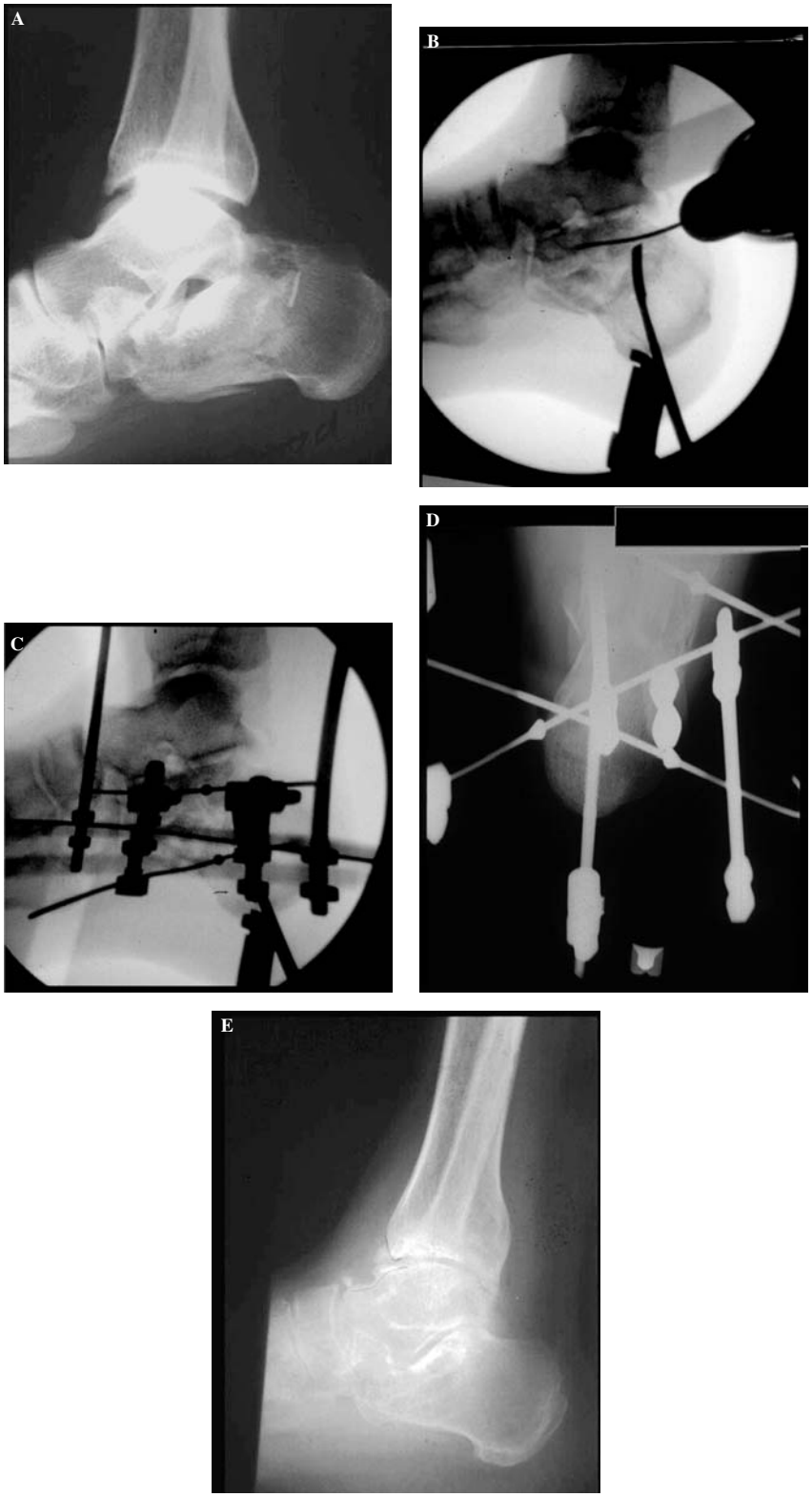

Fig. 1: A, A 44-year-old man fell from a roof, sustaining a joint depression type injury. The patient had substantial swelling and was a smoker at the time of injury. **B,** Percutaneous manipulation was done to the joint depression fragment of the posterior facet through a plantar incision and verified under fluoroscopic control. The fragment was stabilized as necessary by an olive wire in the subthalmic region to support and maintain the articular surface. **C,** Articular reduction of the posterior facet was achieved. Morphology of the calcaneus was restored and maintained by traction applied through the small wire circular external fixator. **D,** Harris view demonstrates good axial alignment. **E,** End result was near anatomic articular reduction and restoration of reasonably normal calcaneal height and width. (Figure 1, A–D reproduced with permission from McGarvey, WC; Burris, MW: Calcaneal fractures: indirect reduction and external fixation. Tech. Foot Ankle Surg. 3:258–268, 2004.)

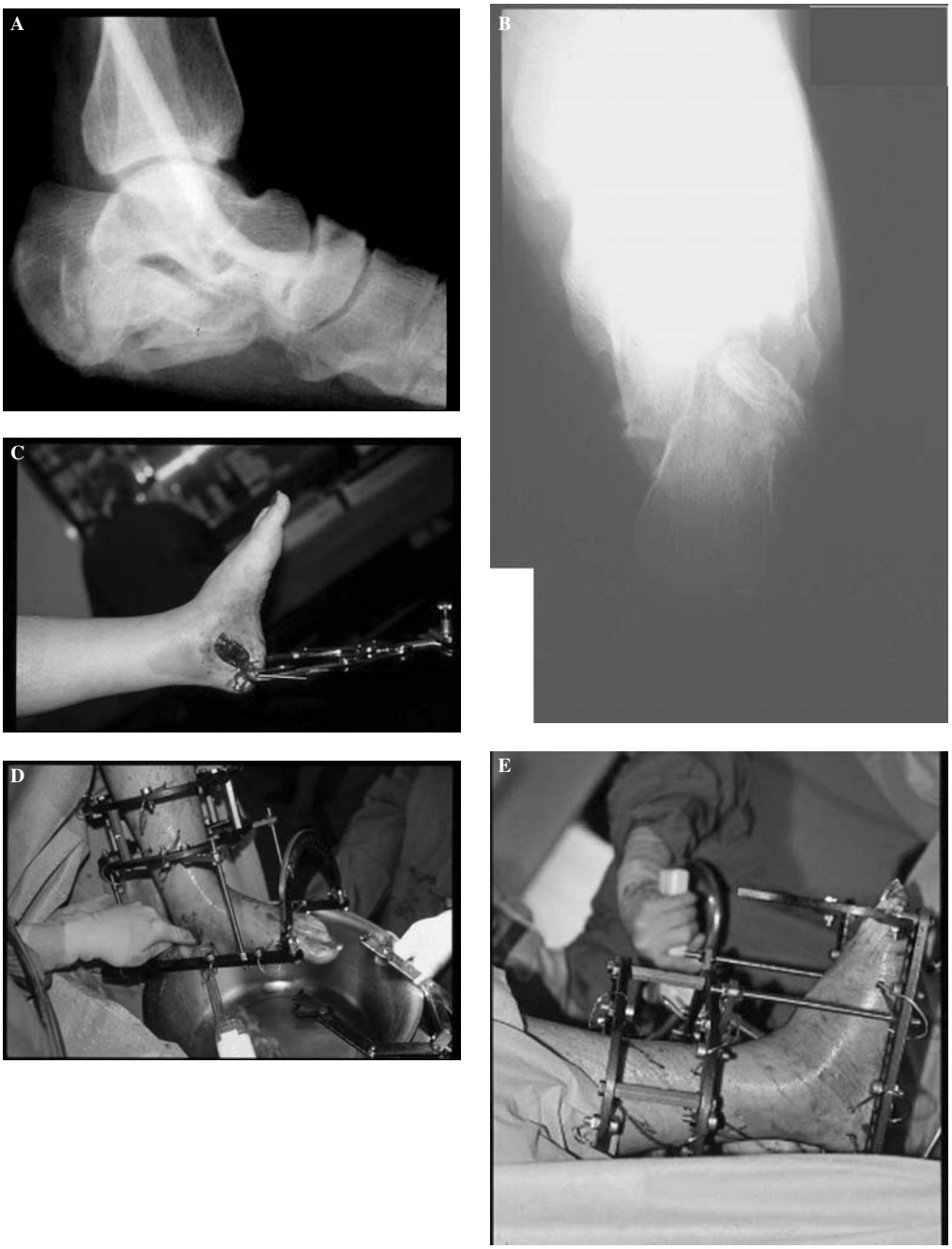

Fig. 2: A, A young woman involved in a motor vehicle accident sustained a comminuted, Grade III open fracture with joint depression and dissociation of the tuberosity fragment. **B,** Harris view demonstrates comminution and substantial impaction. However, large bone fragments are advantageous in helping obtain a quality reduction. **C,** Skeletal traction was applied through a Kirschner traction bow and a tensioned 0.062 Kirschner wire. **D,** After manipulation of fragments using a plantar stab incision, as well as manual reduction through the medial open wound, the external fixation device was applied to stabilize the calcaneus. **E,** Once stabilization was achieved, the wound was able to be managed more easily with free access to the affected tissues allowing easy irrigation, debridement, and tissue repair or coverage as indicated. Dressings were easily applied and removed, and flaps or grafts were easily evaluated without being obscured by bulky splints or casts. (Figure 2, D reproduced with permission from McGarvey WC; Burris, MW: Calcaneal fractures: indirect reduction and external fixation. Tech. Foot Ankle Surg. 3:258–268, 2004.)

flaps, and the other patient's wound was closed and covered with a split thickness skin graft. In this subset, there were no residual deep infections, no fusions, and no amputations. No additional surgeries other than fixator removal have been done since the initial hospital stay.

Complications

Overall there were 11 complications in the 33 fractures. Nine were superficial pin site infections that responded to increased local pin care and oral antibiotics; five of these were in patients with open fractures. One was a superficial

skin necrosis (under the area of a fracture blister) that responded to local wound care. One was a deep infection in a patient with poorly controlled diabetes, severe fracture blisters, and a pack-a-day smoking history; we did not see this patient until after injury. This individual required multiple debridements of his draining fracture blisters and subsequent free-tissue transfer. Four of eight smokers had infection complications.

DISCUSSION

Although there is agreement that untreated displaced intra-articular fractures of the calcaneus can be disabling and potentially devastating injuries, the appropriate management of these fractures remains controvesial.[5,6] Currently, the trend is toward ORIF to obtain accurate reduction and stable fixation. Complications, particularly soft-tissue problems, however, are frequent with ORIF of calcaneal fractures.[1,4,7,21] Although wound complication rates vary, there is a consensus among experienced surgeons that this is one of the most devastating complications resulting from operative management of calcaneal fractures.[13] Benirschke et al.[3] reported two deep infections in 80 patients after ORIF through an extensile lateral approach (16% overall wound complication rate). The same group, more recently, reported better results after ORIF with one deep infection in a patient with neuropathy who ultimately required a below-knee amputation (11% overall complication rate in 218 fractures).[9] The better outcomes were believed to be due to greater attention to soft-tissue handling, better techniques of fixation, and more experience by surgeons. Despite the improved soft-tissue results, 95 additional procedures were performed, most for hardware removal. Seventeen patients, however, required additional reconstructive procedures including seven claw toe procedures, four calcaneal osteotomies for varus malunions, and five subtalar fusions. The average initial surgical time was 4.3 hours.

Folk et al.[7] reviewed 190 calcaneal fractures and found a 25% wound complication rate with 21% requiring re-operation. Abidi, et al.[1] reviewed factors contributing to the complication rates of surgical management of calcaneal fractures and discovered an overall 33% wound complication rate (14% superficial and 18% deep dehiscences). They concluded that risk factors in general were single layer closure, high body mass index, increased time from injury to surgery, and smoking.

Our results compared favorably to the literature in most respects. In 31 patients with 33 Sanders types II, III, and IV fractures, treated with indirect reduction and external fixation, there was one deep infection in a diabetic smoker, with severe fracture blisters who was seen 10 days after his initial injuries. This one infection in 33 fractures (3%) required surgical management, a considerably lower second-surgery rate than reported after ORIF.[1,7] Otherwise, all patients had reasonable results with no fusions required at the time of latest followup. The average AOFAS hindfoot score was 66 for all fractures, but patients with followup longer than 10 months scored an average of 74 and those with isolated calcaneal fractures averaged 77. This supports unpublished observations that AOFAS scores in patients with calcaneal fractures tend to increase with longer followup. Despite comparable and even favorable clinical results in this study in both patients with isolated calcaneal fractures and those with combined and often severe injuries, the utility of the current scoring system seems to be of limited value. Because it does not take into account the severity of ipsilateral and contralateral extremity injuries that affect functional outcomes, its validity is questionable in trauma patients. Nonetheless, for lack of a more complete and specific rating scale, the AOFAS hindfoot score was believed to be sufficient for this study and the most reproducible outcomes measurement for comparison of results with relevant literature. The literature specifically surrounding open calcaneal fracture management is scant but demonstrates generally poor outcomes.[10,20] Siebert et al.[20] reported 14 deep infections in 35 patients with open intra-articular calcaneal fractures. Of those with primary irrigation, debridement, and ORIF, 100% had complications. Overall, five amputations, four arthrodeses, and one partial calcanectomy were required. All 15 patients with grade III open injuries had complications including two with osteomyelitis and one who required amputation.

More recently, Heier et al.[10] reported that 43 open fractures treated by a standard protocol had an overall 37% infection rate and 19% occurrence of chronic osteomyelitis. Higher grade open injuries predictably produced worse results. Thirteen of 26 patients with Gustilo-Anderson[8] grade III injuries developed infections and 27% had osteomyelitis. Three of 13 grade IIIB fractures required amputation. In 27 fractures not requiring amputation, the average AOFAS hindfoot score was 71. Based on their results, the authors recommended that all Gustilo-Anderson types I and II injuries with medial wounds be treated with ORIF after wound irrigation, debridement, and closure. For type II lateral wounds and all type III wounds, they recommended aggressive debridement and percutaneous internal fixation or external fixation for fracture stabilization. The rationale here was that performing a delayed reconstruction of a malunion or arthritic subtalar joint with an osteotomy or fusion was much less risky than application of internal fixation in the acute period. Open fracture management with this technique in conjunction with soft-tissue reconstruction by the plastic surgery service produced excellent results when compared to available data. Of the 11 patients in our series with open calcaneal fractures, all wounds were successfully covered. Although there were several pin track infections, there were no residual infections or osteomyelitis. No repeat procedures were required and all wounds healed. No osteotomies, fusions, or amputations have been done in this group. We attributed these results to early aggressive debridement, careful handling of the soft tissues, early definitive wound coverage, and

avoidance of internal fixation. The rationale of our treatment protocol was to provide rigid fixation, restore heel height, narrow heel width, and allow for patient mobility. Disadvantages to this method are that it is technically more demanding than ORIF, may require more operating room time, certainly provides less control of the articular surface, and the post-reduction radiographic appearance might show complete reduction of the posterior facet. Subtalar motion was restricted during fixator wear, and the procedure itself requires a secondary procedure to remove the external fixation device. The advantages, however, are the minimal invasion, the rigid fixation that allows weightbearing as soon as one day after surgery, the shorter time to surgery, and the ability to have foot-ground contact which may allow heel pad desensitization.[15] Schwartzman (personal communication) treated 100 patients using a similar method with no deep infections and two subsequent fusions. However, there is no definition of a direct mechanism that improves outcomes. The presumptive advantages are that this method provides stability, re-establishes bone morphology and architecture, provides cushioning for the joint, and potentially has the benefits of an acute distraction arthroplasty at the subtalar joint. Several questions remain unanswered. Is an anatomic reduction an absolute necessity? Is this a viable and appropriate alternative to primary arthrodesis? Does the reduction in risk of wound slough and infection acutely outweigh the possibly increased risk of limited range of motion and need for later arthrodesis? Current research involves the development of procedures that combine the benefits of external fixation with limited internal fixation for a more direct articular reduction. Technically simpler and more user-friendly devices also will make this a more expeditious and efficient process. Currently, results of a comparative group of patients treated by a single surgeon with more traditional ORIF is not available, but our preliminary results indicate that indirect reduction and external fixation are reasonable treatment methods of both complex and uncomplicated calcaneal fractures in certain subgroups, and specifically patients with open fractures and those at higher risk for wound complications.

REFERENCES

1. **Abidi, NA; Dhawan, S; Gruen, GS; Vogt, MT; Conti, SF**: Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. Foot Ankle Int. **19(12)**:856–861, 1998.
2. **Beals, T**: Application of ring fixators in complex foot and ankle trauma. Orthop. Clin. N. Am. **32**:205–214, 2001.
3. **Benirschke, SK; Sangeorzan, BJ**: Extensive intra-articular fractures of the foot. Surgical management of calcaneus fractures. Clin. Orthop. **292**:128–134, 1993.
4. **Bezes, H; Massart, P; Delvaux, D; Fourquet, JP; Tazi, F**: The operative treatment of intra-articular calcaneal fractures. Indications, technique, and results in 257 cases. Clin. Orthop. **290**:55–59, 1993.
5. **Buckley, R; Tough S, McCormack R, et al.**: Operative compared with non-operative treatment of displaced intra-articular calcaneal fractures. J. Bone Joint Surg. **84-A**:1733–1743, 2002.
6. **Buckley, R; Meek, R**: Comparison of open versus closed reduction of intra-articular calcaneal fractures: A matched cohort in workmen. J. Orthop. Trauma **6**:216–222, 1992.
7. **Folk, JW; Starr, AJ; Early, JS**: Early wound complications of operative treatment of calcaneus fractures: Analysis of 190 fractures. J. Orthop. Trauma **13**(5):369–372, 1999.
8. **Gustilo, RB; Anderson, JT**: Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. J. Bone Joint Surg. **58-A**:453–458, 1976.
9. **Harvey, EJ; Grujic, L; Early, JS; Benirschke, SK; Sangeorzan, BI**: Morbidity associated with ORIF of intra-articular calcaneus fractures using a lateral approach. Foot Ankle Int. **22**:868–873, 2001.
10. **Heier, KA; Infante, AF; Walling, AK; Sanders, RW**: Open fractures of the calcaneus: soft-tissue injury determines outcome. J. Bone Joint Surg. **85-A**:2276–2282, 2003.
11. **Kitaoka, HB; Alexander, IJ; Adelaar, RS; et al.**: Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int. **15**:349–353, 1994.
12. **Letournel, E**: Open treatment of acute calcaneal fractures. Clin. Orthop., **290**:60–67, 1993.
13. **Levin, LS; Nunley, JA**: The management of soft tissue problems associated with calcaneal fractures. Clin. Orthop. **290**:151–156, 1993.
14. **Myerson, M; Quill, G:** Late complications of fractures of the calcaneus. J. Bone Joint Surg. **75-A**:331–341, 1993.
15. **Paley, D; Fischgrund, J**: Open reduction and circular fixation of intra-articular calcaneal fractures. Clin. Orthop. **290**:125–131, 1993.
16. **Paley, D; Hall, H**: Intra-articular fractures of the calcaneus. A critical analysis of results, and prognostic factors. J. Bone Joint Surg. **75-A**:342–354, 1993.
17. **Sanders, R**: Displaced intra-articular fractures of the calcaneus. J. Bone Joint Surg. **82-A**:225–250, 2000.
18. **Sanders, R; Fortin, P; DiPasquale, T; Walling, A**: Operative treatment in 120 displaced intra-articular calcaneal fractures. Results using a prognostic computed tomography scan classification. Clin. Orthop. **290**:87–95, 1993.
19. **Sanders, R**: Intra-articular fractures of the calcaneus: present state of the art. J. Orthop. Trauma **6**:252–265, 1992.
20. **Siebert, CH; Hansen, M; Wolter, D**: Follow-up evaluation of open intra-articular fractures of the calcaneus. Arch. Orthop. Trauma Surg. **117**:442–447, 1998.
21. **Zwipp, H; Tscherne, H; Thermann, H; Weber T**: Osteosynthesis of displaced intra-articular fractures of the calcaneus. Results in 123 cases. Clin. Orthop. **290**:76–86, 1993.