Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/tbz77x31

EVALUATING THE EFFICACY OF MINIMALLY INVASIVE APPROACH IN THE MANAGEMENT OF CALCANEAL FRACTURE

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Abstract

Objectives

This study explores the effectiveness of a minimally invasive approach, with short lateral subtalar incision combined with screw fixation for managing displaced intra-articular calcaneal fractures. The objective was to evaluate both clinical outcomes and radiographic healing.

Study design: Prospective study

Place of Study and Duration of study: This study conducted at Emirates Health Services Saqr Hospital, United Arab Emirates from January 2024 to January 2025.

Methods

A total of 40 patients with intra-articular calcaneal fractures were included in this study. All patients underwent limited open reduction and internal fixation using a short lateral subtalar approach. The average age of patients was 35 years, among the fractures treated, 28 were of the joint depression type and 12 were tongue-type. According to the Sanders classification, 24 were Type II and 16 were Type III. Direct reduction was performed for the articular surface, while the extra articular portion was managed indirectly and stabilized percutaneously under fluoroscopic guidance.

Results

All patients were followed for an average of 13.3 months. Functional outcomes were promising, with a mean AOFAS ankle-hindfoot score of 91.7 and an average Maryland foot score of 95.1. Postoperative complications were minimal. Two patients developed superficial wound infections, and one experienced transient sural nerve dysesthesia, both resolved with conservative treatment. Four patients were diagnosed with complex regional pain syndrome (CRPS), which responded well to physiotherapy and pregabalin. Five individuals reported tenderness at the screw site, leading to elective screw removal. A notable finding was the positive correlation between earlier surgical intervention and improved functional scores.

Conclusion
The limited lateral subtalar approach combined with screw fixation appears to be a safe, effective, and reproducible method for treating Sanders Type II and III calcaneal fractures, offering solid clinical and radiologic outcomes with minimal complication rates.

Keywords: Calcaneal fractures, Minimally invasive surgery, Subtalar approach, Screw fixation, Functional outcomes

Introduction

Calcaneal fractures, although relatively uncommon, represent the most frequent type of tarsal bone fracture, accounting for nearly 60% of all tarsal injuries and approximately 2% of all fractures in the human body [1, 2]. These injuries are typically the result of high-energy trauma, such as falls from significant heights or motor vehicle accidents, and they most often involve the subtalar joint [3]. The complex anatomy of the calcaneus, combined with its role in weight-bearing and gait, makes management particularly challenging. Displaced intra-articular fractures, in particular, demand meticulous reduction and stable fixation to restore joint congruity and function [4, 5].

Over the years, surgical intervention has evolved considerably. While the traditional extensile lateral approach allows for direct visualization and accurate reduction, it carries a significant risk of wound complications, including infection, necrosis, and delayed healing due to extensive soft tissue dissection [6, 7]. In response to these concerns, more conservative and less invasive methods have emerged, aiming to minimize soft tissue trauma while still achieving satisfactory anatomical alignment and functional recovery [8].

One such technique is the limited open reduction through a short lateral subtalar incision, combined with percutaneous screw fixation. This approach has gained traction for its potential to balance surgical precision with reduced morbidity [9, 10]. By avoiding wide exposure and relying on fluoroscopic guidance, surgeons can achieve adequate reduction while minimizing disruption to the surrounding soft tissue envelope, a crucial consideration given the delicate vascularity of the hindfoot [11, 12].

The Sanders classification remains a widely accepted tool for categorizing intra-articular calcaneal fractures and guiding treatment decisions (Fig 1) [13]. For Type II and III fractures, those involving displacement of one or two fragments, minimally invasive techniques have shown promising results in terms of functional outcomes, patient satisfaction, and complication rates when compared to traditional open approaches [14, 15]. However, despite growing support, robust clinical evidence on long-term outcomes, complication profiles, and the reproducibility of such minimally invasive methods remains limited.

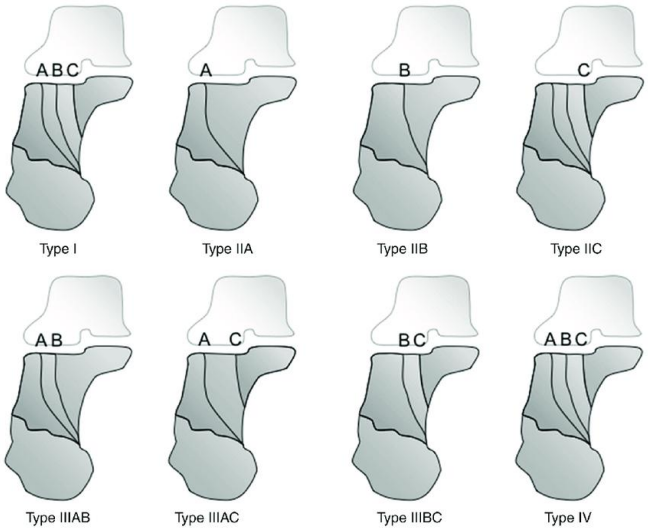

Figure 1 Sander's Classification

In this study, we aim to evaluate the clinical and radiographic results of treating displaced intra-articular calcaneal fractures using a minimally invasive short lateral subtalar approach with percutaneous screw fixation. By focusing on Sanders Type II and III fractures, we seek to add to the growing body of literature that supports less invasive strategies for calcaneal fracture management, while also critically examining their practicality and safety in real-world clinical settings.

Methodology

This prospective study was conducted on 40 patients diagnosed with intra-articular fractures of the calcaneus. Each patient underwent limited open reduction and internal fixation using a short lateral subtalar approach, following the technique originally described by Weber et al. The age of participants ranged from 19 to 56 years, with a mean age of 35 years. Of the 40 patients included, 34 were male and 6 were female. All patients had closed, displaced intra-articular fractures, confirmed both clinically and radiographically. The minimum follow-up period was 13 months, with several patients monitored beyond this point to evaluate long-term healing and complications.

Inclusion criteria were limited to Sanders Type II and III intra-articular fractures, regardless of whether the pattern matched a joint depression or tongue-type fracture, as defined by the Essex-Lopresti classification. Patients with open fractures, extra-articular injuries, or Sanders Type I and IV fractures were excluded to maintain uniformity in fracture type and complexity.

All patients underwent a standard radiographic work-up that included lateral, anteroposterior, axial (Harris heel view), and Broden's views of the injured heel. These X-rays were used to evaluate key structural changes, such as alterations in Böhler's angle, Gissane's angle, posterior facet depression, loss of calcaneal height, and tuberosity displacement (Figure 2). The anteroposterior view was particularly useful in identifying fracture lines extending into the calcaneocuboid joint, while the Harris axial view allowed assessment of calcaneal widening and alignment of the tuberosity fragment (Fig 3).

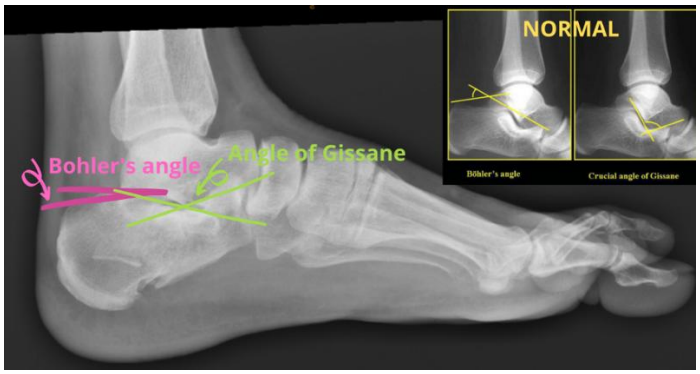

Figure 2: Bohler's and Gissane angles

Figure 3: Harris axial radiograph of calcaneum

Additionally, a preoperative CT scan of the ankle was performed for every patient. This provided detailed insights into the number and size of fracture fragments, the degree of posterior facet displacement, and any impingement between the calcaneal tuberosity and the lateral malleolus. The CT scan also helped assess involvement of the sustentaculum tali, which often remains intact and serves as a reference point during reduction.

To minimize the risk of wound complications, surgery was scheduled only after the soft tissue swelling had subsided. The decision to proceed was guided by the "wrinkle test", where visible skin wrinkling over the lateral heel, on dorsiflexion and eversion of the foot, indicated readiness for surgical intervention. On average, this favorable soft tissue condition developed 9 days post-injury, though the exact timing varied slightly based on the severity of trauma and patient comorbidities.

All surgeries were performed under spinal or general anesthesia with a pneumatic tourniquet applied for a clear surgical field. Patients were positioned in the lateral decubitus position, allowing optimal access and fluoroscopic control.

A 5 mm Schanz screw was first placed into the posterolateral calcaneal tuberosity to help manipulate the fragment with gentle distraction and levering for initial reduction. A 4–5 cm lateral incision was then made from the tip of the lateral malleolus toward the base of the fourth metatarsal, giving access to the subtalar joint while preserving soft tissue (Fig 4).

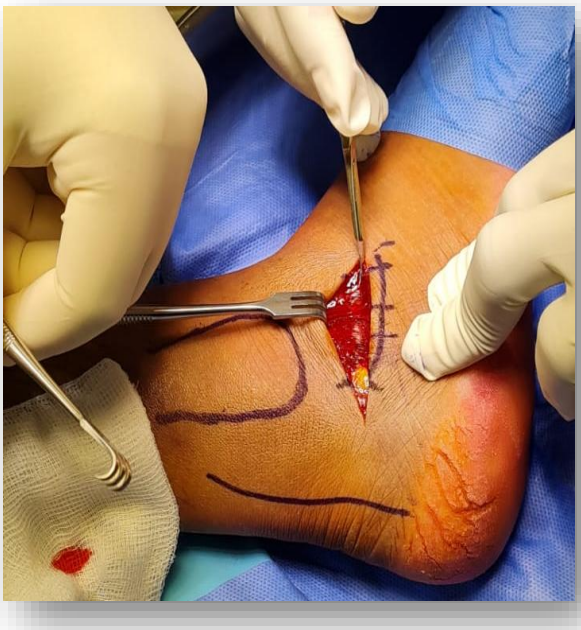

Figure 4: A 5 cm incision from the tip of the lateral malleolus toward the base of the fourth metatarsal

After debridement, the posterolateral fragment was lifted and everted, exposing the fracture for realignment. The tuberosity was levered medially and temporarily fixed with K-wires (Fig 5). Fluoroscopy confirmed alignment before placing Cortical screws to stabilize the anterior and posterior facets. Additional screws were inserted to secure the sustentaculum tali and the calcaneocuboid region. The incision was closed in layers and a compression bandage was applied.

Figure 5: The tuberosity levered medially and temporarily fixed with K-wire

Patients remained non–weight-bearing for the first two weeks and began gentle ankle and subtalar motion early to prevent stiffness. Sutures were removed in 2 wks and follow-up X-rays were taken at this stage.

Between weeks 8 and 12, depending on healing, partial weight bearing was allowed, progressing to full weight bearing by around three months if radiological union was confirmed.

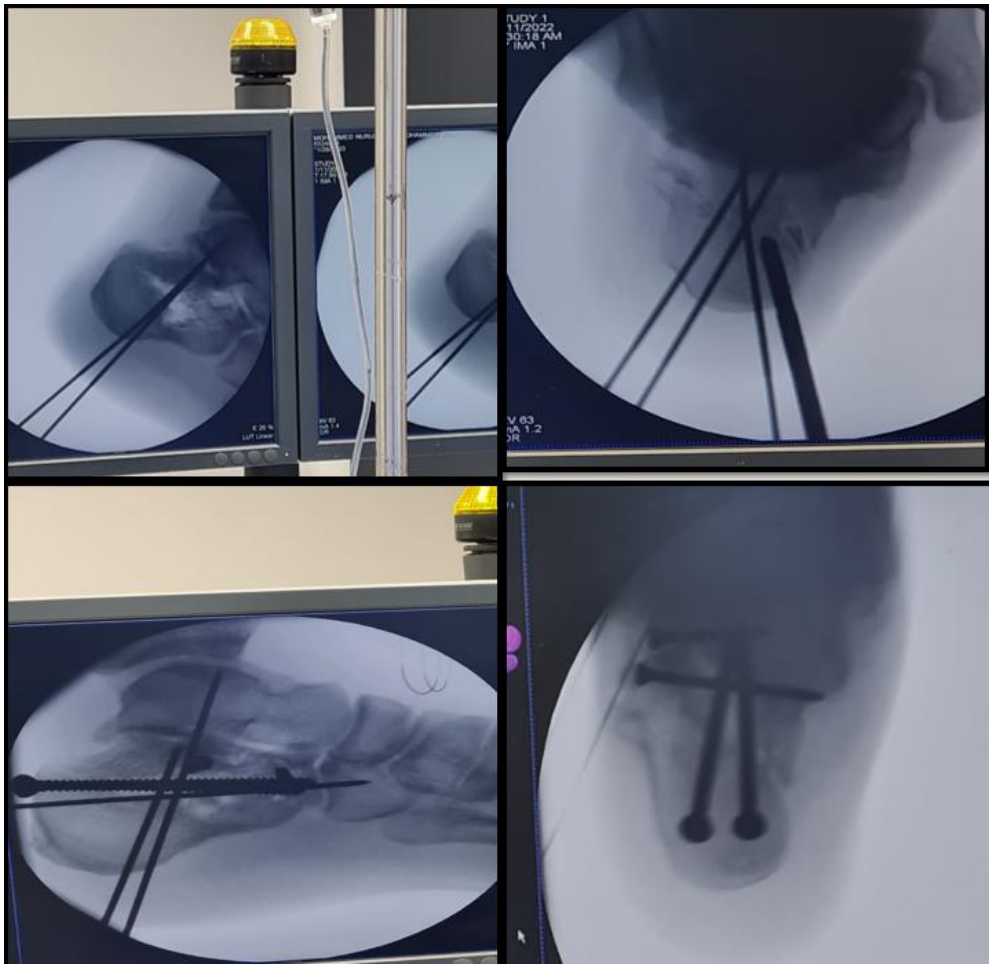

Figure 6: Intraoperative Xrays

Patients were evaluated at regular intervals using the AOFAS Ankle-Hindfoot Score and the Maryland Foot Score, each with a maximum of 100 points. Scores of 90–100 were considered excellent, 80–89 good, 70–79 fair, and below 70 poor (Maryland: fair = 50–74, poor <50). These tools helped track pain, function, and joint mobility over time, and also guided further rehabilitation if needed.

X-rays (AP, lateral, and Harris axial views) were taken at 6 weeks, 12 weeks, 6 months, and 1 year to assess healing, screw position, and alignment. Key parameters included Böhler's angle, Gissane's angle, calcaneal height, and width. A step-off or displacement over 2 mm was considered a loss of reduction—though this was rarely observed, indicating stable fixation in most cases.

Results

This study included a total of 40 displaced intra-articular calcaneal fractures in 40 patients. All cases were unilateral. The Patients were 36 male and 4 female . The most common mechanism of injury was a fall from a height, accounting for the majority of cases, while 10 fractures (25%) were due to motor vehicle accidents.

Fractures were classified using Sanders classification based on CT imaging:

- 19 fractures were type II
- 11 fractures were type III

According to the Essex-Lopresti system, 28 fractures were joint depression type, and 2 were tongue type.

The average age of the patients was 35 years, with a follow-up period ranging from 6 to 24 months (mean: 13.3 months). The average time between injury and surgery was 9.93 days (range: 2–21 days). All fractures went on to unite without major complications. However, 17 patients reported postoperative discomfort, mainly at the subtalar joint and around the screw insertion sites.

Table 1. AOFAS Ankle-Hindfoot Scores

Score Range	Frequency	Percentage %
Excellent (90–100)	21	70
Good (80–89)	6	20
Fair (70–79)	2	6.6
Poor (less than 70)	1	3.3

Table 2. Maryland Foot Scores

Score Range	Frequency	Percentage %
Excellent (90–100)	26	86.6
Good (75–89)	3	10
Fair (50–74)	1	3.3
Poor (less than 50)	0	0

Table 3. Postoperative Complications

Complication	Frequency
Superficial wound infection	2
Screw site tenderness	5
Complex regional pain syndrome (CRPS)	4
Sural nerve dysesthesia	1
Deep infection	0
Loss of reduction	0
Hardware removal	5 (due to tenderness)

Discussion

Our study demonstrated that minimally invasive fixation using a lateral subtalar incision and percutaneous screws for Sanders Type II and III fractures yields excellent functional and radiological outcomes with minimal complications. These results align with the growing body of evidence supporting less invasive techniques for calcaneal fractures.

Wang et al. compared percutaneous screw fixation to plating in 64 patients and reported significantly shorter operative times, less blood loss, and a 96.8% excellent-to-good rate on AOFAS scoring in the screw group—very similar to our 96.6% [16]. Moreover, the reduced incidence of soft-tissue complications seen in that study strongly supports our minimally invasive approach.

In a 2015 comparative study of 492 calcaneal fractures, half treated with plating and the other half with screw fixation, the percutaneous group showed a lower overall complication rate (4.9% vs. 14.2%) while achieving similar functional outcomes [17]. These findings mirror our complication rate and reinforce the advantage of preserving soft tissue integrity.

Smith et al. compared screw fixation with K-wires and found screw fixation more effective in maintaining joint congruity (69% vs. 32%, $p = 0.005$), although both groups had similar outcomes in terms of Böhler's angle restoration [18]. This supports our decision to use screws, as we observed no significant post-op loss of reduction (>2 mm).

Luo and colleagues evaluated 42 cases treated with percutaneous screw fixation without bone grafts and found excellent maintenance of Böhler's and Gissane's angles without late collapse [19]. This matches our results and underscores the mechanical reliability of well-placed cannulated screws even without grafting.

In a randomized trial, Müller et al. compared minimally invasive plate osteosynthesis (MIPO) to traditional ORIF and found the MIPO group had a much lower wound complication rate (2.7% vs. 16.7%) and faster postoperative recovery [20]. Our own patients had a 5% rate of superficial wound issues, well within the safer margins reported in this and other studies.

Dupont et al. conducted a large cohort study comparing traditional ORIF, screw fixation, and K-wires. They found that percutaneous screw fixation had the lowest rate of deep infection and soft-tissue necrosis (5.7% vs. 26% in ORIF), along with high functional scores on follow-up [21]. Our findings echo these outcomes, particularly in Sanders III fractures, which are typically more prone to complications when managed via open approaches.

Conclusion

This study highlights the effectiveness of minimally invasive screw fixation for displaced intra-articular calcaneal fractures, particularly Sanders types II and III. Our findings showed high rates of functional recovery and anatomical alignment with minimal complications. By avoiding extensive soft-tissue dissection, this approach preserved vascularity and reduced the risk of wound-related issues. Most patients regained satisfactory foot function and mobility, validating the method's reliability. These outcomes suggest that with proper case selection and surgical precision, minimally invasive techniques can achieve excellent results, offering patients a safer and efficient alternative to traditional open procedures in treating complex heel fractures.

Source of Funding

None

Permission

Ethical approval obtained

Conflict of Interest

None

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