A Comparative Study of Operative Versus Non-Operative Management of Closed, Displaced Intra-Articular Fractures of the Calcaneum Characterization Demineralized Bone Matrix and Injectable Platelet Rich Fibrin - A Clinical and Radiographic Study

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Abstract

Background: Displaced intra-articular calcaneal fractures (DIACFs) remain challenging injuries, and the optimal management strategy continues to be debated. This study compared the clinical, radiological, and functional outcomes of operative and non-operative treatment.

Methods: A prospective comparative study was conducted between October 2018 and April 2020 involving 60 displaced intra-articular calcaneal fractures in 58 patients. Thirty fractures underwent operative management (open reduction and internal fixation or minimally invasive screw fixation), while 30 received conservative treatment. Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score. Radiological parameters, fracture union, and complicationswerecompared.

Results: The mean AOFAS score was significantly higher in the operative group than in the non-operative group (84.2 ± 7.75 vs. 79.4 ± 9.04; p=0.016). Operative treatment achieved superior restoration of Böhler's angle (21.06° vs. 17.50°; p=0.0012) and Gissane's angle (134.96° vs. 140.20°; p=0.0015). Time to radiological union was comparable between groups (10.1 ± 2.13 vs. 10.6 ± 2.38 weeks; p=0.33). Persistent heel pain and early subtalar arthritis were more frequent following conservative treatment, whereas wound complications and implant-related problems occurred only after surgery.

Conclusions: Operative management of displaced intra-articular calcaneal fractures provides superior functional recovery and anatomical restoration compared with conservative treatment without significantly affecting fracture union time. Although surgery carries procedure-related complications, careful patient selection and appropriate surgical technique can optimize outcomes.

Keywords: Calcaneal fracture; Displaced intra-articular fracture; Open reduction and internal fixation; Conservative treatment; AOFAS score; Functional outcome

Introduction

Calcaneal fractures are the most common fractures of the tarsal bones, accounting for approximately 2% of all skeletal fractures and nearly 60–75% of all tarsal injuries. Approximately 60–75% of these fractures are displaced intra-articular fractures involving the posterior facet of the subtalar joint. They typically result from high-energy trauma, most commonly falls from height and motor vehicle accidents, predominantly affecting young, economically active individuals. Despite being relatively uncommon, these injuries are associated with substantial morbidity, prolonged

disability, and significant socioeconomic consequences.

The complex three-dimensional anatomy of the calcaneus and its critical role in hindfoot biomechanics make displaced intra-articular calcaneal fractures particularly challenging to manage. Failure to restore the normal anatomy may result in heel widening, loss of calcaneal height, varus deformity, subtalar incongruity, chronic pain, stiffness, impaired gait, difficulty wearing footwear, and post-traumatic subtalar arthritis, ultimately leading to poor functional outcomes.

Historically, most displaced intra-articular calcaneal fractures were managed conservatively because of limited understanding of fracture morphology, inadequate imaging modalities, and the absence of reliable fixation techniques. Although conservative treatment can achieve fracture union, residual deformity and articular incongruity frequently persist, predisposing patients to chronic pain, reduced mobility, and long-term functional impairment.

Advances in imaging, particularly computed tomography (CT) with three-dimensional reconstruction, have substantially improved the understanding of fracture morphology and facilitated accurate classification and preoperative planning. Simultaneously, developments in surgical techniques, including open reduction and internal fixation (ORIF) using locking calcaneal plates and minimally invasive fixation through the sinus tarsi approach, have enhanced the ability to restore calcaneal height, width, alignment, Böhler's angle, Gissane's angle, and subtalar joint congruity. Anatomical restoration has been associated with improved functional recovery; however, operative treatment also carries risks such as wound complications, infection, skin necrosis, sural nerve injury, and implant-related problems.

Despite numerous randomized controlled trials and systematic reviews comparing operative and non-operative treatment, controversy remains regarding the optimal management of displaced intra-articular calcaneal fractures. While several studies have reported superior anatomical reduction and improved functional outcomes following surgical fixation, these benefits must be weighed against the increased incidence of postoperative complications. Consequently, treatment decisions should be individualized based on fracture characteristics, soft tissue condition, patient-related factors, and surgical expertise.

The present prospective comparative study was undertaken to evaluate and compare the clinical, radiological, and functional outcomes of operative and non-operative management of displaced intra-articular calcaneal fractures. Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, with the objective of determining the effectiveness of each treatment modality and contributing further evidence toward optimizing the management of these challenging injuries.

Materials and Methods

Study Design and Setting

A prospective comparative study was conducted at VMKV MCH Salem Tamilnadu, India. Institutional Ethics Committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants.

Study Population

A total of 58 patients with displaced intra-articular calcaneal fractures were enrolled during the study period. Two patients had bilateral fractures, resulting in a total of 60 calcaneal fractures included in the analysis.

Patients were randomly allocated into two equal groups:

- Group A (Operative management): 30 fractures
- Group B (Non-operative management): 30 fractures

- Inclusion Criteria
- Skeletally mature patients.
- Closed displaced intra-articular calcaneal fractures with an intra-articular step-off greater than 2 mm.
- Sanders Type II, III, and IV fractures.

- Exclusion Criteria
- Congenital foot deformities.
- Pathological fractures.
- Open fractures.
- Severe soft tissue compromise, including extensive blistering, severe edema, abrasions, or pre-existing
- dermatological lesions.
- Previous hindfoot surgery, refracture, or associated fractures involving other tarsal bones.

Initial Evaluation

All patients underwent detailed clinical evaluation following Advanced Trauma Life Support (ATLS) principles. Associated injuries involving the head, chest, abdomen, spine, and extremities were carefully assessed and managed. Routine laboratory investigations included complete blood count, renal function tests, liver function tests, serum

electrolytes, and viral markers. Standard radiographs (lateral and axial views of the calcaneus) were obtained, followed by computed tomography (CT) with three-dimensional reconstruction to classify fracture morphology and facilitate treatment planning.
Initially, all fractures were immobilized using a below-knee posterior slab with Bohler elevation.

Treatment Protocol

Non-operative Management

Patients allocated to the conservative treatment group initially received Rest, Ice, Compression, and Elevation (RICE) therapy together with below-knee splint immobilization.
Pain and inflammation were managed using analgesics combined with enzyme preparations including serratiopeptidase, bromelain, rutoside, and trypsin-chymotrypsin.
Following reduction of swelling, closed reduction was performed using longitudinal traction, mediolateral compression, and manual correction of heel deformity. A below-knee cast was then applied with the ankle maintained in neutral position.
Immobilization was maintained for six weeks. After cast removal, radiographic union was assessed, and ankle, subtalar, and toe range-of-motion exercises were initiated.
Patients remained non-weight-bearing for approximately 10–12 weeks. Partial weight-bearing was started after radiographic evidence of healing, followed by full weight-bearing at approximately 16 weeks. Patients were advised to wear cushioned closed footwear and avoid walking barefoot or on uneven surfaces during rehabilitation.

Operative Management

Patients assigned to operative treatment also received initial RICE therapy and splint immobilization.
Definitive surgery was delayed until soft tissue swelling subsided and the wrinkle sign appeared, indicating adequate soft tissue recovery.
Depending on fracture morphology, patients underwent either:

- Open Reduction and Internal Fixation (ORIF) using locking calcaneal plates through the extensile lateral approach, or
- Minimally invasive reduction and percutaneous screw fixation through the sinus tarsi approach.

Open Reduction and Internal Fixation

Patients were positioned in the lateral decubitus position under tourniquet control. An extensile lateral L-shaped incision was used to expose the fracture.
Reduction was performed in three sequential steps:

1. Restoration of the anterior calcaneus.
2. Realignment of the tuberosity using a Schanz pin.
3. Anatomical reduction of the posterior facet.

Temporary fixation was achieved using Kirschner wires, followed by definitive fixation with locking calcaneal plates and cancellous screws. Wounds were closed in layers, and a below-knee slab was applied.

Minimally Invasive Technique

The sinus tarsi approach utilized a 2–4 cm incision extending from the fibular tip toward the fourth metatarsal.
Following exposure of the posterior facet, reduction was achieved using a Schanz pin and elevators. Temporary stabilization with Kirschner wires was followed by fixation using cannulated cancellous screws without bone grafting or plate fixation.
The wound was closed with interrupted sutures, followed by sterile dressing and below-knee immobilization.

Postoperative Rehabilitation

- Postoperatively, patients received intravenous antibiotics for 48 hours.
- The affected limb was elevated using Bohler elevation until swelling subsided.
- Toe mobilization exercises commenced after the first dressing at 48 hours.
- Sutures and splints were removed approximately two weeks after surgery, following which active and passive ankle mobilization exercises were initiated.
- Patients remained non-weight-bearing for six weeks, progressing to partial and full weight-bearing after clinical and radiological evidence of fracture union, generally between 12 and 16 weeks.

Outcome Assessment

Patients in both groups were followed at 1, 2, 3, 6, and 12 months.
Clinical, radiological, and functional outcomes were evaluated during each follow-up visit.
Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, which evaluates pain (40 points), function (50 points), and alignment (10 points), giving a maximum score of

100.

Scores were interpreted as follows:

AOFAS Score	Interpretation
90–100	Excellent
80–89	Good
70–79	Fair
<70	Poor

Statistical Analysis

Statistical analysis was performed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Continuous variables between the operative and non-operative groups were compared using the independent Student's t-test, whereas categorical variables were analyzed using the Chi-square test or Fisher's exact test wherever statistically significant.

Clinical Case 1

A 37-year-old male presented with a history of fall from height and sustained a displaced intra-articular fracture of the left calcaneus. The patient was managed conservatively with below-knee immobilization followed by a structured rehabilitation protocol.

Radiological union was achieved at 12 weeks. At the 12-month follow-up, the patient reported mild pain, demonstrated good functional recovery, and had fair hindfoot alignment. The functional outcome, assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score, was 81/100, corresponding to a good functional outcome

Figure 1. Clinical case of a 37-year-old male with a displaced intra-articular fracture of the left calcaneus treated conservatively. Representative pre-treatment radiographs and CT images, follow-up radiographs demonstrating fracture union at 12 weeks, and final radiographs at 12 months showing maintained alignment with a good functional outcome (AOFAS score: 81).

Clinical Case 2

A 35-year-old male presented with a history of fall from height and sustained a closed displaced intra-articular fracture of the right calcaneus, classified as Sanders Type III. The patient underwent minimally invasive reduction and internal fixation using cannulated cancellous screws through the sinus tarsi approach. Postoperative radiographs demonstrated satisfactory anatomical reduction and stable fixation. Fracture union was achieved without complications, and the patient underwent standard postoperative rehabilitation. At the 6-month follow-up, the patient had minimal pain, excellent functional recovery, and normal hindfoot alignment. The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score was 92/100, indicating an excellent functional outcome.

Figure 2. Clinical case of a 35-year-old male with a Sanders Type III displaced intra-articular fracture of the right calcaneus treated with minimally invasive cannulated cancellous screw fixation through the sinus tarsi approach. (A) Preoperative lateral radiograph. (B) Preoperative computed tomography scan demonstrating the fracture configuration. (C) Immediate postoperative radiograph showing satisfactory reduction and screw fixation. (D) Radiograph at 6-month follow-up demonstrating fracture union. (E–H) Clinical photographs showing restoration of hindfoot alignment and ankle–hindfoot function with an AOFAS score of 92 (excellent outcome).

Clinical Case 3

A 38-year-old male presented following a road traffic accident with a closed displaced intra-articular fracture of the right calcaneus, classified as Sanders Type III. Following preoperative evaluation, the patient underwent open reduction and internal fixation (ORIF) using a locking calcaneal plate through the extensile lateral approach. Postoperative radiographs demonstrated satisfactory restoration of calcaneal anatomy with stable internal fixation. The postoperative period was uneventful, and the patient completed a structured rehabilitation program. Radiological union was achieved, and at the 12-month follow-up the patient reported mild pain with good functional recovery and maintained hindfoot alignment. The American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score was 86/100, indicating a good functional outcome.

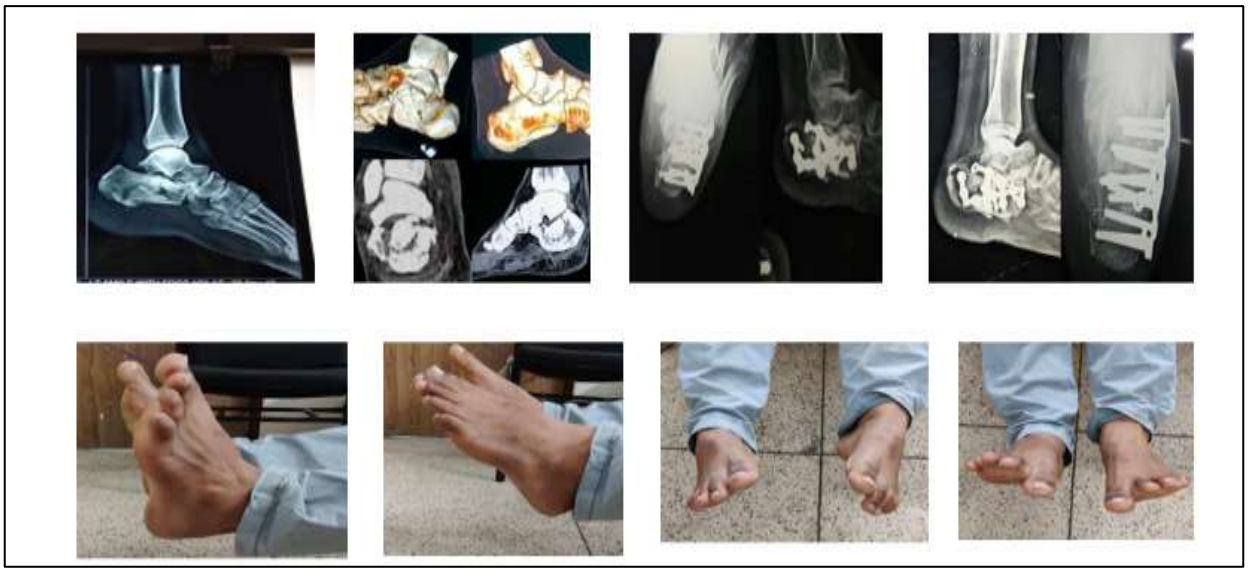

Figure 3. Clinical case of a 38-year-old male with a Sanders Type III displaced intra-articular fracture of the right calcaneus following a road traffic accident, treated with open reduction and internal fixation using a locking calcaneal plate. (A) Preoperative lateral radiograph. (B) Preoperative computed tomography scan demonstrating the fracture pattern. (C) Immediate postoperative radiograph showing anatomical reduction and plate fixation. (D) Radiograph at 6-month follow-up demonstrating fracture union and maintenance of reduction. (E–H) Clinical photographs at the final follow-up showing satisfactory hindfoot alignment and function with an AOFAS score of 86 (good outcome).

Results

Baseline Characteristics

A total of 60 displaced intra-articular calcaneal fractures in 58 patients were included. Thirty fractures were managed operatively (Group A) and thirty were treated conservatively (Group B). Among the operative group, 12 (40%) underwent open reduction and internal fixation (ORIF) with plate osteosynthesis, whereas 18 (60%) underwent minimally invasive screw fixation through the sinus tarsi approach.

Table 1. Baseline demographic characteristics

Mean age (years)	**34.7**	**36.0**
Male, n (%)	25 (83.3)	25 (83.3)
Female, n (%)	5 (16.7)	5 (16.7)

Table 2. Age distribution

Age group (years)	**Operative n (%)**	**Non-operative n (%)**
<25	5 (16.7)	4 (13.3)
25–35	10 (33.3)	11 (36.7)
36–45	14 (46.7)	12 (40.0)
>45	1 (3.3)	3 (10.0)

Table 3. Injury characteristics

Variable	**Number (%)**
Right-sided fracture	45 (75.0)
Left-sided fracture	13 (21.7)
Bilateral fractures	2 (3.3)
Fall from height	44 (73.3)
Road traffic accident	9 (15.0)
Other mechanisms	5 (8.3)

Table 4. Occupation

Occupation	**Number (%)**
Labourer	47 (81.0)
Office worker	5 (8.6)

Housewife	4 (6.9)
Others	2 (3.5)

Table 5. Sanders classification

Sanders type	Operative n (%)	Non-operative n (%)
II	10 (33.3)	10 (33.3)
III	15 (50.0)	5 (16.7)
IV	5 (16.7)	15 (50.0)

Operative Outcomes

Among surgically treated patients, the mean injury-to-surgery interval was 4.1 days. Plate fixation required a longer operative duration than the minimally invasive technique (123.3 vs. 69.1 minutes). Mean radiological union was achieved in 10.1 weeks, with an average follow-up of 12.4 months.

Table 6. Operative characteristics

Parameter	Plate ORIF	Minimally invasive
Number of patients	12	18
Injury-to-surgery interval (days)	5.66	3.05
Operative time (minutes)	123.3	69.1
Follow-up (months)	12.58	12.27
Radiological union (weeks)	10.83	9.61

Table 7. Operative complications

Complication	Plate ORIF n (%)	Minimally invasive n (%)
Persistent pain	3 (25.0)	3 (16.7)
Implant failure	1 (8.3)	1 (5.6)
Superficial infection	2 (16.7)	0
Deep infection	1 (8.3)	0

Functional Outcomes

The mean AOFAS score at final follow-up was 84.2 ± 7.75 in the operative group and 79.4 ± 9.04 in the conservative group.

Table 8. Comparison of clinical and radiological outcomes

Outcome	Operative	Non-operative	P-value
Böhler's angle (°)	21.06 ± 3.10	17.50 ± 3.00	0.0012
Gissane angle (°)	134.96 ± 7.08	140.20 ± 6.64	0.0015
Radiological union (weeks)	10.1 ± 2.13	10.6 ± 2.38	0.33
AOFAS score	84.2 ± 7.75	79.4 ± 9.04	0.016

Operative management demonstrated significantly better restoration of Böhler's angle, Gissane angle, and functional outcome (AOFAS score) than conservative treatment. No statistically significant difference was observed in the time to radiological union.

Non-operative Outcomes

Patients managed conservatively achieved radiological union at a mean of 10.6 weeks with an average follow-up of 11 months. Persistent heel pain was observed in 12 patients (40%), while early subtalar arthritis developed in 4 patients (13.3%). Progressive heel widening and varus deformity were noted in 5 patients (16.7%).

Comparative Analysis

Operative management resulted in superior anatomical restoration and significantly higher functional outcomes than conservative treatment. Although radiological union time was comparable between the two groups, persistent pain and subtalar arthritis were more common following conservative management, whereas wound-related complications and implant-related problems were observed exclusively in surgically treated patients.

Conclusion

Operative management of displaced intra-articular calcaneal fractures resulted in significantly better functional outcomes and superior restoration of radiological parameters compared with conservative treatment. Although the time to radiological union was comparable between the two groups, surgically treated patients demonstrated higher AOFAS scores and a lower incidence of persistent pain and post-traumatic subtalar arthritis. However, operative treatment was associated with surgery-related complications, including wound complications, infection, and implant-related problems. Therefore, treatment should be individualized after careful consideration of fracture characteristics, soft tissue condition, and patient-related factors. Larger prospective randomized studies with longer follow-up are required to establish the optimal treatment strategy and evaluate long-term functional outcomes and complication rates.

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