

Functional and Radiological Outcome of Percutaneous Screw Fixation in Displaced Intra-articular Calcaneal Fractures Using 6.5 mm Cannulated Cancellous Screws

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Abstract

Background: Displaced intra-articular calcaneal fractures are complex injuries associated with subtalar joint incongruity, hindfoot deformity, pain, and long-term functional disability. Percutaneous screw fixation offers a minimally invasive alternative to open reduction, with the potential advantage of reduced soft-tissue complications.

Methods: This prospective observational study included 25 patients with 28 displaced intra-articular calcaneal fractures treated by closed reduction and percutaneous fixation using 6.5 mm cannulated cancellous screws. Patients were evaluated clinically and radiologically. Fractures were classified using the Essex-Lopresti classification. Radiological outcome was assessed using Bohler's angle, Gissane's angle, calcaneal height, and calcaneal width. Functional outcome was assessed using the Maryland Foot Score.

Results: The mean age was 32.4 years, with male predominance. Fall from height was the most common mode of injury. Tongue-type fractures were seen in 64.3% of fractures. Mean Bohler's angle improved from 13.5° preoperatively to 24.5° postoperatively, while mean Gissane's angle improved from 149.21° to 127.42°. Good-to-excellent functional outcome was achieved in 85.70% of fractures. Pain on weight bearing was the most common complication.

Conclusion: Percutaneous fixation with 6.5 mm cannulated cancellous screws is an effective minimally invasive option for selected displaced intra-articular calcaneal fractures, providing satisfactory functional and radiological outcomes with acceptable complications.

Keywords: Calcaneal Fracture; Intra-Articular Fracture; Percutaneous Fixation; Cannulated Cancellous Screw; Bohler's Angle; Maryland Foot Score.

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Introduction

Calcaneal fractures are complex hindfoot injuries, accounting for approximately 2% of all fractures and nearly 60% of tarsal bone injuries. Displaced intra-articular calcaneal fractures form the major clinically significant subgroup, comprising about 60–75% of calcaneal fractures, and are associated with considerable morbidity due to involvement of the posterior subtalar articular surface. [1]

These injuries usually result from high-energy axial loading, most commonly fall from height or road traffic accidents, where the talus impacts the calcaneum, causing articular depression, comminution, loss of calcaneal height, heel widening and hindfoot malalignment. [2,3] They

predominantly affect young and middle-aged males involved in physically demanding occupations, resulting in significant socioeconomic burden. [5] The calcaneum, being the largest tarsal bone, plays an important role in weight transmission, heel height, subtalar movement and gait mechanics. Its cancellous structure and thin cortical shell make it prone to collapse following high-energy trauma. [5]

Intra-articular displacement may disturb posterior facet congruity and lead to chronic pain, stiffness, peroneal tendon impingement, subtalar arthritis and long-term functional disability. [6] Associated injuries, including spine and other extremity injuries, are also commonly reported [7].

Management of displaced intra-articular calcaneal fractures remains controversial. Conservative treatment may be suitable for undisplaced intra-articular and many extra-articular fractures; however, displaced intra-articular fractures often require restoration of subtalar congruity, calcaneal height, width, length and alignment to improve functional outcome. [7,8] Open reduction and internal fixation allows direct visualization and anatomical reduction of the posterior facet and has shown satisfactory results when near-anatomical reduction is achieved. [8,9] However, open surgery is associated with soft-tissue complications such as wound necrosis, infection, sural nerve injury, peroneal tendon irritation and hardware-related problems. [10]

Percutaneous reduction and internal fixation has emerged as a less invasive alternative for selected displaced intra-articular calcaneal fractures. It aims to achieve acceptable reduction and stabilization with Kirschner wires, screws or cannulated cancellous screws while minimizing soft-tissue morbidity. [11,12] Previous studies have reported encouraging outcomes with minimally invasive and percutaneous techniques, including acceptable clinical results, shorter hospital stay, fewer wound complications and faster recovery. [13,14]

Radiological evaluation is essential for treatment planning and outcome assessment. Plain radiographs are useful for measuring Bohler's angle and Gissane's angle, while computed tomography helps assess posterior facet involvement, comminution, displacement and fracture classification. [15] The Essex-Lopresti and Sanders classifications are commonly used for fracture characterization, operative planning and prognosis. Functional outcomes are commonly assessed using scoring systems such as the Maryland Foot Score and American Orthopaedic Foot and Ankle Society score. [16]

Although percutaneous fixation is not ideal for highly comminuted fractures, it may provide a useful balance between fracture stabilization and preservation of the soft-tissue envelope in appropriately selected cases. The present study was therefore undertaken to evaluate the functional, clinical and radiological outcomes of displaced intra-articular calcaneal fractures managed by percutaneous fixation using 6.5 mm cannulated cancellous screws, with assessment of Bohler's

angle, Gissane's angle, union rate and procedure-related complications.

Materials and Methods

This prospective observational study was conducted in the Department of Orthopaedics, Jhalawar Medical College and SRG Hospital, Jhalawar, Rajasthan, from December 2023 to December 2025. The study included 25 patients with 28 displaced intra-articular calcaneal fractures who were managed by closed reduction and percutaneous internal fixation using 6.5 mm cannulated cancellous screws.

Patients aged 18–60 years of either sex with closed displaced intra-articular calcaneal fractures, including unilateral and bilateral fractures, were included. Patients with extra-articular calcaneal fractures, open fractures, pathological fractures, chronic fractures older than three weeks, neurovascular deficit, associated complex ankle or foot injuries, fractures with spinal injury, chronic local infection, or those medically unfit for surgery were excluded.

All patients underwent detailed clinical evaluation, including history regarding age, sex, occupation, mode and mechanism of injury, time since injury, fracture pattern, associated injuries, comorbidities, and treatment received before admission.

Local examination included assessment of swelling, ecchymosis, deformity, skin condition, fracture blisters, distal neurovascular status, and signs of compartment syndrome.

Radiological assessment was performed using standard lateral and axial views of the calcaneum. Additional radiographs, including anteroposterior, oblique, Broden's views, and computed tomography scans, were obtained whenever required. Fractures were classified using the Essex-Lopresti radiological classification. Bohler's angle and Gissane's angle were recorded for radiological assessment.

Initially, the injured limb was immobilized in a bulky Jones dressing or posterior slab with limb elevation and ice application.

In patients with significant swelling or fracture blisters, surgery was delayed until soft-tissue condition improved. Intravenous third-generation cephalosporin antibiotic prophylaxis was administered preoperatively.



Figure 1: Instruments and implants used for percutaneous calcaneal fixation.

All procedures were performed under spinal or general anaesthesia under C-arm guidance. Patients were positioned in the lateral decubitus position on a radiolucent operating table. Closed reduction was achieved by correction of varus or valgus angulation under axial view and elevation of the depressed posterior facet using a Steinmann pin or Kirschner wires according to the Essex-Lopresti technique.

In tongue-type fractures, the depressed fragment was elevated using Kirschner wires inserted lateral to the Achilles tendon. After achieving acceptable reduction, provisional Kirschner wires were replaced with two or three 6.5 mm cannulated cancellous screws as required. Screw length and

position were confirmed fluoroscopically in lateral and axial views, and stab incisions were closed with sterile dressing. Postoperatively, the limb was supported in a below-knee plaster slab and elevated for 48–72 hours. Toe movements and toe-touch walking were encouraged early.

The first dressing was inspected on the second postoperative day, and sutures were removed at two weeks. A below-knee cast was applied for another two weeks. Patients were followed up clinically and radiologically to assess fracture union, restoration of Bohler's and Gissane's angles, functional outcome, and complications. Functional outcome was assessed using the Maryland Foot Score.



Figure 2: (A) Intraoperative photograph showing percutaneous guidewire insertion. (B) Intraoperative photograph showing closed reduction manoeuvre. (C) Immediate postoperative clinical photograph.



Figure 3: (A) Intraoperative fluoroscopic lateral view during guidewire placement. (B) Intraoperative fluoroscopic axial view during guidewire placement. (C) Intraoperative fluoroscopic lateral view during screw insertion.

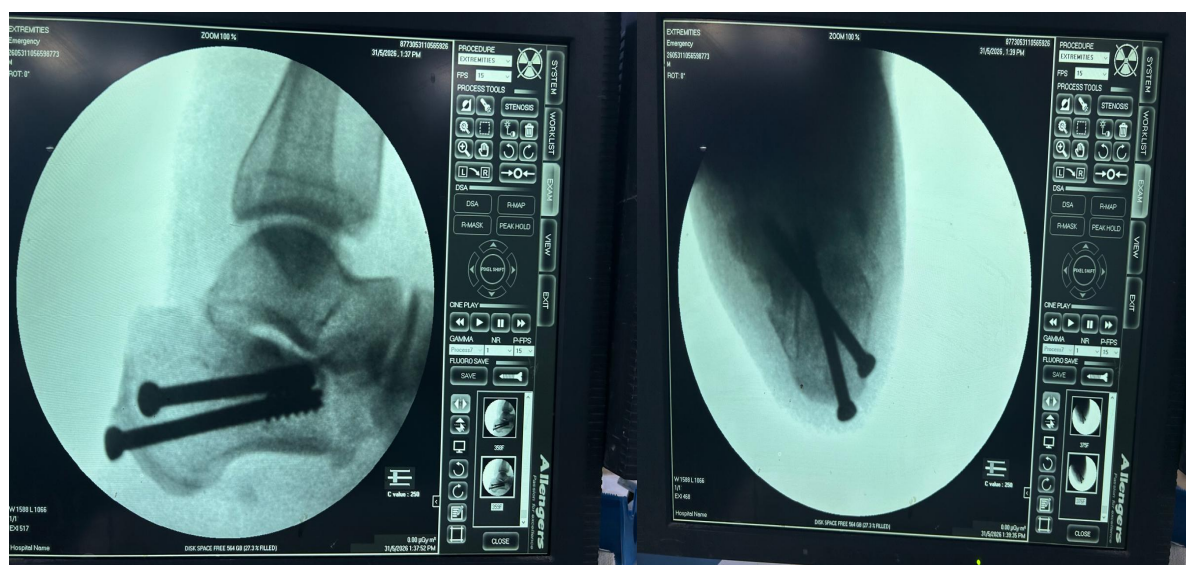


Figure 4: (A) Final intraoperative fluoroscopic lateral view after screw fixation. (B) Final intraoperative fluoroscopic axial view after screw fixation.

Results

The present study included 25 patients with 28 displaced intra-articular calcaneal fractures treated by closed reduction and percutaneous fixation using 6.5 mm cannulated cancellous screws. The majority of patients belonged to the 31–40 years age group (44%), followed by the 21–30 years age

group (36%). The mean age of patients was 32.4 years, with an age range of 20–55 years. Male predominance was observed, with 21 males and 4 females, giving a male-to-female ratio of 5.25:1.

Labourers constituted the largest occupational group (52%), followed by mechanics (16%) and servicemen (12%).



Figure 5: (A) Postoperative follow up clinical photograph - standing anteroposterior view. (B) Postoperative clinical photograph - lateral view of the affected foot. (C) Postoperative clinical photograph - ankle and subtalar movement assessment.

Fall from height was the most common mode of injury, seen in 22 patients (88%), indicating axial loading as the predominant mechanism. Right-sided involvement was seen in 13 patients (52%), left-sided involvement in 9 patients (36%), and

bilateral fractures in 3 patients (12%). Most patients reported within one week of injury. Associated skeletal injuries were present in 3 patients (12%), including spine injury in 2 patients (8%).

Table 1: Baseline demographic profile of patients

Variable	Category	No. of patients	Percentage
Age group	11–20 years	2	8.0
	21–30 years	9	36.0
	31–40 years	11	44.0
	41–50 years	2	8.0
	51–60 years	1	4.0
Sex	Male	21	84.0
	Female	4	16.0
Occupation	Labourer	13	52.0
	Mechanic	4	16.0
	Service man	3	12.0
	Housewife	2	8.0
	Farmer	1	4.0
	Driver	1	4.0
	Student	1	4.0

Table 2: Injury characteristics

Variable	Category	No. of patients	Percentage
Mode of injury	Fall from height	22	88.0
	Other mechanisms	3	12.0
Side involved	Right	13	52.0
	Left	9	36.0
	Bilateral	3	12.0
Associated skeletal injury	Present	3	12.0
	Absent	22	88.0
Spine injury	Present	2	8.0
	Absent	23	92.0

According to the Essex-Lopresti classification, tongue-type fractures were more common than joint-depression-type fractures. Of the 28 fractures, 18 (64.3%) were tongue type and 10 (35.7%) were joint-depression type. Radiological correction was achieved after percutaneous fixation. The mean

Bohler's angle improved from 13.5° preoperatively to 24.5° postoperatively. The mean Gissane's angle improved from 149.21° preoperatively to 127.42° postoperatively. Mean calcaneal height improved from 3.32 cm to 4.17 cm, while mean calcaneal width reduced from 4.71 cm to 3.39 cm.

Table 3: Fracture pattern and radiological outcome

Parameter	Preoperative	Postoperative / Final	Change
Essex-Lopresti type			
Tongue type	—	18 fractures (64.3%)	—
Joint-depression type	—	10 fractures (35.7%)	—
Bohler's angle	13.5°	24.5°	Improved by 11.0°
Gissane's angle	149.21°	127.42°	Improved by 21.79°
Calcaneal height	3.32 cm	4.17 cm	Increased by 0.85 cm
Calcaneal width	4.71 cm	3.39 cm	Reduced by 1.32 cm

Table 4: Follow-up and full weight-bearing status

Parameter	No. of patients	Percentage	Mean duration
Follow-up duration	25	100.0	8.48 months
Full weight bearing in patients with associated injuries	3	12.0	96.66 days
Full weight bearing in patients without associated injuries	22	88.0	73.45 days
Overall interval between injury and full weight bearing	25	100.0	75.44 days

Pain on weight bearing was the most common postoperative complaint, noted in 5 fractures (17.85%). Superficial infection and implant impingement were each observed in 2 fractures (7.14%). Deep infection and loss of reduction were each seen in 1 fracture (3.57%). Superficial infection was managed with antibiotics and dressing, deep infection required debridement, implant impingement was managed by screw

removal, and loss of reduction was managed by immobilization. Final functional outcome was assessed using the Maryland Foot Score. Excellent results were obtained in 11 fractures (39.28%) and good results in 13 fractures (46.42%). Thus, good-to-excellent outcome was achieved in 24 of 28 fractures (85.70%). Fair outcome was seen in 3 fractures (10.71%) and poor outcome in 1 fracture (3.57%).

Table 5: Complications and functional outcome

Outcome parameter	Category	No. of fractures	Percentage
Complications	Pain on weight bearing	5	17.85
	Superficial infection	2	7.14
	Deep infection	1	3.57
	Loss of reduction	1	3.57
	Implant impingement	2	7.14
Maryland Foot Score outcome	Excellent	11	39.28
	Good	13	46.42
	Fair	3	10.71
	Poor	1	3.57
	Good-to-excellent outcome	24	85.70

The follow-up duration ranged from 6 to 12 months, with a mean follow-up of 8.48 months. The mean interval between injury and full weight bearing was 75.44 days. Patients with associated injuries required a longer period to achieve full weight bearing, with a mean of 96.66 days, compared with 73.45 days in patients without associated injuries. Overall, percutaneous fixation with 6.5 mm cannulated cancellous screws showed satisfactory functional and radiological outcomes in displaced intra-articular calcaneal fractures. Restoration of Bohler's and Gissane's angles was

achieved, the mean time to full weight bearing was approximately 75 days, and most fractures had good-to-excellent functional outcome with limited soft-tissue complications.

Discussion

Displaced intra-articular fractures of the calcaneum remain challenging injuries because they affect the subtalar articular surface, disturb hindfoot anatomy, and may lead to long-term pain, stiffness, altered gait, and difficulty in returning to work. In the present study, percutaneous screw fixation using

6.5 mm cannulated cancellous screws provided satisfactory functional and radiological outcomes in most patients, with good-to-excellent Maryland Foot Score results in 85.70% of fractures. These findings support the role of minimally invasive fixation as a useful treatment option in selected displaced intra-articular calcaneal fractures.

The demographic profile in the present study was comparable with the established epidemiology of calcaneal fractures. Most patients were young or middle-aged adults, with a mean age of 32.4 years, and there was marked male predominance. This is consistent with previous observations that calcaneal fractures commonly affect young working males and are frequently associated with occupational and socioeconomic morbidity. [1,5] Labourers formed the largest occupational group in the present series, which further reflects the high burden of this injury among physically active individuals. Fall from height was the commonest mechanism of injury, accounting for 88% of cases. This finding is in accordance with the classical mechanism described for calcaneal fractures, where axial loading drives the talus into the calcaneum, producing articular depression, loss of height, widening, and comminution. [2–4]

In the present study, tongue-type fractures were more common than joint-depression-type fractures according to the Essex-Lopresti classification. Essex-Lopresti described tongue-type and joint-depression-type patterns based on the mechanism of injury and fracture morphology, and this classification remains practically useful for planning reduction in displaced intra-articular calcaneal fractures. [6] Although computed tomography-based systems such as Sanders classification provide more detailed assessment of posterior facet comminution and prognosis, radiographic evaluation using Bohler's and Gissane's angles remains important for assessing reduction and restoration of calcaneal morphology. [15]

Radiological improvement was observed in the present study. The mean Bohler's angle improved from 13.5° preoperatively to 24.5° postoperatively, while the mean Gissane's angle improved from 149.21° to 127.42°. Restoration of calcaneal height and reduction in calcaneal width were also achieved. These findings indicate that closed reduction and percutaneous screw fixation can restore important anatomical parameters in selected fractures. Similar improvement in radiological parameters was reported by Yeung and Ho, who evaluated percutaneous screw fixation of displaced calcaneal fractures using preoperative and postoperative Bohler's and Gissane's angles and found acceptable clinical outcome with minimal skin complications. [14] Meena et al. also reported satisfactory radiological restoration after closed

reduction and percutaneous screw fixation, with average Bohler's angle of 24.5° and Gissane's angle of 120°. [16]

The functional outcome in the present study was encouraging. Excellent results were achieved in 39.28% of fractures and good results in 46.42%, giving an overall good-to-excellent outcome of 85.70%. These results are comparable with previous minimally invasive and percutaneous fixation studies. Tornetta described percutaneous treatment as a useful method for selected calcaneal fractures, particularly when reduction can be achieved without extensive soft-tissue dissection. [11] Rammelt et al. also reported favourable results with percutaneous treatment in less severe intra-articular calcaneal fractures. [13] Similarly, Stulik et al. found that minimally invasive reduction and fixation could provide acceptable outcomes while reducing soft-tissue complications associated with open surgery. [12]

The major advantage of percutaneous fixation is preservation of the soft-tissue envelope. Open reduction and internal fixation allows direct visualization and accurate reduction but may be associated with wound edge necrosis, infection, sural nerve injury, painful neuroma, peroneal tendon irritation, and hardware-related problems. [8,10] Folk et al. observed that smoking, diabetes, and open fractures increased the risk of wound complications after operative treatment of calcaneal fractures. [10] In contrast, percutaneous fixation uses small stab incisions and limited dissection, thereby reducing soft-tissue morbidity. In the present study, superficial infection occurred in 7.14% of fractures and deep infection in 3.57%, which suggests an acceptable complication profile.

Pain on weight bearing was the most common postoperative complaint in the present study, seen in 17.85% of fractures. This may be related to the intra-articular nature of the injury, residual subtalar stiffness, cartilage damage at the time of trauma, or minor residual incongruity. Loss of reduction was seen in one fracture, and implant impingement was observed in two fractures. These findings highlight the importance of proper fracture selection, accurate screw placement, and careful postoperative protection. Percutaneous screw fixation may not be ideal for highly comminuted fractures where stable screw purchase and maintenance of reduction are difficult. Paul et al. emphasized that operative treatment of intra-articular calcaneal fractures is most beneficial when near-anatomical reduction is achieved. [9] The mean interval between injury and full weight bearing in the present study was 75.44 days. Patients with associated injuries required a longer time to full weight bearing than those without associated injuries. This observation is expected because calcaneal fractures may be associated with

spine and other skeletal injuries, which can delay mobilization and rehabilitation. [2,3] Early toe movements, limb elevation, soft-tissue care, and staged progression of weight bearing are important components of postoperative management.

The present study had certain limitations. First, the sample size was relatively small, as only 25 patients with 28 calcaneal fractures were included, which limits the generalizability of the findings. Second, this was a single-centre observational study without a control or comparison group; therefore, direct comparison with conservative treatment or open reduction and internal fixation could not be made.

Third, the follow-up duration was limited, and long-term outcomes such as subtalar arthritis, chronic hindfoot pain, late collapse, implant-related problems, and return-to-work status could not be assessed in detail. Fourth, computed tomography was not uniformly used in all cases; therefore, detailed fracture characterization according to CT-based classifications such as Sanders classification was limited. Fifth, the results may have been influenced by fracture pattern, soft-tissue condition, timing of surgery, surgeon experience, and patient compliance with postoperative rehabilitation. Hence, larger multicentric comparative studies with longer follow-up are required to validate the functional and radiological outcomes of percutaneous screw fixation in displaced intra-articular calcaneal fractures.

Overall, the findings of the present study suggest that percutaneous fixation with 6.5 mm cannulated cancellous screws is an effective and relatively safe technique for selected displaced intra-articular calcaneal fractures. It provides satisfactory functional outcome, restores important radiological parameters, permits fracture union, and reduces soft-tissue complications compared with more extensive open approaches.

However, the technique requires careful case selection and fluoroscopic expertise. Highly comminuted fractures, severely displaced fractures not amenable to closed reduction, and fractures with poor screw purchase may still require alternative fixation strategies. The small sample size and limited follow-up duration are important limitations of the present study, and larger comparative studies with longer follow-up are required to evaluate late subtalar arthritis and durability of functional outcome.

Conclusion

Percutaneous screw fixation with 6.5 mm cannulated cancellous screws provided satisfactory functional and radiological outcomes in selected displaced intra-articular calcaneal fractures. In the present study, most fractures achieved good-to-

excellent functional results on Maryland Foot Score, with restoration of Bohler's angle, Gissane's angle, calcaneal height, and calcaneal width. The technique allowed fracture stabilization with limited soft-tissue dissection and an acceptable complication profile. Therefore, closed reduction and percutaneous screw fixation can be considered an effective, minimally invasive, and soft-tissue-friendly treatment option for appropriately selected displaced intra-articular calcaneal fractures.

Recommendations: Percutaneous screw fixation may be recommended for selected displaced intra-articular calcaneal fractures, particularly tongue-type and less comminuted joint-depression fractures where acceptable closed reduction can be achieved under fluoroscopic guidance. Careful patient selection, proper preoperative radiological assessment, attention to soft-tissue condition, accurate screw placement, and structured postoperative rehabilitation are essential for achieving good results. Highly comminuted fractures, fractures with severe articular depression not reducible by closed methods, poor bone quality, open fractures, and cases with compromised soft tissues should be evaluated carefully before choosing this technique. Larger comparative studies with longer follow-up are recommended to assess long-term outcomes, late subtalar arthritis, and comparison with open reduction and internal fixation.

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