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Functional Outcome of Closed Reduction and Percutaneous Multiple K-Wire Fixation of Displaced Intra-Articular Calcaneal Fracture

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Abstract: Background: Calcaneal fracture, being the most common tarsal bone fracture, accounts upto 65% of the cases, and 2% of all fractures. 75% of calcaneal fractures are intra-articular, which is the most common type of fracture. Displaced intra-articular calcaneal fractures (DIACF) are complex injuries associated with significant morbidity. Minimally invasive fixation seeks to restore the joint congruity while minimizing soft tissue complications seen in open approaches. In our study we evaluated the functional and radiological outcomes of closed reduction and percutaneous multiple K-wire fixation in DIACF. **Methods:** The study was carried out as a descriptive and prospective study in the Department of Orthopaedics, Calcutta National Medical College, Kolkata, India during the period July 2025 to December 2025. Thirty patients of 20 to 60 years, who underwent surgical fixation for displaced intra-articular calcaneal fracture using multiple K wires were followed up. Functional and radiological outcomes at six months follow up were assessed. **Results:** In our study of 30 patients with DIACF who underwent minimally invasive surgical fixation with k-wires, the mean final AOFAS score was 82.4 ± 6.7. Böhler angle improved from 8.6° preoperatively to 27.2° at final follow-up; Gissane angle corrected from 141.8° to 122.3°. Excellent-to-good outcomes were observed in 86.7% of patients. Complications occurred in 13.3% of cases, primarily superficial pin-tract infections; no deep infections or hardware failures were noted. **Conclusion:** Closed reduction and percutaneous K-wire fixation is an effective minimally invasive technique for selected DIACF, providing satisfactory functional recovery and radiographic restoration with low complication rates.

Keywords: Calcaneus fracture, Percutaneous fixation, K-wire, Hindfoot, AOFAS.

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INTRODUCTION

Calcaneal fracture, being the most common tarsal bone fracture, accounts upto 65% of the cases, and 2% of all fractures. 75% of calcaneal fractures are intra-articular, which is the most common type of fracture. Young, energetic men and industrial workers are more likely to sustain calcaneal fractures, which typically happen to those between the ages of 35 – 45 years [1,2]. High energy trauma, such as falls from heights and car crashes, is usually the mechanism of injury for displaced intraarticular fractures.

Displaced intra-articular calcaneal fractures (DIACF) account for 60–75% of all calcaneal fractures and are often associated with long-term pain, hindfoot malalignment, and functional disability if inadequately treated [3]. The complex three-dimensional anatomy of the calcaneus, coupled with the thin overlying soft tissue envelope, makes surgical management challenging.

Nowadays, patients can choose from a wide variety of surgical alternatives, all of which are intended to maximize their anatomical and functional results. Treatment options include conservative or surgical line of management depending mainly on fracture configuration, other associated injuries, and the patient's activity level. Despite being recommended in certain reports, the conservative line carries the danger of articular surface malunion, calcaneal broadening and peroneal impingement, all of which can result in early subtalar arthritis.

Anatomic restoration of the three-dimensional anatomy of calcaneus is the goal of surgery. Management through surgery primarily, open reduction and internal fixation (ORIF) via an extensile lateral L-shaped approach (ELA) offers the benefit of broad exposure, enabling ideal articular surface reduction; however, ORIF entails the risk of wound complication rate of 10-25%, including infection, dehiscence, and flap necrosis at about 14% [4-9], iatrogenic injury to the sural nerve,

and the potential for adhesions and scarring of the peroneal tendon.

In order to circumvent the drawbacks of both conservative and ORIF techniques, minimally invasive (MI) approaches for calcaneal fracture fixation like closed reduction and percutaneous fixation (CRPF) with K-wires or cannulated screws have been developed to reduce these complications while maintaining satisfactory reduction and it demonstrated good clinical and radiological results.

Several studies have demonstrated that percutaneous fixation achieves comparable functional outcomes to ORIF in selected fracture patterns, particularly Sanders type II and III, while reducing the risk of wound-related morbidity. However, the role of closed reduction with multiple percutaneous K-wires in salvageable Sanders type IV fractures remains less well characterized. These techniques rely on indirect fracture reduction under fluoroscopic guidance, preserving soft tissue integrity and potentially allowing earlier rehabilitation.

The purpose of this study was to evaluate the short-term functional outcomes, radiological results and complication profile of patients who had DIACF including selected salvageable type IV fractures and were treated by closed reduction and percutaneous fixation with Kirschner wires.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective study at the Department of Orthopaedics, Calcutta National Medical College and Hospital, Kolkata during the period from July 2025 to December 2025. Thirty patients from 20-60 years age who underwent surgical intervention using multiple K-wires were followed up and assessed. Institutional ethical committee approval was taken for the study before starting the same.

Inclusion Criteria

Patients aged 20 years and above of either sex, who had closed tongue type and depressed type fractures of the calcaneus (which were classified according to Sanders classification as type II and III and salvageable type IV), patients who are fit and gave consent for surgery.

Exclusion Criteria

Patients with open fractures or with distal neuro-vascular deficit, patients with less than 20 years of age, patients with severe osteoporosis, non-articular or un-displaced fractures (Sanders type I), neglected fractures (>2 weeks old) and patients medically unfit and unwilling to give written consent were excluded.

The materials for the present study were collected from patients who attended OPD and emergency and were admitted in the Department of Orthopaedics with DIACF. After approval from the institutional ethics committee and with a written informed consent from the patients and relatives, 30 patients of both sexes were taken up for the study.

All pre-operative routine hematological and radiological investigations were done and patients were posted for operative management after proper consent and fitness from anesthetist.

Surgical Technique

Provisional closed reduction of DIACF was performed using the Essex-Lopresti maneuver using a Steinmann pin under fluoroscopic guidance. Multiple percutaneous K-wires were used to stabilize fracture fragments followed by application of below knee splint for 1 week and then below knee cast for 5 weeks. Post-operatively limb elevation was given, IV antibiotics and analgesics was given for 3 days. X-rays were taken immediately in the post-operative period. Patients were usually discharged on postoperative day 3. K-wires were removed at 6^{th} week followed by mobilization of ankle joint and gradual weight-bearing. Functional use and activities were strongly encouraged by 6 to 10 weeks. During follow-up, patients were assessed for pain, cosmetic appearance, residual deformity, passive range of ankle range of motion, alignment and complications clinically and also radiographs were done at every visit. Minimum of three months of follow up was done before assessment. Time to union, functional and radiological outcome, rate of complication was also assessed.

They were followed up at 2 and 6 weeks, 3 and 6 months and the results were analysed and studied. The analysed data was compared to other series in literature and discussed. A master chart dealing with all aspects has been designed and presented.

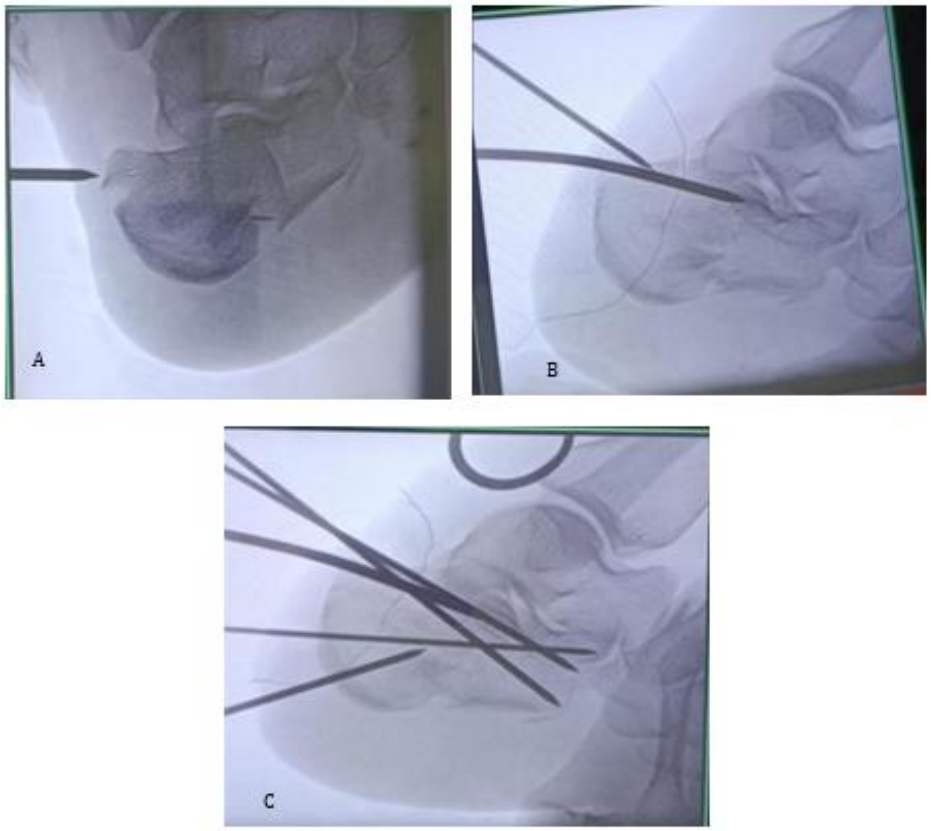

Figure 1: case 1 (A) pre-operative, (B) post-manipulation with Steinmann pin, (C) after percutaneous K-wire fixation

Figure 2: case 1 (A) post-operative with K-wire and Steinmannpinin-situ(B)post-operativeclinicalimages AfterremovingSteinmannpin

Statistical analysis

All responses were tabulated using the Microsoft Excel 2016 software, while the graphical representations were done whenever necessary. Data analysis was done using SPSS software version 16.0 to compute the frequencies and percentage for qualitative variables and the means, median range proportion, standard deviation and chi-square tests for quantitative variables. A p-value of less than 0.001 will be deemed statistically significant.

RESULTS

In our study of the 30 patients, the mean age was 40, 10 were females (33.33%) and 20 were males (66.66%). In this study 16 patients were affected on right side (53.33%) and the rest 14 were affected on left side (46.66%). 20 of them had tongue type while the other 10 had depressed type of Essex-Lopresti calcaneus fracture. Based on CT scan, Sanders classification was

done, 14 (46.6%) had type II, 10 (33.3%) had type III and 6 (20%) ha type IV fractures. Mode of injury in majority of the cases that is 24 (80%) was fall from height, while the other 6 (20%) sustained road traffic accidents. Functional outcome as assessed by the AOFAS score (including pain, function and alignment) was excellent in 12 (40%), good in 14 (46.7%) and fair in 4 (13.3%). Maximum AOFAS score was 95 and minimum score was 70 and mean score was 82.6 with a standard deviation of 7.4. Bohler and Gissane angles were measured radiographically pre-operatively and post-operatively for every patients showed significant improvement. The mean post-operative Bohler angle was 29.1° and Gissane angle was 121.6°. Superficial pin-tract infection was seen in 2 (6.7%) patients, sub-talar arthritis in 1 (3.3%) and 1 (3.3%) patient had loss of reduction.

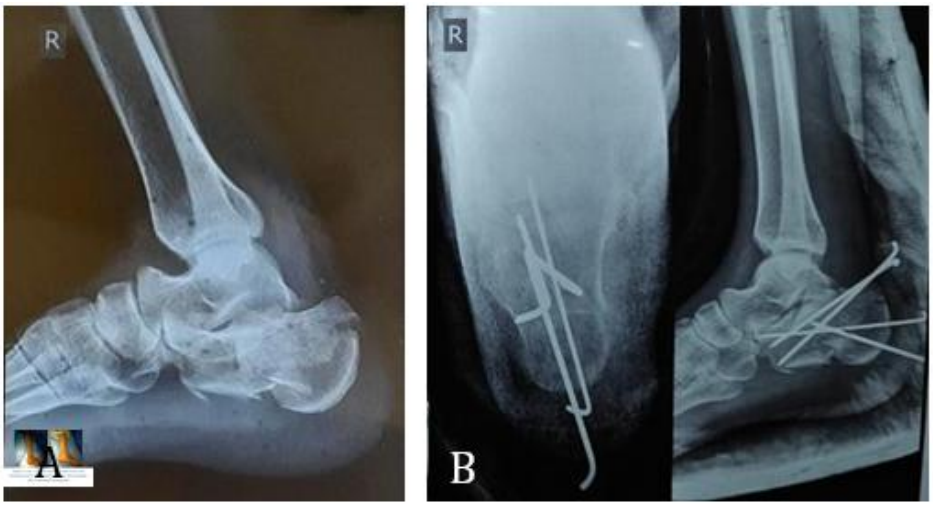

Figure 3: case 1 (A) pre-operative, (B) post-operative after manipulation and percutaneous K-wire fixation

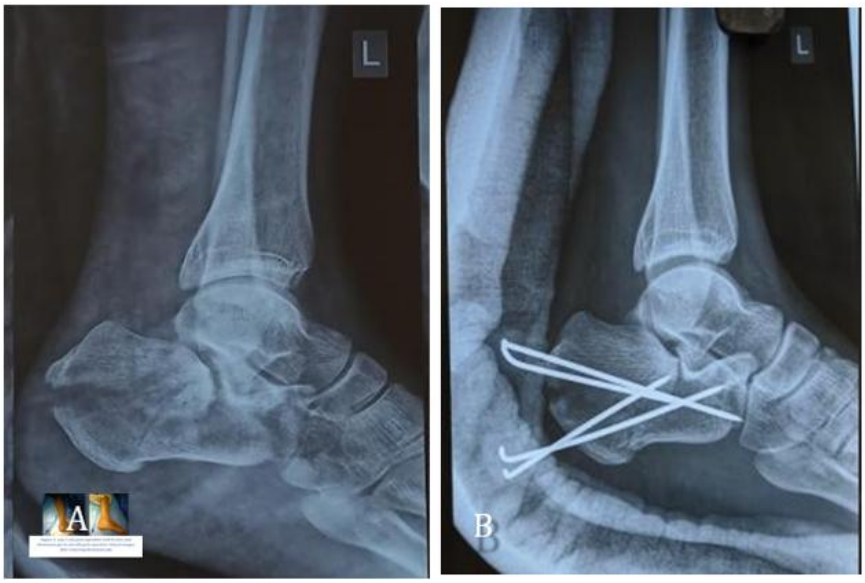

Figure 4: case 2 (A) pre-operative, (B) post-operative after manipulation and percutaneous K-wire fixation

Outcome	NumberofPatients	Percentage
Excellent(90–100)	12	40%
Good(75–89)	14	46.7%
Fair(50–74)	4	13.3%
Poor(<50)	0	0%
MeanfinalAOFASscore	**82.4 ±6.7**	—

Statistically significant improvement p <0.001.

Parameter	Preoperative(mean±SD)	Postoperative	Final Follow-up
Bohler's angle	8.6°±5.1	29.1°±4.3	27.2°±3.8
Gissane angle	141.8°±9.6	121.6°±6.8	122.3°±6.9

Stratified by Sanders Type

Complication	No.	%
Superficial pin-tract infection	2	6.7%
Subtalar arthritis	1	3.3%
Loss of reduction	1	3.3%
Deep infection	0	0%
Wound necrosis	0	0%
Total		13.3%

SandersType	No.ofcases	%	FinalAOFAS
II	14	46.66	86.3
III	10	33.33	83.1
IV	6	20	74.4

DISCUSSION

In our study, the minimum age of patient was 20 years whereas maximum age was 56 years. The mean age was 40 years with a standard deviation of ± 9.81. In a study by *Pan et al.* [10] to assess the percutaneous fixation of displaced intra-articular calcaneal fractures, maximum age was 62 years and minimum age was 23 years and the mean age was 34. The results are quite similar in our study. In a study conducted by *Abidi et al* [11] to assess the wound healing risk factors, the mean age was 41 years and in study by *Buckley et al.* [12] the mean age was 40 years which is near to present study. In the present study, 66.66% patients were males and 33.33% were females, which is slightly different from that of *Pan et al*, where 78.57% were males and 21.42% were females.

In this study, 53.33% patients had calcaneal fractures on right side while 46.66% had the same on left side. *Pan et al.* conducted similar study in which 50% were affected on right side and 35.73% on left side, which is near about close to present study.

Most common mechanism of injury was fall from height (80%) and the rest 20% sustained road traffic accidents, which is nearly similar to that of *Abidi et al* and *Pan et al.*

As per Essex-Lopresti classification, most patients had tongue type fractures (66.66%) while the rest showed depressed type (33.33%), which is near about similar to that of *Pan et al* in which 71.42% had tongue type and 28.57%. had depressed type. In his study by Chandale et al, 10 patients had tongue type (62.5%) while rest 6 (37.5%) had depressed type fractures. 6.66% patients in his study had pin-tract infection and 3.33% had subtalar arthritis, which is quite similar to our study.

In this study as per Sanders classification, 14 cases (46.66%) had type II, 10 (33.33%) had type III and the rest 6 (20%) had type IV type fracture, which is similar to the study conducted by Walde et al. [13] in which 15 patients (16.3%) had type II, 52 (56.5%) had type III and 25 (27.2%) had type IV fracture.

In our study, the maximum AOFAS score was 95 and minimum score was 70 and mean score was 82.6 with a standard deviation of 7.4. Functional outcome as assessed by the AOFAS score was excellent in 12 (40%), good in 14 (46.7%) and fair in 4 (13.3%). In study conducted by *Pan et al* 86% showed excellent result which is higher than our present study, while in a study by *Rajmohan et al* [14], the mean AOFAS score for percutaneous K-wire fixation was 68.75, which is less than this present study. In our study, the mean AOFAS score in Sanders type II was 86.3, in type III it was 83.1 and in type IV it was 74.4. In a study by *Tong et al* [15] using percutaneous K-wire fixation using sinus tarsi approach, the mean AOFAS scores of type II fractures were 92.7± 2.1, type III 90.2±1.8, and type IV 89.7±2.7, m which is quite comparable to our present study.

Functional Outcomes: Excellent-to-good results were observed in 86.7% of patients, suggesting that percutaneous K-wire fixation provides reliable restoration of subtalar joint mechanics and hindfoot function. Patients with salvageable Sanders type IV fractures had lower AOFAS scores (mean 74.4), reflecting the challenge of achieving perfect reduction

in comminuted articular fragments. These findings are consistent with previous literature reporting diminished outcomes in highly comminuted calcaneal fractures treated with minimally invasive methods.

Radiographic Outcomes: Restoration of Böhler and Gissane angles postoperatively indicates that indirect reduction techniques can achieve near-anatomical alignment. The mean increase of Böhler angle from 8.6° to 27.2° and decrease of Gissane angle from 141.8° to 121.6° is comparable to results reported with ORIF, highlighting the effectiveness of fluoroscopic-guided closed reduction in selected fracture patterns.

Complications: The overall complication rate of 13.3% was low, with superficial pin-tract infections being the most common. Importantly, no deep infections, osteomyelitis, or hardware failures were observed. This compares favorably with reported ORIF series, where wound complication rates can reach 20% in high-risk patients. Preservation of soft tissue integrity is likely the key factor contributing to these outcomes.

Clinical Relevance: Minimally invasive K-wire fixation offers an attractive alternative to open approaches, particularly in patients with compromised soft tissue or comorbidities that increase surgical risk. The procedure is technically less demanding than ORIF, requires minimal hardware, and allows early mobilization, which may contribute to faster functional recovery.

Limitations: This study being conducted in a tertiary care hospital, is limited by its prospective case series design without a control group, a relatively smaller sample size, and a follow-up period restricted to 6 months. Long-term evaluation is needed to assess the incidence of subtalar arthritis and functional durability. Furthermore, the number of salvageable type IV fractures was small, limiting the generalizability of outcomes for highly comminuted fractures.

CONCLUSION

Closed reduction with percutaneous multiple K-wire fixation is a safe, effective, and minimally invasive method for managing displaced intra-articular calcaneal fractures (DIACF) in appropriately selected patients. It provides satisfactory functional recovery, restores radiographic alignment of the hindfoot, and carries a low risk of complications. Excellent-to-good functional outcomes can be expected in the majority of Sanders type II and III fractures, while salvageable type IV fractures may achieve fair-to-good outcomes.

This technique should be considered particularly in patients where soft tissue preservation is critical, in resource-limited settings, or in cases where ORIF poses excessive risk. Future studies comparing this technique with ORIF in randomized controlled trials and with longer-term follow-up are warranted to further validate its efficacy and durability.

Recommendations

A multi-centric study having larger sample size with study subjects from both urban and rural places and also with control group and long term follow up can produce better causal relationship between various factors which affect the overall functional and radiological outcomes.

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Conflict of interest *– None Declared*
Ethical approval *– Approved by Institutional Ethics committee, Calcutta National Medical College*
[EC-CNMC/2025/637]

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