



Original Research Article

A PROSPECTIVE STUDY ON OPEN REDUCTION INTERNAL FIXATION OF INTRAARTICULAR CALCANEAL FRACTURES USING LOCKING COMPRESSION PLATE

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ABSTRACT

Background: To evaluate the functional and radiological outcomes of ORIF in displaced intra-articular calcaneal fractures among adults aged 20–60 years.

Materials and Methods: This prospective case series was conducted at Sree Balaji Medical College and Hospital, Chennai, between September 2023 and March 2025. A total of 25 patients, aged 20–60 years, presenting with displaced intra-articular calcaneal fractures were enrolled after obtaining informed consent. Patients with open fractures, peripheral vascular disease, diabetic neuropathy, or those who were unconscious were excluded to ensure a uniform study population. All patients underwent ORIF through an extensive lateral approach using locking plates. Preoperative and postoperative radiological assessments included Böhler's angle, Gissane's angle, and calcaneal dimensions (height, length, and width), while functional outcomes were evaluated at 1, 3, and 6 months postoperatively using the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot score and the Creighton–Nebraska score.

Results: Patients showed significant improvement in functional scores and restoration of radiological parameters. Sander's type II fractures had better outcomes than type III. Smoking and diabetes were associated with delayed recovery and higher complication rates.

Conclusion: ORIF is an effective modality for displaced intra-articular calcaneal fractures, especially in Sander's type II. Early intervention and meticulous soft tissue handling are essential for optimal outcomes.

Keywords: Calcaneal fracture, intra-articular fractures, ORIF, Bohler's angle, AOFAS score, Sander's classification.

INTRODUCTION

Fractures of calcaneum, though accounting for only 2% of all fractures, represent nearly 60% of tarsal injuries and remain one of the most challenging problems in orthopaedic trauma.^[1,2] These injuries, commonly seen in middle-aged working men, usually occur following high-energy axial-loading from falls or road traffic accidents, often resulting in disruption of the subtalar joint and altered hindfoot biomechanics.^[3,4] If inadequately treated, they may

lead to chronic pain, gait abnormalities, and post-traumatic subtalar arthritis.

Traditionally, management strategies have ranged from conservative treatment to surgical fixation. Non-operative approaches, although useful in minimally displaced fractures, are often associated with malunion, loss of heel height, and poor long-term function.^[1-4] ORIF via the extensile lateral approach emerged as a method to restore joint congruity and hindfoot alignment.

However, wound complications, infection, and neurovascular injury initially limited its widespread

acceptance.^[5-6] Advances in surgical technique, careful soft tissue handling, and improved implant design have since lowered complication rates, making ORIF a viable option in selected patients.^[7-8] Patient-specific factors strongly influence outcomes. Smoking is associated with higher wound infection rates, while comorbidities such as diabetes also predispose to delayed healing and adverse results.^[7-8] Fracture severity further impacts prognosis: Sanders type II fractures generally yield better outcomes than type III or IV, which carry increased risks of arthritis and need for fusion.^[9-10] Recent systematic reviews suggest that ORIF provides superior restoration of Böhler's angle, Gissane's angle, and calcaneal morphology, translating into improved function when compared to conservative treatment.^[11-13]

Based on this evidence, the present study aims to evaluate the radiological and functional outcomes of displaced intra-articular calcaneal fractures treated with ORIF using plating, while also examining prognostic factors such as fracture type and patient comorbidities.

Aim

To evaluate the functional and radiological outcomes of intra-articular calcaneal fractures treated with ORIF using plating.

MATERIALS AND METHODS

This prospective case series was conducted in the Department of Orthopaedics at Sree Balaji Medical College and Hospital, Chennai, from September 2023 to March 2025. A total of 25 individuals between 20 and 60 years of age, diagnosed with displaced intra-articular fractures of the calcaneus, were included following informed consent and clearance from the institutional ethics committee. Exclusion criteria comprised open injuries, peripheral vascular compromise, diabetic neuropathy, and altered consciousness at the time of admission. Initial assessment involved clinical examination alongside lateral and axial radiographs, supplemented by computed tomography to delineate fracture morphology. Radiographic indices—namely Böhler's and Gissane's angles, as well as calcaneal dimensions (height, length, and width) were measured before and after surgical intervention to evaluate anatomical realignment.

All patients underwent ORIF under spinal anaesthesia via the extensile lateral approach, with stabilization achieved using locking plates. Postoperative care included intravenous antibiotics for three days, dressing on the second day, and suture removal between 15 and 18 days. Rehabilitation was staged, beginning with passive range of motion exercises from the third week, non-weight-bearing mobilization with walker support until the twelfth week, followed by gradual weight-bearing based on tolerance and radiographic healing. Postoperative functional outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) scoring system and the Creighton–Nebraska scale at follow-up intervals of 1, 3, and 6 months. Descriptive statistics were expressed as mean values, standard deviations, frequencies, and percentages. Continuous data were examined using the independent samples t-test and one-way analysis of variance (ANOVA), while categorical variables were analysed via the Pearson chi-square test. A significance threshold of $p < 0.05$ was applied throughout, and all statistical computations were conducted using IBM SPSS Statistics version 21.0 (IBM-SPSS Science Inc., Chicago, IL, USA).

RESULTS

This prospective study included 25 patients with displaced intra-articular calcaneal fractures treated with ORIF using plating. The patients' ages ranged from 20 to 60 years, with a mean age of 42.68 years. The majority of injuries were caused by falls from height (68.0%), primarily at worksites, while the remaining 32.0% resulted from road traffic accidents. Three patients had associated injuries, including two with left distal radius fractures and one with a left olecranon fracture [Table 1]. Regarding laterality, 10 patients had fractures on the left side, 11 on the right, and 4 had bilateral involvement. Comorbidities included diabetes mellitus in 12.0% of patients, and 24.0% were smokers. According to Sanders classification, 56.0% of fractures were type II, and 44.0% were type III.

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Table 1: Distribution of Patient's Characteristics

Parameter	Category	Number (n)	Percentage (%)
Mode of Injury	Fall from height	17	68.0
	Road traffic accident	8	32.0
Associated Injuries	Left distal end radius fracture	3	12.0
	Left olecranon fracture	2	8.0
	None	20	80.0
Side Involved	Bilateral	4	16.0
	Left	10	40.0
	Right	11	44.0
Diabetes Mellitus	No	22	88.0
	Yes	3	12.0
Smoking	No	19	76.0

	Yes	6	24.0
Sanders Type	II	14	56.0
	III	11	44.0

The mean duration from injury to presentation was 1.71 days, and the interval from injury to surgery averaged 6.90 days. The mean operative time was 98.25 minutes, with an average blood loss of 353 ml. Postoperatively, wound healing at four weeks was good in 76.0% and fair in 24.0% of patients.

Superficial wound infections occurred in 24.0%, and one patient (4.0%) developed a deep infection necessitating implant removal. Overall functional outcomes were favourable, with 68.0% achieving good outcomes, 28.0% fair, and 4.0% poor. [Table 2]

Table 2: Distribution of Wound Healing at Four Weeks, Superficial Wound Infection, Implant Removal, and Overall Outcome

Variable	Category	Frequency (n)	Percentage (%)
Wound Healing at Four Weeks	Fair	6	24.0
	Good	19	76.0
Superficial Wound Infection	No	19	76.0
	Yes	6	24.0
Delayed Complications Requiring Implant Removal	No	24	96.0
	Yes	1	4.0
Overall Outcome	Poor	1	4.0
	Fair	7	28.0
	Good	17	68.0

Radiological assessment demonstrated significant improvements across all parameters. Böhler's angle increased from 14.10° preoperatively to 23.05° postoperatively, while Gissane's angle decreased from 138.00° to 122.30° (p<0.0001). Calcaneal

height improved from 3.98 cm to 4.12 cm, width decreased from 4.05 cm to 3.88 cm, and length increased from 7.05 cm to 7.22 cm (all p<0.0001). [Table 3]

Table 3: Distribution of Bohler's Angle, Gissane's Angle, Calcaneal Height, Width, And Length

Parameter	Time Point	Mean	Standard Deviation (SD)	P value
Böhler's Angle (°)	Pre-Operative	14.10	2.05	<0.0001
	Post-Operative	23.05	2.70	
Gissane's Angle (°)	Pre-Operative	138.00	3.80	<0.0001
	Post-Operative	122.30	3.60	
Calcaneal Height (cm)	Pre-Operative	3.98	0.15	<0.0001
	Post-Operative	4.12	0.14	
Calcaneal Width (cm)	Pre-Operative	4.05	0.17	<0.0001
	Post-Operative	3.88	0.16	
Calcaneal Length (cm)	Pre-Operative	7.05	0.14	<0.0001
	Post-Operative	7.22	0.13	

Functional evaluation using AOFAS and Creighton–Nebraska scores showed steady improvement over time. The mean AOFAS score increased from 50.00 at 1 month to 67.20 at 3 months and 81.40 at 6 months, while the Creighton–Nebraska score improved from 32.00 to 56.00 and 82.00 over the

same periods (p<0.0001). [Table 4] Sanders type II fractures consistently showed slightly higher scores than type III fractures; however, differences were not statistically significant at any follow-up for AOFAS (p = 0.058–0.128) or Creighton–Nebraska scores (p = 0.158–0.830). [Table 5]

Table 4: Distribution of Aofas and Creighton Nebraska Score

Score	Time Point	Mean	Standard Deviation (SD)	P value
AOFAS Score	1 Month	50.00	9.10	<0.0001
	3 Months	67.20	7.50	
	6 Months	81.40	8.20	
Creighton–Nebraska Score	1 Month	32.00	6.20	<0.0001
	3 Months	56.00	9.10	
	6 Months	82.00	7.70	

Table 5: Comparison of Aofas and Creighton Nebraska Score in Sander's Type

Score	Time Point	Sanders Type	Mean	Standard Deviation (SD)	P value
AOFAS Score	1 Month	II	53.00	8.70	0.058
		III	45.50	7.80	
	3 Months	II	68.20	8.80	0.310
		III	65.00	5.00	

	6 Months	II	83.00	10.20	0.128
		III	77.50	4.20	
Creighton–Nebraska Score	1 Month	II	33.00	6.30	0.410
		III	30.50	5.90	
	3 Months	II	56.00	10.90	0.830
		III	55.00	6.60	
	6 Months	II	84.00	8.30	0.158
		III	79.00	6.50	

Analysis of outcomes in relation to patient characteristics revealed no significant differences based on age, mode of injury, associated injuries, or presence of diabetes mellitus. Smoking was associated with poorer outcomes: among six smokers, three had fair outcomes and one had a poor

outcome ($p = 0.006$). Fracture severity also influenced functional recovery: 82.0% of Sanders type II fractures achieved good outcomes compared to 22.0% in type III fractures, whereas type III patients had higher rates of fair outcomes (54.0%) ($p = 0.006$). [Table 6]

Table 6: Comparison of Overall Outcome in Patient Characteristics.

Variable	Category	Fair (%)	Good (%)	Poor (%)	P value
Age Group	<40	14.0	86.0	0.0	0.168
	>40	42.0	44.0	14.0	
Mode of Injury	Fall from height	40.0	52.0	8.0	0.145
	Road traffic accident	0.0	100.0	0.0	
Associated Injury	Left distal end radius fracture	0.0	100.0	0.0	0.738
	Left olecranon fracture	0.0	100.0	0.0	
	None	36.0	56.0	8.0	
Diabetes Mellitus	Yes	100.0	0.0	0.0	0.066
	No	19.0	74.0	7.0	
Smoking	Yes	76.0	0.0	24.0	0.006
	No	16.0	84.0	0.0	
Sanders Type	II	0.0	82.0	8.0	0.006
	III	54.0	22.0	0.0	

DISCUSSION

The present study assessed clinical and radiological outcomes in a cohort of 25 individuals with displaced intra-articular calcaneal fractures managed through ORIF using plate osteosynthesis. Our results suggest that ORIF is effective in restoring calcaneal morphology and improving functional recovery, though risk factors such as smoking and higher fracture severity negatively influenced outcomes.

The average patient age in our study (42.68 years) is comparable to previous large series that identified calcaneal fractures as primarily affecting middle-aged men after high-energy trauma.^[1] Falls from height were the most common mechanism of injury (68%), which aligns with earlier literature that describes axial loading as the predominant cause of these fractures.^[1-5] Although only three of our patients sustained associated injuries, Sanders et al,^[1] emphasised that concomitant injuries are important prognostic factors that can worsen long-term outcomes.

Radiological outcomes showed significant improvement postoperatively, with Böhler's angle corrected from 14.10° to 23.05° and Gissane's angle reduced from 138.00° to 122.30°. These values fall within reported normal ranges and are consistent with the improvements documented in earlier surgical series.^[1,5,6] Emre et al,^[7] and Luo et al,^[8] further demonstrated that anatomical restoration of subtalar alignment strongly correlates with improved functional outcomes. Our study supports

this association, as patients with better radiographic correction also achieved higher functional scores.

Functional recovery was evident, with AOFAS scores increasing from 50.00 at 1 month to 81.40 at 6 months, and Creighton–Nebraska scores rising from 32.00 to 82.00. Similar improvements have been reported in previous prospective studies and multicentre analyses.^[2,13]

When outcomes were compared by Sanders classification, patients with type II fractures achieved slightly better results than those with type III fractures, though differences were not statistically significant. This finding mirrors earlier work by Sanders et al,^[1] and Driessen et al,^[9] which showed poorer long-term outcomes and higher rates of subtalar arthritis in type III and IV fractures. The relatively short six-month follow-up in our study may explain why such differences did not reach statistical significance.

Postoperative wound complications were observed in 24% of our patients, with one deep infection (4%) requiring implant removal. These figures are consistent with previously published reports, which noted wound complication rates ranging between 10% and 25% after extensile lateral ORIF.^[10,11]

Smoking was a significant negative prognostic factor in this study. Among smokers, only 25% achieved good outcomes, while 75% had fair or poor results. These findings corroborate earlier studies demonstrating the adverse impact of tobacco use on the wound healing process and infection risk in calcaneal fracture surgery.^[3,4,12] This reinforces the value of pre-surgical guidance and implementing

smoking cessation initiatives to improve patient outcomes.

The debate regarding operative versus non-operative management continues. The landmark RCT by Buckley et al,^[5] found no significant overall difference in outcomes between the two approaches, though subgroups of younger, non-smoking patients with type II fractures benefited more from surgery. More recent evidence, however, increasingly supports surgical intervention for displaced fractures, citing improved anatomical restoration and better early functional recovery.^[6,7,8,9] Our results add to this growing body of literature by demonstrating that ORIF, when performed in appropriate candidates, produces significant radiological and functional improvements with an acceptable complication profile.

Although the study benefits from a prospective design, consistent surgical methodology, and the application of validated scoring systems, its limited sample size and brief follow-up duration constrain broader applicability. Extended follow-up investigations are warranted to evaluate long-term sequelae such as subtalar joint arthritis and the possible requirement for secondary interventions like arthrodesis.

CONCLUSION

Open Reduction Internal Fixation with plating remains a consistent therapeutic strategy for complex fractures of calcaneum, achieving significant radiological restoration and functional improvement. The restoration of Böhler's and Gissane's angles, along with correction of height and width of calcaneum, is critical for optimal outcomes. Sanders type II fractures generally have superior results compared to type III. While the overall complication rate was low, smoking and comorbidities such as diabetes were associated with poorer prognosis. Careful preoperative planning, meticulous intraoperative technique, and strict postoperative wound management are key to reducing adverse events and enhancing recovery.

CLINICAL MESSAGE

Optimal management of intra-articular calcaneal fractures necessitates precise anatomical restoration

and meticulous preservation of the surrounding soft tissue envelope. ORIF with plating provides good functional outcomes, but patients with risk factors such as smoking and diabetes require special attention to minimize complications.

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