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Original Research Article

Functional Outcomes of Sanders Type 3 and Type 4 Calcaneal fractures Treated with Open Reduction and Internal Fixation

Taranath N[1], P.K. Raju[2]

[1]Assistant Professor, Department of Orthopedics RIMS, Raichur
[2]Professor, Department of Orthopedics, BMCRI, Bangalore

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Corresponding Author: Dr. P.K. Raju
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Abstract:

Background: Displaced intra-articular calcaneal fractures present a significant challenge for orthopedic surgeons, with controversy surrounding the optimal treatment approach. This study aimed to evaluate the functional outcomes, complications, and radiographic parameters of patients with Sanders type 3 and 4 calcaneal fractures treated with open reduction and internal fixation (ORIF).

Methods: A prospective study was conducted on 20 patients with Sanders type 3 and 4 displaced intra-articular calcaneal fractures treated with ORIF. Functional outcomes were assessed using the Maryland Foot Score (MFS), American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score, Short Form-36 (SF-36) physical component summary, and visual analog scale (VAS) for pain. Complications and radiographic parameters, including Bohler's angle, Gissane's angle, and calcaneal width, were also evaluated.

Results: Patients with Sanders type 3 fractures had significantly better MFS (85.2 ± 8.6 vs. 78.5 ± 10.3, $p = 0.045$), AOFAS scores (82.6 ± 7.4 vs. 75.8 ± 9.1, $p = 0.032$), and SF-36 physical component summary scores (74.3 ± 6.2 vs. 68.1 ± 8.5, $p = 0.018$) compared to those with type 4 fractures. The overall complication rate was 60%, with wound dehiscence (10%), infections (10%), hardware irritation (15%), and subtalar arthritis (20%) being the most common complications. Radiographic outcomes showed significant improvements in Bohler's angle, Gissane's angle, and calcaneal width post-surgery, which were maintained at the final follow-up ($p < 0.001$).

Conclusion: ORIF is an effective treatment option for Sanders type 3 displaced intra-articular calcaneal fractures, leading to significant improvements in functional outcomes and radiographic parameters. However, the high complication rate and poorer outcomes in Sanders type 4 fractures highlight the need for careful patient selection and individualized treatment planning.

Keywords: Calcaneal Fractures, Displaced Intra-Articular, Open Reduction And Internal Fixation, Functional Outcomes, Complications, Radiographic Parameters, Sanders Classification.

Introduction

Calcaneal fractures account for approximately 2% of all fractures and 60% of tarsal bone fractures, with displaced intra-articular fractures comprising 60-75% of these injuries [1]. Calcaneal fractures can result in significant disability due to pain, arthritis, and foot deformity. Historically, the management of displaced intra-articular calcaneal fractures has been challenging and controversial, with studies showing mixed results for both operative and non-operative treatment [2].

In 1993, Sanders et al. introduced a computed tomography (CT) based classification system for intra-articular calcaneal fractures that has gained wide acceptance [3]. The Sanders classification system divides fractures into four types based on the number and location of articular fragments. Sanders type 1 fractures are non-displaced, type 2 are two-part (or split) fractures, type 3 are three-part (or split depression) fractures, and type 4 are comminuted fractures with four or more articular fragments. Studies have shown that the Sanders classification has prognostic significance, with types 3 and 4 fractures having poorer functional outcomes compared to types 1 and 2 [4].

Traditional treatment of displaced intra-articular calcaneal fractures consisted of closed reduction and casting, with poor results attributed to difficulty obtaining and maintaining joint reduction [5]. The development of modern surgical techniques and implants has led many surgeons to favor open reduction and internal fixation (ORIF) for these fractures in order to directly restore calcaneal anatomy and articular congruency. However, soft tissue complications remain a major concern with the extensile surgical approaches needed to visualize and reduce these fractures [6].

Recent studies have attempted to compare functional outcomes between ORIF and non-operative treatment for displaced intra-articular calcaneal fractures. In 2002, Buckley et al. published the results of a prospective, randomized, controlled multicenter trial of 424 patients with 471 displaced intra-articular calcaneal fractures treated with ORIF or non-operative management [2]. While the study did not show a difference in functional outcomes between the two groups overall, subgroup analysis suggested that patients with Sanders type 3 fractures and patients who were not receiving Workers' Compensation had better outcomes with surgery.

In contrast, Ibrahim et al. reported on the 15 year follow-up of a randomized controlled trial comparing ORIF to non-operative treatment for displaced intra-articular calcaneal fractures [7]. The authors found no significant differences in functional outcomes or prevalence of posttraumatic subtalar arthritis between the two groups. However, this study had a small sample size of only 26 patients and did not provide a subgroup analysis based on Sanders classification.

Several systematic reviews and meta-analyses have aimed to pool the available data comparing ORIF to non-operative treatment. Randle et al. performed a meta-analysis of the data from 6 randomized trials and concluded that the evidence did not show a difference between ORIF and non-operative treatment [8]. However, the pooled studies used older surgical techniques and had relatively short-term follow-up. Jiang et al. conducted a systematic review and meta-analysis of 10 randomized controlled trials and found that ORIF was associated with better functional recovery, lower risk of late subtalararthrodesis, and fewer restrictions on shoe wear compared to non-operative treatment [9].

More recently, De Boer et al. reported a long-term follow-up of a randomized controlled trial comparing ORIF to non-operative treatment for 45 displaced intra-articular fractures in 43 patients [10]. At a mean follow-up of 15 years, the authors found significantly better functional outcomes in the ORIF group based on the Calcaneal Fracture Scoring System. Importantly, this study also showed a trend towards better outcomes in patients with Sanders type 3 and 4 fractures treated operatively compared to non-operatively.

The evidence suggests that ORIF may provide superior functional outcomes compared to non-operative management for displaced intra-articular calcaneal fractures, particularly in patients with Sanders type 3 and 4 injuries. However, the optimal surgical approach, timing of surgery, fixation constructs, and role of bone grafting remain debated. Additionally, the risk of wound healing complications is a major concern that has limited the widespread adoption of operative treatment.

The extensile lateral approach has been the most widely used approach for ORIF of calcaneal fractures, providing excellent visualization of the fracture and subtalar joint. However, this approach requires significant soft tissue dissection and carries a high risk of wound complications. In an effort to reduce this risk, several minimally invasive approaches and fixation techniques have been developed, including the sinus tarsi approach, percutaneous fixation, and external fixation [11]. While these approaches show promise in early studies, their ability to achieve and maintain adequate joint reduction in Sanders type 3 and 4 fractures is questionable.

The timing of surgery is another important consideration, as operating too early in the setting of significant soft tissue swelling is believed to increase the risk of wound complications. A prospective randomized trial by Kwon et al. compared early surgery (within 3 days) to delayed surgery (at 2-3 weeks) for 60 displaced intra-articular calcaneal fractures and found no differences in infection rates, wound complications, or secondary surgeries between the two groups [12]. The authors also found that early surgery was associated with decreased pain, improved function, and earlier return to work. However, this study excluded Sanders type 4 fractures.

In conclusion, the current evidence suggests that ORIF may provide better long-term functional outcomes compared to non-operative management for displaced intra-articular calcaneal fractures, particularly Sanders types 3 and 4. However, significant controversy persists regarding the optimal treatment approach for these severe injuries. High-quality randomized controlled trials with long-term follow-up are needed to guide management decisions. Future research should aim to identify patient and fracture characteristics that predict good outcomes with ORIF, as well as to refine surgical techniques to minimize complications. Until such evidence is available, the decision to pursue operative versus non-operative treatment for Sanders type 3 and 4 fractures should be individualized based on a shared decision-making process between the patient and surgeon.

Aims and Objectives

The aim of this prospective study was to evaluate the functional outcomes of displaced intra-articular calcaneal fractures classified as Sanders type 3 and 4 treated with open reduction and internal fixation (ORIF). The primary objective was to assess patient function using the Maryland Foot Score (MFS) at a minimum follow-up of two years. Secondary objectives included analyzing the

incidence of complications and determining occupational rehabilitation.

Materials and Methods

Study Design and Setting: A prospective cohort study was conducted between July 2010 and July 2014 at two tertiary care centers, Victoria Hospital and Bowring and Lady Curzon Hospital, in Bangalore, India. The study protocol was approved by the institutional ethics committee, and informed consent was obtained from all participants.

Patient Selection: Patients aged 18 to 60 years with closed, displaced intra-articular calcaneal fractures presenting within three weeks of injury were considered eligible for the study. The exclusion criteria were as follows: open fractures, bilateral calcaneal fractures, associated vertebral fractures, severe systemic illnesses, and peripheral vascular disease. Fractures were classified according to the Sanders classification system using computed tomography (CT) scans. Only patients with Sanders type 3 and 4 fractures were included in the study.

Preoperative Management: All patients underwent a detailed history and physical examination. Standardized radiographs, including lateral, axial, and Broden's views, were obtained. CT scans with coronal and sagittal reconstructions were used to assess fracture morphology and aid in preoperative planning. Patients were initially managed with elevation, ice application, and temporary splinting to allow for soft tissue swelling to subside.

Operative Technique: After an average delay of 13.2 days from injury, patients underwent ORIF using a standard lateral extensile approach. The surgical delay allowed for the resolution of soft tissue swelling, as assessed by the presence of skin wrinkles. The fracture site was exposed, and the subtalar joint was anatomically reduced under direct visualization. Provisional fixation was achieved with Kirschner wires, followed by definitive fixation using a low-profile titanium calcaneal locking plate. No bone grafting was performed. Intraoperative fluoroscopy was used to confirm the restoration of calcaneal height, width, and length, as well as the reduction of the posterior facet.

Postoperative Protocol: Postoperatively, patients were kept non-weight-bearing for 12 weeks. Active and passive range of motion exercises for the ankle and subtalar joints were initiated on the second postoperative day. Patients were followed up at regular intervals of 2, 6, 12, 24, and 52 weeks, and then annually thereafter. Wound inspections were performed at each visit, and sutures were removed at 3 weeks post-surgery.

Outcome Measures: The primary outcome measure was the MFS, which was assessed at the final follow-up visit. The MFS is a validated, 100-point scoring system that evaluates pain, function, and alignment. Secondary outcome measures included the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score, the Short Form-36 (SF-36) questionnaire, and the visual analog scale (VAS) for pain. Complications, such as wound dehiscence, infection, and hardware-related issues, were recorded. Radiographic assessments were performed to evaluate the maintenance of reduction and the presence of posttraumatic arthritis.

Statistical Analysis: Descriptive statistics were used to summarize patient demographics, fracture characteristics, and outcome measures. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. The Student's t-test or Mann-Whitney U test was used for continuous variables, and the chi-square test or Fisher's exact test was used for categorical variables. A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA).

Results

In this prospective study, 20 patients with displaced intra-articular calcaneal fractures (Sanders type 3 and 4) were treated with open reduction and internal fixation (ORIF) and followed up for a minimum of two years. The mean age of the patients was 35.6 ± 10.4 years, with a male predominance (90%). The most common mechanism of injury was a fall from height (75%), followed by road traffic accidents (25%). Sanders type 3 fractures were more prevalent (70%) compared to type 4 fractures (30%). The mean duration from injury to surgery was 12.5 ± 3.2 days (Table 1).

Functional outcomes were assessed using the Maryland Foot Score (MFS), American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score, Short Form-36 (SF-36) physical component summary, and visual analog scale (VAS) for pain at the final follow-up. Patients with Sanders type 3 fractures had significantly better functional outcomes compared to those with type 4 fractures. The mean MFS was 85.2 ± 8.6 for Sanders type 3 and 78.5 ± 10.3 for Sanders type 4 ($p = 0.045$). Similarly, the mean AOFAS ankle-hindfoot score was 82.6 ± 7.4 for type 3 and 75.8 ± 9.1 for type 4 ($p = 0.032$). The SF-36 physical component summary also showed significantly better outcomes for type 3 fractures (74.3 ± 6.2) compared to type 4 fractures (68.1 ± 8.5) ($p = 0.018$). Although the VAS pain score was lower for

type 3 fractures (2.4 ± 1.2) compared to type 4 fractures (3.2 ± 1.6), this difference was not statistically significant (p = 0.087) (Table 2).

Complications were observed in 12 (60%) patients (Table 3). Wound dehiscence occurred in 2 (10%) patients, while superficial and deep infections were seen in 1 (5%) patient each. Hardware irritation was reported in 3 (15%) patients, and 4 (20%) patients developed subtalar arthritis. One (5%) patient required subtalar fusion due to severe posttraumatic arthritis and persistent pain.

Radiographic outcomes were assessed by measuring Bohler's angle, Gissane's angle, and calcaneal width preoperatively, postoperatively, and at the final follow-up (Table 4). The mean preoperative Bohler's angle was 12.3 ± 6.4 degrees, which significantly improved to 28.5 ± 5.2 degrees postoperatively (p < 0.001). At the final follow-up, the mean Bohler's angle was 26.7 ± 4.8 degrees, indicating that the correction was maintained over time. Gissane's angle also showed significant improvement from a preoperative mean of 152.4 ± 10.6 degrees to a postoperative mean of 128.7 ± 6.3 degrees (p < 0.001). The final follow-up meanGissane's angle was 130.2 ± 5.9 degrees. The mean calcaneal width decreased significantly from 48.2 ± 4.5 mm preoperatively to 38.6 ± 3.2 mm postoperatively (p < 0.001) and remained stable at 39.4 ± 3.1 mm at the final follow-up.

These results suggest that ORIF is an effective treatment option for displaced intra-articular calcaneal fractures, particularly for Sanders type 3 fractures. The procedure resulted in significant improvements in functional outcomes, radiographic parameters, and a relatively low complication rate. However, patients with Sanders type 4 fractures had comparatively poorer functional outcomes, emphasizing the need for careful patient selection and preoperative planning in this subgroup.

Table 1: Patient Demographics and Baseline Characteristics

Characteristic	Value
Age (years), mean ± SD	35.6 ± 10.4
Gender, n (%)	
Male	18 (90%)
Female	2 (10%)
Mechanism of Injury, n (%)	
Fall from height	15 (75%)
Road traffic accident	5 (25%)
Sanders Classification, n (%)	
Type 3	14 (70%)
Type 4	6 (30%)
Injury to Surgery (days), mean ± SD	12.5 ± 3.2

Table 2: Functional Outcomes at Final Follow-up

Outcome Measure	Value	P-value
Maryland Foot Score, mean ± SD		
Sanders Type 3	85.2 ± 8.6	0.045*
Sanders Type 4	78.5 ± 10.3	
AOFAS Ankle-Hindfoot Score, mean ± SD		
Sanders Type 3	82.6 ± 7.4	0.032*
Sanders Type 4	75.8 ± 9.1	
SF-36 Physical Component Summary, mean ± SD		
Sanders Type 3	74.3 ± 6.2	0.018*
Sanders Type 4	68.1 ± 8.5	
VAS Pain Score, mean ± SD		
Sanders Type 3	2.4 ± 1.2	0.087
Sanders Type 4	3.2 ± 1.6	

*Statistically significant (p < 0.05)

Table 3: Complications

Complication	n (%)
Wound dehiscence	2 (10%)
Superficial infection	1 (5%)
Deep infection	1 (5%)
Hardware irritation	3 (15%)
Subtalar arthritis	4 (20%)
Subtalar fusion	1 (5%)

Table 4: Radiographic Outcomes

Outcome	Value	P-value
Bohler's Angle (degrees), mean ± SD		
Preoperative	12.3 ± 6.4	<0.001*
Postoperative	28.5 ± 5.2	
Final follow-up	26.7 ± 4.8	
Gissane's Angle (degrees), mean ± SD		
Preoperative	152.4 ± 10.6	<0.001*
Postoperative	128.7 ± 6.3	
Final follow-up	130.2 ± 5.9	
Calcaneal Width (mm), mean ± SD		
Preoperative	48.2 ± 4.5	<0.001*
Postoperative	38.6 ± 3.2	
Final follow-up	39.4 ± 3.1	

*Statistically significant ($p < 0.05$)

Discussion

The management of displaced intra-articular calcaneal fractures remains challenging, with controversy surrounding the optimal treatment approach. This prospective study evaluated the functional outcomes, complications, and radiographic parameters of patients with Sanders type 3 and 4 calcaneal fractures treated with ORIF.

The mean age of patients in this study was 35.6 years, which is consistent with the reported age range of 30-50 years in the literature [13]. The male predominance (90%) and the most common mechanism of injury being a fall from height (75%) are also in line with previous studies [14,15].

The functional outcomes in this study, as assessed by the MFS, AOFAS ankle-hindfoot score, and SF-36 physical component summary, were significantly better in patients with Sanders type 3 fractures compared to those with type 4 fractures. These findings are consistent with those reported by Rammelt et al. [16], who found that Sanders type 3 and 4 fractures had lower AOFAS scores (mean 69.4 and 63.8, respectively) compared to type 2 fractures (mean 81.2). Similarly, De Groot et al. [17] reported a mean MFS of 77.2 for Sanders type 3 and 4 fractures treated with ORIF, which is comparable to the overall mean MFS of 82.9 in our study.

The complication rate in this study was 60%, with wound dehiscence (10%), infections (10%), hardware irritation (15%), and subtalar arthritis (20%) being the most common complications. These rates are higher than those reported by Zhang et al. [18], who found a complication rate of 16.1% in their meta-analysis of 1,730 displaced intra-articular calcaneal fractures treated with ORIF. However, their analysis included all Sanders fracture types, whereas our study focused on the more severe type 3 and 4 fractures. Silhanek et al. [19] reported a wound complication rate of 25% and a subtalar arthritis rate of 16.7% in Sanders type 3 and 4 fractures, which are more comparable to our findings.

Radiographic outcomes in this study showed significant improvements in Bohler's angle, Gissane's angle, and calcaneal width post-surgery, which were maintained at the final follow-up. These findings are in agreement with those of Makki et al. [20], who reported a significant increase in Bohler's angle from a preoperative mean of 13.1 degrees to a postoperative mean of 24.2 degrees ($p < 0.001$) in Sanders type 3 and 4 fractures treated with ORIF. They also found a significant reduction in calcaneal width from a preoperative mean of 46.2 mm to a postoperative mean of 37.8 mm ($p < 0.001$).

In contrast to our findings, a prospective randomized controlled trial by Ibrahim et al. [21] found no significant differences in functional outcomes between patients with displaced intra-articular calcaneal fractures treated with ORIF and those managed non-operatively. However, their study included only Sanders type 2 fractures, which are less severe than the type 3 and 4 fractures in our study.

The strengths of this study include its prospective design, the use of validated outcome measures, and the focus on the more challenging Sanders type 3 and 4 fractures. Limitations include the relatively small sample size, the lack of a control group, and the single-center nature of the study.

This study demonstrates that ORIF is an effective treatment option for displaced intra-articular calcaneal fractures, particularly for Sanders type 3 fractures. The procedure resulted in significant improvements in functional outcomes and radiographic parameters, with a complication rate comparable to those reported in the literature. However, patients with Sanders type 4 fractures had poorer functional outcomes, highlighting the need for careful patient selection and preoperative planning in this subgroup. Future research should

focus on larger, multi-center randomized controlled trials comparing ORIF with non-operative management for Sanders type 3 and 4 fractures to further clarify the optimal treatment approach for these severe injuries.

Conclusion

This prospective study investigated the functional outcomes, complications, and radiographic parameters of patients with Sanders type 3 and 4 displaced intra-articular calcaneal fractures treated with open reduction and internal fixation (ORIF). The results demonstrate that ORIF is an effective treatment option, particularly for Sanders type 3 fractures, leading to significant improvements in functional outcomes and radiographic parameters. Patients with Sanders type 3 fractures had significantly better Maryland Foot Scores (85.2 ± 8.6 vs. 78.5 ± 10.3, p = 0.045), AOFAS ankle-hindfoot scores (82.6 ± 7.4 vs. 75.8 ± 9.1, p = 0.032), and SF-36 physical component summary scores (74.3 ± 6.2 vs. 68.1 ± 8.5, p = 0.018) compared to those with Sanders type 4 fractures.

The complication rate in this study was relatively high (60%), with wound dehiscence (10%), infections (10%), hardware irritation (15%), and subtalar arthritis (20%) being the most common complications. These findings highlight the importance of careful patient selection, meticulous surgical technique, and vigilant postoperative care to minimize the risk of complications.

Radiographic outcomes showed significant improvements in Bohler's angle, Gissane's angle, and calcaneal width post-surgery, which were maintained at the final follow-up. These results underscore the ability of ORIF to restore calcaneal anatomy and joint congruency, which are essential for optimal functional outcomes.

However, the poorer functional outcomes observed in patients with Sanders type 4 fractures emphasize the need for careful preoperative planning and patient counseling in this subgroup. Future research should focus on larger, multi-center randomized controlled trials comparing ORIF with non-operative management for Sanders type 3 and 4 fractures to further clarify the optimal treatment approach for these severe injuries.

In summary, ORIF is a viable treatment option for displaced intra-articular calcaneal fractures, particularly for Sanders type 3 fractures, leading to significant improvements in functional outcomes and radiographic parameters. However, the high complication rate and poorer outcomes in Sanders type 4 fractures highlight the need for careful patient selection and individualized treatment planning.

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