

Functional and Radiological Outcome after Internal Fixation of Intra-articular Calcaneal Fractures

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Learning Point of the Article:

- To understand the pattern and epidemiology of calcaneal fractures.
- To evaluate the outcome both clinical and radiological following internal fixation with plate osteosynthesis for calcaneal fractures.
- To assess the outcome using the AOFAS scoring system.

Abstract

Introduction: Calcaneal fractures are rare injuries constituting 2% of all fractures. Fractures of calcaneum correspond to nearly 60–75% of the tarsal bone fractures. The calcaneum is the most commonly fractured tarsal bone 90% occur in males between 21 and 45 years of age. The calcaneal fracture may be extra-articular (sparing the subtalar joint) and intra-articular involving the subtalar joint. Intra-articular fractures account for approximately 75% of calcaneal fractures and have been associated with poor functional outcomes. In this study, we aim to assess the functional outcome of internal fixation in displaced intra-articular calcaneal fractures.

Materials and Methods: A prospective interventional study was conducted on patients with only intra-articular calcaneal fractures admitted to Chettinad Hospital and Research Institute, Kelambakkam during the period from May 1, 2022, to February 29, 2024, and a total of 32 patients were considered. The functional outcome was assessed by the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle Hindfoot Scoring System.

Results: The average age of the patients in our study was 39 years of which all were male. Fall from height is the most common mode of injury. The right calcaneum is more commonly involved than the left. The mean duration of hospital stay was around 10 days. The fracture classification was based on the Sanders and Essex-Lopresti classification of which 17 patients were Sanders type 3 and 13 patients were Sanders type 2 and 1 patient was Sanders type 4. The mean time for radiological union is 12 weeks. The Bohler's angle and Gissane's angle preoperatively 16.16 ± 8.87 and 121.48 ± 7.47 restored to near normal values after fixation 27.77 ± 6.02 and 113.485 ± 44 , respectively. Heel height and heel width restored to near normal values of (pre-operative heel height - 24.74 ± 3.71 and heel width - 39.97 ± 4.11 and post-operative heel height - 31.55 ± 3.38 and heel width - 34.0 ± 3.1), respectively. The most common complications were wound-related complications (superficial wound infection - 9.7%, deep wound infection - 3.2%, and wound margin necrosis and wound dehiscence 6.4%) and the most common late complications were complex regional pain syndrome - 9.7% and subfibular lateral impingement with peroneal tendinitis - 6.5%. AOFAS grading of functional outcome had shown good to excellent results in 83.8% (26 patients) of the cases. The mean AOFAS score was 83.39 in our study.

Conclusion: The present study shows that open reduction and internal fixation give superior radiographic results as shown by the restoration of Bohler's and Gissane's angle and height and width of the calcaneus to near normal values, indicating anatomical restoration of calcaneal shape. The functional outcome by AOFAS score showed good to excellent results in most of the patients with minimal wound complications.

Keywords: Calcaneal fracture, outcome evaluation, open reduction internal fixation, lower extremity trauma, plate osteosynthesis, tarsal bone fractures.

Author's Photo Gallery



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Access this article online

Website:
www.jocr.co.in

DOI:
<https://doi.org/10.13107/jocr.2024.v14.i08.4700>

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Submitted: 22/05/2024; Review: 10/06/2024; Accepted: July 2024; Published: August 2024

DOI: <https://doi.org/10.13107/jocr.2024.v14.i08.4700>

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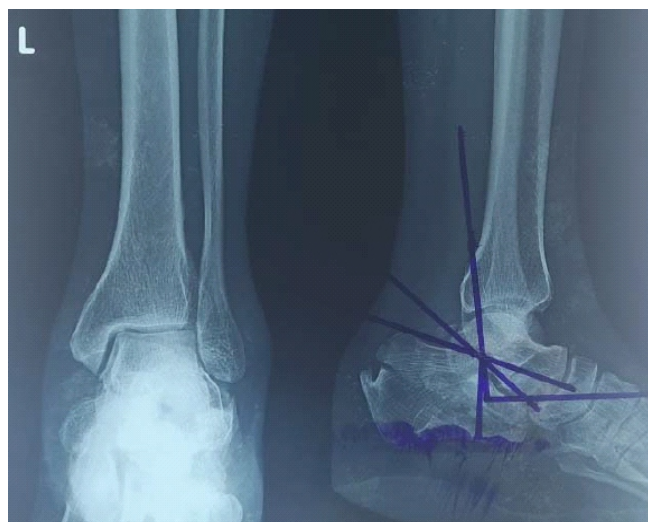


Figure 1: Initial pre-operative X-rays.



Figure 2: Immediate post-operative X-rays.

Introduction

The calcaneum is the largest of the tarsal bones of the body. Calcaneal fractures are rare injuries constituting 2% of all fractures [1]. Calcaneal corresponds to nearly 60–75% of the tarsal bone fractures. The calcaneum is the most commonly fractured tarsal bone 90% occurs in males between 21 and 45 years of age [2]. Calcaneal fractures are known to cause great disability due to pain and chronic stiffness in addition to hindfoot deformities. These fractures are often characterized by poor functional results by their complexity.

The Calcaneal fracture may be extra-articular (sparing the subtalar joint) and intra-articular (involving the subtalar joint). Intra-articular fractures account for approximately 75% of calcaneal fractures and have been associated with poor

functional outcomes [3-5]. Usually, they result from falls from height and may be associated with other axial load injuries such as lumbar, pelvic, and tibial plateau fractures. Literature available has shown that the rehabilitation of calcaneal fractures can take 9 months to several years, implicating a great economic burden to society.

The management of calcaneal fractures has been a subject of debate for at least the past century. These fractures present a number of hindrances to the surgeon. The irregular bony anatomy, the complex joint mechanics between the tarsal bones and the delicate, soft tissue envelope in which they sit had made these fractures a challenge. Plate osteosynthesis of intra-articular fractures is a standard treatment but it has potential complications such as poor wound healing. Calcaneal shape restoration by means of open reduction and internal fixation (ORIF) or primary subtalar arthrodesis, if needed, is mandatory for the prevention of late complications such as malposition, flattening of the longitudinal arch, anterior ankle impingement syndrome, and axial malalignment of the hindfoot [3, 6-8].

Materials and Methods

This study was conducted after obtaining institutional ethical committee approval. Its a prospective interventional study was conducted on patients with calcaneal fractures admitted at Chettinad Hospital and Research Institute, Kelambakkam, during the period from May 1, 2022,



Figure 3: X-rays at 6-month follow-up – showing signs of fracture union.



Figure 4: Clinical follow-up at the end of 8 months – showing the degree of active dorsiflexion and plantarflexion.

to February 29, 2024, were considered.

Inclusion criteria

1. Patients above 18 years of age with calcaneum fractures
2. The patient should be walking before fracture
3. Fresh fractures.

Age groups	Number of patients (%)
21–30	9 (29.0)
31–40	9 (29.0)
41–50	10 (32.3)
51–60	3 (9.7)
Total	31 (100)

Table 1: Distribution of the patients in different age groups.

Exclusion criteria

1. Fracture presentation more than 3 weeks
2. Associated with other injuries in the ipsilateral extremity
3. Fractures in elderly people >65 years of age
4. Fracture in children <18 years of age
5. Open fractures calcaneum.

Materials and Methods

Patients who met the eligibility criteria were included in this study. A thorough history was taken and a clinical examination was done. The swelling of the heel and the status of the skin were noted. X-ray of the calcaneum was taken on admission which will include anteroposterior, lateral, and axial views. Computed tomography scans were obtained to evaluate the fracture pattern. Patients were temporarily put on a below-knee slab with adequate limb elevation. Fractures were classified based on Essex-Lopresti and Sander's classification. The patient would then post for open reduction internal fixation through a lateral extensile approach or any other approach as required.

Post-operative protocol

In comminuted fracture below the knee, a pop slab was applied for support for 2–3 weeks, then sutures were removed between 2 and 3 weeks, the patient mobilized for non-weight bearing in the 1st post-operative week, ROM exercises were started from 3 weeks postoperatively, weight-bearing started between 6 weeks and 8 weeks.

Follow-up and criteria for evaluation

The patients were followed up clinically and radiologically at 6 weeks, 3 months, and 6 months. At every follow-up, clinical examination was done to assess the status of the surgical wound, pain, tenderness, range of motion of the ankle subtalar joint, any complications of the wound and fracture, and clinical union. X-ray of the calcaneum in lateral and axial views was taken and evaluated for the height of the calcaneum, the width of the calcaneum, Gissane's angle, and Bohler's angle in post-operative and final follow-up X-ray and to look for signs of the radiological union.

The functional outcome was measured by "American Orthopaedic Foot and Ankle Society (AOFAS) Ankle Hindfoot scoring system" at 6 months. The AOFAS scoring system is a very useful tool to measure the function of the foot developed by the American Academy of Orthopaedic Surgeons (AAOS) and has been validated by various studies. AOFAS score is a 0–100 point scoring system mainly assessing pain, function, and alignment of the foot.

Parameters	Mean±SD	Range
Ankle dorsiflexion (°)	17.06±3.58	7–20
Ankle plantar flexion (°)	33.42±7.09	17–47
Ankle inversion (°)	20.32±5.31	10–30
Ankle eversion (°)	9.32±2.57	5–15
SD: Standard deviation		

Table 2: Distribution of the patients according to ROM.

Results

About 32.3% of the patients in this study were between the ages of 40 and 50, followed by those who were between the ages of 21 and 30 (29.0%) and 31 and 40 (29%) (Table 1). The most common age group affected was the decade with a mean age group of 39 years. According to this study, there were only male patients with calcaneal injuries. Approximately 80.6% of the individuals in this study had normal body mass index (BMI) (18–25). 6.5% of people had grade I obesity and 9.5% were overweight. Approximately 6.5% of the patients in this study had diabetes mellitus, 6.5% had ischemic arterial disease, 6.5% had coronary artery disease, and 6.5% were smokers. Road traffic collision accounted for 16.1% of the cases, while a fall from a height caused calcaneal injuries in about 83.9% of the instances. In this study, left calcaneal injuries accounted for 48.4% of cases, while right calcaneal injuries made up 51.6%. In this study, the Essex-Lopresti joint depression accounted for about 93.5% of the calcaneal fractures, while tongue-type fractures accounted for 6.5%. According to this study, type 3 Sanders fractures account for 54% of all fractures, whereas type II fractures account for 41.9% and type IV fractures for 3.2% of all fractures. A total of 31 cases of calcaneal fractures intra-articular were operated on. The most often utilized implant was a calcaneal locking plate, which was used in 26 patients. Three patients simply received cancellous screws, while two patients received a recon plate and screws. Twelve days were spent in the hospital by 12.9% of patients, while 32.2% of cases stayed for 10 days. The average length of stay in the hospital was 10 days. In this study, the pre-operative Bohler's angle was 16.2° and the

AOFAS grade	n (%)
Excellent	9 (29.0)
Good	17 (54.8)
Fair	3 (9.7)
Poor	2 (6.5)
Total	31 (100)
AOFAS: American Orthopedic Foot and Ankle Society	

Table 3: Distribution of the study group according to American Orthopedic Foot and Ankle Society grade.

mean of the normal Bohler's angle was 32.77° (Fig. 1). This difference was statistically significant between the normal and pre-operative periods. The mean of pre-operative Bohler's angle was 16.16° which is restored to post-operative Bohler's angle of 27.7° (Fig. 2) which was statistically significant in this study. The normal Gissane's angle was 122.39° and the pre-operative Gissane's angle was 121.48° (Fig. 1) in this study which was not statistically significant. The pre-operative Gissane's angle was 121.48° which is decreased or improved postoperatively to 113.48° (Fig. 3) which was statistically significant. The mean normal heel height was 35.1 mm and pre-operative heel height decreased to 24.74 which was statistically significant. Mean pre-operative heel height was 24.7 mm which is restored to near normal 31.5 mm which was statistically significant. The mean normal heel width was 29.68 mm and the pre-operative heel width increased to 39.97 mm. This difference in heel width was statistically significant. The preoperatively heel width was increased to 39.97 mm. The heel width was reduced to a near normal value of 34 mm postoperatively which was statistically significant. Superficial wound infection was the main post-operative early complication in 3 patients (9.7%) of the cases followed by sural nerve injury in 2 patients (6.4%) and wound margin necrosis and wound dehiscence's in 2 patients (6.4%) in this study. Complex regional pain syndrome (CRPS) was the main late complication in 9.7% of the cases followed by peroneal tendinitis in 6.5% of the cases. The mean duration of hospital stay in patients with complications was 19.92 days and without complications was 10.26 days. The mean Ankle Dorsi flexion (DF) was 17.06° and the mean Plantar flexion (PF) was 33.42°

in this study (Fig. 4). Mean range of movements inversion was 20.32° and eversion was 9.32° in this study (Table 2). The AOFAS grading of functional outcome had shown good to excellent results in 83.8% (26 patients) of the cases (Table 3). The mean AOFAS score was 83.39 in this study.

Discussion

Calcaneal fractures account for nearly 60–75% of the tarsal bone fractures. The calcaneum is the most commonly fractured tarsal bone, 90% occur in males between 21 and 45 years of age. Conventional conservative treatment by the cast is effective only in extra-articular fractures. In intra-articular fracture, conservative treatment leads to deformity, stiffness of ankle joint and post-traumatic arthritis. So, this study is one to assess the functional outcome of internal fixation in displaced intra-articular calcaneal fractures. Surgical techniques include closed treatment with screws or pins and ORIF with plates. Both techniques have both advantages and disadvantages. Closed techniques may have less wound complications but difficult to achieve anatomical reduction in displaced fractures. In the ORIF technique, fracture fragments are directly visualized and can be anatomically reduced and fixed with plate and screws. In this study, we have included all the intra-articular fractures of the calcaneum that is sanders type 2, 3, and 4 and fixed with various fixation devices using locking calcaneal plate (LCP) calcaneal plate in most of the cases, screws alone and recon plates in few cases using lateral approach and combined lateral and medial approach in few cases where it is necessary.

The most common age group affected in our study is between 41 and 50 years with a mean age of 39.3 ± 9.8 years with a range from 22 years to 58 years. A similar age group was reported by Babu et al., with a mean age of 36.9 years [9].

In a study by Jain et al., the mean age of the patients was 31.6 years [10]. All the patients with calcaneal injury were males in our study. In a comparative study, about 62.0% of them were males in a study by Biz et al. [11]. The mean BMI of patients in this study is 23.3 kg/m with a range from 18 to 32. In our study, about 9.5% were overweight and 6.5% had grade I obesity.

In a study by Biz et al., the mean BMI of the patients was 25.2 kg/m² [11]. The most common mode of injury was fall from height which accounts for 83.9% of the cases followed by RTA as a second common mode of injury. In a study by Biz et al., about 74.4% of the cases had injuries due to fall from height [11]. A study by Jain et al. noted that the majority of the fractures were due to fall from height [10]. About 51.6% had a right calcaneal injury in this study. In a study by Babu et al., the laterality was right side in 64% of the cases [9]. About 93.5% of the calcaneal

fractures in this study were Essex-Lopresti joint depression type. In a study by Biz et al., Essex-Lopresti of joint depression was present in 66.7% of the cases [11]. A study by Jain et al. noted that all the fractures were joint depression type of fractures. The most common type was Sanders type 3 fracture accounting for 54% of the cases. In the study by Bremer et al. wherein about 52% of the fractures in his study were Sanders type 2 fractures and 47% of the fractures were Sanders type 3 fractures [12]. In a study by Biz et al., about 42.5% of the cases had type II sanders fractures, 35.7% had type III, and 21.8% of the cases had Type IV fractures [11]. In a study by Babu et al., 68% of the cases had type III sanders type of fractures [9]. The mean duration of hospital stay in the entire group was 10.51 ± 2.2 days with a range from 6 to 28 days. About 32.2% of the cases stayed in the hospital for 10 days and 13% stayed for 12 days. The duration of hospital stay in patients with complications was increased to 19 days compared to 10 days in patients without complications which is statistically significant. The mean pre-operative Bohler's angle was 16.16° (Fig. 1) which is restored to post-operative Bohler's angle of 27.7° (Fig. 2) which was statistically significant in this study.

Upon average, the angle was improved or increased by 11° . The restored angle is about 86% of the normal side.

In a study by Leung et al., mean normal Bohler's angle of 30° ($25\text{--}37^\circ$) as improved to 28.9° after surgery [13]. The angle restored was 96% of the normal side. In the study by Besse et al. he has concluded that the pre-operative mean Bohler's angle of 6.6° was restored to post-operative Bohler's angle of 32.3° [14]. In a study by Biz et al., the pre-operative Bohler's angle was 17.5° and the post-operative angle was 20.9° . In a study by Jain et al., the mean Bohler's angle was improved from 4.15° preoperatively to 27.69° postoperatively. In a study by Schindler et al., the pre-operative Bohler's angle was 1° which was recovered postoperatively up to 23° . The pre-operative Gissane's angle was 121.48° which was decreased (improved) postoperatively to 113.48° which was statistically significant. Upon average, the angle was restored or decreased by 8° . The angle was restored to 93% of the normal side angle. A study by Leung et al. reported Gissane's angle of 120° ($102\text{--}142$) on the normal side and postoperatively angle was restored to 120° . The angle restored is 99% of the normal side. In a study by Jain et al., the mean Gissane angle improved from 151° preoperatively to 120° postoperatively. According to Besse et al., Gissane angle was restored or decreased by 1° compared to normal foot around 117° . A study by Babu et al. noted that the mean pre-operative Gissane angle was 126.9° and the post-operative angle was 119.8° . The mean un-injured heel height was 35.1 mm and pre-operative heel height was decreased to 24.74 which was statistically significant. Mean pre-operative heel height was 24.7

mm which is restored to near normal 31.5 mm postoperatively which was statistically significant. The heel height was restored to 89% of the normal side in our study. Leung et al. reported a normal heel height of 49 mm which restored post-operative to 47 mm which is 96% of the normal side. In a study by Jain et al., the mean calcaneal height improved from pre-operative 35 mm to 45 mm postoperatively. In a study by Babu et al., pre-operative heel height was 59 mm and post-operative heel height was 64 mm. In a study by Besse et al., pre-operative heel height was 44.4 mm which is restored to near normal of 46.3 mm, respectively. The mean un-injured heel width was 29.68 mm and pre-operative heel width was increased to 39.97 mm. This difference in heel width was statistically significant. The heel was reduced or improved to a near-normal value of 34 mm postoperatively which was statistically significant. In a study by Jain et al., the mean calcaneal width improved from 41.2 mm preoperatively to 37.1 mm postoperatively. In a study by Babu et al., the mean heel width was 68 mm during pre-operative and 63 mm postoperatively. In a study by Leung et al., pre-operative heel width was 34 mm which was restored to normal around 33 mm postoperatively. In a study by Besse et al., the pre-operative heel width was 31.7 mm which is restored to near normal foot of 30.6 mm postoperatively. Superficial wound infection was the main post-operative early complication in 9.7% (n = 3) and deep wound infection 3.2% (n = 1) in this study. All the superficial wound infection was treated by regular dressing and antibiotics which resolved uneventfully. The deep wound infection was seen in only one case in our study, which occurred 5 months postoperatively. The fracture was united by that time so implants (plate) were removed, wound was thoroughly debrided, and with intravenous antibiotics gradually, the wound healed. CRPS was the main late complication in 9.7% (n = 3) of the cases. In the study by Biz et al., with a mean follow-up of 17 months, about 5.7% of patients landed up with CRPS which is almost similar to our study and 3.4% developed nerve injury. Subfibular lateral impingement with peroneal tendinitis was seen in 6.5% (n = 2) of the cases. In subfibular lateral impingement, one patient was treated conservatively and another patient required lateral decompression surgery to relieve the pain. The mean duration of hospital stay in patients with complications was 19.92 days and without complications was 10.26 days. The patient with complications stayed longer for treatment of complications. The mean ankle DF was 17.06° and the mean ankle PF was 33.42° in this study (Fig. 4). A study by Jain et al. noted that all having mean dorsiflexion and plantar flexion of more than 30° each. In a study by Beese et al., the mean DF was 13.7° and the mean PF was 35.7° is almost similar to our study. In a study by Palange et al., the mean DF was 35° and mean PF was 20°. In a study by Babu et al., mean DF was 30° and PF was 25°, respectively. The mean range of inversion was

20.32° and eversion was 9.32° in this study. In a study by Besse et al., the mean inversion was 13.6°

In a study by Palange et al., the mean inversion was 20.51° and eversion was 17.32°, respectively [15]. In a study by Babu et al., both inversion and eversion were around 30°. The AOFAS grading of functional outcome had shown good to excellent results in 83.8% (26 patients) of the cases. The mean AOFAS score was 83.39 in this study. In a study by Biz et al., with a mean follow-up was 77 months, the mean AOFAS score was around 80 which is comparable to our study. In a study by Jain et al., 28 patients (26 unilateral and 2 bilateral) with joint depression type of calcaneal fractures as per Essex-Lopresti classification system were operated with LCP within 3 weeks of injury which was noted that at an average follow-up of 14.5 months, the average AOFAS score at final follow-up was 86.3, with 86% having excellent to good results and 2 (7.7%) and 1 (3.7%) having fair and poor results, respectively, which is more than our study. In a study by Rammelt et al., the mean AOFAS score was 88% [16]. A study by Babu et al. noted that about 64% of the cases had good results, 28% had fair and 8% had poor functional results. The mean AOFAS score was 78.3.

Conclusion

Open reduction and internal fixation give superior radiographic results as shown by restoration of Bohler's and Gissane's angle and height and of calcaneus to near normal values, indicating anatomical restoration of calcaneal shape. It also helps us to achieve complete anatomical reduction of fracture fragments under direct visualization. Rigid fixation of the fracture with LCP allows early mobilization, resulting in a good range of motion of the ankle and subtalar joint. It also shows that the functional outcomes assessed by AOFAS score are good to excellent in more than 80% of patients which is similar to most studies in the literature. The downside of open reduction and internal fixation is a higher rate of wound complications such as wound margin necrosis and wound dehiscence's but is also comparable to other similar studies in the literature.

Clinical Message

Surgical treatment with open reduction and internal fixation is extremely effective for managing intra-articular calcaneal fractures and yields favorable outcomes.



Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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Conflict of Interest: Nil
Source of Support: Nil

Consent: The authors confirm that informed consent was obtained from the patient for publication of this case report

How to Cite this Article

Janeson JD, Gopi P, Pradeep E, Haemanath P, Kumar KV, Mohideen S. Functional and Radiological Outcome after Internal Fixation of Intra-articular Calcaneal Fractures. *Journal of Orthopaedic Case Reports* 2024 August; 14(8): 205-211.

