International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2022; 8(4):189-193

www.orthopaper.com
Received: 09-09-2022
Accepted: 30-10-2022

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Prospective study on the functional and radiological outcome of open reduction and plating for intraarticular fractures of the calcaneum

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DOI: https://doi.org/10.22271/ortho.2022.v8.i4c.3262

Abstract
Background: The most common fractures in the hindfoot are calcaneal fractures. There are several debates on how to treat calcaneal fractures, although it is now preferred to undergo open reduction, internal fixation, and early mobilisation.
Aim: To evaluate the functional and radiological outcome of open reduction with plating for intra-articular fractures of the calcaneum.
Method: In a prospective observational study conducted in SRM medical college and research centre duration of September 2019 to March 2021, seventeen male patients satisfying the inclusion criteria were enrolled. In this study, G-bone was used in 7 cases – out of which three patients had Sander's type 2, and 4 patients had Sander's type 3.
Result: The most common mode of injury is falling from height (70.6%). Bohler's and Gissane's angles significantly improved post-operatively (p<0.0001). The AOFAS and Creighton Nebraska scores improved significantly in all follow-ups (p<0.0001). In 4 patients with smoking habits, 3 had fair outcomes, and 1 had a poor outcome which is statistically significant (p=0.006). In 10 sander's type 2 patients, nine (81.8%) had good outcomes, whereas one (9.1%) had a poor outcome. In 7 sander's type 3 patients, two patients (22.2%) had good outcomes, whereas five patients (55.6%) had fair outcomes. (p=0.006).
Conclusion: This study demonstrates that surgical management of intra-articular calcaneal fractures gives better results. Sander's type 2 fracture has a better outcome than Sander's type 3 fracture. With proper soft tissue care, the wound complications rate can also be decreased post-operatively.

Keywords: Intraarticular fractures, plating, calcaneum, internal fixation

Introduction
The most common foot fracture is a Calcaneal fracture. It accounts for 2% of all fractures and 75% of foot fractures. Out of them, 10% are bilateral, 10% have associated injuries, and 75% are intra-articular [1]. Management of calcaneus fracture has been a controversial topic for the last century. Its irregular bony anatomy, delicate soft tissue envelope and complicated joint biomechanism with the tarsal bones always make it challenging for the treating orthopaedic surgeon [2]. Also, these fractures typically affect middle-aged workers, which has an economic impact. Due to the nature of the injury, 25% of calcaneal fractures have been associated with bony injuries [3].
Axial force drives the talus into the calcaneum, resulting in the primary fracture line that extends over the posterior facet, creating anteromedial and posterolateral pieces. Because of strong ligaments, the sustentacular fragment remains attached to the talus. The posterior fragment is significant because it contains the posterior facet. Essex Lopresti defined secondary fracture lines that can result in tongue and joint depressing calcaneal fractures. Secondary fracture lines that continue through the tuberosity of the calcaneum cause tongue type of fractures, whereas lines that extend through the dorsal side of the calcaneum joint cause depression-type fractures [4].
It was stated by Cotton and Henderson in 1916 that "ordinarily speaking, the man who breaks his heel bone is 'done' so far as his industrial future is concerned".

Many treatment methods with better outcomes evolved slowly. Previously these fractures were managed conservatively with the assumption that the functions of the patient won't be affected [5]. Chances of subtalar arthritis are more during the conservative management of displaced calcaneal fractures. Most surgeons employ a large surgical exposure for open reduction and plate fixation, which allows for anatomical firm internal apposition of the pieces [6].

However, infections and skin necrosis have led surgeons to pursue minimally invasive techniques. Less intrusive techniques may have fewer problems, a shorter hospital stay, and a shorter period between first admission and operation. However, possible drawbacks include lower reduction quality and a poor functional result. Therefore, there is a trend towards open reduction and fixation for displaced intra-articular fractures of the calcaneum. Among the various techniques, open reduction with plating has been the gold standard for treating a displaced intra-articular calcaneal fracture [7]. This study aims to evaluate the functional and radiological outcomes of displaced intra-articular calcaneal fractures treated with open reduction and internal fixation with plating through an extensile lateral approach.

Aim

To evaluate the functional and radiological outcome of open reduction with plating for intra-articular fractures.

Materials and Methods

This is a prospective observational study conducted at SRM medical college and research centre duration of September 2019 to March 2021, seventeen male patients satisfying the inclusion criteria were enrolled in this study. Informed written consent was obtained from patients. Ethical committee clearance was obtained from SRM medical college and research centre, Tamilnadu. Inclusion criteria: Age 20-60 years, and Intra-articular calcaneal fractures displaced. Exclusion criteria: Open-fractures, Patients with peripheral vascular disease, Patients with diabetic neuropathy, and Unconscious patients.

Pre-operatively X-ray of calcaneum- Lateral view, Axial view and Computed Tomography (CT) of affected calcaneum Post-operatively X-ray of calcaneum- Lateral view, Axial view Bohler's Angle, Angle of Gissane, Calcaneal height, length and width were assessed pre-operatively and post-operatively. The functional outcome was assessed using AOFAS Score and reighton- Nebraska Score at 1,3 and 6 months.

All patients underwent surgery under spinal anaesthesia once a wrinkle sign was present in the injured site. 3.5 mm D.type, P-type and calcaneal mesh locking plates were used. In this study, G-bone was used in 7 cases – out of which three patients had Sander's type 2, and 4 patients had Sander's type 3. Investigations were carried out Complete blood count, Renal function test, Liver function test, Serology after the consent, and Random blood sugar. In addition, the American orthopaedic foot and ankle society (AOFAS) and Creighton-Nebraska score for calcaneus fracture were evaluated.

Intravenous antibiotics were given for three days. On the second post-operative day, the dressing was done. Delayed suture removal was usually done at 15-18 days post-operatively. Passive range of motion was started in the third week. The patient was advised to walk with walker support. Strict non-weight bearing with walker support till 12th week progressively weight bearing was increased to tolerance.

Data were presented as mean, standard deviation, frequency and percentage. Continuable variables were compared using the Independent sample t-test and one-way ANOVA. Categorical variables were compared using the Pearson chi-square test. Significance was defined by P values less than 0.05 using a two-tailed test. Data analysis was performed using IBM-SPSS version 21.0 (IBM-SPSS Science Inc., Chicago, IL).

Results

This study enrolled 17 male patients with calcaneal fracture treated by open reduction internal fixation with plating. In our study, the age distribution range of 17 patients ranged from 20 to 55 years, and the average age was 41.82.

Table 1: Distribution of patient's characteristics

Variable		Frequency	Percentage
Mode of injury	Fall from height	12	70.6%
	Road traffic accident	5	29.4%
Associated injuries	Left distal end radius fracture	2	11.8%
	Left olecranon fracture	1	5.9%
	Nil	14	82.4%
Side involved	Bilateral	3	17.6%
	Left	7	41.2%
	Right	7	41.2%
Diabetes mellitus	No	15	88.2%
	Yes	2	11.8%
Smoking	No	13	76.5%
	Yes	4	23.5%
Sander's type	2	11	64.7%
	3	9	52.9%

In our study, the most common mode of injury in the calcaneal fracture is falling from height (70.6%), mostly worksite injuries and remaining road traffic accidents (29.4%). Three patients had associated injuries, two patients had left distal end radius fracture, and one had left olecranon fracture. Of 17 patients, 14 unilateral and three bilateral calcaneal fracture patients were treated. 2 (11.8%) had diabetes mellitus. In addition, four patients (23.5%) had a smoking habit. 11 (64.7%) had sander's type-2, and 9 (52.9%) had sander's type-3.

The mean duration delay in presenting with injury was 1.71 days. The mean duration from injury to surgery was 6.90 days. The mean operating time was 98.25 minutes. The mean blood loss was 353 ml.

Table 2: Distribution of Wound healing at four weeks, Superficial wound infection, Implant removal, and Overall outcome.

Variable		Frequency	Percentage
Wound healing at four weeks	Fair	4	23.5%
	Good	13	76.5%
Superficial wound infection	No	13	76.5%
	Yes	4	23.5%
Delayed complications needing removal of the implant	No	16	94.1%
	Yes	1	5.9%
Overall outcome	Poor	1	5.9%
	Fair	5	29.4%
	Good	11	64.7%

The wound healing at four weeks was good for 13 patients (76.5%) and fair for four patients (23.5%). Four patients (23.5%) had superficial wound infections, and one had a deep infection that needed implant removal. (64.7%) Eleven patients had a good outcome, (29.4%) 5 patients had a fair outcome and (5.9%) 1 patient had a poor outcome.

Table 3: Distribution of Bohler's angle, Gissane's angle, Calcaneal height, Width, and Length.

Distribution		Mean and Std Deviation	P value
Bohler's angle	Pre-Op	13.86 ± 1.98	<0.0001
	Post-Op	22.74 ± 2.82	
Gissane's angle	Pre-Op	137.70 ± 3.71	<0.0001
	Post-Op	122.45 ± 3.56	
Calcaneal height	Pre-Op	3.97 ± 0.14	<0.0001
	Post-Op	4.10 ± 0.14	
Calcaneal width	Pre-Op	4.02 ± 0.18	<0.0001
	Post-Op	3.86 ± 0.17	
Calcaneal length	Pre-Op	7.04± 0.13	<0.0001
	Post-Op	7.20 ± 0.13	

Bohler's angle was 13.86 degrees and significantly improved post-operatively with a mean angle of 22.74 degrees (p<0.0001). The preoperative Gissane's angle was 137.70 degrees and significantly improved post-operatively with a mean angle of 122.45 degrees (p<0.0001). The mean calcaneal height improved from preoperative 3.97 cm to 4.10 cm post-operatively. (p<0.0001). The mean calcaneal width improved from preoperative 4.02 cm to 3.86 cm post-operatively (p<0.0001). The mean calcaneal length improved from preoperative 7.04 cm to 7.20 cm post-operatively (p<0.0001).

Table 4: Distribution of AOFAS and Creighton Nebraska score.

Distribution of score		Mean and Std deviation	P-value
AOFAS score	1 Month	49.00 ± 8.90	<0.0001
	3 Months	66.45 ± 7.34	
	6 Months	80.30 ± 8.39	
Creighton Nebraska score	1 Month	31.60 ± 6.03	<0.0001
	3 Months	55.50 ± 9.02	
	6 Months	81.65 ± 7.80	

The mean AOFAS score at 1-month follow-up was 49.0, 66.45 at three months and 80.30 at six months. The AOFAS score was improved significantly in all follow-ups (p<0.0001).

The mean Creighton Nebraska score at 1-month follow-up was 31.60, 55.50 at three months follow-ups and 81.65 at six months. The Creighton Nebraska score was improved significantly in all follow-ups (p<0.0001).

Table 5: Comparison of AOFAS and Creighton Nebraska score in sander's type.

Comparison of Score		Sander's type	Mean and std deviation	P-value
AOFAS Score	1 Month	2	52.36±8.66	0.059
		3	44.89±7.74	
	3 Months	2	68.00±8.77	0.309
		3	64.56±4.95	
	6 Months	2	82.91±10.14	0.127
		3	77.11±4.20	
Creighton Nebraska SCORE	1 Month	2	32.64±6.25	0.410
		3	30.33±5.85	
	3 Months	2	55.91±10.91	0.829
		3	55.00±6.61	
	6 Months	2	83.91±8.31	0.157
		3	78.89±6.51	

There is no statistically significant difference in AOFAS score between sander's type 2 and 3 in all three follow-ups (p=0.059). Likewise, there is no statistically significant difference in Creighton Nebraska score between sander's type 2 and 3 in all three follow-ups (p=0.410).

Table 6: Comparison of overall outcome in patient characteristics.

Variables		Overall outcome			P value
		Fair	Good	Poor	
Age group	<40	12.5%	87.5%	0.0%	0.168
	>40	44.4%	44.4%	11.1%	
Mode of injury	Fall from height	41.7%	50.0%	8.3%	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%	
	Nil	35.7%	57.1%	7.1%	
Diabetes mellitus	Yes	100.0%	0.0%	0.0%	0.066
	No	20.0%	73.3%	6.7%	
Smoking	Yes	75.0%	0.0%	25.0%	0.006
	No	15.4%	84.6%	0.0%	
Sander's type	2	0.0%	81.8%	9.1%	0.006
	3	55.6%	22.2%	0.0%	

There is no statistically significant difference in outcome between age group, mode of injury, associated injury and patients with diabetes mellitus. In 4 patients with smoking habits, 3 had fair outcomes, and 1 had a poor outcome which is statistically significant (p=0.006). In 10 sander's type 2 patients, nine (81.8%) had good outcomes, whereas one (9.1%) had a poor outcome. In 7 sander's type 3 patients, two patients (22.2%) had good outcomes, whereas five patients (55.6%) had fair outcomes. (p=0.006).

Discussion

In the past, many surgeons treated intra-articular calcaneal fractures conservatively. This may be due to fear of operative complications or lack of familiarity with operative methods. Non-operative management of DIACF (Displaced Intra-articular Calcaneal Fracture) usually results in malunion of the calcaneum. They cause impingement, dislocation or peroneal tendons subluxation resulting in instability and pain. Post-traumatic arthritis of sub-talar and calcaneocuboid-joint is also commonly encountered. In addition, hindfoot malalignment causes altered gait and sural or posterior tibial neuritis.

A controlled trial done by Pfluger P *et al*. [8] among calcaneum fracture patients concluded that though there was an excellent functional improvement in the patient undergoing surgery, conservative treatment is better than surgical procedure because of high complication rates leading to re-surgery. About every sixth person who had been surgically operated on required re-surgery.

Another study by Kamath KR *et al*. [9] compared the effectiveness of surgical and conservative treatment approaches and concluded that if Bohler's angle is restored to normal limits, surgery gives a better outcome with patient satisfaction; otherwise, conservative treatment gives fair treatment results. The complication tends to be similar in both groups. A good radiological outcome gives an excellent functional outcome after surgical treatment. Similarly, a comparative study done by Basile A *et al*. [10] among 33 elderly patients (age 65 to 75 years) in Italy stated that the surgery group had a better AOFAS score and reduced pain than the non-operative group; this difference was statistically significant (p=0.05). They also concluded that factors such as age and Sander's type didn't influence the functional outcome. The complication rate was similar to the studies done among the young age group. There was a higher incidence of subtalar arthritis (40%) among elderly patients, probably due to pre-existing changes. Thus, this indicates that surgical therapy is better than the non-operative approach, irrespective of age.

Further, in a study by Fischer S *et al*. [11] 86 patients (lateral extensile approach using locking compression plate) were divided into experienced and less experienced surgeons. This study concluded that the difference in the mean AOFAS score between the above groups is statistically significant. And also, the average duration of surgery time was less in the experienced group compared to the less experienced group.

In our study, about 64.7 percent have a good outcome, 29.4 percent have a fair outcome, and only 5.9 percent have a poor outcome.

Similarly, a study conducted by Dwivedi MS *et al*. [12] among 40 patients treated surgically for intraarticular calcaneal fracture showed excellent overall outcomes in 69 percent of patients, and about 9 percent had poor outcomes. The study described above states that the average union time is 12 weeks, and most patients return to the pre-injury functional status by six months. Similarly, in our study, the average union time was ten weeks. This may be due to the low infection rate and low incidence of complications associated with the surgical procedure.

Mostafa MF *et al*. [13] did an observational study of 18 patients to assess the outcome of open reduction (lateral extensile approach). This study concluded that all fractures completely healed in two months. About 72 percent of patients can stand and walk after four months. Thus, this lateral approach is easy and safe to practice in any setting, especially in low-resource countries. These results also support the above discussion. Bone graft substitutes provide mechanical support in cases of DIACF with bone defects of 5-10cc.

Conclusion

This study demonstrates that surgical management of intra-articular calcaneal fractures gives better results. Radiological parameters such as calcaneal height, width, Gissane's angle and Bohler's angle should be restored to produce a good functional outcome in these fractures. Sander's type 2 fracture has a better outcome than Sander's type 3 fracture. With proper soft tissue care, the wound complications rate can also be decreased post-operatively. Bone graft substitutes or not mandatory for Sander's type 2 and 3 fractures, and Chances of infection increase with the use of bone graft substitutes.

Conflict of Interest

Not available

Financial Support

Not available

Reference

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How to Cite This Article
Madhan, Aravinthan DR, Thirumalai G, Devi Prasad, Anand V. Prospective study on the functional and radiological outcome of open reduction and plating for intraarticular fractures of the calcaneum. International Journal of Orthopaedics Sciences. 2022;8(4):189-193.