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Original Research Article

Comparison of open reduction and internal fixation by lateral extensile approach versus minimal invasive percutaneous fixation (Essex-Lopresti) for the management of Sanders type 2 and 3 calcaneum fractures: a prospective, two-arm, parallel group study

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ABSTRACT

Background: Calcaneum is one of the most common tarsal bone to get fractured accounting for around 50-60% of all tarsal fractures. Due to lack of Indian studies comparing the outcomes of fracture calcaneus managed by operative methods of open reduction internal fixation (ORIF) versus the percutaneous minimal invasive approach (Essex Lopresti); we decided to conduct one such study.
Methods: Adult patients with intra-articular Sander type 2 and 3 calcaneum fractures, managed by ORIF or Essex Lopresti were enrolled. The clinical outcomes (VAS score for pain, range of motion), radiological outcomes (Bohler's and Crucial angle of Gissane) and functional outcomes (American orthopedic foot and ankle society (AOFAS) and Maryland foot score) were assessed at 6th month and 1-year post intervention and compared.
Results: 117 patients managed with percutaneous fixation (n=63) or ORIF (n=54) were enrolled. Mean age of patients was 42.63±7.93 years. Mean VAS score was statistically comparable in both operative groups at 6th month and 1 year ($p>0.05$). Mean dorsiflexion and eversion angles were significantly higher in plating group at 6th month ($p<0.05$) while other movements were comparable in both the groups. Mean Bohler's angle, Gissane's angle, AOFAS and Maryland scores were found to be comparable in both groups ($p>0.05$) on follow-up. Both groups showed similar complications trend.
Conclusions: Percutaneous fixation and plating methods were found to be comparable for calcaneus fracture management based on clinical, functional and radiological outcomes with similar complication rates.

Keywords: Essex Lopresti, ORIF, VAS, Bohler's and Gissane's angle, AOFAS, Maryland foot score

INTRODUCTION

Calcaneal fractures, predominantly caused by falls from height, account for approximately 2% of all fractures and constitute about 60% of tarsal bone fractures.[1] Research indicates a higher incidence among males, with around 90% occurring between ages 21 and 45. These fractures often result in long-term partial to complete impairment, imposing a significant economic burden on patients, their families, and society at large.[2]

The primary treatment goal for calcaneal fractures focuses on alleviating pain and restoring normal foot shape and biomechanics to facilitate the patient's walking ability. Various management approaches, ranging from non-

operative to minimally invasive and open reduction with internal fixation via a lateral extensile approach, have been outlined in literature. However, no single method has proven superior due to the complex bony anatomy, joint mechanics, and delicate soft tissue coverage.[3]

Historically, non-operative procedures utilizing below-knee casts were common due to the perceived high risk associated with open reduction and internal fixation, yet these non-operative methods often failed to maintain proper reduction.[4] This led to debates over the appropriate treatment protocol. To address these challenges, open reduction and internal fixation via an extensive lateral approach gained prominence, allowing direct visualization to restore calcaneal height and Bohler's and Gissane's angles, and maintaining them using lateral plates. However, this technique was linked to wound-related complications and, in certain cases, osteomyelitis of the calcaneum bone.

The technique of indirect reduction and percutaneous pin fixation, initially described by Westheus in 1934 and further refined by Gissane, was systematically outlined by Essex-Lopresti. This comprehensive technique, including the use of a shoe plaster to accommodate the pin, has proven effective in restoring both Bohler's angle and calcaneal height, particularly in tongue-shaped fractures.[5-7]

While open reduction and internal fixation techniques are available, they are associated with significant complications such as wound issues and sural neuritis.[8] These complications can be mitigated through the use of the indirect reduction and percutaneous pin fixation technique.

Only a limited number of Indian studies have prospectively evaluated calcaneal fracture outcomes. These studies have focused on assessing parameters like VAS pain scores, ankle and subtalar joint mobility, calcaneal angles, and functional scores during follow-up. In light of this scarcity in research, a decision was made to evaluate patients with calcaneal fractures admitted and treated at our tertiary care center. The assessment aimed to compare outcomes between plating and minimally invasive percutaneous operative procedures.

METHODS

The current prospective and comparative study was conducted in the Department of Orthopaedics at Government Medical College, Nagpur, from July 2016 to June 2019, with prior approval from the institutional ethical committee and consent from the patients taken. The study enrolled all the adult patients with calcaneus fractures meeting the inclusion criteria: aged 18-75 years and having intra-articular calcaneum fractures of Sanders type 2 and 3. Exclusion criteria comprised patients with open injuries, uncontrolled diabetes, peripheral vascular disease, Sanders type 1 or 4 fractures, associated ankle or foot injuries, or extra-articular calcaneus fractures. Surgical intervention occurred following a 7-10 day waiting period to allow for swelling reduction and the appearance of the wrinkling sign. An extensile lateral approach was employed during surgery using non-locking plates without bone grafts. Although complete swelling resolution wasn't mandatory, minimally invasive procedures required time for swelling reduction. Post-operatively, splints were removed after 2 months, initiating movement exercises at subtalar and ankle joints. Partial weight-bearing began in the 3rd month, with gradual progression based on patient tolerance in both study groups.

Clinical and radiographic evaluations were conducted on patients utilizing computed tomography (CT) scans and X-rays. The affected limb underwent radiographic assessments encompassing ankle anteroposterior and lateral views, calcaneal Harris axial view, and foot anteroposterior and oblique views. Radiological evaluations included the calculation of Bohler's angle and Gissane's angle both pre and post intervention, measured at the 6-month and 1-year marks.[9]

Clinical assessments involved the use of the visual analogue scale (VAS) score to measure pain intensity at various intervals. The VAS scores were recorded at the 6-month and 1-year points post-intervention, specifically when the patient began weight-bearing. The scale, ranging from "no pain" to "worst possible pain," utilized a 10 cm vertical score for pain assessment during weight-bearing activities. Range of motion assessments for both the ankle joint and subtalar joint were conducted pre-intervention, followed by subsequent evaluations at the 6-month and 1-year post-intervention timeframes.

Functional outcomes were assessed using the American orthopedic foot and ankle society (AOFAS) score and the Maryland foot score, two widely recognized and standardized functional grading systems extensively employed by orthopedic surgeons worldwide.[10,11]

Mean scores derived from these systems were compared between study groups at the 6-month and 1-year follow-up intervals to evaluate functional recovery. Post-interventional complications were categorized as either early or late occurrences and were meticulously recorded and expressed descriptively in the final analysis.

Statistical analysis

After data collection, data entry was done in excel. Data analysis was done with the help of statistical software GraphpadInStat. Quantitative data was presented with the help of mean and standard deviation. Clinical, radiological and functional outcomes were compared between the study groups by unpaired t test and between the time intervals by paired t test. P value of less than 0.05 was statistically significant.

RESULTS

During the study period, 117 patients treated in the study center with either open reduction internal fixation plating technique (n=54) or minimally invasive percutaneous approach (n=63) Out of these, 93 were males and 24 were females. The mean age of the patients was found to be 42.63±7.93 years. The maximum age of the patients was 57 years while minimum age noted was 23 years. The most common cause of fracture was found to be road traffic accident (RTA), seen in 53.84% cases (Table 1).

Table 1: Baseline demographic details of patients enrolled in study (n=117).

Parameters assessed	Values calculated
Mean age (years)	42.63±7.93
Maximum age of patient	57 years
Minimum age of patient	23 years
Number of males	93 (79.48%)
Number of females	24 (20.52%)
Cause of fracture	RTA: 63 (53.84%)
	Fall: 54 (46.16%)

On intragroup analysis in both the operative groups, there was a significant decrease in the mean VAS scores at 1 year compared the mean values at 6 months postoperatively ($p<0.05$). However, on comparing the mean VAS score in both the surgical groups, no significant difference was found at both 6th month and 1 year ($p>0.05$) (Table 2).

On intragroup analysis mean range of movements improved significantly at 1 year as compared to at 6 months in both the operative groups ($p<0.05$). On intergroup analysis improvement in mean dorsiflexion and eversion angle was significantly higher in open reduction group at 6th month follow up while improvement in other range of movements were found to be comparable between the two groups at follow ups (Table 3).

On intragroup analysis there was statistically significant improvement in the Bohler's angle and the Gissane's angle in both the operative groups, at 6th month follow-up as compared to the pre-operative status. However, on inter-group analysis, no difference was found between the two operative groups at 6th month and 1 year follow-up (Table 4).

On intragroup analysis the mean functional scores (AOFAS score and Maryland scores) improved significantly at 1 year as compared to at 6 months in both the operative groups ($p<0.05$). On intergroup comparison of the mean functional scores in the two operative groups, no significant difference was found at both 6th month and 1 year ($p>0.05$) (Table 5).

Table 2: Mean VAS scores at follow-up on weight-bearing in operative groups (n=117).

Time point of assessment	Mean VAS score		
	Percutaneous approach (n=63)	Open reduction (n=54)	P value*
6th month	4.93±0.66	4.69±0.79	>0.05
1 year	1.27±0.67	1.19±1.39	>0.05
P value#	<0.001	<0.001	

*P<0.05 considered significant by unpaired t test (intergroup comparison), #p<0.05 considered significant by paired t test (intragroup comparison)

Table 3: Various movements assessed at follow-up in different operative groups (n=117).

Movement assessed	Time point of assessment	Movement (mean degrees)		P value*
		Percutaneous approach (n=63)	Open reduction (n=54)	
Dorsiflexion	6th month	13.13±2.98	17.71±1.85	<0.05
	1 year	23.09±2.21	22.98±2.43	>0.05
	P value#	<0.05	<0.05	
Plantar flexion	6th month	25.92±2.71	26.54±2.77	>0.05
	1 year	48.24±2.81	48.98±2.43	>0.05
	P value#	<0.05	<0.05	
Inversion	6th month	21.25±2.63	21.95±2.57	>0.05
	1 year	33.64±2.81	34.29±2.13	>0.05
	P value#	<0.05	<0.05	
Eversion	6th month	12.02±2.55	18.18±2.12	<0.05
	1 year	23.64±2.13	24.29±2.61	>0.05
	P value#	<0.05	<0.05	

*P<0.05 considered significant by unpaired t test (intergroup comparison), #p<0.05 considered significant by paired t test (intragroup comparison)

Table 4: Bohler's and critical Gissane's angle assessed at follow-up in different operative groups (n=117).

Movement assessed	Time point of assessment	Movement (mean degrees)		P value*
		Percutaneous approach (n=63)	Open reduction (n=54)	
Bohler's angle	Preoperative	13.27±3.52	12.43±3.78	>0.05
	6th month	35.45±2.23	36.17±2.15	>0.05
	P value#	<0.001	<0.001	
	1 year	35.45±2.23	36.17±2.15	>0.05
Critical angle of Gissane	Preoperative	146.57±3.51	147.58±3.51	>0.05
	6th month	126.21±3.17	127.09±2.75	>0.05
	P value#	<0.001	<0.001	
	1 year	126.21±3.17	127.09±2.75	>0.05

*P<0.05 considered significant by unpaired t test (intergroup comparison), #p<0.05 considered significant by paired t test (intragroup comparison)

Table 5: Functional outcome scores assessed at follow-up in the operative groups (n=117).

Movement assessed	Time point of assessment	Mean scores		P value*
		Percutaneous approach (n=63)	Open reduction (n=54)	
AOFAS score	6th month	54.81±1.68	55.11±1.52	>0.05
	1 year	94.85±1.24	95.43±1.95	>0.05
	P value#	<0.05	<0.05	
Maryland score	6th month	51.91±1.21	52.25±1.95	>0.05
	1 year	90.63±1.91	91.31±2.01	>0.05
	P value#	<0.05	<0.05	

*P<0.05 considered significant by unpaired t test (intergroup comparison), #p<0.05 considered significant by paired t test (intragroup comparison)

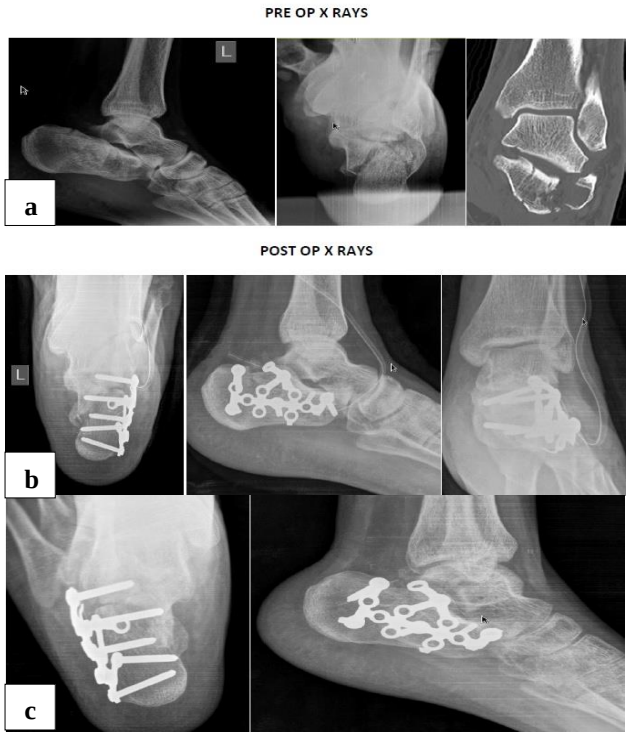

Figure 1: (a)Pre-operative, (b) immediate post-operative, and (c) 1 year post-operative radiographs of a patient with Sanders type 3 calcaneum fracture operated with open reduction and internal fixation with plating.

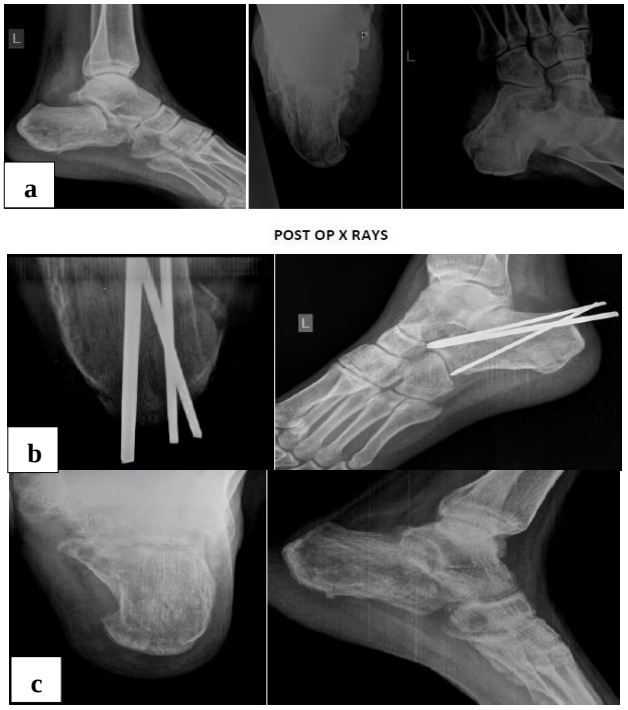

Figure 2: (a) Pre-operative, (b) immediate post-operative and (c) 1 year post-operative radiographs of a patient with Sanders type 2 calcaneum fracture managed with Essex-Lopresti minimally invasive percutaneous technique.

On assessing the complications of the patients in the two study groups, 12 patients in the percutaneous group and 9 patients in the open reduction group developed subtalar arthritis with malunion. Additionally, 6 patients in the percutaneously managed group developed malunion without arthritis. However, 12 patients in the plating group developed wound infection which was treated conservatively with antibiotics and dressing and did not require surgical debridement; while none in the percutaneous approach group developed infection (Table 6).

Table 6: Early and late complications of calcaneum fracture patients (n=117).

S. no.	Percutaneous approach (n=63)	Plating group (n=54)
1	Subtalar arthritis with malunion=12	Wound infection=12
2	Malunion=6	Subtalar arthritis with malunion=9

DISCUSSION

Calcaneal fractures often result in prolonged disability, potentially impacting patients severely on an economic level. Open reduction and internal fixation methods have demonstrated infection rates ranging from 5% to 20%, leading to chronic osteomyelitis and permanent disability. Conversely, non-operative treatments pose their own set of complications, including challenges in maintaining reduction, resulting in heel broadening, muscle imbalances, limited motion, peroneal impingement, gait abnormalities, persistent pain, early onset of subtalar arthritis, and subsequent permanent disability. In contrast, minimally invasive percutaneous approaches, such as the Essex Lopresti reduction method, have shown promising outcomes by enabling early movement without compromising the reduction achieved.

In this study, the mean age of patients enrolled with calcaneal fractures was determined to be 42.63±7.93 years, ranging between 23 and 57 years. The incidence of fractures was notably higher in males than in females, accounting for 79.48% and 20.52% respectively. These findings mirror those observed in other Indian studies on calcaneum fractures, including studies by Kawalkar et al (mean age: 34 years, males: 78.57%, females: 21.43%), Gadhavi et al (mean age group: 31-40 years, males: 81%, females: 19%), and Reddy et al (mean age: 38 years, males: 66%, females: 33%).[4,12,13]

The majority of patients in this study sustained calcaneal fractures as a result of road traffic accidents (RTAs) (63 patients, 53.84%), while the remaining cases were attributed to falls (54 patients, 46.16%). This differs from findings in other similar studies, where falls were a more frequent cause compared to RTAs. However, the discrepancy in patient numbers between the two causes in this study was marginal and might be attributed to a limited sample size or data obtained from a single center.

No Indian study was found comparing the open reduction internal fixation and the minimally invasive percutaneous procedure for calcaneal fracture. However, there are studies which have individually proven the favorable outcomes associated with both the operative procedures. In a study by Kawalkar et al, 14 patients operated by the percutaneous technique were evaluated retrospectively. The treatment outcome, as evaluated by calcaneal fracture scoring system, ranged from 63 to 94 (mean=79). The mean Maryland foot score was 73/100, with 86% of patients attaining fair to excellent results. The authors concluded that percutaneous fixation offers excellent outcomes with few complications.[4] In a study by Devendrappa et al, 20 patients who endured intra-articular calcaneum fractures were operated upon by the Essex Lopresti method, and evaluated over a period of 1 year using Creighton Nebraska Health Foundation Assessment sheet and Maryland score. The authors found that 80% of the patients had good result, while 20% had fair results based on the assessment sheet. 15 patients had excellent, 2 had good and 3 had fair results based on Maryland foot score. The authors concluded that Essex Lopresti technique results in favorable outcome along with acceptable complications.[14] In the study by Gadhavi et al, 34% patients operated by percutaneous method had AOFAS score in the category of good or excellent compared to 31% from conservative group, indicating comparable results.[12] In a British study by Griffin et al, 151 calcaneum fracture patients were treated by open reduction plating method (n=73) or non-operative method (n=78). The authors mentioned that there were no differences in patient reported general health, quality of life, or ability to return to work. Ranges of movement of the injured hind foot were comparable between treatment groups. However, the complication rates were much higher in the operatively treated group, with a 19% infection rate and an 11% requirement for secondary surgery, if any. This finding was similar to our study, where 4 out of 18 patients suffered from infections.[15] A 2014 study conducted in China compared the open reduction internal fixation method (53 patients) and the percutaneous reduction method (54 patients) for managing calcaneal fractures. The study found that there was no significant difference between the two operative groups ($p>0.05$) based on mean AOFAS score, VAS score and radiological determined variables. Open reduction group did show poor wound healing (n=6) and deep infection (n=2), while no such cases were found in the percutaneous group. The authors thus concluded that though efficacy-wise the two operative groups were comparable, percutaneous reduction leads to lower infection rates in calcaneal fractures.[16] This finding was again, similar to that in our study.

The study had some important novelty points. On extensive literature search, we found that this is one of the few studies which takes a holistic view on the outcome of calcaneum fractures, considering the clinical, functional

and radiological outcomes as well as the complications. Also, the two management strategies of percutaneous approach and open reduction internal fixation were compared with each other, which was again a strength of this study. However, study also had some limitations. The sample size was limited (117 patients) and the study was conducted at a single center. Future studies with a bigger sample size and multiple centers can help in creating strong Indian evidence pertaining to outcomes of calcaneum fracture management and validate the findings in this study.

CONCLUSION

The percutaneous fixation approach and the open reduction internal fixation method for calcaneum fracture management were found to be comparable to each other based on VAS score change, functional and radiological outcomes. However, percutaneous reduction lead to lower infection rates compared to open reduction approach. Future studies comparing the two operative approaches can add further to the evidence to substantiate the findings.

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