

# AN OBSERVATIONAL STUDY TO ASSESS FUNCTIONAL OUTCOME WITH VARIOUS METHODS OF MANAGEMENT OF INTRA- ARTICULAR FRACTURE OF CALCANEUM

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## ABSTRACT

**Aim and objectives:** *The present study assessed the functional outcome with various methods of management of intra-articular fracture of calcaneum.*

**Materials and method:** *This prospective randomized clinical study assessed the functional outcome with various methods of management of intra-articular fracture of calcaneum. The study was conducted on acute fracture of calcaneum admitted and treated in Muzaffarnagar Medical College, Muzaffarnagar UP. The student t-test was used for comparing the mean values between the 2 groups whereas chi-square test was applied for comparing the frequency. The p-value was considered to be significant when less than 0.05.*

**Results:** *The mean age of the study population was 45.90±20.57 (range = 11-80) years. There were 9 (30.0%) females and 21 (70.0%) males among the study population.*

*Ankle Society (AOFAS) Ankle Hindfoot scoring system was significantly more among Surgical treatment compared to the Conservative treatment. The mean Bohler Angle 3 months post-operatively and 6 months post-operatively was significantly more among Conservative treatment compared to Surgical treatment. Wound-healing complications were significantly more among Surgical treatment compared to the Conservative treatment.*

**Conclusion:** *The reason behind the improved results with open reduction and internal fixation in our series may be due to less traumatic techniques and stronger but malleable implants. Also locking plates for calcaneum decrease the need for bone graft, allow early weight bearing and it provides rigidity especially in osteoporotic cancellous bone.*

**Keywords:** *Ankle Hindfoot scoring system, Bohler Angle, Conservative treatment, Surgical treatment*

## Introduction

Calcaneum, the largest and strongest cancellous tarsal bone is very well designed to bear the body weight and endure a lot of stresses of daily activities.<sup>[1]</sup> The bone is hard on the outside and soft from inside because of sparse trabeculae, making it prone to impaction of articular surface, fragmentation and collapse with a high velocity impact to the heel mostly due to fall from height.<sup>[2]</sup>

Calcaneus fracture is the commonest fractured tarsal bone (60% of all tarsal bone) and in 5-10% cases both calcaneus are fractured. It accounts approximately 2% of all fractures. 10% patients of calcaneus fracture are open injuries. Nearly 10% of calcaneus fracture are associated with injuries of spine, pelvis and hip.<sup>[3,4]</sup>

Calcaneus fracture are more common in male specially in industrial workers. It is more common in age group of 21-45 years. These fractures result due to axial loading of the calcaneum, that is, fall from height, and therefore, many of these are bilateral or associated with pelvic or vertebral fractures.<sup>[5,6]</sup> Most calcaneum fractures are comminuted and intra-articular. Hence, these are difficult to treat.

Calcaneum fractures are classified into intra-articular and extra-articular fractures based on the involvement of the subtalar joint. The intra-articular fractures, based on plain radiograph, are further classified by Essex-Lopresti (1952) into joint depression- and tongue-type fractures. On plain radiograph, when the fracture line exits behind the posterior facet and anterior to attachment of Achilles tendon, it is called joint depression-type fracture. Tongue-type fracture is one in which there is a secondary fracture line which exits distal to Achilles tendon attachment, and the articular fragment remains attached to the tuberosity fragment.<sup>[7,8]</sup> A further detailed descriptive classification was given by Sanders<sup>[9,10]</sup> based on axial view computed tomography (CT) scan. According to this classification, undisplaced fractures are classified as Type I. Type II is further classified into IIA, IIB, and IIC based on the location of the primary fracture line. Type III is classified into IIIAB, IIIBC, and IIIAC. Comminuted fractures are classified as Type IV.

The treatment of displaced Intra-articular calcaneum fracture was controversial in its whole history. Some suggest conservative method and some suggest operative method but in recent scenario operative treatment is preferred by open reduction and internal fixation by plate and screws. There are some studies suggesting the use of bone cement in operative intervention for maintaining the reduction and boehler's angle for better stabilization.<sup>[11]</sup>

The management of displaced intra-articular calcaneal fractures (DIACFs) remains challenging and controversial.<sup>[12]</sup> Open reduction and internal fixation (ORIF) through an extensive lateral approach has been widely accepted and established as a standard treatment for DIACFs.<sup>[13,14]</sup> However, a fairly high wound-related complication rate has been reported with this approach, including wound edge necrosis, dehiscence, hematoma, infection and injury to the sural nerve.<sup>[15-20]</sup>

Anatomic restoration of the three-dimensional (3D) anatomy of the calcaneum is the goal of surgical management of calcaneal fractures. Over the years, various techniques have been developed to accomplish this goal. All these techniques have certain steps in common including disimpaction of the fragments, reduction of the displaced fragments either manually or percutaneously and protection of reduction with plaster pins and plaster, external fixation and open reduction and internal fixation.<sup>[21]</sup>

Operative treatments for DIACF include reduction (repositioning of the displaced bone fragments) with percutaneous pin fixation, open reduction and internal fixation (ORIF) or primary arthrodesis (joint fusion). In percutaneous fixation, Kirschner-wires (K-wires) and

pins are inserted through only minimal skin incisions. ORIF entails a skin incision through which the fracture fragments are visualised, realigned and then held in position by plate and screws. Subtalar arthrodesis (joint fusion) is generally used as a last resort and reserved for the most severe fractures or when non-union and prolonged joint pain predominate.<sup>[22]</sup> The present study evaluated this fracture on radiological basis and comparison between different treatment methods of Intra-articular calcaneus fractures.

### **Materials and method**

This prospective randomized clinical study assessed the functional outcome with various methods of management of intra-articular fracture of calcaneum. The study was conducted on acute fracture of calcaneum admitted and treated in Muzaffarnagar Medical College, Muzaffarnagar UP. The study was carried out in the period of approximately 18 months. 12 months for data collection and 6 months for data analysis.

#### ***Study procedure***

After approval from the Institutional Ethical committee all patients were selected as per inclusion and exclusion criteria. A detailed history, complete physical examination and routine & appropriate investigations were done for all patients.

All the patients were thoroughly examined including all the injuries apart from the calcaneus fracture. Based on this, proforma was fixed for every patient. Every patient was investigated; including blood profile and all possible view of x-rays and CT Scan. Based on AP View; lateral view; Harris axial view and Brodens view and CT SCAN, fracture was classified according to ESSEX-LOPRESTI CLASSIFICATION and SANDER'S CLASSIFICATION.

#### ***Study population***

The study population for operative treatment included all patient 15-65 years of age who presented with acute calcaneus fracture < 3weeks, with comminuted fracture of calcaneum, agreed with and signed the "informed consent" form, with displaced fracture >2 mm and with gustilo type 1. The study population for conservative treatment included all patient < 15 and > 65 years of age who presented with acute calcaneus fracture > 3weeks, with comminuted fracture of calcaneum, agreed with and signed the "informed consent" form, with displaced fracture < 2 mm and with gustilo type 1 fractures.

The study excluded the patients with History of drug or alcohol abuse, patient with legal incompetence., patient with physical and mental incapacity which makes it impossible to obtain consent, General or local condition adversely affecting bone physiology, patient who have participated in any other device or drug clinical trial within the previous month, Patient unlikely to cooperate or attend all scheduled visits, patient with previous calcaneus pathology, Open calcaneus fracture with Gustilo type > 1, Patient with extra articular calcaneus fracture and comorbidities such as Diabetes mellitus.

#### ***Statistical analysis***

The data was entered into the Microsoft excel and the statistical analysis was performed by statistical software SPSS version 21.0. The Quantitative (Numerical variables) were present in the form of mean and SD and the Qualitative (Categorical variables) were present in the form of frequency and percentage. The student t-test was used for comparing the mean values between the 2 groups whereas chi-square test was applied for comparing the frequency. The p-value was considered to be significant when less than 0.05.

### **Results**

The mean age of the study population was 45.90±20.57 (range = 11-80) years. There were 9 (30.0%) females and 21 (70.0%) males among the study population. (Table 1)

There were 56.7% cases of Joint depression type and 43.3% cases of tongue type fracture among the study population. Bilateral involvement was seen among 10.0%, Left side among 46.7% and Right side among 43.3% subjects. Majority of the subjects had injury due to fall (76.7%) and 23.3% were due to traffic accidents. (Table 2)

The mean Pain, Activity limitations, Maximum walking distance, Walking surfaces, Gait abnormality, Sagittal motion, Hindfoot motion (inversion plus eversion), Ankle-hindfoot stability, Alignment and American Orthopaedic Foot and Ankle Society (AOFAS) Ankle Hindfoot scoring system was significantly more among Surgical treatment compared to the Conservative treatment. (Table 3)

The mean Bohler Angle 3 months post-operatively and 6 months post-operatively was significantly more among Conservative treatment compared to Surgical treatment. (Table 4)

Wound-healing complications were significantly more among Surgical treatment compared to the Conservative treatment. (Table 5)

## Discussion

The management of intra-articular displaced calcaneum fracture has always been challenging for orthopaedic surgeons. The ultimate goal is to achieve proper anatomical reconstruction and early rehabilitation without any complications. The best treatment of this fracture remains controversial.[<sup>23</sup>]

In patients with open calcaneal fractures and multiple trauma, a temporary stabilization with an external fixator medially can be done first, and then converted to a second stage open reduction and internal fixation procedure. Sustentaculum tali screw fixation has provide the advantages of high stability, less postoperative pain, strong fixed strength, rapid functional recovery in treating Sanders type II and III calcaneal fractures.[<sup>21</sup>]

## Demographic characteristics

In current study, the mean age of the study population was  $45.90 \pm 20.57$  (range = 11-80) years. This matched with the study by *Chandramurthy et al.*, [<sup>24</sup>] the whole of the study population was between the age group of 18-60 years with a mean age of 37 years, *Feng et al.*, [<sup>25</sup>] average age of study population was 40.3 years (range of 18-66 years), *Almeida et al.*, [<sup>26</sup>] the age range was 14 to 52 years, with mean age being 32.5 years and *Dalal et al.*, [<sup>27</sup>] the mean age was 39 years with a range of 28-51 years).

The incidence of calcaneus fracture depends upon factors such as gender, age and mechanism of injury. In the study by *Somashekhar*, [<sup>28</sup>] majority were young adults and male patients in the age group between 21 to 60 years of age with a surge among mid-twenties.

In present study, there were 30.0% females and 70.0% males among the study population. The males being predominant to have calcaneous fracture was also reported by *Chandramurthy et al.*, [<sup>24</sup>] with 23 males and 2 females, *Feng et al.*, [<sup>25</sup>] included 80 men and 16 women in the study, *Almeida et al.*, [<sup>26</sup>] 30 patients were males and 3 females and *Dalal et al.*, [<sup>27</sup>] there were 90% males and 10% females.

## Mechanism of injury

In our study, majority of the subjects had injury due to falls (76.7%) followed by the traffic accidents (23.3%). This co-incided with the findings of *Mitchell et al.*, [<sup>29</sup>] the mechanism of injury being mainly fall from height (90%) and road traffic accidents/vehicular accidents among 10% and *Feng et al.*, [<sup>25</sup>] majority of the subjects had injury due to the Falling accident followed by the Traffic accident and other reasons.

*Khetan et al.* [<sup>30</sup>] observed that fall from height was the most common cause of calcaneal fracture which accounted for 68% of the fractures. In the study done by *Hammesfahr and*

*Fleming*<sup>[31]</sup> which reported 60% cases due to fall from height and *Wilson*<sup>[32]</sup> who reported 75%, it was found to be comparable to our series.

### **Type of fracture**

In our study, there were 56.7% cases of Joint depression type and 43.3% cases of tongue type fracture among the study population. This was in similarity with the findings by *Almeida et al.*<sup>[26]</sup> 31.8% had type II, 34.1% had type III and IV fractures each and *Chandramurthy et al.*<sup>[24]</sup> 68% had Sander's type III fracture and 32% had a Sander's type II fracture.

### **Side affected**

In our study, Bilateral involvement was seen among 10.0%, Left side among 46.7% and Right side among 43.3% subjects. This was quite similar to the study by *Almeida et al.*<sup>[26]</sup> there were 11 bilateral cases and 22 unilateral cases. In contrast, *Chandramurthy et al.*<sup>[24]</sup> found that left side was affected in 64% and right side in 36% cases.

### **Functional outcome**

Outcome measurements can be expressed by various scoring systems<sup>[33]</sup> or its modifications based on the author's experience of important symptoms and functional abilities. AOFAS clinical rating system the Ankle Hindfoot Scale for calcaneal area is a standard scoring system for foot function evaluation.<sup>[34]</sup> Using this standard scoring system that takes into account subjective and objective assessments enables to achieve relevant results and comparisons of different patients' studies. Finally, one has to mention optimistic findings of Melcher who followed up patients operated by ORIF 3 and 10 years after the surgery. In his study, subjective and objective results assessed after ten years were better than those achieved in a 3-year follow-up.<sup>[35]</sup>

This is in line with the findings of the studies of *Leung et al.*<sup>[36]</sup> and *O'Farrell et al.*<sup>[37]</sup> which shows better functional outcome in operated cases compared to the non-operated cases.

In the study by *Tank et al.*<sup>[23]</sup> as per Modified Rowe's score, in operative group, 40% had excellent score while 53.33% patients had good score and only 6.66% case had satisfactory outcome at 1 year follow up and observed mean Modified Rowe's score was 87 at 1 year follow up. *Rammelt et al.*<sup>[38]</sup> reported that good to excellent results were seen with open reduction and lateral plate fixation in 60 to 85 percent of cases. While in conservative group 46% had good whereas 54% cases had satisfactory to poor outcome at 1 year follow up.

A study by *Hyer et al.*<sup>[39]</sup> further showed that there was no significant loss of calcaneal height, stability or joint reduction after early weight bearing of calcaneal fractures fixed with locked plates. These outcomes were found to be due to the inherent stability of the locking plate construct.

In study published by *Schepers et al.*<sup>[40]</sup> treatment of intra articular calcaneus fracture by closed method, reported mean AOFAS score was 83, *Jain et al.*<sup>[41]</sup> observed 86.3 in their series of treatment by open method and *Dalal et al.*<sup>[27]</sup> found the mean AOFAS score was 81.25 which is comparable to other studies.

*Mahale et al.*<sup>[42]</sup> did plating for the management of the calcaneous fractures and determined the functional outcome using the modified Merle d'Aubigne Functional Scoring system which is based on severity of pain, walking capacity on toes, heel, with or without support and use of shoes. Of study population, 31.81% had excellent results, 40.90% had good result, 13.63% had fair result and 13.63% had poor results.

*Melcher*,<sup>[35]</sup> in his study followed up patients who underwent ORIF, after a period of 3 years and 10 years following the surgery. He observed that the subjective and objective results assessed after 10 years were better than those achieved after the three-year follow-up. In Sander's study, excellent or good results were seen in 73% of type-II, 70% of type-III, and 27% of type-IV fractures (Sanders classification).<sup>[43]</sup> A similar study conducted in our sub-continent where the sample size was twenty had 65% good and 35% fair or poor results at the end of a 6 months follow up period.<sup>[44]</sup>

In contrast to our study, *Kundel et al*<sup>[45]</sup> reviewed 63 patients found no difference in functional outcome between the operated and conservative groups at 10 years follow-up. *Kennedy et al*<sup>[46]</sup> found that conservative treatment was a safe, effective and cost-effective method of management and functional outcomes were similar between operated and conservative groups. *Khetan et al*<sup>[30]</sup> found no significant difference noted, with respect to the functional outcome, between the operated and non-operated group. Buckley and Meek<sup>[47]</sup> and Ibrahim *et al.*,<sup>[48]</sup> also showed equal outcomes between operative and non-operative treatment.

### **Bohler's angle**

Mean correction in Bohler angle by percutaneous method was 18.7° in series published by *Arastu et al.*<sup>[49]</sup> Mean correction  $\geq 20^\circ$  was achieved in series of intra-articular fractures treated with locking and non-locking plates by *Rak et al.*<sup>[50]</sup> In the study by *Dalal et al.*,<sup>[27]</sup> the mean correction was 22.1°.

*Buckley et al.*<sup>[14]</sup> conducted a prospective cohort study of 95 patients comparing the nonoperative treatment of calcaneum fractures to open reduction and fixation. They found that operative management which enables anatomic reduction has a better outcome than nonoperative treatment, in selected group of patients. A similar study conducted by *Paul et al.*<sup>[51]</sup> concluded the superiority of operative management, especially in those cases where the anatomic reduction of the articular surface and restoration of Bohler's angle was achieved. Previously, calcaneal fractures were mostly treated conservatively leading to increased risk of malunion, stiffness, and arthritis.

### **Complications**

ORIF for calcaneum surgery is associated with many complications. Main complications reported are related to wound healing. Complications reported in literature are heel pain, subtalar arthritis, peroneal tendon impingement and tendinitis, calcaneocuboid arthritis, surgical site infection, flap necrosis and wound dehiscence. Sural nerve can get damaged in extended lateral approach.<sup>[42]</sup>

In the study by *Tank et al.*,<sup>[23]</sup> minor complications like delayed wound healing was observed in 2 patients (13.33%) and no major complications like deep wound infection, subtalar arthritis, peroneal tendinitis and calcaneum malunion was observed in operative group. Whereas in conservative group major complications like subtalar arthritis and calcaneum malunion were seen in 75% of the patients. These results were comparable with the study by *Buckley R et al.*<sup>[14]</sup>, in which lesser complications were reported in cases with surgical interventions as compared to conservative group.

This documented by the study of *Rak et al*<sup>[50]</sup> who compared results of 42 non locking plates with 34 locking plates and found lesser complications and better results with the former.

However, in contrast, *Stapleton JJ et al*, concluded that calcaneal fractures are difficult to manage surgically and do not always give consistent results. Conservative management of displaced intraarticular calcaneal fractures results in significant deformity with posttraumatic arthrosis. In most of the cases an open approach is required to achieve anatomic reduction

and successful long-term results.<sup>[52]</sup> In the study by *Griffin D et al.*,<sup>[53]</sup> there was no symptomatic or functional advantage of operative versus non operative treatment in management of displaced intra-articular fractures of the calcaneus. According to them the risk of complications was higher after surgery. *Buckley and Meek*<sup>[47]</sup> reported a matched cohort study of 34 patients and found no significant difference in clinical and radiographic outcomes between those treated operatively and conservatively.

*Cao L et al.*<sup>[54]</sup> concluded that Sanders type II and III fractures of the calcaneus bone, treatment with a minimally invasive technique combining percutaneous reduction and locking plate fixation provided satisfactory clinical results, with a lower incidence of complications.

The limitations of our study is the small sample size of the study. Large multicentric trials may further show the efficacy of open reduction of calcaneal fractures and fixation with plates.

### Conclusion

To conclude intra articular calcaneal fractures are complex fractures which are difficult to stabilize and manage. The reason behind the improved results with open reduction and internal fixation in our series may be due to less traumatic techniques and stronger but malleable implants. Also locking plates for calcaneum decrease the need for bone graft, allow early weight bearing and it provides rigidity especially in osteoporotic cancellous bone. High cost and steep learning curve are the present limitations.

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**Table 1: Distribution of study population according to age and gender**

		Management		Total
		Conservative	Surgical	
Gender	Female	5	4	9
		41.7%	22.2%	30.0%
	Male	7	14	21
		58.3%	77.8%	70.0%
Age in years (Mean±SD)		50.93±25.55	40.87±13.00	45.90±20.57

**Table 2: Distribution of study population according to Essex-Lopresti fracture-dislocation classification, Side involved and Injury mechanism**

		Management		Total	Chi-square value	p-value
		Conservative	Surgical			
Essex-Lopresti fracture-dislocation classification	Joint depression type	10	7	17	1.339	0.512
		66.7%	46.7%	56.7%		
	Tongue type	5	8	13	3.399	0.183
		33.3%	53.3%	43.3%		
Side involved	Bilateral	2	1	3	3.399	0.183
		13.3%	6.7%	10.0%		
	Left	9	5	14		
		60.0%	33.3%	46.7%		
Right	4	9	13			
	26.7%	60.0%	43.3%			
Injury mechanism	Fall	12	11	23	0.186	0.666
		80.0%	73.3%	76.7%		
	Traffic accident	3	4	7		
		20.0%	26.7%	23.3%		

**Table 3: Comparison of AOFAS scoring system between Conservative and Surgical treatment**

	Conservative	Surgical	Mean	p-value
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	Mean	SD	Mean	SD	Difference	
Pain	26.67	6.51	36.11	5.02	-9.44	0.010*
Activity limitations, support requirement	6.25	1.86	8.67	1.53	-2.42	0.009*
Maximum walking distance	3.58	1.00	4.56	0.51	-0.97	0.008*
Walking surfaces	2.42	1.56	4.11	1.02	-1.69	0.011*
Gait abnormality	3.33	2.31	6.22	2.05	-2.89	0.012*
Sagittal motion	3.33	2.31	6.22	2.05	-2.89	0.007*
Hindfoot motion (inversion plus eversion)	2.50	1.73	4.67	1.53	-2.17	0.008*
Ankle-hindfoot stability	4.67	4.12	8.00	0.00	-3.33	0.002*
Alignment	6.17	3.76	9.11	1.02	-2.94	0.004*
American Orthopaedic Foot and Ankle Society (AOFAS) Ankle Hindfoot scoring system	58.92	20.70	87.67	13.57	-28.75	0.001*

**Table 4: Comparison of Bohler Angle at different time intervals between Conservative and Surgical treatment**

Bohler Angle	Conservative		Surgical		Mean Difference	p-value
	Mean	SD	Mean	SD		
Pre-operatively	2.27	0.32	2.45	0.37	-0.18	0.172
2 weeks post-operatively	30.66	1.77	30.33	2.32	0.32	0.684
6 weeks post-operatively	30.45	1.76	30.09	2.34	0.36	0.653
3 months post-operatively	30.24	1.75	29.39	2.35	0.85	0.046*
6 months post-operatively	30.03	1.74	29.01	2.37	1.02	0.036*

**Table 5: Comparison of Complications between Conservative and Surgical treatment**

Complications	Management		Total
	Conservative	Surgical	
No	14	11	25
	93.3%	73.3%	83.3%
Wound-healing complications	1	4	5
	6.7%	26.7%	16.7%
<b><math>\chi^2</math> value = 3.222, p-value = 0.036*</b>			