

**Original Research Article**

**Minimally Invasive Surgical Correction of Displaced Intraarticular Fractures of Calcaneum Shows better Clinical Outcome over Conventional Plating**

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**ABSTRACT**

**Background**

The gold standard treatment for intra-articular displaced fractures is open reduction internal fixation using an extended lateral approach. However, many calcaneus fractures are associated with severe soft tissue injuries, which increase the risks of skin necrosis and infections, particularly in patients who smoke or have diabetes. Surgeons have opted for less invasive techniques.

**Method**

Here we have operated 42 patients by same surgeon and followed up for minimum 1 year. Here we attempted to compare via X-ray radiographs and AOFAS, VAS, complications and compare with worldwide literature.

**Results**

In this series of 42 patients, majority of them were males (76.5%). More than 2/3rd of the cases came following a fall from height. Fracture geometry according to the Sanders classification, Type 3 (48.6%) predominant. Post surgery mean outcomes, Gissane's angle improved from 163.1 degrees to 139 degrees post-surgery and mean Bohler angle improved from 8.9 degrees to 30.6. Fractures united at an average of 13.1 weeks. As per AOFAS scoring, 57.96% cases had excellent results and 23.45% cases had good, which is statistically significant. There were

no cases of superficial/deep infection, skin necrosis, wound dehiscence, implant failure, subtalar arthritis or non-union. Early mobilisation and shorter hospital stay allowed.

### **Conclusion**

We present a simple technique which is soft tissue friendly, economic yet effective in difficult situations of displaced intra articular calcaneal fractures. Per cutaneous approach is a soft tissue preserving approach helps to avoid post operative subsidence of facet, maintains axial alignment, length and width of calcaneum.

**Keywords:** Calcaneus Fracture, Open, Percutaneous.

## **INTRODUCTION**

Calcaneus fracture is a common fracture with an incidence of approximately 2% of all fractures and is the most common tarsal fracture (> 60%) [1]. Approximately 70% of calcaneus fractures are intra-articular fractures [2]. The gold standard treatment for intra-articular fractures is open reduction internal fixation using an extended lateral approach. However, many calcaneus fractures are associated with severe soft tissue injuries, which increase the risks of skin necrosis and infections, particularly in patients who smoke or have diabetes [3–5]. Surgeons have opted for less invasive techniques to reduce risks associated with performing the lateral extensile approach. For recent years, minimally invasive percutaneous fixation has become increasingly popular [6–8] because the minimally invasive method was associated with lower complication rates, shorter hospital stays, and more rapid healing [8, 9]. However, minimally invasive surgical techniques include limited exposure, which makes achieving a satisfactory closed reduction technically demanding and difficult to accomplish [10]. Cao et al reported that a small lateral wall incision and minimally invasive plate fixation showed a good-to-excellent rate of 93.94% but did not report the wound complication rates [11]. Battaglia et al and Dayton et al reported that with external fixation for calcaneus fractures, 18 of the 50 ankles (36%) developed arthritic changes in the subtalar and 3 with sinus tarsi syndrome [12,13,14]. Post-reduction, trans articular K-wires across the subtalar joint and in some cases, across the calcaneo-cuboid joint maintained joint congruity, axial alignment, height, width and length of the calcaneum. Also, it promoted to decrease the chances of delayed collapse of the articular facet. A number of minimally invasive fixation methods have emerged in neoteric years, proffering an alternative to conventional open reduction and internal fixation with reconstruction plate and screws. These transpiring techniques include percutaneous, minimally invasive as well as arthroscopic assisted internal or external fixation approaches [15]. Mechanism wise there is a preponderance of fall from height as a mode of injury with Sanders Type 3 fracture configuration which was comparable to a study published by Wallace et al [16,17].

## **PATIENT SELECTION AND METHOD**

**PREREQUISITE:** Minimally invasive surgery is ideally done early, usually within 5 to 10 days of injury (preferably within 2 weeks). Otherwise fracture margins become sticky, causing struggle in manipulation causing inadequate reduction. Factors influencing the operative choice are:

### **Patient-related Factors**

1. Systemically critical condition of the patient, to minimize the time of surgery, e.g., polytraumatized, multiply injured patients
2. Contraindications to open reduction, e.g., severe, poorly controlled diabetes, heavy smokers, immunodeficiency.
3. Some bilateral cases.

#### **Soft-tissue-related Factors**

1. Compound fractures
2. Blistering and superficially contaminated wounds with soft tissue compromise
3. Compartment syndrome of foot.

#### **Fracture Pattern Indications for exclusion**

1. Tongue-type fracture pattern
2. Extra-articular fractures not involving weight-bearing posterior facet
3. Sander's type IIc – the fracture line is far medial so that it leaves most of the posterior facet intact

#### **Surgical procedure**

Patient is placed in the lateral position in a radiolucent table. A sheet roll is placed below the distal tibia so that the knee is kept in flexion, allowing ankle and heel manipulations. The preoperative adequate imaging secured and tourniquet is placed at mid-thigh level. We give a stab incision and pass a 3.5-mm Steinman pin from superolateral to the Achilles tendon, directed toward the anteroinferior margin, along the long axis of bone; into the tongue fragment of the calcaneum. Another 3.5-mm Steinman pin can be inserted at the posterior aspect of the calcaneum. The position of these is confirmed. Fracture reduction is performed by manipulating these two pins. Simultaneous dis-impaction and elevation of the posterior fragments is achieved. If heel widening is present, indicating mediolateral displacement of fragments, an additional ball tipped reduction clamp is used. Once fracture reduction is achieved, inserting multiple K-wires from the tuberosity into the anterior process stabilizes the fragments. Two K-wires are introduced from posterior to anterior one on medial side another on lateral side of Achilles tendon. One or two K-wires are introduced from plantar aspect toward the posterior facet. Later those are replaced by full thread canulated cancellous screws. A distractor or external fixator always kept as a backup.

#### **Postoperative Regimen**

Range of motion of ankle started on postoperative day two in simple noncomminuted fractures after dressing change. The patient is kept non-weight bearing till some consolidation occurs. This reduces late collapse of the tuberosity and development of malunions. We start full weight bearing at 3 months, after evaluating union.

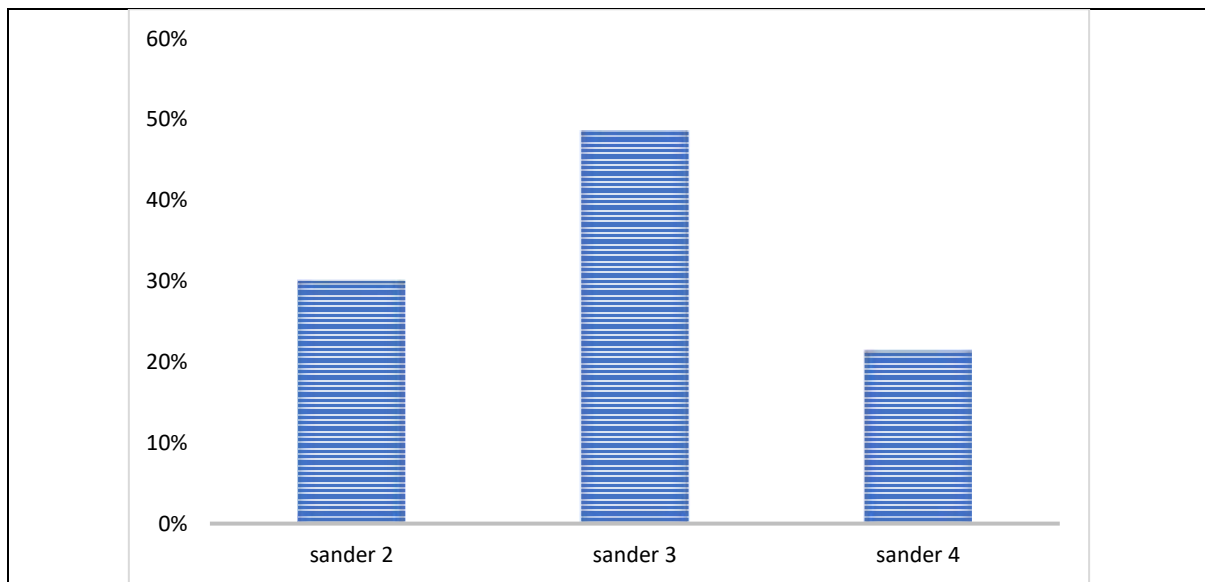
#### **Statistical Analysis**

We will use SPSS version 20 software for data analysis. Categorical variables will be expressed as number of patients and percentage of patients and will compare across the groups using Pearson's Chi Square test for Independence of Attributes.

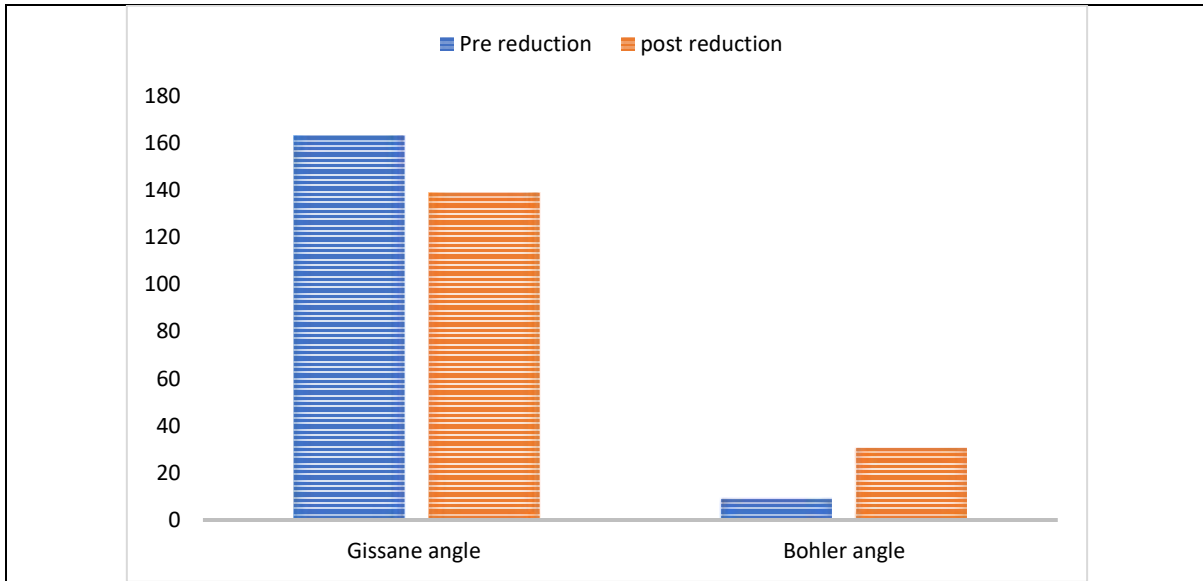
## RESULTS

In this series of 42 patients, majority of them were males accounting for 76.5% and patients were mostly in the age group between 19 to 57 years with a mean age of  $32.1 \pm 4.4$  years (p value 0.27). More than 2/3rd of the cases sustained the injury following a fall/jump from height. Fracture geometry according to the Sanders classification was: Type 2 (30%), Type 3 (48.6%), and Type 4 (21.4%) respectively (Table 1). According to Gustilo- Anderson grading, there were two cases of grade I and one cases of grade II open fractures. Cases were analysed radiologically through x rays, CT scan and clinically by AOFAS scoring system. Post surgery mean outcomes, Gissane's angle improved from a pre surgery mean of 163.1 degrees to 139 degrees (post-surgery mean) and Bohler angle improved from a pre surgery mean of 8.9 degrees to 30.6 degrees (post-surgery mean) (Table 2).

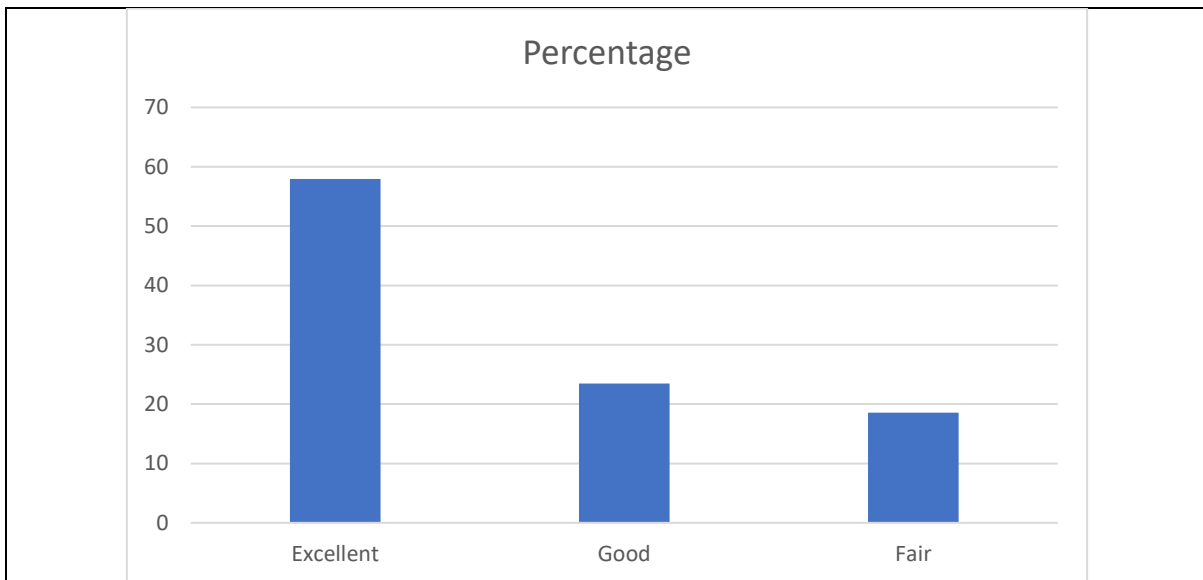
Fractures united at an average of  $13.1 \pm 2.2$  weeks (p-value 0.033). As per AOFAS scoring, 57.96% cases had excellent results, 23.45% cases had good and 18.58% cases had fair results respectively (Table 3). Regarding Post operative complications, only one paraesthesia over lateral aspect of foot but no degenerative changes of subtalar joint. There were no cases of superficial/deep infection, skin necrosis, wound dehiscence, implant failure or non-union.



***Table 1. Distribution according to Sander's classification***



**Table 2. Pre and post operative correction of Bohler's and Gissane angle**



**Table 3. Post-operative AOFAS score at 1 year follow up**



**Figure 1. Joint depression fracture**



*Figure 2. CT scan showing depression and comminution*



*Figure 3. Intra op reduction maneuver*



*Figure 4. Elevation of depressed fragment*



*Figure 5. Medio Lateral widening compressed by reduction clamp*



*Figure 6.*



*Figure 7. Post operative x rays where the pins are replaced by screws,*



*Figure 8. Post operative dorsiflexion at 3 months*



*Figure 9. Post operative Planter flexion at 3 months*

## DISCUSSION

All the fractures in our study had united by 16 weeks, both radio-clinically and the results were comparable to a study published by Meraj et al.[18] It has been reported that wound complications ranged up to 15.4% while utilizing the sinus tarsi approach.[19] In this study, no case suffered from any sort of deep wound complications as well as lateral impingement syndrome. A study published by Weber et al[20] reported 7.69% injuries to sural nerve and Yeo et al[21] stated 5% of sural nerve injuries utilizing minimally invasive sinus tarsi approach, though we have not encountered such event in our study except one patient got paresthesia.

As per the American Orthopaedic Foot and Ankle Society scoring (AOFAS), post-surgery results were satisfactory in all 42 patients with good to excellent functional outcome in 81.41% patients and returned to pre-injury status of daily activities which was comparable to the studies published by Meng et al, Wang et al and Halwai et al [22-24]. Open reduction and internal fixation through conventional extended lateral approach has been considered as a standard method for treating displaced intra-articular calcaneal fractures, however, a study done by Beerekamp et al [25] stated that approximately 15-25% patients have reported associated complications, majorly wound infection and flap necrosis. While comparing our results correspondingly with the previous published literature, the restoration of Gissane's and Bohler angle results in optimum functional outcomes.[23-27] In this series, Bohler angle improved from a pre-surgery mean of 8.9 to 30.6 degrees and Gissane's angle improved from a pre-surgery mean of 163.1 to 139 degrees and these results were comparable to a series published by Jain et al.[28] Even on 1 year of follow up, no patient had to accept subtalar arthritis. Percutaneous K wires fixation of calcaneal fractures curtails the chances of soft tissue complications and postoperative scar formation.[29,30] This minimally invasive techniques have comparable clinical and radiological outcomes with no wound infections, shorter hospital stays, and early recovery.[28-31]

We have compared our results with 5 RCTs, comparing the two operational methods of plate fixation and cannulated screw fixation for displaced fractures. The studies included 707 patients: 433 males and 274 females. The screw fixation group contained 352 patients, and the plate fixation group contained 355 Patients. Three RCTs included Sander's type II, III and



IV.[32,35,36] and two RCTs only included Sander's type II and III [34,36]. There were 303 Sanders type II fractures, 231 Sanders type III fractures, and 173 Sanders type IV fractures.

AOFAS Two studies evaluated the functional recovery after AOFAS.[33,35] Two studies provided data on excellent and good AOFAS ratings. There was no significant difference in the excellent and good AOFAS ratings between the cannulated screw fixation group and the plate fixation group (RR  $\frac{1}{4}$  1.01, 95%CI 0.91 to 1.13, P  $\frac{1}{4}$  0.79; I2  $\frac{1}{4}$  11%).

Four studies evaluated the improvement of Bohler's angle.[32,34-36] The results showed that there was no statistically significant difference between the cannulated screw fixation group and the plate fixation group (SMD  $\frac{1}{4}$  0.12, 95%CI 0.03 to 0.28, P  $\frac{1}{4}$  0.12; I2  $\frac{1}{4}$  0%).

Improvement of Gissane's angle Two studies included the Gissane's angle data.[32,36] The analysis results showed that there were no significant differences between the cannulated screw fixation group and the plate fixation group in the improvement of Gissane's angle (SMD  $\frac{1}{4}$  0.09, 95% CI 0.28 to 0.26, P  $\frac{1}{4}$  0.30; I2  $\frac{1}{4}$  0%).

Regarding complication, five studies provided data on the rate of complications with the two fixation methods.[32,36] The rates of complications were 3.69% (13/352) and 14.93% (53/355), respectively, in the cannulated screw fixation group and the plate fixation group. There were significant differences between the cannulated screw fixation group and the plate fixation group in terms of complications (RR  $\frac{1}{4}$  0.25, 95%CI, 0.15 to 0.44, P < 0.00001; I2  $\frac{1}{4}$  0%). Compared with the cannulated screw fixation group, the plate group had higher rates of infection (plate VS cannulated screw: 3.10% VS 0.28%), skin necrosis (plate VS screw: 1.40% VS 0%), calcaneodynia (plate VS cannulated screw: 3.66% VS 1.99%), wound dehiscence (plate VS cannulated screw: 3.66% VS 0%), peroneal impingement syndrome (plate VS cannulated screw: 1.41% VS 0.28%) and traumatic arthritis (plate VS cannulated screw: 2.25% VS 1.14%). All these values are comparable with our study results while comparing with the Screw fixation counterpart results.

## CONCLUSION

We present a simple technique which is soft tissue friendly, economic yet effective in difficult situations of displaced intra articular calcaneal fractures. Per cutaneous approach is a soft tissue preserving approach for screw fixation with or without sustentacular screw after anatomic reduction of posterior facet helps to avoid post operative subsidence of facet, maintains axial alignment, length and width of calcaneum. This can be safely utilized in skin at risk condition also. As the patho-anatomy is restored the functional outcome following surgery improves and it helps to reduce the incidence of subtalar arthritis also.

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