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RESEARCH ARTICLE

FUNCTIONAL AND RADIOLOGICAL OUTCOME OF SURGICAL FIXATION OF DISPLACED INTRA-ARTICULAR CALCANEAL FRACTURE- A PROSPECTIVE INTERVENTIONAL STUDY

*Arularasan Samraj¹, Madhan Kumar Velu², Lakshmikanth Manickam Ettiappan³

¹MS Orthopaedics, Assistant professor, Government Thiruvapur Medical College and Hospital, Thiruvapur, Tamilnadu, India.

²MD Community Medicine, Assistant professor, Government Thiruvapur Medical College and Hospital, Thiruvapur, Tamilnadu, India.

³MS Orthopaedics, Assistant professor, Government Madras Medical College and Hospital, Chennai, Tamilnadu, India.

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Abstract

The calcaneus is the most frequently injured tarsal bone. Calcaneal fractures have posed a challenge to orthopaedic surgeon for many years. Operative treatment of displaced calcaneal fractures has been a controversial due to tissue condition and wound infection. Anatomic restoration of the three dimensional anatomy of the calcaneum with good wound healing is the ultimate goal of surgical management of calcaneal fractures. **Aim:** To assess the functional and radiological outcome of displaced intra-articular calcaneal fractures managed by open reduction and internal fixation. **Materials and Methods:** A prospective study was conducted from June 2021 to November 2021. A total of 25 patients with intra-articular displaced calcaneal fractures were included in the study. Complete clinical and radiological evaluation was done. The surgical procedure encompassed open reduction and fixation with calcaneal locking plates. Postoperatively, on day three ankle and toe mobilization was begun. Patients were reviewed at 3 weeks, 6 weeks, 3months, 6 months and radiographs in anteroposterior, lateral view and Harrison's axial view were taken in all patients. The patient was finally reviewed at 24 weeks and assessment of ankle function was done as per the American orthopaedic foot and ankle score –Hind foot scale. (AOFAS). **Results:** Of the 25 patients under the study, Excellent outcome was seen in 11 patients (44%) and 13 patients (52%) had good outcome and 1 patient (4%) had fair outcome based on AOFAS. The average time for radiological union of calcaneal fracture was 9.24 weeks ranging from 8 to 12 weeks. **Conclusion:** In our study, Bohlers angle, calcaneal height and restoration of normal anatomy was achieved in most of the patients who underwent open reduction and internal fixation by calcaneal locking plates, which showed a significant correlation between satisfactory functional outcome and restoration of normal anatomy.

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***Corresponding Author:-** Arularasan Samraj¹; MS Orthopaedics, , Assistant professor, Government Thiruvavur Medical College and Hospital, Thiruvavur, Tamilnadu, India.
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Introduction

Calcaneum is the largest and the most commonly injured tarsal bones. Calcaneal fractures constitute about 1-2% of all the fractures, with displaced intra-articular fractures comprising 60-75% of these injuries. (1,2) Displaced intra-articular calcaneal fractures causes high morbidity and socio economic burden to patients by delaying their return to normal work. Displaced intra articular calcaneal fractures commonly results in a varus deformity with widening of heel, loss of calcaneal height and subtalar joint incongruity. Calcaneal fracture management pose a therapeutic challenge to the orthopaedic surgeons. (3,4,5) Conservative management of intra-articular calcaneal fractures rarely achieve good anatomical reduction leading to malunion of fractures and also results in early development of subtalar arthritis. Studies that compared conservative management versus open reduction and internal fixation, showed a better results in fractures treated by open reduction and internal fixation. (6,7) In recent times, with availability of modern surgical technique, low profile of implant and with better knowledge of fracture patterns and with the help of computed tomography scans, the procedure of choice for displaced intra articular fractures is open reduction and internal fixation. (2) Open reduction and internal fixation of calcaneal fractures restores the anatomy by bringing back the normal shape and alignment of hind foot with restoration of articular facet congruency, height and width of the calcaneum. (8) Open reduction and internal fixation helps in decompressing the compartment of foot there by reducing the chances of compartment syndrome and prevents the development of fracture blisters and its subsequent skin complications. Open reduction and internal fixation results in stable fixation of fractures there by allowing early mobilization of joints and early return to work in patients. It also prevents late complications such as flattening of the longitudinal arch, axial malalignment of the hind foot and development of sub talar arthritis. (3,9) Proper selection of patients for surgery, surgeon experience and soft tissue status helps in reducing the complications such as infection and delayed wound healing in open reduction and internal fixation of calcaneal fractures.

Aim:-

To assess the functional and radiological outcome of displaced intra-articular calcaneal fractures managed by open reduction and internal fixation.

Materials & Methods:-

This is a prospective interventional study of 25 patients done over a period of 6 months from June 2021- November 2021 to assess the clinical, radiological and functional outcome of displaced intraarticular calcaneal fractures at the Department of Orthopaedics and Traumatology, Government Thiruvavur Medical College and Hospital, Thiruvavur, Tamilnadu, India. The study was ethically approved and patients were informed about their participation in the study and informed consent was obtained. The study patients were selected based on following criteria.

Inclusion criteria

- Age 18 to 50 yrs
- Intra articular fractures with >2mm displacement Bohlers angle <20° Gissane angle >105°
- CT- Sanders type II,III,IV

Exclusion criteria

- Open and infected fractures Extra articular fractures and sanders type I fractures
- Peripheral neurovascular disease Uncontrolled diabetes mellitus
- Medical contraindications to surgery

Surgical procedure:

Patients with displaced intra-articular calcaneal fractures selected for as per inclusion / exclusion criteria. Patients were subjected to detailed history taking and clinical examination. Associated orthopedic and other systemic injuries were assessed and managed. Proper preoperative assessment was done with classification of

type of fracture on radiology. Open reduction and internal fixation of displaced intra articular calcaneal fracture by locking calcaneal plates were done by extensile lateral approach in all the patients in our study. Postoperatively proper dressing and wound care was done and patients were reviewed at 3 weeks, 6 weeks, 3months, 6 months and radiographs in antero posterior, lateral view and Harrison's axial view were taken in all patients. Based on the radiological union & pain tolerance gradual weight bearing was allowed.

Radiological Evaluation

All patients included in the study were radiologically assessed with the help of X-rays and CT scan. Pre-operative Bohler's angle, calcaneal height, width and type of fracture were determined. Sander's classification based on CT scan was used to classify the fracture pattern in our study.

Outcome assessment

Functional outcome was assessed using American orthopaedic foot and ankle score –Hind foot scale. (10) This scoring system analyses the patients both subjectively and objectively. Subjective analysis includes pain, walking, activity and objective analysis includes radiographic evaluation, ankle joint & subtalar joint function. Radiological outcome was done based upon the radiological parameters of calcaneum such as time taken to achieve union, post operative Bohler's angle, calcaneal height, subtalar joint congruency in all patients .

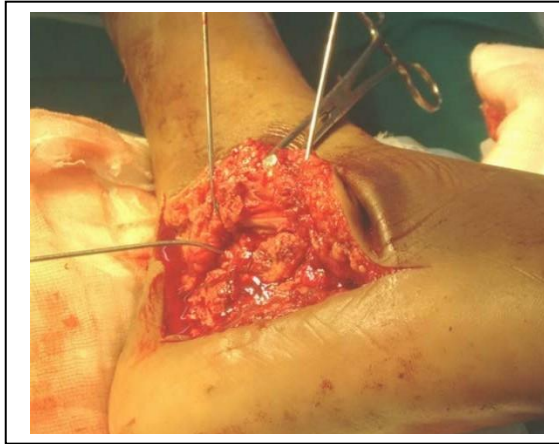


Fig1: Incision and retraction with k wire

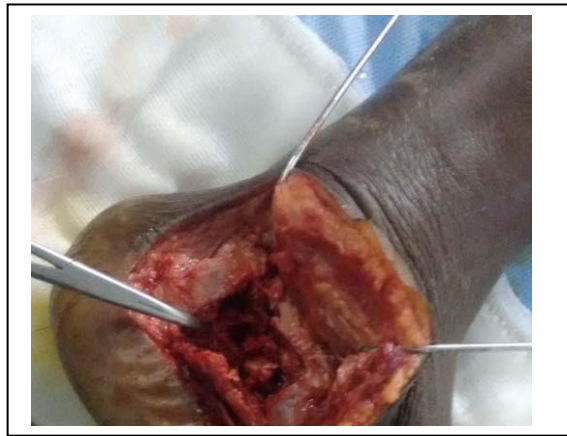


Fig 2: Plating in progress



Fig3: Fixed with Locking calcaneal plate



Fig4: Closure with number 10 drain.



Fig5: Preoperative radiograph.



Fig 6: Post-operative x-ray restoring Bohler's angle.

Statistical Analysis:

The data were entered in EXCEL sheet and further analysis was done using software SPSS 21. Continuous variables were summarized as mean and standard deviation and the significance between their mean variables was analyzed using student T test.

Observations and Results:-

Our study included 25 patients of which 17 were male and 8 were female. The mean age of the patients was 35.8 years ranging from 22 to 48 years. All the patients were taken up for the surgery once the edema has subsided and skin wrinkling has appeared. The mean time taken for surgery after injury was 12 ± 5 days with a minimum interval of 8 days to a maximum of 21 days. About 56% of patient in the study had associated fractures with spine injury being the predominant.

Table 1:- Distribution of Mode of injury.

Mode of Injury	No. of patients	percentage
Fall from Height	24	96
RTA	1	4

Fall from height was the most common mode of injury in our study group constituting 96%

Table 2:- Classification of Fracture Pattern.

Fracture pattern	No. of patients	Percentage
Type II	8	32.0
Type III	13	52.0
Type IV	4	16.0
Total	25	100.0

Out of 25 patients in the study, about 8 patients (32%) had type II calcaneal fracture, 13 patients (52%) had type III calcaneal fracture and 4 patients (16%) had type IV calcaneal fracture. Bone grafting was done in 4 patients (16%) who had type IV fractures.

Table 3:- Mean comparison of Bohler's Angle.

Parameter	Cases		T score	P value
	Preop	Postop		
	Mean \pm SD	Mean \pm SD		
Bohlers angle	11.84 \pm 3	28.5 \pm 5.1	6.07	< 0.05*

***p value <0.05 significant using Student T test**

The pre operative bohlers angle was ranging from 9° to 18° and the mean pre operative bohlers angle was 11.84 $^{\circ}$. The post operative bohlers angle was ranging from 20° to 40° and the mean post operative bohlers angle was 28.36 $^{\circ}$ and there was a statistical significance between the groups. About 12 patients had a corrected post operative bohlers angle ranging between 30° to 40° and 13 patients has a corrected post operative bohlers angle ranging between 20° to 30°

Table 4:- Mean comparison of Calcaneal Height.

Parameter	Cases		T score	P value
	Preop	Postop		
	Mean \pm SD	Mean \pm SD		
Calcaneal Height	32.7 \pm 6.7	48.5 \pm 5.1	3.07	< 0.05*

***p value <0.05 significant using Student T test**

The pre operative calcaneal height was ranging from 21 to 44mm and the mean pre operative calcaneal height was 32.7 \pm 6.2. The post operative calcaneal height was ranging from 40 to 56mm and the mean post

operative calcaneal height was $48.04 \pm 3.9\text{mm}$ and there was a statistical mean significance between these group. About 7 patients had a pre operative calcaneal height ranging between 20 to 30mm and 18 patients had a pre operative calcaneal height between 30 to 40mm. About 17 patients has a corrected post operative calcaneal height between 40 to 50mm and 8 patients had a corrected post operative valve of more than 50 mm.

Table 5:- Postoperative Assessment of Fracture union.

Union in weeks	No. of patients	percentage
8	9	36.0
9	7	28.0
10	4	16.0
11	4	16.0
12	1	4.0
Total	25	100.0
Mean \pm SD	9.24 \pm 1.2	
Range	8-12 weeks	

The radiological union was obtained in all the 25 patients (100%). The period of radiological union was ranging from 8 to 12 weeks. The mean time taken for radiological union was 9.24 weeks. All the fractures united at the end of 12th week invariably.

The subtalar joint incongruence was present pre operatively in all the patients (100%). The Subtalar joint congruence was restored post operatively in all patients with type II and type III fractures and in patients with type IV fractures subtalar congruency was restored in 3 patients. The subtalar joint congruence was not able to be restored in 1 patient with type IV fracture.

Subjective & Functional Analysis:

The main complaint of the majority of patients was pain on the lateral aspect of heel. About 16 (64%) patients had no pain during rest or activity. 8 (32%) developed slight pain on lateral aspect of the foot on excess activity. one patient (4%) who had subtalar joint incongruity experienced pain on normal activity.

On assessing the limitation of activity, walking distance and walking surfaces about 21 patients could walk and stand for unlimited time despite presence of pain in 8 patients. The remaining four patients (16%) had restriction of walking in strenuous activities and one patient (4%) had slight limping.

In the short term follow up period of 6 months with delayed weight bearing none of the patient had post operative collapse and also no varus or valgus deformity were noted in any of the patients.

Table 6:- Functional Outcome.

Functional Outcome score	No. of patients	percentage
Excellent	11	44
Good	13	52
Fair	1	4
TOTAL	25	100

The study results showed that 11 patients (44%) had excellent outcome and 13 patients (52%) had good outcome, 1 patient (4%) had fair outcome and none of the patients had poor outcome.

Discussion:-

Displaced intra articular calcaneal fractures which have devastating outcomes on non operative treatment are nowadays being treated by open reduction and internal fixation. Multiple randomised control trials done comparing operative treatment vs non- operative treatment of displaced intra articular calcaneal fractures as shown that the operative treatment of displaced intra articular fractures has resulted in good functional outcome. (6,7, 11,12,13,14)

In our study closed displaced intra articular calcaneal fractures of sanders type II, type III, type IV were managed operatively. The extra articular, undisplaced intra- articular, type I sanders calcaneal fractures, open calcaneal

injuries and calcaneal fractures associated with medical contraindication to surgery were treated either conservatively or with percutaneous k wire/screw fixation.

Open reduction and internal fixation of displaced intra articular calcaneal fracture were done by extensile lateral approach in all the patients in our study. Raising a single thick flap along with skin, subcutaneous fat and peroneal tendons helps in prevention of the feared wound complication of extensile lateral approach. [Fig1] This approach allows complete visualization of the lateral surface of the calcaneum where plate is placed and also calcaneo cuboid joint, subtalar joint. It also allows direct reduction of posterior facet and indirect reduction of sustentaculum tali and displaced medial wall fracture. [Fig 2, 3]

Our study did not use medial approach because the study conducted by Paley and Hall showed, that the medial approach is not adequate to address the lateral extrusion of bone fragment (15, 16) There is also high risk of injury to the tibial nerve and posterior tibial artery in medial approach. The medial surface being irregular with prominence of the sustentaculum tali will not allow proper placement of plate on that side.

Open reduction and internal fixation helps in restoration of subtalar articular congruency and helps in early mobilisation of subtalar joint which is important in relieving ankle from the rotational forces during walking. (17,18) Perry et al in his bio mechanical study has shown that this relieving mechanism is useful in prevention of stiffness and development of secondary arthritis.(19)

The study conducted by A.k singh showed that bone grafting in displaced intra articular fractures helped in restoration of Bohler's angles and allowed early weight bearing but the functional outcome and complication rates were similar to patients who did have bone grafting. (18) In our study bone grafting was done only in patients with type IV sanders fractures for prevention of collapse and restoration of articular congruency. Bone grafting was not done in rest of the cases. In our study post operative collapse was not seen in any of the patients. A long term follow up is needed in the future to assess the effectiveness of bone grafting.

In our study, Bohlers angle, calcaneal height and restoration of normal anatomy was achieved in most of the patients, which showed a significant correlation between satisfactory functional outcome and restoration of normal anatomy. [Fig 6] A good anatomical reduction of calcaneal fracture is needed to achieve a good functional outcome as shown by Stephenson in his studies. (20) The study conducted by paley and hall showed that the bohlers angle is an indirect reflection of both calcaneal height and arch angle. (15) Leung et al study showed an existence of significant correlation between clinical finding with regard to the subtalar joint and radiological assessment. (18)

Bohler's angle is crucial and predicts the outcome of fractures. Loss of Bohler's angle (normal 25 to 40) was associated with poor outcome and restoration following surgery resulted in excellent outcome. In our study, Bohler's angle measured preoperatively decreased to average of 12 degrees Post-operatively we were able to increase to an average of 28 degrees. (Table 3) Bohler's angle was restored in 24 (96 %) feet after 6 months of follow-up, which was comparable to study conducted by Haddad M et al., who noted restoration of Bohler's angle. (13)

A study conducted by Stephenson in which lateral side plate fixation showed that early initiation of subtalar joint motion resulted in 75% of normal movement. (20) In our study ankle and subtalar joint mobilisation was started in the 4th week of post operative period. At six month of follow up 96% of patients had normal ankle movements. Normal to mild restriction of subtalar motion was seen in 19(76%) patients, moderate restriction was seen in 6(20%) cases and 1(4%) patient had marked restriction of subtalar movements. 96 % of our patients in the study returned to their routine work at the end of 6 months.

Operative treatment of calcaneal fractures has its own complications such as wound dehiscence, chronic osteomyelitis, implant loosening, subtalar restriction and ankle restriction. (3,21). In our study only 1 patient with type IV fracture had wound dehiscence with marked restriction of subtalar movement. The patient was treated with appropriate antibiotics and flap cover. Though subtalar congruency was achieved in rest of the cases there was moderate restriction of subtalar movement in 6 patients.

Out of 25 patients in our study 11 patients had excellent functional outcome, 13 patients had good functional outcome, 1 patient had a fair functional outcome and no poor result was seen. All patients with type II sanders fractures had excellent functional outcome with good anatomical reduction and subtalar congruency. (4,22,23) Among the patients with type III sanders fracture 3 had excellent outcome and rest had good functional outcome.

In patients with type IV fractures 3 patients had good functional outcome and 1 patient had fair outcome. The subtalar congruency was not able to be achieved in one patient with type IV sanders fracture and bone grafting was done in all the four patients to restore the bohlers angle and prevent collapse.

Conclusion:-

Open reduction and internal fixation of displaced intra articular calcaneal fractures, in our study gives an excellent to good functional outcome with proper selection of patients, good preoperative evaluation , timing of surgery, achievement good anatomical reduction, rigid internal fixation with locking plates ,bone grafting in severely comminuted fractures and delayed weight bearing. Thus we conclude that open reduction and internal fixation with locking calcaneal plate is excellent treatment option with good functional outcome for intra- articular displaced fracture of calcaneum. Local skin condition, timing of surgery and soft tissue dissection are most important in determining the success of surgery and rate of infections. As serious complication rates are relatively low and most of the complications are minor, calcaneal plate should be considered as first choice of implant in displaced intra-articular fractures of calcaneum.

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