



"STUDY OF FUNCTIONAL AND RADIOLOGICAL OUTCOMES OF CALCANEAL FRACTURES TREATED WITH MINIMAL ACCESS SURGERIES"

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ABSTRACT

Background Calcaneal fractures accounting for 65% of tarsal injuries. Calcaneal fractures account approximately 2% of all fractures. Most (60%-75%) of them are intra articular. 10% have associated with spine fractures and 26% are associated with other extremity injuries. Several of these fractures are affecting both calcaneum. 90% calcaneal fractures occur in between age group of 21 to 45 yrs of age.

Aims & objectives

- To study the functional and radiological outcome of surgically managed Calcaneum fracture by minimally invasive procedures.
- To document frequency and types of complications associated with this treatment.
- To assess the various factors influencing the final outcome.

Materials & methods This study was conducted in Government Medical College Surat from 2019 to 2021. 30 patients with calcaneal fractures were to be recruited. It was prospective interventional study after institutional ethics committee approval.

Results & Discussions Fractures of Calcaneum are the most common tarsal bone fractures with overall incidence of 2% of all fractures with displaced intra-articular fractures comprising 60%-75% of the cases. Operatively treated patients with sanders type 2, 3 & 4 have better outcome with respect to pain, return to work, heel width, gait abnormalities and radiographic outcomes than patients treated conservatively. Open reduction and internal fixation with calcaneal Locking plate through an extended lateral approach is the mainstay of treatment. Due to the risk of wound dehiscence, CRIF with Cancellous screws is preferred. A clear idea about indication, contraindications and the timing of surgery are important. Preoperative CT scans are essential.

Conclusions The extended lateral approach has been considered the gold standard treatment for intra-articular calcaneal fractures. However, soft tissue complications remain a major concern, ranging from 2 to 30% with the extended lateral approach. Incidence of tongue-type fracture of calcaneum was highest in 30-39 years age group. It was more common in males than in females. The mechanism of injury was either fall from height and landing directly over the heel (93.33%) or road traffic accidents (6.66%). Restoration of Bohler's angle and angle of Gissane had significant association with functional outcome.

KEYWORDS : Calcaneal Fractures, Minimal Access Surgery

INTRODUCTION

Calcaneal fractures accounting for 65% of tarsal injuries. Calcaneal fractures account approximately 2% of all fractures. Most (60%-75%) of them are intra articular. 10% have associated with spine fractures and 26% are associated with other extremity injuries. Several of these fractures are affecting both calcaneum. 90% calcaneal fractures occur in between age group of 21 to 45 yrs of age. 1

Displaced intra-articular fractures of calcaneum typically the result of high energy trauma, such as fall from height or motor vehicle accident. Among them incidence more common in male workers. So functional outcome of calcaneal fracture plays important socio economic role among the worker families. The suitable management of calcaneal fractures is unsettled. Tracing the method of treatment of these fractures is illustrated by period of aggressive surgical fixation of these fractures and later by a period of resorting to closed treatment methods. Till the end of 19th century calcaneal fractures treated non operatively with rest and limb elevation. Advanced imaging modalities that increased desire of restoring the distorted anatomy of this bone.

The operative treatment of calcaneal fractures includes percutaneous k-wire, percutaneous screw, non-locking compression plate and locking compression plate. The controversy between the operative and non operative interventions remains ongoing as subsequent analysis and other related publications has pushed the pendulum towards the surgical option.

Research is still to be needed towards determining exactly which operative exposures, techniques, instrumentations and other parameters are ideal. 3D advancement of CT scan provides information regarding size and number of fracture fragments, sustentaculum displacement relative to the super medial fragment, posterior facet congruity and lateral malleolus.

AIMS & OBJECTIVES

- To study the functional and radiological outcome of surgically managed Calcaneum fracture by minimally invasive procedures.
- To document frequency and types of complications associated with this treatment.
- To assess the various factors influencing the final outcome.

MATERIALS & METHODS

This study was conducted in Government Medical College Surat from 2019 to 2021. 30 patients with calcaneal fractures were to be recruited, but owing to COVID 19 pandemic, the sample size was reduced to 17 patients. 2 patients were lost to follow up have not been included.

Patients with displaced intra articular fractures of calcaneum were selected and treated with open reduction and internal fixation with locking compression plate. Most of these cases resulted from fall from height. Few had history of Road Traffic Accident. The cases presented with swelling and pain of the heel and inability to walk.

All the patients were evaluated with X-ray of the calcaneum — axial, lateral and AP views along with CT scan.

The patients for whom open reduction and internal fixation was planned were treated by limb elevation, ice application and crepe bandage to reduce the edema.

Inclusion Criteria

- age above 18
- displaced calcaneal tuberosity or beak fractures
- Sander's type 2 and type 3 fractures based on CT scan

Exclusion Criteria

- Open fractures
- Fractures associated with ipsilateral limb fracture
- Associated Spine injury
- Undisplaced fracture of Calcaneum
- Patient not willing for operative intervention

Laboratory investigations: performed routinely were: Complete Blood Count, Blood grouping and typing, Serum creatinine, RBS, HIV, HBsAg

Pre Operative Protocol

All study patients in our group were initially immobilized with BK slab and limb elevation was given. For all the study patients plain radiographs (AP, lateral and Harris axial views) and CT calcaneum were taken and thoroughly reviewed to study the personality of the fracture pattern including the number of articular fragments and extent of fracture displacement, extent of overall loss of calcaneal height and length, extent of comminution through anterior process.

It is imperative to wait until the swelling resolves and the blisters re-epithelialize before proceeding with surgery. Factors such as swelling of foot and ankle, swelling associated with blisters and soft tissue damage can lead to the risk of skin necrosis and infection post-operatively. To minimize such complications strict limb elevation, ice pack compression are given. Resolution of swelling was assessed by wrinkle test i.e. skin wrinkles are seen over the lateral aspect of foot, when ankle is in dorsiflexion and eversion.

Position Of The Patient

Patient is placed in Lateral decubitus position. C-arm is placed in order to take fluoroscopy images of both Harris axial view and lateral views without changing its position.

ORIF with Sinustarsi approach

This approach is subfibular and slightly anterior and keeps the peroneal tendons inferiorly. This is a safe, simple incision, but the sural nerve is vulnerable. The lateral calcaneal artery is responsible for the majority of the blood supply to this area. This small incision is much safer than the extended L-incision. It is smaller and is not compromising any skin on the lateral side of the foot. Correct timing of surgery is the most important factor in preventing local wound complication. Early surgery may be appropriate for percutaneous sinus tarsi reduction if foot swelling is not severe. First the skin and then the peroneal retinaculum are incised. Tendons and sural nerve are protected inferiorly. Then the subtalar joint is found and entered. Fracture reduction is achieved under IITV guidance.



Figure: Surface marking for sinustarsi approach

CRIF with Cancellous screw fixation/k-wire fixation

In our study group 4 patients treated with CRIF with Cancellous screw fixation and 6 calcaneal fractures treated with k-wire fixation

For the following patients a) sanders type -2 fracture and type-4 fractures b) displaced calcaneal tuberosity fracture. Reduction of articular surface by simple manipulation through schanz pin and assessed under c-arm. Placement of guide pin is confirmed with lateral and Harris axial view of ankle. Definitive fixation achieved with large cannulated (6.5mm ,4mm)

Post Operative Management

In our study patient Limb elevation, intravenous antibiotics for five days. Closed suction drainage is kept for 24 — 48 hours. Short leg splint is removed at fifth post operative day. If the flap shows uncomplicated healing and the wound is healthy, early active range of motion is begun at that time. At second Postoperative week, active range of motion of the ankle joint is started and gentle passive movement of sub talar joint done. Suture removal at 2weeks. Touch toe Weight bearing is allowed after 12 weeks, till that protection can be provided with removable posterior splint. Full weight bearing is allowed only when there is sign fracture union (i.e.) obliteration of fracture line.

Strict limb elevation until swelling subsides and then gentle ankle and toe movements are encouraged Strict non weight bearing for 6 to 8 wks

Partial weight bearing allowed after confirming radiological signs of union. Full weight bearing allowed after confirming fracture union.

Follow up

All patients were followed up once in two weeks for the first 6 weeks, then once in a month for 6 months and then the patient is reviewed once in 3 months. In each follow up, X rays were taken to assess radiological union, surgical scar examined, range of movements checked and appropriate rehabilitation advised which was custom made for each patient depending on his fracture pattern and radiological healing. The minimum follow-up period was 6months and the maximum was 24 months with an average follow up period of 13 months. Functional outcome of the patients is assessed by AOFAS score, only when the patient was able to walk. So in our study group assessment was done with period varying from 12 wks - 6 months

Functional Assessment of Our study population based on American Orthopedic Foot And Ankle Society Scoring system

	points
1. PAIN	
None	40
Mild	30
Moderate	20
Severe	0
2. ACTIVITY LIMITATION	
No limitation	10
Limitation only in recreational activity	7
Limitation both daily and recreational activity	4
Severe limitation of daily activities	0
3. WALKING DISTANCE	
Greater than 6 metres	5
4-6 metre	4
1-3 metre	2
Less than 1 metre	0
4. WALKING SURFACES	
No difficulty	5
Some difficulty	3
Severe difficulty	0
5. GAIT	
None	8
Obvious	4
Marked	0
6. SAGITAL MOTION (flexion and extension)	
Normal or mild restriction	5
Moderate restriction	3
Marked restriction	0
7. HIND FOOT MOTION (inversion & eversion)	
Normal or mild restriction	6
Moderate restriction	4
Severe restriction	0
8. HIND FOOT STABILITY	
Stable	8
Unstable	0
9. ALIGNMENT	
Good	15
Fair	8
Poor	0
EXCELLENT >85	
GOOD 70-85	
FAIR 55-70	
POOR <55	

Figure: AOF Asscore

OBSERVATIONS & RESULTS

1) Sex: In our study the total number of male patients were 12 and female patients were 3.

Table1: Number of male and female patients from the sample population

Sex	Number	Percentage
Male	12	80%
Female	3	20%
Total	15	100%

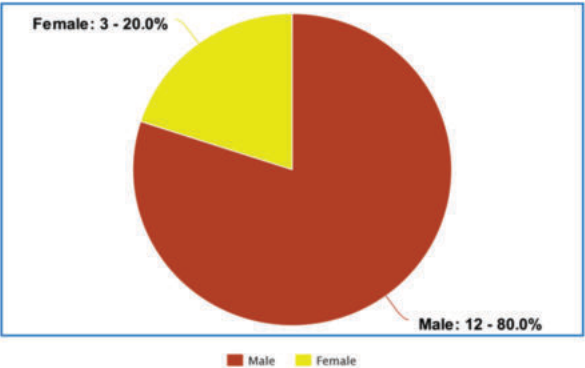


Figure: Sex distribution of patients

2) Age: The number of patients in age group 20-29 years was maximum i.e. 7. While there were 6 patients in the age group 30-39 years. Only 1 patient was younger than 20 years

Table 2: Age distribution of the patients

Age	Number	Percentage
<20	1	6.66
20-29	7	47
30-39	7	47

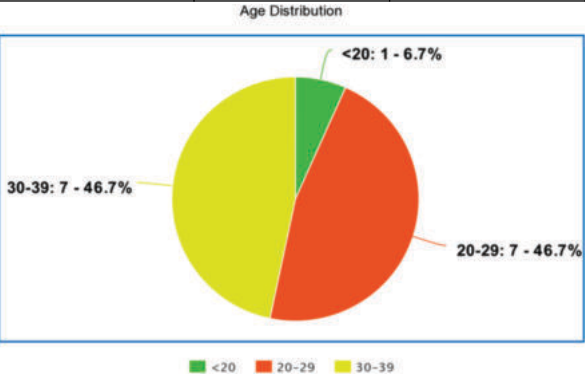


Figure: Age distribution

3) Mode of Injury: Fall from height was the most common mode of injury as recorded in 14 patients. While only 1 patient had a history of road traffic accident as the causative factor.

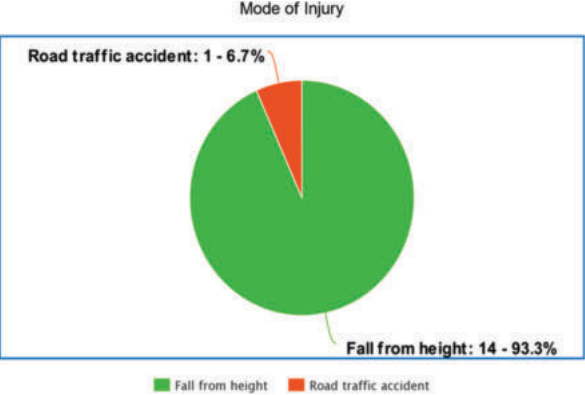


Figure : Mode of injury

Table3:Mode of injury leading to calcaneal fractures

Mode of injury	Number	Percentage
Fall from height	14	93.33%
Road traffic accident	1	6.66%

6) Sander's classification: In this study, out of 15 patients, 3 patients had sander's type 3 calcaneal fractures which are based on CTscan. 12 patients were classified as sander's type 2.

Table4:Sander'sclassification

Sander'sclassification	Number	Percentage
Type2	12	80
Type3	3	20
Total	15	100.0

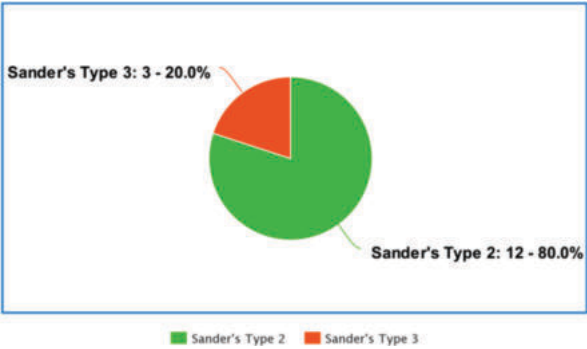


Figure :Sander'sclassification

4) Timing of surgery: In our study patients who were operated early had good functional outcome. Patients operated less than 5 days from trauma had a better functional outcome as assessed by AOFAS score than those operated between 5-10 days and more than 10 days from trauma. Those patients whose surgery was delayed owing to blisters or swelling were given limb elevation/ice application/tablet serratiopeptidase till the local condition was suitable for surgery.

Table5: Timing of surgery post trauma

Timing of surgery	Number	Mean AOFAS	p value
<5days	5	85	0.456735
5-10days	7	78	
>10days	3	78	

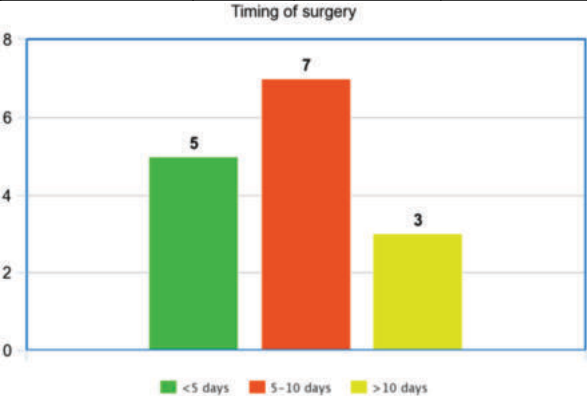


Figure: Timing of surgery

5) Bohler's angle: Mean pre-operative Bohler's angle was 12.26° with majority (14 patients) having angle between 10°-15° which was increased to a mean angle of 16.86° post-operatively (Normal range 20°-40°)

Table 6:Pre op Bohler'sangle

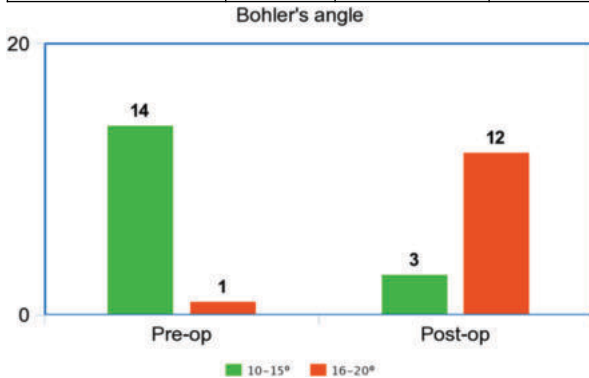
Pre-op Bohlers angle	Number	Percentage
10-15	14	93.33
16-20	1	6.66
Total	15	100

Table7:Post op Bohler'sangle

Post-op Bohlers angle	Number	Percentage
10-15	3	20
16-20	12	80
Total	15	100.0

Table 8:Post op Bohler's angle correction had significant association with functional outcome measured by AOFAS score with p value <0.05

Post-op Bohlers angle	Number	Mean AOFAS	P Value
10-15	3	69.66	0.0474
16-20	12	80.25	

**Figure :Bohler's Angle**

5) Angle of Gissane: Mean preoperative angle of Gissane was 149.73° with 8 patients having angle between 141°-150°; 6 patients having angle between 151°-160°. Mean postoperative angle of Gissane was 144.8° (Normal range 120°-140°)

Table 9:Pre op angle of Gissane

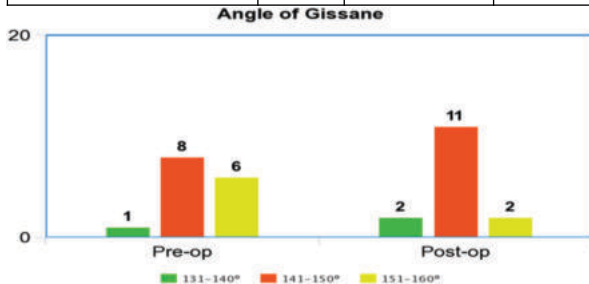
Pre-op angle of Gissane	Number	Percentage
131-140	1	6.66
141-150	8	53.33
151-160	6	40
Total	15	100

Table10: Post op angle of Gissane

Post-op angle of Gissane	Number	Percentage
131-140	2	13.33
141-150	11	73.33
151-160	2	13.33
Total	15	100

Table11: Post op angle of Gissane correction showed a significant association with AOFAS score as p <0.05

Post-op angle of Gissane	Number	Mean AOFAS	P Value
131-140	2	88.5	0.005576.
141-150	11	80.25	
151-160	2	77.45	

**Figure: Angle of Gissane**

6) Range of movements: Normal range of dorsi flexion of ankle is 10-30 degree and plantar flexion is 20-50 degree. Post operatively we achieved dorsi flexion of 10 degree and plantar flexion of 15 degree in 13 patients. 2 patients had restriction of movement.

6) Type of procedure and outcome:

In this study of 15 patients 4 patients who underwent ORIF with plating had mean AOFAS score of 78.5, 1 patient who underwent ORIF+Cancellous screw fixation had AOFAS score of 80 and 10 patients who underwent percutaneous screw fixation had AOFAS score of 77.6.

Clinical examination of surgical scar, ankle-hind foot alignment, walking surface and ability to squat were assessed at each follow up. Clinical & Radiological signs of union were also recorded. Functional outcome was analyzed based on AOFAS score and the results were calculated at the end of our study period, based on the findings recorded at the final follow up of each patient. In our study, 3 patients had excellent outcome, 9 patients had good outcome and 3 patients had fair outcome.

Table12: Type of procedure and outcome

Procedure	Number of fractures	AOFAS score	p value
Sinustarsi+Plating	4	78.5	0.018189
Sinustarsi+CC Screw	1	80	
CRwithpercutaneous fixation	10	77.6	

7) Complications: Out of 15 patients, 3 patients had heel widening, 3 patients had subtalar arthritis and only 1 patient had superficial wound infection which was managed with antibiotics and daily dressing. The patient who developed superficial wound infection was operated on 5th day post trauma which could be possibly due to surgical intervention prior to local tissue condition adequacy, indicating a need for proper patient selection and appropriately delaying surgery if needed.

Table13: Complications like superficial wound infection, heel widening and subtalar arthritis were noted.

Complication	Number	Percentage
Superficial wound infection	1	6.66
Heel widening	3	20
Subtalar arthritis	3	20

DISCUSSIONS

Fractures of calcaneum are the most common tarsal bone fractures with overall incidence of 2% of all fractures with displaced intra-articular fractures comprising 60%-75% of the cases. Intra-articular fractures occur after eccentric axial loading of the talus on the calcaneus. The first widely accepted classification was proposed by Essex lopresti in 1952 based on involvement of sub-talar joint. Soeur and Remy⁽²¹⁾ devised a classification system for intra-articular fractures in 1975 based on mechanism of injury and taking sustentacular fragment as the key to surgery. With the advent of CT scan, a new classification system was developed by Crosby and Fitzgibbons based on posterior facet. Sanders et al proposed a classification system based on coronal view of CT scan, in which 3 fracture lines A,B,C Separate the posterior facet of the calcaneus into 4 potential pieces. The literature review says it is the most widely accepted classification as it considers both fracture pattern and also guides further treatment course. Operatively treated patients with sanders type 2,3 & 4 have better outcome with respect to pain, return to work, heel width, gait abnormalities and radiographic outcomes than patients treated conservatively. Open reduction and internal fixation with calcaneal Locking plate through an extended lateral approach is the mainstay of treatment. Due to the risk of wound dehiscence, CRIF with Cancellous screws is preferred. A clear idea about indication, contraindications and the timing of surgery are important. Preoperative CT scans are essential. Sub talar incongruity or penetration of implants into the joint may cause late arthritis during long term follow up. In our study, pre op Bohler's angle of 10-15 degree was restored to 15-20 degree in 12 patients. The P value for pre op and post op value of Bohler's angle was

0.0474 and the P value for angle of Gissane was 0.005576, showing that restoration of Bohler's angle and angle of Gissane had a significant role in functional outcome similar to what is observed in the studies conducted by Joseph D. Isaacs et al in 2013 and Vishal et al in 2016.⁽²⁶⁾ Joseph D. Isaacs et al concluded that Bohler's angle serves as a useful screen tool in calcaneal fractures. Vishal et al concluded that ORIF of clinical fractures yielded good clinical outcome if Bohler's angle more than 10 degree is achieved. This is similar to the results observed in our study where patients with Bohler's angle of 16-20 degree had a better functional outcome with mean AOFAS score 80.25, whereas patients with Bohler's angle of 10-15 degrees had a mean AOFAS score of 69.66. It was also noted in the study that there was a significant correlation between angle of Gissane and AOFAS score (P less than 0.05) And significant correlation between Bohler's angle and AOFAS score (P<0.05). In our study, mean AOFAS score was 85 when the timing of surgery was less than 5 days and it decreased to 78 when the timing of surgery was delayed by more than 5 days showing that early fixation of calcaneal fractures plays a definite role in the functional outcome⁽¹⁶⁾ In our study 1 patient had immediate post op complication which was that of superficial wound infection. Benirschke and colleagues reported that a sufficient reduction of swelling occurred 5 days after injury to allow surgical ORIF.^(32,33) The patient who developed superficial wound infection was operated on 5th day post trauma which could be possibly due to surgical intervention prior to local tissue condition adequacy, indicating a need for proper patient selection and appropriately delaying surgery if needed.^(31,32)

The study conducted by A.K singh et al it was concluded that intra- articular fractures treated with internal fixation and bone grafting, patients were able to return to full weight bearing earlier than those treated without bone grafting. However the long term efficacy in both the groups was similar showing that patients treated without bone grafting have functional outcome as good as patients treated with bone grafting⁽³³⁾

CONCLUSIONS

15 cases of fracture of calcaneum which were admitted in Government Medical College, New civil hospital surat, were studied. The statistical data and analysis of the cases studied during this period are presented in this study. The extended lateral approach has been considered the gold standard treatment for intra-articular calcaneal fractures. However, soft tissue complications remain a major concern, ranging from 2 to 30% with the extended lateral approach. We performed either closed reduction and percutaneous CC screw insertion or open reduction through the sinus tarsi approach internal fixation was performed using only screws or screws and plate. Incidence of tongue-type fracture of calcaneum was highest in 30-39 years age group. It was more common in males than in females. The mechanism of injury was either fall from height and landing directly over the heel (93.33%) or road traffic accidents (6.66%). Restoration of Bohler's angle and angle of Gissane had significant association with functional outcome.

All cases were operated by either Sinus tarsi approach with screw fixation alone/screw + plating or Essex-Lopresti method of Percutaneous pin fixation and closed reduction. The timing of the surgery and patient selection is a vital determinant for the treatment outcome and determined by subsidence of edema and appearance of wrinkle sign. Those cases which were taken up for fixation within 10 days had good results than those which were operated later. The outcome was excellent in 20%, Good in 60%, Fair in 20% and Poor in none. Follow up range from 6 months to 1 year with an average of 9 months. There were no cases of major soft tissue complications, non-unions, or collapses of the intra-articular calcaneal fracture of the posterior facet. Subtalar Arthritis development was seen in 3 patients (20%), all 3 patients

ending up having fair results. Heel widening was encountered in 3 patients (20%). In this study, AOFAS scores were strongly correlated with the postoperative reduction quality of the posterior facet fracture. They were also moderately correlated to the restoration amount of the Bohler angle and with restoration of angle of Gissane. The restoration of Bohler's angle was not achieved in the normal range however it was restored as close to normal as possible. The sinus tarsi approach may be a good alternative for treating displaced intra-articular calcaneal fractures in select cases (Sanders type II and III) while reducing major soft tissue complications that are associated with the extended lateral approach.

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