

Operative Management of Calcaneal Fractures using Mippo Technique

Parvez Ahmad Ganie¹, Mudasir Ahmad Bhat², Wajahat Ahmad Mir³

ABSTRACT

Introduction: Calcaneal fractures continues to be a topic of controversy in terms of the optimal management modality. Current study aimed to access the sinus tarsi approach for the fixation of calcaneal fractures in terms of radiological and functional results.

Material and Methods: Study was conducted on 30 patients of both genders aged between 20 and 60 years with both joint depression and tongue type fractures, Sanders type 2 and type 3 fractures.

Results: In our study, as per AOFAS Scale at 3 months, 19 (63.33%) calcaneum cases fell into the excellent group, 9 (30%) into good and 2(6.66%) into poor result group. The Mean \pm SD AOFAS scale was 78.43 \pm 7.17 (range 55-85). At 6 months, the result as per AOFAS scale showed further improvement with 28 (93.33%) calcaneum cases falling into the excellent group and 2 (6.66%) falling into the good result group. None of them fell in poor group at 6 months follow up. The Mean \pm SD AOFAS scale was 90.03 \pm 5.24 (range 74-95).

Conclusion: Fixation with plate using MIPPO technique through sinus tarsi approach is an effective and safe method with good clinical and radiological results, for the treatment of calcaneal fractures; to achieve anatomical restoration under vision, stable fixation and early mobilization with minimal soft tissue complications.

Keywords: MIPPO (Minimally Invasive Percutaneous Plate Osteosynthesis), ORIF, ROM, AOFAS, GCA (Gissane's Crucial Angle), GA (Gissane Angle), RTA, FFH, LCP, BA (Bohler's Angle), BTJA (Bohler's Tuber Joint Angle)

INTRODUCTION

Calcaneus is the most common fractured tarsal bone, accounting for 75% of intraarticular fractures involving the subtalar joint.¹ Conservative management is associated with broadening of the hind foot, decreased subtalar motion, muscle imbalance, peroneal tendon impingement and secondary osteoarthritis.² Operative management of calcaneal fractures also poses a significant fixation and reconstruction challenge to the surgeon. This challenge has its roots in the fact that there are three functionally interrelated joints that need to be reconstructed. Open reduction and internal fixation of the calcaneal fractures is most commonly done through the extensile lateral approach.³ However this approach is often beset with problems like soft tissue trauma, disturbed wound healing and necrosis.⁴ The rate of skin necrosis is reported to be 2-11%, infection rate ranges from 1.3-7% and extended approaches have been reported to give a complication rate of 25%.^{5,6,7} These reports highlight the need for a better and optimal approach to calcaneal fixation.

This has led to the development of a surfeit of approaches to the calcaneus. Some of these approaches are lateral, obtuse angled, medial and a combination of the medial and lateral approaches.⁸ Not only are these approaches inherently beset with complications, but they can be disastrous in patients with diabetes, smokers, patients with vascular impairment. They are also problematic in patients with fracture blisters or compounding.⁹ These reasons make the minimally invasive techniques attractive. There are four types of minimally invasive methods.¹⁰

1. Percutaneous methods
2. Distraction by external fixators
3. Ligamentotaxis with percutaneous screw fixation
4. Sinus tarsi approach

Closed reduction and percutaneous screw fixation is a widely reported minimally invasive surgical treatment in the literature to date, which can effectively avoid wound complications due to small incision. However this method seems to be more suitable for these cases with more complete calcaneal fracture fragment and moderately displaced fracture because of the limited screw fixation strength. Thus combined plate fixation is advocated. This study was undertaken to study the sinus tarsi approach for plate fixation of calcaneal fractures.

MATERIAL AND METHODS

This study was conducted on 30 patients at Skims Medical College, Bemina from July 2016 to May 2018. Literature was taken as the historical control. Patients of both genders aged between 20 and 60 years with both joint depression and tongue type fractures, Sanders type 2 and type 3 fractures and the patients who gave the consent for surgery were included. Patients with open calcaneal fractures, associated injuries like spinal fractures, head injury, diabetes, peripheral vascular disease. Sanders type 4 fractures, skin necrosis, patients with osteoporosis as assessed by Jhamaria Lal Index [101] and bilateral calcaneal fractures were excluded. All patients who met the criteria were admitted and following

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investigations were carried out:

X-RAY

Lateral View In intra-articular fractures: To assess loss of height of posterior facet, reduced Bohler angle and increased/decreased Gissane angle

Harris Axial view to visualise tuberosity fragment widening, shortening and varus positioning.

Brodens view with ankle in the neutral dorsiflexion, X-ray is taken at 40, 30, 20, and 10 degrees which is useful in evaluation of intraoperative reduction for posterior facet

4, AP View Ankle to demonstrate lateral wall extrusion causing fibular impingement

Points that were observed on radiographs

1. Grade of Bohler angle
2. Change in Gissane angle
3. Calcaneal width, height and length

CT Scan

Was done in all calcaneal fractures. Surface shaded display was also used.

Sections

1. 30 Degree semi-coronal section reveals articular surface of the posterior facet, Sustentaculum, Shape of heel, Position of the peroneal and FHL tendons
 2. Axial Images reveal calcaneocuboid joint, antero inferior aspect of posterior facet, Sustentaculum
 3. Sagittal Section demonstrates tuberosity displacement
- In addition all baseline investigations were carried out.

On the basis of radiological investigations the fracture were classified as per Essex Lopresti and Sander's classification systems.

All feet were splinted and elevated. Cold sponging was done to decrease the swelling (wrinkle sign). Surgery was conducted within 10 to 14 days of injury.

Procedure: Patients were positioned in lateral position in such a way that all views (axial, lateral and Broden's) are possible intraoperatively. Procedure was done under spinal anaesthesia and under tourniquet control. After preparing the part, painting and draping was done.

Surgical Landmarks (Fig.1)

- Tip of Lateral malleolus
- Base of 5th metatarsal
- Anterior process of calcaneum

Incision: A small horizontal incision (3 to 5cm) was made on lateral aspect from the tip of lateral malleolus to anterior process of calcaneus (Fig.2 and 3)

By this sinus tarsi was approached and was cleaned.

Reduction: Reduction was done directly and indirectly Tuberosity was reduced over the sustentacular fragment by two 4.5 mm steinman pins /shanz screw inserted axially and laterally (Fig.4)

Elevation of Fragment: Depressed fragment was elevated by a schanz pin or periosteal elevator or by both. Compression of the heel was done to reduce the width. Reduction was maintained with the help of k-wire.

Plating: A tunnel was made beneath the peronei tendons with the help of periosteal elevator. Plate was slid into the position and locked with the help of multiple locking screws after assessment by Broden's, Axial and Lateral views (Fig.5 and 6). Wound was sutured after thorough normal saline wash. Short leg slab was applied for one week. Slab was removed after one week and ROM ankle exercises were started. Weight bearing was delayed till union was confirmed radiologically.

Follow up:

- 1 Week to check the wound and start ROM exercises.
- 3 weeks for suture removal and radiological assessment.
- 6 weeks for radiological assessment.
- 3 months for radiological and clinical assessment.
- 6 months for radiological, clinical and functional assessment.

Radiological Assessment

1. Bohler angle
2. Gissane angle
3. Calcaneal height
4. Calcaneal width
5. Calcaneal length

RESULTS

Mean age of patients was 33.73 ± 9.66 years (range 21-53 years). Most of the patients were in age group 20-30 years. Majority of the patients in our study were males. Most common mode of injury in our study was FFH followed by RTA.

Majority of patients pre-op Bohler Angle was between 1 and 10 degrees (mean =5.13°) while in Post-op period Bohler Angle in majority of patients was between 20 and 30 degrees (mean 26.5°) as shown in table 1. The decrease in Bohler angle from 3 weeks to 6 months post-op is by 1.5 degrees which is statistically significant (p<0.001).

Gissane Angle in majority of patients in Pre-op period was between 90 and 110 degrees (mean =102.16°) while in Post-op period Gissane Angle in majority of patients was between

	Mean ± SD	p-value (comparing with baseline)
Pre-op	5.13± 6.19	-
3 weeks	28.0± 2.92	<0.001
6 weeks	27.62± 3.01	<0.001
3 months	27.23± 2.95	< 0.001
6months	26.5± 3.18	<0.001

Table-1: Distribution of Patients according to Bohler's Tuber Angle

	Mean ± SD	p-value (comparing with baseline)
Pre-op	102.16± 7.56	-
3 weeks	118.53± 7.11	<0.001
6 weeks	118.37± 7.17	<0.001
3 months	117.42± 7.12	< 0.001
6months	116.83± 7.35	<0.001

Table-2: Distribution of Calcaneum Cases according to Gissane's Crucial Angle

AOFAS Scale	Number of calcaneum cases at 3 months	Number of calcaneum cases at 6 months
>80(Excellent)	19	28
70-79(Good)	9	2
60-69(Fair)	0	0
<60(Poor)	2	0

Table-3: Distribution of calcaneum cases according to American Orthopaedic Foot and Ankle Society Ankle-Hind Foot scale

Type of pain	No of Patients		Score
	3M	6M	
None	11	20	40
Mild, occasional	16	10	30
Moderate, daily	3	0	20
Severe, almost always present	0	0	0

Table-4: Distribution according to type of Pain

Activity limitation	No of Patients		Score
	3M	6M	
No limitations, no support	4	25	10
No limitation of daily activities, mild limitation of recreational activities, no support.	15	5	7
Limited daily and recreational activities, cane	10	0	4
Severe limitation of daily and recreational activities, walker, crutches, wheelchair, brace	1	0	0

Table-5: Distribution according to Function



Figure-1: Surgical Landmarks



Figure-2: Exposure of Sinus Tarsi; Figure-3: Creation of Subtalar Tunnel

110 and 130 degree (mean=116.83°) as shown in table 2.

Distribution according to Calcaneal Width

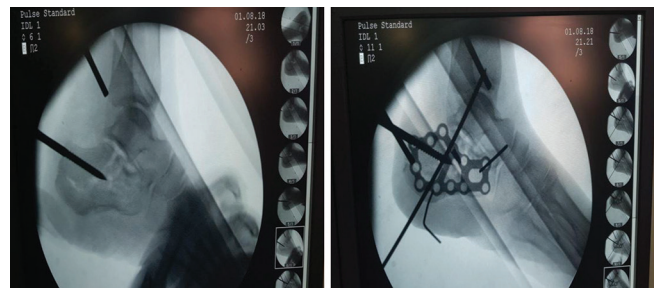
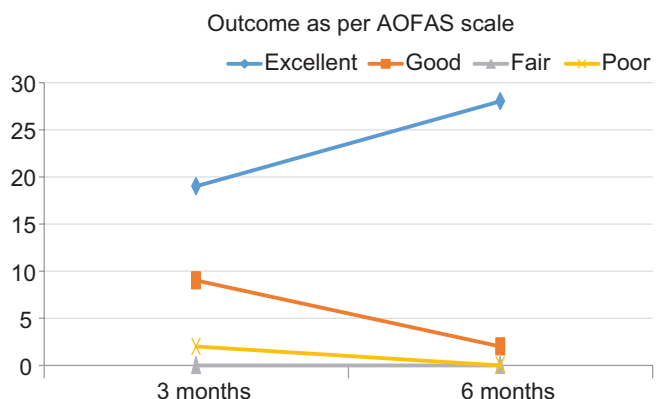


Figure-4: C-Arm Picture of Reduction using Shanz screw, Figure-5: Fixation of Fracture with Plate



Figure-6: Final C-Arm Picture



Graph-1:

In Pre-op period Calcaneal width in majority of patients was between 36 and 40 degrees (mean=37.07), while in Post-op period Calcaneal width in majority of patients was between 31 and 35 degree (mean=32.93°).

Distribution according to Length

Calcaneal Length in Pre-op period in majority of patients was between 51 and 65 degrees (mean 58.9°), while in post-op period majority of patients had Calcaneal Length between 56 and 70 degree (mean 64.87°)

Distribution according to Calcaneal Height

Pre-operatively Calcaneal Height in majority of patients was between 31 and 35 degrees (mean=31.97°), while as Post-operatively Calcaneal Height in majority of patients was between 36 and 40 degrees (mean=36.87°)

Mean AOFAS score at 3 months was 78.43±7.17 (range 55-85); at 6 months it was 90.03±5.24 (range 74-95) as shown in table 3.

DISCUSSION

Calcaneus is the most frequently fractured tarsal bone.¹¹ Calcaneal fractures are one of the most disabling fractures in men with frequent occurrence during the wage earning period of life.¹²

This study was initiated to access clinical and radiological outcome of calcaneal fractures treated by surgical treatment using minimally invasive sinus tarsi approach. In total 30 patients were treated. A thorough follow up was done. Our follow up rate was 100 percent.

Classifying a fracture is of utmost importance, one to ensure the uniformity in description of various components and grades of severity of injury and secondly to make the comparison of various studies scientifically correct and to draw conclusions which would be valid. In fact the treatment of any fracture and its outcome correlates with the identification of the fracture and its classification. The ambiguity in the treatment protocol of calcaneal fractures is evident from the fact that there are more than forty five different classification systems discussed in literature. Out of which nineteen are still in use and considered to be correct.¹³ Introduction of CT may be expected to decrease the ambiguity, but the fifteen CT classifications of calcaneal fractures belie this assumption. The most frequently cited classifications in literature were those described by Essex-Lopresti, Zwipp, Crosby, and Sanders. No classification showed a direct correlation with the choice of treatment.^{14,15} but the CT-based classification systems showed improved correlation with treatment in comparison with classification systems predicted on conventional radiographs.^{14,15} Three of these four classifications were also highly correlated with outcome, large randomized controlled trial.¹⁶ Even when following a specific classification system for example; Sander's CT classification, there is much inter observer variation.^{14,15}

The evaluation of calcaneal fractures and determination of the effect of treatment relies on three pillars.¹⁶ Consisting of standardized questionnaire, physical examination and radiographs in various projections. The standard lateral, axial views and posterior oblique axial view of Harris are well known. Others are oblique view by Broden, Isherwood and Anthonsen. Almost all of them have been replaced by CT scan in the last two decades. The value of radiography at follow up has also been a point of contention. As early as 1955, Maxfield and Mcdermott.¹⁷ conclude that the anatomy as seen radiographically did not correlate well with functional results and that point of view that radiography is of limited value in the evaluation of outcome is shared by several authors.¹⁸⁻¹⁹

In contrast, the plain radiograph is the most extensively used investigation to evaluate calcaneal fractures because it is much more readily available when compared to CT scan and also reduces the radiation dose significantly. So, we also relied upon the use fullness of plane radiography (Bohler's tuber joint angle and Gissane's crucial angle) in determining outcome coupled with specific scores.

The clinical scoring systems used for evaluating outcome in calcaneal fractures are mainly three, as described in literature. The most cited is American Orthopaedic Foot And Ankle Society- Ankle- Hindfoot scale, followed by Maryland Foot Score and the Creighton; Nebraska Score.²⁰ So, we decided to use the widely accepted, reliable and valid AOFAS- Ankle- Hindfoot Scale.

In our study, there were 7(23.33%) female patients and 23 (76.66%) male patients. The age of the patients ranged from 21 years to 53 years with a mean of 33.73±9.66 years. The majority of calcaneal fractures (80-90%) occur in male patients of 20 to 40 years of age. It was observed that the mode of injury in all the patients was either fall from a height or road traffic accident. There was no incidence of direct trauma unlike other orthopaedic injuries.

In this study, the pre-operative BTJA ranged from -9 to 15 degree with mean±SD of 5.13±6.19 degree. The postoperative BTJA at 3 week postoperative, 6 weeks postoperative, 3 months postoperative and at 6 months postoperative was 28.0± 2.92 degree, 27.62± 3.01 degree, 27.23± 2.95 degree and 26.5± 3.18 degree respectively as shown in table 1. The decrease in Bohler angle from 3 weeks to 6 months post-op is only by 1.5 degrees which is statistically significant (p<0.001).

Preoperative GCA ranged from 90 degree to 119 degree with mean±SD of 102.16±7.56.(Range 90 to 119 degrees) The postoperative GCA at 3 week postoperative, 6 weeks postoperative, 3 months postoperative and at 6 months postoperative was 118.53±7.11 degree, 118.37± 7.17, 117.42± 7.12 degree and 116.83± 7.35 degree respectively as shown in table 2. The Mean ± SD of calcaneal width in mm preoperatively in our study was 37.07±1.95 (Range 34 to 40). Postoperatively at 3 weeks, 6 weeks 3 months and 6 months Mean ± SD was 31.97± 2.11(Range 29 to 36), 31.97±2.10(Range 29 to 36), 32.23± 2.16 (Range 29 to 36) and 32.93± 2.19 (Range 30 to 36) respectively. Preoperative Mean±SD of calcaneal length in mm in our study was 58.9± 4.42 (Range 52 to 67). Postoperatively Mean±SD at 3 weeks, 6 weeks, 3 months and 6 months was 63.8± 5.87 (Range 55 to 75), 63.7± 5.80 (Range 55 to 75), 64.3± 6.01 (Range 55 to 76) and 64.87± 6.00 (Range 56 to 76) respectively.

In our study preoperatively Mean±SD of calcaneal height in mm was 31.97± 1.59 (Range 29 to 34). Postoperatively at 3 weeks, 6 weeks, 3 months and 6 months Mean±SD respectively was 38.13± 1.22(Range 36 to 40), 37.77± 1.14(Range 36 to 40), 37.47± 1.20(Range 35 to 40) and 36.87± 1.31(Range 35 to 39). In this study, as per sander's classification; 10(33.33%) calcaneum cases were type 2. 20 (66.66%) Calcaneum cases were type 3

In our study, as per AOFAS Scale at 3 months, 19 (63.33%) calcaneum cases fell into the excellent group, 9 (30%) into good and 2(6.66%) into poor result group. The Mean±SD AOFAS scale was 78.43±7.17 (range 55-85). At 6 months, the result as per AOFAS scale showed further improvement with 28 (93.33%) calcaneum cases falling into the excellent group and 2 (6.66%) falling into the good result group. None of them fell in poor group at 6 months follow up. The

Mean±SD AOFAS scale was 90.03±5.24 (range 74-95) as shown in table 3.

Complications

In this study, there was mild pain in 33.33% cases as shown in table 4 and superficial wound infection in 6.66% calcaneum cases postoperatively. There was no dehiscence and loss of reduction in any case. This was similar as analyzed in study done by Kline et.al. He reported the overall wound complication was 6% in the patients treated with minimally invasive sinus tarsi approach.²¹

CONCLUSION

This study was undertaken to evaluate the results of fixation of calcaneal fractures using MIPPO technique clinically and radiologically. From the patients who presented with calcaneal fractures at our institute, 30 patients were selected as per our criteria adopted for this study. All selected 30 cases of fracture calcaneum were operated, internal fixation was done through sinus tarsi approach and were assessed for clinical and radiological outcome. We used sinus tarsi approach. After reduction, Q type locking calcaneal plate was used for fixation in all cases. All patients were kept non-weight bearing for 8- 12 weeks, but ROM exercises were started at one week. For clinical evaluation American Orthopaedic Ankle and Foot Society Ankle-Hindfoot scale was used after operation. For radiological evaluation changes in Bohler's tuber joint angle and Gissane's crucial angle, calcaneal width, length and height were used pre and postoperatively. Pre operative 3D CT scan for classification of fractures and preoperative x-rays and postoperative x-rays were main imaging modalities used.

The following observations were made from this study

Most of the patients presented with calcaneal fractures in their active period of life. The mean age of presentation was 33.73 years and was common in male sex (23 patients). Most common mode of injury was fall from height in 2/3rd of patients, followed by road traffic accident in remaining 1/3rd. Preoperative Bohler's tuber joint angle mean was 5.13% and on Postoperative 3 weeks, 6 weeks, 3 months and 6 months postoperative Bohler's tuber joint angle mean was 28, 27.62, 27.23, 26.5 degree respectively.

Further, preoperatively, the mean of Gissane's crucial angle was 102.16 degree, and on postoperative 3 weeks, 6 weeks, 3 months and at 6 months postoperative Gissane's crucial angle mean was 118.53, 118.37, 117.42 and 116.83 degree respectively. Mean preoperative calcaneal width was 37.07mm. Postoperatively at 3 weeks, 6 weeks, 3 months and 6 months width was 31.97mm, 31.97mm, 32.23 and 32.93mm respectively. Mean preoperative Calcaneal length was 58.9mm. Postoperatively at 3 weeks, 6 weeks, 3 months and 6 months the mean length was 63.8mm, 63.7mm, 64.3mm and 64.87mm respectively. Similarly, preoperative mean calcaneal height in mm was 31.97 which changed postoperatively at 3 weeks, 6 weeks, 3 months and 6 months to 38.13mm, 37.77mm, 37.47mm and 36.87mm respectively. Most of calcaneal fractures were sander's type 3 (20 cases),

followed by type 2 (10 cases). 28 Calcaneal cases had excellent results (93.33%), 2 case (6.66%) each had good result postoperatively according to American Orthopaedic Ankle and Foot Society Ankle-Hindfoot Scale. None of the patient had poor result at the end of 6 months. Also, we try to correlate between preoperative Gissane's crucial angle, pre-operative Bohler's tuber joint angle, Sander's type of fracture with our final Clinical outcome (AOFAS scale); and it was found that they don't correlate with final outcome after good anatomical reduction and stable fixation.

In Conclusion, it can be said with reasonable degree of certainty, fixation with plate using MIPPO technique through sinus tarsi approach is an effective and safe method with good clinical and radiological results, for the treatment of calcaneal fractures; to achieve anatomical restoration under vision, stable fixation, early mobilization with minimal soft tissue complications and good functional outcome as shown in table 5. It is concluded that CT scan is a better and adequate tool for radiological assessment and for planning further treatment. The outcomes of treatment described in this study are comparable with the outcomes previously reported among other studies.

Additional investigation is required to determine the long term outcomes of surgical treatment for calcaneal fractures and use of CT scan for radiological assessment in follow up. So, we recommend Type 2 and 3 (displaced) calcaneal fractures to be treated with surgical treatment using MIPPO technique.

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