Open reduction and internal fixation of depressed intra-articular calcaneal fractures through a miniopen approach

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Background
Fractures of the calcaneus pose a great challenge both to surgeons and patients. They are considered life-changing injuries. Anatomical reduction of fragments is one of the important variables affecting outcome. Extensile lateral approach has been used widely to facilitate good visualization and reduction. Skin complications like wound infection and dehiscence are a major concern. Therefore minimally invasive approaches came to fame. However, the use of less rigid fixation in minimally invasive techniques has led to inferior results.
Aim
The aim was to combine the merits of rigid fixation and minimally invasive approaches.
Patients and methods
Twenty-three patients with calcaneal fractures were operated upon and followed for a mean of 6 months. All patients were operated upon in the prone or lateral position under tourniquet. A miniopen sinus tarsi approach was used for fracture reduction and fixation. The latter was achieved using a calcaneal miniplate and screws. Patients were assessed radiographically for restoration of Bohler and Gissane angles, clinically using American Orthopedic Foot and Ankle Society score (AOFAS) and the visual analog score for pain.
Results
All patients showed a significant improvement in the mean Bohler and Gissane angles. The majority of the patients scored very good on the AOFAS score, the mean being 83±4. The mean visual analog scale was 3. Mean time to full weight bearing was 12.5±2 weeks after full radiological union was achieved.
Conclusion
Miniplate fixation through miniopen approach combines the merits of open reduction and internal fixation and minimally invasive techniques. Longer follow-up is however required to establish its superiority over screw-only fixation constructs.

Keywords:
Bohler, Calcaneus, Gissane, miniplate, sinus tarsi approach

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Introduction

Calcaneus is the most commonly injured tarsal bone accounting for around three-fourth of all foot fractures. The peculiar anatomy of the calcaneus and its articular surface poses a great challenge to surgeons treating its fractures [1,2].

Let alone the fact that it is considered a life-changing injury, with a great deal of economic and psychological impact, since the majority of patients sustaining this type of injury are working young males [3].

Generally calcaneal fractures are classified as intra-articular or extra-articular. Intra-articular fractures are either joint depressions or tongue type and are further classified according to Sanders' classification [4] into four subtypes. Type 1 and 2 fractures are usually managed operatively, while types 3 and 4 are controversial in the literature. Many surgeons advocate nonoperative treatment to avoid adding further morbidity without improving outcomes. Some surgeons, however, have demonstrated that operative treatment offers superior outcomes as compared with conservative management [5].

For many years, the extensile lateral calcaneal approach was utilized as it provides excellent access to the bone for open reduction and internal fixation (ORIF). Serious complications and high rates of patient dissatisfaction together with lower functional outcomes associated with this approach, urged surgeons attempting to fix those fractures, to use less invasive procedures. This

sheds light on miniopen approaches as the sinus tarsi approach that gained great popularity [6].

Many techniques have been described using this approach to fix the calcaneum with screws or K wires. With comminuted fractures, a strong biomechanical construct is required, therefore, screw-only fixation may not be sufficient and the need for plate fixation arises [7]. This study aims to study and report the outcomes after fixation of calcaneal fractures using miniplates instrumented through sinus tarsi approach.

Patients and methods

The study was conducted on 23 patients between December 2020 and September 2021. All patients were managed using ORIF and cannulated screw fixation through a miniopen sinus tarsi approach. All surgeries were performed in the prone or supine position under general anesthesia and tourniquet, with the help of an image intensifier (II). Ethical committee approval of our institute was obtained before starting the study.

We included patients who are skeletally mature with a closed Sanders type II/III fractures. Patients with Sanders types I and IV, extra-articular fractures, neglected cases, and those with vascular compromise and open fractures were all excluded from the study.

Preoperatively

All patients were evaluated clinically including neurovascular examination and radiologically using plain radiographs in the lateral and Harris axial views. Lateral view was used to assess the Bohler and Gisane angles [2,8] The axial view was used to assess the subtalar joint involvement and varus collapse. Computed tomography was also obtained for classification, better understanding of the fracture pattern, and preoperative planning. Clinically the wrinkle sign is awaited as a sign of disappearance of swelling.

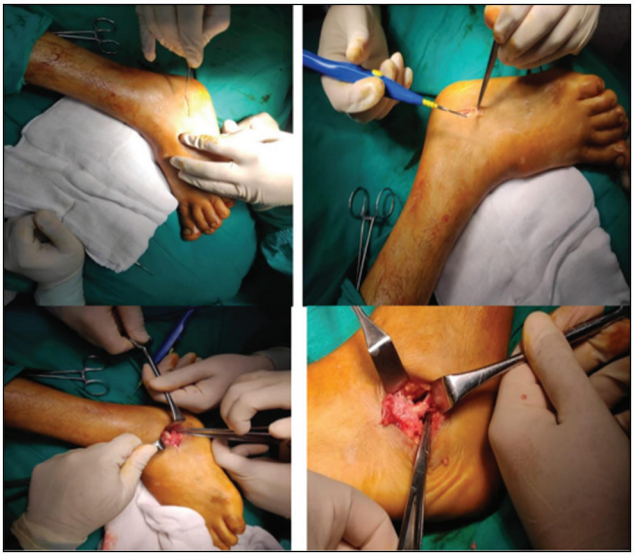
Operatively

A 3 cm skin incision is centered over the sinus tarsi, about 2 cm distal and anterior to the tip of the lateral malleolus. This was followed by deep dissection and removal of the sinus tarsi fat to expose the posterior facet (Fig. 1).

Reduction of the posterior facet and elevation of the joint depression and then temporary stabilization with K wires is performed (Fig. 2).

Image intensifier (II) was used to assess quality and accuracy of reduction on lateral, and Borden views. The restoration of Gissane and Bohler angles was used to confirm good reduction. A low-profile 2.4 mm

Figure 1



Showing steps of exposure of the posterior facet through sinus tarsi approach.

Figure 2

Photograph from II showing reduction and temporary stabilization with K wires.

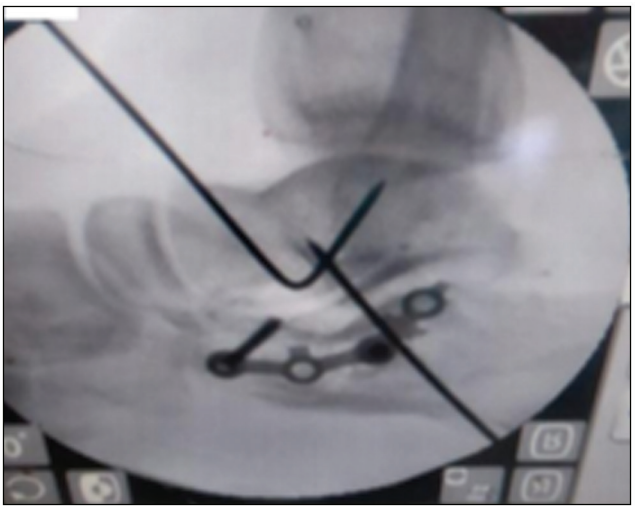
miniplate or sometimes a one-third tubular plate titanium or stainless steel (Orthohouse, New Cairo, Egypt) was used to fix the reduced posterior facet to the anterior part of the calcaneus (Fig. 3).

Axial view was then used to check for and correct varus malalignment and shortening. A steinmen pin was used to aid in manipulation of the tuberosity fragment. Two 4 mm cannulated screws were introduced percutaneously from posterior to anterior maintain reduction and calcaneal length. Another two similar screws were introduced in a vertical manner to support the elevated posterior facet; maintaining calcaneal height (Fig. 4).

Closure of the wound was done in layers with Monocryl 3/0 to skin in a simple interrupted manner. No drain was used. Local anesthetic infiltration was done to the wound as part of the postoperative pain control. A below knee slab was applied for 2 weeks. Third generation oral antibiotics were given for prophylaxis for 1 week. Low-molecular weight heparin was administered for chemical prophylaxis against venous thromboembolism for at least 6 weeks. It is continued in high-risk patients after risk assessment. Range of motion was commenced after removal of sutures and the slab. Strict nonweight bearing was instructed for 12 weeks. Radiographs were obtained immediately postoperative, at 6 weeks, 3 months, and 6 months. All patients were evaluated clinically for functional outcomes at the final follow-up at 6 months using the American Orthopedic Foot and Ankle Society score (AOFAS) and visual analog score for pain.

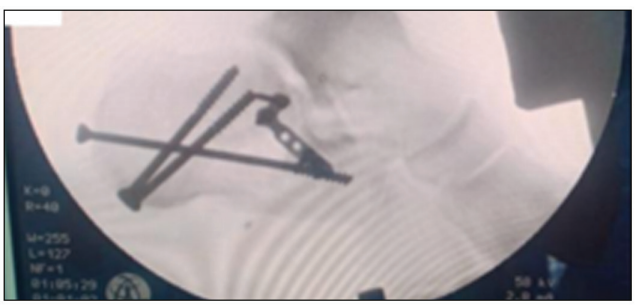
On the AOFAS, a score more than 90 is considered excellent, more than 80 points is good, greater than 70 is considered fair, and less than 70 is considered poor.

Figure 3



Photograph from II in the lateral view, after application of the 2.4 mm miniplate.

Figure 4



Photograph from II showing lateral view of the calcaneum with the final construct.

Subtalar range of motion was also assessed. Secondary outcome measures included postoperative hospital stay, time to full union and weight bearing, time to return to daily activities, and work and complications.

Statistical methods

Data management and statistical analysis were done using SPSS versus 25 (IBM, Armonk, New York, USA). Numerical data were summarized as mean and SD or medians and ranges. Categorial data were summarized as numbers and percentages. Bohler's and Gisane angles were compared preoperatively and postoperatively. Postoperative values were compared with the sound contralateral side using paired *t*-test. All *P* values were 2 sided. *P* values less than 0.05 were considered statistically significant.

Results

Twenty-three patients with 23 calcaneal fractures were included in the study, operated upon, and followed up. All patients reported falling from height as the mode of injury, nine sustained fractures of the right side, while 14 had left-side fractures. The mean age was 30 ± 9 years (21–39). Fifteen patients were males while eight were females. Six patients were smokers, while 17 were nonsmokers. Sixteen patients were classified as Sander's type II, while seven were Sander's type III.

The mean time from injury to surgery was 8 ± 2 days ranging from 3 to 12 days. The mean postoperative hospital stay was 2 ± 1 day, ranging from 1 to 3 days. All patients were followed up for a mean of 6 months.

On assessment and comparing preoperative and postoperative Bohler and Gisane angles from radiographs, we found a statistically significant improvement in both angles; values and *P* values shown in Table 1 (Bohler angle), Table 2 (Gisane angle).

Table 1 Bohler angle preoperative and postoperative

Bohler angle	*N*=23
Preoperative (mean±SD)	5.00 ± 2.00
Postoperative (mean±SD)	25 ± 4.00
Paired *t*-test	63.245
P value	<0-001 (HS)

HS, highly significance.

Table 2 Gisane angle preoperative and postoperative

Gissane angle	*N*=23
Preoperative (mean±SD)	147.00 ± 5.00
Postoperative (mean±SD)	135.00 ± 2.00
Paired *t*-test	–31.514
P value	<0.001 (HS)

HS, highly significance.

According to the AOFAS score; five patients demonstrated excellent results, 15 patients had good results, three were fair, and none showed poor results. The mean AOFAS score at final follow-up was 83 ± 4 which was considered a good result.

Our mean final visual analog scale score was 3 ranging from 1 to 5. Three patients (13%) suffered no pain postoperatively. Sixteen patients (69.5%) had mild pain and four patients (17.5%) had moderate pain postoperatively.

The mean time from surgery to full weight bearing was 12.5 ± 2 weeks ranging from 11 to 14 weeks and this was allowed after full union is achieved clinically and radiologically. Out of 23 patients, 15 patients were able to return to their work and activity of daily living (ADL) by 6 months. Four of them were laborers and 11 were office based. Five patients returned to ADL, but still reported mild difficulty returning to work, four of which were laborers and one was office based. Three patients still found difficulty in ADLs at 6 months.

Four of our patients developed complications. Two patients suffered superficial wound infection that was managed with daily wound dressing and use of a combination of topical and oral antibiotics. The two patients were smokers. Another two patients suffered prominence of cannulated screws which required a second hospital admission and procedure for removal of the prominent screws. None of the patients suffered a life debilitating morbidity and we had no mortalities.

Discussion

Intra-articular fractures of the calcaneus account for around 75% of calcaneal fractures [9]. ORIF via extensile approach is considered standard of management, however, it is associated with high risk of skin complications [10]. Recently, minimally invasive approaches have gained popularity amongst surgeons, using different methods of fixation like K wires and screws [3,6].

Giannini *et al*. [11] reported that the minimally invasive sinus tarsi approach allows for direct visualization of the subtalar joint achieving accurate reduction and minimal skin complications.

K wires are criticized for being a biomechanically weak construct, carry the risk of loss of reduction, and may introduce infection [12]. Screw-only technique does not support the lateral blow out [10]. In this study our aim was to combine the advantages of ORIF and percutaneous fixation techniques.

Based on the current study, both Bohler and Gissane angles improved significantly postoperatively using the sinus tarsi approach for fixation. We compared our results with the results of Shariatzhadeh *et al.* [13], Cong *et al.* [14], and Khira *et al*. [15] Table 3 summarizes patient demographics in our study versus other series.

Concerning the AOFAS score, Table 4 summarizes our results against the results of different series.

Table 3 Comparing the demographics of this study versus other studies in the literature

	Shariatzadeh *et al.* [13]	Cong *et al.* [14]	Khira *et al.* [15]	This study
Number of patients	62	64	28	23
Number of fractures	62	64	30	23
Male (%)	95	48.43	71.42	65.2
Female (%)	5	51.5	28.57	34.8
Contralateral calc fractures	0	0	7.14%	0
Associated fractures	Not mentioned	10.9%	Not mentioned	0
Medical comorbidities	Not mentioned	Not mentioned	Not mentioned	Three patients with DM
Sander's classification	65% type 2	65.57% type 2	33.3% type 2	69.5% type 2
	34% type 3	37.5% type 3	66.7% type 3	30.5% type 3

DM, diabetes mellitus.

Table 4 Comparing the AOFAS score of this study against other studies

AOFAS ankle/hindfoot score	Shariatzadeh [13] (%)	Cong *et al.* [14]. (MIPO group) (%)	Cong *et al.* [14]. (ELA group) (%)	Khira *et al.* [15] (%)	This study (%)
Excellent (90–100)	80	72.7	71.6	28.6	21.8
Good (80–90)	15	21.3	22.4	35.7	65.2
Fair (70–80)	5	3	3	21.4	13
Poor (less than 70)	0	3	3	14.3	0

AOFAS, American Orthopedic Foot and Ankle Society score; ELA, extensile lateral approach; MIPO, minimally invasive plate osteosynthesis.

Our mean final AOFAS score was 83 ± 4, which is comparable with the results of the minimally invasive group of Cong *et al*. [14] with a mean score of 84.4. It is more superior than the mean score of Shariatzadeh *et al*. [13] whose mean score was 79.3. Despite that 80% of their patients were excellent versus 21.8% in our series and 72.7% in the series of Cong *et al*. [14]. This we believe could be because of the larger sample size in their series. The other reason is that in their series, they did not use Sander's classification system and not all patients were evaluated using computed tomography scans. Many of their patients might have started with minimally displaced or depressed fractures.

Our results were superior to that of Khira *et al*. [15], despite comparable sample size. In our series; 65.2% of the patients were good, none were poor, however, in the series of Khira and colleagues, 35.7% were good and 14.3% were poor. This we believe is because of the greater proportion (66.7%) of patients being Sanders' type 3 in their study. On the contrary, around 69% of our patients were Sanders' type 2. In the original paper of Sanders *et al*. [4], they stated that type 3 injuries are likely to have lower outcomes as it is more difficult to anatomically reduce the fracture fragments.

Skin complications were the highest in the extensile-approach group in the series of Cong *et al*. [14], around 37%. We experienced 8.6% skin complications which is similar to the minimally invasive plate osteosynthesis group of Cong *et al*. [14]. Khira *et al*. [15] had experienced a higher skin complication rate of 13%. This we think might be due the short mean time from injury to operation, 4 days. This means they may have operated on bad skin condition and/or with severe swelling before appearance of the wrinkle sign. Shariazadeh *et al*. [13] had 0 skin necrosis and their mean time from injury to surgery is 8.3 days, which is very similar to our study (8 ± 2). It might have been that fewer of their patients suffered significant comorbidities, fewer were heavy smokers. They however, reported four cases of delayed wound healing and one case of deep infection. This might have happened due to the excessive retraction to introduce a large calcaneal plate (Bijan plate, Tehran Iran) through a small wound.

We also compared our results to that of Abdelazeem and colleagues in their series, they operated on 35 patients with displaced intra-articular calcaneal fractures, the majority being joint depression Sander's type II and III. They used the miniopen sinus tarsi approach and screw-only fixation. A greater proportion of their patients were males, however, the mean age, mean time from injury to operation were comparable to this study. They reported a mean postoperative AOFAS score of 91.7 [6]. Their mean score is superior to our study; this we explain by the longer follow-up and the bigger sample size of 35 patients versus 23 in our study. The majority of the patients were graded as very good which is similar to our findings.

The major concern about use of screws only for fixation, is loss of reduction, which may occur. Although in their series, Abdelazeem *et al*. [6] did not report any significant loss of reduction, their mean postoperative Bohler angle is lower than in our study, 19.4 versus 25, which might be explained by the use of screw-only technique as compared with the miniplate.

Conclusion

In conclusion, miniopen sinus tarsi approach for ORIF combines the merits of the two concepts, ORIF and mini-invasive techniques. It allows for more accurate reduction and robust fixation, yet avoids skin complications and wound dehiscence.

This study is not without limitations. The main weaknesses are the small sample size and the short follow-up. Our sample size is smaller than many in the literature, however, our patients were all operated upon in the same hospital and by senior surgeon. This complies with the recommendation of Sander's and colleagues, who highlighted that these are fractures of necessity and that surgeon's cumulative experience matters. Surgeons who operated on more than 50 cases tend to have better outcomes and more satisfied patients [4]. Longer follow-up is still required to establish significant superiority of our technique as compared with others.

Both authors declare that they have contributed to the design of the study, treatment of patients, data collection, writing, and reviewing the manuscript. Both authors have fully read the final work and agree on its submission in its current form to the reputable journal of Egyptian Orthopedic Association (EOA).

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Green DP. Rockwood and Green's Fractures in Adults. Lippincott Williams & Wilkins; 2010.

2 Bucholz RW. Rockwood and Green's Fractures in Adults: Two Volumes Plus Integrated Content Website (Rockwood, Green, and Wilkins' Fractures). Lippincott Williams & Wilkins; 2012.

3 Wang Z, Wang XH, Li SL, Tang X, Fu BG, Wang MH, Xia SL. Minimally invasive (sinus tarsi) approach for calcaneal fractures. J Orthop Surg Res 2016;11:1-9.

4 Sanders R, Fortin P, DiPasquale T, Walling A. Operative treatment in 120 displaced intraarticular calcaneal fractures. Results using a prognostic computed tomography scan classification. Clin Orthop Relat Res 1993; 290:87–95.

5 Abdelgaid SM. Closed reduction and percutaneous cannulated screws fixation of displaced intra-articular calcaneus fractures. Foot Ankle Surg 2012; 18:164–179.

6 Abdelazeem A, Khedr A, Abousayed M, Seifeldin A, Khaled S. Management of displaced intra-articular calcaneal fractures using the limited open sinus tarsi approach and fixation by screws only technique. Int Orthop 2014;38:601-6.

7 Meng Q, Wang Q, Wu X, Peng A, Yan J. Clinical application of the sinus tarsi approach in the treatment of intra-articular calcaneal fracture. Medicine 2018; 97:e0175.

8 Böhler L. Diagnosis, pathology, and treatment of fractures of the os calcis. JBJS 1931; 13:75–89.

9 Ni M, Wong DWC, Mei J, Niu W, Zhang M. Biomechanical comparison of locking plate and crossing metallic and absorbable screws fixations for intra-articular calcaneal fractures. Sci China Life Sci 2016; 59:958–964.

10 Kiewiet NJ, Sangeorzan BJ. Calcaneal fracture management: ex- tensile lateral approach versus small incision technique. Foot Ankle Clin 2017; 22:77–91.

11 Giannini S, Cadossi M, Mosca M, Tedesco G, Sambri A, Terrando S, *et al*. Minimally-invasive treatment of calcaneal fractures: a review of the literature and our experience. Injury 2016; 47:S138–S146.

12 Yip-Kan Y, Yuen-Fong HO. Percutaneous fixation of displaced calcaneal fracture. J Orthop Trauma Rehabil 2011; 15:5–9

13 Shariatzadeh H, Valiollahi B, Mohammadpour M, Haghbin M. Outcomes of minimally-invasive sinus tarsi approach for the treatment of intra-articular calcaneal fracture. J Res Orthop Sci 2020; 7: 47–54.

14 Jin C, Weng D, Yang W, He W, Liang W, Qian Y. Minimally invasive percutaneous osteosynthesis versus ORIF for Sanders type II and III calcaneal fractures: a prospective, randomized intervention trial. J Orthop Surg Res 2017;12:1-9.

15 Khira YM. Limited sinus tarsi approach for treatment of intraarticular fractures of the calcaneus. Int J Orthop Sci 2016; 2:97–101.