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10.21608/zumj.2020.24425.1758**ORIGINAL ARTICLE****Minimally Invasive Surgical Techniques in Management of Intra-articular Fracture Calcaneus**sami sadek¹; khalid Abd Elrahman²; Yousuf mohammed Khira³; el sayed soudy³

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ABSTRACT**Purpose:** To evaluate the outcomes of minimally invasive surgical techniques in reduction and fixation of displaced intra-articular calcaneal fractures.**Methods:** Thirty feet in 26 patients with displaced intra-articular calcaneal fractures were treated using minimal invasive techniques (limited sinus tarsi approach and or percutaneous reduction and fixation). Plain radiography of the affected side including antero-posterior and lateral views of the ankle and axial heel views was taken for all patients. CT scan also was done preoperatively for all patients. The fractures were classified according to Sanders CT classification.**Results:** twelve patients (40%) had no pain; fifteen patients (50%) had mild tolerable pain with activity, and two patients (6.6%) had moderate pain that respond to analgesia as needed. One patient had severe pain (3.4%) necessitating subtalar arthrodesis. Infection rate were three superficial cases and one case had deep infection. Three patients (10%) were complaining of Symptomatic hardware.

According to the American Orthopedic Foot and Ankle Society (AOFAS) score, twelve patients had excellent score (40%), good in fifteen (50%), fair in 2 patients (6.7%) with poor result in one patient (3.3%).

Conclusion: Minimal invasive surgical techniques regarding the approach, reduction and fixation are good methods for treatment of displaced intra-articular fracture calcaneus. These techniques are highly effective in patients with Sander's classification II & III especially in high-risk patients.**Key words:** Calcaneus, sinus tarsi, percutaneous, fracture**INTRODUCTION**

Calcaneal fractures represent 2% of all fractures and account for approximately 60% of all tarsal injuries [1].

The most common cause of this injury is falling from height, when axial load is applied. Axial load is composed of shearing forces and compression forces leading to a primary longitudinal and a primary transverse fracture. Primary longitudinal and transverse fracture lines are associated with secondary fracture lines with increased force at impaction [2].

Sanders et al. developed a classification system based on computed tomographic scanning in semi-

coronal views that was based on the *number* and *location* of articular fracture fragments [3, 4].

The extended lateral L-shaped approach is commonly used for the surgical treatment of intra-articular calcaneal fractures. This approach accurately reduces the subtalar joint, fully exposes, and addresses the intra-articular calcaneal fragments and conveniently places the plate to achieve a stable fixation. Wound dehiscence is the most common problems after open reduction and internal fixation (ORIF) of a calcaneal fracture to be as high as 30% [5].

Minimal invasive surgical techniques have been undertaken in an attempt to reduce complications and improve recovery when surgery is indicated [6].

PATIENTS AND METHODS

This study was conducted on 30 fractures in 26 patients (23 males 88.5% & 3 females 11.5%) with displaced intra-articular fracture calcaneus treated with minimal invasive surgical techniques in the Orthopedics and Traumatology Department of Zagazig University Hospitals from July 2016 to December 2019 with a mean follow up period of 14 months. Written informed consent was obtained from all participants, the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Patient Selection:

Inclusion criteria: Patients included in this study were having displaced intra-articular fracture calcaneus(Sanders classification type II and III). All fractures were treated within two weeks.

Exclusion criteria: We excluded from this study all patients having non-displaced fractures (Sanders type I), Crushed calcaneal fractures (Sanders type IV), neglected fracture (more than two weeks), open calcaneal fractures, infected skin condition and non compliant patients.

This study was performed on patients with age range from 18 years to 58 years with mean age 36 years. Twenty three patients were males (88.5%), 3 were females (11.50%). Four cases were bilateral (15.5%) and 22 cases (84.5%) were unilateral. Most injuries (21 cases) occurred following falling from height (80.7%) while 3 cases following direct trauma (11.5%) and one case following road traffic accident (3.9%) According to Sander's classification, 20 fractures (66.7%) presented with type II fractures, 10 patients (33.3%) with type III fractures. Eight patients (30.8%) presented with other injuries in the form of fracture tibia in 3 patients (11.5%), lumbar spine fractures in 2 patients (7.7%), fracture lateral maleolus in one patient (3.8%) and fracture distal radius in 2 patients (7.7%).

All patients were clinically evaluated for the intactness of neurovascular condition of the foot, signs of impending compartment syndrome of foot and skin condition (open wounds, blisters and abrasions). Plain X Ray radiograph (anteroposterior and lateral ankle views, axial heel view, and oblique Broden's view of the foot [7]. was done for all patients. A lateral view of the healthy foot was done for comparison and measuring Bohler's and Gissane angles in 22 cases (excluding bilateral cases)[8].

Bohler's and Gissane angles were evaluated for all patients (preoperative and postoperative) for the injured side.

CT scan was done for all patients as part of preoperative assessment and for most of patients postoperatively. According to Sanders classification 20 feet was in type II in, 10 feet was in type III. The average time before surgery was 5 days (range 2-10 days).

Surgical technique: We performed surgery under either spinal or general anesthesia. Perioperative 3rd generation cephalosporin antibiotics were taken routinely. Lateral position was used with the affected side is uppermost and a sandbag behind the buttock. With a tourniquet applied to the thigh. **A-Sinus tarsi approach:** With a 2 to 5 cm incision was made from the tip of the fibula to the base of the fourth metatarsal over the sinus tarsi (figure 1)

The extensor digitorum brevis is retracted in cephalic direction to allow exposure of the sinus tarsi and permit visualization of the posterior facet. A Schanz pin or k wire is then placed through a stab wound in the postero-inferior part of calcaneal tuberosity from lateral to medial for distraction allow control of the tuberosity fragment, the lateral wall and The posterior facet fragments are then mobilized using a small elevator and a K- wire is inserted through the fragment directed toward the sustentaculum for temporary reduction fixation. Calcaneal alignment is done using the Schanz pin under manual control with X-ray guidance in axial view (figure 2).

Two or more guide pins of a large diameter cannulated screws (alternatively, fully threaded cancellous screws are used in some cases) are placed from the calcaneal tuberosity into the anterior and distal portion of the calcaneus. These screws are used to restore the axial length and alignment. Fully threaded screws are better used to maintain axial length and preventing height collapse. One or more small diameter cancellous or cortical screws are used from lateral to medial to engage the sustentaculum tali to restore the height, breadth and stabilize the posterior calcaneal facet. A buttress screw may be added from the tuberosity directed to the subchondral bone of the posterior calcaneal facet to act as a "kickstand" [9] (figure 3). Low-profile calcaneal plate or small T plate could be inserted through the sinus tarsi (figure 4 A) and placed with the most postero-inferior hole in line with the incision used for the Schanz pin. Plate fixation allows for adequate stabilization of calcaneus height with three or more screws inserted into the tuberosity and the anterolateral fragments (figure 4 B).

Cancellous screws were used in 26 fractures, plate fixation was added to screws in 4 fractures, and K-wires were left in place with screws in 5 fractures (to support small anterior process fragment).

B-Percutaneous reduction and fixation

In five fractures, closed reduction (following the previously mentioned steps) and percutaneous fixation were done through several stab wounds in different directions according to the entry of screws.

Hemostasis was assured after releasing the tourniquet, then wound closed in layers by interrupted sutures and plaster splint was done in all patients to be removed with stitches after two weeks.

Clinical and radiological assessments were done in a three weeks interval until complete radiological healing and thereafter in three months interval. Patients are allowed to full activity after 16 weeks.

Statistical analysis

Data collected analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance; difference and association of qualitative variable by Chi square test (X²). Differences between quantitative independent groups by t test. P value was set at <0.05 for significant results &<0.001 for high significant result.

RESULTS

A) Functional Results:

[1] AOFAS score:

According to AOFAS score and clinical evaluation, the functional results were graded as excellent in 12 patients (40%), good in 15 patients (50%), fair in 2patients(6.7%),with poor result in one patient(3.3%).The excellent and good results were considered as satisfactory ones while the unsatisfactory included the fair and poor results. Thus, satisfactory results were found in 27 patients (90%), and the unsatisfactory ones were found in 3 patients (10%).

[2] Range of motion:

The mean subtalar joint motion (inversion-eversion arc) as compared to the uninjured side (and to the normal range of motion in bilateral cases) was 85.42 % (range from 100% to 70%).

[3] Pain:

The pain was assessed according to AOFAS questionnaire. 15 patients had mild (occasional) pain (50%), 12 patients had no pain (40%) and two patients had moderate (daily) pain (6.6%) and one patient have severe pain (3.4%).

B) Radiological results

1) Bohler’s and Gissaneangles:

The angles of Bohler’s and Gissane were evaluated on the lateral view plain x-ray of operated and intact contralateral sides of 26 cases with 30 fractures.

Post-operative Bohler's mean angle of operated side was 29.0714⁰ ± 5.92(Range 16⁰- 34⁰ 30⁰ ± 1.176).

Post-operative Gissane mean angle of operated side was 132.33⁰ ±16.157 (Range 125⁰-145⁰).

Mean difference between pre-operative and post-operative angular measurement of injured side:

- In bohler’s angle it was 15.5 ± 3.08, t-test was - 18.8 and the p- value was 0.001 which was considered significant.
- In gissane’s angle it was 11.05 ± 19.7, t-test was 2.38 and the p- value was 0.029 which was considered significant.

Mean difference between intact contralateral and operated sides (table 1):

Post-operative mean difference in bohler’s angle was 3.92 ± 5.9, t- test was 2.49 and the p-value was 0.527 which was considered insignificant.

- Post-operative mean difference in gissane’s angle was -2.38 ±16.59,t-tes t was -0.611 and the p value 0.529 which was considered insignificant.

Complications:

Infection rate in this study ware three superficial and one case of deep infection .One case was complaining of severe subtalar pain. Symptomatic hardware occurred in 3 patients (10%).

Table: Mean difference between intact contra-lateral and operated sides (table 1):

	Paired Differences					t-t[est	Df	P-Value
	Mean	SD	SE	95% Confidence Interval of the Difference				
				Lower	Upper			
Bohler’s angle	3.9285	5.9026	1.5775	0.5205	7.33663	2.49	13	0.527
Gissane’s angle	-2.388	16.592	3.9108	-10.64014	5.86236	-0.611	17	0.549



Figure1: skin incision (Of sinus tarsi) from the base of lateral malleolus to base of 4th metatarsal.



Figure 2: A schanz pin is introduced into the tuberosity fragment (red arrow) to allow fracture reduction with temporary fixation by k wires (blue arrows), followed by definitive fixation by cancellous screws



Figure 3: a buttress screw is placed from the tuberosity (red arrow) directed to the subchondral bone of the posterior calcaneal facet for its support



Figure 4: A



Figure 4: B

Figure 4(A&B): A small T plate is placed through the sinus tarsi to allow rigid fixation of calcaneus



Figure 5: male patient with sanders type III fr. Operated by sinus tarsi reduction & fixation complicated with subtalar arthritis and subtalar arthrodesis was done with complete relieve of subtalar pain

DISCUSSION

The extensile lateral approach has traditionally been utilized for the fixation of most displaced intra-articular calcaneal fractures. The skin incision is L-shaped with the horizontal limb in line with the fifth metatarsal and the vertical limb is between the Achilles tendon and fibula. The incision is carried directly to the bone in order to create thick soft tissue flaps. Proximal extension of the flap allows exposure of the subtalar joint. The primary danger with this approach is damage to the blood supply to the corner of the L-shaped flap. This area receives its blood supply from the lateral calcaneal artery [10]. The use of this approach is complicated by a relatively high risk of wound infection and

Breakdown [11-12].

To avoid the serious soft-tissue complications of extensile approaches, Burdeaux [13] used medial

approach for direct reduction and fixation and indirect reduction of articular surface.

Paley and Hall [14] used only the medial approach for all his cases and reported that this approach was not adequate to address the lateral extrusion of bone fragment

To lower the wound complications, a minimal incision approach at the sinus tarsi has been proposed. Several randomized controlled trials have demonstrated a similar reduction; however, a significantly decreased risk of wound complications can be obtained with this procedure in comparison with the lateral extended approach [15, 16].

In our study, less invasive surgical techniques for treating displaced intra-articular calcaneus fractures have been undertaken in an attempt to reduce complications and improve recovery when surgery is indicated. These recent techniques include limited-incision sinus tarsi ORIF,

percutaneous stabilization with pins and /or screws, and minimal invasive plate osteosynthesis

The mean time elapsed from injury to surgical intervention was 5 days (range from 2- 10 days). Twenty five fractures were treated with minimal incision sinus tarsi approach for reduction and fixation, (3 cases was fixed with special plate introduced through the same incision and 22 fractures was fixed by screws) and 5 cases were treated with percutaneous reduction and fixation.

In our study, most patients (90%) had a satisfactory functional end results. By using the AOFAS score, the functional end results were graded as excellent in 12 patients (40%), good in 15 patients (50%), fair in 2 patient (8.3%), with one patient with poor result. The excellent and good results were considered as satisfactory ones while the unsatisfactory results included the fair and poor results. Thus, satisfactory results were found in 27 patients (90%), and the unsatisfactory ones were found in 3 patients (10%)

Our results were comparable with that of Stulik *J et al* [17] using minimally-invasive technique, the reduction of the calcaneal fractures restoring the length, height, and width of the heel was accepted.

Assessment of the articular surface reduction was good using image intensification intra-operative and on the CT scans postoperative. They reported favorable results compared to those of patients treated by open reduction with 7% superficial and 1.7% deep infection which were significantly lower than those in most series using extensile approaches.

Tornetta [18] treated 46 patients with percutaneous fixation, and reported that the most suitable cases for this method is type II Sanders fractures where the intact posterior facet is in continuity with the tuberosity fragment. Eighty five percent of his patients had excellent to good results. Many authors believe that the minimal dissection decreases the postoperative swelling, peri-articular scarring.

In our study the radiological results were good regarding the Pre-operative mean difference in bohler's angle between intact contra lateral and injured sides was 19.42 ± 4.81 , t-test was 15.097 and the p-value was .001 which was considered significant. Pre-operative mean difference in gissane's angle between intact contra lateral and injured sides was 13.44 ± 22.76 , t-test was -2.506 and the p-value was .023 which was considered significant

In his study with thirty feet in 28 patients with intraarticular fracture calcaneus Khira YM treated those using limited sinus tarsi approach with added percutaneous reduction and fixation found that

eight patients (28.5%) had no pain; sixteen patients (57%) had mild tolerable pain with activity, and four (14.5%) patients had moderate pain needing anti-inflammatory and analgesics. According to the American Orthopedic Foot and Ankle Society (AOFAS) score, eight patients had excellent score (28.6%), good in ten (35.7%), fair in six (21.4%) and poor in four (14.3%). The radiological results were good regarding the Bohler angle which improved from a mean of 4.6 degrees preoperative to 32.5 degrees postoperative. The calcaneal height was average 92% of normal side, and 12% average widening of calcaneus [10].

In his study Zhan J *et al* reported that Bohler's angle, Gissane angle, calcaneal length, width, and height were significantly improved from pre-operation to post-operation after surgery with a p value of <0.01. This indicated that anatomical reconstruction of calcaneal fractures including length, width, height, Bohler's angle, and Gissane angle could be achieved with open reduction and plate fixation through our modified sinus tarsi approach. Better reduction of the calcaneus may result in the better recovery of foot function. The mean AOFAS ankle/hindfoot score was 90.2 ± 17.7 (range 70–98), and the good and excellent rate was 89.7%. The time for fracture healing was 10.8 ± 3.8 (range 9–15) weeks. Only one case showed degenerative changes of subtalar joint at 1-year follow-up period [19].

Complications: In our study infection rate were three superficial cases treated conservatively, and one case of deep infection was treated by surgical debridement and screw extraction. Wound healing was completed in about three to four weeks. One case was complaining of severe subtalar pain and treated with removal of screws and subtalar arthrodesis (figure 5). Symptomatic hardware occurred in 3 patients (10%). The prominent screws (that was directed from posterior to anterior) were removed after five to nine months and the symptoms were disappeared after removal. In this study complicated cases significantly associated with older age and with lower AOFAS score, complications were more in females with no statistical significance(probably due to low number of studied females) also there was no significant association between complications and occupation but there was significant association between complications and addiction.

Our results were matching to that of Zhan1 J *et al*, in their study: Among all the follow-up patients, only one case (3.4%) had skin flap necrosis but was healed after dressing. Another case (3.4%) had symptoms of numbness in the area of sural innervations, which were disappeared after 5 months of physical therapy and drug therapy [19].

As regard complications our results were similar to Khira Y M, in his study infection rate was three superficial treated conservatively, and one case of deep infection treated by surgical debridement and screw extraction. Wound healing was 100% in maximum three weeks [10].

As compared by extensile lateral approach Zhou H CH et al performed a retrospective review of 65 displaced fractures calcaneus. Patients were divided into two groups: 28 cases were in the sinus tarsi approach group and 37 cases were in the extensile lateral approach group. The overall wound complication rate was 3.6% in the minimally invasive group versus 13.5% in the extensile group. Four patients in the extensile lateral approach group had developed hindfoot varus deformity. At the last follow-up, the average AOFAS ankle and the hindfoot score of the minimal group was 88.4 \pm 6.6, and the VAS score was 1.9 \pm 0.7, while that of the extensile lateral approach group was 83.2 \pm 5.6 and 2.3 \pm 1.0, respectively[20].

CONCLUSIONS

In conclusion, these new techniques (sinus tarsi approach, percutaneous reduction and fixation) could obtain wider exposure and provide rigid fixation for Sander's type II and III calcaneal fractures, limiting the soft tissue complications. Furthermore, as compared to the extensile lateral approach, these techniques required a short learning curve and can be easily mastered by beginners. So, it was worthy of application in clinics.

Figure 1: skin incision (Of sinus tarsi) from the base of lateral maleolus to base of the 4th metatars

Figure 2: A schanz pin is introduced into the tuberosity fragment (red arrow) to allow fracture reduction, with temporary fixation by k wires (blue arrows) and followed by definitive fixation by cancellous screws.

Figure 3: a buttress screw is placed from the tuberosity (red arrow) directed to the subchondral bone of the posterior calcaneal facet for its support.

Figure 4(A&B): A small T plate is placed through the sinus tarsi to allow rigid fixation of calcaneus.

Figure 5: male patient with sanders type III fr. Operated by sinus tarsi reduction & fixation complicated with subtalar arthritis and subtalar arthrodesis was done with complete relieve of subtalar pain

Table 1: p value was considered insignificant in mean difference of gissane's angle between intact contralateral and operated sides

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