

Percutaneous Fixation of Calcaneal Fracture by Cannulated Screws

*Ahmed F. Shams MD; *Yasser S. Hannout MD and **Mohammed A.A. Badr MBBCH.

Orthopedics Department, Faculty of Medicine,
Menofia University

*assistant professor, Orthopedics Department,
Faculty of Medicine, Menofia University.

**orthopedic resident, El Sheikh Zayed
Specialized Hospital.

Corresponding Author: Mohammed A.A.
Badr MBBCH.

Address: kom-hamada, El Beheira

Email: dr_mohbadr@yahoo.com

Mob: 0109319212

**The Egyptian Orthopedic Journal; 2019
supplement (2), December, 54: 73-79**

Abstract

Background

Fractures of the calcaneus account for approximately 60% of tarsal injuries and usually are the result of fall from a height. More than 70 % of calcaneal fractures are intra-articular, involving the subtalar joint, with the heel directly hitting the ground. Despite the relative prevalence of this injury, definitive management is controversial. The development of major wound complications is a serious concern in treating calcaneal fractures by open reduction and plate fixation. To avoid the feared soft tissue complications, several minimally-invasive and percutaneous approaches have been proposed throughout the history of calcaneal fracture treatment and recently gained popularity for selected injury patterns. After the first percutaneous operation by the German surgeon Westhues in 1934, a considerable number of percutaneous and minimally invasive open techniques have been used to treat calcaneal fractures.

Objectives

The aim of this study was to treat calcaneal fracture percutaneously by cannulated screws.

Patients and methods

A prospective study included 20 patients with 23 calcaneal fractures treated by percutaneous fixation by cannulated screws in Sheikh Zayed specialized hospital. The results were assessed at the end of follow up clinically using Maryland foot score and radiographically by plain radiographs.

Results

The maximum age incidence in this study was from 21<30 (45%) and the least age incidence was from 31<40 (25%). The youngest patient in this study was 22 years old and the eldest was 46 years old. There were 19 males and only one female showing male predominance. There 13 on the right side and 4 were affected on the left side. Only 4 patients (20) % had associated injuries which included: fracture tibial plateau in 1 patient, fracture pelvis and fracture both bones leg in 1 patient, lumber spine fracture in 1 patient and fracture femur in 1 patient. The predominant mechanism of injury was fall from height and landing on the heel in 17 patients and road traffic accident in 3 patients. All fractures were classified using Sander's Classification.

Conclusion

Percutaneous fixation of type II and III intra-articular calcaneal fractures minimizes soft tissue complications and post-operative scar formation which improves the functional outcome.

Key Words

percutaneous fixation, calcaneal fracture, cannulated screws.

Introduction

Fractures of the calcaneus account for approximately 60% of tarsal injuries and usually are the result of a fall from a height. Of those injured, 80% to 90% are men in their prime working years[1].

More than 70 % of calcaneal fractures are intra-articular, involving the subtalar joint, mostly caused by a fall from a height with the heel directly hitting the ground[2].

Over 80% of calcaneal fractures involve the posterior

articular surface (PAS) of the bone resulting in incongruence of the subtalar joint. This leads to arthritis of the joint with painful limitation of motion and intolerance of uneven surfaces. Increasing difficulty in dorsiflexion of the foot impedes gait, leading to a limp. Reduction of the height of the calcaneal tuberosity leads to impingement of malleoli on the shoe sole and disorders of achilles tendon mechanics, while compression of the peroneal tendons causes tendinopathy. Widening of the flattened heel increases compression and makes fitting standard shoes even more difficult[6-3].

Despite the relative prevalence of this injury, definitive management is controversial. Historically the closed treatment of these injuries had been unsatisfactory, leading Cotton and Wilson to write in 1916, "The man who breaks his heel bone is done [7]."

Infection rates after using the extended lateral approach vary between 1.3% and 7%. Carr [8] suggested that selected approaches based on the displaced anatomy may play a more important role. Several smaller direct approaches to the lateral calcaneal wall, resembling the classical Palmer approach, have been carried out without significantly reducing the soft-tissue problems as they cut through the angiosome of the lateral calcaneal artery. A direct approach over the sinus tarsi requiring retraction of the peroneal tendons and sural nerve with minimal internal fixation resulted in an infection rate of 8.5% and further 9.2% soft-tissue problems like peroneal tendinitis, sinus tarsi syndrome, and even compartment syndrome[8].

To avoid the feared soft tissue complications, several minimally-invasive and percutaneous approaches have been proposed throughout the history of calcaneal fracture treatment and recently gained popularity for selected injury patterns[9].

After the first percutaneous operation by the German surgeon Westhues in 1934, a considerable number of percutaneous and minimally invasive open techniques have been used to treat calcaneal fractures [10].

Although these techniques can minimize the incidence of soft tissue complications, one disadvantage might be the risk of incomplete reduction, especially in difficult intra-articular calcaneal fractures. An incongruence in the posterior facet of the subtalar joint and failure to restore the angle of Bohler have been frequently mentioned as important predictors of outcome after operative treatment of calcaneal fractures[10].

Based on several studies with percutaneous techniques, Rammelt et al [10] concluded in 2004 that percutaneous fixation of displaced calcaneus fractures produces good to excellent results in patients with less severe fracture patterns and that the quality of joint reduction should be directly visualized to avoid problems in subtalar joint motion[10].

Patients And Methods

Patients

Twenty three cases of calcaneal fracture in 20 patients (3 cases bilateral) had been treated by percuta-

neous fixation at sheikh Zayed specialized hospital between October 2016 and June 2017.

The patients were followed for at least 6 months post-operatively. This study included closed intra-articular calcaneal fractures type II and III in adult patients, open fracture, extra-articular fractures type I and IV fractures were excluded.

Methods:

1. Diagnosis:

- History taking.
- Clinical examination.
- Routine preoperative laboratory investigations.
- X-ray of calcaneus. The protocol of radiological evaluation in this study involved measuring 3 angles. The angles measured were: Bohler's angle, the crucial angle and the posterior facet inclination (Sarrafian) angle (Fig 1-3).
- Computed Tomography (CT) to assess Sanders type of fracture, articular and fracture configuration.

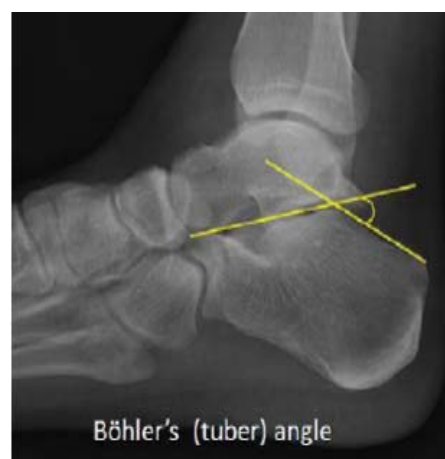


Figure 1 :Bohler's angle used in evaluation of fractures



Figure 2 :Gissane angle (the crucial angle) used in evaluation of fractures



Figure 3 :Posterior facet inclination angle used in evaluation of fractures

2. Treatment:

The patients were placed in lateral decubitus position on a radiolucent operating table, with a firm bump underneath the injured foot, which protruded outside the table, to support a perfect lateral position (Fig. 4).



Figure 4 :Position of the patient on operating table

The surgeon stood posterior to the patient with the C-arm entering the operative field opposite them from the end of the bed.

the end of the bed. The surgeon ensured that satisfactory lateral, Broden, and Harris views were easily obtained (Fig.5)



Figure 5 :The surgeon stood posterior to the patient with the C-arm entering the operative field opposite them from the end of the bed.

3. Operative details:

- *Reduction of subtalar joint depression:*
-



Figure 6 :Elevation of depressed articular surface using periosteal elevator

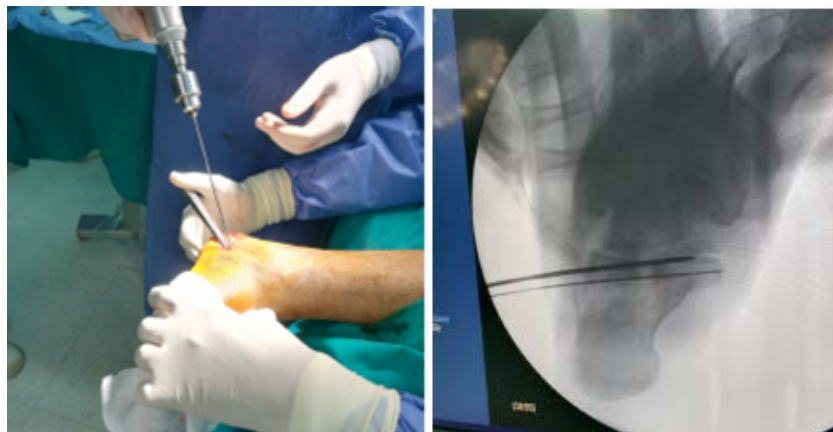


Figure 7: Temporary fixation of reduced subtalar joint



Figure 8: Fixation of depressed articular fragment using 4 mm cannulated screw



Figure 11: Measurement of length of screws.



Figure 9: Temporary fixation of fracture using percutaneous k-wires.



Figure 12: Fixation of fracture fragments using cannulated screws 6.5mm.

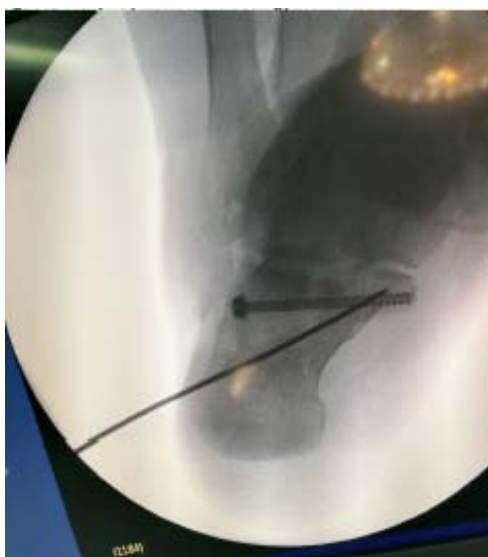


Figure 10 :Temporary fixation of fracture using percutaneous k-wires.



Figure 13: Fixation of fracture fragments using crossing cannulated screws 6.5mm.

Skin closure:

The stab wounds were sutured with absorbable sutures and padded bandage applied.

4. Postoperatively:

- Post-operatively patients received intravenous injection ceftriaxone 1 g for two days .

- The postoperative protocol employed an immediate postoperative radiograph (lateral and axial views) and measurement of the three angles: Gissane, Bohler's angle and posterior facet inclination angles .
- The patients started postoperative ankle mobilization with non-weight bearing axillary crutch mobilization on postoperative day three.
- Follow up at outpatient clinic at 12, 24 weeks and 6 months .

Evaluation:

1. Clinical evaluation:

The patients were evaluated by Maryland foot score 6 months after fixation.

2. Radiological evaluation:

Anteroposterior, lateral and axial views were obtained for all patients immediately after surgery. X-rays were done for all patients at 6 weeks and 6 months. Additional X-rays were also done at any time following the operation if the patient had pain. Loss of reduction was defined as the appearance of $2 \leq$ mm of displacement of the joint or the body of the calcaneus.

Statistical analysis:

Data were collected, tabulated and statistically analyzed by an IBM compatible personal computer with SPSS statistical package version 20 .

Two types of statistics were done:

(1 Descriptive statistics :

A. Qualitative data : number (No), percent .(%)

B .Quantitative data : Mean(x-), standard deviation (SD), median and range .

(2 Analytic statistics :

A. Qualitative data : Chi-square test ($X.^2$)

B. Quantitative data : Mann Whitney and student t-test.

P-value of (>0.05) was considered statistically insignificant. P-value of ($0.05 \geq$) was considered statistically significant. P-value of ($0.001 \geq$) was considered statistically highly significant .

Results

Twenty three displaced intra-articular fractures were treated percutaneously by cannulated screws. The mean time from injury to operation was 5 ($2 \pm$ range 2 -10 days).

The mean age 34 years ranged from 22 to 46 years old, 19 patients were males and only one female patient showing male predominance. M: F =19:1.

Thirteen on the right side and 4 on the left side. Three patients bilateral involvement.

Four patients (20) % had associated injuries which included: fracture tibial plateau in one patient, fracture pelvis and fracture both bones leg in one patient, lumber spine fracture in one patient and fracture femur in one patient.

The predominant mechanism of injury was fall from height and landing on the heel 17 patients. The other mechanism was the road traffic accident in 3 patients .

All fractures were classified using Sander's Classification. Of the 23 calcaneal fractures 18 were Type II and 5 were Type III .

The mean pre-operative Böhler's angle was 15.7 ± 3.50 range 8 -22 (0 and the mean post-operative Böhler's angle was 26.5 ± 3.9 range 20.(0 35 – The result was found to be highly significant (p-value : <0.001). This means improvement of Böhler's angle after fixation .Restoration of Bohler angle was achieved in 15 patients (65.2%) and not achieved in 8 patients (34.8%).

The mean pre-operative Gissane angle was 154.79 ± 0 and the mean post-operative Gissane angle was 139.3 ± 8.1 .The result was found to be highly significant (p-value : <0.001). This means improvement of Gissane angle after fixation .Restoration of Gissane angle was achieved in 12 patients (52.2%) and not achieved in 11 patients (47.8%).

The mean pre-operative Sarrafian angle was 42 and the mean post-operative Sarrafian angle was 55.3 .The result was found to be highly significant. This means improvement of Sarrafian angle after fixation . Restoration of Sarrafian angle was achieved in 10 patients (43.5%) and not achieved in 13 patients (56.5%).

Restoration of normal angles post-operative was achieved in 13 patients for one angle, in 5 patients for two angles and in 5 patients for the three angles. The result was statistically insignificant.

The final results at the end of this study were satisfactory in 91.3% of patients and unsatisfactory in 8.7% of patients.

Regarding complications, only one patient developed superficial wound infection treated by daily dressing and antibiotics for one week. Only two patients developed calcaneo-cuboid arthritis relieved by selective steroid injection. Only one patient developed tarsal tunnel syndrome and she refused surgical release. Two patients developed subtalar joint pain relieved by xylocaine injection.

Discussion

The treatment of displaced calcaneum fractures has been a subject of intense discussion and controversy for the last century with supporters of both operative and non-operative methods [11].

To avoid soft tissue complications, several less invasive procedures have been introduced. The most frequently used minimally invasive technique is closed reduction of fracture and percutaneous screws fixation [12].

The goal of the treatment of intra-articular displaced fractures is to focus on the anatomical reduction of the articular surface, avoid complications, and correct the length, width and angulation of the tuberosity. The open reduction and internal fixation technique allows the operator to view the articular surface directly during the reduction and fixation process but the high rate of wound breakdown and infection (15-40%) is a concern [13].

Calcaneal fractures occur most common in middle aged males and this explains its economic importance. They occur much most common due to falling from height and this explains predominance in males due to nature of work.

The mean age was 34.8 years (range from 22-46) in this study, 42 years (range from 22-76) in Rammelt S study 36 (14) years [range from 18 [54 – in Gamal O study [15] and 49 years (range from 17-73 years) in University Hospital Southampton study [16] There was no significant relationship between age and the final results of this study and also no significant relationship encountered in Rammelt S study nor Gamal O study [15] neither University Hospital Southampton study.[16]

The mean time from injury to time of operation was 5 days (range from 2-10 days) in this study and 7.2 days (range from 1 21 – days) in Gamal O study [15] There was no significant relationship between time from injury to operation and the final results of these studies .

The mean pre-operative Böhler's angle was 15.7 ± 0.35 range 8 -22 (0 and the mean post-operative Böhler's angle was 26.5 ± 3.9 range 20 .(0 35 – Restoration of Bohler angle was achieved in 15 cases (65.2%) and not achieved in 8 cases (34.8%).The result was found to be highly significant (p-value : <0.001). This means improvement of Böhler's angle after fixation. In Abdelgaid S study (17)The average preoperative Böhler's angle was 9 (300–0) 0 compared with an average of 28 (200–18) 0on postoperative evaluation. Preoperative Böhler's angle was reversed in 3 cases. In Rammelt S study [14] öhler's angle improved from 12)0range 0 (220–

angle improved from 12)0range 0 (220–preoperatively to 25)0range 16 (350–postoperatively compared to 28) 0range, 22 (340–on the uninjured side. In Gamal O [15] the mean Bohler's angle improved from 6° preoperatively to 26° postoperatively. In Gamal O [15] the mean Bohler's angle was 28.18) 0range 20 (350–post-operatively compared with 16.4) 0range 10-30 (0pre-operatively. All these studies showed improvement of Bohler's angle to pre-operative values after fixation.

The mean pre-operative Gissane angle was 154 ± 0.79 and the mean post-operative Gissane angle was 139.3 ± 0.81 Restoration of Gissane angle was achieved in 12 cases (52.2%) and not achieved in 11 cases (47.8%). The result was found to be highly significant (p-value : <0.001). This means improvement of Gissane angle after fixation. In Abdelgaid S study [17]The average preoperative Gissane angle was 1130 (range 110 ,(1550–compared with an average of 118) 0range 100 (1380–on postoperative evaluation. In Gamal O study [15] the mean Gissane angle was 132.27) 0range 120-140 (0post-operatively compared with 138.64) 0range 100-160 (0pre-operatively. All these studies showed improvement of Gissane angle to pre-operative values.

The mean pre-operative Sarrafian angle was 42 0 and the mean post-operative Sarrafian angle was 55.3 0 .The result was found to be highly significant. This means improvement of Sarrafian angle after fixation. In Abdelgaid S study [15] the mean preoperative Sarrafian angle was 27 ,0with a range of (14 ,(500–with mean postoperative angle 59) 0range 44 .(740– All these studies showed improvement of Sarrafian angle to pre-operative values after fixation.

Only one patient developed superficial wound infection treated by daily dressing and antibiotics for one week. Only two patients developed calcaneo-cuboid arthritis relieved by selective steroid injection. Only one patient developed tarsal tunnel syndrome and refused surgical release. Two patients developed subtalar joint pain relieved by xylocaine injection. In Abdelgaid S study [17]Secondary collapse of fragments was seen in three cases. Peroneal tendon subluxation was seen in one case. Intra-articular screw placement was seen in one case. No patients developed wound complications or infections. In Rammelt S study [14] no patients were observed with postoperative wound edge necrosis, hematoma, or infection. No postoperative complications related to surgery were seen, most notably compartment syndrome or any other complications attributable to subtalar arthroscopy such as fluid extravasation. In University Hospital Southampton [15] study, There was one patient with wound breakdown, which healed with non-operative measures. There was one case where the screw was promi-

ment in the subtalar joint) necessitating a repeat procedure) and one patient had sural nerve injury. There were 12 patients with symptomatic subtalar joint arthritis. Four of these had subtalar arthrodesis. In Gamal O study [15] six patients (9.4%) developed superficial pin tract infection that responded to local care and parenteral antibiotics therapy and completely resolved with Kirschner wire removal. Only one patient (1.56%) developed widening of the heel. These studies revealed less wound complications with percutaneous techniques.

Regarding weight bearing, in this study, most patients [20] (87%) started weight bearing at 12 weeks while three patients (13%) started weight bearing at 16 weeks. In Stefan Rammelt study [14] Patients returned to work at an average of 11 week. In University Hospital Southampton [15] study, the mean time for return to previous vocation was 5.5 months. In Gamal O study [15] full weight bearing was achieved within 13(range 12-16) weeks post-operative. The mean time to return to full activity was 4.23(range 3-6) months. This proved that percutaneous screw fixation allow early full weight bearing and return to work.

The functional outcome in this study was evaluated using Maryland Foot Score and there were 16 cases (69.6%) excellent, 5 cases (21.7%) good and two cases (8.7%) fair results. In Sherif Mohamed Abdelgaid study %38.3 [17]of all cases (22 cases) had excellent results, 41% good (25 cases), fair results in 15% (9 cases), and poor results in 5% (4 cases). The overall satisfactory results (excellent and good) were 79.3%. In Stefan Rammelt study [14] the AOFAS mean ankle-hindfoot scale in the 24 patients was 92. In Menofia university hospital study [15] the clinical results using the Maryland foot score revealed 52(81%) with satisfactory (27 excellent and 25 good) and 12 (19%) with unsatisfactory (10 fair and 2 poor).

Conclusion

Percutaneous fixation of type II and III intra-articular calcaneal fractures minimizes soft tissue complications and post-operative scar formation which improves the functional outcome.

Further studies on this method of fixation should be conducted. The studies should include only the pa-

tients with isolated unilateral fractures of the calcaneus to eliminate any confounders that can affect the Maryland foot score. Other studies should include Sanders 'type IV patients to assess effect of the use of the concept of percutaneous fixation on the prognosis of these fracture .

Reference

1. Cave EF. Fracture of the os calcis--the problem in general. *Clin Orthop Relat Res.* 1963;30:64-6.
2. Bremner A, Warrick C. Fractures of the calcaneus. *Journal of the Faculty of Radiologists.* 1951;2(3):235-41.
3. Sanders R. Intra-articular fractures of the calcaneus: present state of the art. *Journal of orthopaedic trauma.* 1992;6(2):252-65.
4. Zwipp H, Tschern H, Thermann H, Weber T. Osteosynthesis of Displaced Intraarticular Fractures of the Calcaneus Results in 123 Cases. *Clinical orthopaedics and related research.* 1993;290:76-86.
5. Letournel E. Open treatment of acute calcaneal fractures. *Clinical orthopaedics and related research.* 1993;290:60-7.
6. Levine DS, Helfet DL. An introduction to the minimally invasive osteosynthesis of intra-articular calcaneal fractures. *Injury.* 2001;32:51-4.
7. Cotton FJ. Old os calcis fractures. *Annals of surgery.* 1921;74(3):294.
8. Ebraheim NA, Elgafy H, Sabry FF, Freih M, Abou-Chakra IS. Sinus tarsi approach with trans-articular fixation for displaced intra-articular fractures of the calcaneus. *Foot & ankle international.* 2000;21(2):105-13.
9. Gavlik J, Rammelt S, Zwipp H. Percutaneous, arthroscopically-assisted osteosynthesis of calcaneus fractures. *Archives of orthopaedic and trauma surgery.* 2002;122(8):424-8.
10. Rammelt S, Amlang M, Barthel S, Zwipp H. Minimally-invasive treatment of calcaneal fractures. *Injury.* 2004;35(2):55-63.
11. Buckley R, Tough S, McCormack R, Pate G, Leighton R, Petrie D, et al. Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial. *J Bone Joint Surg Am.* 2002;84-A(10):1733-44.
12. Abdelgaid SM. Closed reduction and percutaneous cannulated screws fixation of displaced intra-articular calcaneus fractures. *Foot and Ankle Surgery.* 2012;18(3):164-79.
13. Gougoulas N, Khanna A, McBride DJ, Maffulli N. Management of calcaneal fractures: systematic review of randomized trials. *Br Med Bull.* 2009;92:153-67.
14. Rammelt S, Amlang M, Barthel S, Gavlik JM, Zwipp H. Percutaneous treatment of less severe intraarticular calcaneal fractures. *Clin Orthop Relat Res.* 2010;468(4):983-90.
15. Gamal O, Shams A, El-Sayed Semaya A. A Protocol for Percutaneous Transarticular Fixation of Sanders Type II and III Calcaneal Fractures With or Without an Added Mini-Open Approach. *J Foot Ankle Surg.* 2016;55(6):1202-9.
16. Vasukutty N, Kumar V, Diab M, Moussa W. Operative treatment of calcaneal fractures: improved outcomes and low complications rates with a strict management protocol. *Ann R Coll Surg Engl.* 2017;99(4):275-9.
17. Abdelgaid SM. Closed reduction and percutaneous cannulated screws fixation of displaced intra-articular calcaneus fractures. *Foot Ankle Surg.* 2012;18(3):164-79.