

Treatment of Subtalar Calcaneal Fractures Using Trans-Osseous Limited Lateral Approach

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SUMMARY

Background. Calcaneal fractures are the most common fractures of the tarsal bones. The majority of these fractures are produced by axial force like a fall from a height. Controversy still exists on the best line of treatment. This study is to evaluate the results of trans-osseous limited lateral approach as a minimally invasive surgical treatment of the displaced intra-articular calcaneal fractures.

Material and methods. The study included forty two patients (46 feet) with displaced intra-articular calcaneal fractures admitted to El-Hadra University Hospital. They were treated by trans-osseous open reduction of subtalar joint and internal fixation by k-wires consuming the trans-osseous limited lateral approach. Out of 42 patients, 36 patients (85.7%) were males.

Results. Using calcaneal fracture scoring system, the mean score was 67.55 ± 17.35 . Satisfactory results were found in 26 patients (61.9%), while 16 patients (38.1%) had unsatisfactory results. There was significant relationship between classification of the fracture and the final results (the more the grade of the fracture, the worse the final score) ($\chi^2=5.914$, $p=0.05$). The value of calcaneal angles were significantly improved after surgery including bohler angle ($p=0.0001$), gissane angle ($p=0.0001$), calcaneal pitch angle ($p=0.001$) and calcaneofibular space ($p=0.0021$).

Conclusions. 1. Trans-osseous limited lateral approach is an effective method for management of intra articular calcaneal fractures. 2. Anatomical reduction for intra articular calcaneal fractures is essential. 3. Functional outcome of intra articular calcaneal fractures depends upon the initial damage of the articular cartilage. 4. There is a need for multi-center prospective randomized study for accurate assessment of the results of operative management of intra articular calcaneal fractures involving pre and post-operative CT for assessment of reduction and using a rational scoring system and a long period of follow up.

Key words. Calcaneal fractures, limited lateral approach, k-wire fixation, minimally invasive technique

BACKGROUND

The calcaneus is the largest and irregularly shaped bone of the foot. It makes up the posterior part of the longitudinal foot arch and the lateral foot column [1,2].

The majority of calcaneal fractures are produced by axial force like a fall from a height or motor vehicle accidents [3]. A primary, shear fracture line divides the calcaneus into a posterolateral (tuberosity) fragment and an anteromedial (sustentaculum) fragment [4,5]. In the joint depression type fractures the secondary fracture line runs downward posteriorly of the impacted posterior facet while in tongue type fractures the secondary fracture line extends backwards, resulting in a large superior tuberosity fragment which is further pulled upwards by the Achilles tendon [6]. Further fracture lines may extend anteriorly and lead to a division in the sustentacular fragment or the calcaneocuboid joint, forming an anterior process and sometimes additional anteromedial fragment [5].

Controversy still exists on the best line of treatment for these disabling injuries including non operative conservative treatment or operative management by either closed reduction, open reduction, minimally invasive methods, external fixation or primary arthrodesis [7,8].

Complications can be summed up into: poor wound healing/infection, pain, thromboembolism, neurologic complications (eg, cutaneous nerve injury, neuromas, nerve entrapment, or reflex sympathetic dystrophy), compartment syndromes, Sudeck's atrophy, peroneal tendon problems (eg, tendinitis, subluxation) and shoe-wear problems [9,10].

MATERIAL AND METHODS

The study was conducted on forty two patients (46 feet) with displaced intra-articular calcaneal frac-

tures admitted to El-Hadra Orthopaedic and Traumatology University Hospital. They were treated by transosseous open reduction of subtalar joint and internal fixation by k-wires consuming the trans-osseous limited lateral approach.

All patients were assessed by taking personal data for name, age, sex, occupation, and date of admission then recording the affected side, mechanism of injury and time lapsed before surgery then clinical assessment of deformity, swelling, skin condition, pain and tenderness, movement of ankle, foot and toes, examination of whole body for associated injuries radiological assessment by plain X-ray of both sides (for comparison and measurements) including lateral, antero-posterior views of the ankle (Fig. 7A,7B), axial view of the heel. CT scan was also done To study the number and direction of fracture lines (Sander's classification) and to define the pathomorphology of the calcaneal fragments.

Informed consent about the study was confirmed for each patient. First aid treatment included splinting, elevation with administration of analgesics and anti-edematous drugs.

After wrinkling of skin, patients will be prepared for being operated. After being anaesthetized, patient is put in the lateral position. Sterile draping is applied exposing foot, ankle and leg. Skin incision about five cm at lateral aspect at the junction between thick and thin skin of the heel (Fig. 1). The incision is carried directly down to the bone without undermining the skin (Fig. 2). Through a fracture line in the soft lateral wall of the calcaneous, the lateral wall is elevated by an osteotome (Fig. 3) till exposure of the subtalar joint with the depressed fragment of the joint. Stienmann pin is introduced through calcaneal tuberosity and stopped just before reaching the fracture



Fig. 1. Skin incision about 5 cm



Fig. 2. The incision is carried down to the bone



Fig. 3. An osteotome through a fracture line in the soft lateral wall to elevate it with the soft lateral wall

site; this will help to distract the posterior tuberosity backwards and downwards to correct the calcaneal pitch and make tendoachilis in the proper tension. The joint fragment is exposed, elevated and reduced underneath its talar location (Fig. 4). Realignment of the anterior calcaneal parts to realign Gissane angle and reduction of calcaneo-cuboid joint is done. The reduced fragments are fixed by kirschner wires (Fig. 5). Also, the reduced calcaneal tuberosity and the reduced anterior subtalar and calcaneo-cuboid joints are fixed by k-wires. After adequate reduction of the displaced fragment and restoration of the calcaneal anatomy and parameters, the width will found to be reduced. Reduction may be checked by an image intensifier and accordingly modification of reduction can be done. The lateral wall is then reduced to its normal position with the skin. The skin is closed (Fig. 6), sterile dressing is applied and below knee plaster slab is applied.

Post operatively, examination of the distal circulation and neurological status of the foot and check x-rays for assessment of reduction and position of the kirschner wires are done. Patient is kept in the hospital under observation for two days.

Follow up assessment is done after two weeks, the slab and sutures are removed, check of the wound status is done and below knee plaster cast is applied. Six weeks later, removal of the cast and kirschner wires and the patient is instructed to start non weight bearing active exercises for four weeks. Ten weeks post operatively, partial weight bearing is started for two weeks then full weight bearing can be allowed. Check x-rays are obtained 2nd, 6th and 12th weeks (Fig. 7B,C , 8B,C) .

All patients were examined both clinically and radiologically at the end of follow up. Some determinants were measured including Bohler's angle, Gissane angle, calcaneal compression angle, calca-

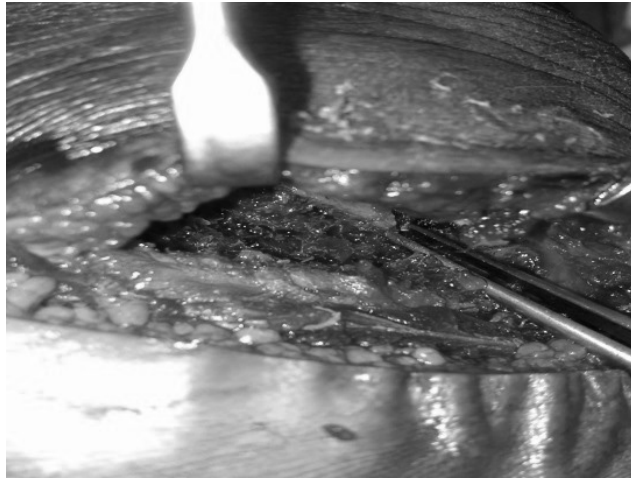


Fig. 4. The depressed fragments are exposed



Fig. 5. The depressed fragments are reduced and fixed by kirschner wires



Fig. 6. Skin closure by interrupted sutures



Fig. 7. Satisfactory case. A – Preoperative, B – Postoperative, C – After 6 months

mean pitch angle, calcanean width, calcanean length and alignment. Patients were assessed according to calcaneal fracture scoring system [11]. A score of 85 to 100 points is an excellent result; 50 to 85 points is a good result; 25 to 50 points is a fair result, and 25 points or less is a poor result.

Maximum 100 points

1- Pain (36 points)

At rest		On activity	
None	18	None	18
Slight	12	Slight	12
Moderate	6	Moderate	6
Severe	0	Severe	0

2-Work (25 points)

No change in job	25
Modification of job	16
Enforced change of job	8
Unable to work	0

3-Walking (25 points)

No change in walking ability	25
Minimal restriction	16

Moderate restriction	8
Severe restriction	0
4-Walking aids (14 points)	
None	14
Occasional sticks	10
Constant sticks	6
2 sticks	3
Crutches	0

The mean age of the studied group of patients was 36.24 years (range 17-60 years). The highest prevalence was in the age group 30-40 years. Out of 42 patients, 36 patients (85.7%) were males. The right side was affected in 24 patients (57.1%) and the left in 14 (33.3%) and four patients were bilateral (9.5%). 30 patients were heavy manual workers (71.4%) and eight were light workers (19%) while four patients were housewives. According to Sanders' classification, 31 fractures (67.4%) were type II, 13 fractures were type III (28.3%) and two fractures were of type IV (4.3%) [12]. Falling from a height was the mechanism of injury in 37 patients (88.1%)

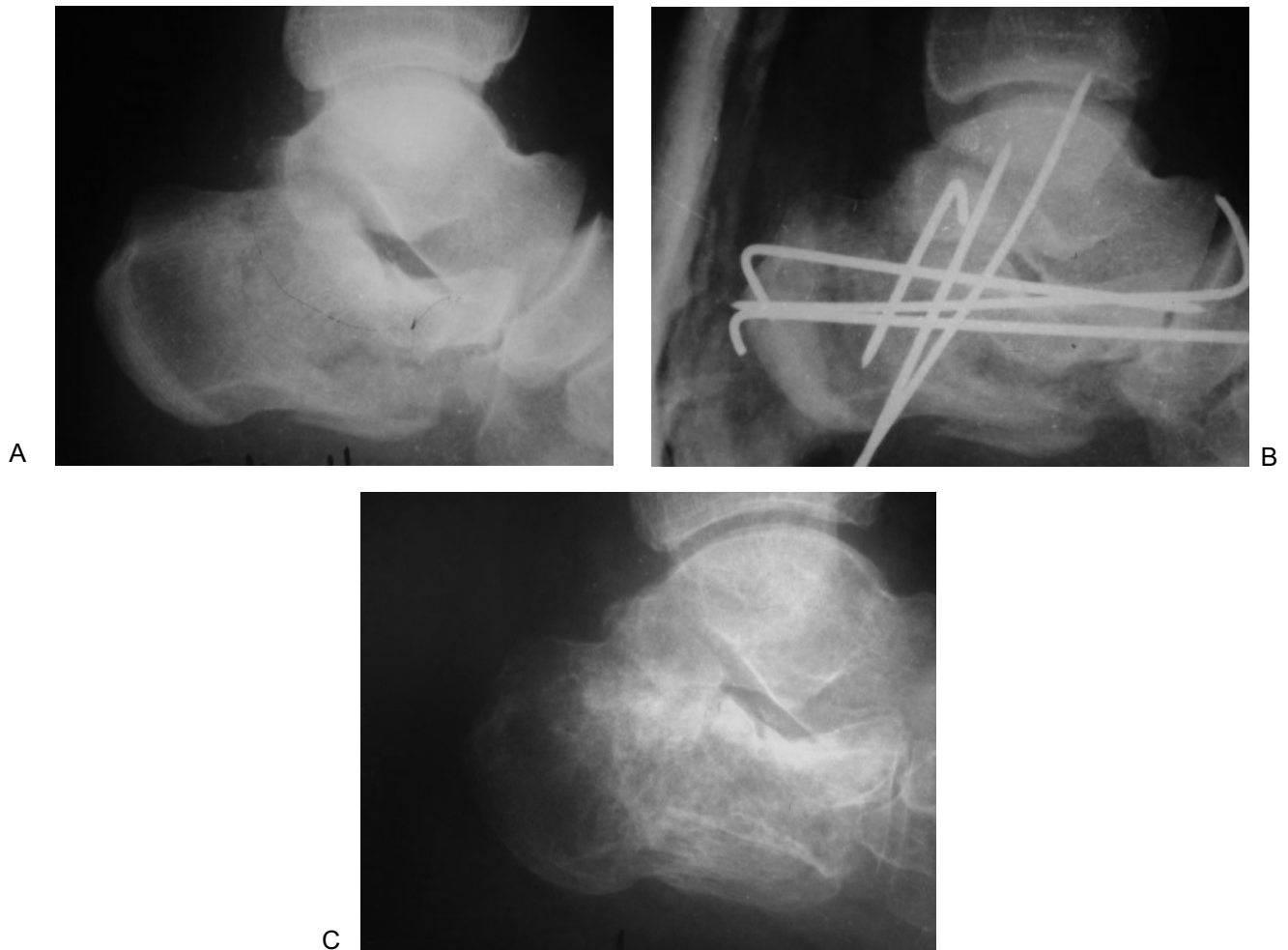


Fig. 8. Unsatisfactory case. A – Preoperative, B – Postoperative, C – After 6 months

and RTA in five. A spectrum of associated injuries was found in four patients (9.5%). One had contralateral fracture talus, fracture distal end radius, fractured third and fourth lumbar vertebrae and pubic rami. The talus and vertebral fractures were managed by open reduction and internal fixation, while the distal end radius was managed by pinning under image. The second patient had fracture femur which was fixed by interlocking nail and showed delayed union. The third patient had wedge fracture of the third lumbar vertebra which was managed conservatively. The fourth had Lis Franc's fracture dislocation on the contralateral side. The mean time lapsed before surgery was 2.95 days (range 1-14 days) with more interference at the second day.

RESULTS

According to the mentioned scoring system, the mean score was 67.55 ± 17.35 . Satisfactory results were found in 26 patients (61.9%), while 16 patients (38.1%) had unsatisfactory results (Tab. 1). The mean age of

satisfactory results was 36.92 ± 12.41 years (range 17-60 years), while that of unsatisfactory results was 35.13 ± 6.91 years (range 23-51 years), $p=0.36$, $X^2=0.36$.

The relation between sex of the patients and final results was found to be insignificant ($x^2=1.36$, $p=0.245$).

All patients having bilateral fractures had unsatisfactory results ($x^2=8.15$, $p=0.017$), which is statistically significant.

Within the satisfactory group, there were two patients as light worker (7.7%), 20 hard workers (76.9%), and four housewives (15.4%). Among the unsatisfactory group, six were light workers (37.3%), ten hard workers. It was found that there was no significant relationship between the previous occupation and the final net result of these group of patients.

Within satisfactory group, 21 fractures (80.8%) were classified as sanders type II, while five (19.2%) type III. While out of unsatisfactory results, ten (50%) were type II, eight (40%) type III and two (10%) type IV. There was significant relationship between clas-

Tab. 1. Distribution of the studied sample patients regarding the net results

	Number	Percent
Excellent	9	21.4
Good	17	40.5
Satisfactory	26	61.9
Fair	8	19.0
Poor	8	19.0
Unsatisfactory	16	38.1
Total	42	100.0
Total score		
Range		32 - 100
Mean		67.55
S.D.		17.35

sification of the fracture and the final results (the more the grade of the fracture, the worse the final score) ($\chi^2=5.914$, $p=0.05$).

The mean length of skin incision was 5.22 ± 0.69 cm (range 4-7 cm). That in satisfactory group was 4.98 ± 0.6 cm (range 4-6 cm) in satisfactory group, while among unsatisfactory group 5.41 ± 0.5 cm (range 4.5-6 cm). There was significant relationship between skin incision and final results ($t=2.01$, $p=0.012$).

The value of calcaneal angles (used for assessment of reduction) were significantly improved after surgery including Bohler angle ($p=0.0001$), Gissane angle ($p=0.0001$), calcaneal pitch angle ($p=0.001$) and calcaneofibular space ($p=0.0021$). Nevertheless, although they were significantly improved, there was no significant relationship between correction of calcaneal parameters and the final score. Also, by comparison, there was no significant relationship between net final score and post operative calcaneal parameters, except for calcaneal pitch angle that was found to be significantly related to final results. It was also found that broadening of the heels (assessed in axial x-ray views) was already corrected in 41 feet (89.1%). Failure of restoration of calcaneal width was observed in five (10.9%). In addition, the height (assessed in lateral x-ray views of both heels) was already corrected in 39 feet (84.8%). Failure of restoration of the original calcaneal height was observed in seven (15.2%), also failure to correct calcaneal pitch angle was found in six feet (13.04%) resulting in flat feet. Varus angulation of the posterior fragment detected in the axial view in 31 feet (67.4%) preoperatively, three of them were not corrected (9.7%).

The mean duration of surgery was 68.37 minutes with standard deviation 13.94 minutes (range 50-90 min.) and the mean number of Kirschner wires used was 4.76 ± 1.26 (range 2-8 k-wires). The mean time length of image exposure was found to be 1.02 sec. with standard deviation of 0.44 sec. (range 0.333-2 sec.).

The mean of the period of follow up was 11.83 ± 6.09 months (range 6-24) with the majority of the

patient in the period of 6-12 months and the mean time till union was 10.52 weeks with standard deviation of 0.89 week (range 10-12 weeks).

Complications were counted per foot. More than one complication could occur in a single patient. Subtalar arthrosis was observed in eight feet (17.4%) diagnosed by the presence of pain around the joint and decrease of ROM and confirmed by injection of a local anesthetic in the subtalar joint through the sinus tarsi. Pain relief indicates abnormal subtalar articulation. Residual varus malalignment and broadening of the hindfoot occurred in seven feet (15.2%). This deformity resulted in lateral impingement of peronei and sural nerve with calcaneo-fibular abutment.

Reflex sympathetic dystrophy occurred in two patients (4.3%) with pain, dusky red discoloration and inability to tolerate touching the ground. This was explained by postoperative immobilization without toe exercises and non weight bearing which lead to disuse atrophy. This was treated by hot fomentation, exercises, assisted walking, analgesics, vasodilators and physiotherapy. Both were improved with improvement of their final outcome.

Decreased subtalar motion was significant in eight ankles (17.4%), while minor degrees of loss of motion occurred in all the other patients.

Subtalar incongruity was observed in seven patients (nine ankles) as incongruent facet articular surface or double shadow of the joint line.

Pain at rest was observed in nine heels with mild pain (21.4%), and other three heels had moderate pain (7.1%). On activity, 30 heels had mild pain (71.4%), while ten heels had moderate pain on activity (23.8%).

No infection or wound complication occurred in the current study.

DISCUSSION

This study included 42 patients with 46 feet, 36 (85.7%) were males and six (14.3%) females. The mean age was 36.24 ± 10.59 years. The right side was affected in 24 (57.1%) patients and the left in 14

(33.3%) and four (9.5%) were bilaterally affected. There were 30 (71.4%) heavy manual workers, eight (19%) with light jobs (sedentary worker and student) and four housewives. The most common cause of injury was fall from a height in 37 (88.1%) patients followed by road traffic accidents in five (11.9%). Four patients (9.5%) had associated injuries. Other studies showed a more or less similar percentages [13-23].

The method of trans-osseous reduction of intra-articular calcaneal fracture through limited lateral approach was found to be effective. This was assured by the significant correction of the angles post operatively including Bohler angle, Gissane angle, calcanean pitch angle and calcaneofibular space ($p=0.0001$, $p=0.0001$, $p=0.001$, $p=0.0021$ correspondingly). In addition, there were no wound complications. This may be attributed to small incision, management without rough manipulation and meticulous wound closure. However, the difficulty encountered in this maneuver was how to manipulate anteromedial (sustentacular) fragment reduce it towards tuberosity fragment.

Eastwood and his associates considered the extended lateral approach to minimise soft-tissue problems and make accurate reduction and secure fixation possible [24]. Harvey et al studied the morbidity with extended lateral approach in a series of 218 displaced intra-articular fractures of the os calcis, a total of seven infections (3.2%); six after primary fixation and one following hardware removal. Eighteen fractures (8.2%) in 14 patients developed primary wound complications. Seventeen of those fractures resolved with local wound care and one patient required free tissue transfer for a foot-crush-type injury [25]. Sanders noted three amputations and five free flaps in 120 patients [12].

McReynolds proposed a medial surgical approach which allowed accurate repositioning of the angulated medial wall fracture and reduction of the sustentacular fragment. Elevation of the lateral portion of the posterior articular facet was accomplished without visualization of the joint [26].

Stephenson proposed that using the medial approach, an accurate reduction of the fragment of the tuberosity relative to the superomedial fragment is possible and at the same time, the lateral approach makes it possible to reduce the posterior facet accurately under direct vision [15].

Walde et al concluded that closed reduction and percutaneous k-wire fixation presented a minimally invasive technique for the treatment of intraarticular calcaneal fractures and that they were able to produce results comparable to open techniques with a lower rate of serious complications. In the majority of cases, an almost identical Böhler angle and geometry

of the calcaneus was achieved when compared to the opposite side at the time of last follow-up. Simple removal of the Kirschner wires and shorter surgery time decrease patient stress and must be recognized as an advantage of this minimally invasive technique [27]. Disturbance of wound healing with skin and soft tissue necrosis requiring operative intervention was not observed.

Holmes proposed that the limited sinus tarsi approach offers a minimally invasive incision with excellent exposure to accomplish the goals of fracture reduction and a relatively short operative time that minimizes the risk of soft tissue injury and he has not encountered any wound dehiscence, osteomyelitis, or wound infection [28]. Spagnolo et al study revealed that sinus tarsi approach achieved restoration of Bohler and Gissane angles from 90 to 97% of the cases in Sanders type II and III fractures, while 15% in type IV fractures; height and thickness have been restored from 87 and 95% in Sanders type II and III, and 19% in type IV. They did not have any cases of infection, hardware mobilization, wound dehiscence or soft tissue complications [17].

Weber et al proposed that anatomical reduction and fixation of displaced Sanders II and III intra-articular fractures of the calcaneum was as reliably accomplished with a short lateral subtalar approach and combined direct and percutaneous fixation as with a standard extended approach using lateral plating. Although The limited-exposure technique is more demanding with respect to the ability to navigate fragments and implants with little visual control. More fluoroscopic time is needed to check the proper position of the percutaneous screws and the overall alignment of the calcaneum [18].

Schuberth et al found that Direct visualization via arthroscopy along with percutaneously placed screws for fracture reduction affords the least amount of soft tissue disruption while allowing anatomical restoration of the joint surface. They also noted that restoration of Boehler's angle was the most difficult parameter to normalize in their group of patients, even though improvement of that parameter reached statistical significance [29].

Schwartzman and his associates found that Illizarov reduction technique is applicable in severely comminuted calcaneal fractures as well as in open fractures and in fractures with such soft-tissue compromise that ORIF of the fracture becomes a risky procedure. The major accent of this method is on restoration of the calcaneal axis, calcaneal width, length, and height but not particularly on anatomic restoration of the crushed surface of the subtalar joint [30].

CONCLUSIONS

1. Trans-osseous limited lateral approach is an effective method for management of intra articular calcaneal fractures.
2. Anatomical reduction for intra articular calcaneal fractures is essential.
3. Functional outcome of intra articular calcaneal fractures depends upon the initial damage of the articular cartilage.
4. There is a need for multi-center prospective randomized study for accurate assessment of the results of operative management of intra articular calcaneal fractures involving pre and post-operative CT for assessment of reduction and using a rational scoring system and a long period of follow up.

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