Medium-term outcome after mini-open reduction and transarticular Kirschner wire fixation for displaced fractures of calcaneus

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Background
The management of calcaneal fractures has been a controversial topic. Open reduction and internal fixation is associated with a high incidence of postoperative soft tissue complications. Minimally invasive open reduction and internal fixation by K-wires through a minimally invasive sinus tarsi approach is a valid therapeutic line of treatment that guarantees stability and anatomic fracture reduction with minimal complications. The aim of our study is to evaluate the outcome of mini-open reduction and transarticular percutaneous K-wire fixation of displaced intraarticular calcaneal fractures.

Patients and methods
This prospective case series study was conducted on 220 (156 men and 64 women) patients with intraarticular calcaneal fractures, who were managed by mini-open reduction and fixation via multiple transarticular K-wires. Mean age was 40 years. Mean follow-up period was 57 months. The following variables were assessed: preoperative and postoperative Böhler angle, angle of Gissane, calcaneal height, and Maryland Foot Score.

Results
Patients were operated on within a mean time of 3 days of injury. All fractures healed after an average of 10 weeks. There were 14 cases of pin-tract infection. The Maryland Foot Score rated 142 (64.5%) patients as excellent, 59 (27%) as good, and 19 (8.5%) as fair. There was significant improvement in Böhler angle, calcaneal height, and calcaneal width. Patients returned to the routine daily activities after an average time of 4 months.

Conclusion
We believe mini-open reduction and transarticular percutaneous K-wire fixation is an effective treatment method for cases of displaced intraarticular calcaneal fractures.

Keywords:
fracture calcaneus, mini-open, percutaneous K-wire

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Introduction

Calcaneal fractures account for 2–3% of all body fractures and 60% of all tarsal fractures [1,2]. Overall, 75% of all calcaneal fractures are intraarticular and involve one or more of the three subtalar articulating facets. Intraarticular fractures usually carry a poorer prognosis than extra-articular ones [3,4].

The most common mechanism of injury is fall from height. The economic importance of the injury is considerable, as 80–90% occur in men in their prime working years. As a result, they may be disabled for several years after the injury, and many are unable to return to their original jobs [5,6].

Owing to their complexity and the diverse treatment options, displaced intraarticular calcaneal fractures remain a therapeutic challenge with long-term complications and adverse outcomes, which are frequently documented after open surgeries [7,8]. Achieving articular surface congruence and restoring the normal hind foot alignment should be the principal aim of the treatment rather than accepting articular step and planning to do an arthrodesis at a later date if symptoms persist. Failure to reduce the articular surface will result in arthritis of subtalar joint [9,10].

The most devastating adverse effects of operative treatment are soft tissues injury and skin necrosis after extensive surgical procedures [11]. To avoid these soft tissue complications, several less-invasive procedures have been introduced [12]. The reported

rates of wound edge necrosis vary between 2 and 11% and those of soft tissue infections vary between 1.3 and 7% after plate fixation via an extended open surgeries [13–15].

The aim of this study was to evaluate the medium-term outcome of mini-open reduction and transarticular percutaneous K-wire fixation in patients with displaced intraarticular calcaneal fractures.

Patients and methods

From March 2011 till April 2017, 220 patients presented with intraarticular calcaneal fractures. The study was approved by the ethical committee of Orthopedic Department, Cairo University. All patients were operated in Cairo University Hospital after they have signed an informative consent form. All patients who received mini-open reduction and fixation via multiple percutaneous K-wires in the casualty department were included in the study.

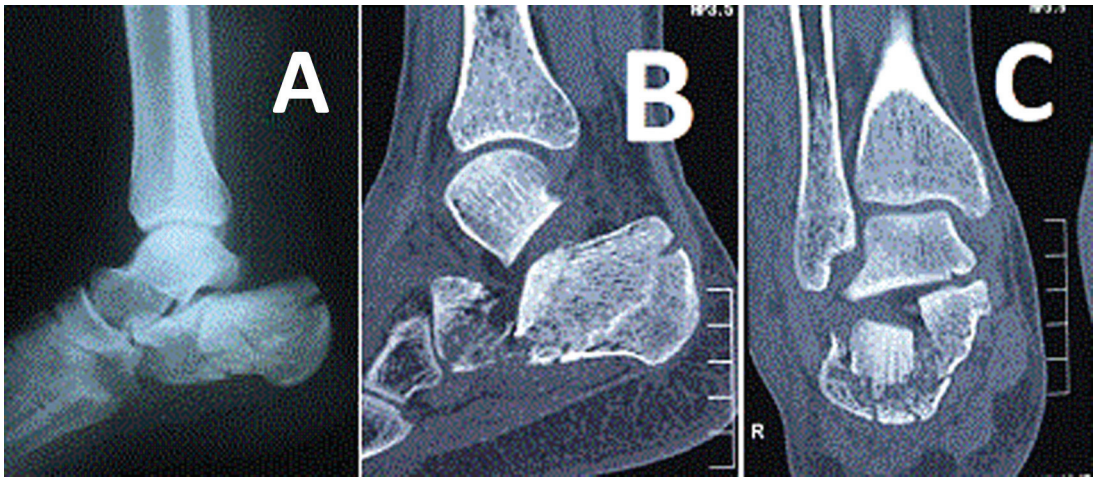
(1) The mean age was 40 years (22–55 years), and there were 156 males and 64 females.
(2) Inclusion criteria were displaced intraarticular fracture of the calcaneus (Sanders II–III).
(3) Exclusion criteria were skeletally immature patients, fractures with severe comminution (Sanders IV), and extra-articular fracture nondisplaced.

A standard series of plain radiographs of the ankle and foot were taken. The anteroposterior view and the lateral view facilitate the measurement of both Bohler's and Gissane's angles, which indicate the severity of the injury and may have a prognostic value. The axial view allows the delineation of primary fracture line, and if there is a secondary fracture line, computed tomographic scanning was performed routinely for classification purposes (Fig. 1).

Operative technique

Under general or spinal anesthesia, the patients were placed in prone position with tourniquet, on split-leg operative table to facilitate lateral imaging using C-arm fluoroscopy. After complete sterilization and draping with the foot and leg left free. The first step was to insert a 3-mm Steinmann pin superolateral to the Achilles tendon insertion. The pin was inserted into the tongue fragment with manipulation to restore the posterior facet as described by Essex–Lopresti. Then mini-open reduction was done by sinus tarsi lateral approach, and under vision, the reduction of the posterior facet was checked, and any further reduction was done by direct elevation of the posterior facet. For the varus or valgus malalignment of the hind foot, this was corrected with the wire positioned perpendicular to the longitudinal axis of the calcaneus. The heel of the patient was held with both hands and compression applied both medially and laterally with thenar muscle to reduce the main medial and lateral fragments. Sometimes, a double blunt-ended forceps was used to compress the fragment if there is no comminution. This reduces the calcaneal width and prevents lateral impingement. The anatomical restoration of the posterior facet was verified with the use of the Brode? n radiographic views (20° and 40°). The reduction of the calcaneus was verified by examining the lateral radiographic and axial views. The traction wire was removed, and the reduction was secured by multiple 2-mm K-wires, the number of which will vary according to the type of

Figure 1



Preoperative radiology.

fracture and the degree of comminution; usually five to eight wires are needed. K-wires should secure both the reduced articular surface and the overall alignment and should be arranged as perpendicular to the fracture lines as possible. The Steinmann pin was removed, after introducing of multiple K-wires. The wires were bent above the skin level. A bulky sterile dressing and a posterior lower leg splint were applied (Fig. 2).

Postoperatively, the bulky dressing and the splint were removed in the first follow-up after 2 weeks, and then active range-of-motion exercises were encouraged. Then, follow-up at 6 and 9 weeks was done with plain radiograph for evaluation of fracture healing and whether weight-bearing walking should be initiated, and physiotherapy was started for both active and passive motions of the ankle and subtalar and midtarsal joints. Subsequent follow-ups were done at 3 months, 6 months, and 1 year. The K-wires were removed after a mean of 10 weeks (9–12 weeks), depending on the type of fracture and the degree of union, and partial weight-bearing was allowed 8 weeks with full weight-bearing at a mean of 11.8 weeks (11–13.6 weeks) after computed tomographic scan to assess union before full weight bearing (Fig. 3).

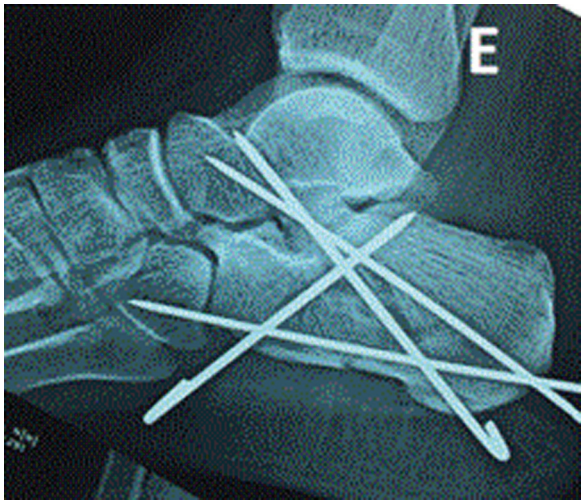
Clinical outcome assessment was done using Maryland Foot Scoring, and rating of excellent (90–100), good (80–89), fair (65–79), and poor (below 64) was assigned to each fracture, which was done at 6 months. Radiological assessment included measurement of Bohler's angle, the angle of Gissane, and height of the calcaneum in lateral view of ankle, width of the calcaneum on the axial view, and the adequacy of reduction of the posterior articular facet on Broden's view of the ankle. Computed tomographic scan postoperatively was done for all patients.

Results

Postoperative patients were followed up for an average period of 57 months (24–80 months). The following variables were assessed: preoperative and postoperative Böhler's angle; calcaneal length, height, and width; and Maryland Foot Score. The patients were operated on within a mean time of 3 days of injury (1–10 days). All fractures healed after an average of 10 weeks (7–11 weeks). There were 14 cases with pin-tract infection. The Maryland Foot Score rated 142 (64.5%) patients as excellent, 59 (27%) as good, and 19 (8.5%) as fair (Fig. 4).

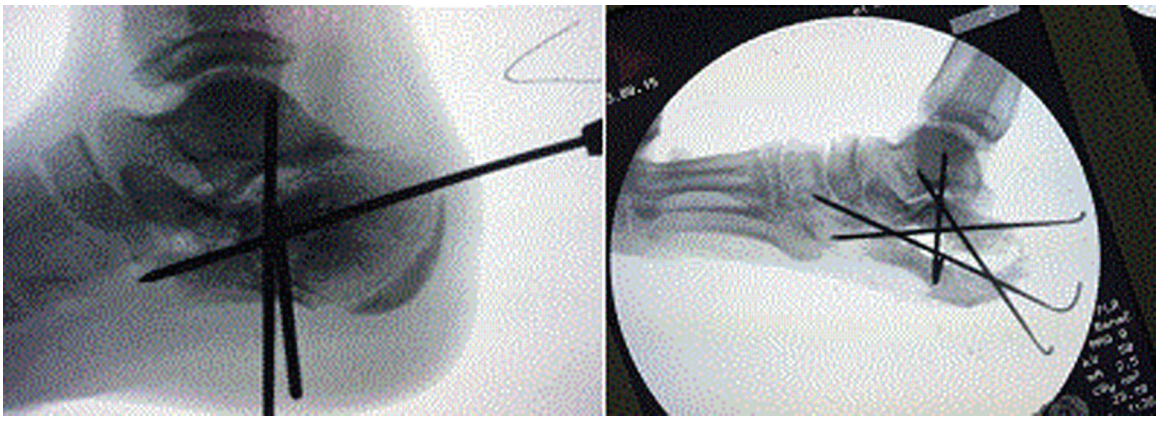
The mean±SD preoperative Böhler's angle was 20±3°, calcaneal length was 8.1±0.5 cm, calcaneal height was 3.4±0.4 cm, and calcaneal width was 4.5±0.5 cm, being significantly decreased from the final follow-up mean. All parameters were significantly increased ($P<0.03$) at

Figure 3



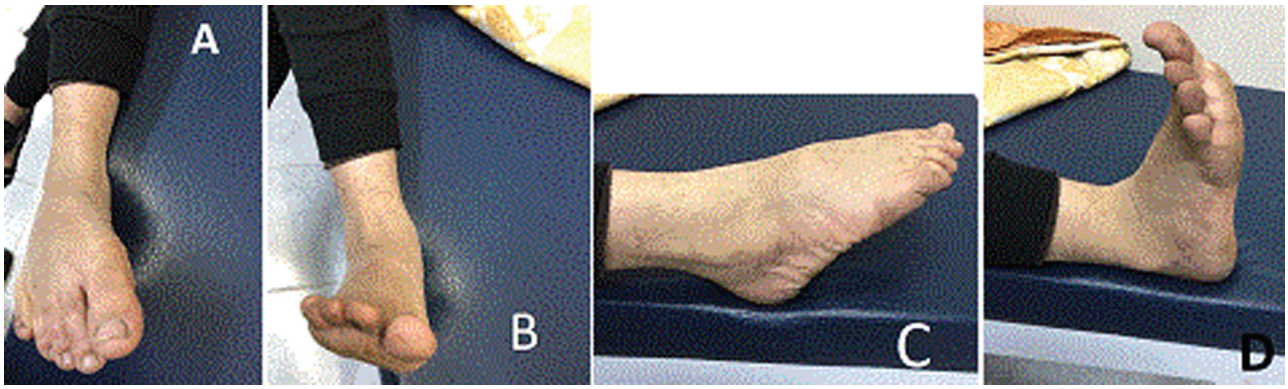
6 weeks postoperatively.

Figure 2



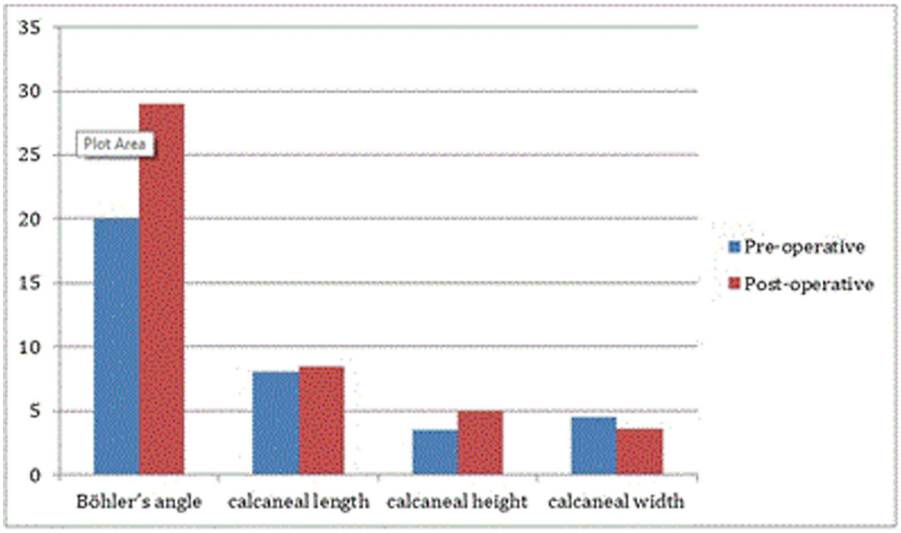
Intraoperative manipulation and fixation.

Figure 4



Postoperative range of motion.

Figure 5



Postoperative radiographic parameters.

the final follow-up (Böhler's angle 29±6.0°, calcaneal height 5±0.4 cm and calcaneal width 3.6±0.5 cm), except for a nonsignificant improvement in the length. The patients returned to routine daily activities after a mean of 4 months (3.5–6 months) (Fig. 5 and Table 1).

Table 1 Preoperative and postoperative radiological parameters

Parameters	Preoperative	Postoperative
Böhler's angle	20	29
Calcaneal length	8.1	8.5
Calcaneal height	3.5	5
Calcaneal width	4.5	3.6

Discussion

The study of Schepers *et al.* [16] showed better results for the percutaneous technique compared with the open technique. Maryland Foot Score, the Creighton-Nebraska score, and the American Orthopaedic Foot and Ankle Society score were 79, 76, and 83 points out of 100, respectively. The average range of motion of the ankle joint was 90% of normal, and subtalar joint movements were almost 70%.

Tomesen *et al.* [17] found that the mean American Orthopaedic Foot & Ankle Society (AOFAS) and the Maryland Foot scores were 84 and 86 points, respectively, of 100 possible points and concluded that this technique is a good choice for the treatment of displaced intraarticular calcaneal fractures in selected patients, although the screw removal may be needed to be removed after fracture healing.

Stefan *et al.* [18] used arthroscopically assisted percutaneous reduction and screw fixation as an alternative treatment of selected intraarticular calcaneus fractures (Sanders type II), and they found that the results of this technique compare favorably to those after open reduction and internal fixation in patients with similar fracture patterns.Khurana *et al.* [19] worked on 21 patients with intraarticular calcaneal fracture comparing between the open and the percutaneous technique. They concluded that minimally invasive methods minimized soft tissue complications and achieved comparable radiological reduction.

Many studies point out restrictions at the subtalar joint for both surgically and conservatively treated fractures. The average range of motion is approximately decreased to one-half compared with the normal leg [20].

The more favorable results presented in this study are supported by the findings of other authors [21]. This can be explained by minimizing the secondary trauma to the soft tissues through the percutaneous method, which may lead to less scar tissue formation around the ankle and subtalar joint and may thus lead to less stiffness of the joint [22].

Conclusion

We presented a minimally invasive technique for the treatment of intraarticular, dislocated calcaneus fractures and were able to produce results comparable to open techniques with a lower rate of serious complications. In most cases, almost identical Böhler angle and geometry of the calcaneus were achieved when compared with the opposite side at the time of the 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. Thus, we found that our minimally invasive technique is a viable alternative for the treatment of intraarticular calcaneal fractures.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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