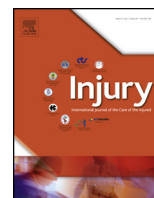




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## The outcome of super-cutaneous locked plate fixation with percutaneous reduction of displaced intra-articular calcaneal fractures

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### ABSTRACT

**Introduction:** Supercutaneous (external) fixation with locking plate is utilized for fixation of long bone fractures. One retrospective study for open reduction and supercutaneous fixation of the calcaneus is reported. We prospectively evaluated the use of this method of fixation combined with percutaneous reduction.

**Materials and methods:** Between January 2014 and June 2015, 32 displaced calcaneus fractures in 30 patients were stabilized with percutaneous reduction and super-cutaneous fixation. They were 24 males and six females. The mean age was  $37.9 \pm 5.7$  years (21–55). All cases were closed. The time to surgery, complications, radiographic alignment, and time to radiographic union were recorded. Clinical results at the final follow-up were assessed by evaluating Bohler's angles for the radiographic alignment, and the system of the American Orthopedic Foot and Ankle Society (AOFAS) for the functional outcome.

**Results:** According to the Sanders' classification, two cases were type II, 17 cases were type III and 13 cases were type IV. The preoperative average Bohler's angle was  $10.57^\circ \pm 4.8$ . The postoperative X-ray films demonstrated that the average Bohler's angle improved to  $29.07^\circ \pm 5.9$  ( $p < 0.001$ ). At the time of radiologic healing (about 3 months), the plates and screws were removed under general anesthesia. The average follow-up was 13.2 months (11–18). Four cases (type IV) showed mal-union and heel pain. According to (AOFAS) rating, the fine score was  $87.1 \pm 17.1$  points.

**Conclusion:** Super-cutaneous fixation with percutaneous reduction of calcaneal fracture is an effective method in type II and III and can be effective with type IV but with less favorable results.

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### Introduction

Calcaneal fractures represent 1–2% of all fractures of the skeleton, and 60% of all fractures of the foot with about 70% of these fractures of the intra-articular type. Moreover, the majority of these fractures occurs in the active working age [1].

The most effective treatment of displaced intra-articular calcaneal fractures is still a controversial issue [1,2], with the comparison between the operative versus the non-operative treatment of calcaneal fractures is still a matter of debate [3,4].

However, operative treatment was supported by some long-term studies. In 2002, a prospective randomized controlled trial was published, that included the results of treating 309 patients with 371 calcaneal fractures with the average follow-up of three years (ranged from two to eight years). This study demonstrated

that operative treatment has better results than non-operative treatment for women patients who were not receiving Workers' Compensation, younger males with a higher Böehler angle, patients with a lighter workload, and those with simple displaced intra-articular calcaneal [5]. In 2013, a study indicated that while the results of operative treatment of displaced intra-articular calcaneal fractures at the first year follow up was not favorable, at eight to twelve years follow up, operative treatment was shown to be beneficial with decreased prevalence in post-traumatic arthritis [6].

Another study demonstrated that better functional outcome was found with the patients of operative treatment, better Bohler's angle with articular surface restoration, and light labor [7].

The majority of surgeons uses a wide surgical exposure for open reduction and plate fixation, which provides the opportunity for anatomical rigid internal apposition of the fragments [1,8].

This wide surgical exposure with the subcutaneous location of the plate can lead to the appearance of purulent- necrotic complications of the skin wound. In this regard, the search continues for methods of minimally invasive surgery [2,9].

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Super-cutaneous (external) fixation using the locking compression plate (LCP) is a minimally invasive method for fixation. A retrospective study reported good clinical results with a stable fixation construct and a low complication rate with the use of this technique. A limited lateral incision was used for reduction [10].

In this study, we prospectively evaluated the use of super-cutaneous plate fixation by LCP for calcaneal fractures combined with the principals of percutaneous reduction.

## Materials and methods

A prospective study was conducted, after gaining the approval of the local ethics committee in accordance with the ethical standards of the 1964 Declaration of Helsinki as revised in 2000, for fixation of displaced intraarticular calcaneal fractures by percutaneous reduction and super-cutaneous locked plating.

Between January 2014 and June 2015, 30 patients with 32 injured feet were included in the study. Informed consents were obtained from all patients before the operation. Detailed documentations were recorded, including; age, sex, mode of trauma, time from trauma to surgery, associated injury, and the radiographic type of the fracture according to Sanders' classification.

All patients had acute closed fractures. The exclusion criteria included fracture duration exceeding 3 weeks, open fractures or infection, medically unfit patients and pre-traumatic foot deformity. All patients were evaluated with standard lateral and axial plain x-ray of the calcaneus. Computed tomography (CT) in the sagittal, coronal, axial and 3D plane was performed (Fig. 1).

The surgery was performed with the re-appearance of wrinkles after subsidence of the acute swelling on the lateral side of the foot (positive wrinkling test).

### Operative technique

Under spinal anesthesia; the patient is put in the lateral decubitus position on a standard radiolucent table. No tourniquet is used. With the C-arm fluoroscopy, a 4.0-mm Steinmann pin is inserted through a stab incision in the posteroinferior portion of the calcaneal tuberosity from a lateral to medial direction. Traction is applied manually along the axis of the tibia to correct the deformity; with pronation/supination of the foot in order to disimpact the fragments.

A blunt tool (screw-driver) is lodged into the calcaneus under image control through a stab incision made in the plantar aspect of

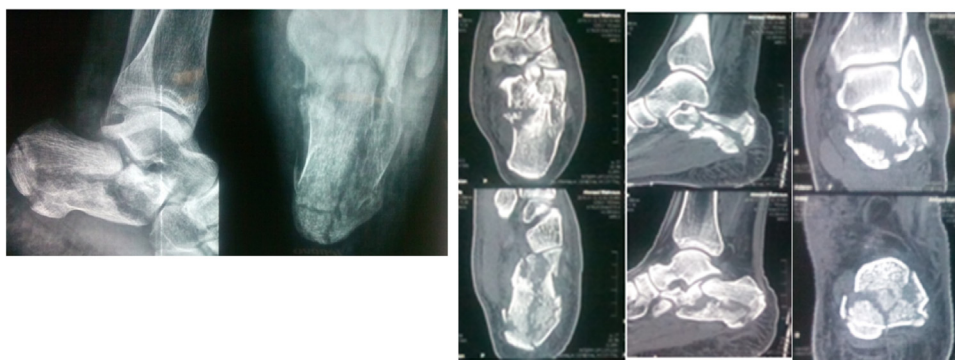
the foot through the posterior tuberosity fracture (opening the path with a drill can be used) to manipulate the inferior surface of the posterior facet. Multiple elevations of the whole surface are used in comminuted fractures (type VI). In cases with tongue fragments; these fragments were held by pointed clamps and fixed to the posterior tuberosity by k-wires converting them into one piece (Fig. 2). For all cases; the fracture parts are provisionally held with 2.0-mm K-wires (longitudinal wires for the length and transverse wire for the sustentacular fragment) then the 4.0-mm then Steinmann pin can be removed.

After attaining an adequate reduction, the intra-operative lateral and axial views are taken; the size and position of the locked plate are fitted to the calcaneus then the screws are passed through the whole width of the calcaneus to stop short of the medial cortex. The distribution and the number of the screws vary according to the type of fracture and the degree of comminution, with more comminution requiring more screws. The clearance between the plate and the skin was about 1–1.5 cm (Fig. 3).

After complete locking of the screws, the provisional K-wires are removed. In some cases with type IV fractures, we leave the longitudinal K wires as a part of fixation in order to support the comminuted fragments that cannot be fixed adequately with the screws.

Postoperative medications included intravenous 3rd generation cephalosporin was given for 48 h. Post-operative X-ray films were obtained (Fig. 4). Weight bearing was not allowed for 12 weeks, and the patients were taught how to take care of the plate and fixing screws and pins (using cotton gauze and anti-septic solution). Passive and active mobilization of the ankle and foot joints was begun 2nd day post-operative. The supercutaneous locking plate and screws were removed in minor operating theater under short general anesthesia, when bone union was confirmed by plain x-ray (lateral and axial films) and CT films (in early cases) after about 12 weeks post-operatively (Fig. 5).

After removal of the plate and screws, weight bearing was permitted. The lateral and axial radiographs of the heel were obtained postoperatively at 4, 8, and 12 weeks and at the last follow-up (at least 6 months). Final evaluations were both functional by the AOFAS rating system (points of 90 = excellent, 80 = good, 70 = fair, and, <70 = poor) and radiological by assessment of the angles of Bohler through the lateral X-ray films. Radiographic measures were recorded in three situations; the pre-operative injured side, the intact contralateral side and the post-operative injured side and compared accordingly.



**A)**Preoperative X-ray of a calcaneal fracture **B)** CT scan axial, sagittal and coronal planes.

fracture classified as Sanders' type III (AC)

**Fig. 1.** Pre-operative Radiographs: A) Preoperative X-ray of a calcaneal fracture classified as Sanders' type III (AC). B) CT scan axial, sagittal and coronal planes.

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