



# Surgical treatment results of displaced intra-articular calcaneal fracture using a locked nail

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The Foot and Ankle Online Journal 8 (2): 4

There is no general agreement for the best surgical treatment of displaced intra-articular calcaneal fractures. The objective of this study was to estimate the outcome of open reduction and internal fixation with locked nail for treatment of displaced intra-articular calcaneal fractures. This prospective study was conducted on twenty seven patients (24 men and 3 women) and 29 calcaneal fractures were stabilized. The average age was 38.7 (18–64). A shortened lateral approach was used to stabilize fractures using screws and a locked nail fixator for maintenance. The following radiological variables were assessed: preoperative and postoperative Böhler's angle; calcaneal length, height, and width. The patients were evaluated by the AOFAS Ankle-Hindfoot Scale and overall results were 82.5 points at 6 month and 83.7 at 12 month follow-up. In conclusion, open reduction and internal fixation with locked nail is an effective treatment for Sanders 2 and 3 cases of displaced intra-articular calcaneal fractures.

**Keywords:** calcaneal fractures, osteosynthesis, locked nail.

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The management of displaced intra-articular calcaneal fractures remains a significant challenge to orthopedic surgeons and patients [1,2]. These fractures are debilitating and have important long-term consequences for patients [1,3,4,5]. The most effective treatment of displaced intra-articular calcaneal fractures is still a matter of debate [1,3,6]. The adverse effects of the lateral extensile approach with plate fixation are the damage to the soft tissues and subsequent wound complications [3,7]. To avoid these soft tissue complications, several minimally invasive methods have been developed [2,7,8]. The aim of this study was to assess the clinical, radiographic, and functional outcomes of patients after locked nail osteosynthesis of displaced intra-articular calcaneal fractures.

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## Materials and methods

A cannulated locked nail and screws is presented for intraosseous osteosynthesis of the calcaneus (Figure 1). Locked nail has a diameter of 8mm and four lengths: 65mm, 70mm, 75mm, 80mm. In addition, the core of the nail has three holes for locking screws. The two of them introduced perpendicular to the central axis of the nail in the horizontal plane and located in the head and tail section of the locked nail. The third hole is oblique to the central axis of the nail at 38° and located in the sagittal plane. The tail of the locked nail has a threaded hole slots for introduction and attaching navigation systems. This localization of holes and locking screws creates stability in the frontal, horizontal and sagittal plane.

Therefore, in our opinion, presented locked nail method has several advantages. First, the stability of the posterior articular area provided via direct support by sagittal locking screw. Second, there is a possibility of closed surgery with fluoroscope control. Third, if necessary to undertake open reposition and bone

grafting, lateral surgical approach can be shortened and minimized. Fourth, there is no conflict of fixative elements with peroneal tendon and lateral ankle. Fifth, intraosseous placement design reduces the risk of necrotic complications.

The purpose of the current study is to evaluate the results of open reduction and locked nail fixation as a surgical treatment of the displaced intra-articular calcaneal fracture.

Twenty nine displaced intra-articular calcaneus fractures in twenty seven patients were stabilized with open reduction and locked nail internal fixation from May 2011 to December 2014. There were 24 men and 3 women. Their average age was  $38.7 \pm 11.1$  years (18–64). The right calcaneus was fractured in 13 cases and the left side in 16 cases. All cases were closed fractures.

At the emergency department the lateral, axial, and Broden's radiographs of the fractured calcaneus as well as lateral radiographs of the opposite foot were taken. A pre-operative CT scan was taken in 5 cases. Thirteen cases were classified as a joint depression type and sixteen as a tongue types according to Essex-Lopresti. There were Sanders II type fractures in 16 cases and III type in 13 cases.

#### ***Surgical technique:***

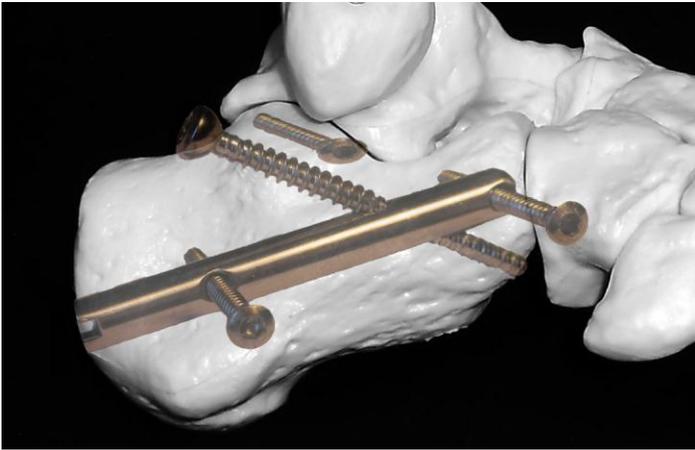
At emergency department of the hospital, the patient's foot was elevated and placed in posterior plaster splint. In operating room, the patient was placed in lateral position on the side opposite the fractured calcaneus. An ankle or thigh tourniquet was applied. Spinal or peripheral regional anesthesia. In case of the open method of surgery a 6-7cm length arcuate lateral incision was performed. The incision originated behind the lateral malleolus from the point midway between the fibula and Achilles tendon, extended down then turned anteriorly reaching anterolateral corner of the calcaneocuboid joint. A full-thickness flap was developed, the peroneal retinaculum was opened and the calcaneofibular and talocalcaneal ligaments were detached from bone. As the flap was developed proximally, the subtalar joint and the sinus tarsi were exposed. After dissection of remaining capsular tissue and washing out the fracture hematoma, it was possible to inspect the posterior articular facet. Then, the fracture was reduced by

elevator and surgical awl under direct visualization. Temporary fixation was performed with several Kirschner wires, the wires were driven through the subchondral region of the posterior articular facet from lateral to medial. Kirschner wires were exchanged for 3.5mm screws as needed for more stable fixation. When elevation of the fragments left a large defect in cancellous bone, autogenous bone graft was used.

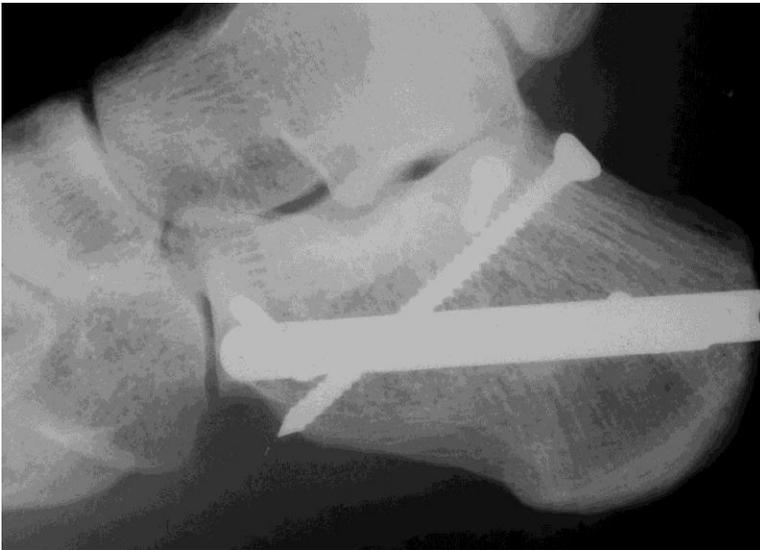
There were three navigation systems for locked nail osteosynthesis. The first navigation system was used for reaming channel and locked nail introduction. Two others were applied for blocking the locked nail with three screws. Firstly we started an introduction of a guide pin. It was inserted from the middle center point of the calcaneal tuber in the area below the insertion of Achilles tendon attachment and directed towards the center of the calcaneocuboid joint. After this, the X-ray control of the reposition and localization of the guide pin was held. Through aiming pin 8mm cannulated drilling to a predetermined depth and positioning of the locked nail was made. The aiming pin was put out. With the second navigation system locked nail was blocked with two 3.5mm blocking screws horizontally. With the third navigation system locking was performed in the sagittal plane through the oblique hole in the locked nail, thus achieving direct support of the posterior articular facet of the calcaneus (Figures 2,3). Temporary fixation was removed, the tourniquet was released, hemostasis obtained, wound was closed with stitches, bulky dressing was applied, and the extremity was elevated. In the postoperative period, additional immobilization was not applicable, limb elevation and antibiotics were given for 5 days.

It may be possible to perform a closed reduction of the fragments and introduce a locked nail through 1 cm cut and cut points for blocking screws using fluoroscopy.

The patients were followed up for 6-12 months after the surgery. On the radiographs and CT scans, we evaluated: Böhler's angle; calcaneal length, height, and width.



**Figure 1** Schematic image of the intracalcaneal location of the locked nail and screws.



**Figure 2** Lateral radiograph of the fixed calcaneal fracture with locked nail and screws.

The severity of subtalar arthritis was graded based on the radiographic appearance according to Paley [5]. The patients were evaluated by a generally accepted AOFAS Clinical Rating System, the Ankle Hindfoot Scale for calcaneal area (100 points total, 90–100 points, excellent; 80–89 points, good; 70–79 points, fair, less than 70, poor).

### Statistical Analysis

Continuous variables (patient statistics and radiographic variables) in the form of the mean and standard deviation were summarized.



**Figure 3** Broden's radiograph of the fixed calcaneal fracture with locked nail and screws.

Categorical variables were expressed by using frequency and percentage. Student's t-test was used to compare the differences among preoperative, and postoperative radiographic measurements. The level of significance was set at  $p < 0.05$ . All statistical analyses were performed using MS Excel 2003 software.

### Results

One patient was lost to follow up. Average AOFAS score at 6 month follow up was  $82.5 \pm 4.8$ , there were three excellent (10.7%), eighteen good (64.3%), six fair (21.4%), and one poor (3.6%) results in 28 cases. For simplicity, the excellent and good cases were rated satisfactory (75.0%), and the fair and poor cases were rated unsatisfactory (25.0%). At 12 month follow up we received four excellent (14.3%), twenty

good (71.4%), three fair (10.7%), and one poor (3.6%), satisfactory 85.7% and 14.3% unsatisfactory results. The mean value was  $83.7 \pm 5.6$ .

At both follow up there was no or slight pain at the lateral aspect of heel. It should be noted that this type of pain was the main complaint of the majority of patients after plate osteosynthesis. Pain that was related to subtalar joint arthrosis had been noted in eleven patients. There was implant irritation pain in retrocalcaneal region in five patients. It was due to the locked nail projection beyond the shape of calcaneal bone which led to implant removing after consolidation of the fragments. No patients showed a normal (as at opposite leg) range of motion of the subtalar joint even in case of anatomic restoration of articular surface and lack of arthrosis at follow ups.

A mild restriction at subtalar joint movement was in seven cases, moderate in twenty one cases, marked restriction in one patient. In one patient it is planned to perform a subtalar arthrodesis to consistent walking pain despite good radiographic parameters.

The average preoperative Bohler's angle was  $7.5^\circ \pm 12.2^\circ$ . (range from  $-18.3^\circ$  to  $27.9^\circ$ ), and the average postoperative angle was  $29.7^\circ \pm 5^\circ$  (range  $22.2^\circ$ – $40^\circ$ ). The mean calcaneal height before operation was  $44.0 \pm 4.5$ mm, at follow up  $51.2 \pm 4.1$ mm. The mean calcaneal length at preoperative measurements was  $78.0 \pm 14.9$ mm and at follow up it was  $80.7 \pm 6.3$ mm. The calcaneal width before operation was  $47.2 \pm 4.5$ mm and after surgery was  $41.4 \pm 4$ mm. The mean preoperative Böhler's angle and calcaneal height were significantly increased ( $P < 0.05$ ) at postoperative follow-up, whereas the mean preoperative calcaneal width was decreased ( $P < 0.05$ ). The reduction was graded as nearly anatomical (less than 2 mm residual articular step-off and satisfactory overall alignment) in 26 (89.7%). The posterior subtalar joint was assessed for subtalar arthritis at 12 month follow up and have been received grade 0 in 23 (82.1%), grade 1 in 4 (14.3%), grade 2 in 1 (3.6%).

## Discussion

In the structure of lesions of the musculoskeletal system calcaneus fractures account for 1-2 % of all fractures of the skeleton, and 60 % of all fractures of

the foot. Moreover, the vast majority of these fractures occur in the active working age, resulting in significant economic losses [1,2]. Depending on the nature of the damage and energy of the injury there are various types of fractures of the calcaneus. But the most unfavorable is intraarticular, which leads to damage and arthrosis of the talocalcaneal joint. Heel widening results for calcaneofibular ligament impingement syndrome, compression tenosynovitis of the peroneal tendon. Loss of calcaneal height and shape leads to weakening of the gastrocnemius-soleus muscles function, varus deformity of the foot, ankle contractures [1,2,4,7].

The many ways of conservative and surgical treatment of fractures of the calcaneus were reported [1,2,4,8]. The existing conservative methods do not provide anatomic reposition and stable fixation. A long-term immobilization of the foot significantly prolongs rehabilitation and worsens outcome. Therefore, preference is given to the methods of osteosynthesis by plates, screws, needles, and external fixators [1,2]. The majority of surgeons apply a wide surgical exposure for open reposition and plate osteosynthesis, which provides the opportunity for anatomic reduction and rigid internal fixation of the fragments [1]. At the same time the subcutaneous location of a fixative device, soft tissue deficit, additional trauma and significant neurovascular violations by surgical exposure, adverse microbial environment in the 24 % -32% causes the appearance of purulent- necrotic complications [3,7]. In this regard, the search continues for methods of minimally invasive surgery: closed osteosynthesis with arthroscopic control, balloon calcaneoplasty, arthrodesis through minimal surgical approach [2,4,8].

There were first foreign reports of minimally invasive osteosynthesis for fractures of the calcaneus with locked nail [9]. But the works in this direction have been few and in Ukraine have not yet carried out [10]. The present study was conducted with the purpose to delineate the role of locked nail osteosynthesis in the management of intraarticular calcaneal fractures.

## Conclusion

The surgical treatment with locked nail fixation of the calcaneal fragments has proved to be simple, easy, safe, and adequate for management of displaced intra-

articular calcaneal fractures. Presented locked nail method of has several advantages: the stability of the posterior articular area provided via direct support by sagittal locking screw, there is a possibility of closed surgery with fluoroscope control, in case of open reduction and bone grafting, lateral surgical approach can be shortened and minimized, there is no conflict of fixative elements with peroneal tendon and lateral ankle, reduced the risk of wound necrotic complications.

It is need to continue investigations in presented method of intracalcaneal locked nail osteosynthesis to improve outcomes for patients with articular fractures of heel bone, improve quality and reduce the invasiveness of surgical treatment of such patients.

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