



Management of calcaneal fractures using the Ilizarov external fixator

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Twenty five intra-articular fractures of the calcaneus in 25 patients were reduced through a minimal incision and fixed with an Ilizarov external fixator. The average age of patients was 38.6 years (range : 17 to 62 years). According to the Sanders CT classification, 10 (40%) were type II, 9 (36%) type III, and 6 (24%) type IV. The average follow-up was 30 months (range : 24-40 months). According to the AOFAS scale for ankle and hind foot there were 6 (24%) excellent, 11 (44%) good, 6 (24%) fair, and two (8%) poor results. The average score was 68 with a range of 48 to 92. The average length of the treatment period with the fixator was 9.7 weeks (range, 8 to 12 weeks). Radiological assessment revealed reduction malalignment $< 5^\circ$ in 22 cases and $> 10^\circ$ in 3 cases. The calcaneal width averaged 112% of the contralateral side. The calcaneal height was restored to 92% of the normal side, the mean (\pm SD) Böhler angle was changed from $11^\circ \pm 9^\circ$ preoperatively to $24^\circ \pm 5^\circ$ postoperatively. The most common complication was superficial skin infection at wire insertion sites. The results with this technique in a small number of non randomised cases with an average follow-up of 2.5 years seem to indicate that it could be a good alternative to traditional methods for management of intra-articular calcaneus fractures, with fewer secondary problems.

Keywords : calcaneus ; fractures ; Ilizarov.

INTRODUCTION

Both operative and non operative treatment methods for calcaneal fractures have their pitfalls.

Non-operative methods do not adequately address restoration of bony anatomy and may result in functional limitations and pain (9,14,15). Open reduction and internal fixation methods have been associated with partial skin flap necrosis and delay of rehabilitation, and with deep infection which can lead to catastrophic failure (13,16).

The distraction technique for indirect reduction and fracture fixation with minimal skin incisions has been suggested for patients with intra-articular fractures (2,4,16).

We assumed that treatment with the Ilizarov apparatus could decrease the risk of complications of open reduction and internal fixation.

The aim of this study is to analyse the clinical and radiological outcome of the management of intra-articular calcaneal fractures with an Ilizarov external fixator and to compare our results to the results of open surgery reported in literature.

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MATERIAL AND METHODS

This prospective study included 25 intra-articular fractures of the calcaneus in 25 patients treated from February 2003 to May 2005 with reduction and Ilizarov external fixator in our Emergency Hospital. They were 15 males and 10 females, with an average age of 38.6 years (range : 17-62 years). To obtain a homogeneous population, patients with bilateral calcaneal fractures and those with associated fractures were excluded from the study.

Twenty-three fractures (92%) resulted from a fall from a height, two (8%) from a motor vehicle accident. Two fractures were open, and 4 fractures had significant skin blistering. Plain radiographs including anteroposterior (AP) and lateral views of the ankle and a Harris axial view, as well as computed tomography (CT) scans in both axial and coronal planes were obtained.

The fractures were classified according to the Sanders CT classification system (13) into 10 (40%) type II, 9 (36%) type III, and 6 (24%) type IV. Type I was excluded from the study.

Preoperative management and surgical technique

All patients were managed using a modification of the technique described by Vladimir and Roman (17). The patient is positioned supine on an operating room table with a pulley at the end of the table. A 1.8 mm Kirschner wire is passed from the medial side of the calcaneus, horizontally through the most posterior and distal part, perpendicular to the body of the calcaneus which is in varus. So doing the wire parallels the original plantar surface of the calcaneus. This location does not interfere with the further application of the foot arch or 5/8 ring. The K wire is placed from the medial side to avoid neurovascular structures. A half ring is then affixed to this traction pin and tensioned to 60 kg. A sterile rope tied to the middle hole of the 1/2 ring and passed over the pulley at the end of the table, permits traction of 4 to 6 kg (fig 1a). Distal and posterior traction in the sagittal plane restores the length and height of calcaneus. A pneumatic tourniquet is applied to the thigh without inflation.

The pre-constructed proximal ring block of the external fixator consisting of 2 proximal rings is now applied to the distal half of the leg.

After inflation of the tourniquet, a lateral incision of approximately 4 cm in length is made, beginning 1 cm below the tip of the lateral malleolus and progressing distally parallel to the subtalar joint and crossing the peroneal tendons. Through this incision a blunt elevator

is introduced to elevate the depressed fragment (fig 1b) and reduction is attempted under control of the image intensifier to anatomically restore the articular surface. Reduction of the depressed fragment is maintained with one or two 1.8 mm K wires inserted immediately below the subchondral bone of the depressed fragment or into the depressed fragment itself.

When the depressed fragment is desimpacted, the width of the calcaneus can be reduced by bimanual compression over the heel. If intraoperative radiographs are satisfactory, the osseous defect left in the subchondral bone is filled with cortico-cancellous bone grafts from the iliac crest to maintain the reduction and to prevent collapse of the reduced fragment.

The distal block fashioned from a 5/8 Ilizarov ring or U-shaped footplate is applied to the heel with the aid of two tensioned olive wires. The distal block should be parallel to the plantar surface of the calcaneal tuberosity and proximal to the tensioned wire used for skeletal traction initially in the procedure. A separate tensioned wire through the metatarsals to maintain the forefoot position and prevent a forefoot equinus contracture is fixed to the distal block. The two wires that are used to maintain reduction of the depressed fragment as was previously described are tensioned and fixed to the distal ring block with aid of two male posts (fig 1c, 1d).

The proximal and distal ring blocks of the fixator are connected by threaded rods of approximately 150 mm in length. Once reasonable stability is achieved and all wires are tensioned and fixed to the appropriate rings, maintenance of reduction is verified fluoroscopically and the traction wire is removed. The wound is then closed. Primary wound closure was possible in all cases. Correction of varus deformity is accomplished by distraction of the medial rods. Acute distraction of the subtalar joint is then carried out by increasing the distance between the proximal and distal ring blocks by a few millimeters.

In case of open fracture, irrigation, debridement, and intravenous antibiotic therapy are done before application of the external fixation device. The open wound is used for manipulation of the fracture.

Postoperative follow-up

Intravenous antibiotics were administered for five days. The operated leg was kept elevated for a few days to help the swelling to subside. Sutures were removed 12 days postoperatively. Pin care is crucial : throughout the duration of treatment it was performed twice a day with saline and local antiseptic. Patients were encouraged

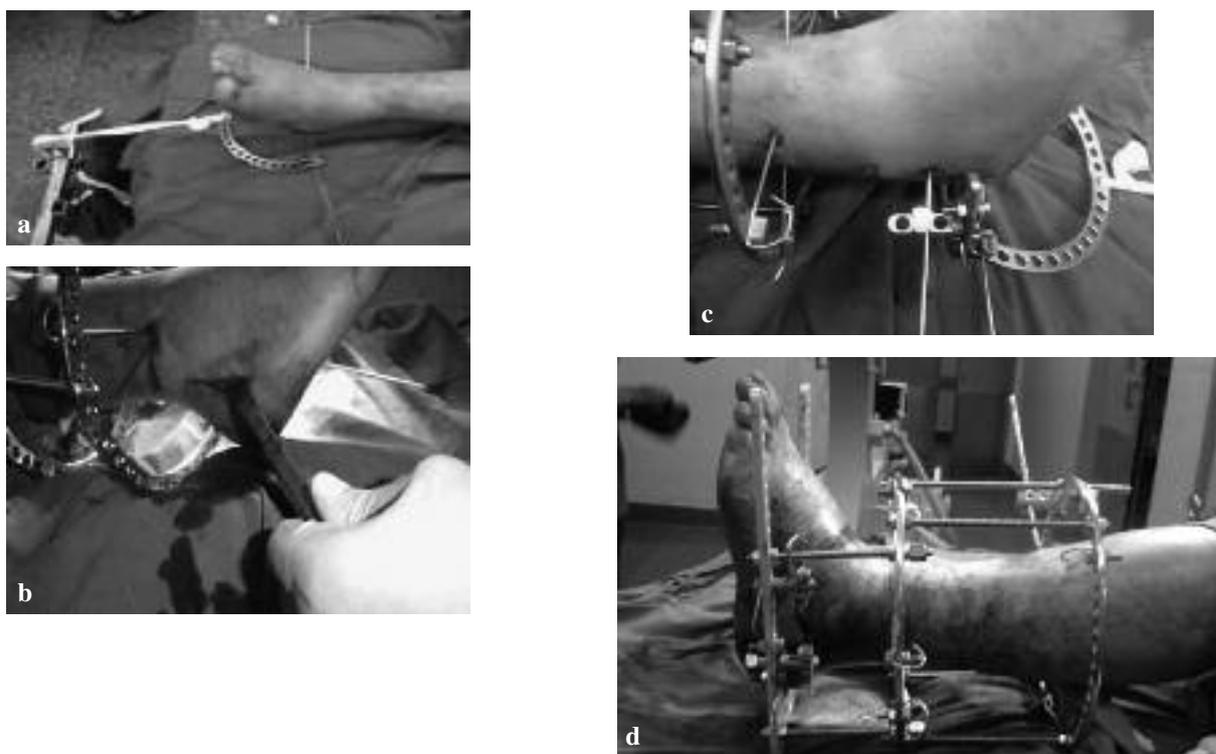


Fig. 1. — (a) : Traction in the sagittal plane is directed distally and posteriorly using tensioned wire and half ring (b) : A blunt elevator is introduced to elevate the depressed fragment (c) : The two wires that are used to maintain reduction of the depressed fragment are tensioned and fixed to the distal ring block with aid of two male posts (d) : final frame.

to partially bear weight as tolerated by the end of the third postoperative week. Patients were followed up both clinically and radiologically every three weeks in the first three months then every three months till final follow-up.

Radiological assessment included the quality of the reduction, which was assessed on the lateral and axial views. The pre and postoperative Böhler angles were compared. Calcaneal height and width as well as subtalar movement were compared with the uninjured foot. Functional assessment was carried out at final follow-up, using the AOFAS scale for ankle and hindfoot (8). The mean follow-up duration was 30 months (range, 24-40 months).

RESULTS

According to the AOFAS scale for ankle and hindfoot (8) there were 6 (24%) excellent, 11(44%) good, 6(24%) fair, and two (8%) poor results. The average score was 68 with a range of 48 to 92.

Treatment time in the external fixator ranged from 8-12 weeks with a mean of 9.7 weeks. The mean time interval between injury and operation was 19 hours (6 hours to 10 days). No additional surgeries other than external fixator removal have been performed since the initial hospital stay.

On the postoperative axial view reduction malalignment was less than 5° in 22 cases and more than 10° in 3 cases. The calcaneal height and width were restored to 92% and 112% of normal, respectively. The mean Böhler's angle was changed from $11^\circ \pm 9$ SD preoperatively to $24^\circ \pm 5$ SD postoperatively. Eleven patients (44%) had arthritic changes in the subtalar joint : 5 of 6 (83.3%) type IV cases, 5 of 9 (55.5 %) type III cases, 1 of 10 (10%) of type II. Six (24%) patients had arthritic changes in the calcaneocuboid joint. No arthritic changes were noted in the ankle joint at last follow-up.

One patient developed reflex sympathetic dystrophy which improved with physiotherapy and



Fig. 2. — (a) : preoperative lateral view of intra-articular calcaneal fracture ; (b) : Computed tomographic scans showing a Sanders type- II calcaneal fracture. (c) early postoperative lateral radiograph ; (d) : lateral view at final follow up ; (e) postoperative C-T view.

medical treatment, five had residual oedema of the foot, and wire bending occurred in one case. Superficial pin tract infection was seen in most of the cases and responded to more frequent pin care and local antibiotics. We had no deep infection.

Two patients complained of mild pain over the lateral aspect of the subtalar joint and one patient had residual heel pain. All patients but one returned to their initial work. Two patients needed shoe modifications. No cases were complicated with hypoesthesia in the distribution of the sural nerve.

In comparison to the normal side, range of motion of the subtalar joint was more than 50% in 20 (84%) feet while, in the remaining 5 (16%), it was less than 50% (three of them were type IV and two type II). Full or almost full range of motion in the ankle joint was achieved in 23 of 25 cases

Using Chi-square test and Fisher's exact test, a statistically significant correlation was found between clinical results and subtalar arthritis ($p < 0.02$). A statistically significant correlation was found between type of fracture and subtalar arthritis ($p < 0.01$).

Using Mann Whitney test, the increase in the postoperative Böhler's angle in comparison to its preoperative values was statistically significant ($p < 0.05$). There was no statistically significant correlation found between type of fracture and Böhler's angle ($p > 0.3108$).

The preoperative and postoperative Böhler's angle was significantly different in type II ($p < 0.001$) and type III ($p < 0.04$), but there was no statistically significant difference concerning type IV (using Wilcoxon test).

DISCUSSION

Various methods have been proposed over the past century for treating calcaneal fractures. Poor skin condition associated with calcaneal fractures can be a contraindication to open reduction. Wound problems are a common complication in surgical management of calcaneal fractures (3,5).

A plantar stab wound is used in the original technique of Vladimir and Roman (17). We preferred a lateral incision because of the wound healing risk in the sole and because a lateral wound allows to deal better with the lateral wall of the calcaneus. This lateral incision, using an elevator and under control of the image intensifier, provides a limited but adequate exposure for the reduction of the posterior facet, the anterolateral fragment, and the lateral

Table I. — Clinical and radiological results according to type of fracture

Sander's fracture classification	Clinical results				Arthritis of subtalar joint
	Excellent	Good	Fair	Poor	
Overall 25	6 (24%)	11 (44%)	6 (24%)	2 (8%)	11 (44%)
Type II 10 (40 %)	4 (40%)	5 (50%)	1 (10%)		1 (10%)
Type III 9 (36 %)	2 (22.2%)	5 (55.6%)	2 (22.2%)		5 (55.5 %)
Type IV 6 (24 %)		1 (16.7 %)	3 (50 %)	2 (33.3 %)	5 (83.3%)

wall. We believe that accurate reduction of the lateral wall of the calcaneus through the lateral incision effectively eliminates peroneal tendon problems.

Most cases had superficial pin tract infection, but there was no case with deep infection. With open reduction Zwipp *et al* (18) reported deep infection in three (7.9%) cases, and one of these cases healed after radical debridement and latissimus dorsi free flap but two required calcanectomy.

With open reduction Jain *et al* (7) restored the height of the calcaneus to 82% of normal. In our study, the calcaneal height was restored to 92% of the normal side. This may be attributed to the distal and posterior traction applied to the calcaneus in the sagittal plane as a preliminary step in the operation.

Thermann *et al* (14) reported arthritic changes in the subtalar joint in 65.2% of type II fractures and in 81.7% of type III IV fractures. In this study, radiological follow-up evaluation showed arthritic changes in the subtalar joint in 44% of cases. In respect to fracture type, 75% of type IV, 70% of type III, 9% of type II showed these arthritic changes. The Ilizarov external fixator allowed slight controlled distraction of the subtalar joint. It is thought that creating a space between the bony surfaces and minimising the mechanical stress will encourage fibrous repair of defects of the articular cartilage and preservation of an intact and congruent articular surface (1, 2, 11, 12).

Unlike ORIF followed by plaster cast, the Ilizarov external fixator permits partial to full early weight bearing in all patients. This may be helpful in desensitisation of the heel fat pad and thus prevent chronic heel pad pain and dystrophy as demonstrated by Houghton (6).

Regarding joint movements, results of this study are in agreement with Levine and Helfet (10) who reported, in their series of intra-articular fractures of the calcaneus treated with a minimally-invasive technique, that subtalar movement was almost completely preserved despite an articular surface reconstruction described as 'nearly anatomical'. They believe that minimal dissection results in less post-operative swelling, less peri-articular scarring and an improved range of movement than formal open reduction, despite imperfect restoration of the joint surface.

In conclusion, Ilizarov external fixator is a safe and effective method in management of calcaneal fractures with, after a period of 2.5 years, a reduced incidence of secondary problems such as subtalar arthritic changes.

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