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Surgical treatment of calcaneal fractures with bioabsorbable screws

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Abstract There is no consensus for the best surgical treatment of intra-articular calcaneal fractures. Bioabsorbable implants have been recommended for the treatment of some fractures. The aim of this study was to estimate the outcome and complications of surgical treatment of calcaneal fractures using bioabsorbable screws. We retrospectively reviewed 58 patients who underwent surgical treatment using bioabsorbable screws. The minimum follow-up was 15 months (mean, 23 months; range, 15–32 months). Fifty-five of 58 patients healed without additional complications. The mean adjusted American Orthopaedic Foot and Ankle Society ankle-hindfoot score was 73.6±22.4, the mean foot function index score was 23.9±7.1, and the mean calcaneal fracture scoring system score was 77.2±8.5. One patient had a superficial wound infection which healed after irrigation and debridement without removal of the implant. Two patients had consistent effusion from the wound for two weeks which healed after drainage and elastic dressing. We identified no evidence of soft tissue irritation or other complications directly attributed to the bioabsorbable screws. Our observations indicate that bioabsorbable screws provide sufficient stabilisation to allow for calcaneal fracture union with the advantage of no implant removal needed.

Introduction

The calcaneus is the most commonly injured tarsal bone in the foot. Roughly three-quarters of calcaneal fractures are intra-articular, which can lead to post-traumatic osteoarthritis.

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Although modern operative intervention has improved the outcome in many patients, there is still no real consensus on the treatment. Currently, open reduction and internal fixation (ORIF) with metallic plates and screws is widely used in the surgical treatment of intra-articular calcaneal fractures [1]. Fixation with metallic plates and screws has been proven to be effective in providing enough stability for bone union. However, long-term complications and adverse outcomes are frequently documented [2]. Some complications might be related to the metallic plates and screws, including soft tissue irritation and impingement, which necessitates the removal of the implant. Recently, many reports have demonstrated favourable results in treating fractures with bioabsorbable screws [3, 4].

The purpose of this report was (1) to determine the radiographic and clinical results of intra-articular calcaneal fractures where the bioabsorbable screws were used and (2) to identify any complications related to the bioabsorbable screws.

Materials and methods

Patients

Between February 2007 and June 2009, we retrospectively reviewed 58 patients with intra-articular calcaneal fractures treated with bioabsorbable screws (3.5 mm, Dikfix TM, Dikang Inc, Chengdu, China). The study was approved by our institutional review board. The material of the bioabsorbable screw was PLLA (Poly-L-Lactide), which is biodegradable. The mean age of the 58 patients was 41.3 years (range, 22–67 years), and the cohort included 46 men (79%) and 12 women (21%). The mechanism of injury included fall from a height in 43 patients and

motorcycle accident in 15 patients. Three of the 58 patients had additional trauma to other parts of the body, including vertebrae and tibial shaft fractures. One patient was diabetic, which was controlled. All the calcaneal fractures were closed and unilateral; the right side was involved in 37 cases and the left side in 21 cases. The fractures were classified according to Sanders scale on the basis of the CT images [5] which included: 23 in type II (40%), 26 in type III (45%), and nine in type VI (15%). Calcaneo-cuboid joint involvement occurred in 19 patients (33%). Indications for surgery in our study included more than 2 mm of subtalar joint displacement, flattening of the foot (decreased Boehler's angle), incongruity of the articular surfaces of the posterior facet, and shortening or broadening of the hindfoot. Surgery was performed after an average duration of 9.2 days from admission (range, five–13 days). All patients were admitted to the hospital and received plaster prior to surgery.

Surgery

Surgery was performed with the patient under general or spinal anaesthetic in the prone position with a pneumatic thigh tourniquet. The middle portion of the standard extended L-shaped lateral approach was used to expose the calcaneus with the full thickness flap technique [6, 7]. For some type II and type III fractures, a small lateral incision was used, which began from 2 cm inferior and posterior to the lateral malleolus extending anteriorly in an almost straight line and ended at the anterolateral corner of the calcaneocuboid joint [8]. The reductions were completed in the following steps [9]: the varus or valgus malaligment of the calcaneus was corrected with a Schanz screw positioned orthogonally to the longitudinal axis of the calcaneus and traction, the lateral cortical wall was pulled back, the medial compressed joint surface was elevated, the lateral portion of the joint surface was reduced onto the medial portion, the calcaneal body and sustentacular fragment was adjusted onto the posterior reconstruction, and the reduction was temporarily held in place with 1.5-mm K-wires. The restoration of Gissane's angle, Boehler's angle, calcaneal height and width were verified by the C-arm fluoroscopy. Bioabsorbable screws (3.5 mm) were then used to stabilise the fracture. The average number of screws used was four (range, three to seven). The number and location of screws varied with the fracture type. The bioabsorbable screws were mostly used to stabilise the following fragments: calcaneal tuberosity, subtalar joint, sustentacular fragment and calcaneal body. Additionally, for some Sanders type VI fractures, two K-wires (2.5 mm) were used percutaneously to strengthen the reconstruction by longitudinally passing through the subtalar joint and calcanealcuboid joint. Before repositioning the lateral wall fragments, the bone defect (>2 cm) under the joint surface was grafted in 30 cases (cancellous autograft from the iliac crest in 21 cases and calcium phosphate in nine cases). The skin was sutured with individual stitches and the drainage tube was imbedded for 36 hours. The foot was bandaged with sterile dressing and an elastic wrap.

Postoperative treatment and follow-up

The active range of motion exercises are initiated from the third day postoperatively. The partial weight-bearing rehabilitation started from eight weeks after the operation. Full weight-bearing was allowed at about 12 weeks postoperatively when signs of bone healing were present. The K-wires were cleaned three times a day with alcohol. The two longitudinal K-wires were removed three weeks postoperatively.

X-rays of both calcanei were taken for all patients on follow-up to measure the Boehler angle, calcaneus height and to assess the subtalar and calcaneo-cuboid joints. The motion of the ankle and foot were assessed by comparison to the non-injured foot. The adjusted American Orthopaedic Foot and Ankle Society ankle-hindfoot scale (AOFAS) [10], the foot function index (FFI) [11], and the calcaneal fracture scoring system (CFSS) were used to assess the results [12]. The total score in the AOFAS scoring scale ranges from 0 to 100, with higher scores indicating lesser impairment. Moreover, the 100-point AOFAS is classified as excellent (95–100 points), good (80–94), medium (50–79) and poor (<50). The FFI total scores range from 0 to 100; however, higher scores indicate greater impairment. The total score in the CFSS also ranges from 0 to 100, with higher scores indicating lesser impairment. All radiographic and clinical results with related complications were documented by one senior doctor who had not participated in the treatment of any of the patients.

Statistical method

The Statistical Analysis System (SAS Institute, NC, USA) for Windows, version 6.12, was used for statistical evaluation of the results. The paired t test was performed for comparisons. Mean and standard deviation were calculated for all measured and calculated values. The significance level was taken as $P<0.05$ for all values.

Results

Surgery in all cases restored normal joint surface, Boehler angle, calcaneal height (Fig. 1b) and width (Fig. 1d). All patients were followed-up for an average of 23 months (range, 15–32 months). Fifty-five of 58 patients (94.8%)

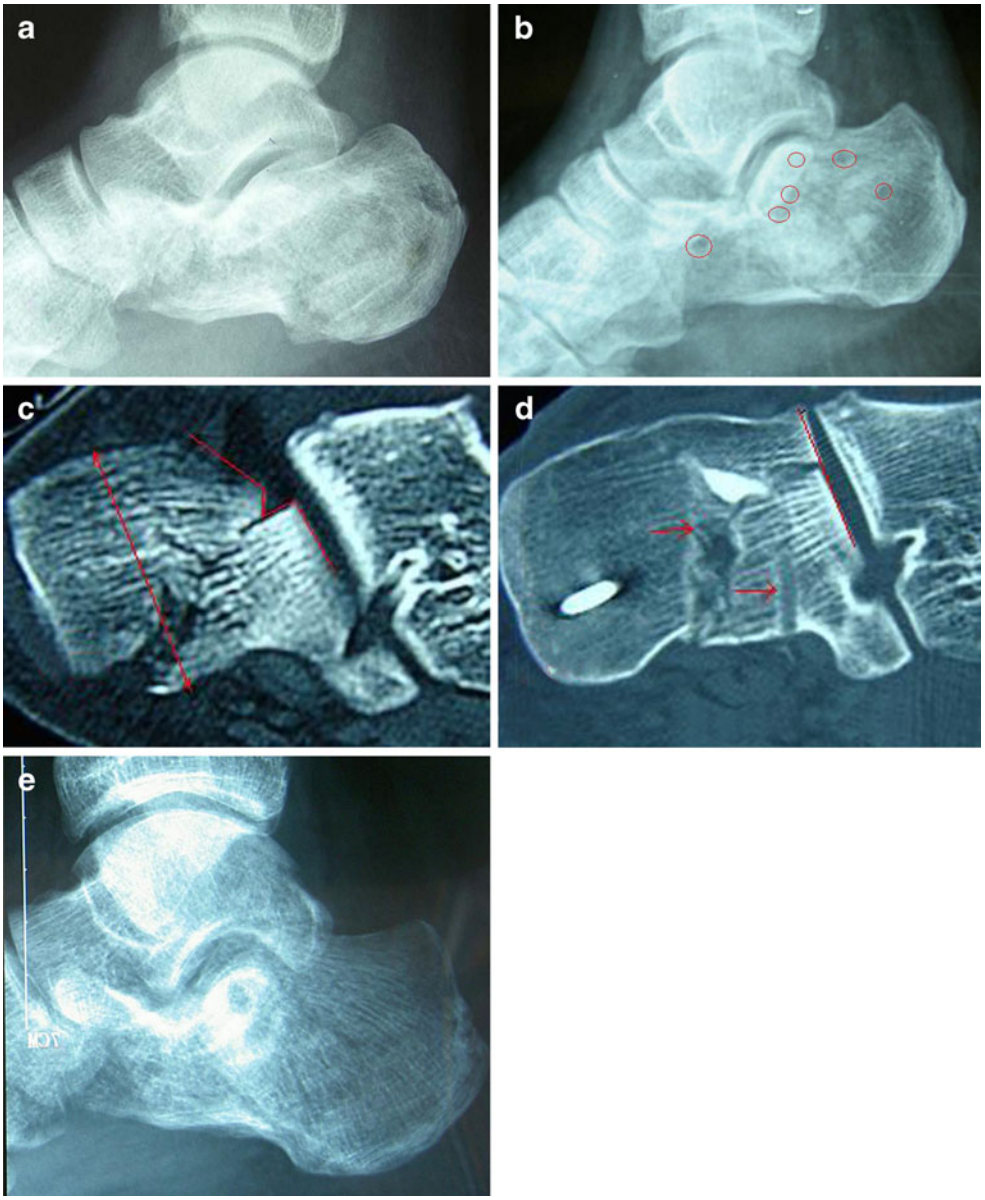

Fig. 1 **a** Preoperative lateral X-ray shows the destroyed Boehler's angle and compressed joint of calcaneus. **b** Postoperative lateral X-ray shows the restored Boehler's angle and joint of calcaneus. *Circles* indicate the positions of bioabsorbable screws. **c** Preoperative coronal CT shows the widening calcaneus. **d** Postoperative coronal CT shows restored calcaneal width; *Arrows* show the positions of bioabsorbable screws. **e** Lateral X-ray shows the healed calcaneus at one year

demonstrated signs of bone union at about three to four months postoperatively without any complications (Fig. 1e). The difference of Boehler angle and calcaneal height between preoperative and postoperative measurements was statistically significant ($P<0.01$) (Table 1; Figs. 1a and 1c). The average measurements at the last follow-up demonstrated little change compared to postoperative values ($P>0.05$). X-rays of three patients in type VI indicated an obscure subtalar joint without compromised function. At average 23 months follow-up, no secondary arthrodesis had been performed for traumatic osteoarthritis in subtalar or calcaneo-cuboid joint.

At final follow-up, the average sagittal range-of-motion of the ankle joint (plantar plus dorsiflexion) was 64° (range, 19–69°), which represented 91% recovery compared to the non-injured foot. The average range-of-motion of the foot (inversion plus eversion) was 43° (range 32–50°), which represented 82% recovery compared to the non-injured foot. The mean score of AOFAS was 73.6±22.4 with nine excellent (16%), 41 good (71%), eight medium (12%), and zero poor outcomes. Five of the eight patients with medium AOFAS scores were with Sanders type VI fractures. The mean score of FFI and CFSS were 23.9±7.1 and 77.2±8.5, respectively. All patients showed normal level of stability and were able to wear normal shoes.

Of the 58 calcaneal ORIF procedures, three complications were noted. One patient had a superficial wound infection on the fifth day postoperatively that healed following irrigation and debridement without removal of the implant. Two patients had persistent effusion for more

Table 1 The preoperative and postoperative radiographic data

Measurement	Preoperative	Postoperative	Final follow-up	Non-injured foot
Boehler's angle (°)	7.5±12.1	32.7±6.3*	31.5±7.2*	34.1±6.7
Calcaneal height	28.2±15.6 mm	47.5±5.3 mm*	45.7±9.6 mm*	47.7±6.4 mm

* Compared to the preoperative value, $P<0.01$

than ten days due to a residual haematoma, which healed after drainage of the wound and compressed dressing. There was no impingement of the peroneal tendon, no osteomyelitis, no wound dehiscences or skin necrosis.

Discussion

Calcaneus fractures are the most common fracture of the tarsal bones, yet controversy continues regarding the most effective treatment for these disabling injuries. Understanding the mechanism and anatomy of fractures is imperative to successful treatment for all calcaneal fractures. It was reported that nearly 75% of calcaneal fractures are the result of falling from heights. Therefore, the resulting fracture pattern is relatively consistent [13]. Intra-articular calcaneal fractures are usually caused by axial loading with the rear foot in valgus position, thereby placing the tibial vector force medial to the calcaneal point of contact. The forces often result in a subtalar joint compression, displacement of sustacular process, loss of calcaneal height, heel widening and varus deformity. The fracture usually concludes with three major fragments: the tuberosity fragment (lateral portion of the posterior facet); the superomedial fragment (the sustentacular portion); and the distal or anterolateral fragment (located anterior to the posterior facet) [14]. During the surgical procedure, these major fragments should be the targets for insertion of the absorbable screws.

By better understanding the fracture patterns with computed tomography scans and modern surgical techniques and implants, ORIF has been proven to be an effective treatment method to improve outcomes and lower morbidity, particularly for the displaced, intra-articular calcaneus fractures. A common problem following ORIF of fractures is pain over the prominent metallic implants. Such tenderness is most frequent when subcutaneous implants are used to stabilise fractures of osseous prominences including calcaneal fractures. Chronic discomfort may necessitate the removal of the hardware after fracture healing. In Brown's report of 126 patients undergoing ORIF of unstable malleolar fractures, 39 (31%) of the 126 patients had lateral pain overlying the fracture hardware. Twenty-nine patients (23%) had had their hardware removed or desired to have it removed [15]. However, the procedure of removing implants also has the risk of complications [16].

For displaced intra-articular calcaneal fractures, the percutaneous technique is not capable of anatomical reduction of the joint surface, which is important in preventing traumatic osteoarthritis. An early study of absorbable implants and calcaneal fractures was done by Kankare. He reported 25 cases of calcaneal fractures which underwent fixation with absorbable implants. The incidence of excellent and good was 48%. In our study, through the lateral approach, the displaced joint surface was reduced anatomically. Based on the understanding of the mechanism and anatomy of calcaneal fractures, the bioabsorbable screws were used to fix the major fragments, including the calcaneal tuberosity, subtalar joint, sustentacular fragment and calcaneal body. Two K-wires (2.5 mm) were used temporarily to strengthen the reconstruction by longitudinally passing through the subtalar joint and calcanealcuboid joint. As a result, 55 of 58 patients (94.8%) demonstrated signs of bone union at about three to four months postoperatively without any complications. The joint surface, Boehler angle, calcaneal height and width were restored to normal levels. At an average of 23 months follow-up, there was no recurrent displacement of the fragments and no secondary arthrodesis had been performed due to traumatic osteoarthritis in subtalar or calcaneo-cuboid joint. The range-of-motion in the ankle and foot recovered to 91% and 82%, respectively, compared to the non-injured limb. The mean scores for AOFAS, FFI and CFSS were 82.3, 22.7 and 75.1, respectively. The incidence of excellent and good was 87% in AOFAS score. All results were better than that in Potter et al.'s report [17], in which they reported long-term (between January 1, 1989, and April 30, 2003) outcomes in 73 patients who were managed operatively with plates. In their study, the mean AOFAS, FFI and CFSS scores were 65.4, 20.5 and 69.3, respectively.

The complications in our study are lower than in previously reported literature in which metallic implants were used. Reports show a superficial skin infection or wound dehiscence rate of about 10%. Deep infections such as osteomyelitis occur at a lower rate [18, 19]. The largest prospective, randomised multicentre study of Buckley et al. in 2002 showed a superficial infection and wound complication rate of 17% and a deep infection rate of 5% for ORIF

[20]. Compared to historical reports, the complication rate in our study was 5%. As for the potential immunological complications caused by absorbable implants, there is no consistent rate. In a series of 83 patients with whom a medial malleolar fracture had been fixed with poly-L-lactic acid screws, one patient had local swelling over the screw-heads 15 months after the operation [21]. In a study of 51 patients in whom a displaced fracture of the ankle had been treated with poly-L-lactic acid screws, one patient had mild local erythema on the lateral side of the ankle over a subcutaneous screw-head 22 months after fixation; the reaction spontaneously subsided within four weeks [22]. In our study using absorbable screws, there was one superficial infection and two poor wound healing results. However, these complications are common. It is difficult to make the conclusion that the immunological reaction is responsible for the complications. Surely, more studies are needed to ascertain potential immunological reactions in the future.

Our early observations in the surgical treatment of intra-articular calcaneal fractures indicate that bioabsorbable screws can afford sufficient stabilisation for bone union. The advantages of using bioabsorbable screws are fewer complications and less need for implant removal. Additional studies, including larger cohorts and longer follow-up time, are needed to further elucidate any definitive advantages.

Conflict of interest The authors declare that they have no conflict of interest.

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