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Balloon-assisted reduction, pin fixation and tricalcium phosphate augmentation for calcanear fracture

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ABSTRACT

Two-thirds of hindfoot fractures involve the calcaneus. The best treatment for intraarticular fractures is still debated. The goal of treatment has been focussed for years on the anatomical reduction of the articular surface. Open reduction and internal fixation enables the surgeon to view the articular surface directly, but it is associated with a high rate of wound breakdown and infection. Therefore, length, width and angular replacement of the great tuberosity are actually the main parameters to consider when treating this type of fracture.

This is a report of our experience of 20 patients treated with a minimally invasive technique of reduction using an inflatable bone tamp filled with tricalcium phosphate, with a mean follow-up of 12.25 months (range 7–26 months). Percutaneous K-wires were used to help reduction and to direct balloon inflation. Surgical goals were restoration of the mechanical stability for earlier full weight-bearing and patient mobilisation.

Introduction

Fractures of the calcaneum constitute approximately 60% of all tarsal injuries, and are usually the result of a fall from a height [1]. The economic importance of the injury is considerable because 80–90% of these fractures occur in men in their prime working years [2]. As a result, these men may be disabled for several years after the injury and many are unable to return to their original occupation [3].

Calcaneal fractures are a challenging clinical problem due to the complex anatomy of the os calcis, the frequent subtalar joint involvement and frequent articular displacement [4–6]. Involvement of the posterior thalamic joint is seen in approximately 80% of cases and is a strong predictor of the eventual clinical outcome [7].

The treatment of these injuries remains controversial [2,8]. In the past, conservative treatment was preferred, generally with unsatisfactory results [9]. The goal of the treatment of intraarticular displaced fractures is to focus on the anatomical reduction of the articular surface, avoid complications, and correct the length, width and angulation of the tuberosity. The ORIF technique enables the surgeon to view the articular surface directly during the reduction and fixation process [10]. ORIF with a lateral plate has been established as a standard therapy [11].

The development of major wound complications is a serious concern in the treatment of calcaneal fractures. The soft-tissue envelope around the calcaneus is particularly thin and vulnerable over the lateral wall, which is exposed for surgery in most cases [12], particularly in patients predisposed to infection because of systemic illness or local factors, such as blisters, swelling and open wounds.

Surgery is difficult and is plagued with potential problems, such as skin necrosis, imperfect reduction and subtalar osteoarthritis [13]. Satisfactory reduction can be obtained using less invasive, percutaneous techniques; however, reduction remains difficult and fixation precarious, necessitating multiple screws and multiple incisions [14,15].

Indirect, closed reduction and percutaneous osteosynthesis of displaced calcaneal fractures may minimise the incidence of soft tissue-related complications; however, these methods carry the risk of incomplete reduction, particularly with complex fracture patterns [16]. This fact should not be underestimated, because even minor residual steps of about 2 mm in the posterior facet lead to a significant load shift within the subtalar joint [17,18] and have an adverse effect on functional outcome [19–23].

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The authors have extensive experience in kyphoplasty and vertebroplasty techniques in the spine, and are confident that such techniques can be used to achieve adequate reduction, as confirmed by the literature [24]. In the current study, the use of these techniques was extended to patients with calcaneal fracture by using a percutaneous balloon reduction technique similar to that used in vertebral compression fractures. Bano et al. [25], in 2009, published one case treated using a percutaneous technique with a double lateral approach to reduce the thalamic surface and the shape of the os calcis, with an excellent outcome. Gupta et al. [24], in 2009, reported three cases using a technique very similar to the one used here, with a good outcome. The technical details of the technique have been described recently in several papers [7,27–29]; however, these studies lack follow-up and clinical evidence of efficacy.

The authors propose a new technique of reduction using an inflatable bone tamp filled with tricalcium phosphate. Percutaneous pinning with K-wires was used to orientate balloon inflation and maintain reduction after device removal. Surgical goals are restoration of the mechanical stability for earlier full weight-bearing and patient mobilisation.

Materials and methods

From 2010 to 2013, 20 patients underwent surgery for fractures of the calcaneus with thalamic articular involvement. This cohort represents the first patients managed by this technique. Patients were treated as consecutive cases by the same surgeon.

Patients

There were 11 males and nine females in the study and the mean age of patients was 59 years (range 34–79 years). The demographic data are shown in Table 1. Three patients had suffered a work-related accident. The initial accident was a fall on the stairs in 10 patients, from a ladder in five, from a window in one and on the rocks in one, and during a vehicle accident in three.

Fractures

Eleven fractures were located on the right side and nine on the left side. Fractures occurred after a low energy fall from a height of 1–3 m in all cases, apart from one patient who sustained a fall at work from higher than 3 m.

Fracture types according to Sanders are shown in Table 2. The mean Böhler angle at the time of presentation was 1.35° (range −20° to 22°). There were no open fractures. Patients underwent surgery on 2–21 days (mean 7.7 days) after the trauma, according to the timing of resolution of soft tissue pain and oedema.

Technique

All patients had epidural anaesthesia; perioperative antibiotic (Cefazoline) and antithromboembolic prophylaxis were always adopted. No adjuvant pharmacologic or physical therapy was adopted and no tourniquet was used. All cases underwent surgery in the prone position, with a double image intensifier control in the lateral and AP/thalamic view, as already described [7,29,30].

Additional reduction techniques were always used; calcaneal traction wire was applied to help correction of varus/valgus (Fig. 1). Fluoroscopy was used to determine the quality of calcaneal alignment and fracture reduction. A stylet and cannula were placed into the calcaneus followed by insertion of a bone tamp attached to a digital manometer. The balloon was inflated gradually under fluoroscopy. Bone cement was prepared immediately prior to its injection into the defect and the balloon was removed (Figs. 2 and 3). To avoid secondary loss of correction after balloon deflation, subchondral K-wires were kept in place for 7 days until the cement hardened. No cast was applied. All patients had the same rehabilitation-protocol; they started passive and active mobilisation of the ankle 24 h after surgery. The patient was able to walk with partial weight-bearing at the removal of K-wires (7th day). Full weight-bearing was performed after 4 weeks. The resultant reduction force of the expanding balloon was usually directed by constraining it with the help of K-wires, which acted as a palisade medially and distally (Fig. 4).

Assessment

Postoperative clinical evaluation was performed by the surgeon after 1, 2, 3, 6, 12 months and each year after the fracture. Radiographs were made at each time point. All patients had a CT scan evaluation prior to the operation, and at 3 months postoperatively to evaluate length, width, height, subtalar joint congruency and position of the sustentaculum tali through the Score analysis of Verona (SAVE) [31] (Fig. 5).

An accurate preoperative planning was always taken to exclude multifragmentary articular fractures, to avoid tricalcium

Table 1
Demographic data.

Case no.	Sex	Age	Work related	Side	Day op	Accident	Follow up	Work
1	M	45	Yes	R	21	Fall/ladder	15	Yes
2	F	72	No	L	12	Fall/ladder	26	Yes
3	M	47	No	R	2	Fall/window	12	Yes
4	F	57	No	L	16	Fall/stairs	11	Yes
5	M	53	No	L	9	Fall/stairs	10	Yes
6	M	63	No	R	2	Fall/stairs	8	Yes
7	F	78	No	L	6	Fall/stairs	7	Yes
8	F	57	No	L	12	Fall/stairs	12	Yes
9	F	77	No	R	6	Fall/stairs	11	No
10	M	37	Yes	R	6	Fall work/ladder	8	Yes
11	M	79	No	R	11	Car accident	9	Yes
12	M	54	No	R	4	Fall/stairs	8	Yes
13	F	69	No	L	5	Fall/stairs	12	Yes
14	F	79	No	R	8	Fall/stairs	24	Yes
15	M	38	Yes	R	3	Fall work/ladder	11	Yes
16	F	59	No	L	5	Fall sea rocks	12	Yes
17	M	43	No	R	4	Car accident	13	Yes
18	F	72	No	R	9	Fall stairs	14	Yes
19	M	34	Yes	L	3	Fall work/ladder	9	Yes
20	M	67	No	L	10	Car accident	13	Yes