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ORIGINAL ARTICLE

Calcaneus fractures, results of the sinus tarsi approach: 4 years of experience

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Abstract
Objective We present the treatment of displaced intra-articular calcaneal fractures using the sinus tarsi approach to reduce the complications described in literature obtaining good clinical and radiographical results.
Materials and methods From January 2002 to December 2006, we have treated 39 displaced intra-articular calcaneal fractures (Sanders type II, III, IV). The patients were operated with open reduction and internal fixation through a limited sinus tarsi approach with cannulated screws.
Results The mean follow-up was of 38 months and the Maryland foot score and the podoscopy were used to analyze the results, with an average of 84 points for type III fractures and 60 for type IV. The reduction of the posterior facet, the subtalar movement and the Bohler and Gissane angle resulted good. We have always performed arthrodesis for type IV fractures.
Conclusions In most part of the cases, we have obtained good functional results with great satisfaction of the patients.

Keywords Calcaneus · Minimally invasive fixation · Intra-articular fractures · Sinus tarsi approach · Complex fractures

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Introduction

The calcaneus is the main tarsal bone, it is complex and it represents the most important part for the supporting base of the foot.

Calcaneal fractures represent 60% of tarsal fractures and 1–2% of all fractures [1]; the most part are due to fall from heights (also 1–2 m) or traffic injuries (pedestrian or bikers), and they are frequently associated with other bone fractures as vertebras or proximal femur.

The main line of fracture has been well described by Essex-Lopresti [2] and it is given by an eccentric weight between talus and calcaneus which formed an angle of 25°–30°. The traumatic weight pushes the calcaneus against the talus and the posterior facet is the fulcrum through which the calcaneus breaks due to shearing and compression forces [3].

The most common treatment is open reduction and internal fixation (ORIF) [4–7], but unsuccessful cases are not infrequent. We have used a minimal-invasive technique which permits to treat also complex fractures decreasing the complications.

It is important to underline that the primary objectives to be gained are to restore the congruity of the posterior facet and of the subtalar joint, to restore the height of the calcaneus (Bohler's angle), to re-establish the integrity of calcaneocuboid joint, to decompress retro-peroneal space and to avoid varus or valgus deformity.

Materials and methods

The series

From January 2002 to December 2006, we have treated 39 calcaneus fractures in 29 patients, 22 males and 7 females,

in ten cases bilateral in polytraumatized patients; the mean age was 44 years old (between 24 and 64). The time from injury to surgery has been from 5 to 13 days. The pre-operative planning foresees common X-rays with lateral and axial projections and CT scan. The fractures have been subdivided according to Sanders classification [8] and they resulted to be type II in 19 cases, type III in 13 and type IV in 7; open fractures have been excluded from our study.

Surgical technique

The surgery has been performed with tourniquet and the time of surgery was from 60 to 90 min; all of the patients have been treated with cefazolin as antibiotic prophylaxis.

The patient is positioned supine, because the most part of our patients are polytraumatized. Using the imaging intensifier, we visualize the fracture both in lateral and in axial view that are the basic projection to evaluate the correct positioning of the fixation devices during the fracture reduction and the other phases of surgery. One fiche is inserted in the calcaneal tuberosity from the lateral side; therefore, a traction toward the bottom is done to correct the calcaneal valgus. Subsequently, an italic S incision is executed at the sinus tarsi; it is done anteriorly to lateral malleolus and it continues until the calcaneocuboid joint is visible (Fig. 1a); peroneal tendons remain inferoposteriorly to the incision and if necessary they can be evaluated and mobilized. The posterior facet is reduced using a curved periosteal elevator which permits to elevate it from the calcaneal body (Fig. 1b); the fixation is obtained using 4 mm cannulated screws and also 2.4 mm screws can be used (Fig. 1c, d). The reduction is temporarily stabilized with a K wire and is checked with the intensifier. The anterior facet is reduced and stabilized with the 4 mm cannulated screws, and the reduction of the medial wall is obtained with a curved periosteal elevator introduced in the sinus tarsi. The sustentaculum tali are reduced with two 5 mm cannulated screws positioned from lateral to medial. The last step is represented by the percutaneous positioning of cannulated screws through the posterior tuberosity directed toward the calcaneocuboid joint; the screw length is 65–70 mm and it permits to maintain the reduction of the extra-articular component and to support the articular component avoiding using bone graft. In fact, we have never used bone graft using this technique. At the end, we suture the window without positioning of any drainage.

The post-operative treatment foresees an elastic bandage, the limb elevated for 48 h and cryotherapy. Since day 2, it is possible to begin passive and active motion without weight bearing of tibio-tarsic joint and isometric exercise for lower limb muscle. The lightly touch weight bearing was possible after 30 days, partial within 60 days and full weight bearing within 90 days. In polytraumatized patients, the time of weight bearing has been subjected to the associated lesions.

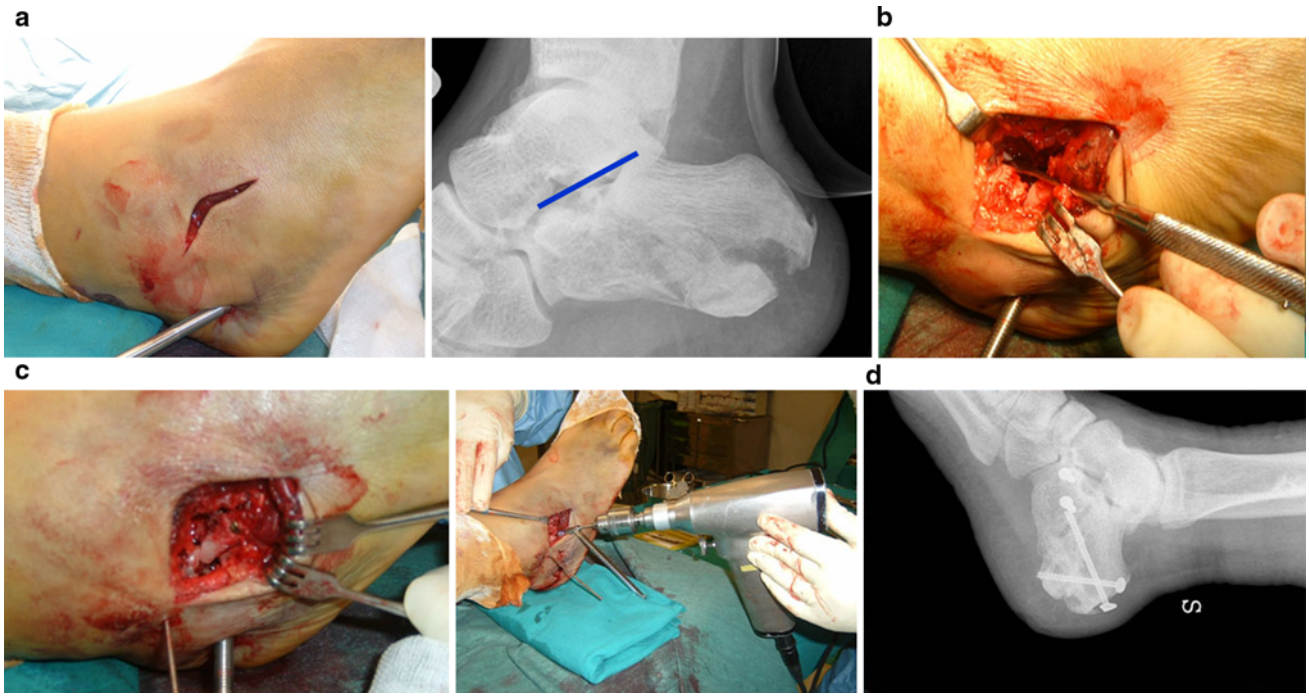

Fig. 1 **a** Sinus tarsi: italic S incision. **b** Using a periosteal elevator, the posterior and intermediate joint facet is elevated and reduced. **c** Fixation with cannulated screws and mini-screws. **d** 18-month follow-up

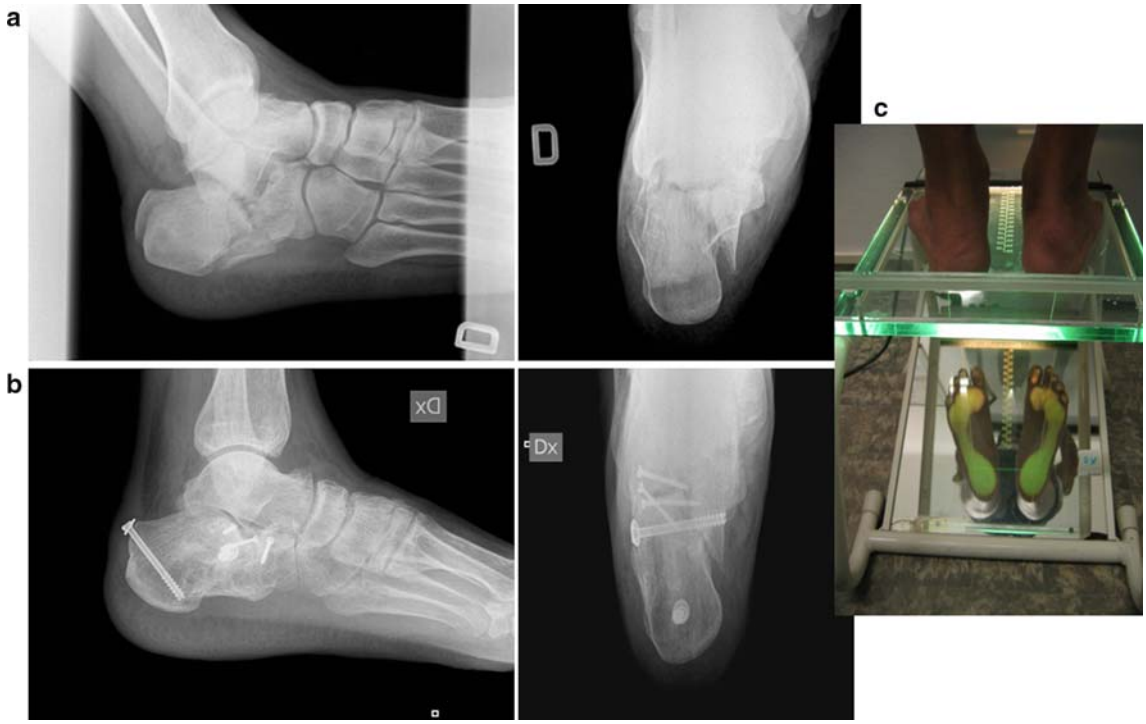

Fig. 2 Clinical case, Sanders type III fractures: **a** pre-op, **b** 3-year follow-up, **c** podoscopy evaluation

Revision criteria

The analysis of clinical results is based on the quality of reduction of the fracture on the basis of the Bohler and Gissane angle, on the restore of the normal morphology of the medial and lateral walls, and on the follow-up evaluations using the Maryland foot score. Besides, we have also used the podoscopy to compare the footprint.

Results

The mean follow-up was 39 months (from 24 to 41). Bohler and Gissane angles have been restored from 90 to 97% of the cases in Sanders type II and III fractures (Figs. 2a–c, 3a–d), while 15% in type IV fractures; height and thickness have been restored from 87 and 95% in Sanders type II and III, and 19% in type IV.

According to Maryland foot score, the mean score is 87 in type II, 83 in type III and 60 in type IV; 10 fractures resulted excellent, 19 good, 7 not satisfactory and 3 bad.

The reduction of the posterior facet has been obtained in 29 of 39 patients.

The subtalar joint movement has been restored in 12 cases at 75%, in 16 cases at 50% and in 10 cases at 25%.

The removal of cannulated screws has been necessary in 12 cases for intolerance of the screws' head at the level of posterior tuberosity and it has been always performed in day surgery.

In 20 patients, we have also used the podoscopy (Figs. 2c, 3d) to control the clinical outcome obtaining results that confirm those of X-rays and the image was similar to the controlateral limb.

In one case, we had residual limp, but the beginning situation was of a bilateral crashed fractures; in four patients with type IV fractures it was necessary to prescribe corrective plantars.

We have never used any bone graft. We did not have any cases of infection, hardware mobilization, wound dehiscence or soft tissue complications.

Discussion

Surgical treatment is the only available possibility for comminuted extra-articular or intra-articular fractures [4, 5, 7].

The main problem the surgeon has to solve is the high rate of complications, about 10–20% [6]; the dehiscence of the wound in 14% of the cases [9–11], deep infection in 1.3–8.5% [9, 12, 13], peroneal tendinitis in 4%, tarsal tunnel syndrome in 2%, compartmental syndrome in 2% [12].

Once the fracture is classified and the soft tissue condition is evaluated it will be possible to take into consideration the right treatment: reduction and stabilization with plate and screws or screws alone, primary arthrodesis or conservative treatment [12]. The result of the surgery is conditioned by the timing of surgery; according to Sanders,

Fig. 3 Clinical case, Sanders type III fractures: **a** pre-op, **b** post-op, **c** 3-year follow-up, **d** podoscopy evaluation

the correct timing is between 7 and 10 days from trauma, because if treated earlier there is compartmental syndrome or soft tissue damage risks, while if treated later the results could be unsatisfactory.

In literature, several surgery techniques are described, some classic and other less invasive [4, 10, 12, 14, 15]. The first are the techniques chosen by most part of the surgeons and they surely are the most tested and widespreaded and these techniques foresee ORIF. The medial access permits a direct reduction of the body of the sustentaculum tali but not of the posterior facet and of the antero-lateral fragment; lateral access permits to operate directly on the posterior facet and the antero-lateral fragment and indirectly on the body of the sustentaculum tali; combined medial and lateral access gives a perfect visualization of the fracture but there is a risk to compromise the vascularisation; extended lateral access permits to avoid damage to peroneal tendons and sural nerve [12].

Several fixation devices have been proposed; it is possible to use plates of various shape, as cervical H plates [5, 14], 3.5 mm reconstruction plate [4, 16], Galveston plates [17], Y plates [4, 13], multihole plates [18].

These treatments guarantee good results in 50–70% of the cases, but they are burdened by a not negligible rate of complications, therefore, many authors have proposed mini-invasive approach to decrease the risk of failure [12, 15].

Mini-invasive treatment of calcaneal fractures has been introduced by Westhues [19] in 1934 and foresees the percutaneous traction obtained with a K wire introduced in the calcaneal tuberosity and maintained thanks to a plaster cast.

Mini-open techniques are generally used in patients in critical conditions (polytraumatized) and in patients in whom ORIF would be contraindicate, as in elderly patients, smokers, decompensate diabetes, immunodeficiency or feet soft tissue injuries [20, 21]. In this case, these techniques have been showed to be valid and with satisfactory results.

Less invasive fixation has the advantage to correct the alignment of the posterior part of the foot and the articular congruity as good as the classic fixation, but with less damage to soft tissues decreasing the risks of complications due to its healing. The fixation is executed with percutaneous cannulated screws [22, 23]; the first author who presented this technique was Essex-Lopresti [2]. Other treatments using external fixation with Ilizarov technique have been described [24] but reserved to complex fractures or severely compromised patients, because it neither allows anatomic reduction of the articular fragments nor fixation with reabsorbable pins in polyglycolide [25], which is burdened by a risk of displacement of 40% when the weight bearing is allowed and the reduction of the lateral wall is not possible.

The less invasive technique through a sinus tarsi approach permits to rebuild the articular surface of the anterior and medium facet; with a simple window at the sinus tarsi, the section of periosteum of the bone is decreased,

increasing the vascularisation with a consequent decreased risk of acute or secondary post-operative complications, as infections or hardware failure.

In literature, we have found two authors who use a technique similar to ours, Holmes [15] and Ebraheim et al. [12].

Holmes uses an incision from the apex of the peroneal malleolus to the base of fourth metatarsal which allows the access to the sinus tarsi, to subtalar joint and to the vision of joint facets. A second mini-incision is executed anteriorly to calcaneal tuberosity and posteriorly to peroneal tendons on the lateral side. In 18 years of his experience, he did not have any of the complications described in literature and he never used any bone graft.

Ebraheim's technique always performs small incisions at sinus tarsi to exhibit and reduce the fracture of the posterior facet and of the antero-lateral fragment. The tuberosity would be reduced with a Steinmann wire in the primary fracture line. The author considers that this kind of incision is advantageous because it also permits to perform a subtalar arthrodesis from the same approach if necessary [12].

He has never used any plates to avoid the major sufferance of the soft tissues, because even if applied the plate could not afford the early weight bearing. No bone graft has been used to fill the gap which remains afterwards the reduction of the posterior facet and the antero-lateral fragment is reduced. This is a very debated topic because in literature many different opinions are explained [12].

In his paper, Ebraheim presents 99 patients treated with 106 intra-articular fractures with a mean age of 42 years old and a mean follow-up of 29 months. The complications he has evaluated have been: infections in 8.5%, peroneal tendonitis in 3.8%, tarsal tunnel syndrome in 1.8%, compartmental syndrome with fasciotomy in 1.8% and sural neuritis later solved in 0.9%. The results have been evaluated as good or excellent in 80 cases and not satisfactory in 26 cases [12].

In our experience with the sinus tarsi technique, we have never had any infection as Holmes (no complications described) but differently from Ebraheim [12].

In Sanders type IV fractures, we have always performed the subtalar arthrodesis using the same sinus tarsi approach, as described in literature, in fact nowadays the arthrodesis is the treatment of choice in this kind of fractures to avoid new surgery.

A good reduction of the sustentaculum tali is necessary to avoid tendinopathies to flexor hallucis longus.

Peroneal tendonitis has been reported in just one case of type IV fracture and it has been solved conservatively.

We have never used bone graft because we think that a stable osteosynthesis and a surgery technique which respect soft tissues and vascularisation are enough to guarantee fracture healing and the fill of the bone gap [12, 14].

Conclusions

For the choice of the right treatment of complex intra-articular calcaneal fractures, it is basic to consider soft tissue conditions and collateral disease of the patient. The minimal-invasive technique we have described, nevertheless complex to be performed, is a valid therapeutic solution which guarantees stability principles, anatomic reduction of the fracture and soft tissue preservation. The results described by other authors are encouraging but not completely without complications.

First of all, it is basic to obtain a good reduction of the posterior joint facet, to re-establish the Bohler and Gissan angles, not to traumatize soft tissues and to execute a correct rehabilitation.

To conclude, the advantages offered by this approach are represented by the possibility to have a less invasive incision which permits to have a good visualization and anatomic reduction of articular surfaces and the advantage to execute a subtalar arthrodesis when necessary, and so it could represent a valid option of treatment for intra-articular calcaneal fractures.

Conflict of interest statement None.

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