

A new perspective on management of open calcaneus fractures

Ali Oznur · Mahmut Komurcu · Salih Marangoz ·
Ersin Tasatan · Mümtaz Alparslan · Ali Sabri Atesalp

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Abstract The treatment protocol of closed calcaneal fractures has been described in the literature extensively. However, treatment of open calcaneal fractures has not been discussed in detail. Various treatment alternatives have been suggested including external fixator, primary subtalar distraction arthrodesis, and partial calcaneotomy according to the type of fracture. We have retrospectively reviewed 36 adult patients with 39 open calcaneal fractures who were treated with our new philosophy. Average follow-up time was 9.29 years (range, 1.25–28 years). The American

Orthopaedic Foot and Ankle Society (AOFAS) scoring system was used in functional evaluation. The average score was 77.9 (range, 67–92). All of the patients had limited subtalar movement. We propose an algorithm for the management of open calcaneus fractures, although treatment largely depends on the physical status of the patient, type of the fracture, localisation of the open wound and the surgeon's choice.

Résumé Le protocole du traitement à foyers fermés des fractures calcanéennes est amplement décrit dans la littérature. Cependant, le traitement des fractures ouvertes n'est jamais bien rapporté. Plusieurs possibilités de traitements sont possibles, du fixateur externe en passant par l'arthrodèse ou la résection partielle du calcanéum. Matériel et Méthode: nous avons revu de façon rétrospective 36 patients adultes présentant 39 fractures ouvertes du calcanéum. Le suivi moyen a été de 9.9 ans (de 1.25 à 28 ans). Le score de l'AOFAS a été utilisé de façon à les évaluer fonctionnellement. Le score moyen a été de 77.9 (de 67 à 92), tous les patients avaient une limitation des mouvements sous astragaliens. En conclusion, nous proposons un algorithme de traitement des fractures ouvertes du calcanéum mais, le traitement dépend largement de l'aspect physique du patient, du type de la fracture, de la localisation, de l'ouverture et du choix du chirurgien.

A. Oznur
Department of Orthopaedics and Traumatology, Güven Hospital,
Ankara, Turkey

M. Komurcu · A. S. Atesalp
Faculty of Medicine, Department of Orthopaedics
and Traumatology, Gülhane Military Medical Academy,
Ankara, Turkey

M. Komurcu (✉)
GATA Ortopedi ve Travmatoloji AD,
Etlik,
06018 Ankara, Turkey
e-mail: mkomurcu@hotmail.com

S. Marangoz
Department of Orthopaedics and Traumatology,
John Hopkins University,
Baltimore, MD, USA

E. Tasatan
Department of Orthopaedics and Traumatology,
Iskenderun Military Hospital,
Iskenderun, Turkey

M. Alparslan
Faculty of Medicine, Department of Orthopaedics
and Traumatology, Hacettepe University,
Ankara, Turkey

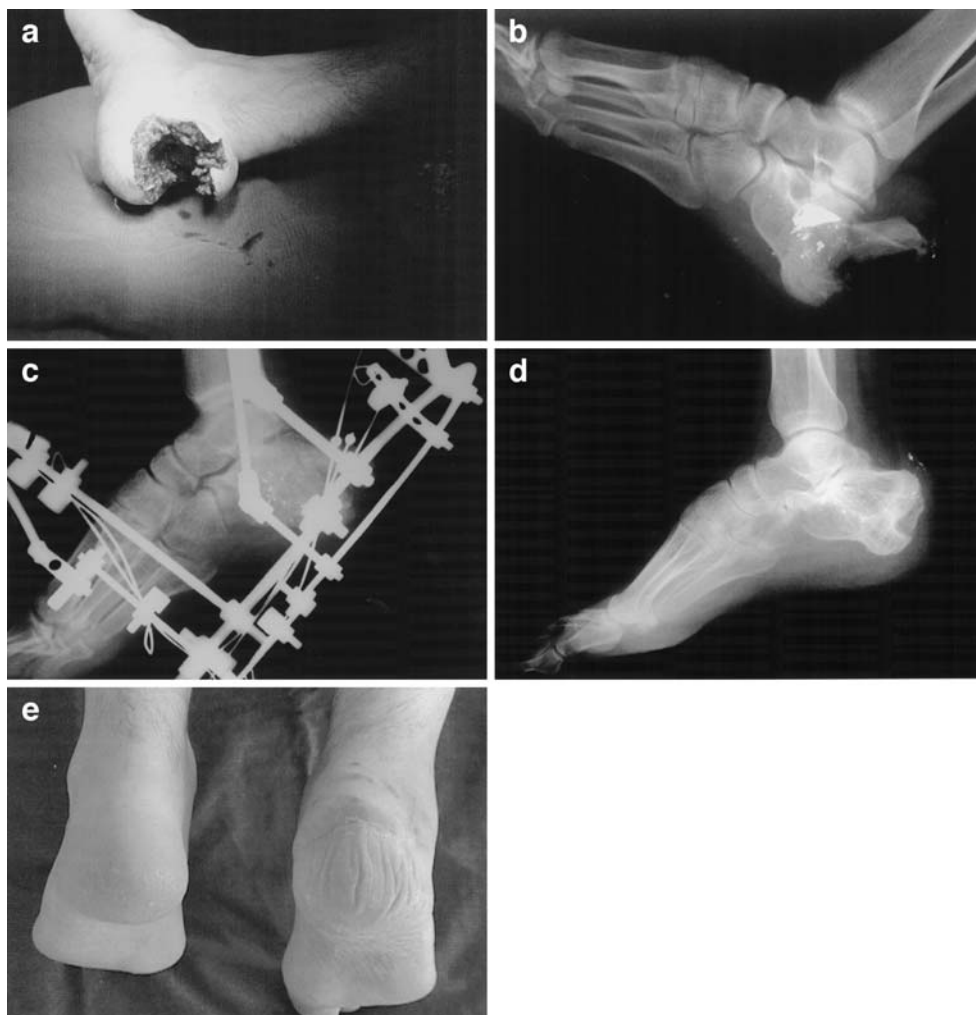
Introduction

Figure 1 shows a type P fracture due to gunshot and the treatment.

Table 1 shows the summary of our study data.

Indications for conservative and surgical management of calcaneal fractures have been described in the literature,

Fig. 1 **a** Type P fracture. The picture shows a type-IIIB open calcaneal fracture based on the Gustilo et al. classification with posterior wound after close gunshot injury. **b** The lateral X-ray revealed a tongue-type calcaneal fracture and pieces of bullet. **c** Application of external fixator with the foot held in equinus position after debridement was performed. **d** The lateral X-ray at the first year follow-up postoperatively. **e** Clinical appearance from posterior at the latest follow-up



although no consensus has been established. There are many studies on either conservative or surgical treatment, timing of surgery, type of incision preferred and late follow-up results of closed calcaneus fractures. However, there have been limited articles on incidence, and the principles of treatment of open calcaneal fractures [2–4, 10]. To date there is only one study describing the wound localisation [13]. We are not aware of any studies classifying open calcaneal fractures and giving treatment protocols based on such classification. In our study, choices of open calcaneal fracture treatment and late follow-up results are presented. We also propose a new classification for open calcaneus fractures treatment according to the localisation of the open wound and its impact on the treatment.

Materials and methods

One hundred and ninety calcaneal fractures that were treated at the Department of Orthopaedics and Traumatology, Gülhane Military Medical Academy and Hacettepe University

Faculty of Medicine between years 1985 and 2000 were enrolled in this study. Thirty-nine (20.5%) of these in thirty-six patients were open fractures. All thirty-six patients were male with an average age of 35 (range, 20–70). The mechanism of injury included motor vehicle accidents in five, falls in seven, gunshots in eight, land mines blast injuries in 15 and crush injury in one. Fifteen patients had a fracture on the left and eighteen patients on the right side. Three patients had bilateral fractures. The patients with open fractures classified type-II, -IIIA or -IIIB according to Gustilo et al. [11, 12] were included in this study. The number of patients were seven, ten and 19, respectively. Thirteen out of 36 patients had additional trauma of other parts of other parts of the body, including vertebrae, femur and tibia fractures. Patients presenting with mutilating foot injuries, such as blast injuries, accompanying talus fractures, and Gustilo et al. type IIIC open calcaneal fractures were not included within this study.

The location of the open wound was on the medial side (Type M) in 18 cases, posterior (Type P) in 11, and lateral (Type L) in four. In six cases the wound was much more complex (Type C).

Table 1 Summary of data

Foot #	Age/ Sex	Side	Open type	Fracture type	Our proposed Subtype	Additional trauma	Cause	Treatment	Complication	Follow-up (year)	AOFAS score
1	33/M	L	IIIB	Tub cal	Posterior	Open tibia fx	MVA	Screw, F*, CL	Inf	14	70
2	67/M	R	IIIB	S II	Lateral	-	Crush	Cast	Inf	15	80
3	22/M	R	IIIB	Tub cal	Complex	Ulma,vertebra fx	Fall	Cast, CL	Inf, RSD 28		75
4	30/M	R	IIIB	Tongue	Posterior	-	Gun-shot	Ilizarov	Transient NL	2	90
5	45/M	R	IIIA	S IIIAC	Medial	Vertebra fx	Fall	Ilizarov	Inf	1.25	70
6	45/M	L	II	S IIIAC	Medial	Vertebra	Fall	Ilizarov	Inf	1.25	70
7	42/M	L	IIIA	S IIIAB	Posterior	-	Gun-shot	PC, Ilizarov, F	Inf	7	80
8	65/M	L	II	S IV	Medial	Tibia fx	Fall	PSDA	-	9	80
9	70/M	R	IIIA	S IV	Medial	-	Fall	PSDA	-	5	80
10	50/M	L	IIIB	Tub cal	Complex	Femur, tibia fx	MVA	Ilizarov	Inf, RSD, NL	2	80
11	52/M	L	IIIB	S IIIAC	Medial	-	MVA	PC	Inf	11	70
12	64/M	L	IIIB	S IV	Medial	-	Fall	PSDA	-	8	75

Fx, fracture; MVA, motor vehicle accident; Ilizarov, Ilizarov external fixator; PSDA, primary subtalar distraction arthrodesis; PC, partial calcaneotomy; F, flap (medial plantar artery based); F*, radial forearm flap; CL, cross-leg flap; infection; NL, nerve lesion; RSD, reflex sympathetic dystrophy; open type, Gustilo et al.; Tub cal, calcaneal tuberosity; S, Sanders.¹

Autogenous bone graft was used in nine patients in whom primary subtalar distraction arthrodesis was applied and in three patients in whom there was a cavitory defect.

In our experience there are four patterns of wound in open calcaneal fractures which we have classified according to the localisation of the wound:

Medial wound

Generally results from high-energy axial-loading injuries. The medial spike of the medial wall of calcaneus leads to extensive soft tissue disruption medially. Temporary broad spectrum antibiotics and repeated irrigations with debridement are the mainstay for therapy. After the control of active infection, exposure is achieved with lateral incision and the bone fragments causing tension in the medial soft tissues are removed. Calcaneal height is restored, while its width is decreased. Open reduction and internal fixation (OR-IF) was performed only if subtalar joint surface is reconstructable. If there was significant comminution and the fracture was not amenable to reconstruction, a primary subtalar distraction arthrodesis was performed.

Posterior wound

Close-range gun-shots or heavy load accidents result in this type of injury. The open wound is either transverse or a cavitory defect. The fracture could be the tongue-type or defective along with the open wound. The defect often seems

larger than it is, due to the contraction of Achilles tendon and, thus, primary closure may not be possible. As for the OR-IF, following irrigation and debridement minimal fixation can be achieved either by means of screws or K-wires or Ilizarov type circular external fixator using K-wires with an olive.

Illustrative case

A 30-year-old police officer was admitted to the emergency room following a close-range gun-shot injury of his right heel. There was no exit wound. The patient had a transverse open wound posteriorly sized at 14×6 cm. The radiographs demonstrated a tongue type fracture of the calcaneus.

The wound was classified as a Gustilo et al. type-IIIb open fracture, and during exploration the bullet fragment was extracted. After proper irrigation with pulsatile lavage and debridement, the ankle was fixed by means of an Ilizarov external fixator in 35° plantar flexion to decrease the pull of the Achilles tendon.

The entrance wound, sized at 2×2 cm, was left open, and secondary healing was achieved in four weeks uneventfully. The degree of plantar flexion of the ankle was reduced in time and gradual correction of the equinus deformity was achieved. The Ilizarov frame was removed at the tenth week. Four months later, the remaining calcaneal cavity was filled with autogenous iliac bone graft, which was harvested from anterior iliac crest. He suffered from a transient nerve lesion, which later recovered completely. The patient has been followed up for two years without any

sequelae and currently walks without difficulty. He returned to work as an active police officer at the end of his treatment.

Lateral wound

If the lateral wound is too large to be closed primarily, extensive lateral incisions should be avoided. Tornetta [18] advocated a temporary external fixator for open calcaneus fractures. Minimal open reduction and use of external fixator would be the choice as described by Paley and Fischgrund [16].

Complex wound

The plantar skin is avulsed completely and the fracture is often from the dorsosuperior part towards distal inferior. Debridement, plantar skin reattachment and use of an external fixator, free flaps or partial calcanectomy are the recommended possibilities for treatment.

Results

Between January 1985 and December 2000, one hundred and ninety calcaneal fractures were treated at our clinic, 39 fractures (20.5%) in 36 patients were open. All 36 patients were seen at their final clinical and radiographic follow-up at 9.29 years. (range: 1.25 to 28 years) One patient died at the 15th month of follow-up, due to other reasons. All patients healed after above-mentioned modalities of treatment. At the final follow-up all patients had limited subtalar movement. In two patients in whom arthrodesis was applied, minimal resorption occurred in the bone graft; however, union was achieved. Hypoaesthesia developed in eight patients along the sural nerve dermatome. Severe reflex sympathetic dystrophy developed in five patients, but with appropriate medical and physical therapy they were managed well, although one of them had to receive medical therapy for seven months. In three patients there was insufficient movement in metatarsophalangeal and interphalangeal joints. In patients to whom primary subtalar distraction arthrodesis performed, the outcome was generally reasonable, but there was no subtalar motion. In patients with other modalities applied there were 5 degrees of inversion and no eversion at all. Flexion-extension range was -10 to 35 degrees. The mean AOFAS score of the patients at their latest follow-up was 77.9 (67–92). Three chronic osteomyelitis cases were managed with partial calcanectomy in two and with aggressive debridement and vancomycin embedded bone cement in four. Eradication of infection has been achieved in all.

Discussion

This study overviews our experience in treating open calcaneal fractures, which resemble other open fractures, and can be summarised as irrigation, debridement, early skeletal fixation, short term antibiotic use, and daily wound care.

The calcaneus is the most frequently injured tarsal bone and most fractures are intra-articular due to high-energy transfer from causes like falling from a height or motor vehicle accidents. Due to the significant amount of energy involved, these injuries can frequently result in an open fracture. The fractures of the posterior-superior tuberosity are divided into two types: beak fractures and avulsion fractures. A beak fracture does not involve the Achilles tendon. An avulsion fracture involves the insertion of the Achilles tendon. In a tongue-type of fracture, the fracture line continues posteriorly to include the posterior facet and exits through the posterior aspect of the tuberosity. If separation of the fragments is greater than one centimetre, open reduction is recommended.

Extra-articular fractures were generally seen either with posterior or complex open wound cases in our relatively small series. Paley and Fischgrund [16] advocated circular external fixator for closed calcaneal fractures. They described step-by-step application of the circular external fixators for closed intra-articular calcaneal fractures after open reduction. Their technique could be applied for open calcaneal fractures. Tornetta mentioned temporary triangular external fixator for open calcaneal fractures [18]. He preferred open reduction and internal fixation after soft tissue healing as a definitive procedure.

Forty percent of open fractures occur in the lower limb and the tibial and femoral diaphyses are most commonly affected [14]. Open fractures occurred in 2% of adult ankle fractures [7]. Although it has been mentioned that it constitutes a minor proportion of all calcaneal fractures, the incidence of open calcaneal fractures has not been well documented. In a recent study by Coughlin et al. [6], three calcaneus fractures out of 48 were open, indicating a 6.25% incidence. Heier et al. published their experience with open calcaneal fractures, in which the incidence for open calcaneal fractures was 8.5% [13]. In a multicentre study by Buckley et al. [5] there were 21 open cases among a total of 559 fractures, pointing out a 3.75% incidence.

In addition, the treatment protocol of open extra-articular calcaneal fractures has not been clearly described in the literature [13, 17]. The main aim in the treatment of open calcaneal fractures is to close the fracture site and achieve reduction as soon as possible and to decrease the risk of infection. Immediate primary closure of open fracture wounds after a thorough debridement by an experienced fracture surgeon appears to cause no significant increase in infections or delayed union/nonunions [8]. It would be

unlikely to have soft tissue healing and to avoid infection without providing a clean environment and achieving stability in severe open fractures of the calcaneus. In open fractures that resemble a bag of bones soft tissues are under much tension, which is detrimental for their healing. Thus ligamentotaxis obtained by means of an external fixator would help fracture alignment and following soft tissue healing. Furthermore, compartment syndrome of the foot must be kept in mind in open calcaneal fractures, so that the patients must be examined carefully.

Performing OR-IF after soft tissue healing lengthens the period in hospital. After 3–4 weeks, reduction is more difficult to perform and it is almost like treating a malunion. In the study by Heier et al. [13] the open wounds were not closed immediately, but at an average of 10.6 days (range, 0–41 days). In our series which is rather small, treatment was initiated as soon as possible to achieve a stable environment and satisfactory results were obtained except for two cases.

Smoking, diabetes, and open fractures all increase the risk of wound complication after surgical stabilisation of calcaneus fractures [9].

Among surgically treated calcaneus fractures we have noted a significant incidence of open calcaneus fractures, 20.5%. This high dehiscence rate has not been reflected in the literature to date. The reason that we have come across such a high incidence of open fractures might be the fact that our clinic is tertiary referral hospital. Repeated soft tissue and bony procedures are often required in these patients. Soft tissue procedures that can be performed in these patients have been described [15]. Application of an Ilizarov frame provides safe wound healing without an increase of the infection risk and allows gradual correction of the equinus deformity without any undue tension on the avulsed fragment. Circular external fixation is a safe and effective technique for treatment of the open fractures of the calcaneus with posterior open wound.

It is well known that hospital stay is longer for open fractures. Repeat operations are performed, but infection rates remain high, and late functional results are still poorer compared to those of closed fractures of the same region.

The AOFAS hindfoot scores of the patients with open calcaneal fractures in our series have been found to be lower than the scores of the patients with closed calcaneus fractures in whom OR-IF has been performed [1].

We propose the following algorithm for the management of open calcaneal fractures, although treatment depends on the physical status of the patient, type of the fracture, localisation of the open wound and the surgeon's choice:

Medial open wound

Five to seven days following initial wound care if there is not any sign of infection, the medial wound is covered by a

drape, and with a lateral approach either OR-IF is performed or if the subtalar joint is damaged primary subtalar distraction arthrodesis would be the treatment of choice.

Posterior open wound

If the fracture is a tongue type, the fragment is stabilised by means of K-wires with an olive. The foot is positioned in partial equinus with either circular or uniplanar external fixators.

Lateral open wound

OR-IF or use of external fixator is applied following wound healing.

Complex open wound

There is no standard protocol for treatment. Whatever the treatment protocol chosen is, the prognosis is poor.

In conclusion, the type of treatment modality should be individualised according to the type of fracture and localisation of wound in open calcaneal fractures. The reason open calcaneal fractures are not discussed in detail in the literature might not be only that they are relatively rare but also because they are excluded from the study groups because they adversely affect the good results of the series. The presumed underlying cause of this is that these fractures have not had a standard protocol for treatment, yet.

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