

Original Article

Clinical efficacy and prognosis factors of open calcaneal fracture: a retrospective study

Xuebin Zhang*, Yueju Liu*, Aqin Peng, Haili Wang, Yingze Zhang

Trauma & Emergency Center, The Third Hospital Hebei Medical University, Shijiazhuang, China. *Equal contributors.

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Abstract: Background: Treatment of open calcaneal fractures remains to be a challenge for orthopaedic surgeons. The aim of this study is to assess factors affecting the treatment results of open calcaneal fractures. Methods: A total of 98 patients who have 101 open calcaneal fractures were recruited in our hospital, they were all treated with a standard protocol based on the appearance of the traumatic wound. Data on mechanism of injury, location and size of wound, classification, fixation methods and subsequent soft-tissue complications were collected and evaluated. AOFAS Ankle-Hindfoot Survey and physical examinations were performed to assess outcomes. Results: No statistical difference was found in complication and AOFAS score in open calcaneal fractures treated with different fixation, and no statistical difference was found in AOFAS between Gustilo I and II type open calcaneal fractures ($P > 0.05$). There was significant difference between Gustilo I and III type or Gustilo II and III type fractures ($P < 0.05$). The more serious soft tissue injury of open calcaneal fracture lead to the worse outcome and higher incidence of complications obtained. Conclusion: Open calcaneal fractures have a high propensity for soft-tissue complications no matter which fixation method was chosen. There was no significant difference between patients who had been treated with different fixations in complication rates. Soft-tissue injury played an important role in outcomes of open calcaneal fractures. Deep infections and osteomyelitis were rare by means of emergency debridement and following repeated debridement.

Keywords: Open calcaneal fracture, ORIF, pinning, soft-tissue complications

Introduction

Calcaneus is the biggest bone of foot, which plays an important role in the body weighing and walking of human. Calcaneal fractures are most common type of all tarsal fractures, and comprise approximately 60%-70% of all tarsal injuries [1]. However, open calcaneal fractures are relatively rare, only accounting for 3%-6% of all calcaneal fractures [2-4]. As one of serious bone damage, the treatment difficulties of open calcaneal fracture came from the serious cartilage injury, and which is accompanied by severe comminuted intra-articular fractures of calcaneus [5]. Because special anatomy of the calcaneus and related bone soft tissue, the treatment of open calcaneal fractures is relatively difficult with poor prognosis, and will cause serious infection or amputation [6].

With the development of diagnostic technique and treatment instrument, it has made progress in treatment of open calcaneal fractures in

recent years [7, 8]. However, much attention was paid to the diagnosis and treatment of open calcaneal fractures, and accompanied scholars reported many related articles, few specific injury classifications or treatment principles have been established till today. In this study, we collected 101 open calcaneal fractures data and conducted a study to discuss related factors which could affect the prognosis of open calcaneal fractures.

Methods

Patients

Approved and registered in our hospital Ethics Committee in January 2007, we reviewed the records of all patients who sustained calcaneal fractures in our hospital from January, 2007 to May, 2013.

The Ethics committee approved relating screening, treatment, and data collection of these

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Table 1. Number, wound location, Gustilo classification, and complication of 101 open calcaneal fractures with different fixation

	No. of fractures	Wound location		Gustilo type (n)					Skin graft	Flap graft	Complication rate
		medial	lateral	I	II	IIIa	IIIb	IIIc			
Pinning	74	65	9	3	27	26	6	12	9	7	24%
ORIF	15	15	0	1	9	5	0	0	3	0	20%
Screw	7	4	3	0	6	1	0	0	1	0	14%
Casting	5	3	2	0	5	0	0	0	1	0	20%

tures were treated through operation.

Of these 101 open calcaneal fractures, 81 fractures were in men and 20 were in women. Their average age was 39 years (range 11 to 81). Eighty-seven wounds were medial, and

14 were laterally (**Table 1**). The most fracture were caused by falls from height (85), followed by traffic accident (14), and crush injuries (3).

Surgical procedure

Open calcaneal fracture often accompanied by other limbs or axial bone injury, so associated injury must be estimated accurately at first. Sterilized dressing, temporary immobilization to hind foot, and tetanus antitoxin were used for these wound management before the operation. All open calcaneal fractures were treated by emergency operations. According to the Gustilo classification [9], soft-tissue injury was assessed in each fracture. At the time of presentation each patient received an intravenous antibiotic (first-generation cephalosporins 2.0 g), which was administered in the emergency room just before surgery. More than 6-litre of 0.9% saline was used for wound irrigation. Fifteen fractures (1 of Gustilo I, 9 of Gustilo II and 5 of Gustilo III, specific types were demonstrated in **Figure 1A-C**) with medical wounds was treated by leverage reduction and anatomical plate fixation after irrigation and debridement in emergency. Debridement and percutaneous pins fixation were conducted in 74 fractures (3 of Gustilo I, 27 of Gustilo II and 44 of Gustilo III) in emergency operating room.

Internal plate fixations (**Figure 2A-J**) were performed through a minimally invasive lateral approach [10]. During operation, one or two 3.5 mm Steinmann pins are introduced from the superoposterior portion of the calcaneus into the fracture fragment along its axis to reduce the posterior facet. The 2.5 mm pins were drilled into anterior part of calcaneus for temporary fixation once the posterior facet and Bohler's angle are reduced. After reduction and temporary fixation of the calcaneal fracture, the plate is placed on the lateral calcaneal. Each calcaneal, which was fixed by plate, had enough soft-tissue covered in medial side.



Figure 1. The fractures classified by Gustilo classification: A. Gustilo I; B. Gustilo II and C. Gustilo III.

patients, all subjects signed written informed consent form. All works were undertaken following the provisions of the Declaration of Helsinki.

Collected information including patients' medical history, patients' computed tomography was performed at the time of injury and post operation. During the data collection period, a total of 2101 calcaneal fractures were treated in 2083 patients, which including 101 open calcaneal fractures in 98 patients. All these frac-

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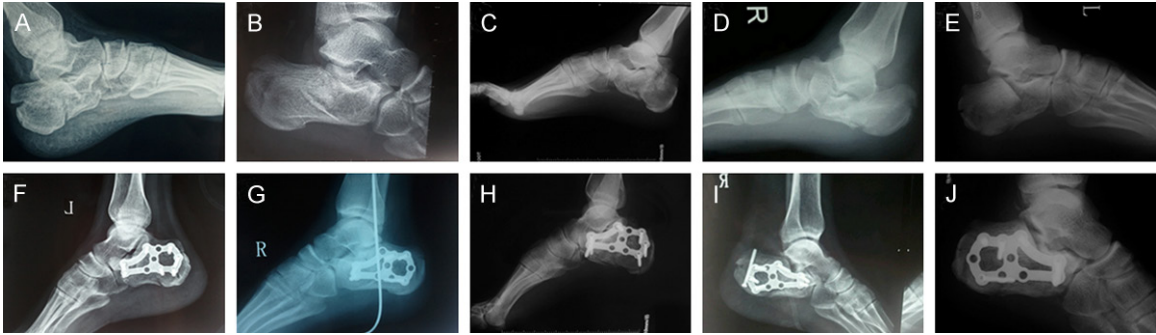


Figure 2. Open calcaneal fractures fixed by plates: A-E. Before treatment; F-J. After treatment.

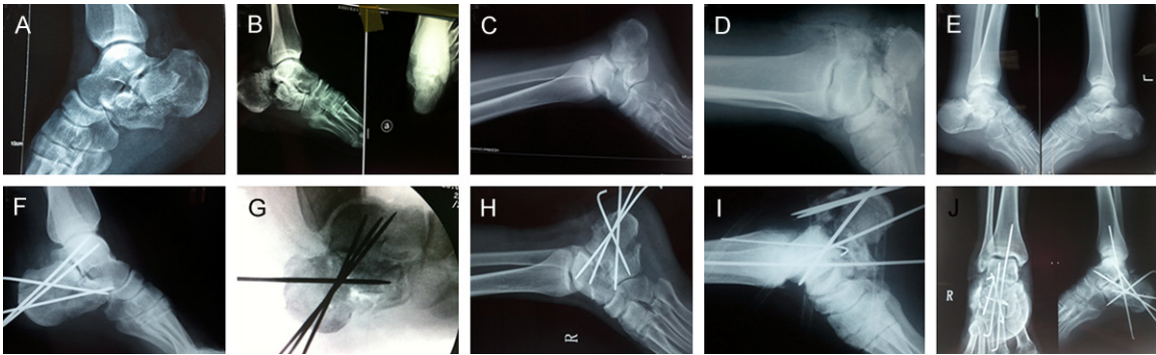


Figure 3. Open calcaneal fractures treated by percutaneous pinning: A-E. Before treatment; F-J. After treatment.

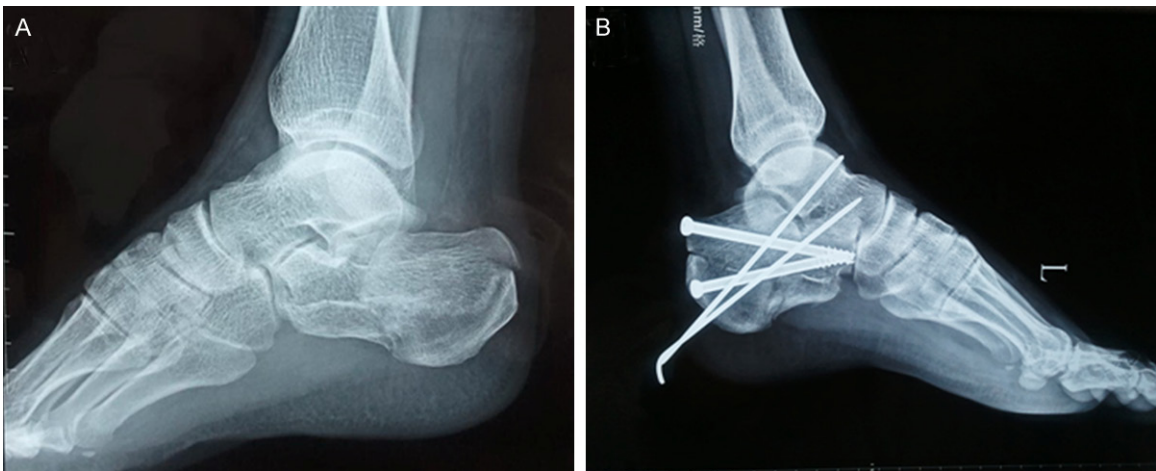


Figure 4. Open calcaneal fractures fixed by hollow screw: A. Before treatment; B. After treatment.

Seventy-four fractures were fixed by percutaneous pins (**Figure 3A-J**) after the restoration of Bohler's angle and the reduction of the posterior facet. Usually, four 2.5 mm Steinman pins were introduced to fix fractures in our hospital, including two of four from calcaneal tuberosity into the talar body across the posterior facet, and others along calcaneal axis for fixation of

main fracture fragments. During the operation, try to avoid reduction through open wounds, which may reduce the infection opportunity. Most open calcaneal fractures can be reduced by leverage. The pins were removed after 6 weeks (**Figure 4A, 4B**). Seven fractures were fixed with hollow screw after leverage reduction, and casting were used in five open calca-

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Table 2. The results of variance analysis in AOFAS of patients with different fixation ($P > 0.05$)

	Sum of Squares	Df	Mean Square	F	P
Between Groups	565.890	3	188.630	2.313	0.081
Within Groups	7749.100	95	81.569		
Total	8314.990	98			

Table 3. Number of different complications in different Gustilo classification

	Total	Skin graft	Flap graft	Deep infection	Amputation	Complication rate
Gustilo I	4	0	0	0	0	0
Gustilo II	47	4	1	0	0	10%
Gustilo III	50	10	6	2	2	40%

Table 4. The results of Bonferroni correction in AOFAS of open calcaneal fractures of different Gustilo classification

	Gustilo Classification		Mean Difference	Std. Error	P
Bonferroni	I	II	12.187500	9.469860	0.604
		III	55.484043*	9.477606	0.000
	II	I	-12.187500	9.469860	0.604
		III	43.296543*	3.734090	0.000
	III	I	-55.484043*	9.477606	0.000
		II	-43.296543*	3.734090	0.000

*, $P < 0.05$, compared with other Gustilo classifications (Listed in the second column).

neal fractures for slight extra-articular fracture.

Data collection post operation

Most (95%) gustilo II and III wounds were irrigated and debrided thoroughly every 48 to 72 hours until the wound was cleaned. All gustilo I wounds were closed in emergency operation. Patient with open calcaneal fracture received intravenous antibiotic (first-generation cephalosporins) within 7 days post operation. Management of open wound varied from vacuum sealing drainage to free musculocutaneous flap coverage depending on the severity of the soft-tissue injury.

Data of mechanism of injury, location and size of wound, classification, fixation methods and subsequent soft-tissue complications were collected and recorded. Long-term follow-up was performed using the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score [11]. Wound complication such as infection,

need for skin graft or flap coverage, osteomyelitis, and amputation were recorded. Osteomyelitis was diagnosed by positive bone and indium or magnetic resonance imaging scan results, or positive bone cultures testing results.

Data analysis

SPSS 13.0 (SPSS Inc, Chicago, Illinois) was used for data analysis. The variance analysis was performed to analyze the AOFAS scores between patients with different fixations. The Bonferroni correction was used to determine significant relationship about the AOFAS scores between fractures with different Gustilo classification. A P value of less than 0.05 was considered statistical significance.

Results

The average follow-up times were 38.4 months (range, 8-78 months) in these 98 patients (101 fractures). The overall complication rate was 22%. Twenty-one of 101 open calcaneal fractures received sustain skin graft or flap graft to treat serious soft-tissue injuries. Three of 101 open calcaneal fractures presented deep infection, and two amputations were performed because of serious bone and soft-tissue injury. Fifteen fractures were fixed by plates, seventy-four fixed by percutaneous pinning and seven fixed by hollow screw. The rest were treated with no internal fixation but casting for slight fracture.

Different complication rate is related with gustilo classification but not AOFAS score

Gustilo classification was used to evaluate soft-tissue injuries of open calcaneal fractures (Table 1). No statistical difference ($P > 0.05$) was found in complication and AOFAS score in open calcaneal fractures treated with different fixation methods (Table 2). There was significant difference in complication rate of different Gustilo classification (Table 3). The complication rate of Gustilo III type open calcaneal fractures reach to 40%. No statistical difference was found in AOFAS between Gustilo I and II

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type open calcaneal fractures ($P > 0.05$), but there was significant difference ($P < 0.05$) between Gustilo I, II and III type fractures (**Table 4**). The more serious soft tissue injury of open calcaneal fracture is, the worse outcome and higher incidence of complications obtained.

Discussion

Compared with various factors affect the treatment results of open calcaneal fractures, the fractures of Gustilo I and II had good prognosis in our preliminary clinical practice, which means the extent of soft tissue injury is the most important factor affecting the therapeutic effect of open calcaneal fractures. Open calcaneal fracture-a high energy injury, usually results from fall from height or traffic accident, often accompanied by other limbs or axial bone injury, as well as other organ injury. Because the powerful forces of injury, open calcaneal fracture in patients with serious multiple trauma need emergency resuscitation. The treatment of open calcaneal fractures is difficult for its clinical characteristics, such as difficulty in anatomical reduction, relatively high incidence of wound infection and osteomyelitis [12].

Seibert [13] was the first doctor who reported series of open calcaneal fractures. His report indicated that the overall complication rate of open calcaneal fractures exceeded 60% and 48% of patients had poor functional outcomes. The researchers used Gustilo classification to evaluate the soft-tissue injury, and recommended that the primary key of management is to salvage the soft tissue envelope and prevent infection, but not fracture reduction or fixation [13, 14]. Until today, most patients have to endure repeated operations, even amputation. Treatment goals of open calcaneal fractures focus on prevention of infection, soft tissue management, and repair/reconstruction of bony and chondral injuries with restoration of hind-foot function [12, 15-17]. Therefore, the balance between fracture reduction and repairment of soft tissue is important in treatment of open calcaneal fracture.

In recent years, treatment of calcaneal fracture has become more aggressive, and has focused on restoring the articular surface of the posterior facet [16]. Development of various internal fixation devices has improved the outcome and reduced complications of calcaneal fractures.

However, open calcaneal fracture management is still controversial. Open calcaneal fractures involve complex hind foot injuries characterized by a series of osseous and soft-tissue injuries. They comprise approximately 3%-11% of all calcaneal fractures [17]. In our study, open calcaneal fractures only account for 4.8% of all calcaneal fractures, which is similar to a 3%-11% incidence reported by Siebert *et al* [13].

Heier *et al* [18] reported 43 open calcaneal fractures with infection rate of 37% and osteomyelitis rate of 19%, and their mean American Orthopedic Foot and Ankle Society (AOFAS) score was 71. They concluded that soft tissue injury determines clinical outcomes. Aldridge [19] reported 19 open calcaneal fractures treated over a 10-year period. The overall complication rate was 11%, and average AOFAS hind foot score was 81.6. Berry [12] retrospectively studied a series of 30 compound fractures. The average AOFAS score was 60; the mean Maryland Foot and Ankle score was 63.5. In our study, the overall complication rate was 21%, and average American Orthopedic Foot and Ankle Society (AOFAS) score was 81.6, which is consistent with these reported data.

Medial hind foot wounds most often present in patient with open calcaneal fractures [10, 14]. Calcaneus, which has 5 degree valgus angle, locates in the lateral of astragalus. When the axial load through talus to calcaneus, medial wound appeared because of calcaneal strongly eversion and medial skin tension. Therefore, the size of medial wound in some open calcaneal fractures was less than 1cm; we considered it might cause by fragment pierce the medial skin. The medial hind foot wounds present in 86% of open calcaneal fractures, which are similar to other reports [10, 15].

Nowadays, controversial issues related to the management of open calcaneal fractures exists, but the initial treatment of these injuries with irrigation and debridement, intravenous antibiotics, and fracture immobilization have become fairly standardized operation. The choice of fixation and timing are key problems of treatment of open calcaneal fractures. The stability of the fractures could reduce infection rate to some extent. In recent years, the 4 forms of fracture fixation seem to predominate: anatomical plate fixation; percutaneous cannulated screw fixation; percutaneous pinning fixa-

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tion and external fixation. In our study, anatomical plate, screw and percutaneous pinning fixation were performed in 96 of 101 open calcaneal fractures; there was no significant difference in infection rates between patients with different fixation. Therefore, the degree of damage of soft tissue is closely related to outcomes of open calcaneal fractures and complication rate.

In addition, early soft tissue coverage is also an important and controversial issue. 28 patients sustained delay free skin grafting and skin flap grafting in order to manage soft-tissue injuries. Lawrence [16] indicated that the goals of open calcaneal fracture management include timely healing of the soft-tissue envelope without infection and maintenance of bony alignment [16]. In our study, the management of soft-tissue injuries is more important than treatment of calcaneal fracture, all fractures were reduced by percutaneous leverage, which was proved by a safe, easy and effective method. The infection rate could be reduced by this minimally invasive closed reduction technique. The anatomical plates were performed through a minimally invasive lateral approach, which may reduce the complication rate as compared with the traditional incision. All fixations were performed in emergency operation after debridement and irrigations. We considered that early fixation could not increase the infection rate.

In conclusion, patients with Gustilo III type open calcaneal fractures had higher complication rate and poorer outcome compare with patients with Gustilo I or II in open calcaneal fractures, and there was no statistically significant difference in internal fixation methods for treatment of open calcaneal fractures. Management of soft-tissue injury is more important than fracture reduction and fixation. Through this study, we considered that anatomical plate fixation could be performed in emergency operation in patients with Gustilo I, II type open calcaneal fractures. Furthermore, percutaneous leverage and percutaneous pinning fixation may be considered as a safe and effective treatment in all types of open calcaneal fractures.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Yingze Zhang, Trauma & Emergency Center, Third Hospital He-

bei Medical University, 139 Ziqiang Road, Shijiazhuang 050051, Hebei Province, China. Tel: +86-311-886-03000; Fax: 86-311-70206183; E-mail: yingzhang699@qq.com

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