The Journal of Foot & Ankle Surgery xxx (2017) 1–8

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

Short-Term Outcomes of Open Reduction and Internal Fixation for Sanders Type III Calcaneal Fractures With and Without Bone Grafts

Hong Cao, PhD [1], Yun-Guang Li, MD [1], Qing An, MD [1], Bo Gou, MD [1], Wei Qian, PhD [1], Xiao-Peng Guo, MD [2], Ying Zhang, PhD [3]

[1] *Orthopedist, Department of Orthopedic Surgery, Renmin Hospital, Hubei University of Medicine, Shiyan, Hubei, People's Republic of China*
[2] *Orthopedist, Department of Orthopedic Surgery, Taihe Hospital, Hubei University of Medicine, Shiyan, Hubei, People's Republic of China*
[3] *Assistant Professor, Reproductive Medicine Center, Renmin Hospital, Hubei University of Medicine, Shiyan, Hubei, People's Republic of China*

ARTICLE INFO

Level of Clinical Evidence: 3

Keywords:
bone graft
calcaneal fracture
injury
open reduction and internal fixation
Sanders type III

ABSTRACT

Calcaneal fractures, often caused by a fall from a height, are the most common injuries encountered by orthopedic surgeons. Currently, open anatomic reduction and internal fixation (ORIF) is considered a valuable treatment of displaced intraarticular fractures of the calcaneus; however, the need for bone grafting in the treatment is still controversial. Therefore, in the present study, we investigated the outcomes of 2 methods (with and without bone grafting) used for the surgical treatment of Sanders type III calcaneal fractures. From January 2013 to September 2015, 57 cases (55 patients) with displaced Sanders type III calcaneal fractures (53 unilateral and 2 bilateral) were enrolled. The patients were divided into 2 groups: group I was treated by ORIF with bone grafting (n = 28) and group II was treated by ORIF without bone grafting (n = 29). The radiologic evaluation included Böhler's angle, Gissane's angle, and the height and width of the calcaneum. In addition, the American Orthopaedic Foot and Ankle Society questionnaires and visual analog scale were completed by the patients. During the follow-up period, no differences were found in the outcome measures (Böhler's angle, $p = .447$; Gissane's angle, $p = .599$; calcaneal height, $p = .065$; calcaneal width $p = .077$; and American Orthopaedic Foot and Ankle Society questionnaires, $p = .282$) with or without bone grafting. The only difference between the 2 groups was the occurrence of postoperative pain ($p = .024$ and $p = \leq .05$), which was greater in the patients who had undergone bone grafting. We have provided evidence that bone grafting with internal fixation in the treatment of intraarticular calcaneal fractures failed to improve the restoration of Böhler's angle or Gissane's angle. No statistically significant difference was found in the short-term outcomes between the 2 methods used for the surgical treatment of Sanders type III calcaneal fractures.

Calcaneal fractures, often caused by a fall from a height, are the most common injuries encountered by orthopedic surgeons (Fig. 1). Calcaneal fractures comprise 1% to 2% of all fractures (1) and approximately 75% of the fractures affecting the foot (2). Approximately three quarters of calcaneal fractures are intraarticular fractures (3,4).

Historically, patients' prognosis has been poor and surgery was controversial and often unsuccessful. Computed tomography (CT) has improved our understanding of the injury mechanism and led to advances in surgical techniques and management. CT plays an important role in the evaluation of calcaneal fractures and aids surgeons by providing details that affect decisions on the final treatment (5). The Sanders classification system is based on the CT scan findings and is the most commonly used system for describing intraarticular fractures of the calcaneus (6,7). It consists of 4 types determined by the fracture line location at the posterior facet. Nondisplaced fractures or displacement of <2 mm are classified as type I regardless of the fracture lines. Types II to IV are displaced fractures with an increasing number of fracture lines and fragments, and type III fractures consist of 3 articular pieces resulting from 2 fracture lines (Fig. 2) (8).

Currently, open reduction and internal fixation (ORIF) is considered the reference standard treatment of displaced intraarticular fractures of the calcaneus (9,10), because anatomic reduction is important for feet and ankles to have functional outcomes. Also, ORIF is the best method for achieving calcaneal morphology restoration and anatomic reduction of the articular surface (11,12). However, the need for bone grafting in the treatment of displaced intraarticular calcaneal fracture is still controversial. Orthopedic surgeons who insist on bone grafting believe

Financial Disclosure: This study was supported by the National Natural Science Foundation of China (Grant 81602867), Hubei Province Health and Family Planning Scientific Research Project (Grant WJ2015Q042), and Hubei Provincial Science and Technology Department funded project (Grant 2013CFC031).

Conflict of Interest: None reported.

H. C. and Y.-G. L. contributed equally.

Address correspondence to: Ying Zhang, PhD, Reproductive Medicine Center, Renmin Hospital, Hubei University of Medicine, Shiyan 442000, Hubei, People's Republic of China.

E-mail address: 33556511@qq.com (Y. Zhang).

1067-2516/$ - see front matter © 2017 by the American College of Foot and Ankle Surgeons. All rights reserved.
http://dx.doi.org/10.1053/j.jfas.2017.05.037

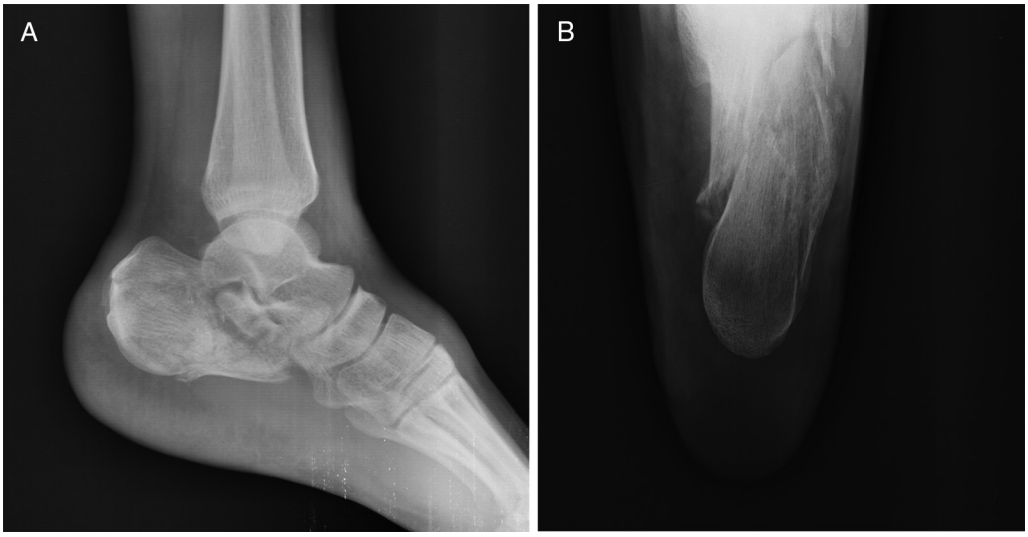

Fig. 1. Calcaneal fractures are shown. A typical radiograph contains the lateral and axial views of the calcaneus. (*A*) Lateral view of the calcaneus. (*B*) Axial view of the calcaneus.

it will stimulate fracture healing, leading to early full weightbearing, preventing posttraumatic arthritis, and increasing mechanical strength, and, thus, helping to prevent significant late collapse (13). Those who do not prefer bone grafting have suggested that internal fixation can adequately support the articular surface and that autografting could the infection rate, blood loss, postoperative pain, donor site morbidity, and complications (14–17).

Therefore, in the present study, we investigated the outcomes of 2 methods (ORIF with or without bone grafting) used for the surgical treatment of Sanders type III calcaneal fractures. We analyzed 57 cases (55 patients) with Sanders type III calcaneal fracture by comparing the outcomes between the 2 groups. We compared the reduction of Böhler's angle and Gissane's angle, changes in the calcaneal height and width, and analyzed the results from the American Orthopaedic Foot and Ankle Society (AOFAS) questionnaires and visual analog scale. The present study might provide important information on whether bone grafting is needed in addition to internal fixation in the treatment of Sanders type III calcaneal fractures.

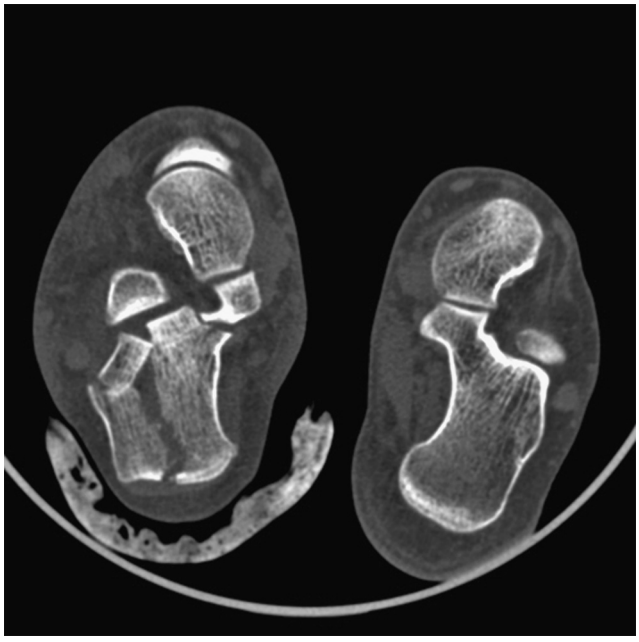

Fig. 2. (*Right*) A typical type III calcaneal fracture, consisting of 3 articular pieces resulting from 2 fracture lines. (*Left*) A normal computed tomography scan of the calcaneus.

Materials and Methods

Study Design

The present study was a prospective comparative study that was approved by the Ethical Committee and Reproductive Medicine Center, Renmin Hospital, Hubei University of Medicine (Shiyan, China). From January 2013 to September 2015, 55 patients (57 displaced Sanders type III calcaneal fractures; 53 unilateral and 2 bilateral) were enrolled using the following inclusion and exclusion criteria.

Inclusion Criteria

1. Displaced intraarticular calcaneal fractures (articular facet step-off of >2 mm) of Sanders type III
2. Minimum follow-up period of 1 year
3. Age ≥18 years old and a closed epiphyseal line

Exclusion Criteria

1. Nondisplaced or minimally displaced (articular facet step-off of <2 mm) extra-articular fractures
2. Open calcaneal fractures or with a grossly contaminated wound
3. Fractures in patients with peripheral vascular disease, diabetes mellitus, bleeding disorders, or neuropathic foot
4. Pathologic fracture of the calcaneum

The 57 cases were divided into 2 groups: group I (28 cases, 26 unilateral and 1 bilateral) was treated by ORIF with bone grafting; and group II (29 cases, 27 unilateral and 1 bilateral) was treated by ORIF without bone grafting. The average age was 39.4 (range 23 to 64) years in group I and 40.9 (range 19 to 67) years in group II.

Preoperative Evaluation

The patients were evaluated for associated injuries and anteroposterior, lateral, and axial radiographic views of the calcaneum were obtained (Fig. 3*A* to *C*). CT and 3-dimensional (3D) reconstruction were also performed to assess the details of articular depression (Fig. 4*A* to *D*). After injury, the limb was elevated and an ice pack was applied to decrease the swelling. The patients underwent surgery once the swelling had subsided and the wrinkle test finding was positive (18).

Procedure

All procedures were performed by the same surgical team. After the patients were under anesthesia, they were placed in a lateral position. An L-shaped skin incision