

# A Study of Wound Healing in 402 Calcaneus Fracture Cases Using Precise Extensive L-Shaped Incision

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## Research Article

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# Abstract

**Background:** To investigate wound healing in 402 calcaneus fracture cases using precise extensive L-shaped incision.

**Method:** We retrospectively analyzed 402 calcaneus fracture cases, involving patients who underwent heel bone reduction and internal fixation, using precise extensive L-shaped incision, at the second hospital of Shanxi medical university between January 2018 and December 2020. Postoperative wound healing was evaluated using a self-designed skin margin grading system.

**Results:** The patients experienced osseous healing after the surgery. A Maryland foot score of  $\geq 90\%$  was considered excellent. The skin margins from Grade I, II, III injuries healed spontaneously after dressing change. However, Grade IV injuries healed after debridement or removal of internal fixation.

**Conclusions:** The precise extensive L-shaped incision, used in this study, allowed for fewer postoperative wound complications and lower incidence of skin necrosis.

## 1. Introduction

402 calcaneus fracture cases (200 males and 202 females), including 160 SandersⅡ, 230 SandersⅢ, and 12 SandersⅣ[1, 2], were received at the xx hospital between Jan 2018-Dec 2020. All patients were preoperatively examined, using lateral X-ray of the injured foot, axial X-ray of the calcaneus, CT, and three-dimensional reconstruction[3]. Two radiologists and one orthopedic physician performed the preoperative fracture classification. A summary of all relevant patient information is summarized in Table 1.

## 2. Preoperative Condition

The patients were initially treated with casts or splint immobilization. Simultaneously, the affected limb was raised (to reduce blood flow to the injured area) and compressed with ice until the skin wrinkled (to cool the affected tissue and prep it for surgery). Subsequently, surgery was performed on an average of 8–10 days after the injury[4, 5].

## 3. Intraoperative Operation

After spinal anesthesia, patients with unilateral calcaneus fractures were placed in a lateral position with the affected limb faced upwards, while patients with bilateral calcaneus fractures were placed in the prone position. All surgeries[6], analyzed in this paper, were conducted by a single physician (Senior Deputy Director). Moreover, a tourniquet was used during surgery to restrict blood flow to the surgical area. Prior to the operation, the incision site was marked on the body surface and an L-shaped incision was precisely made and expanded about 1cm above the cusp of the lateral malleolus[7]. The posterior 1/3 of the line between the posterior margin of the lateral malleolus and the Achilles tendon's anterior margin was considered the longitudinal arm of the L-shaped incision, whereas the transverse arm followed the horizontal extension line of the fifth metatarsal head bisector horizontal extension line distal arc to the metatarsal head. The junction of the longitudinal and transverse arms formed an obtuse angle. The precise position of the operational incision is illustrated in Fig. 1. A round razor blade (No.20) was used to cut through the skin, followed by a smaller razor blade (No.15) to penetrate into deeper tissue. A full-thickness skin flap was collected from the periosteum while ensuring preservation of as much of the periosteum as possible. Additionally, the abductor digitorum minimis membrane and the tendon sheath of long and short peroneal muscles were entirely preserved, with forward exposure to the calcaneocuboid joint. In the meantime, the calcaneal fibular ligament was cut along the lateral wall of the calcaneus. Subsequently, three Kirschner wires (2.0 mm) were fixed to the cusp of the lateral malleolus[8], talar neck, and cuboid. The lateral wall was completely lifted to ensure direct visualization of the subtalar and calcaneocuboid joints. Next, traction reduction was performed, based on fracture type, to restore the length, width, and height of the calcaneus[9, 10], in cooperation with other Kirschner wires necessary for temporary fixation. The internal fixations were mostly conducted with Hindis calcaneal locking plate, with no usage of electric knife or retractor. Furthermore, fluoroscopy was used, in the Broden position[11], to evaluate the intraoperative recovery of the articular surface and screw length. Upon the completion of a reduction with a suitable length of screws, the incision was washed with a large amount of clean saline and negative pressure drainage tube was positioned in place. Lastly, a subcutaneous suture was performed with three 0 vicryl sutures, followed by suturing of the skin with four 0 vicryl sutures, using the Donati-Allgower procedure[12, 13]. After the surgery, the injury was covered with sterile dressings and bandaged with elastic bandages.

The surgery, on an average, took one and a half hours to complete and not required a bone graft[14]. Relevant images from a typical surgical case are depicted in Fig. 2.

## 4. Postoperative Management

After the surgery, the patients' affected limbs were raised and the patients received appropriate antibiotics and regular dressing changes. Smoking was forbidden and blood glucose was actively monitored in patients with diabetes[15]. The drainage tube was removed 2–3 days after the operation.

Additionally, patients received symptomatic treatment, based on injury classification. For instance, patients with Grade II injury were treated with regular dressing change for 2 weeks, followed by suture removal. Alternately, patients with Grade III injury were treated with suture removal after 3–4 weeks and patients with Grade IV injury required debridement or internal fixation removal. The injury classification of all patients is summarized in Fig. 2. The postoperative injury was graded as follows:

Grade Ⅰ: Blood supply was adequate, and the skin surrounding the injury did not turn dark;

Grade Ⅱ: Ⅱa Evidence of epidermal necrosis at 1–2 surgical insertion points on the skin, Ⅱb Presence of epidermal necrosis on one corner of the skin flap; Ⅱc Evidence of epidermal necrosis at 4–5 surgical insertion points on the skin, Ⅱd Presence of epidermal necrosis at the transverse and longitudinal arms of the L-shaped incision;

Grade Ⅲ: Evidence of full-thickness skin necrosis at 1–2 surgical insertion points at the corner of the skin flap;

Grade Ⅳ: Presence of extensive full-thickness skin necrosis originating at the corners of the skin flap and the transverse arm of the L-shaped incision.

## 5. Results

The fractures healed successfully, in all patients, by the last follow-up, as evidenced by an excellent Maryland foot score of  $\geq 90\%$  [1, 16]. In total, there were 250 cases with Grade I, 140 cases with Grade II, 9 cases Grade III, and 3 cases with Grade IV incision injuries. Patients with Grade I-III incision injuries had their sutures removed 2–4 weeks post surgery. Grade IV incision injuries, however, experienced massive bloody blisters and, notably, the patients had a history of smoking[17] and diabetes. Among the 3 patients with Grade IV incision, 2 were successfully treated with debridement and silver ion dressing, whereas 1 was successfully treated with the removal of internal fixation 6 months after surgery, followed by debridement. A summary of relevant patient medical data is summarized in Table 1.

## 6. Discussion

Multiple incision approaches can be used for calcaneus fracture. The medial calcaneal incision has been gradually abandoned due to limited visibility and high risk of injury[18]. Conventional lateral incision, on the other hand, presents difficulty in precisely determining incision points for calcaneus fracture surgery. Comparatively, the L-shaped incision[19, 20], designed by the author of this paper, allows for precise incision and better visualization of the underlying fracture. Moreover, the curved design of the incision dramatically reduces skin margin tension and facilitates suture placement. Currently, there is little consensus on a postoperative injury grading scale. This study used its own systematic postoperative injury grading scale, as described above, to aid in postoperative injury care. This study had several limitations; specifically, patients with open fractures were excluded from the study and there may have been subjective bias in our self-designed injury grading system.

## Abbreviations

CT Computed Tomography

## Declarations

Ethics approval and consent to participate. Not applicable.

## Consent for publication

Written informed consent was obtained from the patient's parent for publication of this report and any accompanying images.

## Competing interests

The authors declare that they have no financial or other conflicts or interest in relation to this research and its publication.

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## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Level of Evidence:**Therapeutic level III

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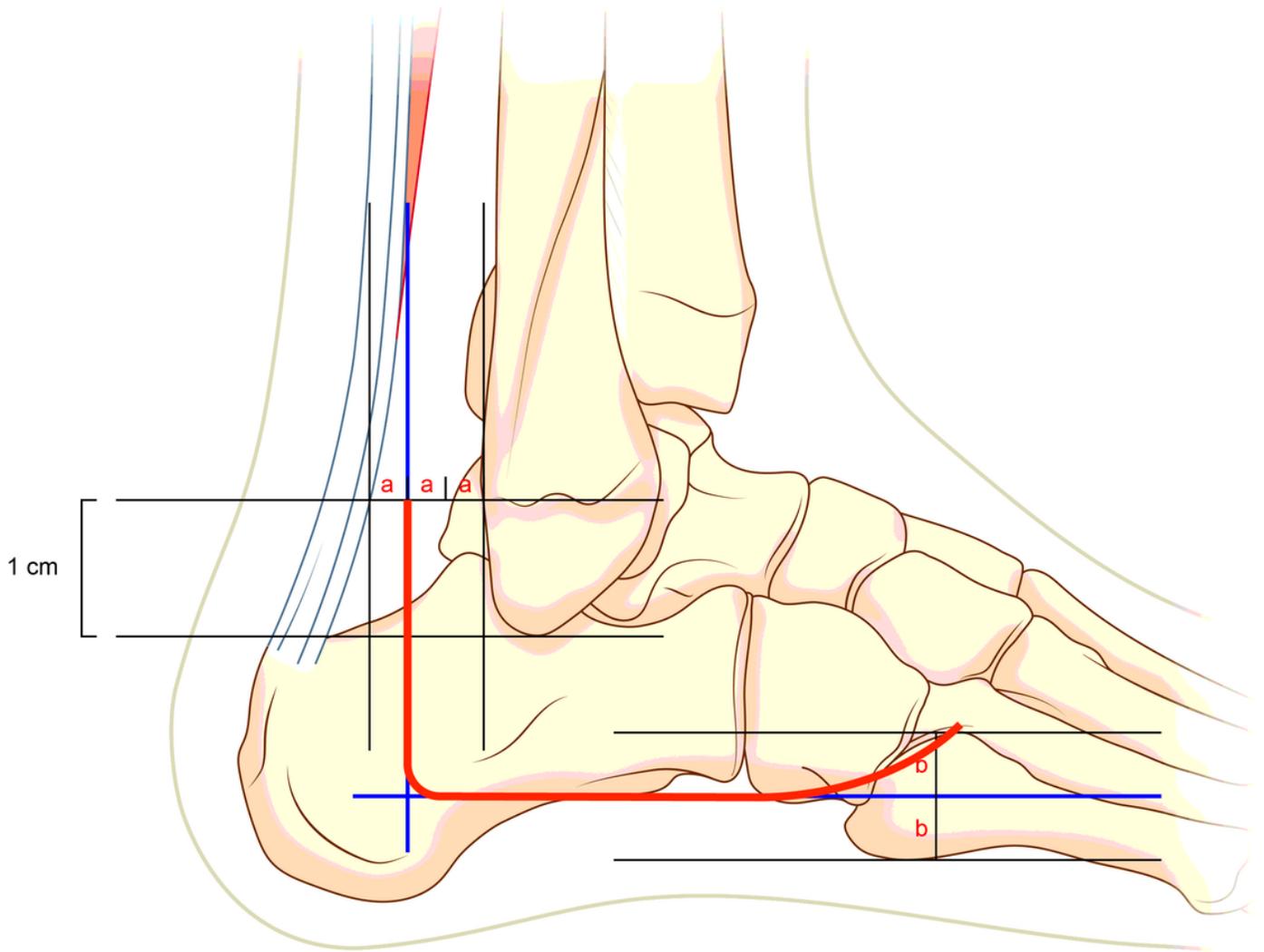
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## Tables

Table 1

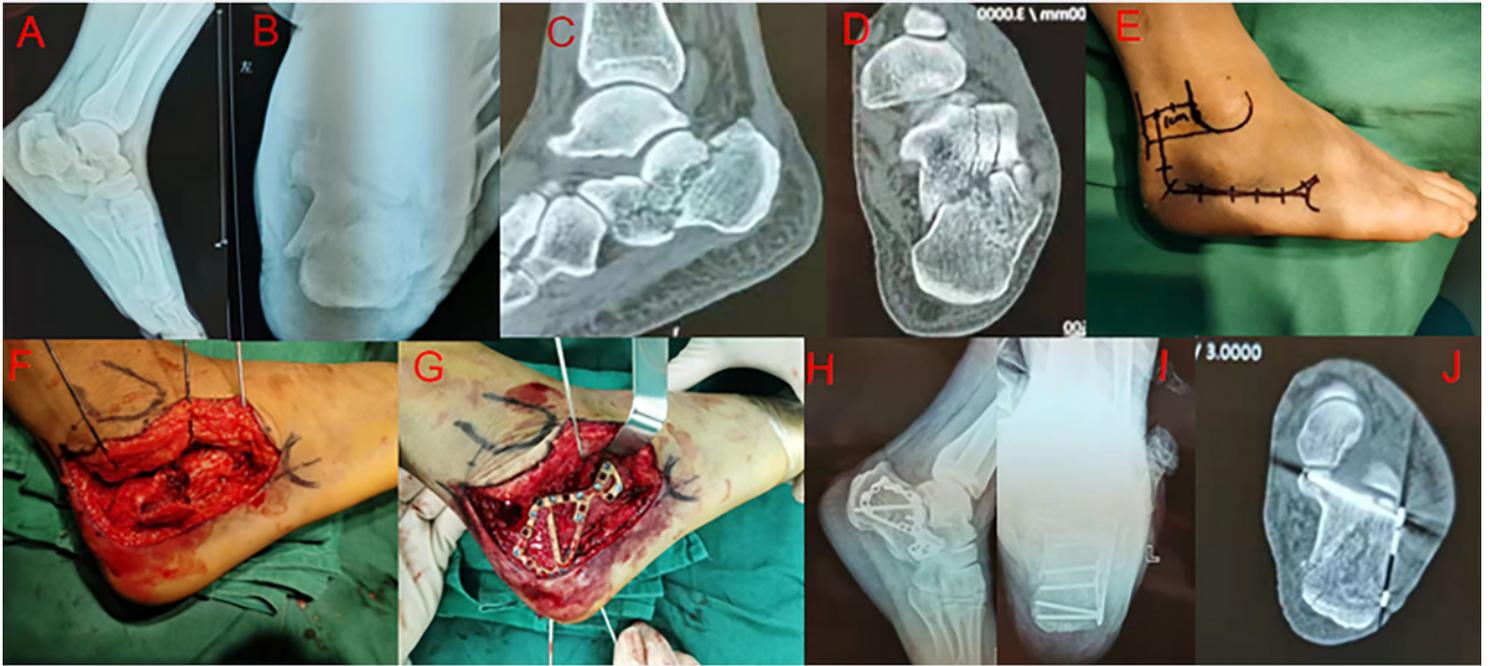
Cases	Male	Female	Sander □	Sander □	Sander □	Grade □ incision	Grade □ incision	Grade ▯ incision	Grade □ incision	Excellent and good ratio Maryland score	Average follow- up time (months)
402	200	202	160	230	12	250	140	9	3	90□	18

## Figures



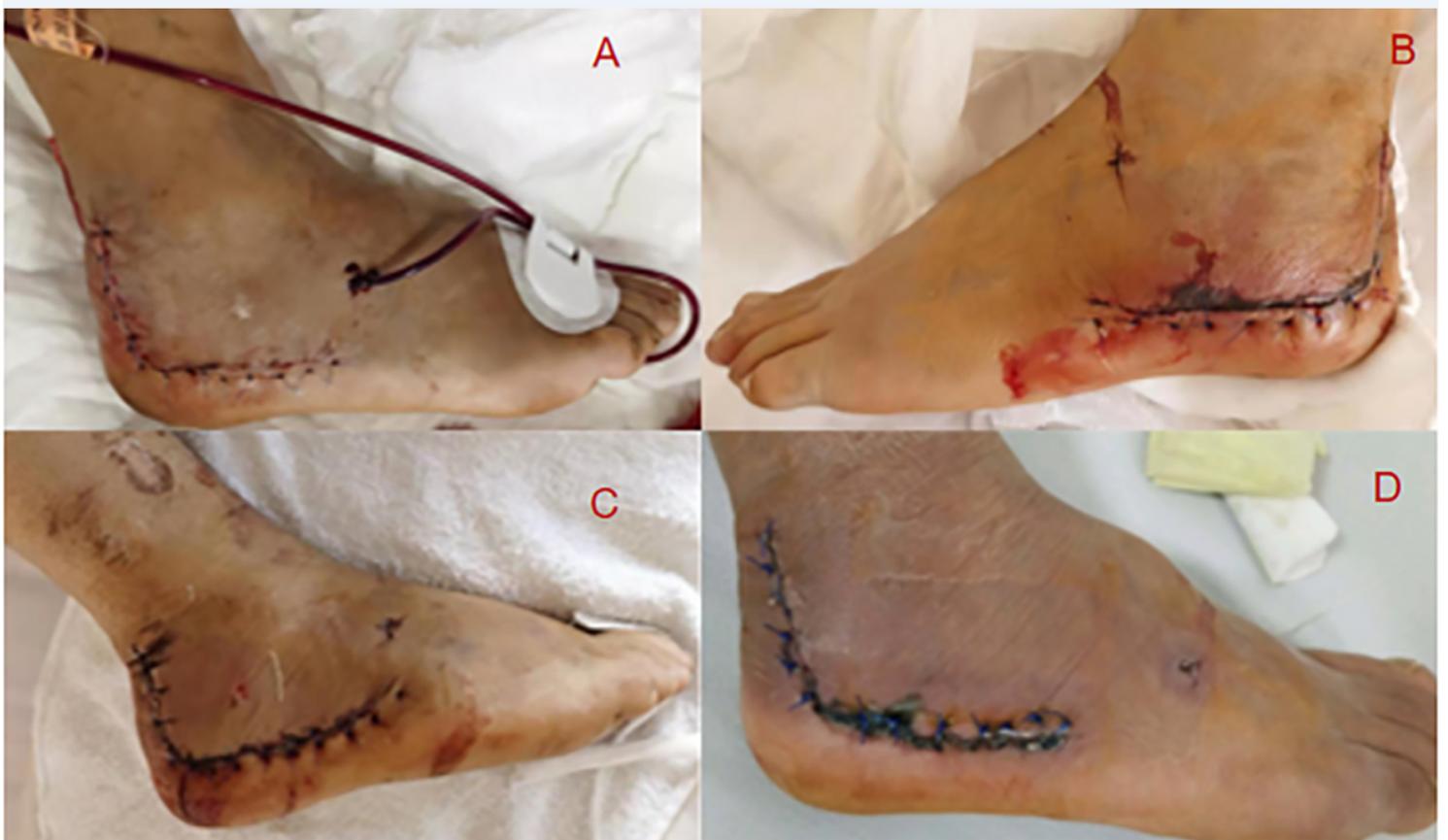
**Figure 1**

An illustration of the precise position of the calcaneal incision for calcaneus fracture. The red line represents incision site.



**Figure 2**

(A) A lateral X-ray of the patient's right calcaneus fracture, (B) An axial X-ray of the patient's right calcaneus fracture, (C) Preoperative coronal CT image of the calcaneus, (D) Preoperative axial CT image of the calcaneus, (E) Preoperative marking on the body surface to ensure precise incision, (F) Intraoperative fracture exposure, (G) The plate and screw placement after reduction, (H) Postoperative lateral X-ray of the calcaneus, (I) Postoperative axial X-ray of the calcaneus, (J) Postoperative axial CT of the calcaneus.



**Figure 3**

Injury classification (A) Grade 1 injury; (B) Grade 2 injury; (C) Grade 3 injury; (D) Grade 4 injury.