

## Case Report

# Etiology and treatment of calcaneal nonunion: a report of two cases

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**Abstract:** In clinical diagnosis and treatment, there are many complications after calcaneal fracture, but nonunion is quite rare. We report two related patients, one of whom underwent two salvage procedures after nonunion, subtalar arthrodesis (fixed differently from the previous literature) achieved good results. In another case, the nonunion healed spontaneously after conservative treatment, because the internal fixation was broken, the fracture healed again under the stress of loading. We analyzed the characteristics of the disease in two cases and reviewed the previous literature to explore the etiology and treatment of the disease.

**Keywords:** Calcaneus, nonunion, etiology, treatment

### Introduction

Calcaneal fractures are the commonest tarsal bone injuries, taking up nearly 65% of the total tarsal bone fractures. Treatment-related complications occur frequently. Nonunion after a calcaneus fracture is rare compared with soft tissue infection, subtalar arthritis or malunion, with the incidence reported from 0.4 to 1.3% [1]. Herscovici et al. [2] recruited 42 patients (44 fractures) aged 65 years or older and having undergone surgery for a calcaneal fracture; of which only one case of nonunion occurred. In this article, 2 patients will be reported, and past literature will be reviewed to gain insights into the disease. In the meantime, some cases displaying nonunion of the anterior process and the sustentaculum tali were excluded [3-5].

### Cases report

#### Case 1

A 32-year-old man sustained a bilateral calcaneal fracture (the left side is Sanders IV type, the right side is an open fracture, Gustilo type II) as having fallen from a height of 4 meters. He was treated with debridement and suture in another hospital. The patient underwent open reduction and internal fixation on the left fracture and percutaneous reduction on the right

side by stages respectively, depending on the soft tissue condition in our hospital. Nevertheless, he was hospitalized several times for the right wound infection, which was recovered 1 year after injury. Three years later, the patient, however, returned to our outpatient department for complaining about left foot pain when walking. A computed tomography (CT) scan suggested the broken plate and pseudarthrosis of the left calcaneus (**Figure 1**), so the factor of infection was excluded. Since the patient is a young male, the broken plate was taken out, and the nonunion was then debrided to produce a fresh bleeding surface and fixed to promote healing. At the follow-up visit 12 weeks after the operation, the internal fixation position was good. However, the plate was re-broken after 4-month follow-up (**Figure 2**), and the patient has not taken a full weight till now. Two months after conservative treatment, no enhancement was detected. The plate removal and subtalar joint fusion with bone graft were performed, and the anterior calcaneal nonunion was fixed to the talus (**Figure 3**). After 3 months of plaster fixation, limited weight-bearing walking could be achieved. One year later, X-ray showed effective fusion at the subtalar joint and fracture healing, and AOFAS score reached 85. The patient had a long history of smoking, 10 cigarettes a day.



**Figure 1.** The patient developed nonunion of the calcaneal neck 4 years after surgery (A-C).



**Figure 2.** Hardware failure and nonunion were rediscovered 4 months after the first revision operation.

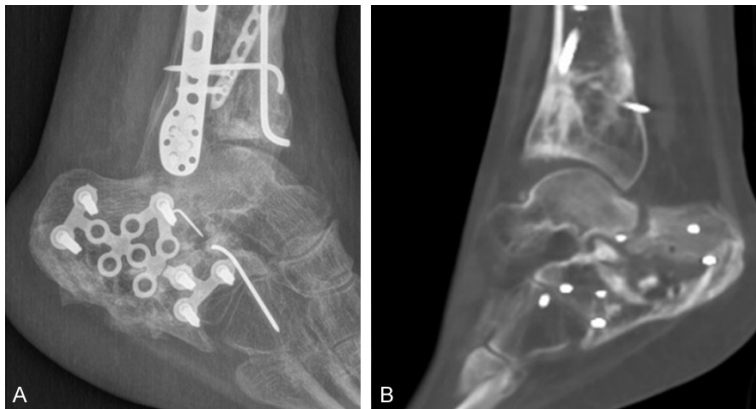


**Figure 3.** The nonunion healed after subtalar arthrodesis.

## Case 2

A 17-year-old girl, having fallen from the 6th floor, was subject to suffered polytrauma, hemorrhagic shock, lumbar fractures, pelvic fractures, open pilon fracture on the left side, as well as bilateral calcaneal fractures (the left side was an open fracture, Gustilo grade III, Sanders type IV, Essex-Lopresti joints compressed type). After the rescue in the emergency department, this patient received debridement and VSD, closed reduction and external fixation of the left side fracture. After the patient recovered to a stable condition, lumbar spine fracture surgery, open reduction and internal

fixation of the bilateral calcaneus and left Pilon fracture, and left lower limb autologous flap transplantation were performed in sequence. After the operation, the patient remained hypoesthesia below the level of Lumbar 4, underwent rehabilitation exercise and started walking with weight in four months after the injury. In the following 4 months of the reexamination, the radiologic findings suggested that the internal fixation was broken, and the fracture had not healed. In the meantime, subtalar arthritis was present (**Figure 4**), whereas no apparent discomfort was discovered. Five months later, internal fixation was removed for personal reasons; preoperative X-ray and CT indicated that



**Figure 4.** The patient was reexamined 8 months after the operation (A, B). X-ray and CT showed broken plate, nonunion and subtalar arthritis.



**Figure 5.** The nonunion was found to be healing on imaging when the internal fixation was removed (A, B).

the nonunion had healed (**Figure 5**), and Intraoperative exploration confirmed effective healing of the left calcaneus without displacement loosening. At the last follow-up, the AOFAS score reached 80 at 14 months after the removal of the internal fixation.

## Discussion

Calcaneus primarily consists of cancellous bone with abundant blood supply, so nonunion is rare. A review of the previous English literature reveals that studies were almost case reports (**Table 1**), indicating that the conservative treatment was prioritized to nonunion [6-8]. However, in a range of case studies by Moolly et al. [9], 93.3% of calcaneus nonunion took place after surgery, and the probable reasons include: surgery is now the mainstay of treatment for calcaneal fractures, whereas it can disrupt the

blood supply to the fracture; surgical treatment is commonly used for the more serious trauma, which is also one of the reasons for poor prognosis; smoking and diabetes are generally known independent risk factors of fracture healing [8, 10]. Thevendran et al. [11] studied the risk factors of bone nonunion after foot-ankle arthrodesis. They concluded that smoking, firmness of fixation and local vascular condition are the critical factors. In our case, the male patient had a long smoking history and still refused to quit smoking perioperatively. He recovered after a second salvage operation. Given this, smoking cessation guidance is vital, especially for patients with a history of smoking.

Are open calcaneal fractures more prone to nonunion? Open fractures were detected in 3 patients with nonunion [7, 9]. The female patient in our report with an open fracture as well finally achieved a well-healed fracture, though the open fracture was highly susceptible to infection.

Nonetheless, there has not been evidenced that these patients (including our case) had nonunion due to chronic occult osteomyelitis [9]; thus, it is speculated that open fractures are not a direct risk factor for nonunion.

Both cases were treated with the identical type of plate, broken in the calcaneal neck, which is consistent with the fact that nearly 80% of nonunion reported in the literature occurred in the calcaneal neck [9]. Note that both of our cases were bilateral calcaneal fractures, and two cases of bilateral calcaneal fractures have been reported in the existing literature as well [8, 9]. Zeman et al. [12] reported that bilateral calcaneal fractures were more prone to complications, and also they had a poor prognosis because high-energy injuries resulted in bilateral fractures and more severe damage to the subtalar joint. Renovell-ferrer et al. [13] also

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**Table 1.** Summary of the literature

Study	Gender	Age	Type	Initial treatment	Associated risk factors	Salvage procedure	Follow-up (months)
Thomas (1993) [6]	Female	36	Undisplaced	Conservative	-	Osteotomy, plate, bone graft	3
Karakurt (2004) [7]	Male	42	Open, comminuted	Conservative	20 years of Smoking	Bone graft	8
Molloy (2007) [9]	9 male 5 female (15 nonunion)	42 (27-64)	2 Gustilo grade I, 2 Sanders II, 7 Sanders III, 1 Sanders IV, 2 tongue-type/joint depression	14 ORIF 1 conservative	7 smokers	Subtalar fusion, Triple arthrodesis, Calcaneal osteotomy, Bone graft	72 (24-102)
Schepers (2008) [8]	Male	49	Sanders II	Percutaneous	Smoking	Subtalar arthrodesis, Bone graft	14
	Female	53	Sanders II	Conservative	Smoking, Diabetes	Subtalar arthrodesis, Bone graft	3
	Male	39	Bilateral, Sanders II-III	Conservative	Smoking	Subtalar arthrodesis, Bone graft	6
Kumar (2015) [20]	Female	29	-	Conservative	Diabetes, Obese	Subtalar arthrodesis, ORIF with screws, bone graft	12
Wajdi (2018) [18]	Female	40	Undisplaced	Percutaneous	-	Bone Marrow Concentrates	12
Our study	Male	32	Sanders type IV	ORIF	Smoking	Subtalar arthrodesis, Bone graft	11
	Female	17	Sanders type IV, Gustilo grade III	ORIF	-	conservative	14

identified a positive association between the severity of trauma and prognosis. In brief, bilateral calcaneal fractures suggested more serious energy damage and poor prognosis, requiring clinicians' attention to the occurrence of serious complications (e.g., nonunion).

Studies suggested that for femoral neck fractures, patients with normal protective sensation can safely bear weight sooner after operation, whereas most surgeons recommend a period of protected weight bearing for patients with calcaneal fractures [14]. A retrospective study by Kayali et al. [15] revealed that partial weight bearing at the early stage (within 6 weeks) was feasible compared with the existing more conservative weight bearing protocols. De Boer et al. [16] found that there has been no literature to support the risk of complications associated with early weight-bearing. The current view is more conducive to early weight-bearing for rigid fixation of calcaneal fractures. The girl in this report began to carry partial weight four months after surgery, and the broken plate was discovered four months later. It is therefore speculated that the patient suffered nerve injury due to a lumbar spine fracture, causing hypoesthesia of the lower extremities and pain tolerance. The delayed union healed again after the plate was broken, and the stress shielding was removed. Though there was subtalar arthritis, the patient was asymptomatic. Therefore, for such high energy calcaneal fractures, early weight-bearing rehabilitation exercise is also recommended after achieving a rigid internal fixation. Loading stress stimulation is the catalyst for normal fracture healing. Long-term limited weight-bearing not only impedes functional recovery, but also leads to delayed union or even nonunion. In addition, if the broken calcaneal plate bone nonunion was found, surgical intervention is not the first choice. Weight-bearing conservative treatment may be able to provide a good opportunity for healing, but it is necessary to always pay attention to whether there is displacement deformity in nonunion, which may be a sign of operation.

The major existing surgical method to treat calcaneal nonunion is arthrodesis. For the complexity of the surgery, the poor quality of the bone and the extent of the defects, multiple revision operations may be required [9]. The male patient in our report, having undergone a failure of bone grafting and refixation, achieved

a satisfactory result after subtalar arthrodesis. Discussing this as part of the informed consent will help the patient lower their expectations and allow for the inevitable time.

Due to the need for simultaneous removal of internal fixation and revision surgery, and give the patient's soft tissue conditions, the selection of a suitable skin incision is critical. Percutaneous removal of the retained hardware is feasible [17], whereas the internal fixation in patients with nonunion is usually broken, making the operation more complicated. The original extensile incision is employed for both reconstructive operations. The removal of the internal fixation and subtalar arthrodesis were performed successfully based on the sufficient interval and the soft tissue (infection on the right side). If internal fixation can be removed percutaneously, the subtalar arthrodesis can be performed with a standard tarsal sinus incision [9].

Wajdi et al. [18] reported a case of calcaneal nonunion treated with platelet-rich plasma (PRP); they achieved satisfactory results, indicating that local freshness of nonunion and stimulation of tissue regeneration are noticeably crucial. In revision surgery, according to our experience, the surrounding fibrous tissue and avascular bone should be debrided thoroughly until punctate fresh bleeding is observed, accompanied by drilling to fresh the nonunion. The fixation of the subtalar joint and the nonunion follows the scale and extent of the defect. Reliable fixation cannot be achieved if this fragment is below 2 cm long antero-posteriorly. Subsequently, a triple arthrodesis will be performed [9]. Nevertheless, the fragment can also be fixated with the talus (**Figure 3**), which also prevent the internal fixation from damaging blood circulation. Such fixation has not been reported in the existing literature about calcaneal nonunion. In the case of comminuted nonunion, arthrodesis can be accomplished using plates. Arthrodesis should be supplemented by deformity correction and bone graft; fusion without correction of the deformity does not mitigate the symptoms [9, 19]. Our aim of correction is to restore the calcaneal triaxial length; complete debridement of the necrotic tissue and bone grafting are performed while preventing the lateral impingement caused by the calcaneus and fibula. Proper application of triple arthrodesis can help complete the correction of severe deformity.



Calcaneal nonunion refers to a rare but serious complication after calcaneal fractures. At present, orthopedic surgeons should be alert to the risk factors and take precautions when treating calcaneal fractures. Patients should quit smoking and control blood sugar. More attention is required to patients with severe trauma, who should be given rehabilitation guidance and followed up timely. If nonunion is present, conservative treatment after rigorous evaluation ought to be attempted. After the nonunion has developed a displacement deformity, a well-developed surgical strategy with detailed and adequate preoperative communication is critical. The weakness of our study is that case data are limited, and no more reliable conclusions can be drawn. Considerable high-quality, evidence-based studies are required to explore the etiology of the disease and appropriate treatment options in the future.

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## Disclosure of conflict of interest

None.

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