

# CLINICAL OUTCOMES OF SURGICAL TREATMENT FOR TALAR MALUNIONS AND NONUNIONS

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## ABSTRACT

**Objective:** To present our experiences of treating talar malunions and nonunions. **Method:** Between January 2000 and September 2009, 26 patients with malunions or nonunions after talar fractures underwent surgical treatment according to different types of talar deformities. The treatment outcomes were evaluated using AOFAS ankle-hindfoot scale as well as plain radiographs. **Results:** 20 patients were available for follow-up for 30 (range, 24 to 60) months. No wound healing problems or infections occurred and solid unions were achieved in all patients. Radiological unions were achieved at a mean time of 14 (range, 12 to 18) weeks. The mean time to complete weight-

bearing was 16 (range, 14 to 20) weeks. The mean AOFAS score increased significantly from 36.2 (range, 27 to 43) to 85.8 (range, 74 to 98). **Conclusion:** Surgical interventions for malunions and nonunions after talar fractures can bring about satisfactory outcomes, and the appropriate procedure should be adopted according to different types of posttraumatic deformities. **Level of Evidence: IV, Retrospective Study.**

**Keywords:** Talus. Fractures, malunited/therapy. Fractures, malunited/surgery. Fractures, Ununited/therapy. Fractures, Ununited/surgery.

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## INTRODUCTION

Fractures of the talus are quite rare and account for about 3% of all foot fractures.<sup>1-3</sup> However, the fractures' incidence ranks second in all tarsal bone fractures following the calcaneal fractures.<sup>4</sup> It's a challenge to deal with talar fractures because of the bone's special anatomic characteristics. The talus has no muscle or tendon attachment and about 60% of the bone surface is covered with articular cartilage, which leaves a limited region for vascularisation.<sup>5,6</sup> The outcome of talar fractures varies widely and depends on the degree of initial damage and the accuracy of fracture reduction.<sup>7</sup> Talar malunions or nonunions are common complications with variable incidences in the literature and almost inevitably lead to functional impairment and significant disability. Surgical treatment for these two complications was reported mostly focusing on the articular fusions.<sup>8-10</sup> However, not all patients were satisfied with arthrodesis, especially the triple arthrodesis. The purposes of this study were to explore the operative methods and report our experience in treating malunited and nonunited talar fractures.

## PATIENTS AND METHODS

During the period from January 2000 to September 2009, 26 patients with malunited or nonunited talar fractures received delayed surgical treatments, which were performed at a mean time

of 14 months (range, 9 to 20) after fractures of the talar body or neck. Twenty patients were followed for 30 months (range, 24 to 60) and six patients were lost during follow-up. The patients who were followed-up included 15 males and five females with a mean age of 34.5 years (range, 15 to 53). (Table 1)

The talar deformities were categorized according to the classification system described by Zwipp and Rammelt<sup>11</sup> in 2003. Type I: malunion with or without joint displacement; Type II: nonunion with joint displacement; Type III: type I or II with partial avascular necrosis (AVN); Type IV: type I or II with complete AVN; Type V: type I or II with septic AVN. Patients enrolled in current study were classified as type I in nine cases, type II in seven cases and type III in four cases.

All cases were evaluated preoperatively with weight-bearing radiographs of anteroposterior view, lateral view, and mortise view. Computed tomography scans and three-dimensional reconstructions were performed in all the patients to enhance our understanding of the fracture position and classification. Regarding type III deformities, MRI was used to help to confirm the presence of talar AVN and to determine the extent of necrosis. These data contributed to identify the deformity patterns and helped to make surgical decisions. Moreover, routine leukocyte counts and serum levels of C-reactive protein were obtained from all patients to evaluate infection.

All the authors declare that there is no potential conflict of interest referring to this article.

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Before the surgical correction, the AOFAS (American orthopaedic foot and ankle society) ankle-hindfoot scale<sup>12</sup> was used to assess the hindfoot function in all patients. The preoperative mean value of AOFAS score was 36.2 (range, 27 to 43).

The following surgical procedures were performed: open reduction and anatomic reconstruction in 9 cases, anatomic reconstruction combined with bone grafting in five cases, and anatomic reconstruction combined with subtalar fusion in 6 cases. (Figure 1A-H and Figure 2A-G) All the patients were operated by a senior orthopaedic surgeon.

### Surgical Techniques

The operations were performed with a tourniquet at the ipsilateral thigh and with the iliac crest draped free to allow for bone grafting when necessary. Surgical incision and patient's position depended on the location of the talar deformity. For talar neck deformities, we used an anteromedial approach, starting from the anterior border of the medial malleolus and bisecting the space between the tibialis anterior and posterior tendons. The incision curved proximally along the axis of the tibia to allow visualization of tibiotalar joint. For reconstruction of talar body deformities, the incision started at the navicular tuberosity and exposed the talar neck. If necessary, the incision would extend proximally to perform a malleolar osteotomy for the convenience of reducing any talar body fracture. A combined oblique lateral approach was used in six cases to perform subtalar arthrodesis. Careful soft tissue dissection was mandatory. Extensive soft tissue dissection at the tip of the medial malleolus and the inferior aspect of the talar neck was to be avoided to preserve the blood supply. To obtain an optimal access to the joints, a joint tractor was used, being extremely helpful. For malunions after talar fractures, we performed correctional osteotomy along the former fracture plane. Nonunions required complete resection of the fibrous pseudarthrosis and sclerotic bone until viable bone. The resulting bone defect was filled with autologous bone grafting from the ipsilateral iliac crest to correct the varus mal-alignment. After anatomic reconstruction, Kirschner wires were used to temporarily fix the talus and cannulated screws or



**Figure 1A.** A lateral view radiograph showed talar nonunion (type II) with the fragment dorsal displacement leading to articular incongruity.



**Figure 1B.** A sagittal CT scan showed absence of a severe articular degeneration of the ankle joint and the subtalar joint.

**Table 1.** Patient Data.

No.	Gender/Age (years)	Fracture Site	Deformity Type (Zwipp)	Time of delay (months)	Arthritis Change	Surgery	Bone healing (wk)	Full weight-bearing (wk)	AOFAS Score (pre-op)	Follow-up (months)	AOFAS Score (post-op)
1	M/24	Neck	I	12	—	AR	13	15	43	28	89
2	M/39	Neck + Body	III	14	—	AR+BG	15	17	35	32	86
3	F/53	Neck	II	10	Subtalar OA	AR+SF	17	19	29	24	79
4	M/45	Body	I	9	—	AR	12	14	40	32	91
5	M/26	Body	II	14	—	AR+BG	13	15	33	28	87
6	F/34	Neck	I	12	—	AR	12	14	36	32	92
7	M/35	Body	III	16	Subtalar OA	AR+SF	16	18	34	24	81
8	F/30	Body	II	20	—	AR+BG	13	15	38	27	89
9	M/28	Neck	I	16	—	AR	12	14	42	24	92
10	M/41	Neck	II	18	Subtalar OA	AR+SF	15	17	32	26	83
11	M/32	Neck	I	14	—	AR	14	16	37	60	88
12	M/15	Body	I	12	—	AR	13	15	42	30	98
13	M/34	Neck	II	9	—	AR	14	16	39	25	87
14	F/42	Neck + Bdo	III	18	Subtalar OA	AR+SF	18	20	27	26	74
15	M/40	Neck	I	10	—	AR	12	14	41	32	83
16	M/32	Neck	III	16	—	AR+BG	13	15	35	28	80
17	M/51	Neck	II	18	Subtalar OA	AR+SF	16	18	30	36	78
18	M/29	Neck	I	14	—	AR	13	15	39	24	91
19	F/38	Neck	II	16	—	AR+BG	14	16	32	28	87
20	M/22	Body	I	12	Subtalar OA	AR+SF	15	17	40	34	81

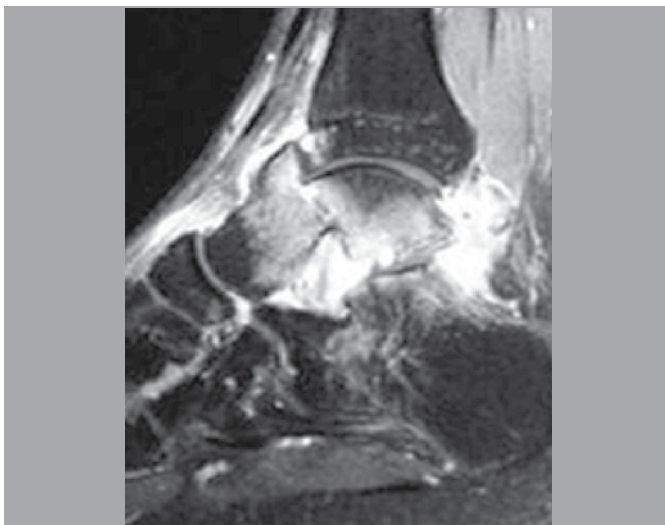
OA, osteoarthritis; AR, anatomic reconstruction; SF, subtalar fusion; BG, bone graft.



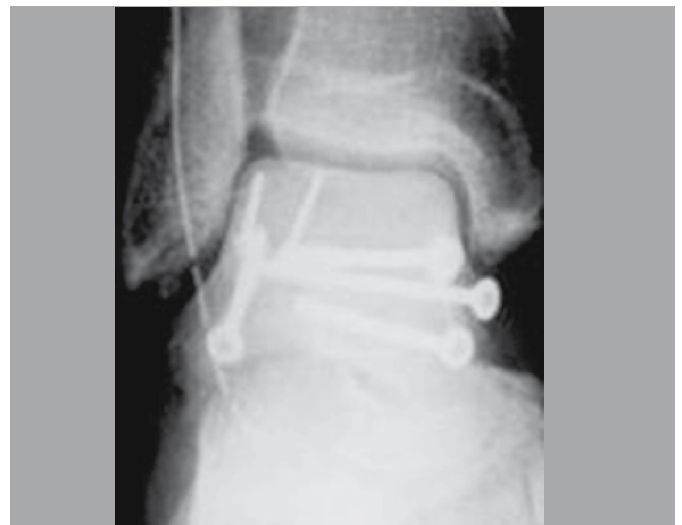
**Figure 1C.** The T1 weighted MRI image showed absence of talar AVN.



**Figure 1E.** The postoperative radiograph (lateral view).



**Figure 1D.** The T2 weighted MRI image showed absence of the talar AVN.



**Figure 1F.** The postoperative radiograph (anteroposterior view).

mini-plates were used for definitive fixation. If extensive full-thickness cartilage defects of the weight-bearing areas were observed, fusion of the affected joint should be considered after correction of the deformity. In six cases (four type II and two type III), the preoperative X-ray, CT and intra-operative observation showed severe posttraumatic arthritis at the subtalar joint and partial avascular necrosis of the talus. Two 6.5 mm whole-threaded screws were used to perform the subtalar arthrodesis while the ankle joint was reconstructed and preserved.

#### Rehabilitation

Postoperatively, a short leg cast was applied for 2-3 weeks until the suture removal, which relieved early pain and allow soft tissue recovery. Range of motion exercises of the forefoot was started at 24h postoperatively. After the plaster was removed, functional exercises of the ankle and subtalar joints were started. Partial weight-bearing was commenced as tolerated by the patients after 6 weeks postoperatively. Full weight-bearing

was allowed after radiographic evidence of bone union at an average of 14 weeks postoperatively.

#### Postoperative Assessment

During the follow-up, the hindfoot alignment, the bony union and the presence or absence of avascular necrosis of the talus were assessed. Radiographs were taken monthly in the first three postoperative months. Thereafter, patients were generally followed every three months, which changed to every six months one year later. In addition to the radiographs, severe patients (type II and type III) were examined with CT scans to evaluate the arthritic changes, and MRI was used to evaluate the development of AVN. Meanwhile, patients were assessed with respect to subjective satisfaction, pain, early wound complications, level of activity, muscular and tendinous problems, and so on. Functional outcomes were evaluated with the AOFAS ankle-hindfoot scale. At the last follow-up, the AOFAS scores were recorded and compared with the preoperative scores.



**Figure 1G.** At two year follow-up, the lateral-view radiograph showed solid union of the talus with no articular degeneration of the peripheral joints.



**Figure 2A.** The anteroposterior-view radiograph showed a talar malunion with partial AVN (type III).



**Figure 1H.** At two year follow-up, the anteroposterior-view radiograph showed solid union of the talus with no articular degeneration of the peripheral joints.



**Figure 2B.** The lateral view radiograph showed articular incongruity, osteosclerosis, and significant degeneration of the subtalar joint.

## RESULTS

Twenty patients received follow-up with a mean time of 30 months (range, 24 to 60) (Table 1 and Table 2). No postoperative complications such as wound healing problems or infections occurred. Solid union was obtained without redislocation in all patients. No development or progression of AVN was observed in any patients. The mean time to achieve bone union was 14 weeks (range, 12 to 18). The mean time to complete weight-bearing was 16 weeks (range, 14 to 20). The mean AOFAS score increased from 36.2 (range, from 27 to 43) to 85.8 (range, from 74 to 98). All patients stated that they were satisfied with the results.

## DISCUSSION

The talus takes part in the composition of the ankle, subtalar and talonavicular joints and plays a pivotal role in overall foot function. Because two thirds of the talar surface is covered with articular cartilage, and the blood supply to the talus is vulnerable to injury, once talar fractures happen, neglected or

mal-reduced talar fractures may produce talar malunions or nonunions. The common complications associated with talar fractures include skin necrosis, osteomyelitis, AVN of the talus, malunion, nonunion, and post-traumatic arthritis. Among these complications, malunion may be more common.<sup>2,7</sup> Malunited talar fractures would lead to shortening and deformity of the medial column, thus leading to disability of the foot function. Talar nonunions would lead to articular incongruity and malposition of the related joints, thus leading to osteoarthritis and long-term pain. Deformity correction and anatomic reconstruction are essential to restore the normal foot function and prevent other complications.

There are few classification systems of malunions or nonunions after talar fractures. In 2003, Zwipp and Rammelt<sup>11</sup> reported a classification of posttraumatic talar deformities. According to their suggestions, and in consideration of our experiences, we draw the conclusions for treating talar malunions and nonunions as follows: For type I to III deformities, delayed talar anatomic reconstruction with preservation of the joints can be attempted





**Figure 2C.** The sagittal CT scan image showed the talar AVN.



**Figure 2E.** The postoperative lateral-view radiograph showed favorable correction of the malalignment of the talus.



**Figure 2D.** The postoperative anteroposterior-view radiograph showed favorable correction of the malalignment of the talus.



**Figure 2F.** At the 21-month follow-up, the anteroposterior-view radiograph showed sound union of the talus and thorough fusion of the subtalar joint.

in young, compliant and active patients who have sufficient bone stock. Patients who have type I to III deformities in combination with severe, symptomatic posttraumatic arthritis or who have systemic diseases can be treated with deformities realignment in combination with subtalar or ankle joint fusion. Patients who have type IV deformities can be treated with excision of necrotic bone and tibiotalocalcaneal fusion with autologous bone grafting. For type V deformities, a repeated debridement of infected and necrotic bone is needed and a subtotal talectomy is almost inevitable. In our cohort, nine patients (type I) received anatomic reconstruction, five patients (three type II and two type III) received anatomic reconstruction combined with bone grafting, and six patients (four type II and two type III) received deformities realignment combined with subtalar fusion. The choice of surgical approach depends on the site and classification of talar deformities, as well as soft tissue conditions.<sup>13</sup> Anteromedial approach is chosen in cases of malunions or nonunions after talar neck fractures which can easily expose

the ankle and talonavicular joints. With plantar flexion of the ankle joint, the talar neck can be seen in its entirety, but this can easily damage part of the talar blood supply. Where there is a severe deformity of the talar neck with concomitant lateral process malunion, or where a subtalar malalignment requires correction, a combined oblique lateral approach can be used to reach the subtalar joint, the lateral part of the talar head, the talar neck and the anterior part of the talar body. A careful combined surgical approach preserves the blood supply of the talar body, especially the blood supply from tarsal sinus and tarsal canal. For malunions or nonunions after talar body fractures, anteromedial approach and medial malleolar osteotomy can reach the medial part of the talar body. A chevron osteotomy of a predrilled and pre-tapped medial malleolus is performed to facilitate an anatomic reduction of the malleolus at the end of the operation. This approach preserves the medial blood supply and keeps the deltoid ligament intact. A posteromedial or posterolateral longitudinal incision can help expose any de-



**Figure 2G.** At the 21-month follow-up, the lateral-view radiograph showed sound union of the talus and thorough fusion of the subtalar joint.

**Table 2.** Statistical description of talar deformities classification, surgical treatment, and outcomes.

Variable	Number/Mean $\pm$ SD
Age(years)	34.50 $\pm$ 9.49
Female	5
Zwipp Classification	
I	9
II	7
III	4
Time of delay (months)	14 $\pm$ 3.23
<b>Surgery</b>	
Anatomic reconstruction	9
Anatomic reconstruction + bone graft	5
Anatomic reconstruction + subtalar fusion	6
Bone healing (weeks)	14 $\pm$ 1.75
Full weight-bearing (weeks)	16 $\pm$ 1.75
Preoperative AOFAS Score	36.2 $\pm$ 4.66
Follow-up (months)	30 $\pm$ 7.93
Postoperative AOFAS Score	85.8 $\pm$ 5.85

formity of the talar posterior process. Screws were inserted in a direction from posterior to anterior cross the central portion of the talar neck and perpendicular to the plane of fracture. They therefore, theoretically, have a better biomechanical advantage than screws inserted from anterior to posterior, which pass eccentrically through the dorsal part of the talar head or neck and oblique to the plane of fracture. In addition, the anterior approach provides direct visualization of the fracture site and also does not disturb the vulnerable blood vessels entering posteriorly. The posterior approach using cannulated screws seems to be appropriate when the fracture is minimally displaced. Based on the above, in our cases, we chose appro-

priate approaches to deal with different talar deformities. No soft tissue complications, such as wound healing problems or infections occurred.

For talar malunions or nonunions, the operation should be performed as early as possible in order to avoid secondary traumatic arthritis. Sanfeorzan et al.<sup>14</sup> reported the effects of malalignment of the talar neck on the contact characteristics of the subtalar joint. Their study showed that 2-mm displacement of the talar neck significantly changed the loading distributions of the subtalar joints, which could easily lead to osteoarthritis. In light of this, anatomic reconstruction of the talus is the obvious goal of dealing with these talar deformities. While in some cases, arthrodesis should be the final choice, before which, an anatomic realignment of the hindfoot is necessary. According to our experiences, some surgical techniques should be emphasized in order to receive a favorable outcome. For talar malunions, any collapse of the articular surface should be elevated and bone graft is needed. Small bone grafts (<1cm) can be harvested from the distal tibial metaphysis, and large ones (>1cm) should be taken from the iliac crest. For talar nonunions, both edges of the pseudarthrosis should be excised until alive bone tissue is reached. Any malalignment of the talus needs to be corrected using autogenous corticocancellous bone graft. Subchondral drilling or microfracture can prevent further progression of the talar necrosis. After having obtained a correct position, the reduction was maintained temporarily with 2.0-mm Kirschner wire, and then the definitive fixation could be achieved by cannulated screws. In most of our cases, we chose the cannulated screws. Occasionally, a mini-plate was used for a stable fixation. The occurrence and development of arthritis depends on the extent of initial cartilage damage, the quality of the initial articular surface reduction and the time from the fracture to the second surgery.<sup>15-17</sup> MRI is a powerful tool in the preoperative assessment of arthritis and necrosis. But it is better to make a decision of the arthrodesis on the basis of the intraoperative observation, which provides direct visualization of the articular cartilage. Subtalar joint fusion is usually performed using two 6.5mm cannulated screws. When dealing with osteoporotic bone, or in bone defect reconstruction, full-threaded screws are recommended, since the "lagging" of partially threaded screws will result in shortening and foot arch collapse. In addition, titanium hardware should be selected so as to allow for MRI detection of talar AVN during the period of follow-up.

Our patients received proper managements and gained satisfactory results. We evaluated the functional outcomes using the AOFAS ankle-hindfoot scale. The function of the hindfoot improved significantly. The mean postoperative AOFAS score was in accordance with other reports.<sup>7,17,18</sup> This could be attributed to the facts that most of our patients only had type I and type II deformities, for which an anatomic reconstruction was performed, and only six patients received limited arthrodesis. Besides, the operation was performed by senior surgeons and appropriate procedures were adopted, which also contributed to the favorable outcomes. Moreover, the patients, who gained follow-up, were compliant and received reasonable postoperative management and rehabilitation.

## CONCLUSIONS

Surgical interventions for malunions and nonunions after talar fractures can bring about satisfactory outcomes. If the hindfoot joints are still healthy, every effort should be made

to anatomically reconstruct the talus. Arthrodesis should be considered as a final salvage operation. The appropriate procedure should be adopted according to the different types of posttraumatic deformities.

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