Talar Body Reconstruction for Nonunions and Malunions

Abstract

Background: Talar body and neck nonunions and malunions may undergo a reconstructive surgery when joint cartilage is still viable, and no talar collapse or infection has occurred. This is a rare condition and the studies supporting the procedure have small number of cases. The objective of the present study is to report a case series of six patients who underwent talar reconstructions. **Materials and Methods:** Six patients with talar malunions or nonunions who underwent surgical treatment were reviewed in this retrospective study. There were three nonunions and two malunions of the talar body and one malunion of the talar neck. Clinical evaluation included all the parameters used in the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot scale. Arthritic degeneration of the ankle joint was assessed according to a modified Bargon scale. **Results:** The mean followup was 86 months (range 24-282 months). There were no cases of postoperative avascular necrosis of the talus. Four of the six patients in our series required a subtalar fusion as part of the reconstruction procedure. The average preoperative AOFAS hindfoot score was 34, and at the time of the last evaluation, it was 74. The mean preoperative score on the modified Bargon scale for the tibiotalar joint was 1.17. At the last followup, it rose to 1.33. Three different deformities of the talus were identified (a) flattening of the talus (b) extra-articular step and (c) intraarticular step. **Conclusion:** Reconstruction of talar nonunions and malunions improved function in selected patients with a low risk of complications. Three different anatomical patterns of talar nonunions and malunions were identified.

Keywords: *Bone reconstruction, malunion, nonunion, talar fracture*
MeSH terms: *Fracture fixation; ankle joint; ankle injuries*

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Introduction

Talar body and neck nonunions and malunions occur most frequently as a result of either a misdiagnosed fracture or a failed surgical reduction. Misdiagnosis of talar fractures may be the result of various associated fractures, especially in polytraumatized patients. In our institution, 47.8% of the patients with talar fractures have another fracture,[1] which may divert attention from foot injuries. Some of the patients will not complain of foot pain until several weeks after the injury when they begin to bear weight after a pelvis- or long bone-associated fracture heals. Low-energy trauma is an uncommon cause of central talar fractures. Young *et al*. reported seven cases of talar body and neck fractures caused by minor injuries, such as tripping down the stairs and twisting the ankle when climbing that were misdiagnosed as ankle ligament injuries.[2]

The rate of malunion in surgically treated talar central fractures varies from 0% to 32.5% in the most recent series of studies.[3-10] Varus heel is the most common deformity after talar neck fractures and results in medial column shortening with impairment of hindfoot motion.[11,12] Malunited talar body fractures lead to joint incongruence and secondary arthritis of tibiotalar and subtalar joints.

Salvage procedures after talar nonunions and malunions with joint involvement include re-orientating arthrodesis procedures of the ankle, subtalar and/or talonavicular joints, and tibiocalcaneal arthrodesis with or without astragalectomy.[13-16] Although these measures frequently result in substantial improvement, none of them will restore normal foot function.

Nevertheless, anatomical reconstruction of nonunions and malunited talar fractures has been described in the literature; it appears attractive if the joint cartilage is still viable and if no talar collapse or infection has occurred.[17] According to Zwipp and Rammelt modified classification,[18] malunions or nonunions with no or partial avascular necrosis in an active and reliable

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patient with no symptomatic arthritis are appropriate for reconstruction.

Recently, a considerable amount of literature has been focused around the theme of reconstruction. In 1996, Migues *et al*. reported the successful surgical treatment of a talar neck nonunion 8 months after the initial injury.[19] Monroe and Manoli reported a case of talar neck malunion that was treated with a corrective osteotomy using an iliac crest graft fixed with a screw in 1999.[20] Since Asencio *et al*. published the first research with seven cases of talar nonunions and four cases of malunions in 2000,[21] studies with a small number of cases have been published supporting the procedure.[17,22-27]

The present study describes the radiological features, surgical treatments, and clinical outcomes of talar nonunion or malunion after reconstructions.

Materials and Methods

Six consecutive patients with talar malunions or nonunions who underwent surgical treatment between January 1992 and January 2016 were retrospectively reviewed. There were 3 nonunions and 2 malunions of the talar body and 1 malunion of the talar neck. Five patients were male and one was female, with a mean ± standard deviation age at the time of the procedure was 33 ± 14 years (range 17–51 years). The right foot was affected in three patients; the left foot, in three. All fractures were closed, and the initial treatment was nonoperative with immobilization, except in 1 patient who had a percutaneous fixation with Kirschner pins. The interval time between the fracture onset and the reconstructive surgery was 15 ± 7 months (range 9–29 months). The distribution of talar deformities according to Zwipp and Rammelt classification[28] was as follows: 3 cases were classified as Type I (malunion with joint displacement), and 3 cases were classified as Type II (nonunion with displacement); [Table 1].

Comorbidities were found in 5 patients: two were smokers, two had hypertension, and one patient had a chronic syndesmotic disruption on the same side as the talar nonunion.

All patients were evaluated preoperatively with weight-bearing radiographs of the ankle in mortise and lateral views and of the foot in anteroposterior, lateral, and oblique views. Patients numbers III, IV, V, and VI had computed tomography (CT) scans of their ankle performed to permit accurate preoperative planning. Magnetic resonance imaging (MRI) was used to help to evaluate the presence of avascular necrosis in patients numbers I, II, and V. In cases where the subtalar joint had arthritic degeneration with stiffness, a subtalar arthrodesis was indicated.

Clinical evaluation included all the parameters used in the American Orthopaedic Foot and Ankle Society (AOFAS) hindfoot scale: pain, activity limitations and support requirement, maximum walking distance, walking surfaces, gait abnormality, sagittal motion, hindfoot motion, and ankle-hindfoot stability and alignment. The AOFAS hindfoot score was calculated preoperatively and at the last evaluation. All patients had pain and activity limitations. In four patients, the pain was severe and almost always present, and in the other two patients, it was moderate and daily. Four patients had limitations on recreational activities, and in the other two patients, daily activities were also limited. One patient had an equinus deformity of 10°.

Arthritic degeneration of the ankle joint was assessed preoperatively and at the last followup according to a modified Bargon scale [Table 2].

This study was approved by the Local Ethical Committee and Institutional Review Board.

Operative procedure

All the patients were operated on with a tourniquet applied to the ipsilateral thigh, and the iliac crest draped free to allow bone grafting when necessary. Associated anterolateral and anteromedial approaches were used unless a medial malleolus osteotomy was necessary, and in these cases, only the anteromedial approach was performed. After identification of the former fracture line, resection of the pseudoarthrosis was carried out in cases of nonunion [Figure 1a]. In the cases of a malunited talus, an osteotomy was performed under fluoroscopy guidance to recreate the original fracture line [Figure 1b]. The subtalar joint was debrided, when an arthrodesis was necessary, through a posterior extension of the anterolateral approach. In one patient, the subtalar joint was prepared for fusion through the pseudoarthrosis of the talus since an isolated anteromedial approach with medial malleolus osteotomy was used. After reduction of the talus was achieved, bone grafting and fixation were performed [Figure 1c]. Cancellous graft used to fulfil the bone defect was obtained from the iliac crest or proximal tibia, depending on the amount of bone necessary. Conventional or headless 3.5 mm screws were used for fixation of the

Table 1: Zwipp and Rammelt classification of posttraumatic talar deformities

Type I	Malunion and/or joint displacement
Type II	Nonunion with joint displacement
Type III	Types I/II with partial avascular necrosis
Type IV	Types I/II with complete avascular necrosis
Type V	Types I/II with septic avascular necrosis

Table 2: Rammelt *et al*. modification of Bargon scale

Grade 1	Absence of arthritis
Grade 2	Mild arthritis: subchondral sclerosis and lateral osteophytes
Grade 3	Severe arthritis: subchondral cysts, narrowing of the joint space, and uneven joint surfaces

talar fracture. The number of screws used in each patient was the minimum necessary to achieve adequate stability. Interfragmentary compression was preferred whenever the fracture line permitted, but in cases with large defects, positional fully threaded screws were used. Fixation of the subtalar arthrodesis was accomplished with one or two 7.0 mm screws inserted from the plantar surface of the calcaneus [Figure 2].

The patient with chronic syndesmosis disruption was treated with open debridement, reduction of the fibula within the incisura, and fixation with two 3.5 mm lag screws. No reconstructions using tendon grafts were performed.

Postoperative care consisted of a cast splint applied to the leg and foot with no weight-bearing for the 1st week. As soon as soft-tissue healing permitted, usually in the third postoperative week, the patient was instructed to wear a walker boot. Very light weight-bearing was encouraged at this time and progressively increased until full support was allowed at 6 weeks. After bone healing, the boot was discontinued, and physical therapy was initiated to encourage gait, aid muscular strengthening, and improve proprioception. Followup radiographic studies were performed every month until bone healing was observed and then every 6 months until the last evaluation. If a nonunion of the reconstruction was suspicious, a CT examination was requested.

Results

The mean followup was 86 months (range 24-282 months). There were no intraoperative complications. There were two major postoperative complications. One patient had cellulitis on the 2nd postoperative week and was treated with intravenous antibiotic therapy. He developed complex regional pain syndrome and was submitted to the physical medicine department of our institution for treatment. He eventually had the screws removed (patient number IV). The other patient developed a subtalar arthrodesis malunion with varus heel. After he remained symptomatic due to the lateral overload caused by the varus malalignment, he was submitted to a revision surgery of the subtalar arthrodesis 17 months after the talar reconstruction. After screw removal, a correction osteotomy was performed along the original subtalar joint, and a new fixation was carried out with screws. The osteotomy healed with no complications (patient number II).

There were no cases of postoperative necrosis of the talus. The average preoperative AOFAS hindfoot score was 34 (range 15–56), and the average postoperative AOFAS hindfoot score at the time of the last evaluation was 74 (range 57–89). The mean improvement in the AOFAS score was 42 (range 29–63). Considering only the evaluation of pain, the average score rose from 6 (range 0–20) to 28 (range 20–40) with a maximum of 40. Ankle motion increased in all patients, and the upper limit of dorsiflexion changed from 2° (range -10–10) to 10° (range 0–20).

The mean preoperatively score on the modified Bargon scale for the tibiotalar joint was 1.17. Only one patient had mild arthritis at the time of the reconstruction surgery. All other patients had normal articular joints. At the last followup, the average modified Bargon score rose to 1.33 because of one patient who had an increase of one grade in the scale [Table 3].

There were no cases of secondary procedures after the reconstruction except the patient with the subtalar fusion malunion mentioned above.

Figure 1: Peroperative photograph of a patient showing (a) talar body nonunion after resection of the pseudoarthrosis through a medial malleolar osteotomy approach (b) A K-wire was inserted under fluoroscopy control along the former fracture line in this malunion of the talar neck. The K-wire guided the saw to recreate the original fracture line (c) The talus after reduction, fixation and bone grafting

Discussion

Recently, a considerable amount of literature has focused on the theme of talar malunion and nonunion reconstruction. However, fracture of the talus is an uncommon injury with an incidence of 4.6 cases of acute fractures per year in our country.[1] Fractures suitable to reconstruction are even more rare; thus, most of the studies are based on small case series.[17,19-30]

Three of our cases were classified as Type I and the other three as Type II according to Zwipp and Rammelt classification. We had no cases of partial necrosis of the talus (Type III), although some flattening of the talar body was seen in two patients. An MRI investigation of the ankles was performed to confirm the absence of necrosis [Figure 3]. One interesting finding was that there were three different deformities of the talus:

a. Flattening of the talus – Figures 4 (patient I) and 5 (patient II)
b. Extra-articular step – Figure 6 (patient III) and 7 (patient IV)
c. Intraarticular step – Figures 8 (patient V) and 9 (patient VI).

We found a Type A deformity in two cases, and as mentioned above, flattening of the talar body was observed with no evidence of necrosis. Flattening was accompanied by dorsiflexion of the talar neck that left the superior portion of the neck very close to the anterior lip of the tibia, which is very similar to the anterior impingement found after calcaneus fracture malunions.

Deformity Type B was observed in two cases. In both cases, a superior step of the talus just anterior to the lip of the tibia was present. This superior extra-articular step caused anterior impingement of the ankle and completely blocked foot dorsiflexion. The only talar neck fracture studied in this paper was a Type B deformity, but clinical and radiographic presentations were the same as the other case with this type of deformity.

The other two cases had Type C deformities. Unlike the Type B deformities, an intraarticular step caused

Figure 2: X-ray of the ankle joint lateral view showing a reconstructed malunited talus body fixed with screws associated with a subtalar fusion

Figure 3: Magnetic resonance imaging T2W sagittal cut showing no necrosis in the talus body malunion

Table 3: Results

Patient	AOFAS* pre-surgery	AOFAS* last followup	Ankle dorsiflexion pre-surgery†	Ankle dorsiflexion last followup†	Bargon‡ pre-surgery	Bargon‡ last followup
1	35	79	10	20	2	2
2	56	89	0	20	1	1
3	16	57	-10	0	1	1
4	43	82	0	10	1	1
5	15	78	10	10	1	1
6	39	68	0	0	1	2

*AOFAS hindfoot score, †Dorsiflexion in degrees, ‡Modified Bargon scale

Figures 4: X-ray ankle joint lateral view (patient 1) showing (a) Type 1 deformity comprises flattening of the talus that causes extension of the talar neck and consequent impingement with the anterior lip of the tibia. (b) Final followup radiograph: ankle joint congruent with more or less convex talar dome and subtalar joint fusion

Figures 5: X-ray ankle joint lateral view (patient 2) showing (a) Type 1 deformity comprises flattening of the talus that causes extension of the talar neck and consequent impingement with the anterior lip of the tibia (b) Final followup radiograph: well maintained convex dome of talus, congruent ankle joint and subtalar fusion

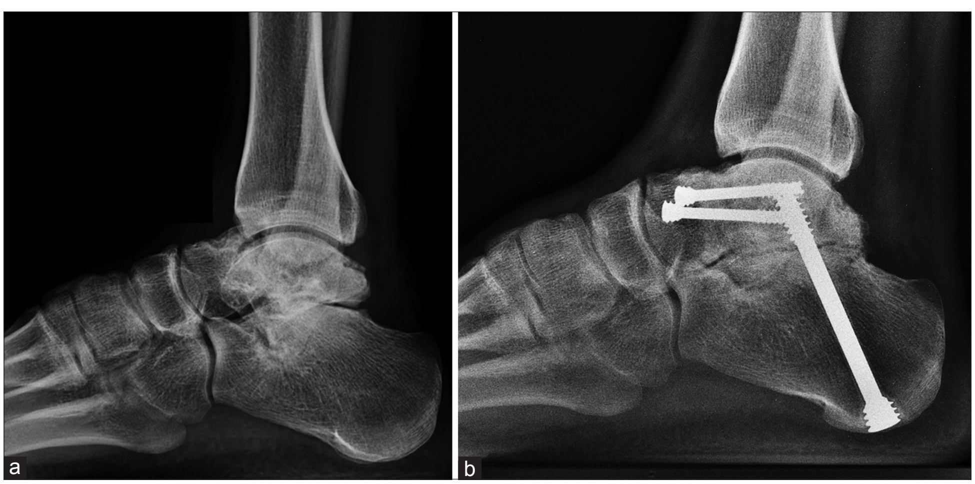

Figure 6: X-ray ankle joint lateral view showing (a) Type 2 deformity an extra-articular step. The anterior segment of the talus displaces superiorly and blocks dorsiflexion of the ankle joint. (b) Final radiographs showing well maintained tibiotalar joint

no impingement but promoted joint incongruence. An implication of this anatomical classification is the possibility that it may help the treating physician in defining surgical approaches. In fact, both of our Type B cases were treated with double anteromedial and anterolateral approaches, while the Type C cases were operated on using a medial malleolus osteotomy. The objectives of the reconstructions also differ between deformity types. In

Figures 7: X-ray ankle joint lateral view showing (a) Type 2 deformity shows an extra-articular step. The anterior segment of the talus displaces superiorly and blocks dorsiflexion of the ankle joint. (b) Final radiograph showing subtalar fusion with congruent ankle joint space

Figures 8: (a) CT scan showing Type 3 deformity is distinguished by an intraarticular step that causes incongruity of the tibiotalar joint. Final radiographs (b) anteroposterior (c) lateral view showing congruent tibiotalar joint surface

Figure 9: X-ray ankle joint lateral view showing (a) Type 3 deformity is distinguished by an intraarticular step that causes incongruity of the tibiotalar joint. (b) Radiograph showing congruent tibiotalar joint, implant *in situ*

deformity Type A, the talus must be plantarflexed at the site of malunion/nonunion to recuperate the normal talar dome convexity and increase the distance between the anterior lip or the tibia and the dorsum of the talar neck. In Type B, the step must be removed by translation and rotational realignment of the anterior talus to attain a free dorsiflexion movement of the foot. Finally, in Type C, the objective is to restore the smooth articular surface of the talar dome.

The interval time between the fracture onset and the reconstructive surgery of our cases was 15 ± 7 months. This observation seems to be consistent with other studies, which found a delay varying from 10 to 18 months.[17,21-24] Only one of our patients underwent surgical treatment with a percutaneous K-wire fixation before he was referred to our institution. All other patients were misdiagnosed and took a long time to arrive at our hospital.

Four of the six patients in our series required a subtalar fusion as part of the reconstruction procedure (patients I, II, III, and IV). Even though subtalar radiographic arthritic changes were not very advanced in all of the patients who underwent fusion, the high degree of stiffness made us add the arthrodesis in this situation. This result corroborates the ideas of Asencio *et al*.[21] who performed eight subtalar isolated fusions or combined with other hindfoot fusions in a total of 11 patients (72%). The authors mentioned that the frequent presence of arthritic changes of the subtalar joint justified the fusions. However, the findings of the current study and of Asencio's study are not in accordance with previous studies.[17,22-24,26] The incidence of subtalar fusion in these studies varied from 0%[23] to 30%,[22] and in all studies, the finding of an arthritic joint was the indication. There is no reference to subtalar stiffness associated with mild/moderate arthritis as a parameter to indicate fusion. The reason we elected arthrodesis for these cases is because our previous experience with subtalar arthrolysis showed that movement recovery was not maintained for a long time and that varus malposition of the hindfoot relapsed.

We found an average preoperative AOFAS hindfoot score of 34 that improved postoperatively to 74. The outcome observed in this investigation was below the ones observed by other studies,[17,20,22-24,26,27] in which the postoperative score was approximately 85. This difference can be explained in part by two of our cases: one complication with an infection and complex regional pain syndrome and the other who had a followup time of 282 months and presently has moderate ankle arthritis [Figure 8b]. Their scores were 57 and 68, respectively. The patient with a complication was the only one in the present group that had undergone surgical treatment before the reconstruction; thus, a less favorable result was expected.[18] He never recovered completely from the complex regional pain syndrome, and thus far, he has moderate pain and limited daily and recreational activities and walks with the aid of a cane. The patient with very long followup had a score of 91 at 2 years after the reconstruction surgery, but as the arthritic changes in the tibiotalar joint progressed, the score dropped to the present level. Another possible explanation for the lower postoperative score in the present study is the higher number of patients who had subtalar fusion, as they all scored zero in the hindfoot motion evaluation. Nevertheless, all patients stated that they were satisfied with the result and would undergo the same procedure again.

There were no cases of avascular necrosis after the reconstruction procedure in the present paper. This finding matches those observed in earlier studies,[17,20-24,26,27] in which a total of 78 cases of talar reconstruction were performed, and only one case of necrosis occurred.[24] This combination of findings provides some support for the conceptual premises that the risk of developing or aggravating an avascular necrosis of the talus is very low, and this risk should not prevent a surgeon from deciding to perform a reconstruction. The low incidence of necrosis may be explained by the study of Miller *et al*.,[31] in which the arterial anatomy of the talus was studied in fresh-frozen cadaver limbs with the use of gadolinium-enhanced MRI. The authors found that the posterior tibial artery contributed 47% of the blood supply to the talus and concluded that in contrast to the findings in previous studies, a substantial portion of the talar blood supply can enter posteriorly, which helps to explain why all talar neck fractures do not result in osteonecrosis.

The increase in the modified Bargon score from 1.17 to 1.33 postoperatively was exclusively caused by the patient with a 282-month followup. Her initial evaluation was Grade 1, and she had a nonunion with an intraarticular step (Type C deformity) that was repaired through a medial malleolus osteotomy; however, after >20 years, degenerative changes occurred in her ankle joint. This result is consistent with Suter *et al*.[26] who found no arthritic degeneration in seven cases of talar neck malunion reconstruction after 48 months. However, Rammelt *et al*.[17] verified that radiographic arthritic changes progressed in the ankle joint by 1 grade in the modified Bargon classification in 3 patients and by 2 grades in 1 patient out of ten treated for malunited talus fractures after 48 months. Huang and Cheng[24] also noted that 5 of 9 patients submitted for talar reconstruction developed subtalar arthritis after 53 months, but no secondary procedures were necessary. Although some progression of peritalar joint arthritis is expected, rates are similar to those of a primary internal fixation of a talus fracture.[18]

The main limitation of this paper is the small number of cases studied in a retrospective design. The small sample size did not allow for statistical analysis of the results, and no definitive conclusions could be made. Despite that fact, talar nonunions and malunions suitable for reconstruction are rare, and many other studies are also based on <10 operated cases.[20,23,24,26,30]

A key strength of the present study was the identification of three different anatomical patterns of talar nonunions and malunions: flattening of the talus, extra-articular step, and intraarticular step. This finding enhances our understanding of the objectives of talar deformity correction. Further studies are needed to validate this proposed classification.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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