Case Report

Talar body fracture nonunion and osteonecrosis with adjacent arthritis can be successfully treated with tibiotalocalcaneal arthrodesis using circular external fixation

Eugene Wilson Borst, Scott J. Ellis[1], Austin Thomas Fragomen

Department of Orthopedics, Limb Lengthening and Complex Reconstruction Service, Hospital for Special Surgery, [1]Department of Orthopedics, Foot and Ankle Service, Hospital for Special Surgery, New York, NY 10021, USA

Abstract

Fractures of the talar body often result from high-energy trauma. These fractures are at risk for nonunion and put the talus at risk for avascular necrosis due to an inadequate blood supply. We present the case of a 57-year-old male that presented to our practice with talus fracture nonunion, talar body osteonecrosis, ankle and subtalar posttraumatic osteoarthritis, and deformity including a mild equinus contracture and mild hindfoot varus. Successful ankle and subtalar fusion, talus fracture union, and deformity correction were performed using a circular external fixator with fine wire fixation and compression. This is the first reported case where fusion of both the tibio-talar-calcaneal joints and the talar body nonunion was achieved using external fixation. At the time of this report, the patient is over 3 years postfusion, stands with neutral alignment, is relatively pain-free, is able to resume normal daily activities, and has no progression of talar osteonecrosis.

Key Words: Ankle fusion, circular external fixator, talar body nonunion, osteonecrosis, tibio-talar-calcaneal fusion, tibiotalocalcaneal arthrodesis

Address for correspondence:
Dr. Austin Thomas Fragomen, 535 East 70th Street, New York, NY 10021, USA. E-mail: fragomena@hss.edu
Received: 19.10.2015, **Accepted:** 27.10.2015

Introduction

Fractures of the talus are rare injuries that comprise <1% of all fractures.[1,2] Talar neck fractures are the most common in occurrence with talar body fractures occurring less frequently, comprising approximately 40% of all talar injuries.[2] The literature reports a high incidence of sequelae associated with talus fractures with arthrosis, osteonecrosis, and malunion being the most commonly cited and nonunion occurring less frequently.[1,3,4] Nonunion is attributed to a lack of blood supply as a consequence of the talus' anatomic location and damage to the surrounding soft tissue. As a result, these fractures are often challenging to treat. Osteonecrosis can lead to painful ankle and subtalar arthritis.[2,4] Hindfoot deformity can exist as well as the friable talus is prone to collapse. Unfortunately, the treatment of these combined problems can further jeopardize the talus since penetration with screws or an intramedullary (IM) nail will increase bony trauma. To preserve talar integrity (avoiding talectomy with tibo-calcaneal arthrodesis) a more delicate technique may be required.

We present the first reported case of a patient with a talar body nonunion and osteonecrosis that was treated with a simultaneous tibio-talar-calcaneal (TTC) arthrodesis using

Access this article online	
Quick Response Code:	Website: www.jlimblengthrecon.org
	DOI: 10.4103/2455-3719.168749

How to cite this article: Borst EW, Ellis SJ, Fragomen AT. Talar body fracture nonunion and osteonecrosis with adjacent arthritis can be successfully treated with tibiotalocalcaneal arthrodesis using circular external fixation. J Limb Lengthen Reconstr 2015;1:54-9.

fine-wire fixation with a circular external fixator. Fixation with the external fixator provided the stability and compression needed to unite both the talar fragments and the TTC fusion.

Case Report

A 57-year-old male fell from a ladder, which resulted in a closed fracture of the talar body of the left ankle. The patient was treated emergently at a level I trauma center with a medial malleolar osteotomy and anatomic, open reduction and internal fixation of the talus. The fracture line was oblique but ran primarily in the coronal plane (from medial to lateral). The patient's wounds and fracture appeared clinically healed, and he was allowed full weight bearing after 3 months. He presented 1-year postinjury to our practice with a chief complaint of hindfoot and ankle pain and stiffness. Pain was localized mostly to the medial and lateral aspects of the heel and was present only during weight bearing. He also complained of catching and crepitus with ankle joint motion. Surgical history was significant only for multiple previous knee surgeries. Medical history was significant for hypertension and high cholesterol. He denied smoking.

Physical examination

Physical examination showed ankle motion to be 0°–25°. Subtalar motion was 5°–0°. The patient had a negative Tinel's sign over the tarsal tunnel though there was a slight decrease in sensation to light touch noted over the plantar aspect of the foot. Sensation along the dorsal aspect was normal. Pulse examination showed normal dorsalis pedis and posterior tibial artery pulses, as well as full motor power of dorsiflexion, plantarflexion, and hallucal extension. Gait examination showed mild varus deformity of the hindfoot. The patient walked with his foot externally rotated and in equinus, presumably to avoid pain. He walked slightly on the lateral border of his foot, and his left knee hyperextended during midstance.

Images

Weight-bearing radiographs of the ankle showed a collapse of the talar dome with severe ankle and subtalar osteoarthritis. The malleolar osteotomy appeared to be well healed, but the talus fracture union was difficult to assess [Figure 1]. A computed tomography (CT) scan confirmed an atrophic nonunion of the talus fracture that was suspected to be fibrous [Figure 2]. The medial malleolar osteotomy was completely healed. The axial images revealed a mostly transverse fracture line of the talus that ran from posterolaterally and to anteromedially with no bony bridging and comminution of the posterolateral talus [Figure 3]. Despite the presence of the nonunion and superior collapse, the two talar fragments appeared to be mostly viable inferior to the screw fixation and had normal density when compared with adjacent cancellous bone [Figure 4]. The talonavicular (TN) joint appeared normal on plain radiograph and mildly narrowed but without cysts or osteophytes on CT scan. A TTC fusion was selected as the best solution to improve deformity, reduce pain, and prevent further progression of necrosis and collapse.

Surgical technique

The ankle was approached both medially and laterally. The medial hardware was removed, and the talar hardware was left in place to support the talus. The fibula was excised distally and used for the local bone graft. The talus was observed to be in good condition laterally and necrotic posteromedially. This poor medial bone was debrided. The nonunion site was visualized. It was 1 mm wide, which would make it difficult to formally prepare. The decision was made to drill through it with a K-wire to avoid over-manipulation while still provoking an inflammatory response. The resulting posteromedial talar defect was filled with a combination of small pieces of bone marrow aspirate concentrate-bone morphogenetic protein (BMAC-BMP) soaked collagen sponge and local graft from the fibula. A total of 5 mg of BMP was used.

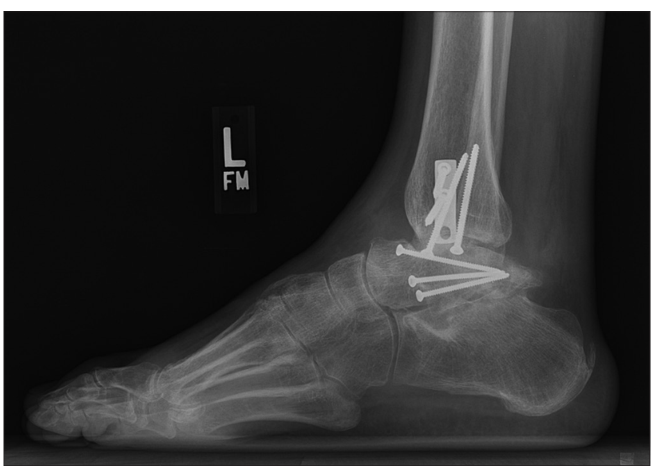

Figure 1: This lateral preoperative, weight-bearing radiograph shows the intact cortical screws in the talus. The medial malleolar osteotomy had been fixed with a small buttress plate and screws, which were also intact. The talar integrity is difficult to assess

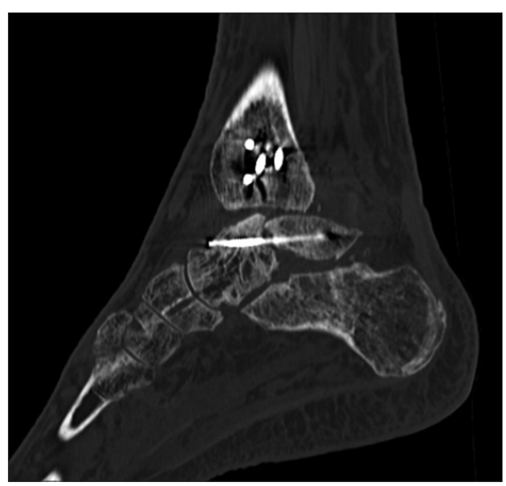

Figure 2: This sagittal computed tomography view of the ankle demonstrates superior collapse of the talar dome superior to the screw fixation with a step-off of the articular surface of the talus

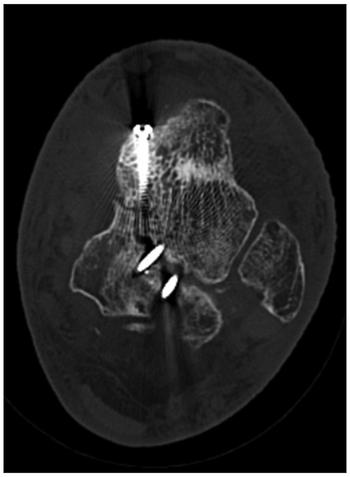

Figure 3: This axial computed tomography image of the talus demonstrates a clear fracture line despite the previous fixation. The posterolateral fragment is distinct and separate

Figure 4: This coronal computed tomography image shows the nonunited, talar fracture line. The density of the talar fragments is not significantly more sclerotic than the surrounding bone suggesting that the osteonecrosis is not severe inferior to the fixation

The lateral aspect of the tibio-talar articulation was prepared for fusion and also treated with pieces of the collagen sponge mixture. The surfaces were first scraped free of cartilage with a curved osteotome and curette followed by drilling of the bone with a K-wire and use of an osteotome to fish scale the surfaces. The subtalar joint was prepared through the lateral incision in a similar manner. The cartilage was removed, and the bone was prepped through a combination of drilling with a K-wire and roughing with an osteotome. The collagen sponge pieces were placed into the subtalar joint. The remaining two intact collagen sponges were wrapped medially and laterally around the fusion site. The varus deformity was corrected through a combination of the subtalar joint preparation, which tends to bias a valgus reduction, and grafting the medial tibio-talar joint, which prevented varus collapse. The reduction was maintained with a provisional axial K-wire. Later, the external fixator was placed and used to maintain this optimal alignment.

The circular external fixator was applied after wound closure. A two-ring construct was selected. No talus wire was used as the direction of the nonunion would not allow for effective compression, and the constant axial compression of the fixator would prevent displacement of the talus. The rings were connected with five threaded rods. The reduction was observed under fluoroscopy and was determined to be ideal. The fusion site was then compressed 7 mm acutely [Figure 5]. The foot was observed to be in an acceptable position for fusion with plantigrade sagittal alignment, slight external rotation, and a 3° valgus hindfoot. The pathology report was "ischemic necrosis of the bone marrow" which confirmed osteonecrosis postsurgery.

Patient outcome

The patient was allowed 50% weight bearing as a precaution against over-compression of the grafted area. He was allowed full weight-bearing at 6 weeks. At 10 weeks, a hindfoot CT scan was obtained where we measured 70% fusion at both the tibio-talar and the subtalar arthrodesis sites [Figure 6]. The frame was removed after a total of 14 weeks.

At the 6th-month follow-up visit, a CT scan was ordered to assess healing and talar integrity. A solid TTC fusion was observed. The talus nonunion was also seen to have healed. There was no further collapse of the talus [Figure 7]. He continued to use the rocker bottom shoe and walk with no restrictions.

About a year and a half after his initial fusion, the patient began to complain about more severe pain over the TN joint. A magnetic resonance imaging showed arthritic changes at the TN joint, and an ultrasound guided cortisone injection provided significant pain relief [Figure 8]. An *in situ* TN fusion was performed which alleviated the patient's symptoms.

At latest follow-up, he is three and 1½ years post-TTC fusion and a year and a half post-TN fusion. The patient is able to ambulate throughout the day without foot and ankle pain. He occasionally complains of foot swelling and a cold sensation in the foot at the end of the day, which is alleviated with rest, stretching, and massage. The patient currently wears a rocker bottom shoe. He is capable of maintaining a normal, busy lifestyle relatively pain-free. His radiographs show continued talar integrity without complication [Figure 9]. Clinically his foot is healthy and plantigrade [Figure 10].

Discussion

Talar body fractures are rare, and nonunions of these fractures are even more unusual. When considering all talus fracture nonunions, the incidence quoted by Higgins and Baumgaertner

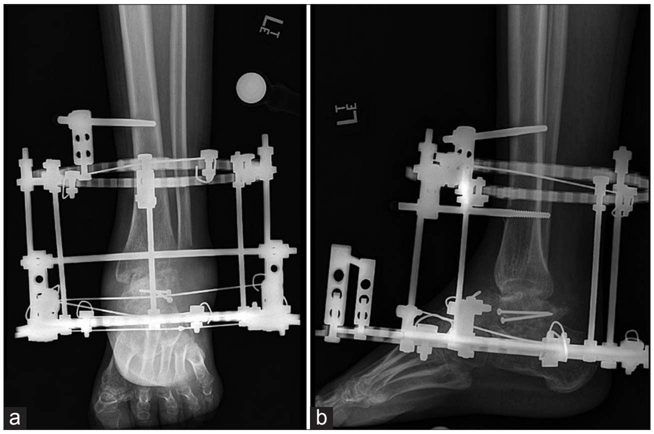

Figure 5: The final frame construct and reduction are seen on this anteroposterior (a) radiograph taken immediately postoperative. The arched wires indicate strong axial compression on both the ankle and subtalar fusion sites. Both fusion sites are well visualized on this immediate postop lateral (b) radiograph

Figure 7: This 6th-month postframe removal computed tomography scan confirmed excellent bony healing with full integration of both fragments as well as healing of the fracture nonunion site

ranges between 0% and 10%.[2] Avascular necrosis (AVN) or osteonecrosis is the more common complication associated with talus fractures occurring in up to 25% of talar body fractures. This rate can increase to more than 50% if there is a history of ankle dislocation.[2] Osteonecrosis can contribute significantly to joint arthrosis as well.[2,4] AVN is marked by hardening and sclerosis of the bone. The talus was sclerotic and has sustained partial collapse based on CT and inspection. Our patient was particularly unique since he had both a nonunion and osteonecrosis of the talar body.

Given the extent of the injury, surgical options were carefully considered and discussed with the patient. The challenge was to provide the stability needed to achieve union through a compromised talus without further disruption of this weak bone. We elected to salvage the talus through fusion to the adjacent well-vascularized bones (tibia and calcaneus). The

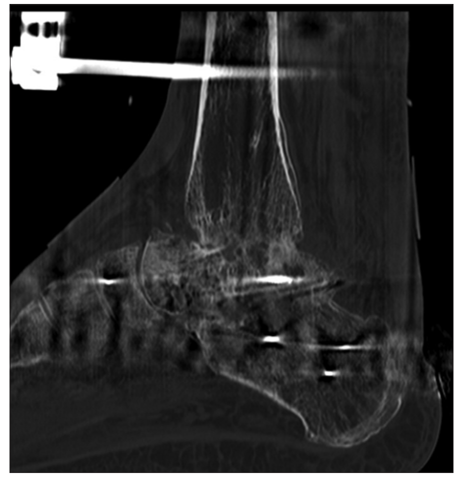

Figure 6: This sagittal computed tomography image was obtained while in the frame at the 10th-week follow-up appointment. It shows successful ossteointegration at both the ankle and subtalar fusion sites. By scanning through all sagittal images in the series and assessing the amount of healing, a total of 70% healing was calculated

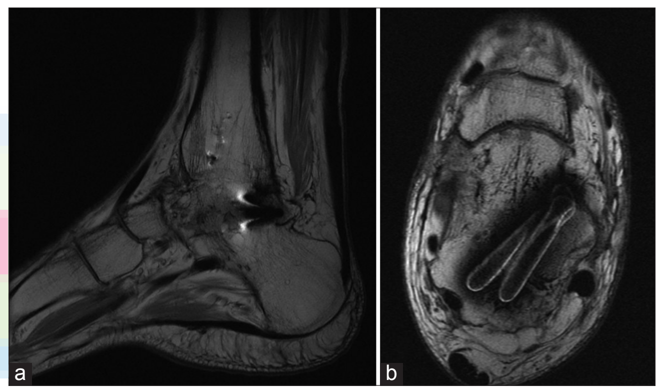

Figure 8: Sagittal (a) magnetic resonance imaging showing bony union at both the ankle and subtalar joint but arthritic changes at the talonavicular joint. Note the homogeneity of the signal throughout the tibio-talar-calcaneal fusion. An axial (b) scan from the same magnetic resonance imaging series shows obliteration of the fracture nonunion line and no sign of bone necrosis. There is talonavicular arthrosis present as well

hope was that we would not only obtain union of the fusion but also revascularize the talar fragments. If the fusions were successful, then union of the fracture nonunion would not be needed for success. Not only did the fusion sites heal well, but also the nonunion healed without any direct grafting. At latest follow-up of 3 years, the talus has not collapsed any further and no longer appeared necrotic. The TTC fusion likely led to increased stress at the TN fusion, which did require subsequent arthrodesis.

Other treatment options would have included talectomy with either a tibiocalcaneal fusion or reconstruction with a femoral head allograft.[5] Retaining the talar body, whenever possible, has been cited as a better option.[6] Placement of internal

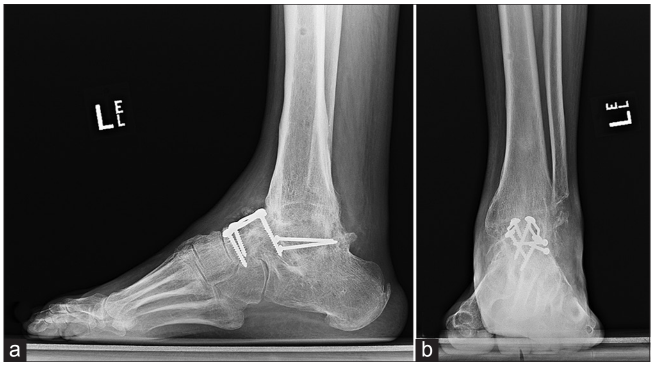

Figure 9: The anteroposterior (a) and lateral (b) radiographs, taken 3½ years posttibio-talar-calcaneal fusion, demonstrate a successful tibio-talar-calcaneal and talonavicular fusion. There has been no talar collapse and no further sign of necrosis

hardware, particularly a retrograde ankle fusion IM nail, would risk further compromising the talus. Consideration was made to use a lateral fixation plate, but screw fixation into the nonunited talar body could have been difficult and might not have given the sustained and controllable compression afforded by external fixation. Therefore, a TTC fusion with internal fixation was not deemed appropriate due to the fragility of the remaining talar fragments. Previous biomechanical and clinical studies have shown that ankle arthrodesis using external fixation is not only an effective method of fusion,[7] but is also as good as or superior to internal fixation in providing stability for complex ankle fusion.[8-10] The use of tensioned, K-wires would minimize trauma and provide the compression and stability needed to heal the fusion sites and possibly reunite the talar fragments. Therefore, we felt that circular external fixation would be the right option to provide the conditions needed to achieve stability for union.

Another obstacle to healing was the poor local biology at the nonunion and fusion sites. The addition of recombinant human bone morphogenic protein (rh-BMP)-2 has been shown to have a significant positive impact on ankle fusion union rates in complex ankle arthrodesis.[11,12] The use of autologous stem cells has been reported to lead to successful union in cases of bony nonunion.[13,14] It is difficult to assess the effectiveness of the biology-enhancing products used in this case as success could be attributed to the frame, the rh-BMP-2, or the BMAC. However, we believe the use of compression and external fixation is a far more powerful of an effect than BMP. The BMP enhanced the union rate while successful fusion would not be possible without the necessary compression and fixation capable with the external fixator. Our practice routinely uses BMP as part of our protocol in the repair on nonunions but do not believe that its use is mandatory.

Rh-BMP-2 functions largely by facilitating the differentiation of mesenchymal stem cells toward the osteoblastic pathway. The

Figure 10: Anterior (a) and posterior (b) comparative photographs of both feet showing a plantigrade foot with neutral alignment. Lateral (c) and medial (d) photographs of the ankle show well healed surgical incisions and an overall healthy appearance

direct application of BMAC (and the accompanying stem cells) onto the BMP soaked collagen sponges will, in theory, hasten the process of stem cell differentiation. This patient's talus was felt to have a compromised inherent supply of stem cells. We postulated that the addition of transplanted cells from the iliac crest would augment the healing response at the operative site.

The patient did not have any BMP-related problems including excessive swelling, local cancer development, or heterotopic ossification. In our practice, we advocate judicious use of BMP as complications are dose related. These authors recommend cutting the soaked sponges into small pieces and placing them directly into the fusion or nonunion site only. We no longer wrap the pads around the bony perimeter. Excess product is discarded.

Arthritis of the TN joint is a common complication of ankle fusion surgery.[15] In this case, the TN joint deteriorated within 1.5 years of the fusion surgery, though there may have been some underlying cartilage damage due to the initial nature and location of the trauma.

Conclusion

A successful TTC fusion can be achieved using fine-wire fixation for salvage of a talar body nonunion with osteonecrosis. To our knowledge, this is the first reported case where this technique was used to preserve the talus in this rare circumstance. Though uncommon, a talar body nonunion should be acknowledged as a severe and debilitating consequence of a talar body fracture. Fine-wire fixation using a circular external fixator can help to provide the compression and stability needed to fuse the joints while simultaneously salvaging the talus and obviating the need for a talectomy. The addition of rh-BMP-2 and BMAC may have expedited the healing of both fusion sites and the nonunion site.

Financial support and sponsorship

Nil.

Conflicts of interest

Eugene W. Borst, BA and Scott J. Ellis, MD have declared they have no conflict of interest. Austin Thomas Fragomen, MD, is a paid consultant for Smith and Nephew and Synthes, receives royalties from Stryker outside of the work submitted.

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