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Metal-reinforced Cement Augmentation for Complex Talar Subsidence in Failed Total Ankle Arthroplasty

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ABSTRACT

There are limited options for failed total ankle arthroplasty (TAA) with major talar bone loss and component subsidence. Surgical options for this condition include revision arthroplasty, salvage arthrodesis, or amputation. Revision arthroplasty generally has been considered in situations of loose components with minimal bone loss or use of expensive custom-fabricated prosthetic components with elongated stems. Historically, failure that involves major talar bone loss has been considered resistant to reconstruction, and responsive only to complex arthrodesis or amputation. In this report, we describe a unique method of restoring talar support and preserving ankle function after failed TAA with major talar bone loss and component subsidence. Talar reconstruction using metal-reinforced bone cement augmentation is combined with the Inbone (Wright Medical Technology, Inc., Arlington, TN) total ankle system to restore talar height and ligamentous support. This technique has been used successfully in the last 4 years for various patterns of talar bone loss and obviates the need for custom components. When successfully performed, the revision technique results in restoration of mechanical alignment, anatomic height, and component support, in addition to providing substantial symptomatic relief.

Despite the continued success in total ankle replacement in recent years, in the event of prosthesis failure, the surgeon is often faced with critical loss of bone mass and deformity. In a review of 20 clinical series on total ankle arthroplasty (TAA), there is a need for revision surgery in 12.4% of cases after 5.3 years (1). The various failure patterns include: deep infection, aseptic loosening, periprosthetic osteolysis, and component subsidence. One of the greatest challenges in TAR revision surgery is the management of aseptic loosening of the talar component with talar subsidence. This bone loss can occur through direct mechanical fatigue of the underlying trabecular bone or through periprosthetic osteolysis from premature or accelerated polyethylene wear.

Talar component subsidence results in a shift of the ankle joint axis as well as loss of talar height and impingement of the talomalleolar facets (2). The bone loss and subsidence can be severe enough to erode completely through the talar body and encroach upon or even invade the subtalar joint (2).

There are many authors who have suggested that salvage is the only option available in failed TAR that involves major subsidence of the talus. These salvage options have included ankle arthrodesis (3–15) as well as amputation (16–20). In the setting of major bone loss, conversion to arthrodesis is complicated and associated with increased hindfoot stiffness and non-union rate (21). Custom prosthetic devices have also been suggested for revision (2,21,22). However, custom devices are difficult to insert and do not provide for versatile positioning of the talar component. Furthermore, the interface between the underside of the revision talar component and the native bone is irregular and inconsistent from patient to patient. As such, during insertion, additional bone needs to be removed to provide a stable, flat configuration for the placement of the talar component.

The use of metal-reinforced cement augmentation has been used successfully in hip and knee revisions (23,24). The primary advantages are the ability to substitute for vacant bone and to provide a stable interface between the ultimate components and the native bone mass. This technique can be performed with readily available materials and avoids the need for a custom prosthesis. To date, this concept has not been adapted to the ankle when there is failure of a joint replacement. The purpose of this article is to provide a versatile technique for the management of failed TAR with substantial talar

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bone loss based on the early success of this procedure and lack of other suitable options for preservation of function.

Indications and Contraindications

Candidates for use of metal-reinforced cement augmentation revision of failed TAR are patients with aseptic component loosening with minor or major talar bone loss (Fig. 1). These patients would also be considered for tibial-talar-calcaneal fusion, ankle fusion, or custom prosthetic reconstruction. The technique relies on existing bone stock of the calcaneus in combination with intact bimalleolar ligamentous support. The goal of this reconstruction is to restore talar height and prosthetic component alignment with a durable mechanical support. Any significant loss of malleolar or medial ligamentous support, poor soft tissue coverage quality, and failure of custom metal-augmented prostheses are relative contraindications to performing this procedure. Active infection is an absolute contraindication for this technique.

Preoperative Planning

Patient Evaluation

The evaluation consists of a comprehensive lower extremity examination and workup with diagnostic imaging/laboratory testing. The patients undergo a methodical lower extremity examination in both a non-weight-bearing and weight-bearing attitude. The overall quality of soft tissues, leg and foot alignments, and functional gait status is assessed. Any previous insults to the cutaneous envelope or soft tissue compartments are analyzed with careful assessment of the neurovascular status. Evaluation for equinus contracture or other tendon disorders are also ruled out. Structural analysis takes into account any hindfoot or supramalleolar misalignments, relative malleolar position shifts, and residual joint excursion and flexibility of the hindfoot.

Diagnostic Imaging and Testing

Preoperative preparation also entails baseline weight-bearing radiographs of the foot and ankle to determine basic segmental alignment and delineate the extent of bone loss. If there is concern about a complicating limb malalignment, standing long-leg films are obtained. To better comprehend the morphology of the talar subsidence and quality of periprosthetic bone, computerized tomography is helpful to fine tune the surgical plan. If deep infection is suspected, routine screening is performed with complete blood count, sedimentation rate, and C-reactive protein. Clinical impressions are correlated with radiographic findings to determine if ancillary procedures need to be included in the surgical plan.

Surgical Technique

The patient is placed supine on a radiolucent operating table and typically placed under general anesthesia. The patient is positioned with sand bag under the ipsilateral hip and the contralateral leg suspended in a lithotomy position with a leg holder or stirrup. A thigh

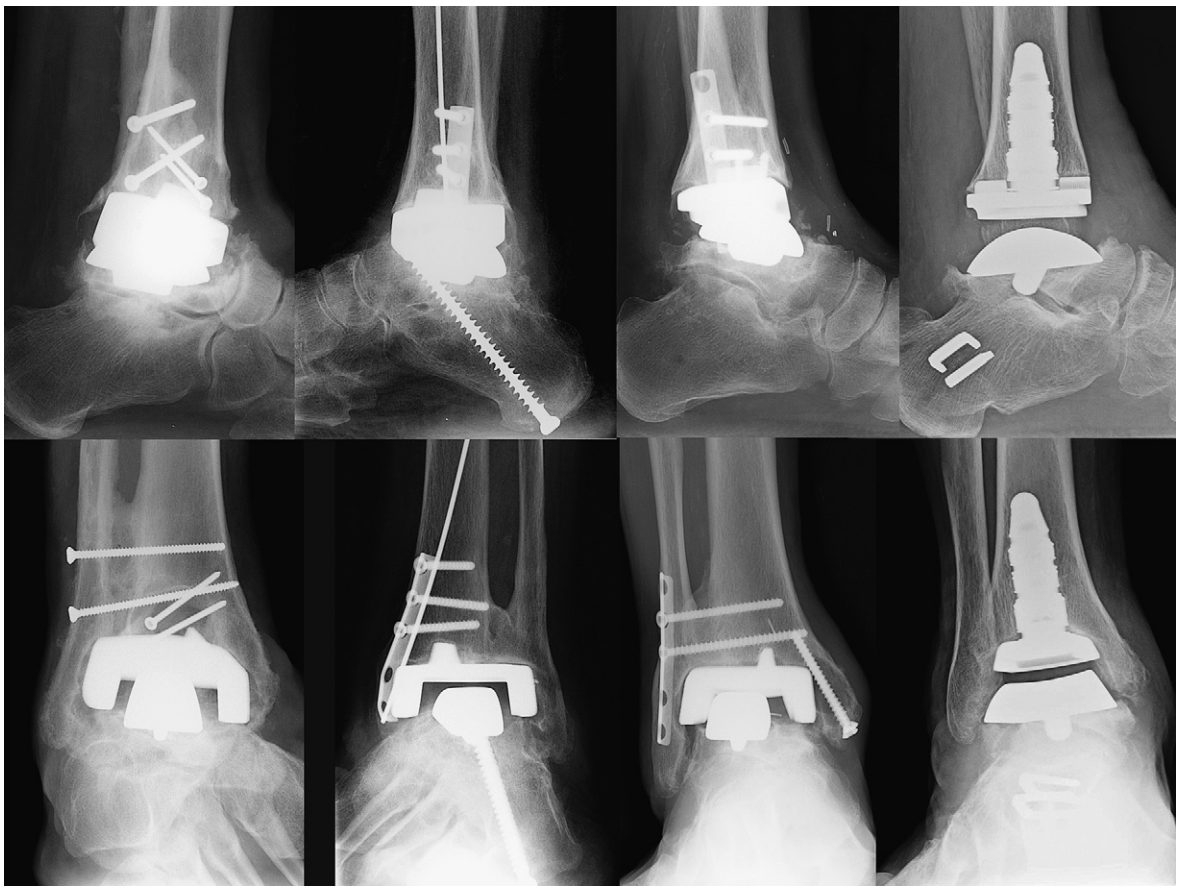

Fig. 1. Examples of 4 patients with a varying amount of talar bone loss and talar subsidence. The upper row of radiographs represents the lateral projection with the corresponding anteroposterior or mortise view below.

tourniquet is positioned and placed on standby to use as needed during the procedure. After standard skin preparation and draping, the lower leg is fully exposed to include the patella. An antimicrobial incise barrier drape (Ioban; 3M, St. Paul, MN) is then circumferentially adhered to the exposed extremity in preparation for the incision.

Surgical access to the ankle joint is generally through the previous longitudinal anterior incision. If ancillary procedures are necessary, careful incisional planning is needed to ensure an adequate skin bridge between exposures. The incisions are deepened in a full thickness fashion with careful dissection adjacent to the dorsalis pedis neurovascular bundle, which can be difficult to identify because of extensive scarring. Dual sets of aerobic and anaerobic cultures are obtained from the bony cavities followed by initiation of the appropriate antibiotic prophylaxis. Once the ankle joint is fully exposed, the components are assessed. Components that are well fixated should be removed last after additional working space has been established. Removal must be done in a meticulous manner and is facilitated with the use of thin or flexible osteotomes to preserve bone mass.

The defect area, with exposed osseous interfaces, is thoroughly debrided down to bleeding bone. After debridement, the morphology of the resultant defect is visualized fluoroscopically (Fig. 2). Any soft tissue scar restraints of the talus are released (most commonly along the gutters), such that the talus is liberated and freely mobile in all planes. The foot is placed on the specialized leg holder for intramedullary containment during the tibial reaming. The tibia is reamed in standard fashion a sufficient distance to accommodate the proposed stem length. The length of the stem should be such that it surpasses the zone of loosening or lysis and good cortical contact by the stem will be attained. In addition, the distal end of the tibia is sculpted such that the distal surface is perpendicular to the long axis of the bone in both the sagittal and frontal fluoroscopic views. This can be done freehand or with the use of the cutting block after attaching it to the frame. Minimal bone resection should be exercised. The tibial components are sequentially assembled and inserted. Once the tibial tray has been seated and tamped into place, the leg is removed from the leg-holding frame.

The preparation of the talar component insertion begins with the establishment of the ultimate height of the talar component. The talar component will rest on 3 or 4 metallic supports placed into the remaining talus, across the subtalar joint and into the calcaneus (Fig. 3). The technique uses several 3- or 7-mm titanium plasma-coated fusion rods (Inbone, Wright Medical Technology, Inc., Arlington, TN) placed in either a triangular or quadrangular orientation around the periphery of the talus/calcaneus. These devices are placed as vertical as possible to minimize the amount of cubic space taken up by the metallic supports. Furthermore, the distance between fixatives should be maximized within the confines of the bony anatomy

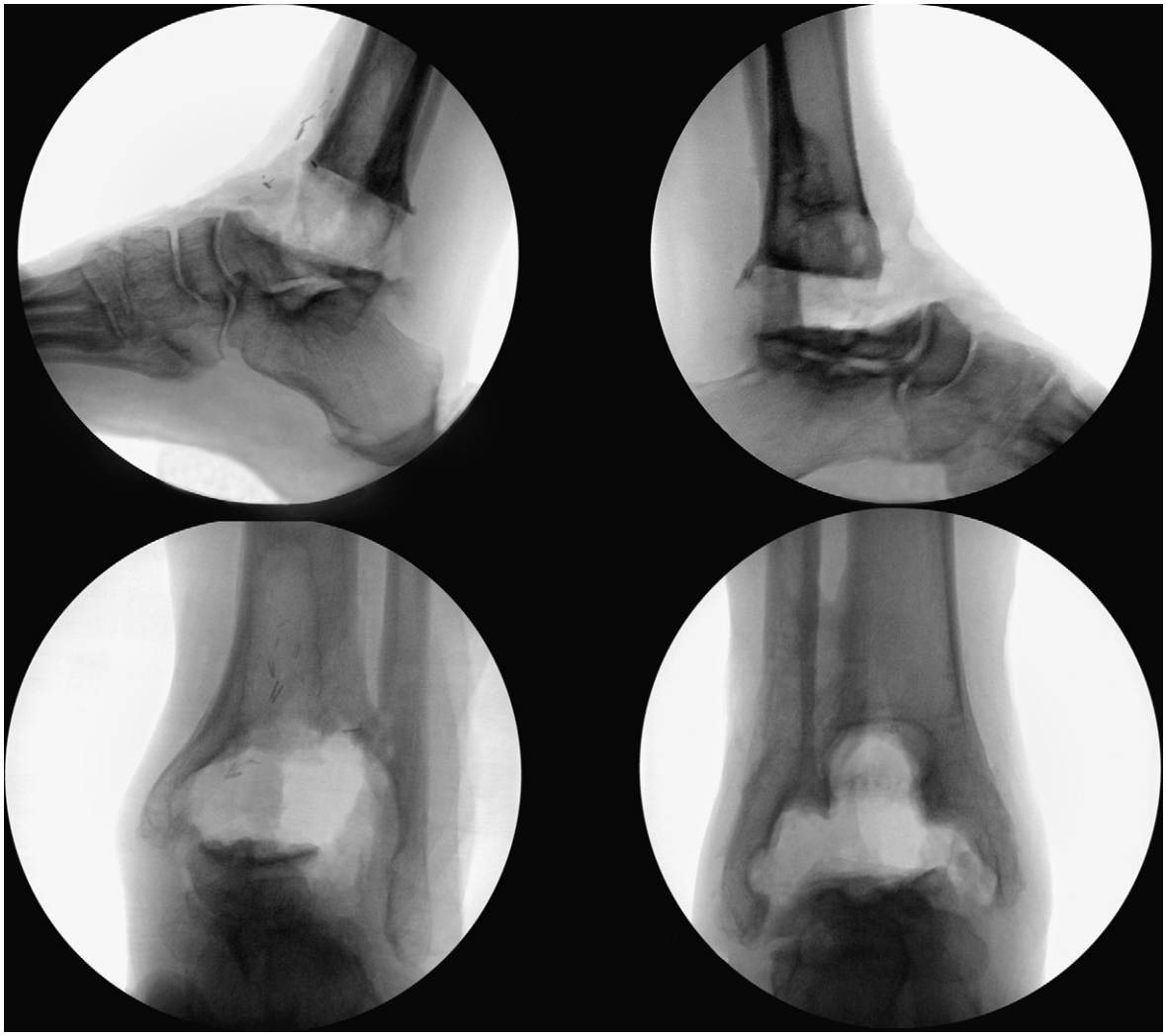

Fig. 2. Intraoperative fluoroscopic images showing the prepared substrate after component removal. Note the significant resultant defect in both cases.

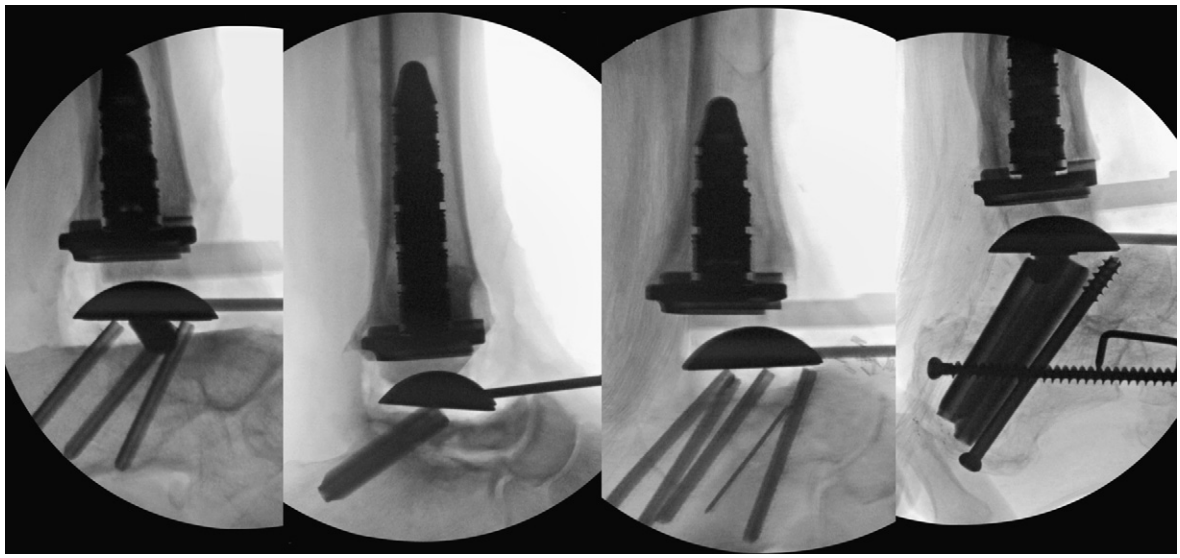

Fig. 3. Intraoperative fluoroscopic images demonstrating the balance and position of talar component over the fusion rods. There are variable patterns of orientation of the fusion rods to support the talus in a horizontal alignment before cementation.

(Fig. 4). Alternatively, acetabular screws can be used in a similar construct. The metallic supports will ultimately bridge and be fully integrated in the cement augmentation and firmly incorporated into the remaining talar body and calcaneus. The height of the metallic supports is determined with a trial talar and polyethylene insert, which are placed into the ankle. The foot is loaded and alignment is confirmed fluoroscopically to assess alignment on the sagittal and frontal projections. The undersurface of the talar trial component should be parallel to the tibial tray in both projections while the foot is loaded (Fig. 3). Fine tuning adjustments are usually necessary to assure functional ligament balance and full contact compliance with the talar and polyethylene surfaces. Once the ultimate talar component position is determined, a guide pin is placed through the trial so that the talus and calcaneus can be reamed over the guide pin. In some cases the bone loss exceeds the height of the proposed stem. The depth of the reaming should accommodate a 10-, 14-, or custom 50-mm stem.

Once the metal supports have been placed, tuned, and dry fitted the cement augmentation is formed with high viscosity bone cement (Palacos R+G; Heraeus Kulzer GmbH, Wehrheim, Germany) prepared in standard fashion. Cement is leveled up to the top of the metal supports and mounded up more anteriorly to limit posterior extrusion during talar component positioning. The final talar component with the attached stem is coated with cement inferiorly, and then inserted onto the metal support–cement combination (Fig. 5). The position is governed by a congruent interface between the actual talar component and the trial polyethylene insert. The foot is loaded while the cement cures. During the setting process, excess cement is removed from the gutters. The final polyethylene spacer is placed after the bone cement has set (Fig. 6). When indicated, soft tissue procedures such as ligament plication are performed after insertion of the components. The wound is closed in standard fashion over a suction drain followed by bandages and a short leg splint.

Postoperative Management

At the first postoperative visit at 7 to 14 days, the staples and/or sutures were removed, and a short leg cast was used until 6 weeks postoperatively. Radiographs were taken to assess for component migration. The patients were allowed to bear weight after 6 weeks, usually in a removable walking boot. In some instances in which ancillary procedures have been performed, a short leg walking cast is used. Transition to conventional shoe gear takes place over the subsequent weeks. The interfaces of the metallic fixation in the talo-calcaneal mass are scrutinized on routine standard

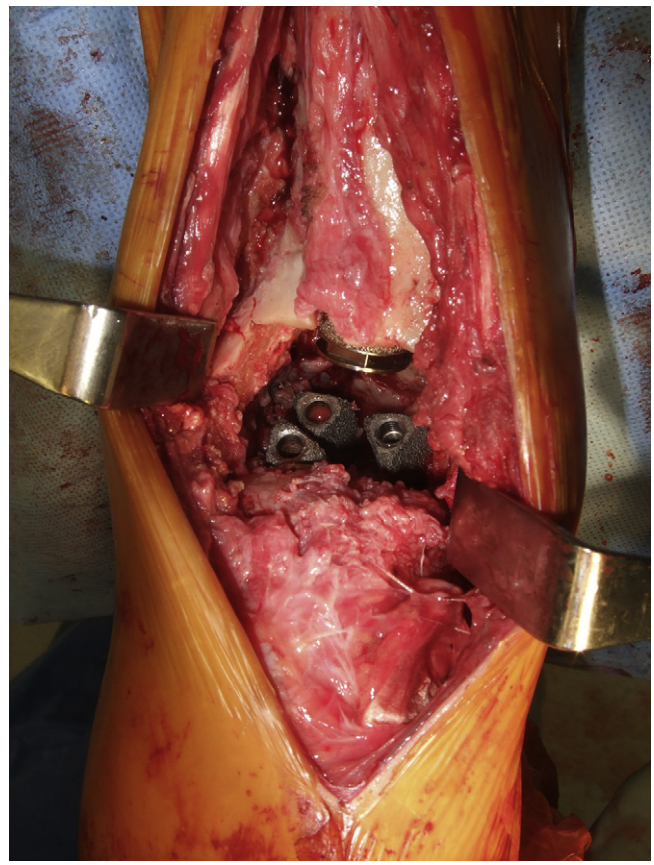

Fig. 4. Intraoperative photograph showing the triangular orientation of the fusion rods. Note that there is a central area that will accommodate the stem on the talar component.

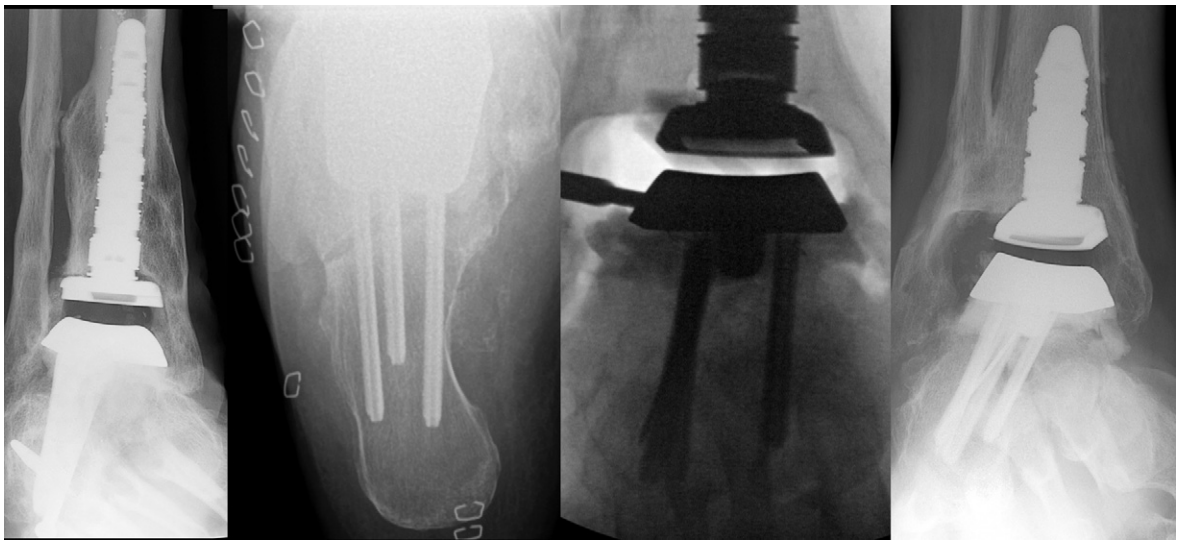

Fig. 5. Radiographic examples showing axial orientation of talar component on cement-metal supports.

weight-bearing radiographs for any lysis about the metallic fixation. Fluoroscopy is also used to visualize the cement-bone interface. This requires careful manipulation such that fluoroscopic beam is orthogonal to the interface.

Results and Complications

The preliminary results are gathered from a series of 17 patients with a minimum follow-up of 6 (range 6 to 48) months (mean follow-up 1 $\pm$ 0.3 year). There were no wound complications, even though many of these patients had numerous prior operations. In 2 of the patients, some separation of the cement from the talo-calcaneal bone mass has been noted at 6 months postoperatively; however, these interfaces have remained stable at 1 year and 18 months, respectively. No lysis around the metal-bone interface has been observed in any of the 15 patients. Two of the fixation devices (1 acetabular screw, 1 fusion rod) have undergone fatigue failure. In both cases, the fractured devices were the most posterior support and occurred at the level of the subtalar joint where a fusion was attempted. However, the subtalar joint was not debrided down to a raw cancellous substrate for fear of devitalizing the remnant talus. However, the cement interface in these patients has remained stable for 2 years and 9 months, respectively, without subsequent migration of any of the components.

Two of the patients at the time of reconstruction had compromised medial ligamentous support from invasion of polyethylene wear disease of the medial distal tibia. After revision, 1 of those patients had frank lateral dislocation of the talar component and was revised to ankle arthrodesis. The second patient had modest lateral subluxation of the talar component and is being managed with an ankle-foot orthosis. Both of these failures involved the earlier version of the talar component (Inbone I), which has a very shallow and smooth central sulcus. In the other 15 patients there has been no loosening of the cement-metal-bone interfaces and the components have remained congruent at the polyethylene interface as well.

Discussion

Most of the patients who have had this technique previously had the Agility (DePuy, Warsaw, IN) prosthesis. This implant is semi-constrained and, until it was revised, had a very narrow talar component-bearing surface and was subject to high bone interface stress (25,26). Regrettably, there are no studies that indicate a longer survivorship with the wider talar base plate and a wider bearing surface. Nevertheless, the fact that the Agility was the only implant widely available in the United States until 2006 (aside from the STAR Study Group) means that there are numerous patients who may require revision in the near future as subsidence and/or talar bone loss ensues.

It has been suggested that patients with 50% or greater talar bone loss are not amenable to reconstruction with the use of standard TAR components and should be managed with arthrodesis (3,21). An alternative method to negotiate large uncontained bony defects includes the use of structural allograft or autogenous bone to build up the bony substrate in conjunction with revision arthroplasty. However, lack of graft incorporation, fracture, or infection can lead to implant failure (23,24,27). The use of custom prosthetic components can be implemented, but precise placement can be unpredictable and inconsistent. In turn, the resultant construct is prone to instability and premature failure. The use of cement in these cases, regardless of the modality of metal fixation, allows for the management of variable morphological patterns of bone loss. Although custom components can be obtained for salvage of these complicated cases, the ultimate position of a solid, stemmed custom talar component is dependent on preoperative imaging coupled with intraoperative judgment by the surgeon. Unfortunately, there is no capability to make any significant adjustments once the operation begins or unrecognized defects in the native bone are discovered. This may lead to less than optimal congruity at the polyethylene bearing. Moreover, the use of these custom implants still may depend on using the same implant system that failed originally. Likewise, there may be a tendency for significant polywear and mechanical issues (22,28). In additional, the use of custom components adds significantly to the overall expense of the revision procedure.

DeOrio recommended the technique of incorporating porous, coated rods with a TAR to fuse the subtalar joint and provide support to the TAR talar component in cases of weakened or thin talar bone mass (29). Our technique similarly uses coated fusion rods and screws in combination with bone cement, which negates stresses at the bone-cement interface. This is accomplished through biologically fixated rods that would require failure of the entire unit before the cement mantle could separate from bone. This emphasizes the need for multiple support struts to disperse loads and limit the possibility of eccentric loading of the underlying bone. In turn, the oblique

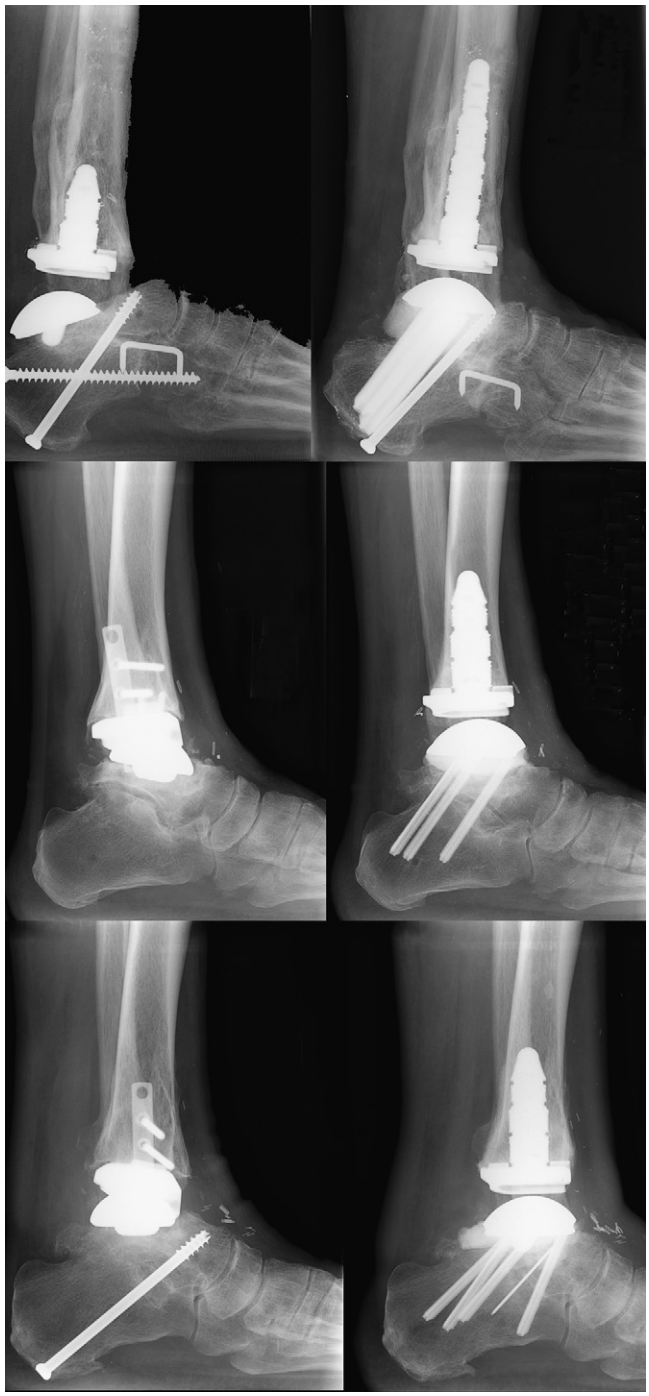

Fig. 6. Preoperative and corresponding postoperative radiographs of 3 separate patients.

orientation of the fusion rods will dampen shear and rotational forces across the cement-bone interface during ankle motion. Although we have not seen failure of the bone-cement interface to date, it may become an issue with longer-term follow-up. Polyethylene wear disease, loss of biologic fixation, or both may mediate this potential separation.

However, because of Food and Drug Administration regulations, only custom 1-piece stemmed implants are available. Although the obligate void from bone loss can be reduced by a stemmed custom talar component, the lack of availability of long stems that are separate from the actual talar component presents a significant problem. Our technique allows for increasing the potential for biologic fixation with multiple fusion rods. In turn, these fusion rods allow for precise positioning of the talar component directly under the tibial tray such that a congruent interface is realized. Furthermore, the increased availability of longer stems and the potential use of trabecular metal may enhance the likelihood of bony ingrowth and success of biologic fixation. However, even if Food and Drug Administration approval were forthcoming, the use of such stems will not obviate the potential void between the stock talar component and the talocalcaneal bone mass.

The Inbone system is used for several reasons. First, this TAR prosthesis is better able to manage bone loss as compared with other available devices. In addition to its larger size, the intramedullary design of the system allows for solid biologic fixation of the tibia. Second, the wide array of available polyethylene inserts in 2-mm increments allows one to handle most revision situations. Finally, the flat undersurface of the talar component allows for versatile placement and a stable platform to achieve a coaxial orientation to the tibia. Even the largest defects with a compromised subtalar joint can be effectively revised.

Although ligament integrity and tension are probably the most important factors in maintaining frontal plane stability, some patients tend to experience residual varus or valgus thrust. The standard Inbone system allows for frontal plane swivel of the components because the sulcus has a large radius curvature (6.6 to 9.4 cm). With a lack of a malleolar buttress or when slight ligamentous imbalance persists, the components could shift in the frontal or transverse plane when loaded, particularly if there is no coaxial alignment. The V-shaped sulcus of the Inbone II lends better frontal and transverse plane stability and may limit planar shifting in some instances.

The technique described herein allows for revision of complex failed TAA with massive bone talar bone loss from subsidence and/or polyethylene wear disease. In most cases, both conditions have led to the demise of a functioning implant, loss of height of the extremity, increasing deformity or instability, and pain. To date there are few good options to restore function. Ankle arthrodesis can be considered, but the technical execution of this procedure is difficult because of the bone loss and instability. Furthermore, many patients have already had hindfoot fusions that make arthrodesis of the ankle less desirable. We have used this technique for over 4 years without loss of fixation to date. We are currently evaluating the entire cohort of 17 patients for signs of loosening, or impending failure, in addition to functional outcomes.

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Erratum

In the July/August 2011 issue (volume 50, issue 4, pp 377–382) of *The Journal of Foot & Ankle Surgery*®, the article "Lapidus Arthrodesis with a Single Lag Screw and a Locking H-Plate" did not note that the use of locking plate technology with the Lapidus arthrodesis had been described previously in 4 publications (1–4). This article also did not note that early weight-bearing following Lapidus arthrodesis also had been described (5).

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The Journal regrets these omissions.

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