Revision of Failed Ankle Implants

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KEYWORDS

• Total ankle joint replacement • Ankle joint arthrodesis • Degeneration • Arthritis

KEY POINTS

- TAR offers the benefit of perseveration of joint motion, with potential decreased occurrence of adjacent joint degeneration, and a more expedient path to weight bearing.
- Studies have demonstrated that the new generation of TAR systems provides superior patient satisfaction outcomes compared with prior systems and with ankle arthrodesis.
- A plantargrade foot type provides the optimal setting for application of TAR, and adjunctive procedures may be necessary to rectify concomitant biomechanical factors.

INTRODUCTION

Total ankle joint replacement (TAR) has been offered as an alternative to ankle joint arthrodesis since the 1970s. Historically, ankle arthrodesis has been viewed as the gold standard of treatment of end-stage arthritis, because it offers reliable reduction of pain with good functional outcomes.[1] However, as with any surgical endeavor there are complications, including nonunion, malalignment, and gait alterations. These issues, in addition to a tenuous postoperative course, may decrease patient satisfaction and functional outcomes. In addition, degeneration of joints adjacent to the ankle, specifically the subtalar joint, is a concern and may predispose the joints to arthritis after ankle arthrodesis has been performed.[2]

Alternately, TAR offers the benefit of perseveration of joint motion, with potential decreased occurrence of adjacent joint degeneration, and a more expedient path to weight bearing. Studies have demonstrated inherently better patient outcomes with ankle arthroplasties, when performed with the second-generation implants.[2,3]

Since their introduction, TAR devices have undergone a variety of modifications, specifically in regards to the number and type of components used. These modifications have been necessary because previous success rates of TAR long-term outcomes did not equivocate with those of total knee and hip replacements.[4,5] The reasoning behind this trend is thought to be multifactorial. It may be because a high proportion of patients suffering from degeneration of the ankle joint are often younger, more active

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patients who have likely suffered a traumatic injury.[6] Generally, lower patient outcome scores have been related to younger populations, whereas higher rated outcomes are seen with older patients who have a smaller body mass index.[7]

OVERVIEW OF TAR AND SYSTEMS

Indications for TAR include posttraumatic osteoarthritis, systemic arthritis, primary arthritis, or revision from prior ankle arthrodesis.[3]

The early implant models were cemented, and constructed of two components, which were described as constrained, semiconstrained, or nonconstrained.[8] These early models proved to be unstable when applied, leading to high rates of failure and disappointing long-term results.[9,10]

The initial models were followed by a generation of three-component models that had a central component that allowed multiaxial motion of the joint.[8] The models used currently are typically cementless, with a mobile-bearing polyethylene component. Each of the available models varies in structure and composition. The Salto (Tornier SA, St. Ismier, France) device is composed of cobalt-chrome alloy, followed by a layer of pure titanium and calcium hydroxyapatite.[11] This hydroxyapatite layer is intended to decrease the occurrence of radiolucency surrounding the implant. Another commonly used implant device is the Agility Total Ankle System (DePuy, Warsaw, IN).[3] This product has two components, which are composed of titanium and cobalt-chromium, and is semiconstrained. Bone ingrowth is a key factor for secure implantation of this device because cement is not used for application.[3] In addition, this implant partially relies on fusion of the distal tibiofibular syndesmosis for added stability.[12]

The Scandinavian Total Ankle Replacement (STAR) has three uncemented components, and is considered to be a mobile-bearing unit. The tibial and talar components are composed of cobalt-chrome, with a double coat of titanium and calcium phosphate. The third piece is ultra-high molecular weight polyethylene.[9]

Another implant device is the AES (Ankle Evolution System, Biomet, Nimes, France). This is an uncemented, three-component, meniscal-bearing unit, offering a triangular-shaped tibial stem, which offers increased stability.[13]

Preoperative planning to prevent failure of TAR is a key component for positive outcomes. Chances for postoperative lack of range of motion, implant instability, and lack of fusion of the tibiofibular syndesmosis may be avoided with thorough preoperative evaluation of the mechanical axis of the causing deformity.[12] Furthermore, realistic expectations regarding outcomes after the procedure must be conveyed to the patient. Specifically, a decrease in the amount of ankle joint range of motion as compared with a normal joint is likely to be expected and has been documented.[14]

MECHANISMS OF FAILURE

Complications leading to failure of TAR can be caused by several factors. The necessity for revision may be linked to the type of implant system used, surgeon experience in performing the procedure, or the severity of the patient's preoperative condition. Specifically, it has been found that surgeon experience can be related to long-term survival rate of ankle implants. Research has shown that after the surgeon has performed the application of 30 implants, the 5-year success rate increases from 70% to 86% (**Fig. 1**).[11]

Historically, aseptic prosthetic loosening and wound healing issues were among the most common complications arising after TAR with mechanical loosening occurring most commonly.[2,8,11] Other problems that frequently occur include infection of bone

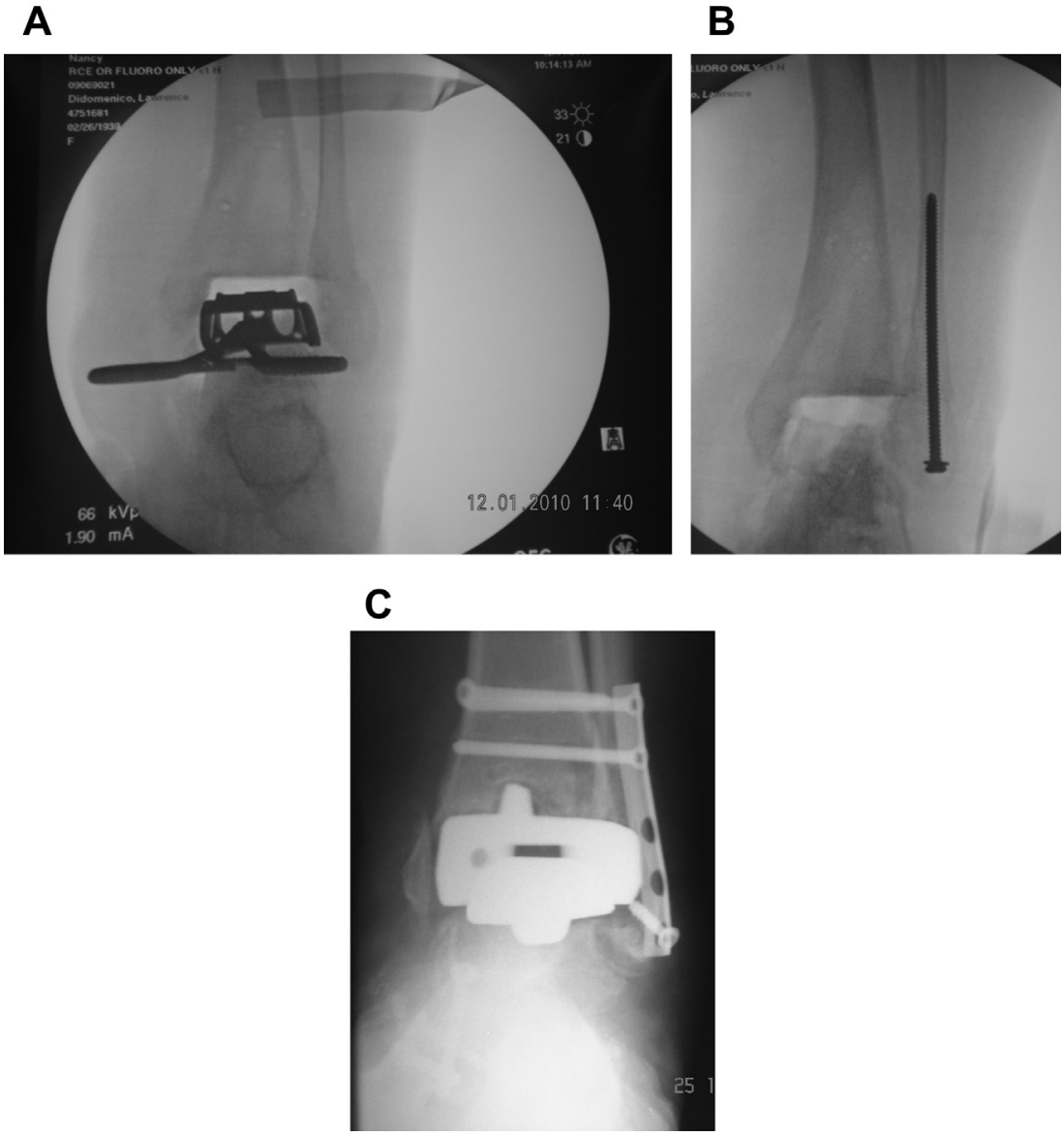

Fig. 1. (*A*) Intraoperative view demonstrating a transverse fibular fracture of the distal fibula. (*B*) Intraoperatively a 4.0 interfragmentary screw is used with a washer for compression and realignment of the distal fibular fracture. (*C*) Postoperative view demonstrating a medial malleolus fracture secondary to stress, and the medial malleolus was cut too thin.

and soft tissue, nonunion of the tibiofibular syndesmosis, malalignment, joint impingement, and persistent pain (**Fig. 2**).[5]

A thorough understanding of ankle joint anatomy is key for interpreting the mechanical and functional relationship between the prosthesis and joint, and may lend insight into mechanisms of failure.[15] Because of the lack of muscular reinforcement between the talus and surrounding bony structures, there is increased importance placed on the quality and integrity of the surrounding ligamentous structures (**Fig. 3**).[16]

One of the factors that make successful application of TAR inherently challenging is that many of the conditions that warrant the initial need for augmentation of the joint may cause complications after application. Preoperative failure to recognize inherent soft tissue or bony structural deformities contributes to this problem. Furthermore, inadequate soft tissue repair or component placement could be contributory factors to subsequent failure.[7,17] Tibiotalar varus or valgus have been linked to the highest incidence of complications.[6] It has been recommend that

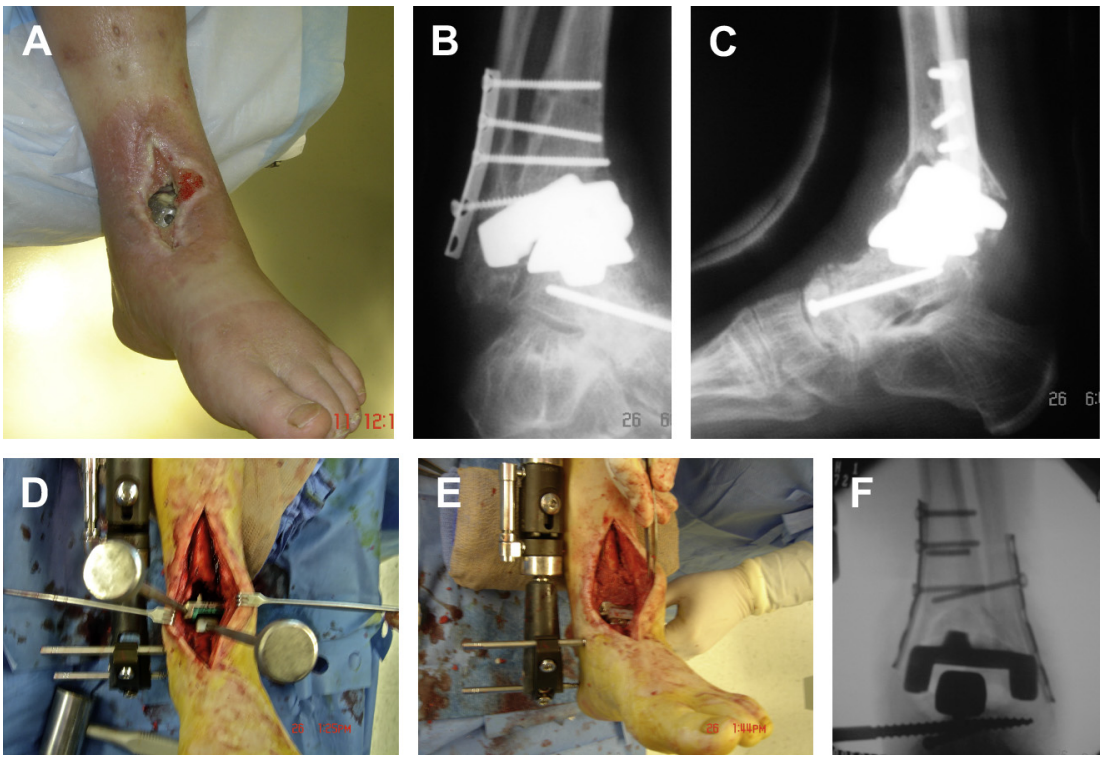

Fig. 2. (*A*) Rheumatoid patient postoperative with a wound dehissence. In particular, rheumatoid patients have a higher rate of wound complications because of the thin soft tissue envelope. (*B*) A patient who sustained a traumatic accident with a distal tibial fracture and subsidence of an Agility implant. (*C*) Lateral postoperative view after a traumatic accident with a distal tibial fracture and subsidence. (*D*) Intraoperative view demonstrating the amount of distal tibial bone loss from the subsidence. A trial implant is viewed demonstrating the amount of bone graft needed to secure the implant. (*E*) Intraoperative view demonstrating bone graft packed tightly into the distal tibia for the revision surgery. (*F*) Intraoperative view demonstrating the bone graft and the revision components of the Agility implant secured by a medial and lateral plate.

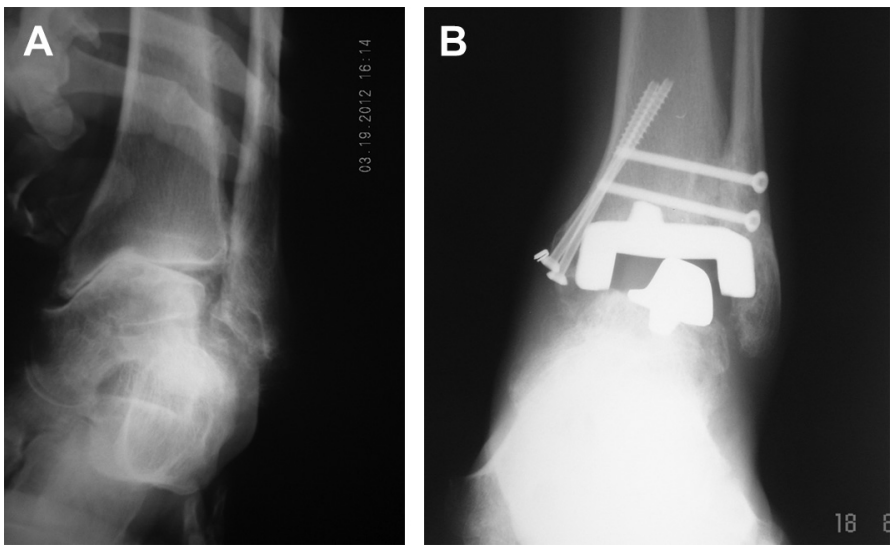

Fig. 3. (*A*) A patient with a varus ankle and ankle instability with loss of lateral ligamentous structures. (*B*) Postoperative view of a patient who had inadequate soft tissue repair and component placement, which led to this varus deformity and failure of the implant.

TAR procedures be avoided in patients with a coronal deformity of greater than 10 to 15 degrees.[18] In addition, equinus deformity has been noted to be an impacting factor in TAR, and some authors have recommended performing lengthening of the Achilles tendon if less than 5 degrees of dorsiflexion is achieved after placement of the implant.[11] This and other adjunctive procedures including osteotomies, arthrodesis, or tendon transfers may be necessary to provide the best environment for successful TAR outcomes (**Fig. 4**).

The type of implant used can be related to the mechanism of failure, depending on the shape, thickness, or angulation of the components. For example, osteolytic cysts have been demonstrated to develop more frequently in the uncemented, mobile-bearing implants. Wear debris particles or cysts are another sequalae that are thought to be caused by an unevenly loaded polyethylene component.[19] These cysts tend to weaken the stability of the implant, and may lead to implant loosening or fractures in the surrounding bone.[20]

Several indications for reoperation after TAR have been described. These include uncontrolled pain, along with radiographic evidence of component loosening, malpositioning, hypertrophic bone growth at the level of the implant, or signs of nonunion (**Fig. 5**).[3]

It is highly recommended that the surgeon acquire a CT scan before performing the revisional procedure to evaluate the surrounding bone stock.[20,21]

REVISIONAL RATES

Henricson and Agren[22] in a study examining 186 patients who had undergone previous TAR determined that the type of deformity present before the initial TAR may indicate the likelihood of the necessity of revisional surgery. In their research they found that revision rates for patients with a varus type of deformity was 31%, compared with 17% in those with either neutral or valgus position. The authors found an overall revision rate of 21%. Wood and Deakin[23] experienced 14 failures

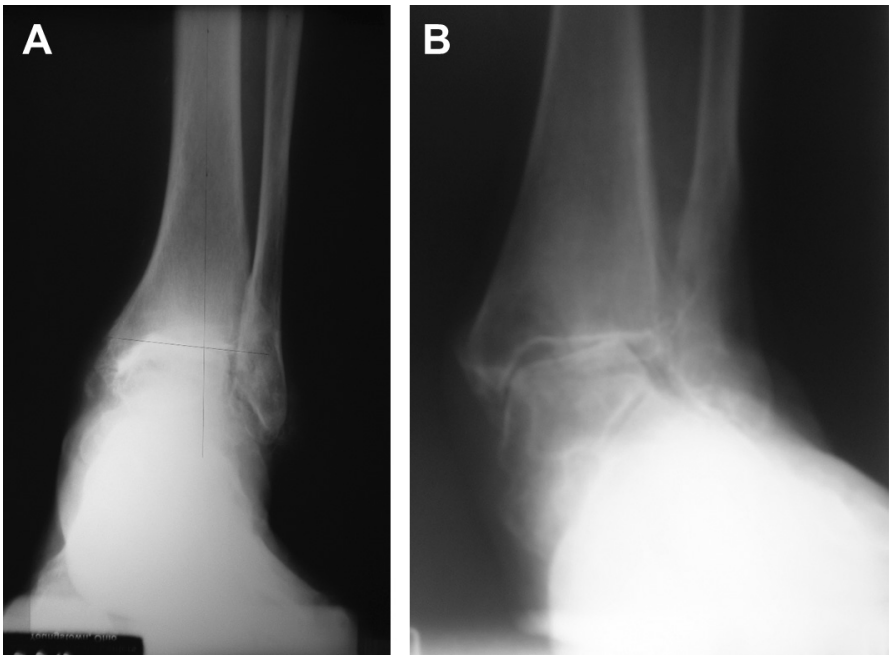

Fig. 4. (*A*) Preoperative radiograph demonstrating a congruent varus ankle. The axis of the tibial falls lateral to the central talus. (*B*) Preoperative radiograph clearly showing an incongruent ankle valgus secondary to medial deltoid insufficiency.

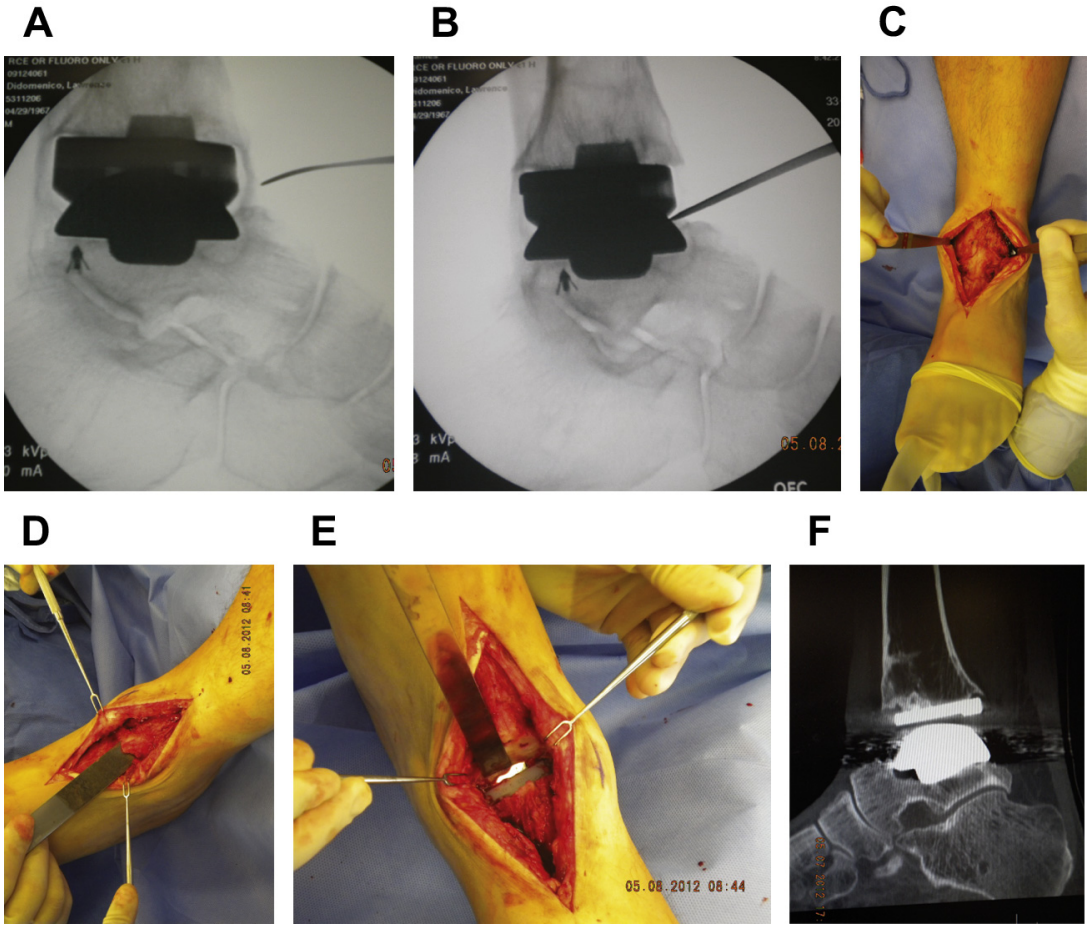

Fig. 5. (*A*) Intraoperative view demonstrating a large bony bridge over the anterior aspect of the implant, which limited the range of motion of the ankle joint. (*B*) Intraoperative lateral view after an aggressive resection of the hyptertrophic bone. (*C–E*) Intraoperative views demonstrating the hypertrophic bone (*C*), resecting of the hypertrophic bone with an osteotome (*D*), and after complete resection of hypertrophic bone anteriorly. (*F*) Preoperative CT scan displaying subsidence of the talar component of an Agility ankle replacement.

out of 200 patients who had had the STAR prosthesis in place. Zhao and colleagues[24] in a large systematic review of STAR failure rates in 2088 implants at mean follow-up of 52 months found 232 to be failed, for a combined failure rate of 11.1%. They found 11 primary complications, with the three earliest including loosening, deep infection, and malalignment. Additionally, Karantana and coworkers[9] reviewing 45 patients with STAR implants related that eight patients required revisional surgery consisting of component replacement (six) and arthrodesis (two).

Spirit and coworkers[3] in a review of 306 TAR procedures demonstrated the need for revisions in 86 patients. Of those requiring revision, 57 had one revision done at a mean of 17.8 months. Eighteen of the patients required two reoperations, and those were performed at 13.7 and 10.6 months post initial TAR, respectively. Nine of the patients required three reoperations, and those were performed at 10.8, 7.2, and 5 months, respectively. Lastly, one of the patients required seven reoperations.

Henricson and coworkers[13] in a review of 93 patients who had the AES ankle arthroplasties demonstrated a 5-year survival rate of 90%. Interestingly, the authors also reported a low revisional rate in their patients with rheumatoid arthritis (RA), which is beneficial because patients with systemic arthritidies often have poor bone quality.

REVISIONAL PROCEDURES AND METHODS

Henricson and coworkers[13] proposed the application of definitions to follow-up procedures for TAR. These included "revision," which entailed replacement or removal of the components, not including the polyethylene piece. "Reoperation" was another type, and this described surgery involving the joint but not the components. Finally, "additional procedure" was the term used for a secondary surgery not involving the ankle joint or the components. The type of reoperation procedure varies depending on the pathology present at or near the implant. Bony debridement, exchange of components, infection control, fracture or nonunion repair, extra-articular soft tissue procedures, and below-knee amputation have all been described.[3,13]

Redo-revision, or reapplication of an implant, has been found to be more difficult than revision converted to arthrodesis, primarily because of poor bone quality and availability, which is necessary to place a new implant.[2] In cases where this is the circumstance, or if there is surrounding soft tissue compromise, ankle arthrodesis may be the most viable revisional option.[5] The surgical technique for performing this procedure varies. Berkowitz and colleagues[5] detailed arthrodesis techniques in 24 patients who had previously undergone TAR. The incisional approach was similar to the original TAR, and the implant was removed using Arbeitsgemeinschaft für Osteosynthesefragen (AO) osteotomes. The authors further recommended thorough debridement of any excess synovial tissue in addition to acquisition of bone biopsy samples to rule out any infectious process.

Some surgeons have demonstrated the use of a retrograde intramedullary nail for revisional procedures.[25] Arthrodesis as a salvage procedure for previous TAR has been shown to have a reliable fusion rate, but this decreases in patients with RA.[26] Doets and Zurcher[26] in their review of 18 patients undergoing this procedure experienced seven nonunions, and all were in patients with inflammatory joint disease. Also in this study, the authors preferred fixation of the fusion site with either a blade plate for normative subtalar joints, or intramedullary-locking nails for degenerated joints. To promote fusion rates, use of structural bone graft to augment the arthrodesis site has also been highly recommended by several authors.[5,9,26] The use of the intramedullary nail in combination with a cage filled with morsellized cancellous bone grafting material has also been described.[27] This method offers stability with the cage apparatus, in combination with the superior biologic properties of the cancellous graft. However, alternately, there have been some reported failures of fusion when using this technique (**Fig. 6**).[28]

In instances where adequate bone stock remains and there is little soft tissue compromise, several authors have detailed success when removing the failing TAR device, and replacing it with a different style. Use of the Agility custom prosthesis has been recommended because of its customizable polyethylene thickness, stem angulation, diameter, and length.[20] This is accomplished by using preoperative radiographic templates to determine the appropriate sizing modifications. In addition, the tibial component can remain in place if it is in the proper position, and a specialized mismatch-type polyethylene piece can be used to approximate the two components.[20] Others have performed TAR conversion, creating a combination or hybrid system using STAR and AES components simultaneously. Specifically, Kharwadkar and Harris[29] presented two cases with excellent outcomes that entailed replacing only the STAR tibial components with the AES components, while preserving the STAR talar and polyethylene pieces (**Figs. 7** and **8**).

Bony overgrowth is a fairly common problem with TAR. This occurs secondary to subsidence of the talar component, and although a short-term solution may include

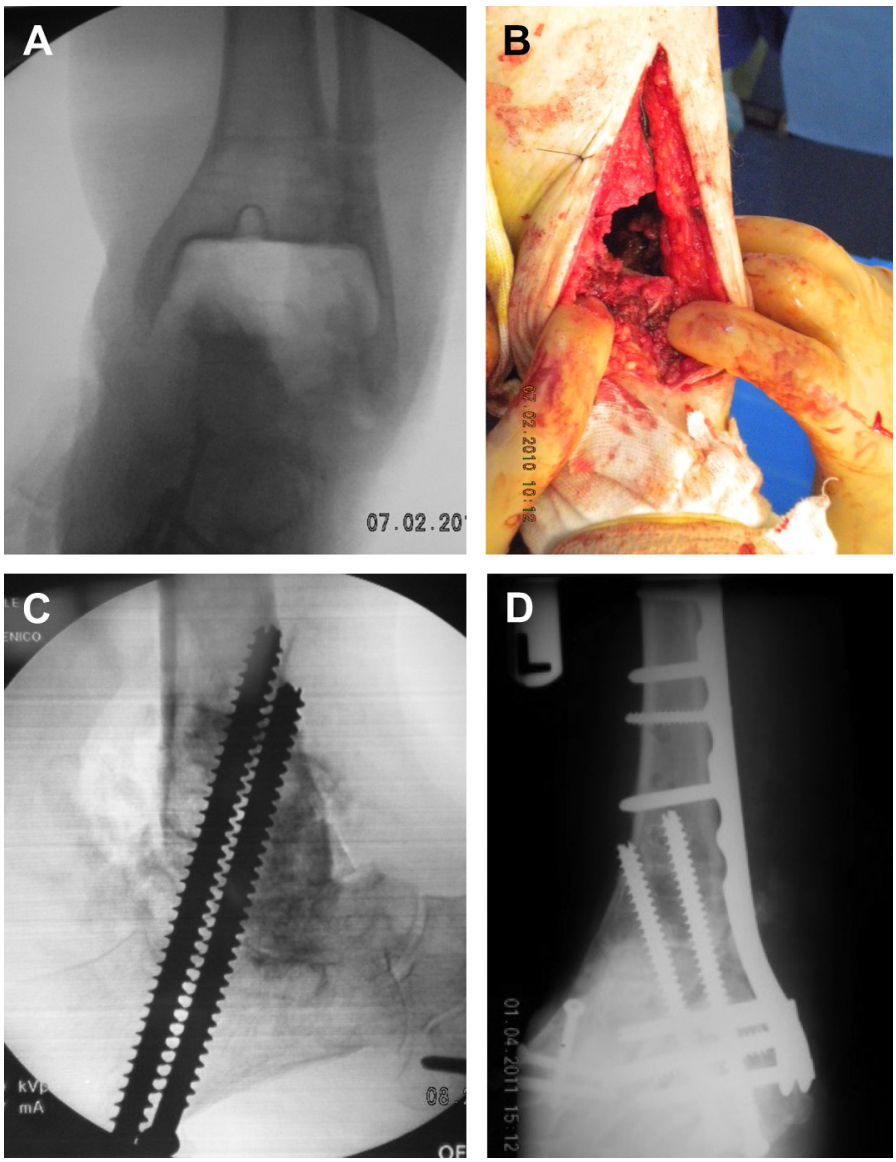

Fig. 6. (*A*) Intraoperative radiograph demonstrating significant talar bone loss after a trauma to an Agility ankle replacement several years postoperatively. Note the amount of bone void secondary to the trauma. (*B*) Intraoperative view after removal of the Agility implant demonstrating a large bone void after removal of the implant and the sustained bone loss. (*C*) Lateral intraoperative view with an autogenous cortical cancellous bone graft at the tibial calcaneal joint fixated with two fully threaded cancellous positional screws. (*D*) Postoperative view demonstrating complete incorporation of the autogenous bone graft, which is fixated with two large fully threaded cancellous positional screws and a femoral locking plate.

debridement within the medial and lateral gutters, it has been proposed that a more definitive method may include talar component revision, with application of a piece that covers more surface area (**Fig. 9**).[30]

Severe subsidence of the talar component can also cause tremendous bone loss. In these instances, it has been demonstrated that moderately successful revision can be achieved using an inbone-style implant.[31] Alternately, other authors have proposed using metal-reinforced cement augmentation, which has been previously used with success in other joint replacement revisions.[32] Another modification that has been used in patients with RA is augmentation of the tibia with hydroxyapatite.[33] However, in their review of TAR in 16 ankles in patients with RA, Shi and colleagues[33]

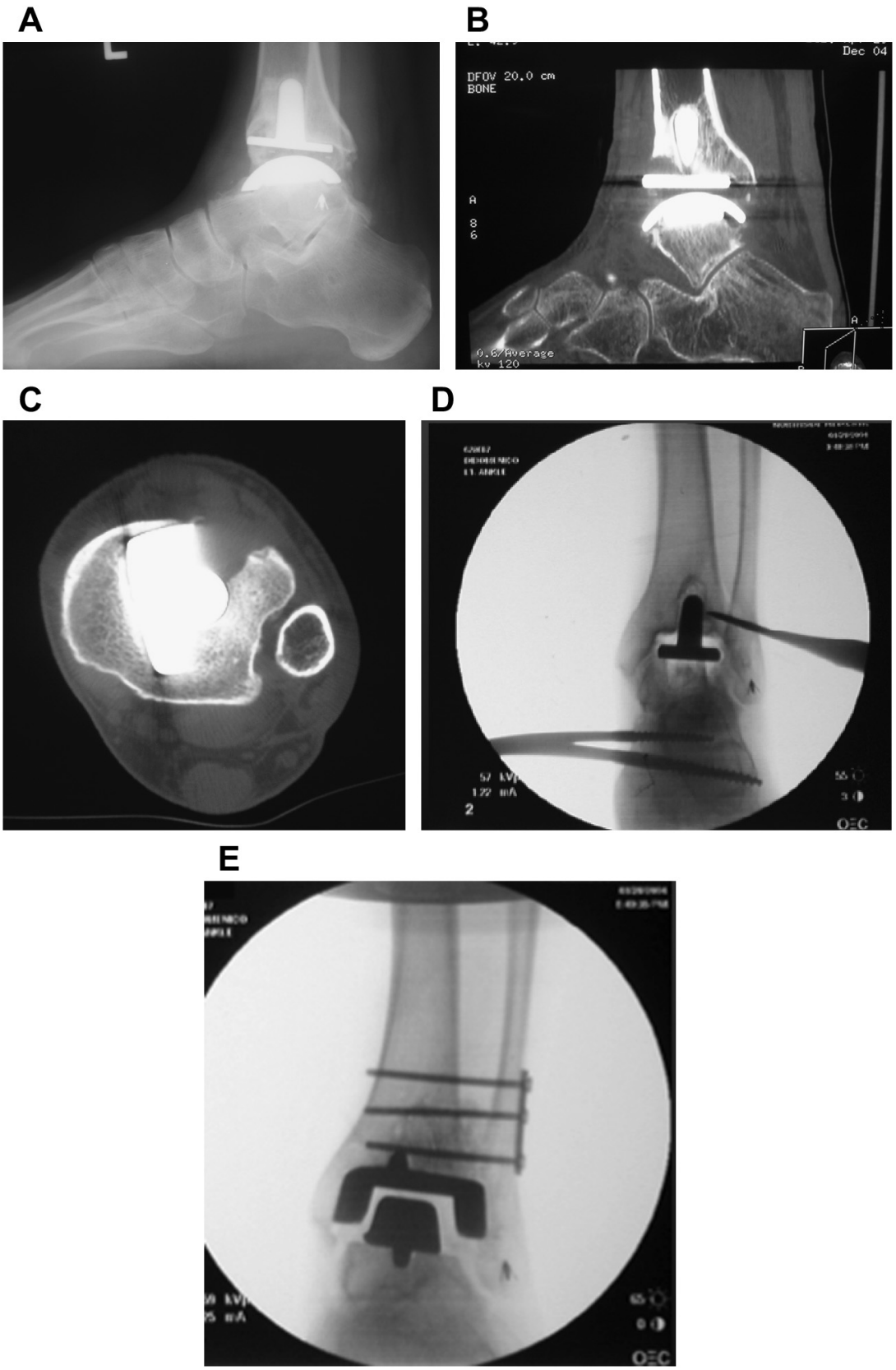

Fig. 7. (*A*) Postoperative lateral radiograph of a Buechel Papas implant demonstrating a distal tibial cyst and loosening of the tibial tray. (*B*, *C*) CT scans demonstrating the distal tibial cyst and the bone loss allowing for micromotion of the tibial tray of the Buechal Pappas implant. (*D*) Intraoperative view removing the tibial tray of the Buechal Pappas implant. (*E*) Intraoperative view demonstration of bone grafting of the bone void and insertion of an Agility implant.

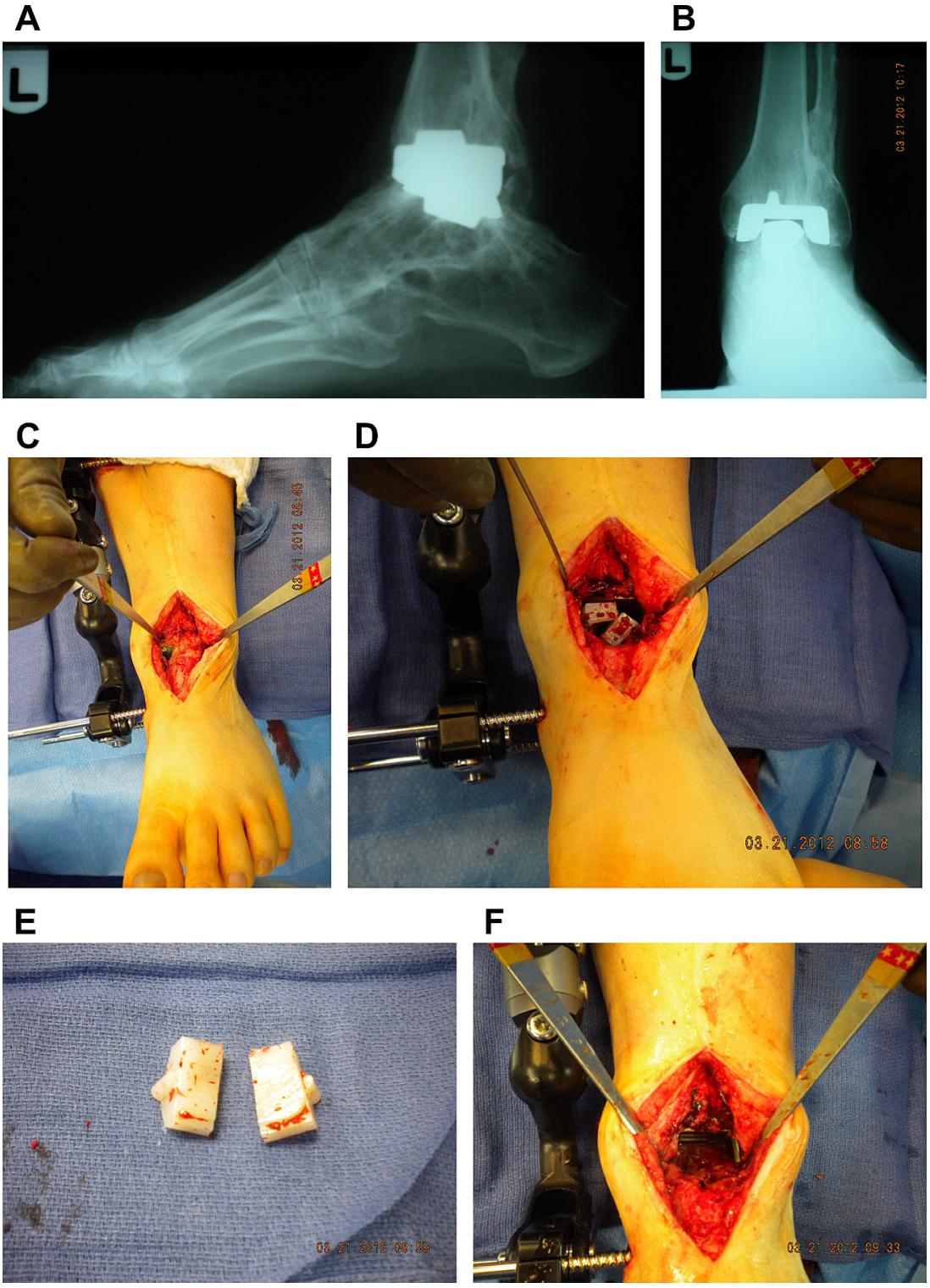

Fig. 8. (*A*, *B*) Preoperative anterolateral and lateral radiograph of a patient who had an Agility ankle replacement implanted approximately 12 years ago. The patient is now experiencing pain because of talar subsidence. (*C*) Intraoperative view demonstrating a large fibrous build up of tissue limiting the range of motion of the ankle joint. (*D*) Technique of splitting the polyethylene piece is used to remove the polyethylene in the presence of talar subsidence. (*E*) The polyethylene piece on the back table after removal from the implant. (*F*) Intraoperative view after the removal of an Agility talar component and polyethylene piece. (*G*, *H*) Revision Agility low-profile talar component with the extended wings to cover the bony cortices of the talar body. (*I*, *J*) Intraoperative lateral and ankle mortise radiographs demonstrating a well-positioned revision Agility low-profile talar component with excellent talar cortex coverage.

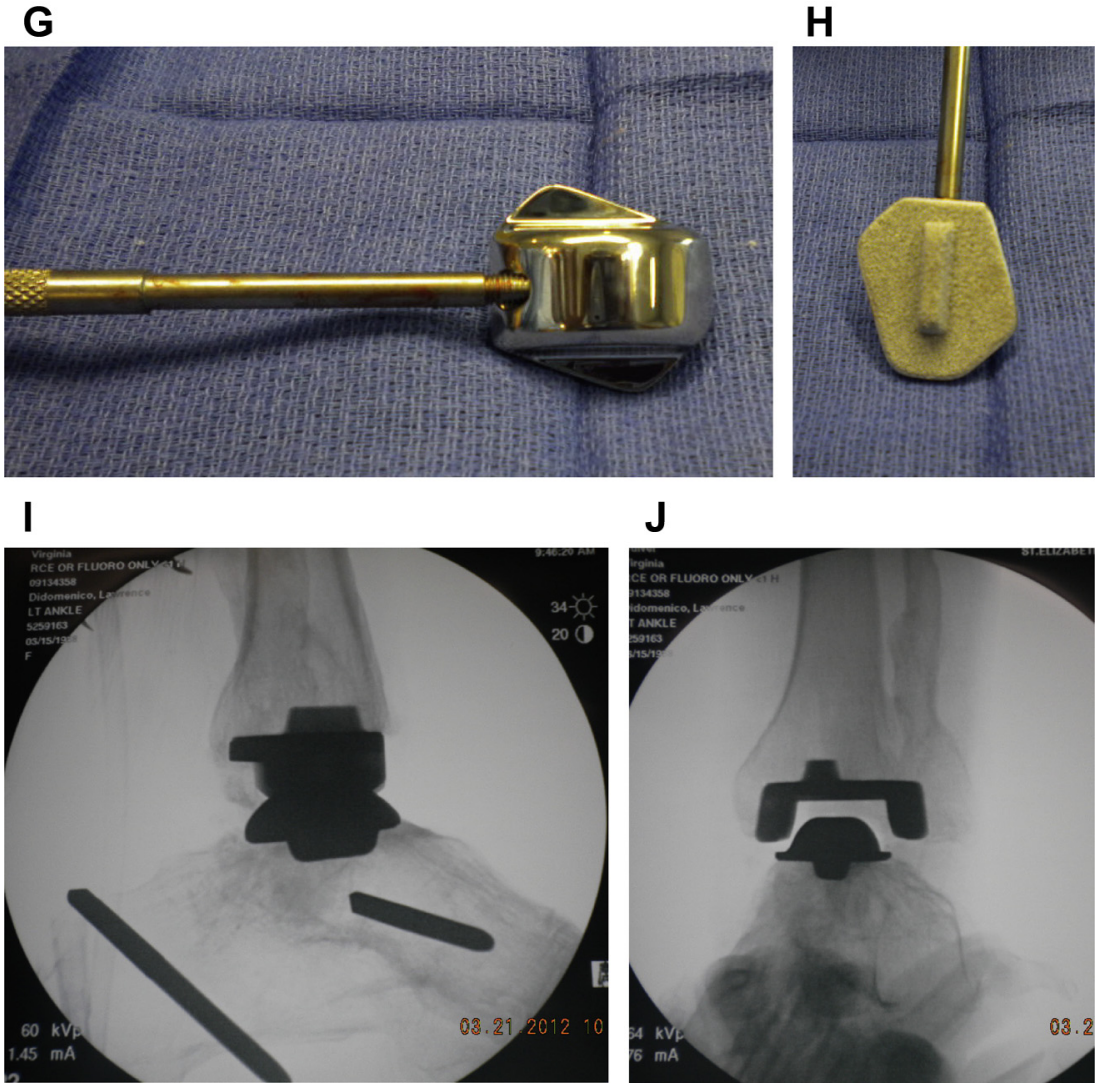

Fig. 8. (*continued*)

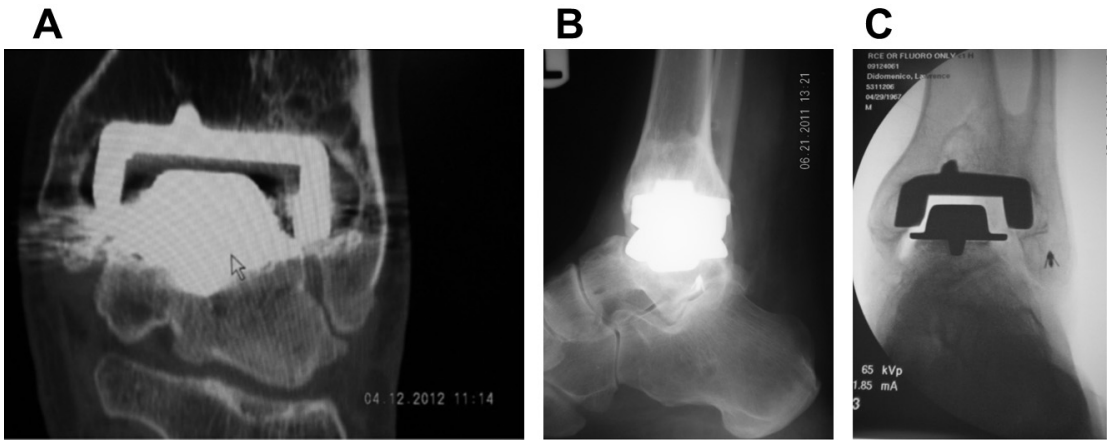

Fig. 9. (*A*, *B*) Preoperative CT scan and lateral radiograph demonstrating talar subsidence and bony overgrowth of the medial and lateral gutters. The bony overgrowth limited the range of motion of the ankle joint. (*C*) Intraoperative radiograph demonstrating a winged Agility talar low-profile component inserted and cemented with polymethyl methacrylate. The medial and lateral gutters were debrided decompressing the joint and allowing for increase in range of motion.

demonstrated bony clearing between the hydroxyapatite, implant, and bone in all the patients.

When performing a revisional-type surgery of TAR, replacement of the polyethylene meniscus may be necessary because of degradation of the component.[13] This is where implant design may affect the integrity of the device. Degradation may occur if the polyethylene does not fully conform to the bony components, if there is lack of capture by the other components to guide the polyethylene, or if it is larger than the surface of the tibial component.[34] Brooke and coworkers[17] in a case review of two patients undergoing revisional procedures for prior TAR noted deterioration specifically at the superiolateral aspect of the polyethylene piece in both patients, necessitating its removal. In addition to removal of the polyethylene, the same authors also recommended augmenting the revisional procedure by using a fibular-lengthening osteotomy if residual valgus deformity was present.

SUMMARY

Studies have demonstrated that the new generation of TAR systems provides superior patient satisfaction outcomes compared with prior systems and with ankle arthrodesis.[2] Ideally, a plantargrade foot type provides the optimal setting for application of TAR, and adjunctive procedures may be necessary to rectify concomitant biomechanical factors. If there is failure to address these areas, revisional procedures may be required.

A variety of TAR systems are available, and each has its own assets and pitfalls. When revisional or redo surgery is required, the standard main procedures consist of either joint arthrodesis or partial-total replacement of the implant. Additionally, soft tissue or bony debridement may prove useful for short-term or initial treatment. Arthrodesis is the modality chosen when there is inadequate bone stock or severe soft tissue compromise at the joint. A variety of methods to this procedure as previously described can be applied. Creativity can be used when exploring the implant replacement route, because it has been demonstrated that replacement of isolated or total implants can be performed with success, and hybridization of different implant systems.

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