Evaluation and Management of the Painful Total Ankle Arthroplasty

Abstract

Total ankle arthroplasty (TAA) is an increasingly popular treatment option for patients with end-stage ankle arthritis. Although improved short- and long-term clinical and radiographic outcomes have been achieved with TAA, revision surgery may be necessary in the setting of aseptic loosening, subsidence, impingement, arthrofibrosis, or infection. Factors such as patient selection, implant design, and surgical technique can all contribute to TAA failure. Treatment of patients with a painful TAA is complex and requires careful consideration of symptom history, workup, and nonsurgical and surgical treatment options. Surgical management of failed TAA includes arthrodesis, revision surgery, or below-knee amputation.

Major advances in total ankle arthroplasty (TAA), including implant design, surgical techniques, surgeon training, outcomes, and survivorship, have resulted in a resurgence in the use of and research on this procedure over the past two decades. Second- and third-generation implants that are currently used have improved features such as anatomic designs, enhanced modularity, and increased coronal and rotational stability, thus decreasing tensile and shear forces at the bone-prosthesis interface and improving wear patterns.

Although published results on TAA systems have largely noted good short-term clinical and radiographic outcomes, relatively high reoperation rates have also been reported. For most implant systems, failure rates of 10% to 20% have been reported within the first 10 years after primary TAA.

In a prospective, multicenter, controlled trial of the second-generation Scandinavian total ankle replacement (STAR) system (Small Bone Innovations), Saltzman et al reported that 11% of cases required secondary surgery within 2 years after index TAA, most commonly for débridement of bony impingement. In a study of 77 ankles treated with TAA using the STAR system, prosthetic survival rates of 70.7% and 43.6% at 10 years and 14 years, respectively, were reported, and 38% of ankles required revision of at least one metallic component. Management of failed TAA is challenging, and only a few series report on treatment options and outcomes. Given the increasing number of TAA procedures, continually expanding indications, and the variety of implant systems available, the burden of revision TAA will likely increase. Therefore, surgeons must be aware of the proper evaluation, workup, and nonsurgical and surgical interventions available for treating patients with a painful TAA.

History and Clinical Evaluation

Pain is the primary symptom that indicates early TAA failure. Pain
location, quality, and onset can provide useful information to clarify the underlying etiology and mechanism. Lack of any symptom relief after surgery may be indicative of an indolent deep infection, whereas progressive worsening of pain over time may point toward implant loosening and subsidence. Discomfort is often described as start-up pain or mechanical pain associated with increased physical activity. Intermittent periods of pain and swelling are more common in patients with limited preoperative range of motion (ROM) who are gaining mobility after surgery. However, this pain is not typically located in the ankle joint itself, but rather in periarticular structures that experience increased tension as motion improves.

The clinical examination should include evaluation of the surgical incision, tibialtalar and subtalar ROM, ligamentous stability, alignment, gait, and tenderness to palpation about the ankle gutters (ie, along the medial and/or lateral borders of the ankle joint). Gutter discomfort is typically seen in cases of chronic pain after TAA, but it can also appear early in the postoperative period with inadequate gutter débridement, which leads to impingement. Static and dynamic assessments of varus and valgus malalignment should be performed, observing the patient from the front and back as well as during gait. Vascular examination should focus on signs of venostasis or vasculopathy because poor blood flow may indicate poor wound healing potential if a revision becomes necessary. Neurologic examination should focus on the superficial peroneal nerve if an anterior approach was used for TAA and on the tibial or sural nerves if osteotomies for deformity correction were performed.

Subtalar arthritis should be considered in the differential diagnosis. An injection of 2 to 3 mL of a local anesthetic and a corticosteroid into the joint can be both diagnostic and therapeutic. Proper subtalar joint injection through the sinus tarsi should not inadvertently leak anesthetic into the ankle joint, and only small volumes of anesthetic should be used. Ankle stiffness and limited ROM are common complaints after TAA and may be influenced by preoperative motion, component sizing and positioning, soft-tissue and/or bony impingement, and arthrofibrosis. Ankle stiffness may exacerbate pain in the subtalar joint, and this contribution must be discerned from other etiologies of TAA failure.

Although the underlying source of ankle pain after TAA (ie, loosening, subsidence) is often clear on standard radiography alone, patients who have continued pain and normal radiographic findings pose a diagnostic challenge. Diffuse anterior ankle pain typically indicates component loosening, whereas medial or lateral pain indicates gutter impingement. CT of the ankle should be obtained for both diagnostic and therapeutic planning of any revision procedure. In rare cases in which imaging shows no pathology but patients have a tight joint with limited ROM, scant data exist to guide treatment options. In our experience, revision surgery for these cases often has unpredictable and unsatisfactory results. An intra-articular injection of anesthetic with a corticosteroid may improve symptoms, but relief is often temporary.

**Workup**

Workup for periprosthetic infection should be performed before that of other chronic pathologies. Serum white blood cell count and inflammatory markers including C-reactive protein level and erythrocyte sedimentation rate should be checked when patients present with new onset of pain or chronic pain after TAA.

Low-grade deep infection can present with nonspecific pain and normal radiographic findings without the classic signs of fever, open wounds, or soft-tissue erythema. Ankle joint aspiration can be useful to determine synovial fluid white blood cell count, polymorphonuclear cell percentage, and the presence of bacteria, particularly in cases of wound healing problems, draining sinuses, and recent systemic infection.

In patients with persistent pain despite normal laboratory values with a negative or dry aspirate, we have found that bone scan or single photon emission computed tomography can be useful for further evaluation. If either of these radiographic findings is positive, a clinical decision is needed to determine whether pain is caused by implant loosening that is not evident on radiography or subclinical infection. In these cases, we recommend reoperation to explore the joint for either component osteolysis or infection. It is important to note that bone scans have been shown to have variable rates of false-positive and false-negative results when used to diagnose periprosthetic loosening and/or infection. Therefore, a comprehensive history and physical examination and laboratory tests are essential for interpretation of bone scan findings to distinguish between potential underlying etiologies of pain. A synovial biopsy performed near the components is useful, and treatment is determined by cell count per high-power field. If >10 cells per high-power field are found in the early postoperative period (<4 weeks after index TAA), treatment should begin with extensive irrigation and débridement and polyethylene exchange followed by a 6- to 8-week course of culture-specific parenteral antibiotics. In cases of chronic infection, a two-stage revision procedure is necessary. To evaluate for adjacent joint degeneration, osteolysis, component
subsidence, malalignment, and cyst formation, serial weight-bearing views of the foot and ankle and hindfoot alignment views should be obtained. Weight-bearing flexion and extension views can be used to discern true motion in the ankle joint as opposed to the transverse tarsal joint. These views are particularly useful in patients with restricted ankle motion caused by periprosthetic fibrosis, overstuffing the joint, or a tight Achilles complex. Ballooning osteolysis can be a silent, progressive process that leads to implant loosening and failure and should be closely monitored on CT along with potential gutter impingement. The remaining talar bone, in particular, should be assessed on CT because significant bone loss at this level may preclude revision. Diagnostic ultrasonography is appropriate in situations where soft-tissue injury is considered in the differential diagnosis; MRI cannot be used to assess tendon ruptures or ligament insufficiency because of the metallic interference of the implant.

Aseptic Loosening and Subsidence

In a systematic review of 49 primary studies that evaluated TAA and ankle arthrodesis, Haddad et al\(^27\) reported implant survival rates of 78% and 77% at 5 years and 10 years, respectively. The revision rate for TAA was 7%. Component loosening and/or subsidence (28%) were the primary reasons for revision (Figure 1). Failure to correct coronal plane deformity and/or ankle instability can cause edge loading on the polyethylene component, leading to increased wear, component loosening, and failure.\(^22\) The diagnosis of implant loosening or subsidence is suspected when >5° or 5 mm of component movement is seen on serial radiography. However, these threshold measurements vary from surgeon to surgeon and there is limited evidence in the literature for their use. In addition to coronal plane deformity, malrotation of the talar component, with respect to the tibial component, creates increased contact stress and peak pressures on the polyethylene component during rotation ≥7.5°, thus potentially increasing wear.\(^28\)

Osteolysis and Cyst Formation

The development and progression of osteolysis is multifactorial because of a combination of mechanical and chemical processes, but its precise etiology largely remains unknown.\(^29-31\) Implant wear debris has been implicated in the progression of osteolysis, and increased hydrostatic fluid pressure in the joint further exacerbates the spread of the debris around the joint, expanding the effective tibiotalar joint space and progression of osteolysis.\(^30\) However, basic science research has shown that receptor activator of nuclear factor kappa-B ligand (RANKL) stimulates CD163+ RANK-expressing cells in periprosthetic tissues to move toward fusion, thus causing local formation of multinuclear foreign body giant cells.\(^33\) Therefore, periosteal osteolysis after TAA may be caused by RANKL-driven chronic foreign body inflammation targeted against necrotic autologous tissues instead of implant-derived particles.\(^31\)

Small, nonprogressive cysts can be caused by stress shielding and bone remodeling after implant insertion, whereas large progressive lesions are likely the result of a macrophage-led immune response to polyethylene and metal wear particles in the periarticular tissues.\(^15,32\) It is critical to evaluate for cyst formation on serial radiographs in the early postoperative period and monitor for evidence of progression over time. Radiographic lucency around an implant is defined as a lucent line <2 mm in width at the bone-implant interface; ballooning osteolysis is a lucency ≥2 mm.\(^33\) CT performed with metal artifact-reducing protocols is superior to radiography in detecting periprosthetic lucencies, and osteolytic lesions have been shown to be approximately three times larger on CT than on radiography.\(^33\) Lesions should be measured in three planes to calculate an affected volume and surface area in cubic millimeters.

Rapid cyst progression, particularly in symptomatic patients, warrants prompt intervention because it can progress to implant loosening and failure.\(^39\) In cases of slow osteolysis progression without symptoms, observation can be performed over a 6-month period, with a repeat CT scan obtained for evaluation. The onset of pain can be traced to microfracture caused by cortical lysis of cysts. Surgical options include curettage of cysts and bone grafting onto healthy bleeding bone with or without polyethylene component exchange or metal component.
If abnormal polyethylene wear is found and the surgeon is not able to exchange the polyethylene component because of a lack of implant availability or technical challenges, revision of all components using modern prostheses should be considered. Bonnin et al. reviewed 87 TAAs and, at an average follow-up of 8.9 years, found that 19 ankles (22%) had tibial or talar cysts >5 mm on CT. In eight patients, curettage of the cyst followed by packing with autograft and polyethylene exchange resulted in good cyst resolution and clinical outcomes.

Asymptomatic cysts pose a treatment dilemma because the likelihood of progression must be weighed against the benefits and risks of secondary surgery to prevent long-term failure. Currently, no evidence exists in the literature to support the management of asymptomatic cysts because it is difficult to predict how quickly cystic progression will occur. In situations where patients prefer to avoid additional surgery, the surgeon should emphasize the need for serial examinations and CT scans to evaluate the destructive nature of these cysts. In our experience, most cysts progress over time. If symptoms develop, the need for surgical intervention becomes more rational to the patient, and curettage and grafting can be performed before implant subsidence occurs. Although there is no specific cyst size to help the surgeon determine when intervention is warranted, we have found that cysts located directly inferior to the talar component are particularly concerning for subsidence. Medial tibial cysts are typically less concerning, but large cysts may lead to medial malleolar fracture and deltoid insufficiency. Large asymptomatic cysts in the talus or tibia are likely to cause fracture and must be managed with revision surgery.

**Impingement and Arthrofibrosis**

Overstuffing the ankle joint by using too large an implant, inserting a polyethylene component that is too thick, or leaving too much bone on the distal tibia can lead to early ankle stiffness and arthrofibrosis. Gutter impingement must be distinguished from arthrofibrosis because impingement is an isolated event that is generally easier to manage. Persistent soft-tissue impingement and synovitis can be managed surgically with arthroscopic or open débridement, synovectomy, and/or periarticular decompression. Postoperative arthrofibrosis can be treated with open arthrolysis, Achilles tendon lengthening, and/or gastrocnemius recession, with good pain relief and increased ROM reported. Gutter débridement in cases of symptomatic impingement must be thorough and typically requires additional bone débridement and scar tissue removal. In our experience, an additional posterior capsulotomy combined with gutter débridement can be useful for increasing ROM.

**Infection**

Reported rates of infection after TAA range from 1.2% to 3.5%. Periprosthetic infection is often associated with poor clinical outcomes and results in failure >50% of the time. In a series of 26 patients...
with confirmed periprosthetic joint infection, Kessler et al\textsuperscript{16} examined the risk factors for infection and found that history of previous ankle surgery, low preoperative American Orthopaedic Foot and Ankle Society ankle-hindfoot scores, and prolonged surgical time (eg, 119 minutes) were associated with higher infection rates. Management of septic TAA failure requires two-stage revision with an antibiotic cement spacer and culture-specific parenteral antibiotics followed by either revision TAA, hindfoot arthrodesis, retention of cement spacer, or below-knee amputation.

Ferrao et al\textsuperscript{37} examined six patients with postoperative deep infection after TAA. The antibiotic cement spacer was retained as definitive treatment after a 6-week course of intravenous antibiotic therapy. All patients were low demand, had multiple comorbidities, and, at final follow-up (20 months), were mobile and able to perform basic activities of daily living with minimal pain. In patients with higher levels of activity, it is preferable to replace the cement spacer with an ankle prosthesis to obtain better clinical outcomes once the infection has been eradicated. Myerson et al\textsuperscript{35} evaluated 19 cases of infection following primary or revision TAA that required removal of the ankle prosthesis for acute postoperative infection (3 cases), late chronic infection (15 cases), or acute hematogenous infection (1 case). Implant salvage was attempted in the cases of early postoperative and acute hematogenous infection, but all ultimately required complete prosthesis removal. The mean follow-up after prosthesis removal was 19 months. The authors reported successful outcomes in 3 of 19 patients who underwent revision with replacement, 6 treated with arthrodesis, 7 treated with a permanent antibiotic spacer, and 3 treated with below-knee amputation.\textsuperscript{34}

### Nonsurgical Management

After TAA, soft-tissue inflammation associated with increased physical activity can be managed nonsurgically with oral NSAIDs, activity modification, and immobilization with a lace-up ankle brace or a CAM boot. Physical therapy, with a focus on stretching and strengthening, may help alleviate symptoms. A local injection of anesthetic and a corticosteroid can help relieve pain related to synovitis or subtalar arthritis. Nonsurgical management plays a limited role in management of failed TAA with chronic pain. Older, low-demand patients with significant surgical or medical comorbidities may elect for prolonged immobilization in a CAM boot or brace, but this treatment should be tailored to the individual needs of the patient.

### Surgical Management

Surgical management of failed TAA includes three primary interventions: arthrodesis of the tibiotalar or tibiocalcaneal joints, revision TAA, and below-knee amputation in severe cases. Arthrodesis often requires structural bone block grafting with internal fixation and has a higher rate of failure and worse functional outcomes compared with those of primary arthrodesis.\textsuperscript{38} Given the functional limitations of arthrodesis, revision TAA has emerged as a viable alternative, with promising outcomes recently reported in the literature.\textsuperscript{20,21,39} Fully informing patients of the risks and benefits of each intervention and tailoring treatment to their desires and needs is paramount.

The decision-making process for selecting arthrodesis versus revision TAA varies and is based on surgeon experience, with case series of revision TAA recently reported in the literature.\textsuperscript{20,21} We prefer revision TAA with another prosthesis in the following settings: (1) it is technically achievable in the presence of a viable soft-tissue envelope, (2) there is adequate remaining bone stock, (3) good ROM is present, and (4) the patient is compliant and requires early ambulation. In patients with stiff and painful ankles following failed TAA or massive bone loss associated with fractures, we believe that definitive treatment with arthrodesis provides better outcomes and patient satisfaction.

### Arthrodesis

Primary or staged tibiotalar arthrodesis is appropriate for cases of severe osteolysis, component subsidence, and severe talar bone loss. Soft-tissue quality is a key factor to consider when creating a surgical plan to convert failed TAA to ankle arthrodesis. If the anterior skin is viable and healthy, it is better to reuse the anterior approach. However, in the setting of prior skin healing issues or vascular dysfunction, it is preferable to perform arthrodesis through a lateral or posterior approach. In failed TAA, the talus is typically loose and easy to remove with an osteotome, but the tibia can be firmly in-grown, making it difficult to remove while preserving as much of the native bone as possible. Tibiocalcaneal fusion is recommended in cases of severe subtalar arthritis and pain, large talar bone loss, and nonreconstructable subsidence of the talar component into the subtalar joint.

Management of massive bone loss and achieving rigid fixation are the two biggest issues in conversion of TAA to ankle fusion. Berkowitz et al\textsuperscript{18} suggested using different bone grafting strategies after removal of the implant and nonviable bone and joint surface preparation based on the available talar bone stock. A standard tibiotalar arthrodesis with local autograft or allograft...
supplementation can be performed if a bone defect <2 cm in size is present and there is no significant limb-length shortening. It is critical to address any malleolar impingement that may occur during compression across the joint because impingement may prevent union and correction of malalignment and can be a source of postoperative pain and functional limitation.\(^4\) If talar bone loss is >2 cm, structural bone grafting is necessary to provide a stable fusion construct, restore limb length, and maintain anatomic alignment.

Commonly used bone grafts include tricortical iliac crest and fibular autografts as well as distal tibia, iliac crest, and femoral head allografts.\(^38,41\) Femoral head allograft is readily available, and it can be used to manage massive bone defects, with an acetabular reamer used to prepare host bone and allograft. Den Hartog and Palmer\(^42\) described a novel technique for bone preparation in which a reverse reamer is used on the femoral head and a standard acetabular reamer is used on the surface of the remaining talus and calcaneus (Figure 2). This creates congruent surfaces for bone apposition, allows for easy adjustment of rotation, and preserves the strength of the potentially weaker allograft bone by reaming only into the subchondral surface of the femoral head.

Internal fixation of the fusion site in situ can be achieved with a variety of techniques, including anterior, lateral, or posterior plating. More rigid fixation is necessary if structural allograft is used to achieve bony incorporation through creeping substitution.\(^43\) Fusion constructs can be supplemented with linear or circular external fixation for compression across the fusion mass or to help correct limb-length discrepancy through distraction osteogenesis at a separate, proximal location.\(^44,45\) In these select cases, it is important to preoperatively educate and inform patients regarding the potential lengthy rehabilitation and daily pin-site care required with external frames. If tibiotalocalcaneal arthrodesis is required, fixation may include a fusion nail, locking plate, blade plate, or hybrid construct.

Rates of nonunion following conversion of failed TAA to arthrodesis using various surgical techniques range from 11% to 42%.\(^46-49\) Berkowitz et al\(^38\) reviewed 12 TAAs converted to isolated ankle fusion and 12 treated with ankle-hindfoot fusion. Isolated ankle fusions were stabilized with an anterior plate and screws, with successful union reported in all but one case. Ankle-hindfoot fusions were performed using an anterior plate and screws, intramedullary nail, or combination of the two. Only 7 of 12 patients (58%) achieved union and 4 patients had subtalar nonunion.

**Revision TAA**

In all revision cases, emphasis is placed on achieving a plantigrade foot below the revision prosthesis. This is achieved through osteotomies, ligament reconstructions, and tendon transfers in a combined or staged fashion. The surgeon must examine the hindfoot and forefoot carefully for bony balance, using axial fluoroscopic images to evaluate heel position and the balance of the metatarsal heads. Simply revising the prosthesis and ignoring an abnormal foot position or ligament laxity often leads to early failure and poor clinical and radiographic results.

The most challenging issues in revision TAA are achieving solid tibial and/or talar fixation on residual bone stock without violating the subtalar joint, restoring ligamentous tensioning, and correcting hindfoot/forefoot alignment. The status of the soft-tissue envelope is a key aspect of revision surgery that directs the surgical approach to avoid potential wound complications. Full-thickness flaps should be used, with identification of as many surrounding neurovascular structures as possible because these structures are often adhered to adjacent structures in nonanatomic locations. Iatrogenic nerve injury can be a significant source of postoperative pain and can easily occur in the multiply operated ankle because nerves are often encased in scar tissue. It is critical to carefully remove all periarticular scar tissue and release the surrounding capsule, ligaments, and tendons as much as possible to restore ankle mobility and the anatomic center of rotation. For revisions in which components are removed, it is helpful to insert a large laminar spreader to distract the joint and then access and remove the posterior joint capsule.

Most modern TAA implant systems require an anterior surgical approach, and the surgeon must be prepared for potential prior violation of the anterior tibial artery. Saw cuts for certain implants can result in damage to the posterior tibial artery that is not always obvious. The surgeon must promptly recognize violation of this artery because it may stop the collateral flow and compromise the extremity in the setting of anterior tibial artery violation or clotting after revision surgery. In addition, the patient must be prepared for additional sensory loss following revision surgery because superficial nerves are often entrapped in scar tissue and are not definable despite careful dissection. If suspicion of vascular insufficiency exists, a noninvasive Doppler ultrasound study should be performed.

The tibial component can be revised to an alternative prosthesis if adequate medial and lateral bone support is available along with a healthy cancellous bone base of >50% of the tibial articular surface.\(^22\) However, there is often minimal bone remaining.
on the medial malleolus and fibula. In these cases, it is possible to circumvent this bone loss through the use of a stemmed, intramedullary referencing TAA system.\textsuperscript{50,51} A modular, stemmed intramedullary tibial implant provides stable fixation of bone defects and has the advantages of a larger bone-implant surface area, adjustability to match individual bone defects, and insertion through the tibial canal rather than through an anterior bone window. Bulk allograft should be used sparingly in revision surgery to provide bony ingrowth because the interface with the prosthesis is of poor quality.

The use of bone graft behind a revision tibial implant or a thicker polyethylene component may compensate for the loss in tibial height to prevent symptomatic leg-length inequality. Bone defects inferior to the weight-bearing surface of the tibial base plate can be grafted and impacted in place for structural support before insertion of revision components.\textsuperscript{22} Large bone defects can be filled with a variety of grafts including iliac crest and proximal tibial metaphysis autograft, allograft chips, fresh-frozen allograft, or demineralized bone matrix.\textsuperscript{52} Any remaining gaps at the bone-implant interface should be completely filled and sealed from wear particles to reduce cyst formation.\textsuperscript{22}

**Figure 2**

Mortise (A) and lateral (B) weight-bearing radiographs of the ankle demonstrating tibial and talar component osteolysis and loosening with concurrent subtalar arthritis after total ankle arthroplasty with a Scandinavian total ankle replacement implant. The patient elected to undergo tibiotalocalcaneal arthrodesis with bulk femoral head allograft. A fibular osteotomy was performed using medial and lateral plate fixation in addition to lag screws. Postoperative AP (C) and lateral (D) radiographs 3 months after surgery showing good hardware alignment without evidence of failure or graft collapse. E, Coronal CT of the ankle showing successful fusion with spot welding. (Courtesy of Bryan Den Hartog, MD, Des Moines, IA.)
Talar component revision can be achieved with a standard component of the same implant design or a different design, but it is generally more difficult than tibial revision because of the lack of talar bone stock and its relatively small size as well as the delicate blood supply (Figure 3). The degree of subsidence, osteolysis, and cyst formation should be considered when choosing a talar implant for the revision procedure. Talar subsidence should be evaluated in relation to its location relative to the subtalar joint; this will help to direct surgical planning. Custom long-stemmed talar implants for revision of failed TAAs are not currently approved for use by the FDA despite previous reports showing better force distribution and good initial clinical outcomes. Subsidence slightly above, at, or below the subtalar joint requires structural bone grafting of the inferior aspect of the talus (Figure 4).

Patients with limited subtalar ROM and pain secondary to arthritis require a subtalar arthrodesis at the time of revision TAA. Arthrodesis may be compromised by both a lack of sufficient bone quality for adequate fixation and dysvascularity to the talus caused by superior and inferior surgical approaches (for the TAA and subtalar arthrodesis, respectively). Subtalar arthrodesis with existing implants can be performed through a posterior approach, thus allowing access to most of the posterior facet without compromising the blood supply to the sinus tarsi. It may be easier to perform such an arthrodesis in a staged manner before revision TAA so that the fusion mass can be confirmed on CT before implant revision. This strategy allows the prosthesis to be implanted in a routine fashion, with good bone stock available for structural support.

Various TAA systems allow for size mismatch of the tibial and talar components. This makes it possible to insert a larger talar implant to compensate for bone loss and increase the force distribution across the remaining talus without having to revise the tibial component if it is well fixed. However, the surgeon must be careful not to overstuff the joint with a talar component that is too wide because the prosthesis will create medial and lateral gutter impingement and ultimately limit motion. Similar to tibial component revision, talus impaction grafting along with a thicker polyethylene component after coronal balancing can be used to address loss of bone height.

Hintermann et al. reviewed a series of 83 patients who underwent revision TAA. The average follow-up was 5.4 years, and the authors reported good to excellent results in 69 patients (83%), with 47 patients (56%) pain free at final follow-up. The overall loosening rate was 6%, and revision TAA was deemed to be a promising option for select patients with failed TAAs. In a follow-up study, the same authors reviewed a series of 117 failed TAAs with several different implant systems after an average of 4.3 years. The tibial component was revised in 106 cases (91%), and the talar component was revised in 104 cases (89%), with further revision surgery necessary in 14 cases (15%) because of loosening. Survival of the revision TAAs at 9 years was 83%, with component loosening used as the end point.
In a series of 41 patients who underwent revision TAA with the Agility ankle implant (DePuy) at an average of 4.2 years after the index surgery, revision arthroplasty was converted to arthrodesis in 5 patients and 2 underwent below-knee amputation. Of the remaining patients, 22 (54%) had a subtalar arthrodesis at the time of revision TAA, and 19 received a custom long-stemmed talar implant to compensate for the degree of deformity and bone loss. The authors found that lower levels of preoperative talar subsidence were a predictor of a good outcome after revision surgery based on American Orthopaedic Foot and Ankle Society ankle-hindfoot scores. They proposed a grading system for talar subsidence, with grade 1 indicating no subsidence, grade 2 indicating the presence of subsidence but not to the level of the subtalar joint, and grade 3 representing subsidence to the level of or inferior to the subtalar joint.

**Future Directions**

Revision TAA systems with modular, adjustable components are likely to become important given the current limitations on custom implants. Patient-specific surgical plans and cutting guides using preoperative CT may prove valuable in revision cases to reduce procedural complexity and increase surgical efficiency. Treatment of patients with a failed TAA is complex and warrants investigation to further improve surgical technique and implant design. Vigilant surveillance and national TAA registries are necessary to help provide accurate and up-to-date information regarding short- and long-term outcomes and survivorship of primary and revision TAAs using different implant systems.

**Summary**

TAA has become a viable alternative to tibiotalar arthrodesis for management of ankle arthritis. Indications for ankle arthroplasty have expanded to include younger patients and patients with greater deformity. With the growing number of TAA procedures being performed, the number of failures will likely increase as longer follow-up is obtained and components reach their life spans. Surgical management of failed TAA consists of ankle or hindfoot arthrodesis, revision TAA, or amputation. Treatment of patients with a painful TAA requires careful consideration of symptom history, workup, and nonsurgical and surgical interventions.

**References**

*Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, references 5 and 19 are level II studies. References 25, 33, and 36 are level III studies. References 2-4, 6-18, 20-24, 26-32, 34, 35, 37, 38, and 40-54 are level IV studies. References 1 and 39 are level V expert opinion. References printed in bold type are those published within the past 5 years.*


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