Evaluating and Managing the Painful Total Ankle Replacement

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Abstract

The number of total ankle replacements (TARs) performed in the United States has dramatically increased in the past 2 decades due to improvements in implant design and surgical technique. Yet as the prevalence of TAR increases, so does the likelihood of encountering complications and the need for further surgery. Patients with new-onset or persistent pain after TAR should be approached systematically to identify the cause: infection, fracture, loosening/subsidence, cysts/osteolysis, impingement, and nerve injury. The alignment of the foot and ankle must also be reassessed, as malalignment or adjacent joint pathology can contribute to pain and failure of the implant. Novel advanced imaging techniques, including single-photon emission computed tomography and metal-subtraction magnetic resonance imaging, are useful and accurate in identifying pathology. After the foot and ankle have been evaluated, surgeons can also consider contributing factors such as pathology outside the foot/ankle (eg, in the knee or the spine). Treatment of the painful TAR is dependent on etiology and may include debridement, bone grafting, open reduction and internal fixation, realignment of the foot, revision of the implants, arthrodesis, nerve repair/reconstruction/transplantation surgery, or, in rare cases, below-knee amputation.
Level of Evidence: Level V, expert opinion or review.

Keywords: total ankle replacement, total ankle arthroplasty, complications, subsidence, lucency, osteolysis, cysts, ankle arthritis

The number of total ankle replacements (TARs) performed in the United States is rapidly expanding, from under 200 per year in the 1990s to more than 4000 annually in the 2010s,[43] with unpublished projections of nearly 10 000 to 13 000 by the 2020s. This increase is associated with improvements in implant design and techniques, which have led to expansion of indications and patient candidacy. The past decade has ushered in many newer designs of TARs. In addition, there has been development of new and refined revision TAR techniques, novel patient-specific instrumentation systems, and advanced imaging modalities to evaluate TAR.[17,39,68] Unfortunately, as the prevalence of TAR increases, so does the likelihood of encountering complications and the need for further surgery. Therefore, this review has two objectives: first, to describe the evaluation and management of the painful TAR, including workup, imaging, diagnosis, and treatment options, and, second, to develop an algorithmic approach that is applicable to all orthopedic foot and ankle providers treating patients with pain after TAR (Figure 1).
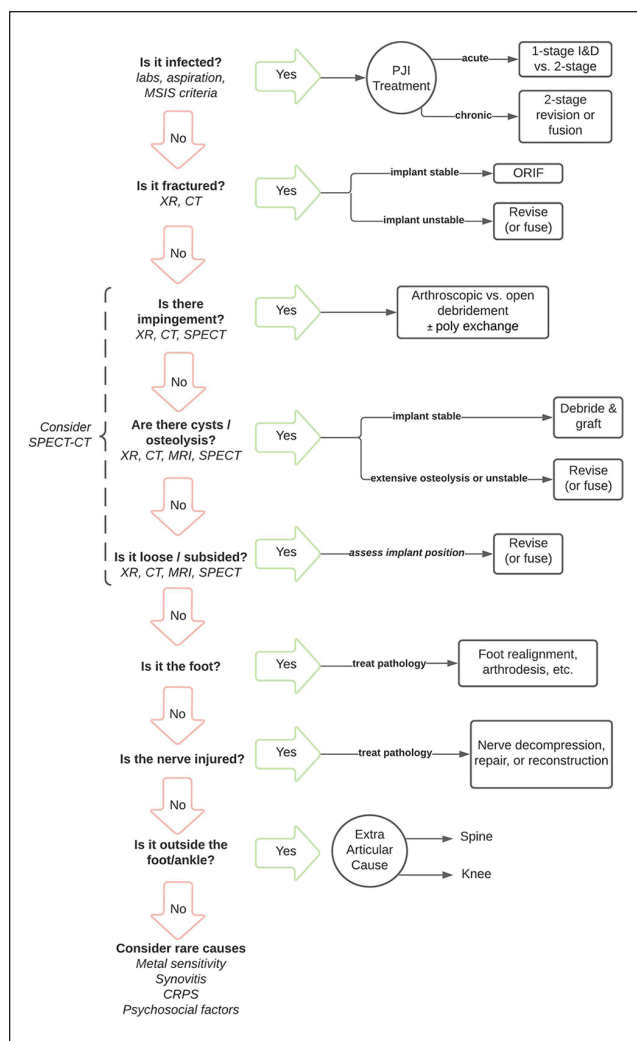
Evaluating the Painful TAR

Evaluation of any patient begins with a careful history and physical examination. The provider should clarify when the pain started (immediately after the TAR or more recently) and the anatomic location, as well as any inciting injuries or events. Pain should also be analyzed using a validated tool like the visual analog scale (VAS) or the pain interference subsection of patient-reported outcome measures. Timing of the pain may also elucidate the etiology—startup pain is associated with a loose implant, whereas pain with increased activity may signify gutter impingement or stress reaction.[110] Standing alignment must be assessed. Palpation, especially over the medial and lateral gutters, tibia, talus,

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Figure 1. Algorithm detailing systematic evaluation and management of the painful total ankle replacement. CRPS, complex regional pain syndrome; CT, computed tomography; I&D, irrigation and debridement; MRI, magnetic resonance imaging; MSIS, Musculoskeletal Infection Society; ORIF, open reduction internal fixation; PJI, periprosthetic joint infection; SPECT, single-photon emission computed tomography; XR, x-ray.

subtalar joint, and ankle joint, may identify areas of concern. A proper neurovascular exam should be conducted. Finally, weightbearing radiographs, including a hindfoot alignment view, should always be obtained and compared to prior images.

Is It Infected?

Initial evaluation of any painful TAR should rule out periprosthetic joint infection (PJI). If severe, the patient may present with a red, swollen, warm, and tender ankle

and systemic symptoms. However, many PJIs present more indolently and must be considered in any patient presenting with pain. As a result, even in patients undergoing revision TAR for aseptic failure, surgeons are recommended to obtain intraoperative cultures to rule out indolent infection.[27] It is imperative to clarify the timing of symptoms with regards to the index TAR to determine if this is an acute early postoperative infection, an acute hematogenous infection in a TAR that was previously doing well, or a chronic PJI.

Initial laboratory evaluation includes serum inflammatory markers: C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and white blood cell (WBC) count with percentage of polymorphonuclear leukocytes (PMNs).[79] The utility of serum D-dimer as a diagnostic criterion has been described in the total hip/knee replacement literature as comparable to serum CRP, but this has not been evaluated in the TAR literature.[79]

If there is clinical concern for infection, the next step is joint aspiration to assess synovial WBC count and PMN percentage. Additional useful tests can include identification of the presence of leukocyte esterase and α-defensin.[2] Synovial α-defensin was 100% sensitive, 94% specific, and 94% accurate in diagnosing PJI in TAR.[103] Aspiration may be performed by the surgeon or radiologist via image guidance to ensure an adequate sample. There are limited data in the TAR literature regarding the utility of saline lavage and reaspiration after a dry tap. Based on total hip/knee literature, lavage and aspiration may dilute the synovial WBC count and render it nondiagnostic; however, the PMN percentage remains consistent and is therefore a useful tool for PJI diagnosis.[44]

PJI is classically defined by the Musculoskeletal Infection Society (MSIS) criteria, which use a combination of major criteria (positive cultures, sinus tract with communication to the joint) and minor criteria (elevated serum/synovial values) to establish the diagnosis.[79] These criteria were developed based off of PJI in total hip and knee replacements and do not account for the thinner soft tissue envelope of the foot and ankle or other potential differences between total hip/knee replacement and TAR.[45,79] Nonetheless, due to the limited number of TAR-specific objective data, they are commonly applied to TAR PJI studies.[45]

The overall rate of deep infection after TAR is reported to range from 0% to 6.7%.[34,57,75,116] The timing of the TAR and symptoms is key. Acute infections are characterized as either early postoperative or acute hematogenous, with symptom duration fewer than 4 weeks.[64,75] In acute cases, debridement, antibiotics, and implant retention (DAIR) with polyethylene exchange is often attempted first. Chronic infections are classically treated with 2-stage revision, starting with removal of all implants and insertion of an

antibiotic cement spacer, followed by at least 6 weeks of intravenous antibiotics. The second stage may consist of reimplantation with a revision TAR implant, conversion to arthrodesis, definitive retention of the antibiotic spacer, or below-knee amputation (BKA).[62]

In a small series of earlier generation implants, implant retention after DAIR was abysmal, with all patients going on to revision TAR, tibiotalocalcaneal (TTC) fusion, or permanent antibiotic spacer.[75] In a more recent series of 14 acute hematogenous infections treated with DAIR, the long-term failure rate was 54%[64]; this is somewhat higher than the approximately 35% to 50% failure rate from the total hip and knee replacement literature.[10,64,105] Similar to hip/knee PJI, though, the success of DAIR in TAR is associated with a shorter time period from symptom onset to operative irrigation and debridement, as well as with less virulent organisms, such as methicillin-sensitive *Staphylococcus aureus* compared to methicillin-resistant *S aureus*.[10,64,105]

Individual studies of chronic ankle PJI are low-powered. In a meta-analysis of 6 studies representing 105 infected TARs, 11 patients (10%) had reinfections after operative treatment of any kind.[62] Of the 22 total patients treated with 2-stage revision, though, the reinfection rate was 0%.[62] Similarly, in a single-center series of ankle PJI, the 10 patients who were treated with exchange of the tibial and talar components all went on to infection-free survival.[57] Unfortunately, clinical outcomes data after staged revision TAR are limited.[62,75]

Definitive antibiotic cement spacer has also been described after chronic ankle PJI. Noninfectious complications are not consistently well recorded, but after definitive antibiotic cement spacer, 18% of patients experienced noninfectious adverse events and 22% went on to BKA.[62] While some authors have described minimal pain, full weightbearing, and satisfied patients after cement spacer, others have described complications including spacer fracture and conversion to BKA.[62,75] After arthrodesis, 3 of 13 patients in this cohort went on to BKA.[62]

Unfortunately, the literature has only limited case series with small numbers of infected TARs, so broad conclusions about optimal strategies and outcomes are difficult. Moreover, rates of infection and successful outcomes after PJI may change with newer implant designs and shorter operative times, especially as our techniques, extent of surgical dissection, and implants improve.[58,75] In general, the literature supports high rates of infection eradication following 2-stage revisions with antibiotic cement spacer and satisfactory infection eradication for acute infections with low-virulence microorganisms via DAIR (Figure 2). However, the ultimate outcome may not include a TAR, and patients should be prepared accordingly.
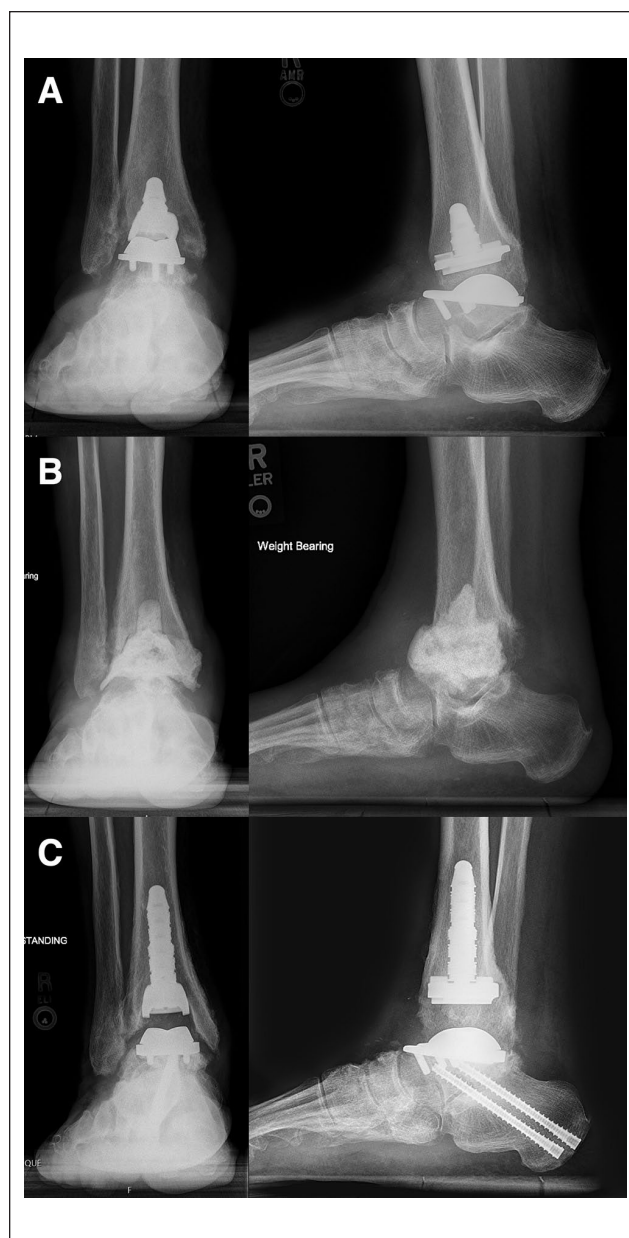
Figure 2. (A) This 62-year-old man presented with systemic symptoms, severe pain, redness, swelling, and purulence 2 months after his index total ankle replacement (TAR). His C-reactive protein and erythrocyte sedimentation rate were elevated at 18 and 88, respectively. (B) Although his symptoms were relatively acute, given the severity of infection and abscess, he was treated with a 2-stage revision (the first stage was an antibiotic spacer) and intravenous antibiotics for methicillin-resistant *Staphylococcus aureus* infection. He was maintained on chronic suppressive antibiotics for 1 year after surgery. (C) At his most recent follow-up 2 years after the second stage of the revision, which included conversion to a stemmed implant and a subtalar fusion, he was doing well with retention of the revision TAR.
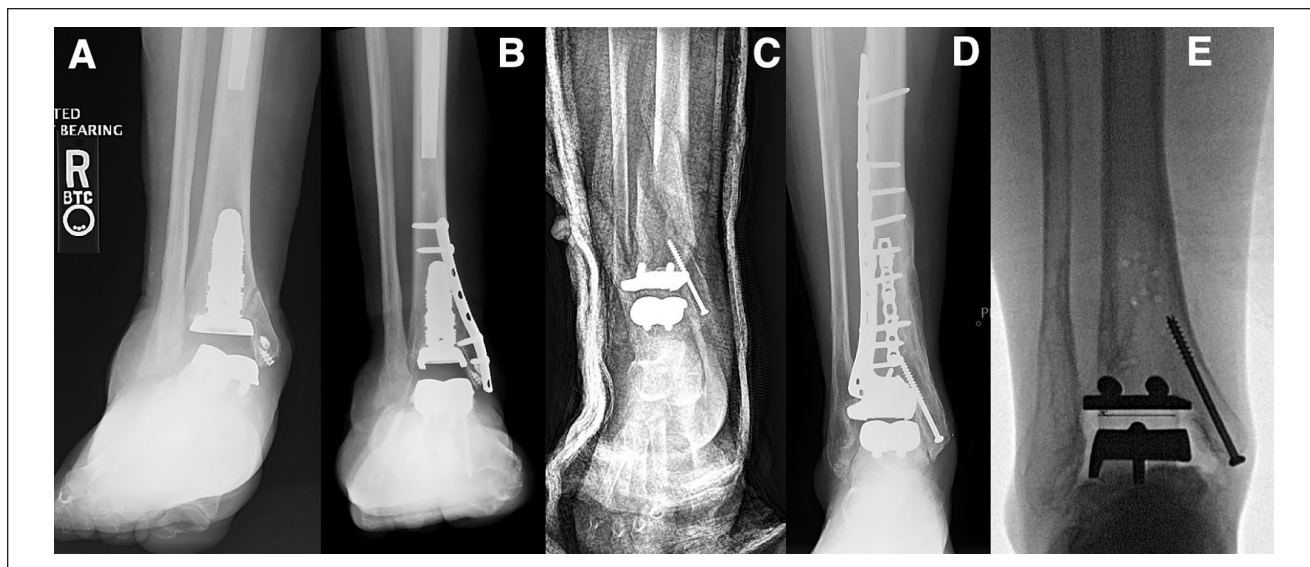
Figure 3. Periprosthetic fractures around a total ankle replacement may require (A, B) fixation with open reduction internal fixation (ORIF) and implant revision, (C, D) implant retention with extra-articular ORIF, or (E) percutaneous screw fixation for isolated nondisplaced injuries at the medial malleolus.

Is It Fractured?

Periprosthetic fractures occur after approximately 2% to 4% of primary TAR cases and can be a significant source of pain (Figure 3).[12,65,69] Intraoperative fractures that arise during TAR typically involve internal fixation during the index procedure and will therefore not be discussed in this section. Postoperatively, the medial malleolus is the most common periprosthetic fracture location, followed by the tibial diaphysis, talus, and fibula.[12,65,69] Few studies have investigated the effects of periprosthetic fracture on clinical outcomes, but when an appropriate treatment algorithm is followed, these fractures do not necessarily lead to worse outcomes.[65,106]

Initially, it is important to rule out a pathologic fracture that has occurred in the setting of an occult infection, although this is rare.[65] Certain conditions such as rheumatoid arthritis, chronic kidney disease, prolonged steroid use, endocrinopathies, and collagen disorders can lead to abnormal bone mineral density (BMD) and also increase the risk of fracture.[108] Lower tibial BMD, measured using Hounsfield units (HU) on preoperative computed tomography (CT) scans, was strongly associated with periprosthetic fracture risk.[12]

Plain radiographs, CT, metal artifact reduction magnetic resonance imaging (MRI), and single-photon emission CT (SPECT) may all play a role in the radiologic workup of periprosthetic fracture.[18,77] SPECT, which combines the anatomic features of CT with the function of nuclear medicine bone scans, may be especially helpful for detecting bony stress reactions after TAR.[39]

Fracture location is important to note on imaging studies. Medial malleolar fractures do not typically compromise implant stability, but talus fractures frequently create an unstable implant construct.[65] The presence of osteolysis, cysts, and implant malalignment/subsidence should also be noted.

Two recent studies have developed treatment algorithms that incorporate fracture location and implant stability to guide the management of periprosthetic fractures after TAR.[65,69] Radiographic implant instability in both of these studies was defined as osteolysis around the implant or evidence of loosening and/or subsidence related to the fracture.[65,69] Implant stability should also be assessed intraoperatively when applicable.[65] The timing of the fracture after the index procedure should be elucidated, because less time to fracture is a positive predictor of implant instability: fractures occurring closer to the index procedure may lead to instability because of inadequate healing of the surrounding bone to the implant.[65] Ultimately, however, postoperative outcomes after periprosthetic fracture treatment are usually satisfactory even in cases of implant instability.[65,106]

Nonoperative treatment of periprosthetic fractures has been shown to be an independent predictor of treatment failure.[65] In one series, up to 80% of periprosthetic fractures with stable implants that were initially treated nonoperatively with immobilization ultimately required operative intervention.[65] Periprosthetic fracture nonunion, which can lead to persistent pain and disability, is a major concern with nonoperative management.[65,71] Therefore, unless a patient is medically unfit for surgery, operative

management of periprosthetic fractures should be recommended.[65] Fractures that are radiographically and clinically stable at the time of surgery, especially those that involve the medial malleolus, tibial shaft, and fibula, can be successfully treated with open reduction and internal fixation.[65,69] Fractures that lead to implant instability, especially fractures involving the talus, are better served with revision TAR or conversion to arthrodesis.[65] Patient-reported pain and functional outcomes have been favorable in the short to mid-term when following the aforementioned treatment algorithms, but large, high-quality, long-term outcome studies are needed to better define the optimal management strategy of periprosthetic fractures after TAR.[65,69,106]

Is There Impingement?

Bony or soft tissue impingement is the most common cause for reoperation following TAR.[16] Impingement in the gutters can compromise the results of an otherwise well-positioned, well-fixed TAR. Patients with impingement present with a characteristic history of pain and focal tenderness to palpation over the medial and/or lateral gutter, exacerbated by activity. Bony proliferation and heterotopic ossification can lead to pain and stiffness in the ankle.[46] Plain radiographs may not be conclusive, but SPECT may reveal the diagnosis with increased uptake at the gutter(s) (Figure 4).

A wide range of factors are implicated as causes of impingement, including implant malposition/malrotation, persistent varus/valgus malalignment, overstuffing the joint (often due to oversizing of the talar component), insufficient ligamentous balancing, implant subsidence, heterotopic ossification, or movement of the polyethylene insert in mobile-bearing designs.[35,55,92] For patients with symptomatic impingement, malposition and malalignment must first be ruled out. Aside from these, a major cause of impingement is the failure to adequately debride the gutters at the index TAR.[35] Rates of reoperation for symptomatic impingement range from 7% to 18%.[11,50,92] However, in a study of more than 300 modern implants, the reoperation rate was 18% if the authors did not perform a gutter debridement at the time of the index surgery; this rate dropped to 2% if the gutters had been debrided initially.[92]

Heterotopic ossification (HO) and bony proliferation have been described after TAR and also cause impingement.[13,55] HO is typically seen posterior to the implant, although it has also been described anteriorly.[13,46,55] HO has been associated with inadequate coverage (ie, undersizing of the tibial and/or talar components) and patients with osteoarthritis due to posttraumatic causes.[13,46,55]

Once impingement is identified as the source of pain, the surgeon may choose to treat it open or arthroscopically. In a study of 1000 TARs with a 7.5% reoperation rate for impingement at a mean of 2.4 years after the index surgery, the group of authors used both open and arthroscopic techniques depending on the patient and pathology.[35] Among patients who required additional procedures at the time of debridement (eg, bone cyst grafting, calcaneal osteotomy, subtalar fusion, ligamentous repair), the authors performed open debridement with polyethylene exchange; when patients did not require any additional procedures, the authors exclusively performed arthroscopic debridement.[35] Overall, debridement resulted in excellent improvement in pain, with 84% of patients asymptomatic at 1 year after debridement.[35] However, there was a nonsignificant trend toward revision debridement in arthroscopic (11.5%) vs open (4%) surgery.[35] At our institution, we favor open gutter debridement and concomitant polyethylene exchange, regardless of the need for additional procedures.

Are There Cysts/Osteolysis?

Periprosthetic osteolysis and cysts are common after TAR, and their sequalae can cause significant pain and, ultimately, implant instability. Periprosthetic cysts can be challenging to treat because they are often not painful until the implant becomes loose. Moreover, some implants preclude adequate radiographic assessment of cysts beneath the metal on plain radiographs and therefore require CT for diagnosis and evaluation. In early generations of TAR, osteolysis was frequent and aggressive, and it caused extensive bone loss and implant failure.[7,38] Although this has substantially improved with newer generations of TAR design, osteolysis—and its potential for loosening and subsidence—is still a primary concern.[16,60,73] Importantly, osteolysis and cysts may be asymptomatic but still problematic; management of these cases has been detailed elsewhere.[30,73,86]

Osteolysis is associated with multiple processes: the presence of intracellular and extracellular polyethylene particles; the activation of the receptor activator of nuclear factor κ-B ligand (RANK-L) pathway; the inflammatory deluge of macrophages, giant cells, and lymphocytes; and the release of proinflammatory cytokines that recruit osteoclasts.[8,23,33,91,93] In one series of patients revised due to osteolysis, the number of polyethylene particles counted in cysts did not correlate with the length of time from index surgery to revision, suggesting that osteolysis is not purely time dependent but also related to factors such as biomechanical alignment, implant design, and local anatomy and physiology.[109]

The most common presenting complaint related to osteolytic loosening is startup pain and/or new-onset, persistent pain about the anterior ankle.[51] Radiographic findings range from thin radiolucent lines around the bone-implant interface to large, ballooning, cystic changes.[41] Cystic lesions inferior to the talus should raise concern for talar subsidence, while medial tibial cysts can predispose to medial malleolus fracture.[51]
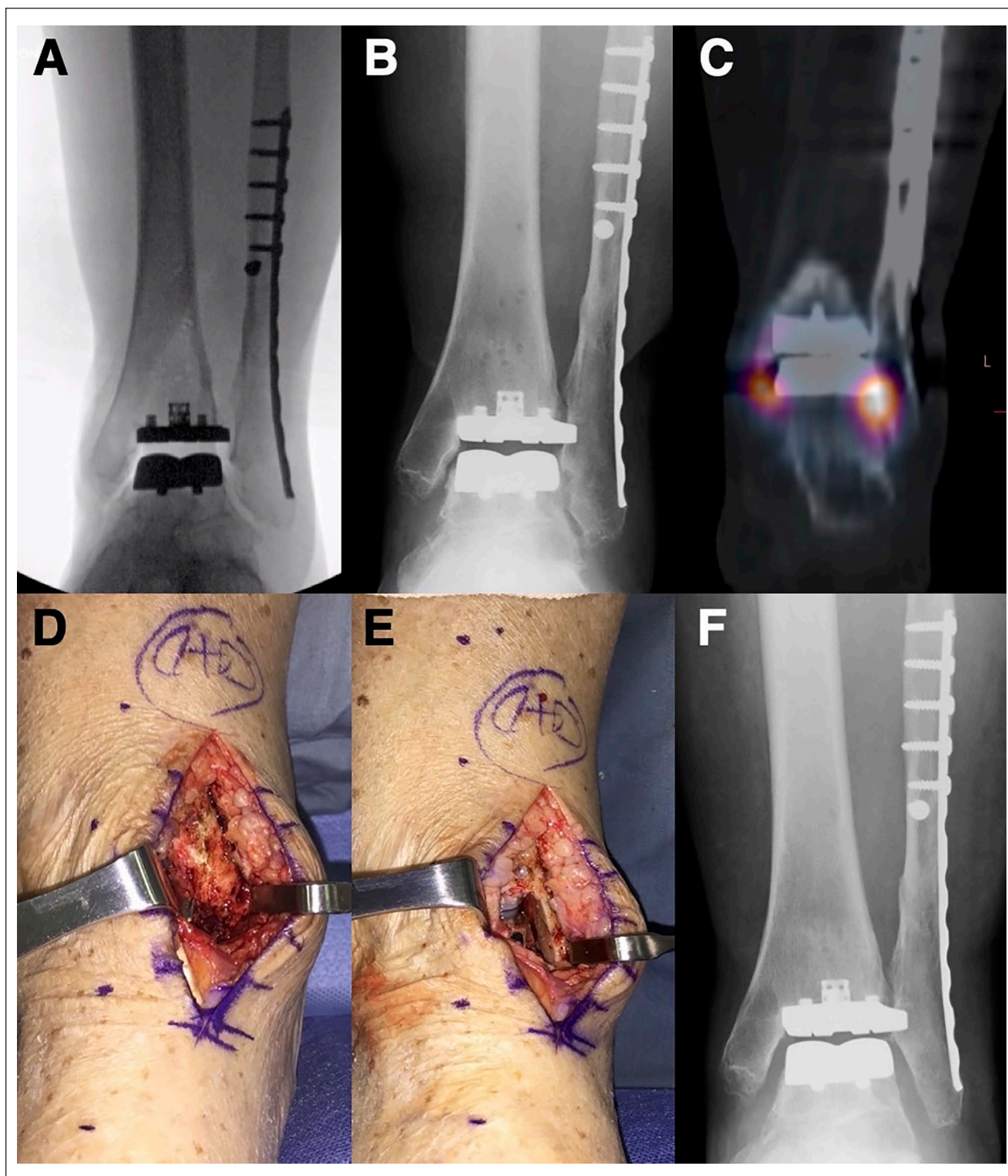
Figure 4. This patient underwent (A) uncomplicated index total ankle replacement but began experiencing pain (B) approximately 6 months later. (C) Single-photon emission computed tomography demonstrated uptake at the medial and lateral gutters. The authors' technique of gutter debridement, illustrated in a different patient, is shown (D) before and (E) after debridement. (F) Postoperative radiographs are shown, and the patient reported excellent resolution of symptoms.

Up to 98% of patients may show some degree of osteolysis on postoperative radiographs.[23,94] Even in asymptomatic patients, periodic radiographic surveillance should be performed postoperatively so that any clinically silent cystic lesions can be detected early. It is crucial to monitor cysts radiographically for progression, as large, progressive cysts can increase the risk of fracture and the need for revision surgery.[51] In addition, surgeons should not hesitate to order advanced imaging to evaluate for cysts/osteolysis in the painful TAR, as plain radiographs often do not adequately characterize cysts, and the sensitivity may be only 50%.[3,41,42,113] CT can define and quantify the size of lesions significantly better than plain radiographs.[41,86,111,113] Weightbearing CT is a valuable tool, because it can identify periprosthetic cysts and also help the surgeon associate cyst location with underlying malalignment.[68] SPECT may also be used and can identify areas of increased physiologic activity at the bone-implant interface, which may represent loosening or cyst formation.[39,70,94] Metal artifact reduction MRI is also useful and can identify significantly more osteolysis and edema in painful TAR compared to traditional MRI techniques.[17]

Multiple factors have been identified as potential etiologies for the development of cysts and osteolysis. Micromotion is a common source and well described in the total hip/knee replacement literature.[32,89,100] Synovial fluid pressure, which may be exacerbated by lack of bony growth to the implant and can lead to increased wear particles around the implant, may also be a culprit[31,100]; however, this theory has not yet been confirmed in clinical studies. This phenomenon may also occur if the entire surface of the cut bone is not covered by the implant or if the anterior tibial cortex is violated due to implant design, whereby synovial fluid may escape into the bone surrounding the implant.[24] Soft tissue and bony necrosis, potentially due to soft tissue stripping and large bony cuts intraoperatively, can also generate this inflammatory osteolytic process.[61,91] Finally, the hydroxyapatite coating of specific implants has been implicated as a cause.[95]

Implant design and position may also play a role. Theoretically, since mobile-bearing implants have less constraint, they may have less micromotion and less osteolytic loosening; this was also theorized in a biomechanical retrieval analysis.[15,72,76] However, a prospective randomized trial demonstrated that mobile-bearing TAR actually had higher rates of cysts and lucency around both the tibial and talar implants compared to fixed-bearing TAR.[72,76] This could be explained by backside wear that occurs in mobile-bearing implants, which generates more polyethylene particles.[14]

Management strategies for osteolysis vary based upon the presence and chronicity of symptoms, lesion size and location, and the effects on the implant and bone. Cysts that
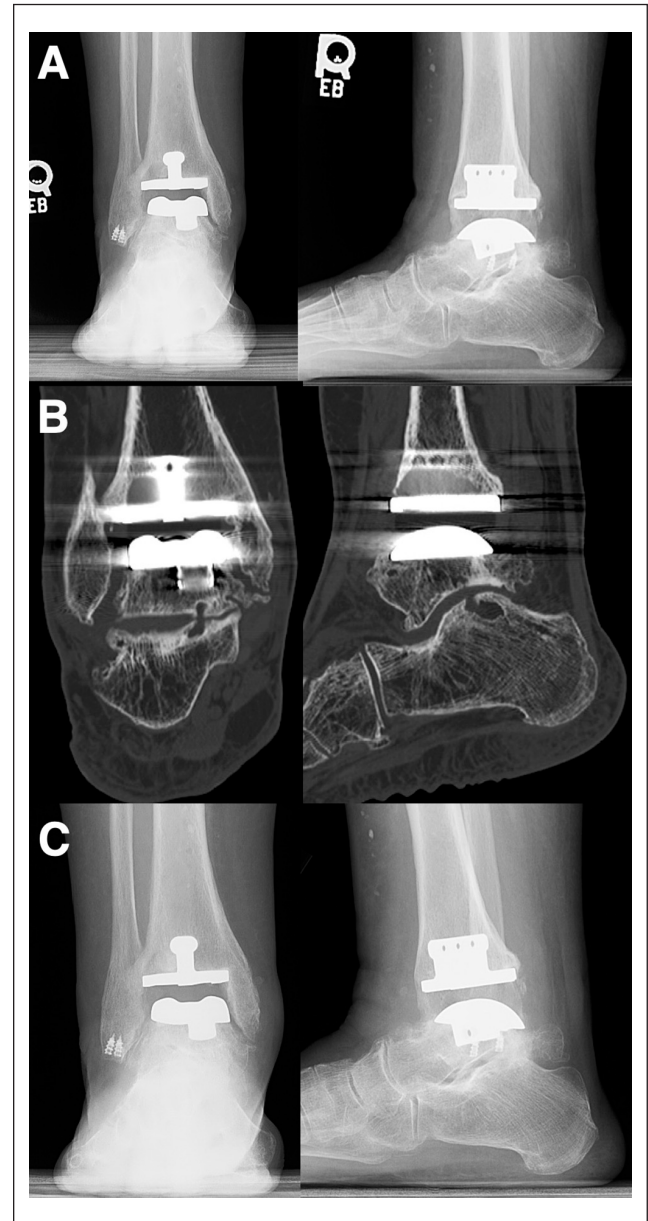
Figure 5. This patient was 2 years out from her total ankle replacement and initially was very satisfied. She had gradually worsening anterolateral ankle pain and a large cyst on (A) radiographs and (B) computed tomography. (C) She underwent bone grafting and implant retention with postoperative improvement.

are progressive or symptomatic should be managed operatively to avoid consequences such as loosening or failure (Figure 5).[86] Lesion location is a crucial consideration for operative planning; tibial lesions and more anterior lesions are generally more easily accessible. Painful, progressive osteolytic lesions with stable implants can be treated successfully with curettage, debridement of cystic material,

and grafting, with or without polyethylene exchange.[73] Grafting provides immediate implant support and can improve the overall stability of the construct.[73] Graft options include autograft, allograft, calcium phosphate, and polymethylmethacrylate (PMMA) cement.[6,9] Oral bisphosphonates can be a beneficial adjunct for patients with cysts larger than 1 cm in diameter.[5,36] In cases where the osteolysis is extensive or the lesion is difficult to access, it may be better to completely revise the implant, even if it is not painful or clinically loose. If left untreated or if inadequately grafted, cystic lesions can lead to implant subsidence and periprosthetic fracture, especially in the talus.

Success after curettage and grafting is variable. One series described 100% success with no cyst progression at a mean 6-year follow-up,[112] whereas other studies have demonstrated excellent short-term results but drop-offs over time, with eventual implant failure rates of 19% to 40% by 4 years postgrafting.[36,104] Certainly, the optimal treatment of isolated periprosthetic osteolytic lesions with stable implants has yet to be determined. Additional investigation examining the optimal graft choice and long-term functional outcomes is needed. In the case of extensive osteolysis with an unstable implant, revision or fusion is typically indicated. This will be discussed in the next section.

Is There Subsidence/Loosening?

Aseptic loosening and subsidence are the most common causes for revision after TAR.[30,63] In a large meta-analysis of more than 800 TARs, most of the 7% of TAR revisions were due to loosening and/or subsidence.[40] In large-scale, long-term studies from Europe, revision rates due to loosening were greater than 10%.[107,115] Although overall revision rates have declined with newer generations of implants, the proportion due to loosening has remained the same.[107] In a single-institution study of more than 500 TARs with 7-year follow-up, 6.4% were revised due to implant failure, with loosening and talar subsidence as the most common culprits, accounting for 21% and 41% of the failures, respectively.[11]

In the patient's history, implant loosening or subsidence may be associated with startup pain or mechanical pain with increased activity.[51] Advanced imaging can be valuable to identify loosening: in a study of patients with painful TAR who underwent SPECT, loosening was identified as the etiology in 36% of cases.[39] SPECT may show increased uptake at the affected areas that represents pathologic activity. However, within the first year after TAR, the utility of SPECT is unclear, as there are unclear thresholds for normal early physiologic activity vs pathologic uptake.

Multiple factors can cause TAR loosening or subsidence. Implant loosening and/or subsidence may represent the culmination of progressive cyst formation and massive osteolysis. However, poor initial fixation and stability of the implant may lead to failure in the first 2 years due to inadequate healing of the bone onto the implant. On the bony side, poor distal tibia bone quality has been implicated as a cause of aseptic failure, but this has yet to be confirmed in additional studies.[88] On the implant side, both implant design and position strongly influenced implant-bone micromotion and bone strains in a biomechanical model of TAR failure.[98] In a randomized trial of fixed- and mobile-bearing implants, mobile-bearing implants had significantly higher rates of tibial (7% vs 0%) and talar (15% vs 5%) subsidence.[76] Among mobile-bearing implants, increased implant failure was linked to increased varus position of the tibial component.[115]

Implant malposition, especially involving the talar component, can reduce contact surface area, thereby increasing contact pressures, leading to increased risk of subsidence.[25,80] Anterior talar translation is often a culprit and may be due to preoperative deformity that was not adequately addressed, a tight heel cord or posterior capsule, overstuffing of the joint, or improper implant insertion.[114] Malalignment of the underlying foot can also lead to rapid failure and is discussed in a later section.

The painful TAR with loosening or subsidence can be treated with isolated tibial or talar component revision if the other component remains stable or complete revision if there is loss of fixation around both components (Figure 6).[67] It is critical to assess the amount of residual bone stock around each component of the implant, as structural support is vital to obtaining a stable revision construct. Tibial component revision requires a healthy cancellous bone base that comprises at least 50% of the tibial articular surface, as well as medial and lateral structural support, and maintenance of both malleoli.[53] If there is minimal bone stock in the medial and lateral columns, these defects can be bypassed with a modular stemmed TAR to achieve stability.[21,51] Loss of tibial height from bone loss can be managed by grafting behind a revision component or using a thicker polyethylene insert.[53] Although graft options are variable and widely debated, it is important to fill as much of the osteolytic defect as possible because residual defects that are left unsealed at are risk for infiltration by wear particles, which will lead to lesion progression.[49,51,53,73,87]

On the talar side, revision is often complicated by the residual bone voids that occur after removal of the loose talar component.[67] The location of bone loss and the amount of talar subsidence in relation to the subtalar joint must be considered prior to revision.[67] If the talar component has subsided to or below the level of the subtalar joint, conversion to tibiotalocalcaneal (TTC) arthrodesis with bulk allograft should be strongly considered.[73] A 2-stage technique for revision TAR in the context of bone loss has also been described, involving addressing bony defects with grafting in the first stage, followed later by secondary implant insertion.[4]
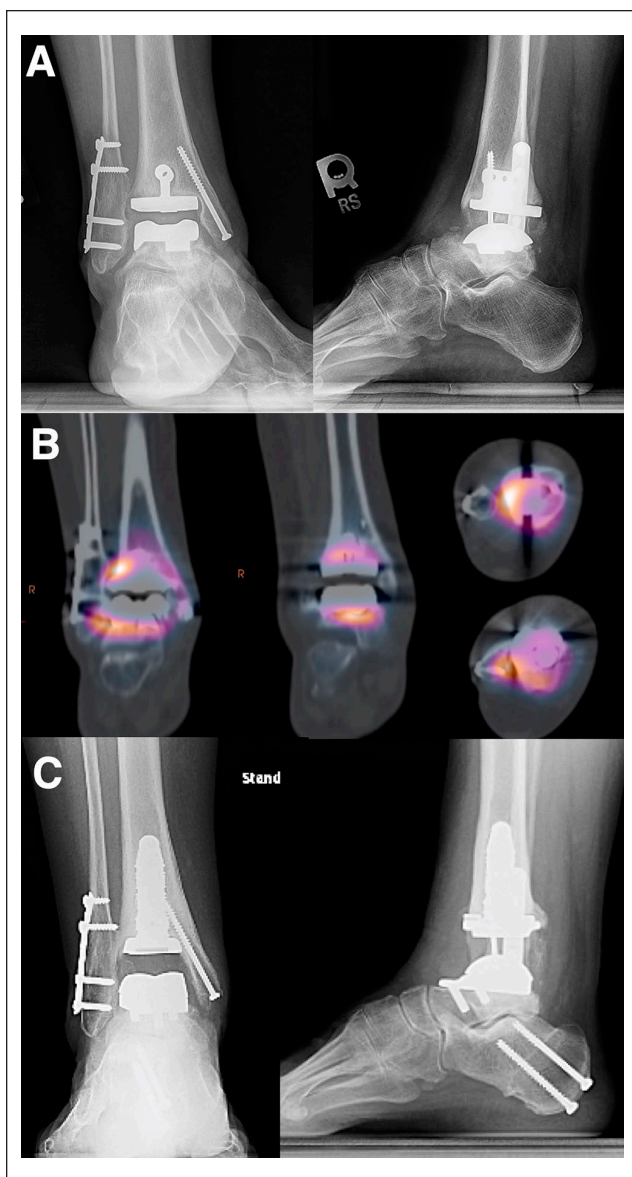
Figure 6. This patient is a 66-year-old woman approximately 10 months after total ankle replacement with vague intermittent ankle pain. (A) Radiographs demonstrated lucency around the tibia and talar subsidence. (B) This was confirmed with increased uptake on single-photon emission computed tomography. (C) She underwent revision of both the tibial and talar components as well as calcaneal osteotomy to address cavovarus.

There are limited reports on outcomes after revision TAR for aseptic loosening. A series of revision TAR for all causes (80% due to subsidence or loosening) reported a 10% failure rate at 3 years postrevision, while a separate study identified a 17% failure rate at 9 years.[47,63] Of note, patients undergoing revision TAR took at least twice as long to reach maximal improvement compared to patients undergoing primary TAR,[63] and the rate of reoperation for any cause was 15%.[47,63]

Arthrodesis is viable option for a failed TAR not amenable to revision. The severity of bone loss, degree of component subsidence, and status of the soft tissue envelope should all be considered when planning to convert a failed TAR to arthrodesis. Nonunion rates of arthrodesis after failed TAR range from 11% to 42%,[48,52,59] and postoperative outcomes are typically less favorable in this situation compared to those after primary TAR.[56,83] While 1 recent study reported better patient-reported outcomes after revision TAR compared to salvage arthrodesis,[22] there is no clear consensus in the literature demonstrating clear benefit of revision TAR over arthrodesis.[56]

When nonreconstructible subsidence of the talar component into the subtalar joint or massive talar bone loss is encountered, TTC fusion can be performed.[1] Unfortunately, salvage options like TTC fusion are still plagued with complications, including nonunion.[6] Revision with custom 3-dimensional printed implants for talar bone loss has increased in popularity in recent years; in the limited studies available, these implants had significantly greater fusion rates and lower graft resorption compared to traditional femoral head allograft techniques.[1,99] Finally, BKA is salvage option for treatment of a failed TAR, but functional outcomes are unsurprisingly inferior to those reported for revision arthroplasty or conversion to arthrodesis.[23]

Is There Pathology in the Foot?

Attention to the alignment of the foot is critical when evaluating the painful TAR. Pathologies such as stress fracture, loosening, and subsidence may all be caused by underlying deformity that requires correction.[85] Adjacent joint arthritis and sinus tarsi impingement can also cause pain after TAR. The history should include the location and character of the pain, and the physical examination should focus on the standing alignment and adjacent joint motion and tenderness. Radiological workup may consist of serial radiographs, MRI, weightbearing CT, and/or SPECT.

Often, malalignment may require reoperation or revision surgery (Figure 7). In a study of 64 TARs with short-term follow-up, 1 patient (1.6%) underwent reoperation for realignment of hindfoot varus.[90] Similarly, among 80 TAR patients with severe preoperative valgus deformity, 1 (1.3%) patient returned to the operating room for correction of persistent deformity.[20] In a study of more than 1000 TARs with 5-year follow-up, 13.5% required subsequent operative treatment with reconstructive osteotomy, fusion, and/or ligament repair/reconstruction.[11] Returning to the operating room for reconstructive surgery may not only improve the patient's pain but also increase the longevity of the TAR.
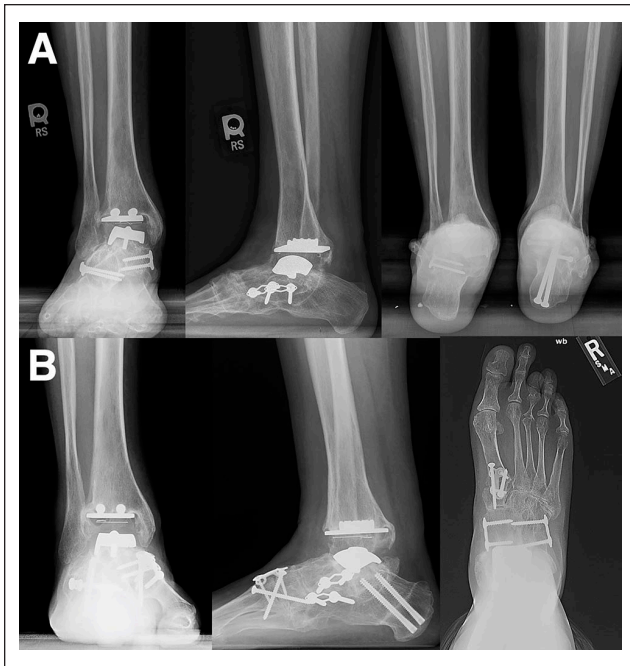
Figure 7. This 44-year-old woman with rheumatoid arthritis underwent total ankle replacement and hindfoot fusion more than 7 years previously at an outside hospital. She initially was satisfied postoperatively but then developed gradual worsening pain over the ankle/hindfoot, lateral gutter, and deltoid. (A) Preoperative radiographs demonstrated hindfoot valgus with deltoid insufficiency. Intraoperatively, the tibial and talar implants were stable and retained, so only the polyethylene was exchanged. She also underwent medializing calcaneal osteotomy to correct hindfoot valgus, first tarsometatarsal (TMT) arthrodesis to correct first ray elevation and TMT instability, deltoid reconstruction with an internal brace to fix the residual valgus instability, and Achilles tendon lengthening. (B) Postoperatively, her symptoms and alignment were both improved.

Pain after TAR may also be caused by adjacent joint disease. Although the TAR protects adjacent joints from aberrant motion and arthritic changes more than an ankle fusion, adjacent joint pathology can still occur.[97] Among 140 TAR patients with greater than 5-year follow-up, more than one-quarter had increased progression of subtalar arthritis, and 31% had increased progression of talonavicular arthritis.[19] Diagnosis of adjacent joint arthritis as the etiology of the patient's pain may be confirmed by local injection to the site and evaluation of the extent of relief. In cases where nonoperative treatment fails to control pain, reoperation with arthrodesis of the affected joint can result in substantial clinical improvement (Figure 8).

In a series of more than 900 TAR patients, 4% underwent secondary subtalar fusion due to osteoarthritis, instability, talar osteonecrosis, or cystic change.[96] In a 15-year follow-up of 84 STAR TARs, 1 patient (1.2%) required subsequent
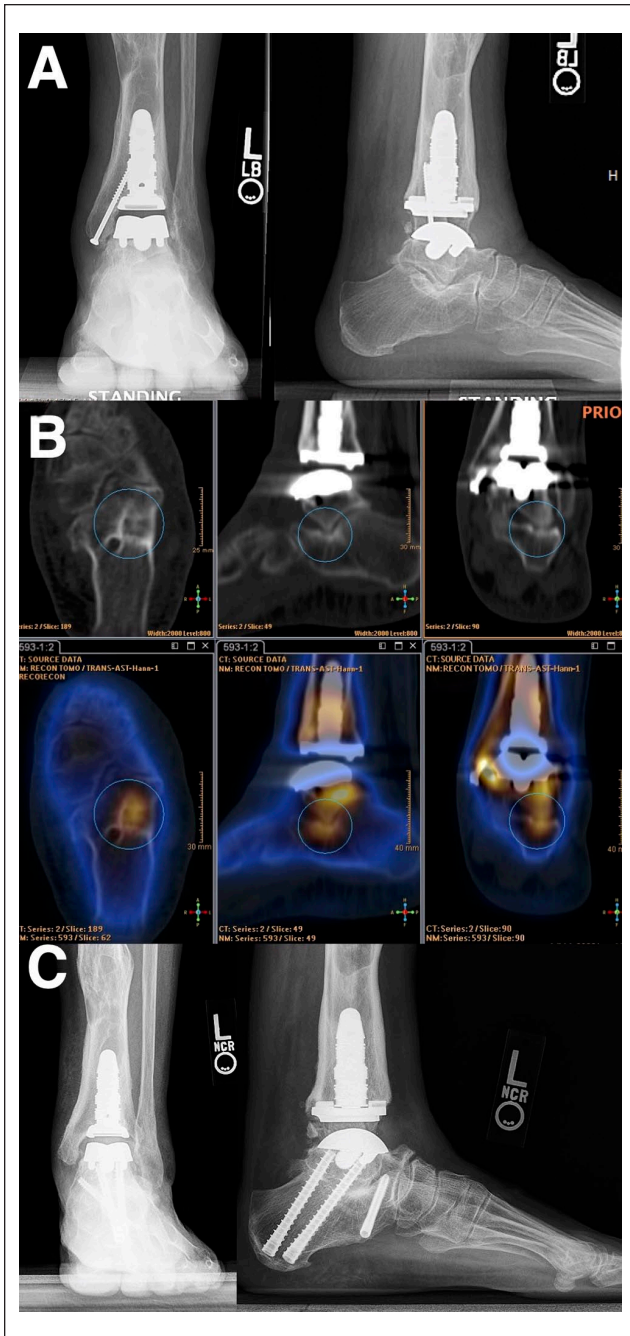
Figure 8. (A) This patient began to have lateral ankle/hindfoot pain 2 years postoperatively. (B) Single-photon emission computed tomography demonstrated increased uptake at the subtalar joint. She underwent diagnostic subtalar corticosteroid injection with excellent temporary relief. (C) She was treated with subtalar fusion and retention of her total ankle replacement with excellent improvement in symptoms.

subtalar fusion.[78] Also, in a series of more than 1000 TARs, nearly 3% of patients returned to the operating room for a subtalar, talonavicular, double, or triple arthrodesis.[37]

Fortunately, arthrodesis of adjacent joints after TAR is relatively successful: 92% of patients achieved union, and 85% had resolution of symptoms, with significant improvement in pain and outcomes scores.[37]

Is There a Nerve Injury?

Nerve injury or compression is a rare complication but can be a source of persistent pain, numbness, and intrinsic muscle atrophy after TAR.[74,82] This is especially true if the diagnosis is delayed due to axonal death, scarring, and motor target deterioration.[54] Patients may present with altered sensation, motor paralysis, disordered autonomic function, and a Tinel's sign at the site of injury.[54] Insult to the tibial, superficial peroneal, deep peroneal, sural, and saphenous nerves has been reported.[82] Tibial nerve injury is the most common; severe preoperative deformity and the sequelae of posttraumatic arthritis can alter the normal anatomy of the nerve, making it more susceptible to injury during TAR.[66,74,82]

Nerve injuries can occur most commonly as a result of the initial surgical approach, inadequate release/mobilization, excessive retraction, and inadequate protection during placement of the cutting guides and bony cuts (especially posterior advancement of the saw blade).[66,74,82,84] Surgeons should exercise caution during these portions of the case to minimize nerve injury that could potentially be a source of persistent pain postoperatively. Even in the absence of direct insult, laceration, or transection, compression or distraction nerve injuries can occur: tarsal tunnel syndrome with entrapment of the tibial nerve and its branches has been reported after TAR.[81]

The diagnosis can be confirmed with the use of electromyographic and nerve conduction studies[66]; ultrasound and MRI may be beneficial but have not been consistently described in the literature. There is little high-level evidence that outlines appropriate treatment of nerve injuries after TAR. Collaboration with a surgeon with expertise in nerve repair/reconstruction may be beneficial. Treatment strategies are dependent on the nerve injury and include decompression of structures compressing the nerve, nerve allograft reconstruction, and end-to-end nerve repair.[54,66,81] The limited reports of these injuries in the literature suggest that symptoms may improve to an extent, but the process can take years and may still result in persistent pain, allodynia, numbness, and paresthesias even after appropriate recognition and treatment.[54,66,81]

Is There Pathology Outside the Foot/Ankle?

After local etiologies have been excluded, the surgeon should consider orthopedic causes outside the foot and ankle, including referred pain from the knee, the spine, or elsewhere. In a study of more than 100 TARs, more than a quarter of patients had ipsilateral knee pain at baseline.[102] The TAR patients with knee pain had similar preoperative ankle pain scores, functional scores, and disability scores compared to the cohort without knee pain and reported significant improvements in their ankle outcomes scores following TAR.[102] However, 5 years postoperatively, the TAR group with concomitant knee pain had significantly lower foot and ankle outcomes scores in nearly all categories compared to the TAR patients without knee pain.[102]

In a similar study, 35% of TAR patients had concomitant lower back pain, although similar baseline functional scores to TAR patients without back pain.[101] Yet again, at 5-year follow-up, despite improvements from baseline, the TAR patients with back pain had significantly worse postoperative Short Form (SF)–36 physical component scores and ankle outcomes scores compared to regular TAR patients.[101] Obviously, providers should still evaluate the foot and ankle first, before assuming the pain is referred from another region. Nevertheless, these results may provide an explanation for the TAR patient who does not achieve characteristic satisfaction postoperatively. If identified, referral to the appropriate provider (eg, physiatry, spine, adult reconstruction) is warranted.

Is It Something Unique/Rare?

If this algorithm fails to result in a definitive diagnosis, especially after comprehensive laboratory and radiologic workup, rare or unique causes of pain can be considered, including synovitis, recurring hemarthrosis, metal sensitivity, complex regional pain syndrome, or psychosocial factors.[26] There is a case report of a TAR patient with a severe metal allergy necessitating implant removal and conversion to fusion.[29] In addition, a study of ankle fusion patients with workers' compensation reported significantly lower American Orthopaedic Foot & Ankle Society scores and higher pain scores postoperatively.[28] However, most of these potential causes are extrapolated from the total hip/knee replacement population and have not been well described in the TAR literature. We do not know if the incidence of these rare causes is truly different from total hip/knee replacement or if it is just not borne out in the literature yet due to the comparatively fewer numbers of TARs.

Conclusions

This review of the modern literature demonstrates that the patient with pain after TAR can be approached methodically using a strategic algorithm. Each patient should undergo a careful history, physical examination, and radiologic evaluation. Radiologic studies may include serial radiographs, metal artifact reduction MRI, weightbearing CT, and/or SPECT. Despite recent advents in implants and

technology, most of the long-term studies in the TAR literature describe implants that are no longer in wide use. Therefore, the next decade of research will be critical in describing long-term data regarding the current generation of implants. Moreover, novel imaging modalities may reveal more specific pathologies. Importantly, most large-scale studies in the current literature are dominated by a limited number of institutions and the same patient data sets. This underscores the need for additional research from more institutions as the number of TARs inevitably continues to rise.

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