Ankle Arthritis: You Can’t Always Replace It

Abstract
End-stage arthritis of the tibiotalar joint is disabling and causes substantial functional impairment. Most often it is the residual effect of a previous traumatic injury. Nonsurgical treatment of end-stage arthritis of the ankle includes bracing, shoe-wear modifications, and selective joint injections. For patients who fail to respond to nonsurgical modalities, the two primary treatment options are arthroplasty and arthrodesis. Each has its proponents. Although no ideal treatment of ankle arthritis exists, high-quality studies can help guide treatment in patients of varying demographics. Inherent risks are linked with each treatment option, but those of greatest concern are early implant loosening that requires revision following arthroplasty and the acceleration of adjacent joint degeneration associated with arthrodesis.

Incidence and Etiology
The ankle joint is far less commonly affected by arthritis than other major joints. The reasons for this include differences in articular cartilage, joint motion, and the susceptibility of cartilage to inflammatory mediators. One of the biggest differences between the ankle and the knee is the relatively greater containment and conformity of the ankle joint. The talus is firmly bound on three sides by the fibula, tibial plafond, and medial malleolus and their strong ligamentous attachments. This design potentially gives the ankle a better cartilaginous loading profile than that of the knee, which relies heavily on the menisci for congruent loading. Whereas the knee has components of sliding, rolling, and rotation, the ankle is largely a rolling joint with very little rotation. Interestingly, although the ankle experiences loads similar to those of the knee or hip and its contact surface area is less than one third that of these joints, the incidence of primary arthritis is dramatically less.

The most common cause of end-stage arthritis of the ankle is trauma. Additional causative factors include arthropathies, chronic ankle instability, malalignment, and certain medical conditions, such as hemophilia. In a large series from a tertiary referral center, 70% of patients with ankle arthritis had a history of trauma. Inflammatory arthritis accounted for approximately 12% of all cases.

The incidence of ankle arthritis is difficult to accurately predict because of its low prevalence and a lack of correlation between radiographic and clinical findings. In a large cadaver study, the overall incidence of end-stage arthritis was 2%, whereas all cadavers aged >66 years demonstrated at least mild wear...
patterns. Similarly, in a smaller cadaver study, Meachim examined 45 randomly selected cadavers and demonstrated a 5% incidence of full-thickness cartilage loss.

**Diagnosis**

A patient who presents with end-stage ankle arthritis often reports considerable limiting pain. It is important to obtain a thorough history to differentiate between the most common causes of ankle arthritis. The examiner should ask about a history of trauma to the extremity, including fracture or recurrent sprains. Other less common etiologies to inquire about include a history of inflammatory or infectious arthropathies, gout, hemophilia, or neuropathy.

The examiner should clarify the patient’s specific discomfort because it often indicates whether the patient has global or focal disease. A history of diffuse ankle pain with activities is more commonly seen with global disease, whereas a more activity-specific complaint suggests focal disease. Pain with activities requiring maximal plantar flexion, such as descending stairs or downhill walking, often suggests posterior ankle pathology. When discomfort is anterior and occurs with activities of ankle dorsiflexion, anterior joint disease is a possibility. Subfibular pain may be suggestive of either subtalar or ankle pathology. Posteromedial ankle pain often has a soft-tissue origin.

The examination should begin with simple observations of the patient while he or she is standing. This assessment should entail looking for any residual signs of trauma, such as previous surgical incisions or skin graft sites. The overall alignment of the lower extremity should then be evaluated. It is not uncommon to find deformity through the ankle or subtalar joints. On standing, the heel should fall into slight valgus of 5° to 7°. It is also important to evaluate the alignment of the knees. Next, the gait pattern should be assessed, specifically looking for abnormal loading of the foot as it contacts the ground. A neurovascular examination should be performed with the patient seated; neuropathy is not uncommon in this demographic.

Motion of the ankle and subtalar joints should be assessed, noting any discomfort this produces as well as areas of point tenderness. Although it is uncommon to have instability in the setting of arthritis, the ligamentous integrity of all joints should be assessed and documented.

After the physical examination, the patient should receive a complete weight-bearing radiographic series to further evaluate the extent of his or her arthrosis. At our institution, all patients receive standard three-view, weight-bearing radiographs that include AP, mortise, and lateral ankle views (Figure 1). We also recommend standard three-view, weight-bearing radiographs of the foot to assess for adjacent joint arthritis. If there is suspicion of hindfoot malalignment, the addition of a weight-bearing alignment view is obtained,
as described by Saltzman and el-Khoury. On occasion, CT may be obtained when a deformity is present, talar topography is altered (as in osteonecrosis), or further characterization of the joint is desired.

Treatment

Nonsurgical

The mainstay of initial treatment of ankle arthritis is managing the patient’s symptoms nonsurgically. Options include NSAIDs, bracing, selective joint injection, shoe modifications, and mechanical unloading. NSAIDs can provide sustainable pain relief but may not be tolerated by the patient. Bracing options include the use of a prefabricated carbon-fiber, nonarticulating ankle-foot orthosis or the use of a custom ankle-foot orthosis in an attempt to eliminate motion across the joint. These braces are best suited for a patient who is compliant with regular wear and is not concerned with cosmetic appearances. Selective joint injections, such as NSAIDs, have a widely varied response but can be very helpful for some patients in terms of pain relief. In the authors’ experience, some patients receive up to 6 months of relief from a single injection. In this subset of patients, long-term satisfactory management can be maintained with serial injections. For those who receive an injection that provides <3 months of pain relief, long-term relief is unlikely to be obtained solely with injections. In these instances, subsequent injections are primarily reserved only for brief reprieves in light of special upcoming events, such as planned trips or weddings. Shoe modification may be helpful with the addition of a rocker bottom to help decrease ankle motion. In addition, mechanical unloading of the joint with the use of a cane or other assistive device may be helpful.

Surgical

When nonsurgical measures do not provide adequate symptom relief, two primary treatment options exist for global end-stage arthritis: ankle arthrodesis and total ankle arthroplasty (TAA). Both have reported similar good or excellent outcomes (arthroplasty, 69%; arthrodesis, 68%) and similar 1-year postoperative revision rates (arthroplasty, 9%; arthrodesis, 5%). Clinicians who favor arthroplasty point to the risk of nonunion with arthrodesis, which is reported to be 7% in one series. In other series, the nonunion rate with arthrodesis is reported to be as high as 43% in high-risk subgroups. Furthermore, supporters of arthroplasty note that the risk of adjacent joint disease, reported to be as high as 90%, is increased secondary to the loss of a major motion segment. In the long term, loss of normal ankle motion has been shown to affect a patient’s functional status. In a series of 28 patients who considered themselves highly satisfied after ankle arthrodesis, reported functional limitations included difficulty walking on uneven ground (80%), difficulty with ascending or descending stairs (75%), and aches after prolonged activity (64%), despite what was considered a successful arthrodesis.

Arthroplasty

Contrary to arguments in favor of TAA, evidence suggests that arthroplasty should be approached with caution. Patient selection is of utmost importance in TAA. Not every patient with end-stage arthritis is a candidate for TAA. Patients with acute or chronic joint infections, an insensitive foot, severe multiplanar deformity, Charcot arthropathy, osteonecrosis of the talus, and compromised soft tissues are often poor candidates for this procedure.

Outcomes data for TAA are daunting and somewhat difficult to interpret. Dramatic variations in length of follow-up, patient selection, and definition of failure all make interpretation of these studies challenging. Reported failure rates range from 2% at short-term follow-up to as high as 55% at long-term follow-up. In a systematic review by Haddad et al, implant survival rates for patients who had undergone ankle arthroplasty were 78% and 77% at 5 and 10 years, respectively, with 1 of every 14 patients requiring a revision. In one study of a mobile-bearing TAA system with longer-term follow-up, the authors reported that the average implant survival rate at 14 years was only 45.6%. The argument often made to counter these high failure rates, most of which occur because of talar-component subsidence, is that newer systems preserve more bone and that implants have a more anatomic design. In a series that examined a new-generation implant system at an average of 3.7 years, the authors reported that 11% of the ankle implants had been revised or were deemed impending failures. In a recent multicenter study by Daniels et al, the revision rates of arthrodesis and ankle arthroplasty at a mean follow-up of 5.5 years were 7% and 17%, respectively. In a later study, Daniels et al reported on the intermediate- to long-term outcomes of a mobile-bearing TAA system; the revision rate of the metal component was 12%, and the failure rate of the polyethylene-bearing component was 18% at a mean of 4.3 and 5.2 years.

An advantage of arthrodesis is the ability to avoid the higher risk posed by the anterior incision. Currently, only one total ankle system, the Zimmer Total Ankle, allows for component implantation through a lateral incision. All other FDA-approved
systems require an anterior approach. An anterior approach to the ankle has been associated with wound complications in as many as 7% of patients undergoing TAA.22–25

Arthrodesis
Numerous techniques for ankle arthrodesis have been described. Here, we describe five techniques and the advantages and disadvantages of each.

Arthroscopic-assisted Technique
Recent advances in arthroscopic equipment and instrumentation have popularized an arthroscopic-assisted fusion technique. Proponents of this technique report decreased soft-tissue disruption and maintained biology. The main benefit of this technique is that the rate of union is similar to that of open techniques, with the relative elimination of wound problems that are more commonly seen with open-ankle arthrodesis techniques. The biggest limitations of this technique are that it is challenging to correct the deformity and it should not be used for patients with >15° of varus or valgus in the coronal plane.26,27 We prefer to use this technique in the patient with nondeformed, end-stage ankle arthritis and a compromised soft-tissue envelope.

Arthroscopic-assisted arthrodesis has been well described by Ferkel and Hewitt.26 The patient is positioned supine with the leg held in a padded thigh holder such that the hip is flexed approximately 45°. A noninvasive ankle distractor is applied, and working portals are established in standard fashion anteromedially, anterolaterally, and posterolaterally. Joint preparation is then begun with the removal of any remaining articular cartilage (Figure 2). This can be done with a combination of arthroscopic curettes, periosteal elevators, and shavers. An abrader is then used to resect down to bleeding subchondral bone, taking care to not disrupt the normal contours of the tibia and talus. The final step in joint preparation is to induce channels for vascularized ingrowth using a 2.0-mm burr (Figure 3). After joint preparation, guidewires for large cannulated screws are placed.

We use one of several different fixation constructs, typically with large cannulated screws that are either 6.5 or 7.3 mm in diameter. In one commonly used construct, a “homerun” screw, is placed posterolaterally approximately 2 to 3 cm above the joint line just off the lateral border of the Achilles tendon. The trajectory of this screw is positioned down the long axis of the talus neck. The key consideration in placing this screw is that the talar axis will be slightly medial to the midline. The sural nerve should be protected. A second guidewire is placed in the midaxis of the tibia from the medial side, beginning approximately 2 to 3 cm above the joint line. This guidewire is placed into the talar neck-body junction. The third and final guidewire is directed proximally from the talar neck into the tibia. Once all the guidewires are placed, cannulated screws are inserted over the wires in the same sequence as that for placement of the wires (Figure 4).

Postoperatively, regardless of technique, all patients are placed into a well-padded splint, and non–weight-bearing restrictions are implemented. At 2 weeks, a wound check is performed, sutures are removed, and the patient is placed into a short leg cast with no weight bearing for a total of 6 to 12 weeks. The duration of restricted weight bearing depends on radiographic signs of union and...
patient comorbidities. After demonstration of radiographic bony union, the patient is placed into a walking boot and allowed to progressively begin weight bearing as tolerated. Physical therapy is also begun to assist in strengthening the extremity.

Reported results have been promising for arthroscopic-assisted ankle arthrodesis. In a large multicenter series that compared open ankle arthrodesis with arthroscopic ankle arthrodesis, Townshend et al. found that the arthroscopic group had a shorter length of hospital stay (2.5 days versus 3.7 days) and improved outcomes at 1 and 2 years. In a similar multicenter comparative study, O’Brien et al. demonstrated that an arthroscopic technique had shorter surgical and tourniquet times and decreased blood loss. Both studies reported similar union rates and outcomes after 1 year.

**Miniarthrotomy**

This technique, popularized by Paremain et al. and Stamatis and Myerson, is a variation on the arthroscopic-assisted arthrodesis. It offers the benefit of being relatively minimally invasive, thereby preserving the biology and vascularity of the joint and decreasing the risk of wound complications. Its limitations are similar to those of the arthroscopic-assisted technique and are based on its limited ability to correct larger coronal plane deformities. In addition, it is difficult to adequately reduce an anteriorly subluxated talus through this approach. We prefer to use this technique in joints with mild deformity and minimal talar dysplasia.

The surgeon establishes two 1.5-cm working portals, one anteromedial and one anterolateral, in the same areas where the arthroscopy portals are located. These incisions are made in a longitudinal fashion. The anteromedial incision is placed just medial to the anterior tibial tendon; care is taken to avoid the saphenous nerve and vein. After this portal is established, the anterolateral portal is made using spinal-needle localization. The anterolateral incision is made with care taken to protect the superficial peroneal nerve. Visualization is improved by removal of anterior osteophytes and synovial tissue with the use of a rongeur. Once clear visualization of the joint is achieved, a laminar spreader is introduced through the anterolateral portal (Figure 5). Distraction force is applied, and joint preparation is performed in a standard fashion through the anteromedial working portal. The portals then reverse roles, and the anterolateral portal becomes the working portal while the anteromedial is used for placement of the laminar spreader and distraction. Some authors describe using these portals to perform deformity correction through bone wedge resection, but in our experience, this is difficult, and an often less-than-ideal correction with marked deformity is noted. The joint is then reduced, and screw fixation is performed as described earlier in the arthroscopic section. The postoperative...
protocol is also the same as described in the arthroscopic section.

The reported results of this technique have been promising and are further supported by our anecdotal clinical experience. In a study of this technique using cadaver models, Miller et al.\textsuperscript{32} compared the vascular insult after the miniarthrotomy technique with the vascular insult after an open technique. Results showed that a major contributing blood supply to the fusion site was compromised by the open technique in 40% of the cadavers. This was not seen in any of the cadaver specimens that underwent the miniarthrotomy technique. The authors further evaluated their clinical results in a cohort of 32 patients who had undergone fusion using this method. A nonunion occurred in one patient, and two patients had delayed unions. No wound complications occurred, and the only significant postoperative complications were prominent instrumentation and a transient ankle inflammation after union. These resolved in all patients.\textsuperscript{30-32}

**Fibular-sparing Technique**

This technique is a modification of the lateral transfibular approach described by Mann et al.\textsuperscript{33} The fibular-sparing technique was designed to maintain an intact fibula. In the classic transfibular approach, the fibula is removed and used as bone graft or as a strut for the fusion. It is the opinion of the senior authors (J.T.S., C.P.C., E.M.B.) that removing the fibula has several disadvantages and can destabilize the ankle, potentially leading to increased rates of nonunion.\textsuperscript{10,34} An intact fibula may serve as a guide to proper rotation and positioning of the talus within the mortise, provides additional surface area for fusion, and may block valgus drift in cases of delayed union. Furthermore, preservation of the fibula enables conversion to TAA, when necessary. The other benefits of this technique include preparing the joint surfaces in situ as opposed to performing flat cuts and using a single site (ie, fibular window) for autologous bone graft.\textsuperscript{11}

In the fibular-sparing approach described by Smith et al,\textsuperscript{11} the patient is positioned supine with a stack of towels under the ipsilateral hip. An approximately 12-cm curvilinear incision is made directly over the lateral ankle. It is centered at the tip of the fibula and curves distally in line with the base of the fourth metatarsal. Division of the anterior talofibular and calcaneofibular ligaments is performed to allow the talus to rotate out from underneath the mortise (Figure 7).

For joint preparation, a sharp curette is used to remove the cartilage. Subchondral tibial and talar bone is then fenestrated with a 4-mm burr at low speed (20,000 rpm) with continuous saline irrigation. After preparation of the tibia and talus, autogenous bone graft is harvested from the distal fibula through a fibular window. A medium-sized curette is used to harvest cancellous bone. The autograft is then packed onto the prepared tibial and talar surfaces.
The ankle is placed in the described optimal position of 0° of dorsiflexion, 5° of hindfoot valgus, and 10° of external rotation.

Fixation is performed using cannulated screws. Two partially threaded screws are passed from lateral to medial as described by Mann et al. One screw with a washer is passed from the base of the talar neck to the tibia. The second screw is inserted from the lateral process of the talus and is directed into the distal tibia posteriorly. Intraoperative fluoroscopy is used to confirm the position of the screws. The postoperative protocol is the same as that described earlier for the arthroscopic technique.

In a retrospective case series by Smith et al., the authors analyzed 50 consecutive ankle arthrodeses done using the fibular-sparing approach. At an average of 28 months postoperatively, 38 patients (42 ankles) were reviewed. Ninety-three percent of patients achieved union at an average of 12 weeks postoperatively, and 86% of patients reported being “completely satisfied” with the outcome. The average American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score was 84 (out of a possible 86), and the average Foot Function Index pain score was 1, indicating no pain. Two ankles (5%) were fused in excessive varus; no patient required revision surgery for malalignment. All patients stated that they would have the surgery again.

**Anterior Open Plating**

Anatomic compression arthrodesis was first described by Holt et al., who reported on the benefits of preservation of the bony anatomy, minimal bone resection, and rigid multiplanar screw fixation. However, despite these benefits, biomechanical studies have found that construct stiffness can vary depending on the position of the screws and on the quality of the patient’s bone. In two cadaver studies by Thordarson et al. and Mears et al., described the use of an anterior tension plate to improve construct stiffness; this technique offers improved joint visualization, high fusion rates, and good coverage of instrumentation by soft tissue. In a cadaver model, Tarkin et al. showed that supplemental anterior plating and compression screws increased construct rigidity and limited micromotion at the ankle fusion interface compared with the use of multiplanar lag screws alone. Further studies looking at fixation with anterior contoured plates alone have shown that rigid construct fixation leads to fusion rates of >90%. Proponents of the anterior plating technique also stress its benefit in patients who have posttraumatic bone loss and/or poor bone quality that requires more rigid fixation than that provided by multiplanar screws alone. An anterior approach to the ankle is used to perform anterior plating. This approach is familiar to most surgeons and allows for enhanced visualization as well as future conversion to TAA, if needed, because the fibula and medial malleolus are spared in the procedure.

The patient is positioned supine with a stack of towels under the ipsilateral hip. A standard anterior approach to the ankle is performed, and the tibiotalar joint is visualized (Figure 8). A laminar spreader can be placed within the ankle joint for distraction and visualization. Meticulous joint preparation is performed using a sharp curette, elevator, chisel, or osteotome. It is important not to disrupt the contour of the tibial plafond and talar dome. After the joint is prepared and the cartilage is removed, a 2.0-mm burr or drill (usually 2.5 mm) may be used to penetrate the subchondral plate and stimulate vascular ingrowth. The ankle is then reduced into the appropriate position and held with the anterior plate. The use of nonlocking or locking plates is dependent on the quality of the bone and the surgeon’s preference for implant design. The senior authors (J.T.S., C.P.C., E.M.B.) prefer to use anterior-contoured nonlocking plates for most cases. Many plates are precontoured distally with an anterior bend to fit the anterior talar neck.

Two or three screws are placed first into the talus, followed by similar screws in the tibia using compression techniques specific to each plate design. If additional fixation to increase stability is needed at this time, multiplanar lag screws may be
placed (Figure 9). The alignment and position of the instrumentation is checked clinically and fluoroscopically. Once acceptable fixation is obtained, the wound is copiously irrigated and closed. Closure includes approximation of the extensor retinaculum with No. 1 absorbable suture, followed by subcutaneous closure with No. 3 absorbable suture and skin-layer closure with either simple interrupted or horizontal mattress sutures. No drain is used, and standard postoperative protocol is initiated.

Anterior plating has had good outcomes, with low complication rates reported in the literature. Guo et al40 performed a retrospective study of 10 patients who underwent fusion with anterior contoured plates. Ninety percent of patients had fusion at 15 weeks, and one underwent revision because of screw loosening, which went on to fusion 12 weeks later. There were no postoperative wound complications, and all patients reported improvements in pain. Rowan and Davey43 used an anterior T-plate in 33 consecutive patients and had a fusion rate of 94%. Tibial stress fractures developed in two patients and healed without fixation, and four patients had superficial wound infections. Plaass et al42 used an anterior double-plate system in 29 patients and reported a fusion rate of 100%, an improvement in mean AOFAS scores from 37 to 68, and no wound complications; 93% of patients (27 of 29) were satisfied with their outcome and would have the procedure again. The low rates of infection, complication, and nonunion in these studies are similar to those of other reported results on isolated anterior plating, as well as combined anterior plating and multiplanar screws.34,40,41

**External Compression Arthrodesis Using a Circular External Fixator**

In difficult cases, such as a previously failed arthrodesis with or without infection, talar osteonecrosis, soft-tissue compromise, or severe ankle deformity, ankle arthrodesis using a circular external fixator may be a good option for ankle arthrodesis.44,45 Various techniques can be used for compression arthrodesis using external fixation rings.44-47 The method of preparing the joint for arthrodesis depends on the surgeon’s preference and the specifics of the case. In revision cases, prior incisions often must be used. At times, it helps to place Steinmann pins to hold the alignment of the ankle while placing the frame. Once the joint has been prepared, the frame is applied and often consists of one or two rings placed orthogonal to the distal tibia and a foot-plate half ring. Fixation is accomplished with half pins, and tensioned thin wires are placed in a multiplanar fashion. Typically, the tibial ring or rings are applied first, followed by the foot plate. Usually the plantar foot is placed distal to the foot ring. Talar wires can be used to provide increased stability and protect the subtalar joint from compression. The proximal ring or rings are connected to the foot construct by struts, and tibiotalar compression is performed. Wound closure is performed in a standard fashion, and dressings are applied to the pin sites.

The overall results of external compression arthrodesis reported in the literature have been good. In a study by Hawkins et al,44 the authors used an Ilizarov technique for ankle fusion in 21 patients with complex distal tibial pathology or failed ankle arthrodesis. Sixty percent of patients had a good result after solid ankle arthrodesis, with expected functional capacity after fusion and no reports of pain or infection. Twenty percent of patients had a fair result, classified as a solid ankle fusion with marked residual reports of pain or deformity, and 20% had a poor result, with a residual infection in one patient and nonunion in three patients. Eylon et al46 examined 17 patients who had either a primary or

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**Figure 9**

Weight-bearing AP (A) and lateral (B) radiographs of the ankle demonstrating anterior plating with placement of an additional multiplanar “homerun” screw for additional compression. (Courtesy of James Jastifer, MD, Kalamazoo, MI.)
reviewed ankle arthrodesis using an Ilizarov frame with 6-year follow-up. All ankles had a solid fusion, and the average AOFAS score was 65. In a retrospective review of 91 patients who had undergone a complex ankle arthrodesis using the Ilizarov method, Fragomen et al. <sup>48</sup> reported a fusion rate of 84% and a mean AOFAS score of 71 at 27-month follow-up. Easley et al. <sup>45</sup> reported on 45 consecutive patients who underwent revision tibiotalar arthrodesis. Eleven patients underwent repeat internal fixation, 22 had placement of a ring external fixator, and 12 underwent tibiotalocalcaneal arthrodesis. Average follow-up was 50.3 months, and fusion was achieved in 80% of all patients and in 87% of patients (19 of 22) in the ring external fixator group. Current evidence supports the use of ring external fixation in some complex and revision arthrodesis cases.

### Summary

In some patients, global end-stage ankle arthritis can be effectively managed nonsurgically. In patients who have persistent symptoms despite having undergone nonsurgical care, the treating surgeon often faces the difficult decision whether to fuse or replace the ankle joint. The literature supports both arthrodesis and arthroplasty. Patient-specific factors, such as medical comorbidities, age, and activity level, influence this decision. The key to a successful outcome is to engage the patient in the decision-making process.

If the surgeon and patient arrive at the conclusion that arthrodesis is the preferred treatment, then numerous technical options exist. Questions that aid in determining the most appropriate technique include the following: Is there coronal plane malalignment? Is there sagittal plane translation? Is there talar dysplasia? The more of these questions that have positive responses, the more the surgeon should consider an extensive approach rather than a less invasive procedure. If the answers are mostly negative, then the surgeon is afforded the option of using a less invasive technique that can potentially preserve the blood supply, decrease the risk of nonunion, and decrease the risk of wound complications. The specific approach must be individualized for each patient. No uniform treatment algorithm exists for this complex pathology.

### References

References printed in bold type are those published within the past 5 years.


