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Unipolar Osteochondral Allograft Transplantation of the Ankle for Posttraumatic Tibial Necrosis: A Case Report

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ABSTRACT

We present the case of a 31-year-old male with debilitating post-traumatic arthritis of the ankle secondary to osteonecrosis of the tibial plafond. He was treated with a custom-cut tibial osteochondral allograft transplantation. At 1-year follow-up, radiographs confirmed incorporation of the graft. He had demonstrated significant improvement in terms of both subjective pain and functionality of the ankle and was ready to return to work. Our observation in this case suggests that osteochondral allograft implantation may be a viable alternative treatment in cases of ankle arthritis in the younger patient.

End-stage osteoarthritis of the ankle is a condition that occurs at a significantly lower rate than that of osteoarthritis of the other major weightbearing joints in the lower extremity. Posttraumatic arthritis accounts for upward of 70% of cases and occurs at an average age range of 52 to 58 years (1,2). Total ankle arthroplasty (TAA) and ankle fusion are 2 well-established procedures used in the treatment of this condition. However, when dealing with a younger patient population, the longevity and potential future complications of these procedures must be taken into consideration. Both arthroplasty and fusion have demonstrated relatively high reoperation rates at 5 and 10 years, and adjacent joint disease eventually becomes an issue for most patients. Also, although TAA has shown good survivorship at 10 to 15 years, long-term data for newer generations of implants are lacking. With this case, we present an alternative surgical option for a young and active patient with posttraumatic arthritis and bony necrosis limited to the tibial plafond.

Case Report

History

A healthy 31-year-old male presented to our outpatient clinic in January 2017 with a chief complaint of right ankle pain. He had sustained a fracture to the right ankle in 2006 and underwent open reduction internal fixation with subsequent removal of hardware 1 year later. Following his initial injury, he had been able to return to his job at a convenience store and to a normal level of activity with only minimal pain. However, without inciting trauma, he had been experiencing worsening diffuse ankle pain during the previous 2 months that was becoming severely limiting to the point that he had been unable to work for the previous month. At the point of referral to our clinic, he had exhausted several conservative treatments for pain including multiple corticosteroid injections and physical therapy; he was heavily dependent on narcotics for pain control, including a 50 mcg/72 h fentanyl patch and 40 mg daily of hydrocodone. He was unable to spend more than a total of 1 hour per day bearing weight on the ankle.

Physical examination revealed a mildly diffusely swollen right ankle without any erythema or warmth to touch. Previous surgical incisions were completely healed. Range of motion testing of the affected ankle showed 30° of both dorsiflexion and plantarflexion (compared with 60° and 45°, respectively, in the contralateral ankle). A small amount of crepitus within the joint was present with ranging, but no instability was detected. The retrospectively analyzed American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale score (0 to 100, composed of pain, function, and alignment) was 48 (this was calculated at the patient's first postoperative visit, approximately 3 months after his initial presentation, and we recognize this fact as an inherent limitation).

Imaging studies that included weightbearing plain radiographs, bone scans, and magnetic resonance imaging were reviewed at the patient's presentation. Sclerosis of the lateral tibial plafond and significant lateral tibiotalar joint space narrowing could be seen on the weightbearing radiographs (Fig. 1). Bone scan revealed increased uptake in the distal tibia (Fig. 2), and the magnetic resonance image was consistent with necrosis of the distal tibia (Fig. 3).

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Fig. 1. Weightbearing plain radiographs of the right ankle at the time of the patient's initial presentation. Mortise (*A*) and lateral (*B*) views depict arthritic changes to the lateral aspect of the ankle joint as well as significant sclerotic changes to the lateral tibial plafond.

Operative Course

Surgical implantation of the allograft was performed with the patient under general anesthesia, in the supine position with a thigh tourniquet, and through a midline anterior approach to the ankle. A custom cutting jig that had been predesigned with the use of computed tomography guidance was used for the tibial cut, which resected the entirety of the necrotic bone that was present. The cut was performed by using a no. 4 INBONE™ (Wright Medical, Memphis, TN) guide with the joint distracted and a custom plastic liner in place to protect the talus from any iatrogenic damage. After the cut, significant avascular necrosis and subchondral collapse in the resected segment were noted; in contrast, the talar surface appeared normal and without any chondral insult. We then turned our attention to the graft, which was cut to the proper size by using the jig and was prepared for implantation according to the manufacturer's specifications. The donor site was prepared first with a bath of platelet-derived growth factor augment (Wright Medical); subsequently, Pro-Stim (Wright Medical) was placed as a grout on each of the receiving surfaces. After insertion, the allograft was secured using 2 medial-to-lateral 4.5-mm titanium screws. Finally, a short leg splint in neutral position was applied.

Fig. 2. Technetium-99m bone scan at the time of the patient's initial presentation showing increased uptake in the right ankle that is most pronounced laterally.

The allograft was donated by a 26-year-old male and processed by MTF Biologics (Edison, NJ). Harvest to implantation time was 34 days. The donor was screened for multiple pathogens including HIV, hepatitis B virus, hepatitis C virus, and syphilis. The graft was stored in a nutritive medium and refrigerated in a temperature range of 1°C to 10°C and was not removed from this medium until the time of implantation.

Postoperative Course

The patient was discharged from the hospital on postoperative day 1 and was immobilized and kept non-weightbearing. He was advanced to a controlled ankle movement walker boot at 3 weeks, allowed to bear 50% weight at 6 weeks, and finally was advanced to full weightbearing at 10 weeks postoperatively.

Follow-Up

At his most recent follow-up visit at 12 months after surgery (March 2018), the patient was doing well and continuing to improve clinically. He had painless range of motion of the ankle and had achieved 45° of dorsiflexion and 30° of plantarflexion. He still had some complaint of pain with extended periods of walking or standing but he was

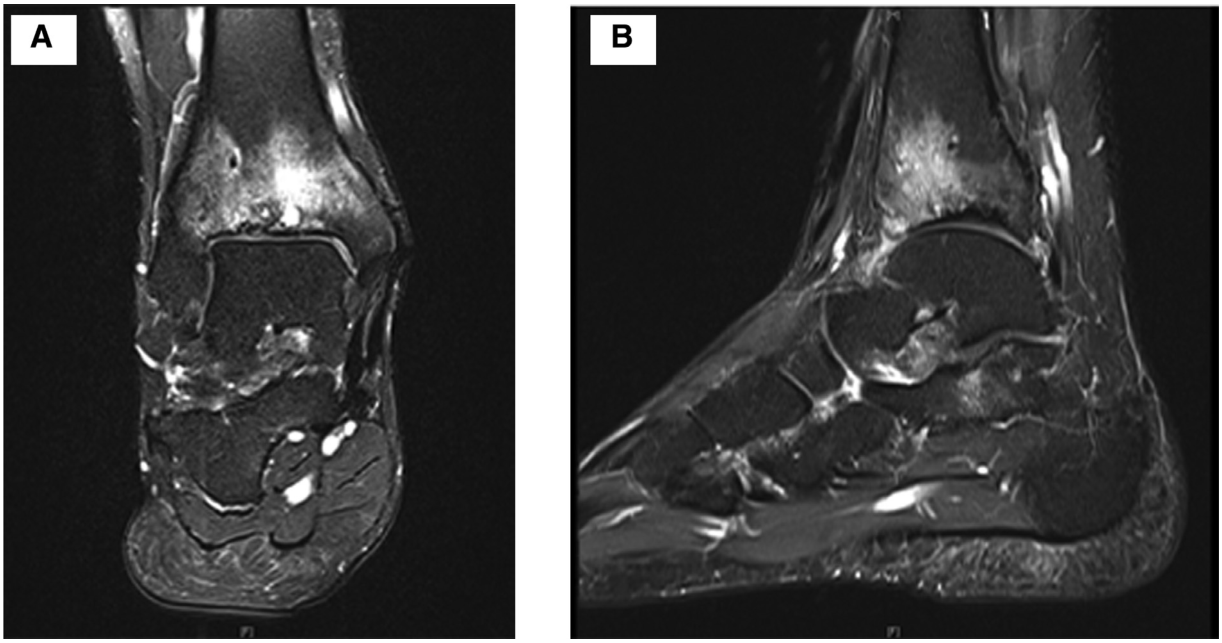

Fig. 3. T2-weighted magnetic resonance images at the time of the patient's initial presentation. Coronal (*A*) and sagittal (*B*) slices show increased signal at the tibial plafond, suggestive of necrosis of the distal tibia.

continuing to improve. At that time, he was ambulating with an ankle stabilizing orthosis brace in a normal shoe and occasionally using a cane for longer trips. His American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale score significantly improved to 73 and his subjective pain score was 3 of 10 (compared with 9 of 10 preoperatively). Weightbearing images (Fig. 4) show near-complete fusion of the graft–host interface as well as similar density of the graft and native bone, signaling incorporation. At this point, the patient was pleased with the result of his surgery and was planning to return to work.

Discussion

Osteoarthritis of the ankle is a condition that occurs at a much lower rate compared with other major weightbearing joints. The knee, for example, is approximately 8 times more likely to present with clinically significant arthritis despite the fact that the ankle has the greatest load of any weightbearing joint in the body with only about one-third the total contact area of the hip or knee (3). Thus, the vast majority of cases of ankle arthritis can be attributed to prior ankle trauma, which

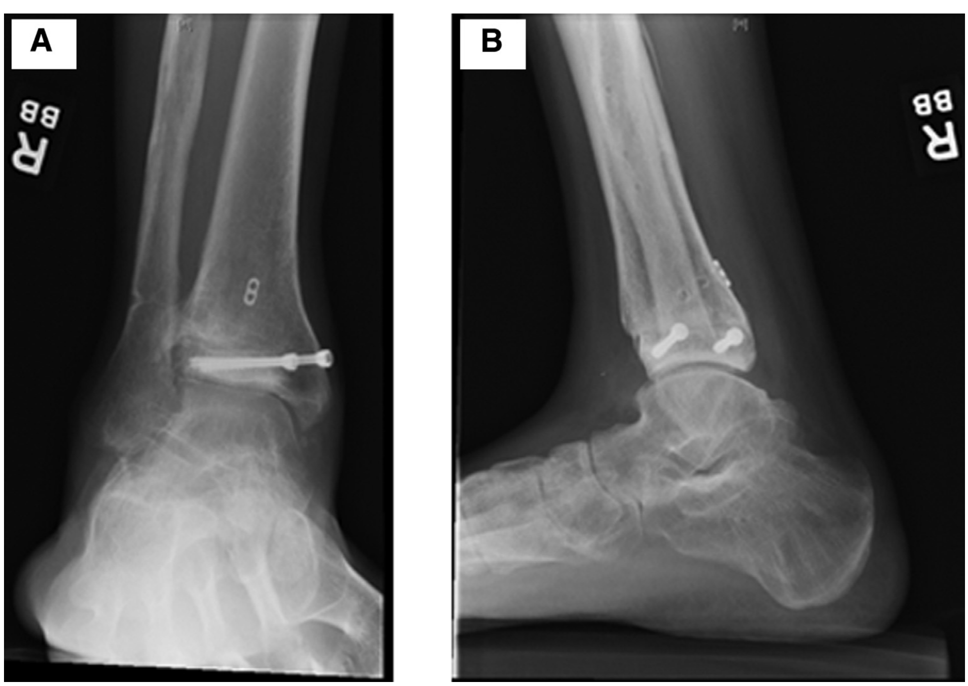

Fig. 4. Weightbearing plain radiographs at the patient's 1-year follow-up. Mortise (*A*) and lateral (*B*) views show a well-fixed graft, intact hardware, and similar-appearing density of both the graft and surrounding native bone, suggestive of graft incorporation.

accounts of up to 78% of cases (1,2). The subset of patients with posttraumatic arthritis are younger than those patients with primary arthritis (average age 52 to 58 and 65 to 67 years, respectively); it is rare that patients present under the age of 40 years (1,2). All ankle fractures carry a significant risk of subsequent symptomatic arthritis. A study by Lindsjo et al (4) showed a 14% overall incidence of arthritis in follow-up of >300 surgically managed ankle fractures. This risk changed significantly depending on the fracture pattern, considering both the lateral malleolus pattern and the presence and size of a posterior malleolar fracture. The risk of developing arthritis was as high as 33% for those with a Weber C pattern and 34% with a large posterior malleolar fragment (4). Additionally, studies have shown cartilage damage to be present in >70% of ankle fractures by using preoperative arthroscopy to assess the joint surfaces (5,6). Finally, the development of osteonecrosis of the tibial plafond, as was present in our patient, is a documented but much rarer complication of ankle fracture. A large study of >600 arthritic ankles found that of patients with posttraumatic arthritis, only 2.2% had radiographic findings of osteonecrosis (1).

The gold standard of surgical treatment for symptomatic ankle arthritis has long been tibiotalar fusion. Although arthrodesis touts a union rate of 89% to 94% and excellent short-term pain and function scores, mid- and long-term complications are well documented (7,8). Adjacent joint arthritis is one of the major concerns and typically only takes a few years to become radiographically apparent. It is well documented in long-term studies that advancement of arthritis in the subtalar and Chopart joints is apparent compared with the contralateral foot, and intermediate-term studies have shown arthritic changes to be radiographically visible at rates of up to 50% by 8 years postoperatively (9–12). Also, although pain is reliably relieved in the short to intermediate term, studies that have followed patients for ≥20 postoperatively have shown that both significant pain and hindfoot and gait functional deficits are present in the long term (8,9,11). The literature suggests that, although effective, arthrodesis should be considered as a salvage procedure, and significant long-term deficits as well as high reoperation rates should be expected, especially in the younger, more active patient.

In recent years, TAA has been gaining popularity among surgeons. Throughout the course of its development, implant survival has been a major limitation in ankle replacement. However, more recent studies on the mid- to long-term results of newer generation implants are more promising. A meta-analysis from JBJS, completed in 2013 and including nearly 8000 ankles, showed a 10-year implant survival of 89% and an annual failure rate of 1.2% (13). A smaller study that followed 24 Scandinavian total ankle replacement implants showed a 15-year survival rate of 73% (14). Total ankle replacement preserves the tibiotalar arc of motion and has been shown to increase total ankle motion compared with preoperative measurements (13). This preservation of motion is theorized to help prevent the development of adjacent joint arthritis; although TAA does have lower rates of adjacent disease compared with fusion, radiographic adjacent joint arthritis can been seen in 12% to 19% of patients at 5 years (15). In addition, minor reoperation is frequently required in the initial 5 to 10 years, and in this time frame, approximately 5.3% of patients undergo conversion to fusion (15,16). In terms of surgical indication, studies have shown conflicting evidence as to whether TAA performed for posttraumatic arthritis is as effective as TAA used to treat primary or inflammatory conditions. Although radiographic and survival parameters are not significantly different, functional outcome scores have been shown to be slightly lower in mid- to long-term follow-up in patients who underwent the procedure for posttraumatic arthritis (17,18). Another important factor is the age of the patient; patients younger than 55 years at the time of surgery have been shown to have a significantly higher 5-year implant failure rate (19). Thus, although TAA shows promise as a reconstructive option, high reoperation rates coupled with relative lack of long-term data for newer implants should make a surgeon wary of its application to younger patient populations.

A potential alternative treatment for ankle arthritis in young patients presents itself in osteochondral allograft transplantation. Although this procedure is well described in the literature for its use in the treatment of osteochondritis dissecans lesions in the hip, knee, and talus, there are limited data regarding its use for the treatment of arthritis. Our case involved unipolar osteonecrosis of the tibia with no involvement of the talus. Only 1 case has been described in which a similar condition was treated with unipolar tibial allografting in a case series of 11 patients by Meehan et al (12) in 2006. Most of the literature regarding the use of osteochondral allograft (OCA) for treatment of arthritis describes bipolar grafting or unipolar grafting of the talus. The first of these series was published in 2002 and followed 7 patients treated for posttraumatic arthrosis with OCA transplantation. At 12-year follow-up, 4 of 7 patients had excellent result, and 5 of 7 stated that they would again elect to undergo the procedure (20). Another significantly larger series by Bugbee et al (21) in 2013 followed 86 ankles treated with bipolar fresh OCA at follow-up periods of 5 and 10 years. During the initial 5 years, 42% of patients required reoperation of some kind, and 29% were designated as clinical failures (described as requiring a conversion to arthrodesis or TAA). However, of those designated failures, 85% of patients reported significantly improved pain and 83% felt their function had improved. At 10-year follow-up, survival had dropped to 44%.

Finally, a study by Giannini et al (22) in 2014 assessed the viability of OCA transplantation in multiple joints, including the ankle, with largely successful results. Graft survival at 4 years was 84%, and patients reported an average of 59% improvement at this time. Another facet of this study examined the use of a light immunosuppressive therapy for 6 months after surgery. Patients receiving cyclosporine and steroids had a significantly faster recovery, better pain scores at 12 months, and better overall survival rates at 4 years compared with patients who did not receive cyclosporine and steroids. Interestingly, pain scores were not significantly different in either group beyond 12 months. Although limited, these series of bipolar ankle allografting have shown fairly promising initial results.

In terms of the graft itself, proper storage and surgical technique are paramount in achieving a good clinical result with transplantation. Cellularity of the graft and chondrocyte viability at the time of implantation are important indices of biological performance (23,24). How the graft is stored and the time from harvest to transplantation significantly affect these variables. A 2003 study by Williams et al (24) analyzed the viability/density of chondrocytes in grafts stored at 4°C, and they authors found that there were no significant changes up to 14 days. However, after 28 days of storage, the synthesis of proteoglycans had decreased and the density of viable chondrocytes had been reduced by 29%. In vivo studies have shown that grafts implanted within a 14-day window of harvest have up to 99% chondrocyte viability 12 months after implantation and 91% at 3.5 years (25). Although frozen storage of grafts has been proposed to lengthen their shelf life, this process significantly affects chondrocyte viability. A study by Pallante et al (23) in 2012 showed that at 1 year after transplantation, frozen grafts showed 93% less cellularity compared with grafts stored at 4°C. Another factor affecting graft health and viability is the risk of disease transmission. Even with proper processing and pretreatment, fresh OCAs carry a 7% risk of bacterial transmission, and even though few result in a clinically significant infection, the risk is present and must be considered (26). Other, more technical factors have also been linked with graft performance. For example, graft thickness has been correlated with failure via fracture or fragmentation, and grafts <7 mm thick have been shown to be at increased risk for failure in such a manner (12). The use of the graft for any correction of malalignment or limb-length discrepancy has also been linked to higher rates of failure (22).

The risk of viral transmission is also real, and although donors are screened, as of 2015, there have been 2 reported cases of HIV infection, 1 case of hepatitis virus infection, and 3 cases of hepatitis C infection as a result of OCA transplantation. Although the overall risk is small, amounting to about 1:1.6 million for HIV infection (slightly higher compared with a 1:1.8 million risk in blood product transfusion), patients should be counseled nonetheless (27).

In conclusion, we believe that fresh osteochondral allograft transplantation is a viable treatment option for posttraumatic arthritis in young, active patients. With this report, we present a unique case of osteonecrosis isolated to the distal tibia treated with a custom-cut distal tibia allograft with good outcome at 1-year follow-up. Factors contributing to success in the patient include use of fresh allograft, lack of need for joint realignment or limb lengthening, and surgeon expertise with the anterior ankle approach as well as total ankle cutting equipment and cutting jigs. Although prior research on the use of OCA in the ankle does show higher failure rates than its more classic applications in the knee, we believe that with proper patient selection and surgical technique, this procedure can significantly delay the need for TAA or arthrodesis and the long-term morbidities associated with each procedure (28). Also, successful conversion to arthrodesis in cases of OCA failure have been documented; thus, this procedure does not preclude patients from receiving more classic treatment options (22). We recognize that 1 case with 1-year follow-up provides limited evidence for this procedure, and multiple cases will be necessary to substantiate this treatment approach. Also, additional research regarding the immunogenicity of osteochondral allografts and the use of immunosuppressive therapy in OCA transplant recipients could further our understanding of OCA incorporation and help improve graft survival and patient outcomes.

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