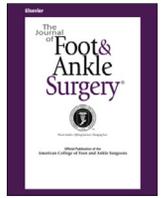


Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Complications of En Bloc Osteochondral Talar Allografts and Treatment of Failures: Literature Review and Case Report

Christopher A. Juels, DPM, AACFAS¹, Eric So, DPM, AACFAS¹, Chad Seidenstricker, DPM, AACFAS², Jeffrey Holmes, DPM, FACFAS³, Ryan T. Scott, DPM, FACFAS⁴

¹ Fellow, The CORE Institute Foot and Ankle Advanced Reconstruction Fellowship, Phoenix, AZ

² Surgeon, New Mexico Orthopaedics, Albuquerque, NM

³ Surgeon, The CORE Institute, Phoenix, AZ

⁴ Director, The CORE Institute Foot and Ankle Advanced Reconstruction Fellowship, Phoenix, AZ



ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:

ankle arthrodesis
ankle arthroplasty
complications
graft failure
osteochondral lesions
osteochondral talar allograft

ABSTRACT

Reoperation rates and complication rates can be high for patients receiving an osteochondral talar allograft transplant. Complications can include graft failure, delamination of the graft, arthrofibrosis, advancing osteoarthritis, nonunion of malleolar osteotomies, and partial or complete osteonecrosis of the talus. Graft failure refers to failure of graft incorporation with subsequent necrosis and subsidence. Treatment options for talar graft failure are limited, and outcomes for these treatments have rarely been reported. We present a review of the published data on the complications and treatments for failed talar allograft transplantation. A case report is presented on a young woman who experienced graft failure and osteonecrosis of her talar allograft transplant. Because of the size of the present osteonecrosis, an ankle arthrodesis was performed as the initial revision procedure. Talar necrosis was removed and revascularized from the ankle fusion with solid fusion was confirmed with computed tomography. Symptomatic adjacent joint pain quickly developed in the hindfoot after the ankle fusion, and 12 months later an ankle fusion conversion to total ankle arthroplasty was performed. The patient has returned to normal activity with significant reduction in pain at most recent follow-up visit. This patient was followed for 7 years from initial osteochondral talar allograft transplantation and for 2 years from conversion of ankle fusion to total ankle arthroplasty. It is important to understand the techniques, indications, and outcomes for the various revision options for talar allograft failure. This case report illustrates how multiple revision options can be used to provide the best outcome for the patient.

© 2019 by the American College of Foot and Ankle Surgeons. All rights reserved.

Osteochondral lesions of the talus (OLTs) are defects of the articular cartilage of the talus and underlying subchondral bone (1–4). These lesions have poor ability to heal without surgical intervention secondary to the delicate vascular supply to the talus. Traditional treatment options include osteochondral autograft transfer system (OATS), mosaicplasty, bone marrow stimulation, subchondral drilling, autogenous chondral grafts, and autologous chondrocyte implantation (5–11).

Most OLTs can be treated arthroscopically with debridement or marrow stimulation techniques (8,9). However, open techniques may be indicated when these techniques fail or when the morphology, location, and severity of the lesion are such that arthroscopic techniques

are inadequate (12–21). There is a subset of OLTs that are uncontained and involve the talar shoulder. These are typically large lesions that involve a substantial amount of the weightbearing portion of the talar dome and either the medial or lateral articular surface. Fresh osteochondral allograft transplantation is a viable alternative to other treatment options and may be suitable for these lesions. The rationale for allograft transplantation is that the implantation of a viable osteochondral segment is capable of surviving the transplantation and ultimately will fully integrated by the host (22). Osteochondral allograft transplantation fills the defect with mature hyaline cartilage structure while addressing underlying bone deficiency (23,24). Osteochondral allografts may be created to match any size defect and eliminate the need for donor site morbidity. Thus, this technique is advantageous for large, deep, or uncontained OLTs (2).

Despite successful clinical outcomes, the reoperation rate has been reported as 25% in a systematic review and has been as high as 33%, with failure rates up to 35% (14,25,26). Complications may include failure of the graft, graft delamination, arthrofibrosis, nonunion, and

Financial Disclosure: None reported.

Conflict of Interest: R.T.S. discloses consultant/advisory roles with Wright Medical Technologies, Stryker Corporation, Medline Industries, Parcus Medical, and Artelon and research funding (not for this report) from Amniox and Zimmer Biomet. None reported for the other authors.

Address correspondence to: Christopher A. Juels, DPM, AACFAS, 18444 North 25th Avenue, Suite 210, Phoenix, AZ 85023.

E-mail address: juelsc@gmail.com (C.A. Juels).

malunion of malleolar osteotomies (12,14,25,27,28). Graft failure is one of the most devastating complications and refers to failure of allograft incorporation with subsequent necrosis and subsidence. Several articles have published case series outcomes and failure rates for osteochondral allograft transplantation of the talus (12,14,15,18,25,27). However, the treatment for these failures has not thoroughly been discussed, and limited case examples have been published. The purpose of this article is to review the treatment of graft failure of fresh talar allograft transplantation. A case example is presented of an unfortunate osteochondral talar allograft failure in a young healthy patient, along with our treatment approach.

Case Report

A 34-year-old woman presented in October 2015 with chronic right ankle pain. She had a past history of a talus microfracture 5 years earlier as a result of an osteochondral defect in her talus. The talar microfracture was not successful, and the patient received an en bloc osteochondral talar allograft 3 years prior to presentation, followed by hardware removal 1 year later. There was no associated vascular or neurologic pathology or history, and she had significant pain on range of motion testing. At this time, magnetic resonance imaging (MRI) revealed roughly 50% healing of the talus allograft. As an initial treatment option, an ankle arthroscopy with debridement of the talus allograft and curettage of the medial malleolar screw holes, with autograft used for back-filling, was performed.

The patient continued to have right ankle pain, and 3 months after ankle arthroscopy, repeat radiography and ankle MRI revealed chondromalacia of the tibiotalar joint (Fig. 1 and 2). Because of continued necrosis and collapse of the talus allograft, an ankle arthrodesis was recommended. Discussion was extended to include the option for a



Fig. 1. Preoperative ankle radiographs showing the necrosis of the partial talar dome allograft, with lucency between the graft and host talus.

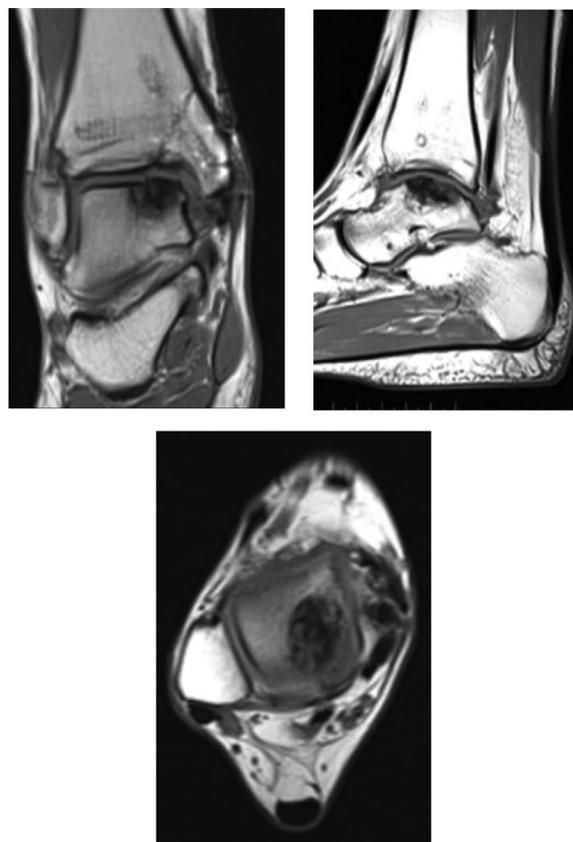


Fig. 2. Preoperative ankle magnetic resonance image showing continued tibiotalar chondromalacia and necrosis of the partial talar dome allograft.

future takedown of ankle fusion with conversion to total ankle arthroplasty if the patient developed adjacent joint osteoarthritis (Fig. 3). Approximately 1 year after initial presentation, an ankle arthrodesis



Fig. 3. Postoperative ankle radiographs after ankle arthrodesis with calcaneal autograft and allograft supplementation. Postoperative ankle radiographs after conversion of ankle arthrodesis to total ankle replacement as a result of painful adjacent joint arthritis, after revascularization of the talus.

was performed with autograft and allograft supplementation to the arthrodesis site (Fig. 3). The patient progressed to solid osseous fusion, confirmed on computed tomography (CT), as well as incorporation and revascularization of the talar body. She was transitioned into an ankle brace and returned to full activity.

Hindfoot pain quickly developed postoperatively with emphasis over the subtalar and talonavicular joints. Clinical and radiographic examinations of the patient's right talonavicular and subtalar joint showed early signs of adjacent joint arthritis. Right ankle fusion taken down to total ankle arthroplasty was performed in May 2017, 1 year after the ankle arthrodesis (Fig. 3). The patient progressed from a walking boot at 6 weeks postoperatively to an ankle stabilizing brace and received physical therapy and home range of motion exercises. The pain has significantly reduced in the hindfoot, and she is back to normal activity. At the 2-year follow-up visit in May 2019, including 7 years of follow-up from initial osteochondral talar allograft transplantation, she had 41° of ankle sagittal plane range of motion, with 9° of dorsiflexion. Her American Orthopaedic Foot and Ankle Society Hindfoot and Ankle Scale score was 87 after 2 years, and she was satisfied with her outcome. When asked, the patient stated that hypothetically she would have the procedure again for the condition.

Discussion

Graft Failure

Early failure of an osteochondral graft can result from failure of bony ingrowth, chondrolysis, or delamination of the cartilage. The allograft bone is slowly incorporated and replaced by the host bone through a process of creeping substitution. Revascularization may take from 1 to 4 years, depending on the size of the allograft and the quality of the host bone (29). During the revascularization process, the allograft bone is very vulnerable to collapse (17). Graft collapse ultimately can result in malalignment and late failure of the graft. Another late complication is degeneration of the joint. This is a result of overload of the healthy cartilage adjacent to the graft owing to graft mismatch or late subsidence. The most common complication is failure in the osseous portion, where subchondral collapse, delayed union, or nonunion may occur (30). Graft fragmentation and collapse are among the main failure mechanisms, usually presenting as new onset of pain, joint effusion, and mechanical symptoms. As a milder complication, allograft subsidence may occur (30). It has been documented that osteochondral allografts lose 1 to 2 mm of height depending on the stresses applied (29,31–34). Whenever patients show radiographic evidence of graft subsidence, despite remaining asymptomatic, observation may be indicated.

Graft survival has varied from 66% to 100% (10,14,15,19,27,35). A common reason for revisions is fragmentation and resorption of the graft that subsequently lead to collapse (10,14,19,35). Graft failure is consistently associated preoperatively with the presence of subchondral cystic lesions, prior operation, and large lesions (27,36,39). It is important to avoid these complications and to be aware of these risk factors to aid in patient outcomes and prevent reoperations. Before entering the care of the authors, our patient had undergone arthroscopic ankle debridement with subchondral microfracture, as well as reportedly having a large lesion. These risk factors may have had a role in the graft failure of the patient. These risk factors were also prevalent in the study of El-Rashidy et al (27). Of the 4 of 38 patients who required reoperation, 3 patients previously received arthroscopy with microfracture, whereas the fourth patient had also failed prior osteochondral autograft transfer (27). Although risk factors are important to be aware of, clinical and surgical judgment must be used on an individual patient basis. Some patients, such as our reported case, are young, healthy, and active patients who are poor candidates for ankle

arthrodesis or arthroplasty because of the functional limitation of these procedures. These limitations are what make fresh osteochondral talar allograft transplantation a viable treatment option for some patients.

According to a systematic review, the reoperation rate is 25% for osteochondral talar allograft transplantation (25); 8.8% underwent subsequent arthrodesis or arthroplasty. With failure being defined as postoperative graft nonunion or resorption or the persistence of symptoms leading to subsequent arthrodesis or arthroplasty, the overall failure rate is 13.2% (25). Haene et al (37) reported failure of graft incorporation in 2 of 16 ankles, and the mean graft position relative to the native talus was subsided 0.5 mm according to postoperative CT scans (37). On the latest radiographs and CT scans, osteolysis and subchondral cysts of >2 mm in diameter were found in 5 and 8 of the grafts, respectively. Degenerative changes outside of the graft area consisting of subchondral cyst formation and joint space narrowing were found in 7 of the ankles. Five of the ankles were considered a failure (37). Specifically, 2 ankles either had undergone or were awaiting arthrodesis as a salvage procedure (37).

Gross et al (14) reported on 9 patients with OLTs who underwent fresh osteochondral allograft transplantation. At a mean follow-up of 11 years, 6 grafts remained in situ. The 3 failed allografts demonstrated radiographic and intraoperative evidence of fragmentation or resorption, and these patients subsequently underwent ankle arthrodesis at 36, 56, and 83 months, respectively, following the allograft surgery (14). The late conversion to arthrodesis indicates the need for long-term monitoring of patients who have been managed with osteochondral talar allografts (14). This is currently the longest follow-up study (14), indicating that other studies may have had higher failure rates if patients had been followed for longer periods.

Raikin (18) reported on 15 patients who underwent bulk fresh osteochondral allografting for large-volume cystic lesions of the talus. Only 2 grafts failed and necessitated the performance of ankle arthrodesis. Some form of graft collapse, graft resorption, or joint space narrowing was seen in all patients (18). In Raikin's retrospective review of 8 patients, lucency at the interface of the allograft and host bone was found in 5 patients (12). However, the presence of graft–host lucency did not seem to affect the treatment outcome in 4 of the 5 patients. Four of the 8 patients required additional surgery, 2 patients required additional ankle arthroscopic debridement, 2 patients required hardware removal, 1 patient required medial malleolus osteotomy nonunion revision, and 1 patient required tibial and calcaneal osteotomies to correct varus malalignment (12). Orr et al (38) reported a case series of 8 structural allograft transfers with an average follow-up visit of 28 months. Three of the 8 cases were considered failures, although only 1 allograft failed to incorporate with subsequent graft resorption, which ultimately required ankle arthrodesis (38).

Disease Transmission

Allograft-associated infection is rare but may be fatal. *Clostridium* contamination risk increases with the length of time between donor death and procurement (40,41). Safety guidelines established by the American Association of Tissue Banks advocate donor screening; extensive serologic, bacterial, and viral testing; procurement and storage requirements; and graft quarantine until negative testing results are ensured (42). Deep infection following allograft transplantation should be considered for surgical debridement and graft removal.

Disease transmission is a concern with any transplantation procedure, and disease transmission resulting from osteochondral allografting remains a concern. The current estimated risk of human immunodeficiency virus (HIV) transmission through allograft tissue is 1 in 1 million (42). There have been 3 reported cases of HIV transmission, 2 cases of hepatitis C virus transmission, and 1 case of hepatitis B virus transmission through allograft tissue (42). Appropriate counsel about

the risks and benefits of receiving allograft tissue should be made. Advances in serological testing for HIV, hepatitis, and other pathogens have significantly decreased the risk of transmittable diseases (43).

Immunogenicity

The body's immune response also plays a role in osteochondral allograft transplantation. It has previously been suggested that articular cartilage is relatively immunoprivileged; the surrounding matrix around the chondrocytes protects against the host's immune cells, whereas bone marrow components of the allograft may not (44–46). Although animal studies have shown less immunologic reaction in cross-matched donor allografts, unmatched allografts have not yet been shown to have a significant decline in clinical outcomes (45,47). In a study by Meehan et al (17), 10 of 11 of the authors' patients tested positive for serum HLA cytotoxic antibody postoperatively after receiving fresh osteochondral allografting for the ankle joint. The 1 patient who did not test positive was receiving immunosuppressant medication for a kidney transplant, and this patient's radiographic and clinical outcome scores proved to be the most successful in the cohort (17). A report from Phipatanakul et al (48) indicated that in 8 of 14 of their osteochondral allograft patients, there was an immunologic response to cartilage-specific protein.

A study by Sirlin et al (49) compared MRI results of 2 groups of patients receiving bipolar osteochondral allografts in the knee. MRI results showed greater edema, thicker interface, and worse graft marrow signal in the treatment group that generated positive serum HLA antibodies (49). It has been shown that in failed osteochondral allografts of the talus, because of graft failure/collapse, nonunion, progressive arthritis, and/or pain, there is likely a CD4⁺ and CD8⁺ lymphocyte-mediated failure mechanism (26). This was demonstrated at the graft–host interface in 8 of these cases because histologic staining showed substantial loss of sulfated glycosaminoglycans and osteocalcin, whereas (CD68) and CD4⁺ helper T cells, CD8⁺ cytotoxic T cells, and natural killer cells were all found to be in high concentrations (26). These are all commonly seen in allogeneic organ transplant rejections.

It may be helpful to weaken the immunologic reaction to the allograft by taking precautions such as alcohol rinses, high-pressure washes, and specific treatments to destroy proteins and eliminate blood and bone marrow cells (50).

Complications From Malleolar Osteotomy

Many osteochondral talar allograft transplantations require either a medial or a lateral malleolar osteotomy to gain access to the subsequent talar shoulder. This step in the procedure comes with the potential complication of malunion, nonunion, or irritable hardware that may need an additional operation (12,28,38). A retrospective case series was performed by Bull et al (28) that reviewed 50 patients after medial malleolar chevron osteotomies for medial talar dome exposure. This study showed a 30% malunion rate and an average displacement of 2 mm of incongruence at final follow-up visit.

In the case series by Adams et al (12) of 8 patients who received talar osteochondral allograft transplantation, 1 patient underwent revision open reduction and internal fixation of an ununited medial malleolar osteotomy, and a second patient required malleolar hardware removal (12). Two cases of delayed union of the medial malleolar osteotomy were reported in the case series by Orr et al (38). In addition, 3 patients underwent removal of symptomatic medial malleolar osteotomy hardware (38). Haene et al (37) had better results, with all malleolar osteotomies healing in their series of 14 patients; there was 1 malunion of a medial malleolar osteotomy site with slight proximal migration that did not require additional treatment.

Other Complications

During our literature review, we found that several other complications occurred during the postoperative period of some case series reports. These additional complications included lateral impingement syndrome, allograft screw removal, osseous spur impingement, superficial wound infection, advancement in tibiotalar joint arthritis, and mechanical malalignment (12,15,17,27,51). In the study by El-Rashidy et al (27), 4 of 7 patients had lateral impingement syndrome secondary to an excess amount of lateral synovial tissue. All 4 grafts were found to be intact on arthroscopic probing. However, 1 graft contained a 5- to 6-mm area of denuded cartilage (27). Hahn et al (15) reported that 4 of 13 patients required the removal of a screw that was thought to be impinging on the tibial surface, and 1 patient necessitated debridement of an impingement spur.

In the 2011 study by Adams et al (12), 1 patient with a medial allograft was found to have varus malalignment of the ankle and underwent supramalleolar osteotomy and calcaneal osteotomies to protect the graft. The 2018 case series by Adams et al (51) reported that 5 of 14 patients required ankle arthroscopy and screw removal of the allograft, because of continued pain and stiffness.

Treatment of Graft Failure

Total ankle replacement, ankle arthrodesis, and total talus allograft replacement have been described in the literature for the treatment of graft failure (Table) (14,17,18,20,21,37,38). Although ankle arthrodesis is one of the most reported revision options, it remains a challenge in young patients, because arthrodesis can provide predictable pain relief but at the risk of functional limitations and the development of adjacent joint arthritis. Adjacent hindfoot arthritis is inevitable after ankle arthrodesis, with an occurrence reported as approximately 50% at 8 years and nearly 100% at 20 years (52–55). It can be seen in the Table that there are 66 reported revision cases for treating osteochondral talar allograft failure: 25 ankle fusions, 24 revision allografts, and 17 total ankle arthroplasties. Outcomes for these revisions have infrequently been reported (14,17,18,20,21,37,38).

In the retrospective case series by Raikin (18), 2 of the 15 patients required an ankle arthrodesis after their talar allograft procedure, because of graft collapse and ankle arthritis. This procedure was required for these 2 patients as a result of eventual ankle arthritis that occurred at 32 months and 76 months postoperatively (18). In the 2004 retrospective review by Raikin (19), 1 of 6 cases resulted in graft failure that eventually required arthrodesis. Although follow-up after this revision was not reported, the patient was satisfied with the procedure and would have undertaken the osteochondral talar allograft procedure if given the option in retrospect (19). In the study by Orr et al (38), because 1 of the grafts did not incorporate and led to resorption, it was elected to revise the patient with an ankle joint arthrodesis. This patient continued to have poor outcomes at final follow-up visit; overall American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale score worsened by 12%, and the visual analog pain scale score worsened by 5% (38). In our patient, ankle arthrodesis was successful at initial pain relief for the patient, as well as revascularization and bone growth into the osteonecrosed allograft portion of the talus. Unfortunately, adjacent joint arthritis developed quickly in this patient, likely as a result of the eliminated ankle joint range of motion from the arthrodesis. To prevent subsequent hindfoot fusions, it was then elected to convert the patient to a total ankle arthroplasty.

Total ankle arthroplasty is a second option for treating failed talar allograft implantation. This option is limited to certain cases, as too much osteonecrosis or allograft collapse in the talus can interfere with the talar component and lead to early failure of the implant. This is why ankle arthroplasty was not an initial salvage option for our patient. In

Table
Reported salvage procedures from failed osteochondral talar allografts

Study	Study Design	Patients (N)	Failures and Revision Procedures	Length of Time Revisions Occurred After Initial Procedure	Follow-Up After Revision	Reported Outcomes From Revision
Haene et al (37)	Prospective case series	16	2/2 arthrodesis	N/A	N/A	N/A
Gross et al (14)	Retrospective case series	9	3/3 arthrodesis	36, 56, and 83 mo	N/A	N/A
Raikin (18)	Prospective case series	15	2/2 arthrodesis	32 mo, 76 mo	N/A	N/A
Orr et al (38)	Retrospective case series	8	1/1 arthrodesis	N/A	22.9 mo from initial surgery	Patient remained active duty, AOFAS –12%, –5% VAS pain score
Meehan et al (17)	Retrospective case series	11 (9 bipolar allografts)	3/5 revisional allograft 1/5 TAA 1/5 elected no revision	18 to 36 mo	Revisional allografts: 12 and 13 mo, 1 unknown TAA: N/A	Revisional allografts: 3/3 patients satisfied TAA: 1/1 reported good result
El-Rashidy et al (27)	Retrospective case series	380	2/4 TAA 1/4 arthrodesis 1/4 bipolar allograft	N/A	N/A	2/4 incomplete charts 2/4 report poor patient satisfaction, and would choose not to undergo procedure again
Adams et al (51)	Prospective case series	14	2/2 TAA	N/A	N/A	N/A
Raikin et al (19)	Retrospective review	6	1/1 arthrodesis	17 mo	N/A	Patient reported satisfaction with arthrodesis, would undergo procedure again
Gortz et al (35)	Prospective review	12	1/1 arthrodesis	N/A	N/A	N/A
Gaul et al (20)	Prospective case series	20	20/20 revision allograft	3 y	10.3 y	6 failures, 84% survivorship at 5 y, 65% at 10 y; 58.3% patient satisfaction
Gaul et al (21)	Comparative case series	24	13/24 arthrodesis 11/24 TAA	3.4 y arthrodesis 6.1 y TAA	7.4 y arthrodesis 3.8 y TAA	Arthrodesis: 3 failures, 84.6% survivorship at 5 y, 87.5% patient satisfaction TAA: 2 failures, 83.3% survivorship at 5 y, 50% patient satisfaction
Current report	Case report	1	1/1 arthrodesis converted to TAA	4 y	2 y	Complication: adjacent joint arthritis 1 y postoperative, conversion to TAA Outcomes after TAA: greatly satisfied, 9° ankle dorsiflexion, AOFAS score of 87

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale; N/A, not available; TAA, total ankle arthroplasty; VAS, visual analog scale; –, negative.

cases where the osteonecrosis and graft failure can be resected with the talar cuts, ankle arthroplasty becomes a primary revision option (51). In a recent prospective case series of 14 patients receiving fresh osteochondral allograft transplantation to the talar shoulder with an average follow-up of 55 months (51), 5 (36%) of these patients required additional surgery for pain and stiffness, and 2 patients were considered failures because of cartilage delamination. Of the 2 failures, 1 patient received a total ankle replacement, whereas the other patient was awaiting the same treatment (51).

El Rashidy et al (27) reported on 42 patients, 38 of whom had completed their postoperative evaluation. The authors reported 4 failed allografts, creating an overall failure rate of 10.5%. The 4 graft failures were revised to 2 total ankle replacements, 1 ankle arthrodesis, and 1 bipolar total ankle allograft. The authors reported that a previous failed osteochondral allograft did not negatively affect their ability to perform a repeat allografting, an ankle arthrodesis, or a total ankle replacement (27). However, 2 of these patients were poorly satisfied with their outcome and would not choose to undergo the original osteochondral talar allograft procedure again (27).

Another reported salvage technique is total ankle (bipolar) allograft transplantation. In the case series by El-Rashidy et al (27), 1 reported graft failure was salvaged with repeat grafting using a bipolar allograft.

Unfortunately, no specific outcomes on this case were reported. Meehan et al (17) reported on 11 patients with end-stage ankle arthritis that was treated with fresh osteochondral allograft procedures, 9 of which were bipolar. This study reports 5 failures (45%) in the average 33 months of follow-up: 3 cases required complete revision of the osteochondral allograft, 1 case was converted to a total ankle arthroplasty, and 1 case had severe graft collapse with no further surgery elected (17). Of the 4 revision cases, subjective satisfaction results were reported after 6 to 12 months from revision surgery, and all 4 patients were reportedly satisfied (17). A total second operation rate of 63.6% occurred in this study (17). Although this study was not specifically addressing failed talar allograft transplantation, it does report a large complication and failure rate of bipolar osteochondral allografts. According to Meehan et al (17), the main advantage to a repeat osteochondral allograft procedure is that it further preserves the option of arthrodesis and arthroplasty, which can potentially be harder to revise (17). Jeng et al (56) reported on 2-year outcomes from 29 patients who had received osteochondral ankle allografts, although all of their grafts were bipolar and only 1 of these cases was used to treat an osteochondral lesion of the talus. They reported another low success rate of 31% (56); 14 of the 29 revisions required a repeat ankle transplant, prosthetic total ankle arthroplasty, or bone block arthrodesis (56). Kim et al

(57) published a case series on 7 patients with bipolar allograft ankle procedures and reported a 42% failure rate. Although these 3 articles report outcomes on failed allografts that were bipolar, they provide Level 4 evidence that revisional ankle allograft replacement comes with low success rates and high reoperation rates (17,56,57).

Two recent case series reports by Gaul et al (20,21) showed results for all 3 of these revision techniques for their own failed osteochondral allograft cohort: ankle arthrodesis, total ankle arthroplasty, and revision allograft. In a comparative study, Gaul et al (21) reported that 24 patients underwent salvage procedures (13 patients underwent ankle arthrodesis and 11 patients underwent total ankle arthroplasty) after the failure of ankle osteochondral allograft transplantation. Of the 13 patients who received an ankle arthrodesis, 3 (23%) failures were reported; of the 10 patients without failure, 88% were satisfied at 7.4-year follow-up (21). The mean pain level was 1.9, and the American Academy of Orthopedic Surgeons Lower Limb Outcomes Assessment: Foot and Ankle Module (AAOS-FAM) score was 83 (21). Of the total ankle arthroplasty cohort of 11 patients, 2 (18%) failures were reported, and of the 9 patients without failures, 55% were satisfied with the procedure at 3.8-year follow up (21). The mean pain level was 1.3, and the AAOS-FAM score was 82 (21). Twenty patients received a revisional allograft in the case series report by Gaul et al (20). Six (30%) failures were reported, 10 (50%) required further surgery, and of the 14 patients without failures, only 41.7% were satisfied at 10.3-year follow-up (20). The mean AAOS-FAM score was 70.5, and the mean pain level was 3.7 (20). Bipolar osteochondral ankle allografts remain a revision option, but compared with ankle arthrodesis and total ankle prosthetic arthroplasty, case series results have thus far shown more successful outcomes with the latter (17,20,21,27,56,57).

In cases where there is a large amount of talar necrosis as a result of large OLTs or a failed osteochondral allograft, tibiototalcaneal arthrodesis or tibio-calcaneal arthrodesis may also be a salvage option (58). DeFontes et al (58) presented a tibiototalcaneal arthrodesis technique for a large OLT with osteonecrosis and used a full talar allograft as bone graft for the fusion procedure. With minimal follow-up (<1 year), 6 of these procedures were successfully performed without any nonunions, deep infections, or amputations (58). In large OLTs with massive talar necrosis, an alternative to arthrodesis, and a future consideration, may include custom total talus implants, although limited cases and outcomes have been reported on this technique (59).

In conclusion, reoperation rates and complication rates can be relatively high for patients receiving osteochondral talar allograft transplantation. Many of these patients are young or middle-aged and still have high functioning lifestyles, making it important to give them a successful lower extremity reconstruction and outcome. When the cases of graft failure and talar osteonecrosis occur, revision techniques of ankle arthrodesis, total ankle replacement, bipolar talar allograft replacement, tibiototalcaneal arthrodesis, and custom total talus are all potential treatment options. The outcomes of these revisions are infrequently reported, and stronger literature with longer follow-up periods is needed to make good clinical and surgical decisions for these patients. Ankle arthrodesis is currently the most reported and predictable revision procedure, but the other revision options may be more beneficial to patients in certain situations. Risk stratification, such as age, activity level, comorbidities, and smoking history, should be examined to determine who is most likely to have a successful outcome with an allograft talus. In the event of symptomatic graft resorption or collapse, ankle fusion can be considered with the option to convert to total ankle replacement if needed.

References

- Berndt AL, Harty M. Transchondral fractures (osteochondritis dissecans) of the talus. *J Bone Joint Surg Am* 1959;41:988–1020.
- Giannini S, Vannini F. Operative treatment of osteochondral lesions of the talar dome: current concepts review. *Foot Ankle Int* 2004;25:168–175.
- Pappas AM. Osteochondrosis dissecans. *Clin Orthop Relat Res* 1981;158:59–69.
- Tol JL, Struijs PA, Bossuyt PM, Verhagen RA, van Dijk CN. Treatment strategies in osteochondral defects of the talar dome: a systematic review. *Foot Ankle Int* 2000;21:119–126.
- Al-Shaikh RA, Chou LB, Mann JA, Dreeben SM, Prieskorn D. Autologous osteochondral grafting for talar cartilage defects. *Foot Ankle Int* 2002;23:381–389.
- Hangody L, Fules P. Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. *J Bone Joint Surg Am* 2003;85:25–32.
- Verhagen RA, Struijs PA, Bossuyt PM, van Dijk CN. Systematic review of treatment strategies for osteochondral defects of the talar dome. *Foot Ankle Clin* 2003;8:233–242.
- Ferkel RD, Sgaglione NA, Del Pizzo W. Arthroscopic treatment of osteochondral lesions of the talus: technique and results. *Orthop Trans* 1990;14:172–180.
- Ferkel RD, Zanotti RM, Komenda GA, Sgaglione NA, Cheng MS. Arthroscopic treatment of chronic osteochondral lesions of the talus: long-term results. *Am J Sports Med* 2008;36:1750–1763.
- Cuttica DJ, Smith WB, Hyer CF, Philbin TM, Berlet GC. Osteochondral lesions of the talus: predictors of clinical outcome. *Foot Ankle Int* 2011;32:1045–1051.
- Hyer CT, Berlet GC, Philbin TM, Lee TH. Retrograde drilling of osteochondral lesions of the talus. *Foot Ankle Spec* 2008;1:207–209.
- Adams SB, Viens NA, Easley ME, Stinnet SS, Nunley JA. Midterm results of osteochondral lesions of the talar shoulder treated with fresh osteochondral allograft transplantation. *J Bone Joint Surg Am* 2011;93:648–654.
- Easley ME, Scranton PE Jr. Osteochondral autologous transfer system. *Foot Ankle Clin N Am* 2003;8:275–290.
- Gross AE, Agnidis Z, Hutchinson CR. Osteochondral defects of the talus treated with fresh osteochondral allograft transplantation. *Foot Ankle Int* 2001;22:385–391.
- Hahn DB, Aastoos ME, Wilkins RM. Osteochondral lesions of the talus treated with fresh talar allografts. *Foot Ankle Int* 2010;31:277–282.
- Hangody L, Kish G, Szerb I, Gaspar L, Zoltan D, Kendik Z. Mosaicplasty for the treatment of osteochondritis dissecans of the talus: two to seven year results in 36 patients. *Foot Ankle Int* 2001;22:552–558.
- Meehan R, McFarlin S, Bugbee WD, Brage ME. Fresh ankle osteochondral allograft transplantation for tibiotalar joint arthritis. *Foot Ankle Int* 2005;26:793–802.
- Raikin SM. Fresh osteochondral allografts for large-volume cystic osteochondral defects of the talus. *J Bone Joint Surg Am* 2009;91:2818–2826.
- Raikin SM. Stage VI massive osteochondral defects of the talus. *Foot Ankle Clin N Am* 2004;9:737–744.
- Gaul F, Tirico LE, McCauley JC, Bugbee WD. Long-term follow-up of revision osteochondral allograft transplantation of the ankle. *Foot Ankle Int* 2018;39:522–529.
- Gaul F, Barr CR, McCauley JC, Copp SN, Bugbee WD. Outcomes of salvage arthrodesis and arthroplasty for failed osteochondral allograft transplantation of the ankle. *Foot Ankle Int* 2019. <https://doi.org/10.1177/1071100718824082>. journals.sagepub.com/home/fai [Epub ahead of print].
- Vannini F, Buda R, Pagliuzzi G, Ruffilli A, Cavallo M, Giannini S. Osteochondral allografts in the ankle joint: state of the art. *Cartilage* 2013;4:204–213.
- Bugbee WD. Fresh osteochondral allografts. *J Knee Surg* 2002;15:191–195.
- McCulloch PC, Kang RW, Sobhy MH, Hayden JK, Cole BJ. Prospective evaluation of prolonged fresh osteochondral allograft transplantation of the femoral condyle: minimum 2-year follow-up. *Am J Sports Med* 2007;35:411–420.
- VanTienderen RJ, Dunn JC, Kusnezov N, Orr JD. Osteochondral allograft transfer for treatment of osteochondral lesions of the talus: a systematic review. *Arthroscopy* 2017;33:217–222.
- Pomajzl RJ, Baker EA, Baker KC, Fleischer MM, Salisbury MR, Phillips DM, Fortin PT. Case series with histopathologic and radiographic analyses following failure of fresh osteochondral allograft of the talus. *Foot Ankle Int* 2016;37:958–967.
- El-Rashidy H, Villacis D, Omar I, Kelikian AS. Fresh osteochondral allograft for the treatment of cartilage defects of the talus: a retrospective review. *J Bone Joint Surg Br* 2011;93:1634–1640.
- Bull PE, Berlet GC, Canini C, Hyer CF. Rate of malunion following bi-plane chevron medial malleolar osteotomy. *Foot Ankle Int* 2016;37:620–626.
- McDermott AG, Langer F, Pritzker KP, Gross AE. Fresh small-fragment osteochondral allografts. Long-term follow-up study on first 100 cases. *Clin Orthop* 1985;197:96–102.
- Marwin S, Gross A. Fresh osteochondral allografts in knee reconstruction. In: Harner C, Fu FH, Vince KG, eds. *Knee Surgery*, Baltimore: Williams & Wilkins, 1994:1223–1234.
- Aubin PP, Cheah HK, Davis AM, Gross AI. Long-term follow up of fresh femoral osteochondral allografts for posttraumatic knee defects. *Clin Orthop* 2001;391:S318–S327.
- Convery FR, Meyers MH, Akeson WH. Fresh osteochondral allografting of the femoral condyle. *Clin Orthop* 1991;273:139–145.
- Meyers MH, Akeson W, Convery FR. Resurfacing of the knee with fresh osteochondral allograft. *J Bone Joint Surg Am* 1989;71:704–713.
- Shasha N, Aubin PP, Cheah HK, Davis AM, Agnidis Z, Gross AE. Long-term clinical experience with fresh osteochondral allografts for articular knee defects in high demand patients. *Cell Tissue Bank* 2002;3:175–182.
- Gortz S, De Young AJ, Bugbee WD. Fresh osteochondral allografting for osteochondral lesions of the talus. *Foot Ankle Int* 2010;31:283–290.
- Chuckpaiwong B, Berkson EM, Theodore GH. Microfracture for osteochondral lesions of the ankle: outcome analysis and outcome predictors of 105 cases. *Arthroscopy* 2008;24:106–112.

37. Haene R, Qamirani E, Story RA, Pinsker E, Daniels TR. Intermediate outcomes of fresh talar osteochondral allografts for treatment of large osteochondral lesions of the talus. *J Bone Joint Surg Am* 2012;94:1105–1110.
38. Orr JD, Dun JC, Heida KA, Kusnezov NA, Waterman BR, Belmont PJ. Results and functional outcomes of structural fresh osteochondral allograft transfer for treatment of osteochondral lesions of the talus in a highly active population. *Foot Ankle Spec* 2017;10:125–132.
39. Giannini S, Buda R, Vannini F, Di Caprio F, Grigolo B. Arthroscopic autologous chondrocyte implantation in osteochondral lesions of the talus: surgical technique and results. *Am J Sports Med* 2008;36:873–880.
40. Kainer MA, Linden JV, Whaley DN, Holmes HT, Jarvis WR, Jernigan DB, Archibald LK. Clostridium infections associated with musculoskeletal-tissue allografts. *N Engl J Med* 2004;350:2564–2571.
41. Malinin TI, Buck BE, Temple HT, Martinez OV, Fox WP. Incidence of clostridial contamination in donors' musculoskeletal tissue. *J Bone Joint Surg Br* 2003;85:1051–1054.
42. Mroz TE, Joyce MJ, Steinmetz MP, Lieberman IH, Wang JC. Musculoskeletal allograft risks and recalls in the United States. *J Am Acad Orthop Surg* 2008;16:559–565.
43. Vaishnav S, Thomas Vangsness C Jr, Dellamaggiora R. New techniques in allograft tissue processing. *Clin Sports Med* 2009;28:127–141.
44. Langer F, Gross AE. Immunogenicity of allograft articular cartilage. *J Bone Joint Surg Am* 1974;56:297–304.
45. Langer F, Czitrom A, Pritzker KP, Gross AE. The immunogenicity of fresh and frozen allogeneic bone. *J Bone Joint Surg Am* 1975;57:216–220.
46. Stevenson S, Dannucci GA, Sharkey NA, Pool RR. The fate of articular cartilage after transplantation of fresh and cryopreserved tissue-antigen-matched and mismatched osteochondral allografts in dogs. *J Bone Joint Surg Am* 1989;71:1297–1307.
47. Czitrom AA, Keating S, Gross AE. The viability of articular cartilage in fresh osteochondral allografts after clinical transplantation. *J Bone Joint Surg Am* 1990;72:574–581.
48. Phipatanakul WP, VandeVord PJ, Teitge RA, Wooley PH. Immune response in patients receiving fresh osteochondral allografts. *Am J Orthop* 2004;33:345–348.
49. Sirlin CB, Brossmann J, Boutin RD, Pathria MN, Convery FR, Bugbee W, Deutsch R, Lebeck LK, Resnick D. Shell osteochondral allografts of the knee: comparison of MR imaging findings and immunologic responses. *Radiology* 2001;219(1):35–43.
50. Tomford WW. Transmission of disease through transplantation of musculoskeletal allografts. *J Bone Joint Surg Am* 1995;77:1742–1754.
51. Adams SB, Dekker TJ, Schiff AP, Gross CP, Nunley JA, Easley ME. Prospective evaluation of structural allograft transplantation for osteochondral lesions of the talar shoulder. *Foot Ankle Int* 2018;39:28–34.
52. Coester LM, Saltzman CL, Leupold J, Pontarelli W. Long-term results following ankle arthrodesis for post-traumatic arthritis. *J Bone Joint Surg Am* 2001;83:219–228.
53. Morrey BF, Wiedeman GP Jr. Complications and long-term results of ankle arthrodeses following trauma. *J Bone Joint Surg Am* 1980;62:777–784.
54. Mazur JM, Schwartz E, Simon SR. Ankle arthrodesis. Long-term follow-up with gait analysis. *J Bone Joint Surg Am* 1979;61:964–975.
55. Lynch AF, Bourne RB, Rorabeck CH. The long-term results of ankle arthrodesis. *J Bone Joint Surg Br* 1988;70:113–116.
56. Jeng CL, Kadakia A, White KL, Myerson MS. Fresh osteochondral total ankle allograft transplantation for the treatment of ankle arthritis. *Foot Ankle Int* 2008;29:554–560.
57. Kim CW, Jamali A, Tontz W Jr, Convery FR, Brage ME, Bugbee W. Treatment of post-traumatic ankle arthrosis with bipolar tibiotalar osteochondral shell allografts. *Foot Ankle Int* 2002;23:1091–1102.
58. DeFontes KW 3rd, Vaughn J, Smith J, Bluman EM. Tibiotalocalcaneal arthrodesis with bulk talar allograft for treatment of talar osteonecrosis. *Foot Ankle Int* 2018;39:506–514.
59. Taniguchi A, Yoshinori T, Tanaka Y, Kurokawa H, Tomiwa K, Matsuda T, Kumai T, Sugimoto K. An alumina ceramic total talar prosthesis for osteonecrosis of the talus. *J Bone Joint Surg Am* 2015;97:1348–1353.