Bipolar Osteochondral Allograft Transplantation of the Tibiotalar Joint for Ankle Arthritis

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Introduction

Bipolar osteochondral allografting is a technically complex procedure envisioned as an alternative to arthrodesis or arthroplasty¹ in carefully selected young patients with advanced tibiotalar arthritis, usually as a result of trauma. Arthrodesis or implant arthroplasty is virtually contraindicated in these patients. Allograft transplantation is considered as an alternative to arthrodesis in a younger person with tibiotalar arthritis. The advantages of allografting over arthrodesis are relative preservation of joint motion that may provide higher function and longer preservation of surrounding midfoot and hindfoot joints than is seen after arthrodesis. The main potential advantages of allograft surgery are predictable pain relief, maintenance of tibiotalar joint function, and ease of conversion to other reconstructive procedures at a later date. Disadvantages include relatively high reoperation and failure rates. Perhaps the most influential characteristic in determining the choice of allografting over arthrodesis is the patient's decision-making. Virtually all patients undergoing allografting have been offered arthrodesis but, after careful consideration, have a strong desire to avoid arthrodesis and accept the higher reoperation rate and relative long-term uncertainty of the allograft procedure.

The surgical steps and technical aspects of the procedure parallel those for a typical total ankle arthroplasty with the key difference being the preparation and implantation of a fresh two-part allograft consisting of the distal part of the tibia and the talar dome (Video 1). This procedure is technically challenging and should not be considered by those with limited experience with ankle reconstruction.

The reconstruction is done in the following stages.

Step 1: Preoperative Planning

Confirm that the grafts are not damaged and that the

side (left or right) and size (not too small) are properly matched to the donor.

- Using plain radiographs, measure the width of the talar dome and correct for magnification.
- Obtain size and side-matched fresh allograft tissue from a tissue bank accredited by the American Association of Tissue Banks or equivalent. Size the allograft by measuring the mediolateral width of the talus at its midbody and match it to within 1 to 2 mm of the direct measurement (with magnification corrected) of the width of the recipient's talus on an anteroposterior or mortise radiograph. Try to avoid grafts that are smaller than the recipient's talus. Larger grafts can often be trimmed to fit properly.
- Prior to the incision, visually inspect the graft and confirm that it is of acceptable size, quality, and side (left or right).

Step 2: Placement of the External Fixator

Place an external fixator across the ankle joint using fluoroscopy and distract the ankle prior to incision.

- Place a pad under the patient's hip to maintain the lower limb in neutral rotation and another pad under the ankle to facilitate imaging and manipulation.
- With the ankle in the neutral position, mount the external fixator on the medial side (Fig. 1), beginning with the talar neck pin, followed by the calcaneal pin and then by the two midtibial pins.
- Lock the fixator with the ankle in neutral dorsiflexion/plantar flexion.
- Carefully distract the ankle joint under fluoroscopic visualization.
- Obtain 2 to 5 mm of ankle joint distraction and confirm symmetric opening without creating a varus or valgus deformity.
- Particularly in a tight joint, be careful to avoid

fracture of the malleoli and cutout of the pins with an excessive distraction force. Further distraction can be obtained after surgical exposure.

Step 3: Anterior Approach to the Ankle

Perform a standard anterior approach to the ankle joint.

- Inflate the tourniquet. The procedure usually requires at least two hours of tourniquet time.
- Incise the skin longitudinally and develop the interval between the tibialis anterior and the extensor hallucis longus.
- Retract and protect the neurovascular bundle laterally.
- Enter the ankle joint and elevate the capsule both medially and laterally to expose both gutters, the anterior aspect of the tibia, and the talar neck.
- Remove any anterior osteophytes from the tibia and talus.
- Titrate the amount of ankle joint distraction to 4 to 5 mm (Fig. 2).
- The incision should be adequate to allow for placement of the cutting jig (Fig. 3).

Step 4: Positioning of the Cutting Jig

Mount the jig on the ankle and confirm the cutting block position both visually and fluoroscopically (Fig. 4).

- Determine the cutting block size visually or by radiographic templating. Size 2 or 3 is appropriate for most women and size 3 or 4, for most men. The graft will be cut to one size larger.
- Place the Agility ankle arthroplasty jig (DePuy Orthopaedics, Warsaw, Indiana) parallel to the tibial axis and provisionally fix it with pins.
- Adjust the cutting block position for a symmetric resection of the tibia and talus (which is approximately 7 to 10 mm from each side of the joint) and 2 to 4 mm of the medial malleolus. Take adequate time and use fluoroscopy to ensure that the block is positioned properly in all planes: proximal-distal, medial-lateral, flexion-extension, and rotation.
- Place a free saw blade through the cutting block to visually confirm resection. Make fluoroscopic images with the saw blade in place for further confirmation (Fig. 5).
- Fix the cutting block with pins and remove the jig.

Step 5: Bone Resection

Using a reciprocating saw and careful technique to pro-

tect the tendons and neurovascular structures, perform osseous resection of the distal part of the tibia and the talar dome.

- Place retractors into the joint prior to cutting.
- Cut the talus first and then proceed with the tibial cut. Take great care to avoid the posteromedial neurovascular structures and the posterior tibial tendon.
- Do not include the fibula in the bone cut defined by the cutting block. The fibula should remain intact.
- Avoid inadvertently cutting the fibula when making the talar and tibial cuts laterally. It is a posterior structure.
- Finish the cuts freehand or with gentle use of an osteotome after removing the cutting block.
- Remove the resected bone manually. Often the posterior aspect of the tibia is scarred to the capsule and must be removed piece by piece.
- Inspect the resected surfaces and debride the medial and lateral gutters.
- Using calipers, measure the resection gap. It should be between 17 and 20 mm in height (Fig. 6).

Step 6: Preparation of the Allograft

Prepare the tibial and talar allografts from the donor tissue to match the resection gap created in Step 5.

- Confirm the geometry of the resection gap in the patient once more, paying attention to any variations in angle or rotation, which theoretically can be adjusted with graft preparation.
- The talar allograft cut is performed freehand. Measure a 10-mm resection depth from the center of the talar dome and mark this on the graft medially and laterally.
- Mark the anterior and posterior extent of articular cartilage on the graft. Connect the marks to define a resection plane that is 10 mm in maximum thickness and parallel to the joint surface.
- Make the talar cut with a wide oscillating saw (Fig. 7).
- Pin a cutting block one size larger than that used for the ankle resection onto the distal tibial allograft. Do this freehand using free saw blades or metal rulers placed through the cutting slots to estimate the resection depth and angles.
- Make the resection thickness 10 mm at the highest point (midcoronal) of the tibial graft and confirm equal flexion and extension and proper rotation.
- Cut the tibial graft with a reciprocating saw (Fig. 8).

- Articulate the two allograft parts together and use calipers to measure the combined thickness. Ensure that the graft dimensions match the resection gap, and perform minor modifications of the graft as necessary (Fig. 9).

Step 7: Insertion and Fixation of the Allograft

Insert and fix the allograft construct and remove the external fixator.

- Remove all remaining soft tissue from the allograft.
- Trial fit each component of the allograft (talus and tibia) separately to confirm an independent fit.
- Trim the graft of excess bone to improve fit. This is usually required on the tibial side.
- Check for abutment on the fibula. Be prepared to trim the graft further or to use a burr to remove fibular bone and cartilage if necessary.
- Irrigate the graft copiously to remove blood and marrow.
- Articulate the graft parts and insert them together as one unit.
- Release the ankle distraction and remove the fixator to allow ankle motion.
- Check for stability and graft position through observation and with fluoroscopy.
- Fix the graft with two 3.0-mm screws in the tibia angled superiorly and posteriorly and two 3.0-mm screws in the talus countersunk just at the articular margin (Fig. 10). If the fixation seems suboptimal after placement of screws then make one attempt to reposition screws. Avoid multiple drill holes into the allograft to avoid weakening the graft. Questionable stability is treated by prolonged postoperative cast immobilization (six to twelve weeks) rather than an early range of motion.
- Obtain final fluoroscopic images to confirm graft position and screw length (Figs. 11 and 12).
- Perform routine closure and apply a bulky splint dressing.

Step 8: Rehabilitation

Postoperative care is straightforward, including initial immobilization and a three-month period of non-weight-bearing.

- Apply a non-weight-bearing short leg splint initially. This should be worn until suture removal at ten to fourteen days.
- Transition the patient to a controlled ankle mo-

tion (CAM) boot and start gentle range-of-motion exercises. Strict non-weight-bearing is maintained for a minimum of six weeks, after which the patient is progressed to partial (25% to 50%) weight-bearing while wearing the CAM boot.

- At twelve weeks, if radiographs confirm adequate graft-host healing, full weight-bearing is allowed, first with the patient wearing the boot for two to four weeks and then in a regular shoe.

Results

In our recent clinical study², we used our clinical outcomes database to identify eighty-four consecutive patients (eighty-eight ankles) who underwent bipolar osteochondral allograft transplantation of the tibiotalar joint, had surgery in 1999 or later, and had not had a previous arthroplasty or osteochondral allograft transplantation involving the tibial plafond and/or talus. Operations performed after 1999 were selected in order to study a homogeneous group of patients in whom the contemporary and standardized surgical technique described here had been employed. We followed all but two patients (two ankles) for a minimum of two years; therefore, the study population comprised the remaining eighty-two patients (eighty-six ankles).

The indication for allograft surgery was symptomatic arthritis of the tibiotalar joint and failure of previous nonsurgical or surgical treatment. The mean age at the time of surgery was 44.3 years (range, eighteen to seventy-one years); 52% of the patients were male. At the time of follow-up at a mean of five years after the osteochondral allograft transplantation, 42% (thirty-six) of the eighty-six ankles had undergone additional surgery; 13% (eleven) of the ankles underwent reoperations, such as hardware removal, debridement, synovectomy, and distraction, that did not involve the graft. Of the eighty-six allograft transplantations, 29% (twenty-five) were considered clinical failures. With a mean time to failure of 3.7 years, survivorship of the osteochondral allograft was 76% at five years and 44% at ten years. At the last follow-up evaluation, 71% (sixty-one) of the eighty-six ankles still had the allograft in situ. Scores increased postoperatively by 33 points and 62% of the ankles were categorized as having a good (61 to 90 points) or excellent (91 to 100 points) result on the Olerud-Molander Ankle Score. Less pain was reported by 85% of the patients, improved function was reported by 83% of the patients, and satisfaction with the procedure was reported by 92% of the patients.

What to Watch For

Indications

- Younger patients with posttraumatic arthritis.

- Preserved ankle motion and little deformity.
- A sound mechanical environment evidenced by absent or correctable ankle instability and minimal hindfoot malalignment.
- Patients with a stiff ankle can benefit from the procedure but will not regain normal motion.
- A patient who understands that there is a potential for additional surgery and declines arthrodesis.

Contraindications

- Severe malalignment, deformity, or instability.
- Massive bone loss.
- Osteonecrosis is not an absolute contraindication.
- Unclear infection status.
- A severely compromised soft-tissue envelope.

Pitfalls & Challenges

- Proper placement of the external fixator and adequate joint distraction at the outset are essential to the subsequent surgical steps.
- Great care must be taken during the bone resection because of the typically scarred and distorted anatomy seen in patients with posttraumatic ankle arthritis and the proximity of important structures around the ankle joint. Cutting or fracturing of the malleoli is not an uncommon complication.

- Consider staging hardware removal if doing so would require additional incisions or a more extensive approach. This also provides the opportunity for biopsy or bone culture if necessary.
- The allograft size or shape may not match the recipient site despite adequate preoperative size matching. This can be managed by modifications of the grafts. A too large or thick graft can be modified relatively easily. A too small or thin graft creates a difficult problem.
- Final fitting may require repeated trimming or modifications of the allograft. Avoid recutting the recipient ankle and work directly with the allograft to trim or thin it in a sequential manner. Avoid making either graft thinner than 8 mm.

Clinical Comments

The allograft procedure is very challenging technically as a series of difficult surgical steps must be completed in sequence to create a successful surgical result. Many nuances have been learned over many years and many procedures³. While we feel strongly that the essential steps outlined here are important, many other surgeons performing this procedure have solved the surgical problems differently⁴⁻⁶. The relatively high reoperation and failure rates clearly underscore the need for further improvements in patient selection and surgical technique. We welcome insight and specific feedback on ways to improve this surgical technique.

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Figures

Fig. 1

Placement of the external fixator distractor on the medial side of the lower limb. The fixator is placed close to the joint, with the ankle in neutral position.

Fig. 2

Intraoperative fluoroscopic image after distraction is applied to the ankle. Note both the extent and the symmetry of the joint distraction.

Fig. 3

The anterior approach to the ankle has been performed. The neurovascular bundle is lateral (left) and the tibialis anterior is medial (right). The joint is exposed to allow visualization of both malleoli. Note the large osteophytes on the anterior aspect of the tibia.

Fig. 4

The Agility ankle jig has been mounted on the tibia and the cutting guide has been pinned to the distal part of the tibia after fluoroscopic confirmation of the correct position.

Fig. 5

Intraoperative lateral fluoroscopic image showing the resection planes for the tibia and talus. Note the saw blades placed through the cutting guides, which are helpful in estimating the angle and depth of the cuts. An anterior tibial deficiency is noted in this case.

Fig. 6

Intraoperative photograph after joint resection and debridement. The cut is symmetric and measures 19 mm. A minimal medial malleolar resection has been performed, and no fibular resection has to be performed.

Fig. 7

Preparation of the talar allograft using a freehand technique. The cut is made 10 mm from the talar dome and parallel to the joint surface.

Fig. 8

The tibial jig has been mounted on the tibial portion of the allograft, and the reciprocating saw is used to cut the graft from the tibia.

Fig. 9

The allograft parts are cleaned of residual soft tissue and articulated. The composite thickness and symmetry of the graft should be measured with calipers and compared with the recipient site prior to final insertion. Minor modifications are made at this time.

Fig. 10

An intraoperative photograph after the grafts have been inserted, distraction has been removed, and screw fixation has been achieved.

Fig. 11

Final anteroposterior intraoperative fluoroscopic image of a bipolar fresh osteochondral allograft transplantation of the ankle.

Fig. 12

Final lateral intraoperative fluoroscopic image of a bipolar fresh osteochondral allograft transplantation of the ankle.

Fig. 1

Fig. 2

Fig. 3

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