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Operative Techniques in
Orthopaedics

The Use of Allograft for Osteochondral Lesions of the Talus ☆

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Osteochondral lesions of the talus is a common problem affecting the ankle, particularly in you active patients. Patients recalcitrant to conservative modalities may require surgical correction. While many lesions may respond to arthroscopic management, larger or recurrent lesions may require osteochondral transplantation for which autograft of allograft tissue can be used. This chapter reviews the basic science and biology of fresh talar allograft ostechondral transplnattaion. Two techniques are described in detail. The first utilized osteochondral plugs using a system similar to that used for autograft OATS procedures. The second utilized larger bulk allograft pieces inserted following a talar dome hemitalectomy for more massive lesions. The surgical techniques, indications, concerns and results are described in the chapter.
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Introduction

The talar dome is the most common area in the foot and ankle region to develop an osteochondral lesion, termed an osteochondral lesion of the talus (OLT). This is a well-recognized source of ankle pain and dysfunction, frequently seen following an ankle sprain–type injury.[1-3] In most cases, the remaining articular cartilage of the talus and the cartilage on the opposing tibial plafond remain intact and unaffected, and joint motion is well preserved.[4,5] Failure of nonoperative management may necessitate surgical intervention; however, mixed outcomes have been noted owing to the unpredictability of cartilage restoration, especially for larger size lesions.[6] Potential surgical options include procedures such as arthroscopic debridement combined with microfracture or drilling of the subchondral bone to stimulate the underlying bone marrow, autologous chondrocyte implantation, and osteochondral autograft transplant (OAT) or mosaicplasty procedure.[7-9] Each of these, however, have limitations in the treatment of the larger lesion, where the success rates of arthroscopic management decreases significantly in lesions larger than 1.5 cm^2.[10,11] Autologous chondrocyte implantation is best suited for surface lesions, and special techniques are necessary when large bone defects are present such as in large OLT. For osteochondral autologous transfer procedures, there is a limited tissue available owing to the concerns of harvest site morbidity in the knee as well as with the difficulty of achieving acceptable anatomical restoration of the talar geometry. The unique anatomy of the talus can make it difficult to match the contours of a graft harvested from, for instance, the femoral condyle of the knee.[12] Additionally, shoulder lesions that require the implanted graft to have cartilaginous coverage traversing the corner of the graft are difficult to obtain for other harvest sites. Limitations become even more evident when treating larger type VI massive cystic lesions,[4] where multiple OAT plugs may be required or even a hemitalectomy performed.[4,5,12] There is a quantitative limit as to how much graft can be harvested from the femoral condyle before knee mechanics are altered and the development of arthritis is promoted.[12-14] The hyaline cartilage of the femoral condyles from which both OAT plugs and autologous chondrocytes sample harvesting is performed is biomechanically different to talar hyaline cartilage. The knee cartilage is thicker than that of the talus but is not as biomechanically resilient and does not maintain its mechanical properties with aging as well as that from the talus, making it an inferior material for transplantation. Fresh osteochondral talar allograft offers numerous advantages in challenging situations such as large

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OLT by allowing defective tissue (both bone and cartilage) to be anatomically reconstructed through transplantation. Size-matched fresh osteochondral allografts (OCAs) resolve each of these issues by having matching anatomical contours and a volume to match that of the host talus. Through this technique, there is the ability to transplant mature hyaline talar cartilage, with viable chondrocytes that can sustain its surrounding collagen matrix, into a large defect to recreate a congruent joint.[4-6,9,15] This article reviews the processes of allograft tissue recovery, processing, storage, and the biologic and immunologic response, in addition to reviewing techniques for implantation and outcomes of OCA transplantation procedures.

Donor-Recipient Matching

To obtain an appropriate talus for implantation, size matching is required. Anteroposterior and lateral radiographs with a magnification marker are obtained of the patient's ankle. These radiographs (and alternatively a computed tomography scan) are sent to an accredited tissue bank that is experienced in the recovery, testing, and processing of fresh allografts. Donor and recipient are size matched (no tissue or blood typing is performed), and after completion of all the testing requirements, the graft is released for implantation.

Allograft Recovery, Processing, and Storage

Historically, in North America, fresh OCA procedures were performed at university-based centers that had associated tissue banks, which independently established recovery, processing, and release protocols. Fresh OCAs were typically stored in lactated Ringer solution and transplanted fresh within a week after donor death. Beginning around 1998, commercially supplied allografts became available in the United States through a number of tissue banks that established new protocols under the oversight of the Food and Drug Administration. Commercial distribution of grafts required a prolonged storage interval (10-45 days) to allow for completion of recovery and testing protocols. This resulted in an increase in the number of fresh allografts available to surgeons.

Allograft tissue recovery is performed within 12-24 hours of donor death.[16] Suitable donors are generally between 15 and 35 years of age with macroscopically healthy articular cartilage. Because the transplantation procedure is based on cartilage substitution, a process that maintains allograft cartilage tissue health during storage is mandatory. Many studies have been carried out to identify the ideal storage media and to evaluate the effects of hypothermic storage on chondrocytes and extracellular matrix.[17-22]

OCAs can be stored frozen, cryopreserved, or fresh. Each of these options affects chondrocyte viability, immunogenicity, and length of time to transplantation. Frozen grafts showed a chondrocyte survivorship of less than 5%, because of the freezing process at −80°C.[23] As chondrocytes are responsible for maintenance of the extracellular matrix, studies have shown that the matrix in these frozen allografts tends to deteriorate over time.[24,25] Along with the decreased chondrocyte viability, fresh-frozen allografts showed decreased immunogenicity.[26]

With cryopreservation, it is possible to maintain chondrocyte viability during this freezing process by adding glycerol and dimethyl sulfoxide to the tissue. Theoretically, the addition of these chemicals prevents ice formation within cells. Multiple studies have reported variable results, with chondrocyte survival ranging from 20%-70%.[27-30] Unfortunately, viable cells were found only at the surface of the articular cartilage layer.[31] Fresh allografts proved to have the highest rates of chondrocyte viability of the 3 different methods of storage.[32,33] Fresh grafts are usually placed in tissue culture medium at 4°C. Chondrocyte viability is significantly affected by length of storage, with little effect from storage times less than 1 week.[34,35] Studies have shown a time-dependent decreased chondrocyte viability and degradation of biomechanical properties of fresh grafts stored for greater than 14 days.[36-38] Currently, the trend of the tissue banks is to hold transplants for a minimum of 14 days to allow completion of microbiologic and serologic testing before release.[39]

Biologic Response to Fresh Allografts

Intact hyaline cartilage is a relatively immunoprivileged tissue, as it is not vascularized and its cellular portion is embedded in the extracellular matrix, inaccessible to the host immune system. Conversely, the osseous component of the graft is laden with potentially immunogenic cells and proteins, which can be partially mechanically removed by graft lavage before implantation. Several studies have demonstrated that the osseous portion of the graft is replaced, with time, by host bone via creeping substitution, which may or may not lead to complete replacement of allograft bone by host bone.[40,41] These studies have led to our practice of transplanting the minimal bone volume necessary for osseous restoration or fixation to facilitate this integration process.

Immune Response to Fresh Allografts

Although hyaline cartilage is considered a relatively immunoprivileged tissue, it is evident that osteochondral grafts can potentially elicit a variable immune response.[15,42] Current practice does not require nor recommend human leukocyte antigen (HLA) or blood-type matching, but the surgeon does need to consider the potential immunologic ramifications of using a fresh OCA.[15] In a study, 57% of patients received a fresh OCA generated serum anti-HLA antibodies, signifying immune sensitization.[43] In another study, larger grafts (>10 cm^2) were noted to be far more likely to elicit a systemic immune response.[44] There was, however, no correlation between the presence of the anti-HLA antibodies and the outcome of the procedure, or survivability of the graft. There is only 1 case report in the literature of an acute rejection thought