Multiple Osteochondral Allograft Transplantation with Concomitant Tibial Tubercle Osteotomy for Multifocal Chondral Disease of the Knee

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Abstract: Symptomatic patellofemoral chondral lesions are a challenging clinical entity, as these defects may result from persistent lateral patellar maltracking or repetitive microtrauma. Anteromedializing tibial tubercle osteotomy has been shown to be an effective strategy for primary and adjunctive treatment of focal or diffuse patellofemoral disease to improve the biomechanical loading environment. Similarly, osteochondral allograft transplantation has proven efficacy in physiologically young, high-demand patients with condylar or patellofemoral lesions, particularly without early arthritic progression. The authors present the surgical management of a young athlete with symptomatic tricompartmental focal chondral defects with fresh osteochondral allograft transplantation and anteromedializing tibial tubercle osteotomy.

Symptomatic patellofemoral chondromalacia is a challenging clinical scenario in young, active individuals. Although previous reports have shown good to excellent outcomes with combined tibial tubercle osteotomy in conjunction with autologous chondrocyte implantation,[1-3] a recent publication reported only 63% return to preoperative physical function in an active population at minimum 2 years after tibial tubercle osteotomy with or without a cartilage restoration procedure.[4] Similarly, osteochondral allograft transplantation (OCA) is a well-established surgical option that addresses the injury to both the articular cartilage and underlying subchondral bone, with reported rates of return to sporting activity of up to 88%.[5-7] At our institution, a recent analysis of the OCA patient population revealed an overall 87% allograft survival rate for all lesions of the knee at an average 5-year follow-up.[8] Treatment of concomitant pathology such as patellar maltracking or rotational malalignment is critical to enhance more long-term osteochondral allograft viability and prevent progression of disease. The purpose of this surgical technique description was to describe the method for concomitant fresh osteochondral allograft transplantation and anteromedializing (AMZ) tibial tubercle osteotomy for treatment of multicompartment articular cartilage defects of the knee.

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The authors report the following potential conflicts of interest or sources of funding: B.R.W. reports other from the American Journal of Orthopedics, Arthroscopy, *Arthroscopy Association of North America, Elsevier Publishing, and from the Society of Military Orthopaedic Surgeons, outside the submitted work. B.J.C. reports other from Aesculap/B.Braun, the* American Journal of Orthopedics, *American Orthopaedic Society for Sports Medicine, and from American Shoulder and Elbow Surgeons; personal fees and other from Arthrex; other from* Arthroscopy, *Arthroscopy Association of North America, Athletico, Carticept, Cytori, DJ Orthopaedics, Elsevier Publishing, International Cartilage Repair Society,* Journal of Bone & Joint Surgery—American, Journal of Shoulder and Elbow Surgery, Journal of the American Academy of Orthopaedic Surgeons, *Medipost, National Institutes of Health (National Institute of Arthritis and Musculoskeletal and Skin Diseases and National Institute of Child Health and Human Development), and Ossur; personal fees and other from Regentis; other from Saunders/Mosby-Elsevier, Smith & Nephew, and from Tornier; personal fees and other from Zimmer, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.*

Received March 29, 2017; accepted May 24, 2017.

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2212-6287/17421/$36.00

http://dx.doi.org/10.1016/j.eats.2017.05.025

Technique

Diagnosis

In addition to history and physical examination, standard, weightbearing preoperative knee radiographs, including large cassette alignment views, should be performed (Fig 1).[9] Sizing markers are used on these

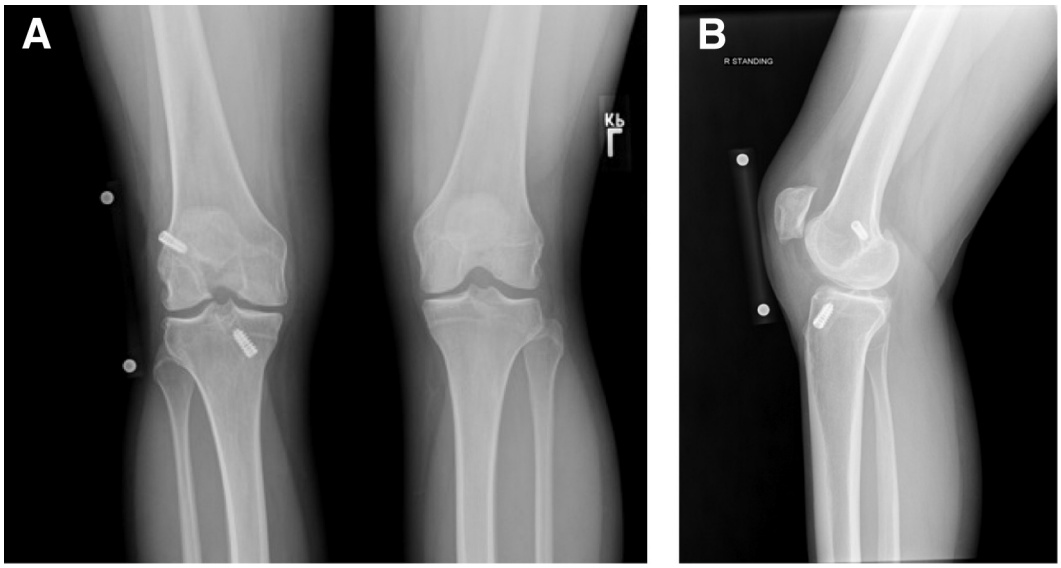

Fig 1. (A) Standing posterior-anterior (PA) flexion radiograph of a patient with symptomatic anterior right knee pain after previous right knee anterior cruciate ligament reconstruction with mild decreased joint space and numerous osteophytes present. (B) Lateral radiograph of the right knee in the same patient showing joint space narrowing between the patella and the distal femur.

radiographs to allow appropriate graft size matching.[10] Advanced axial imaging is frequently used to better delineate the tibial tubercle–trochlear groove distance (TT-TG) prior to tibial tubercle osteotomy,[11] and magnetic resonance imaging may be performed preoperatively to better assess the extent of subchondral involvement and concomitant ligamentous or meniscal pathology.[9]

Indication

OCA is predominantly indicated for high-demand, nonobese, physiologically young (i.e., age <50 years) patients who have failed conservative and/or prior articular cartilage repair techniques.[12,13] OCA may be used as primary treatment of focal, medium to large cartilage defects that are less amenable to marrow stimulation and in patients not ideally indicated for arthroplasty procedures.[8,14] Conversely, significant osteoarthritis or diffuse, nonfocal chondral pathology remains a contraindication to OCA. Symptomatic concomitant pathology such as malalignment (i.e., coronal and rotational), meniscal insufficiency, ligamentous injury, or adjacent compartment chondral disease may be treated simultaneously to optimize clinical outcomes.[15,16] AMZ has been indicated for patients with refractory anterior knee pain to offload the pathologic contact pressures, particularly in the presence of cartilage restoration.[17]

Patient Positioning and Anesthesia

The patient was positioned supine on a flat-top table with a thigh tourniquet and general anesthesia. Although not the authors' preference, a foot positioner may be useful to maintain adequate knee flexion (70°-110°) for visualization of condylar defect(s).

Surgical Technique

If not previously performed (i.e., 3-6 months), staging arthroscopy is preferred to determine the extent of location of symptomatic cartilage disease prior to ordering fresh osteochondral allograft. Diagnostic arthroscopy confirmed the presence of moderately sized, focal, Outerbridge grade III/IV chondral defects of the patella, trochlea, and medial and lateral femoral condyles without further ligamentous or meniscal injury (Video 1).

A 10-cm longitudinal midline incision and dissection was performed from the superior aspect of the patella distally to the tibial tubercle. Fresh (15-28 days post-harvest) osteochondral allografts (JRF Ortho, Centennial, CO) of the distal femur and patella were thawed in room-temperature saline on the back table. The Arthrex T3 AMZ (Arthrex, Naples, FL) system was used to perform the tibial tubercle osteotomy (Video 1). On visualization of the patellar tendon insertion, the pin guide was inserted into the tibial tubercle perpendicular at the level of the Gerdy tubercle. The 60° cutting guide was assembled and provisionally pinned on the anteromedial aspect of the tibia (Fig 2). The horizontal guide and tibial pin were removed and the anterior compartment was sharply elevated in subperiosteal fashion. The anterior compartment was sharply elevated, and multiple Chandler retractors were placed around the posterolateral flare of the tibia. An oscillating saw was used to obliquely cut the tibial tubercle distally through the slot capture and ½- and 1-in.

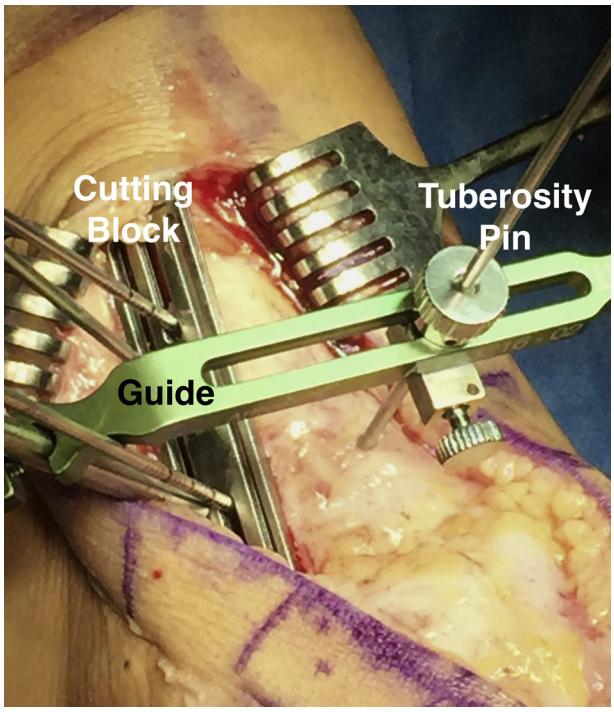

Fig 2. Intraoperative image of the right knee of a patient in supine position showing the Arthrex T3 AMZ system loaded onto the tibia with guide pins over the tibial tubercle and medial aspect of the system to hold the cutting block system in place during tibial tubercle osteotomy.

osteotomes were used to complete the cut laterally and superiorly beneath the patellar tendon, while maintaining the distally based periosteal sleeve. To normalize TT-TG and offload bipolar, lateral defects of the patellar and trochlea, approximately 10 mm of translation of the tibial tubercle was confirmed. Two 4.5-mm cortical screws were drilled in standard lag fashion and placed perpendicularly to the plane of the osteotomy. Prominent anteromedial bone was sharply resected and employed for bone grafting of the anterolateral defect after translation. Alternatively, tibial tubercle fixation may be delayed until after OCA depending on difficulty of surgical exposure.

A lateral parapatellar arthrotomy with soft tissue lengthening and limited, medial vastus-sparing arthrotomy were performed for exposure and perpendicular lesion access (Video 1). With an assistant gently flexing the knee, the trochlear defect was delivered using a large rake and z-retractor (Fig 3A). Cannulated cylindrical sizing guides from the Allograft OATS system (Arthrex) were placed over the defect to determine the diameter of donor allograft needed. The 22.5-mm trochlear defect was sized, and a 2.4-mm guide pin was inserted through the cannulated sizing guide in the center of the defect to a depth of at least 3 cm (Fig 3 B and C). The sizing guide was removed and a cannulated recipient harvester of the same size was placed over the guidepin to score the peripheral cartilage. A cannulated cutting reamer was then placed over the guidepin, and the defect was reamed to a depth of approximately 7 mm under cold irrigation to prevent thermal necrosis. The reamer, guidepin, and particulate debris were removed and a small ruler was used to measure the depth of the 4 quadrants (3-, 6-, 9-, and 12-o'clock). A fresh no. 15 blade may be used to debride any frayed cartilage around the rim.

On the back table, a bushing of the same size as the defect was placed over the donor condyle at the exact location and held firmly by an assistant, while the surgeon used a donor harvester to extract donor osteochondral graft (Fig 3D). Graft measurements were marked out on the donor plug, and the donor allograft was trimmed to the appropriate depth using an oscillating saw, rasp, and rongeurs. Pulsatile lavage with bacitracin-mixed saline was used for 2 minutes over the donor plug. The donor plug was then press-fit by hand, with care to ensure that the 12-o'clock position on the graft and recipient site were matched. An oversized tamp was used to impact the plug flush to the surrounding articular surface (Fig 3E). A similar technique was applied to lesions on the patella, medial femoral condyle, and lateral femoral condyle with increasing degrees of knee flexion. To access the undersurface of the patella, the deep capsule in the suprapatellar pouch and prepatellar fat pad may be elevated to allow an assistant to evert the patella 90°. After graft implantation and copious irrigation, layered wound was performed with titrated lateral retinacular lengthening, and a hinged knee brace was applied (Table 1).

Postoperative Rehabilitation

A hinged knee brace is locked in full extension and taken off only for physical therapy and use of a continuous passive motion machine. At 2 weeks, the brace is unlocked and discontinued when the patient is able to perform a straight-leg raise without an extension lag. Depending on the quality of fixation, weight bearing may range from complete non—weight bearing to touch-down weight bearing. Partial weight bearing is initiated at 6 weeks with range-of-motion goals of 130° knee flexion and full extension. Full weight bearing and range of motion should be achieved by 8 weeks. Physical therapy begins closed-chain exercises and gait training. At 12 weeks, strength training including stationary bicycling and light jogging is advanced with full return to vigorous athletic activities discouraged until approximately 8 months.

Discussion

Recently, several authors have reported clinical outcomes of osteochondral allografts for treatment of isolated full-thickness patellofemoral cartilage defects.[5,18] Historically, OCA for patellar lesions have yielded

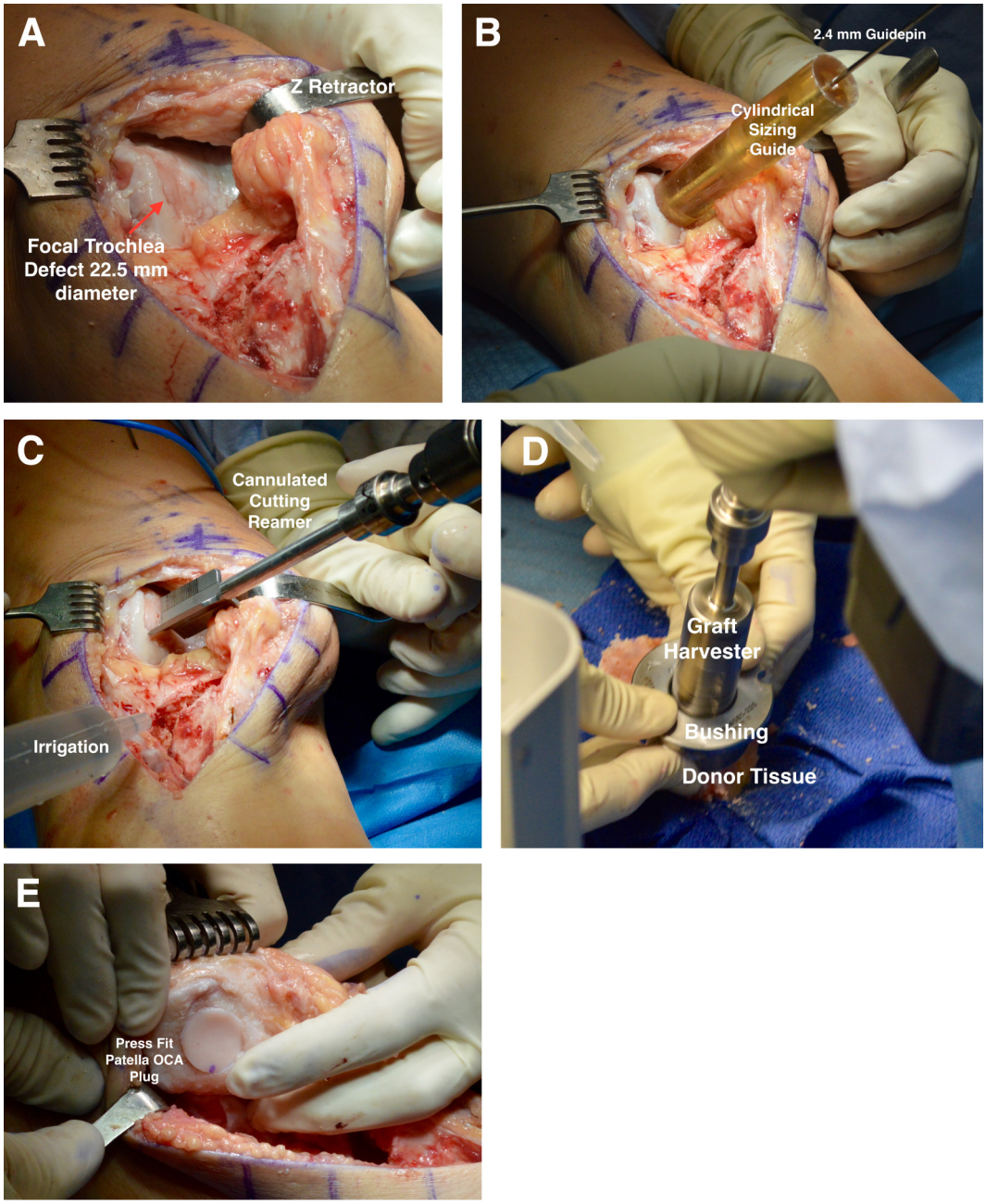

Fig 3. (A) Intraoperative image of a 22.5-mm-diameter right knee lateral trochlear chondral defect in a patient positioned supine. The defect is identified by approximately 75° knee flexion and retraction of the surrounding soft tissue using a z-retractor and large rake. (B) Intraoperative image of a right knee trochlear defect. The defect is sized using a cannulated cylindrical sizing guide (Arthrex) to encompass the full extent of the defect. A large rake was placed laterally and a z-retractor was placed medially, superior to the patella to allow the cylindrical sizing guide to be placed flush over the defect. (C) Intraoperative image of a right knee trochlear defect being prepared to be reamed to a depth of approximately 6 mm to 8 mm using a cannulated cutting reamer of the same size as the cylindrical sizing guide previously used to measure the diameter of the defect. (D) Intraoperative image of a graft harvester placed over a bushing of the same size as the measured defect and used to core the donor plug through the full extent of the donor tissue. An assistant is used to hold the bushing firmly in the appropriate location on the donor tissue. (E) Intraoperative image showing an osteochondral allograft plug is being press fit into the previously reamed patella defect. The graft was then gently tamped flushed to the surrounding articular cartilage.

inferior results when compared with corresponding defects involving the femoral condyle or trochlea. However, for patients with extensive failure of both conservative and surgical interventions, few evidence-based treatment options address large, multifocal defects with restoration of the native osteochondral architecture in a single-stage procedure.[5,8,18] To date, limited clinical outcomes are available

Table 1. Pearls and Pitfalls of the Described Multiplug Osteochondral Allograft With Concomitant Anteromedialization Tibial Tubercle Osteotomy

Step	Pearls	Pitfalls
Graft preparation	• Ensure perpendicularity of graft harvest	• Avoid obliquity to mitigate graft and donor mismatch • If using multiple plugs on a condylar surface, avoid excessive coring depth of initial plug harvest to allow harvest of adjacent overlapping plug
Disease transmission and biologic incorporation	• Sustained pulsatile lavage saline with admixture of bacitracin to mitigate immunogenicity • Adjunctive use of bone marrow aspirate concentrate or platelet-rich plasma at base to enhance biologic incorporation	• Avoid overaggressive recipient site reaming to limit thermal necrosis and interface for graft incorporation
Site preparation	• Safe residual osseous reamings for packing at the base if incongruity or asymmetry is present after preparation or provisional graft placement • Score surrounding cartilage to prevent iatrogenic damage to intact periphery from reamer	• Ensure recipient site preparation is readily visible through a mobile soft tissue window with ideal knee flexion for condylar lesions (lateral femoral condyle 90°-120°; lateral femoral condyle 70°-90°) • Avoid creating unshouldered lesion through oversizing of lesions, particularly in the patella
Graft placement	• Use a Freer or digital pressure to "shoehorn" a graft into place • Ensure appropriate graft orientation and radius of curvature prior to final fixation	• Avoid strong impaction or oversizing osteochondral plug depth to preserve chondrocyte viability • Limit excessive seating of the graft
Final evaluation	• Use adjunctive biologic or biocomposite implant fixation if inadequate stability after placement or >40% graft circumference is unshouldered • May perform final contouring of slight incongruity with a no. 15 blade	• Failure to recognize inadequate graft stability after final impaction

detailing the results with multiple OCA. In selected patients (i.e., young, active) with multiple, focal cartilage defects of the knee, this approach represents a viable strategy for joint preservation with anatomic reconstruction. Conversely, certain limitations must be acknowledged, including its technical difficulty, increased cost, and limited graft availability with a 4- to 6-month waiting period (Table 2).

For focal patellofemoral chondral defects, adjunctive AMZ may be performed to optimize underlying pathomechanics, correct rotational malalignment, and transfer adverse contact pressures.[2] Although our technique highlights the utility of OCA for multiple, symptomatic chondral lesions, it also underscores the importance of concomitant AMZ in improving the patellofemoral kinematics. The TT-TG should be normalized to a target goal of less than 10 to 12 mm, whereas a 60° cut is commonly used by the senior author to achieve offloading of lateral and distally based patellar lesions while avoiding overmedialization.[19,20] Maintaining optimal patellofemoral biomechanics is essential to protect the biologic microenvironment of the osteochondral allograft, both to enhance incorporation and reduce adjacent articular disease progression.

Table 2. Advantages and Disadvantages of the Described Technique for Multiplug Osteochondral Allograft Transplantation With Concomitant Anteromedialization Tibial Tubercle Osteotomy

Advantages	Disadvantages
• Restoration of hyaline cartilage articular surface in multiple compartments	• Added cost and morbidity of recommended staging arthroscopy
• Off-loads contact stressors across patellofemoral compartment	• Limited by donor tissue availability
• Delaying fixation of the osteotomy allows easier visualization and treatment of chondral defects	• High associated cost

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