Technical Note

Osteochondral Allograft Transplantation of the Medial Femoral Condyle With Orthobiologic Augmentation and Graft-Recipient Microfracture Preparation

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Abstract: Osteochondritis dissecans (OCD) has been recognized for over 100 years yet still poses treatment challenges owing to both the avascular nature of articular cartilage and the inability to generate hyaline cartilage. The knee is most commonly involved, and without repair, patients have chronic knee pain, loose bodies, and early-onset osteoarthritis. There are a number of surgical techniques for repairing OCD, some of which are still being refined. Currently, common procedures used to treat OCD lesions include microfracture, autologous chondrocyte implantation, osteochondral autograft transplantation, and osteochondral allograft transplantation. In this Technical Note, we describe osteochondral allograft transplantation with the addition of platelet-rich plasma and graft-recipient microfracture. We believe the micropores augment the osteoconductive and osteoinductive properties of the allograft and aid in the incorporation of the allograft plug by improving angiogenesis, enhancing clot formation in the allograft, and providing a homogeneous environment for remodeling.

Osteochondritis dissecans (OCD) is a condition in which a focal portion of subchondral bone undergoes osteonecrosis. With repeated shearing, the lesion detaches from the surrounding bone and the overlying avascular articular (hyaline) cartilage fractures.[1] The defect results in greater friction at the articular surface and a reduced ability to displace axial forces evenly.[2,3] The knee is most commonly involved, making up about 75% of cases, with lesions commonly located at the lateral portion of the medial femoral condyle.[1,4]

The cause of OCD is uncertain; however, OCD is thought to be caused by trauma, repeated microtrauma, local ischemia, and genetics.[1,5,6] The defect may be stable and isolated to the subchondral bone, or it may be detached from the surrounding bone with articular cartilage damage, leading to complications such as joint pain, loose bodies, and early osteoarthritis.[2,4] This pathophysiology forms the basis for classifying OCD (Table 1).[6]

In addition to classification, patient characteristics guide treatment (Table 2).[7] OCD most commonly occurs during childhood and adolescence. Patients with open growth plates are better equipped to undergo healing of osteochondral lesions because of active mesenchymal tissue and its excellent blood

Table 1. Clanton and DeLee Classification of Osteochondritis[6]

	Description
Type I	Depressed osteochondral fracture
Type II	Fragment attached by osseous bridge
Type III	Detached nondisplaced fragment
Type IV	Displaced fragment

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Table 2. Indications for Treatment[7]

Indication	Classification
Knee pain	Yes
	No
Mechanical symptoms	Yes
	No
Knee effusion	Yes
	No
Skeletal maturity on plain films (distal femoral physis)	Open growth plates
	Partially or fully closed growth plates
Stability of OCD fragment (imaging)	Stable
	Unstable
Integrity of OCD fragment (imaging or arthroscopy)	Salvageable: has bone on deep surface, is 1 piece, and has predominantly normal articular cartilage
	Unsalvageable: consists of cartilage only, has multiple pieces, or has damaged or absent articular cartilage

OCD, osteochondritis dissecans.

supply.[2,3] Nonoperative treatments include restricted weight bearing, bracing, and gentle range-of-motion exercises.[4,6] OCD lesions occurring in skeletally mature patients are less forgiving and usually require surgery.[4,6,8,9] There are a number of surgical techniques for repairing OCD lesions, some of which are still being refined. Procedures include internal fixation, debridement, microfracture (MF), autologous chondrocyte implantation, osteochondral autograft transplantation (OAT), and osteochondral allograft (OCA) transplantation.[4,6-8] The focus of this Technical Note is on OCA transplantation with platelet-rich plasma (PRP) and graft-host MF.

Surgical Technique

Imaging Assessment

Magnetic resonance imaging without contrast is used to assess the knee (Video 1). Relevant findings include a 1.8 × 0.8 × 2.3-cm medial femoral condyle osteochondral lesion (Fig 1).

Patient Positioning and Preparation

The patient is placed supine on a standard operative table. A nonsterile padded tourniquet is placed proximally on the thigh to maximize the surgical field. The operative leg is placed in a padded leg harness, and the

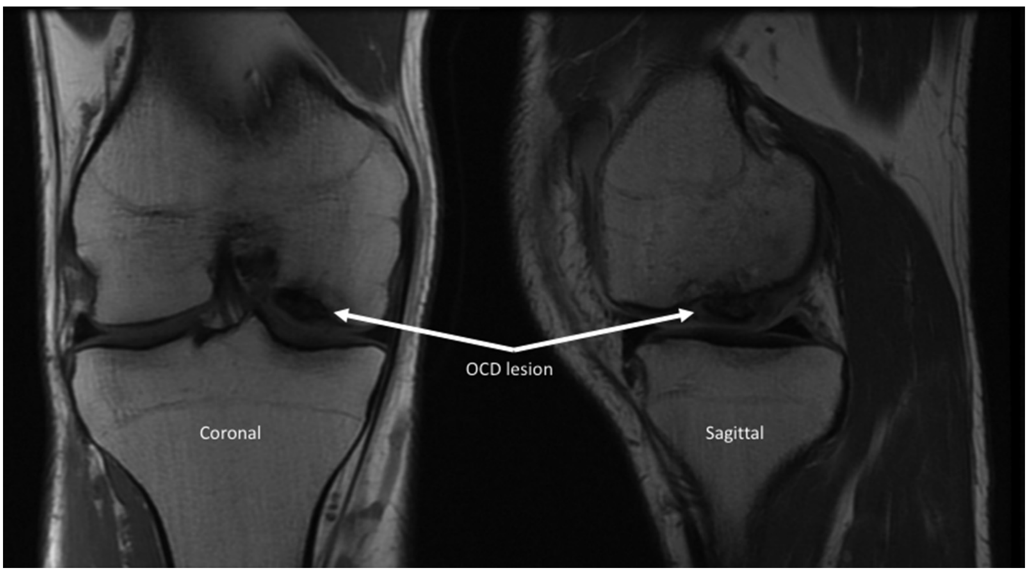

Fig 1. An osteochondritis dissecans (OCD) lesion of the right medial femoral condyle is seen on magnetic resonance imaging in the coronal and sagittal views. The lesion measures 1.8 cm mediolaterally by 0.8 cm superoinferiorly by 2.3 cm anteroposteriorly. Chondral thinning of the medial femoral condyle is seen posteriorly. The menisci, cruciate ligaments, collateral ligaments, and quadriceps and patellar tendons are intact.

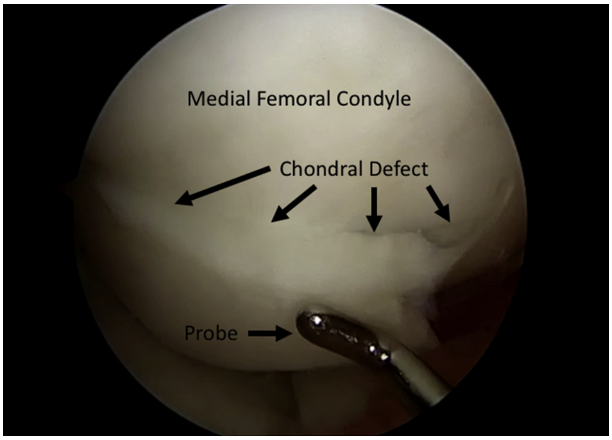

Fig 2. Arthroscopic view from the anterolateral portal showing the osteochondritis dissecans lesion on the surface of the right medial femoral condyle. A diagnostic arthroscopy is first performed to confirm the need for osteochondral transplantation before proceeding with a more invasive arthrotomy. The medial and lateral gutters are free of loose bodies and synovitis. The medial and femoral condyles and tibial plateau do not have any other cartilage defects.

contralateral leg is placed on a popliteal pad. The foot of the bed is dropped, which flexes the knees to 90°. The surgical site is prepared and draped in sterile fashion, and the tourniquet is inflated to 250 mm Hg.

Diagnostic Arthroscopy

We perform a diagnostic arthroscopy to assess the chondral defect and confirm the need for osteochondral transplant prior to performing a more invasive arthrotomy. We confirm the lesion's size and location and elect to proceed with the operation (Fig 2).

Preparation of PRP

Harvesting of Bone Marrow Aspirate. The marrow is accessed using a guide pin to drill from inferior to superior perpendicularly through the femoral notch[10] (Fig 3). The guide pin is removed, and an 11-gauge bone marrow aspirate (BMA) needle is inserted through the pilot hole and tapped with a mallet until the line on the needle is flush with the cortex (Fig 4). Two 30-mL syringes are used to extract a total of 60 mL of BMA (Fig 5).

Centrifugation of BMA. The harvested BMA is centrifuged using the Arthrex Angel System to separate the cellular products into the PRP concentrate (Fig 6). We perform centrifugation while the rest of the procedure is continued. A total of 4 mL of PRP is obtained from 60 mL of BMA.

Preparation of Recipient Site

Medial Parapatellar Approach. The OCD lesion is accessed using a standard medial parapatellar approach.

Measurement of Lesion With Sizer. The Cannulated Allograft OATS Sizer from the Arthrex Allograft OATS Instrument Set is placed over the lesion, perpendicular to the chondral surface, ensuring the entire lesion is covered.

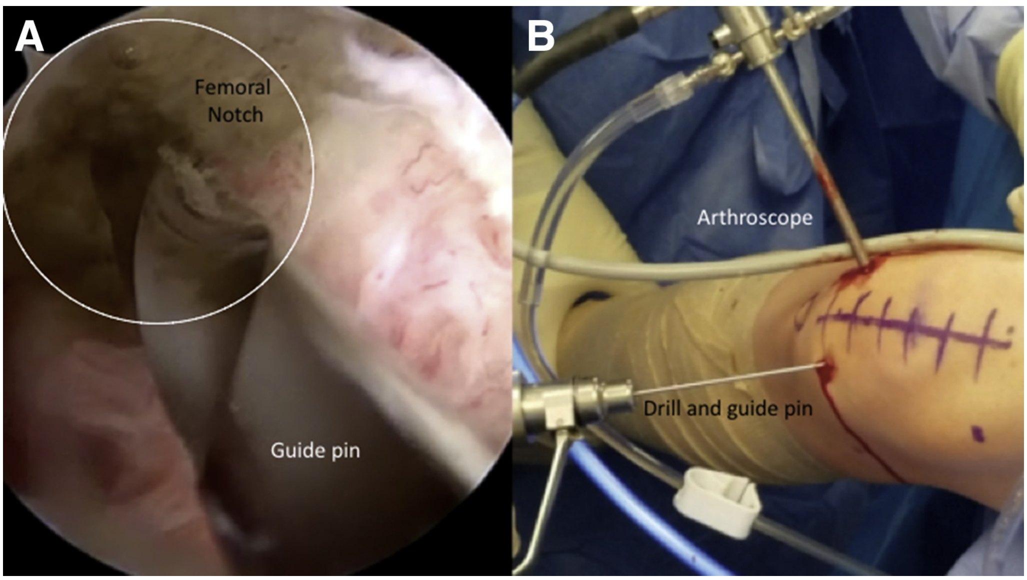

Fig 3. (A) Arthroscopic view from the anterolateral portal showing the guide pin drilled orthogonally at the femoral notch from the anteromedial portal. (B) Intraoperative photograph of the guide pin drilled arthroscopically from inferior to superior into the right knee femoral notch for bone marrow harvesting. The drill and guide pin are seen in the anteromedial portal, whereas the arthroscope is seen in the anterolateral portal.

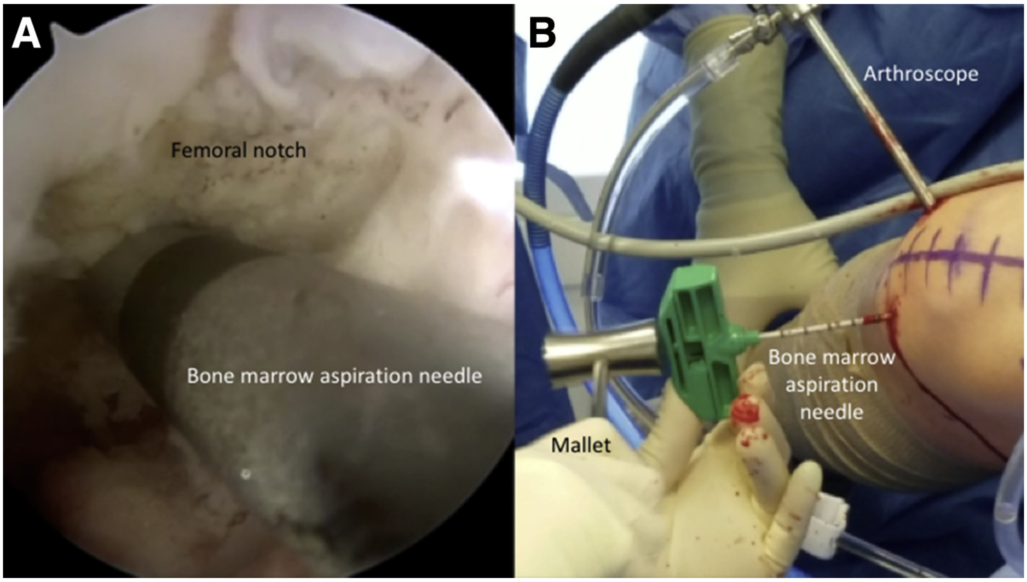

Fig 4. (A) Arthroscopic view from the anterolateral portal showing an 11-gauge bone marrow aspiration (Jamshidi) needle in the femoral notch of the right knee. The needle is tapped with a mallet until the bold line lies flush with the cortex. (B) Intraoperative photograph of the 11-gauge bone marrow aspiration (Jamshidi) needle placed through the anteromedial portal into a predrilled hole in the right knee.

Placement of Guide Pin Using Sizer. With the sizer covering the entire lesion, the guide pin is placed through the sizer 90° to the articular surface. A drill is used to insert the guide pin into the lesion (Fig 7). The sizer is removed from the guide pin with care taken not to dislodge the guide pin in the process.

Scoring and Reaming of Lesion. A T-handle is attached to the Recipient Harvester (Arthrex) and placed over the guide pin (Fig 8). The lesion is scored with the goal of removing the entire lesion while taking as little bone as possible. The Allograft OATS Recipient Counterbore (reamer) (Arthrex) is placed on a drill and then over the guide pin (Fig 9). The reamer is used to core the lesion 8 to 10 mm deep. The reamer is then removed along with any bone fragments.

Measurement of Socket Depths. The depths of the socket are measured along its periphery at the 12-, 3-, 6-, and 9-o'clock positions. It is important to measure the depths precisely because they are used to size the donor plug. We write down the recorded depths in the proper clock orientation.

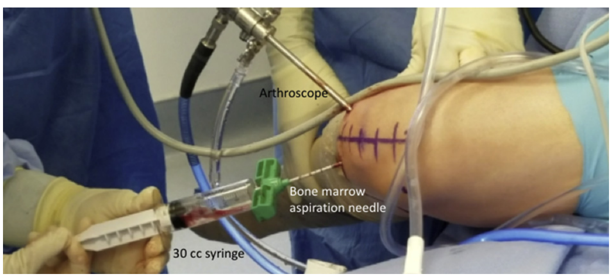

Fig 5. Intraoperative photograph of bone marrow suctioning through the anteromedial portal of the right knee with an 11-gauge bone marrow aspiration (Jamshidi) needle and a 30-mL syringe. Once the Jamshidi needle is tapped into place, its trocar stylet is removed and the syringe is connected.

MF of Recipient Site. The guide pin is removed. The PowerPick (Arthrex) is used to perform MF of the recipient site at a set depth of 4 mm, which provides adequate penetration of bone to induce bleeding into the socket (Fig 10). The PowerPick system allows the surgeon to perform MF quickly with great precision and accuracy.

Preparation of Allograft Plug

Securing of Specimen in Workstation. The specimen is secured in anatomic orientation to the Allograft OATS Workstation (Arthrex). The sizer is used to measure and mark the site from which the donor plug will be harvested (Fig 11).

Harvesting of Allograft. The bushing is positioned over the corresponding site on the donor condyle to match the contour of the recipient's articular surface. The collar is placed in the reamer to prevent the bone plug from becoming stuck in the reamer. The harvester is used to core around the donor plug (Fig 12). Next, an oscillating saw is used to cut through the condyle, perpendicular to the lesion, at the depth of the reaming. The plug is then retrieved when the condylar specimen is removed from the workstation and inverted.

Sizing of Allograft. The plug is marked using the depth measurements obtained from the recipient socket. The

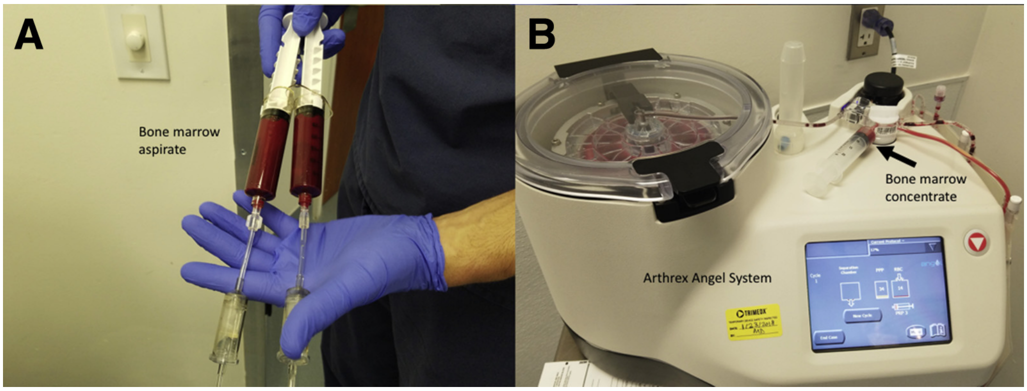

Fig 6. (A) Two 30-mL syringes containing a total of 60 mL of bone marrow aspirate collected from the right knee. (B) The harvested aspirate is centrifuged using the Arthrex Angel System while the rest of the procedure is continued. A total of 4 mL of platelet-rich plasma is produced from 60 mL of bone marrow aspirate.

plug is grasped with the Allograft OATS Holding Forceps (Arthrex) and cut to the specific measurements using a sagittal saw. We bevel the edge of the plug circumferentially for smooth insertion into the socket (Fig 13).

Microfracturing of Allograft Plug. We then use the PowerPick to perform MF of the donor plug. The depth of MF we use is about half the depth used for the recipient site because the graft is thin and there is no vascular bed that we are trying to reach. The donor plug is then soaked in PRP while a tamp is used to create a firm base in the recipient (Fig 14).

Insertion of Allograft Plug. The harvested donor plug is gently inserted and then advanced into the recipient socket (Fig 15). Half of the tamp is placed over the recipient condyle, and the other half is placed over the donor plug to prevent burying the plug while ensuring it lies flush with the articular surface (Fig 16, Table 3).

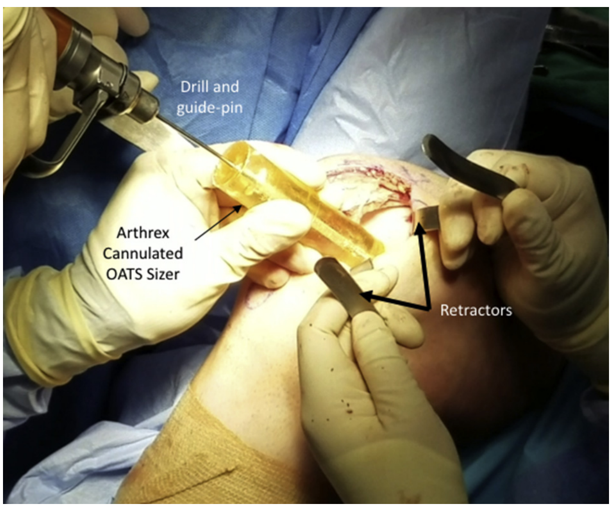

Fig 7. Intraoperative photograph of a right knee with a guide pin drilled through an Arthrex Cannulated OATS Sizer. Once the medial femoral condyle has been accessed with a medial parapatellar approach, an appropriately sized sizer is selected so that it covers the entire osteochondritis dissecans lesion. It is then positioned orthogonally on the articular surface, and a guide pin is drilled through the center.

Discussion

OCD has been described for over 100 years, yet optimal management has yet to be determined. Treatment of OCD is based on individual surgeon training and experience, anecdotal evidence, and small studies. In a literature review, the American Academy of Orthopaedic Surgeons' recommendations for the management of OCD were based solely on expert opinion with "limited" or "inconclusive" empirical evidence, emphasizing the need for quality studies and improvement in treatment strategies.[5]

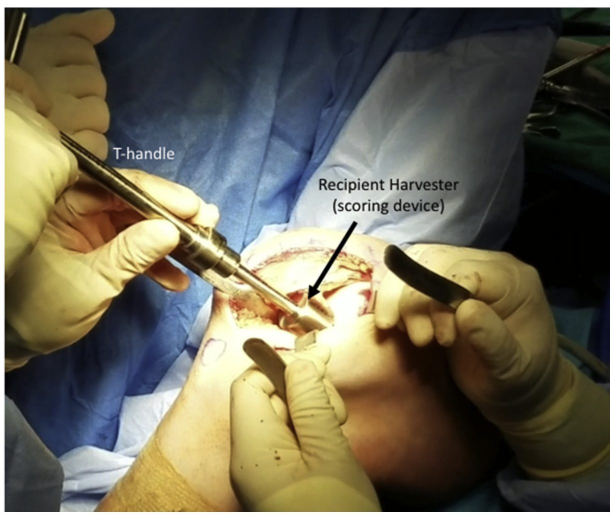

Fig 8. Intraoperative photograph of a right knee with a T-handle Recipient Harvester placed over a guide pin. The osteochondritis dissecans lesion is scored by rotating the T-handle clockwise and counterclockwise several times.

Fig 9. Intraoperative photograph of a right knee showing a triple reamer being used to core out the osteochondritis dissecans lesion on the medial femoral condyle to a depth of approximately 10 mm. After coring out the lesion, the depth of the socket is measured precisely at the 12-, 3-, 6-, and 9-o'clock positions.

Treatment of OCD is challenging because of the avascular nature of articular cartilage and the inability to generate hyaline cartilage. When a lesion extends through subchondral bone, exposing the articular cartilage to a vascular source, fibrocartilage grows in its place.[1-3] Steadman et al.[11] developed the MF technique in the early 1990s using this natural healing mechanism. However, fibrocartilage lacks the biomechanical properties of hyaline cartilage, resulting in increased joint wear and early degenerative changes.[1-3]

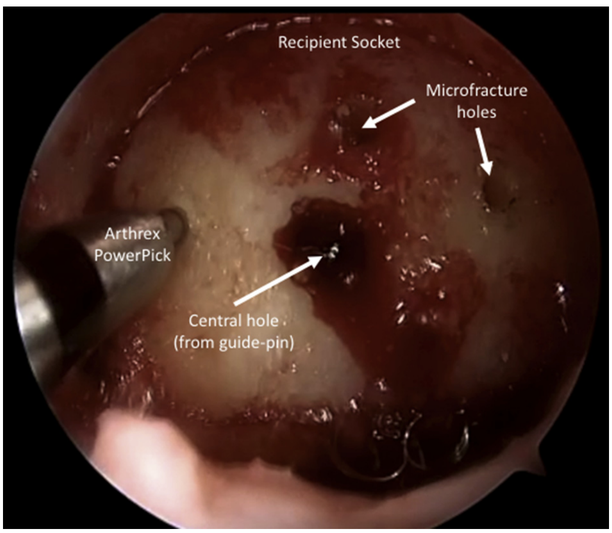

Fig 10. Intraoperative photograph of the PowerPick used to microfracture the cored-out recipient site on the medial femoral condyle of the right knee. We use a PowerPick that produces holes measuring 1.5 mm in diameter and 4 mm deep (different sizes are available). A total of 7 holes are placed approximately 3 mm apart at the recipient site.

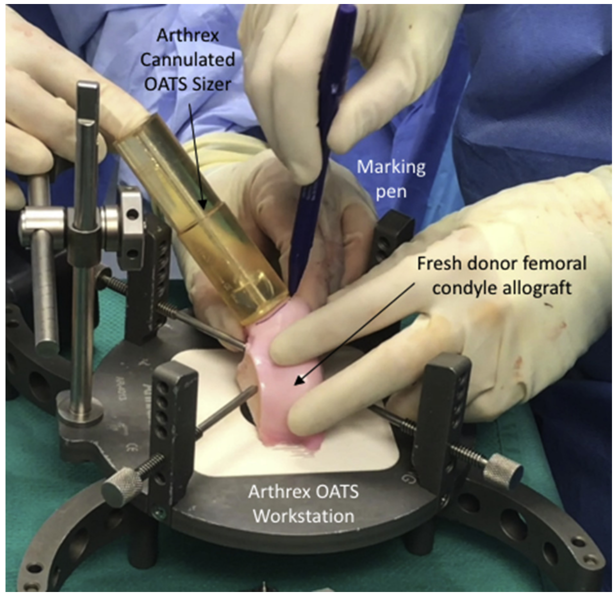

Fig 11. Intraoperative photograph of a fresh right medial femoral condyle donor allograft secured to the Arthrex OATS Workstation. An Arthrex Cannulated OATS Sizer is positioned over the corresponding site on the allograft so that the donor plug will match the contour of the recipient's native articular surface. The sizer lies perpendicular to the allograft surface, and its borders are marked with a pen.

Other techniques have since been developed to more accurately restore the native environment of the knee. In 2012, Gudas et al.[12] found mosaic OAT to be superior

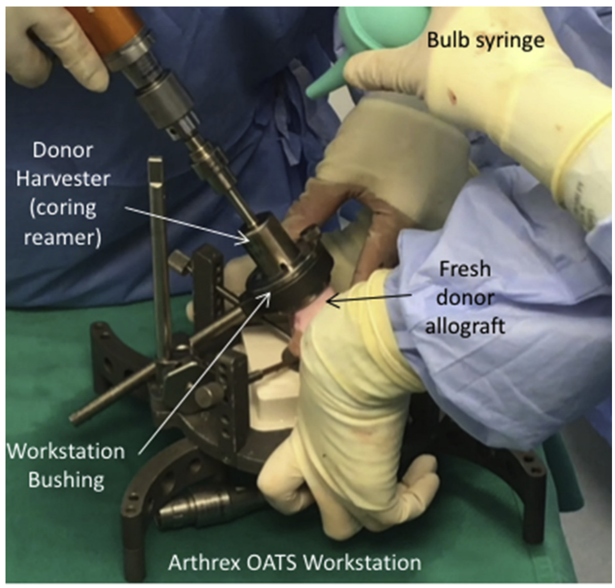

Fig 12. Intraoperative photograph of the coring reamer used to harvest the right medial femoral condyle allograft plug. A donor harvesting reamer is placed through the Arthrex OATS bushing at the previously marked allograft donor site. The allograft is irrigated with normal saline solution using a bulb syringe. After reaming, the 12-o'clock position is marked on the allograft plug.

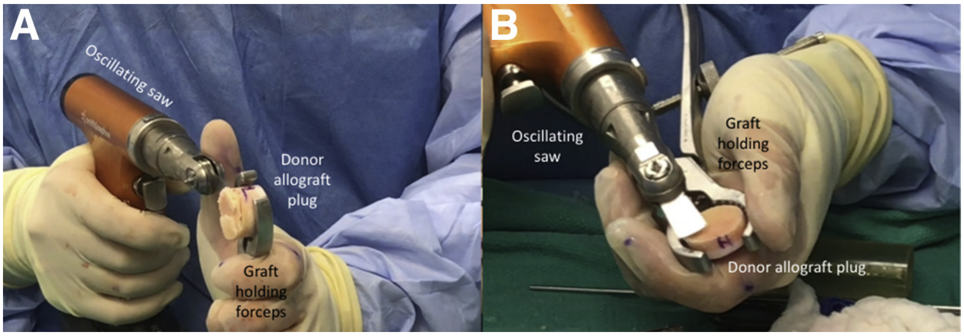

Fig 13. (A) Intraoperative photograph of the harvested right medial femoral condyle allograft plug held with Arthrex graft-holding forceps while an oscillating saw is used to size the plug height so that it will lie flush with the recipient articular surface. (B) The plug is shaved until the height approximately measures the depth of the recipient socket at the 12-, 3-, 6-, and 9-o'clock positions. The plug is held in the forceps such that the articular side of the graft lies within the clamp and the cutting surface is level to the 12-, 3-, 6-, and 9-o'clock markings.

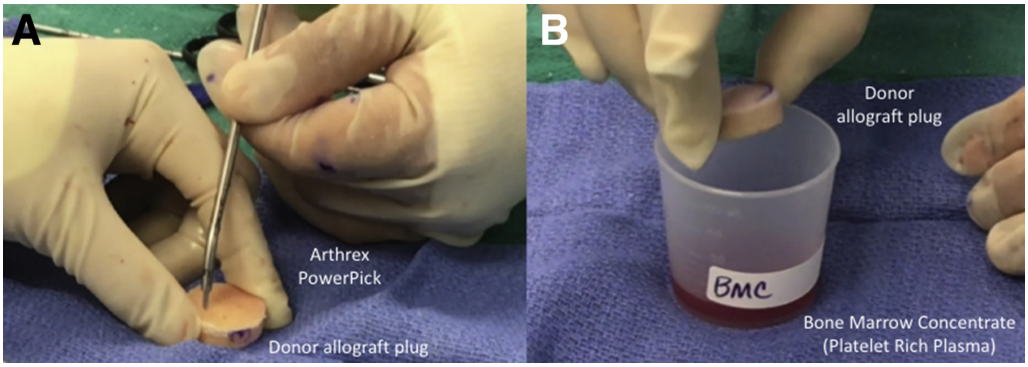

Fig 14. (A) Intraoperative photograph of the PowerPick used to microfracture the harvested right medial femoral condyle donor allograft plug. (B) The donor plug is then soaked in the platelet-rich plasma prepared previously using the Arthrex Angel System. (BMC, bone marrow concentrate.)

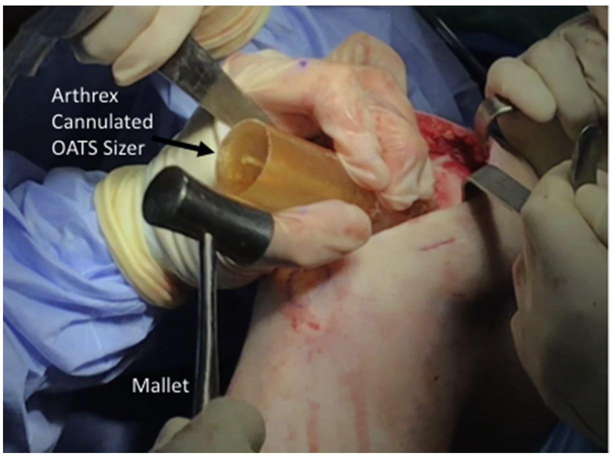

Fig 15. Intraoperative photograph of a right knee showing an OATS Sizer and mallet used to tamp the donor allograft plug into the recipient socket in the medial femoral condyle. Half of the sizer is placed over the plug, whereas the other half lies over the recipient femoral condylar surface. Tapping the sizer with a mallet in this orientation prevents the plug from advancing unevenly into the recipient socket.

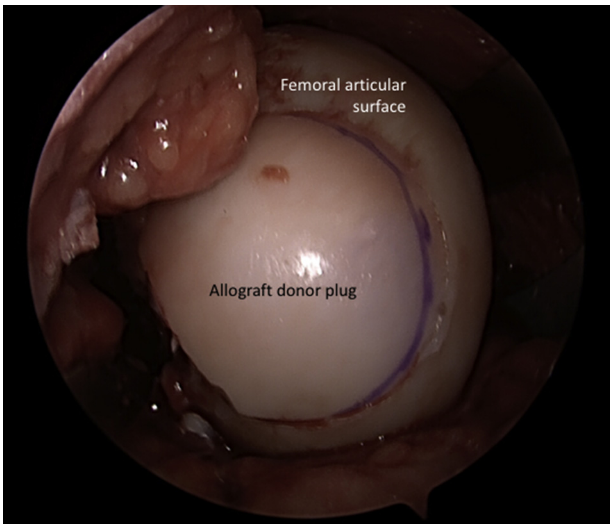

Fig 16. Intraoperative photograph of the donor allograft plug implanted flush with the articular surface of the right medial femoral condyle. A completed osteochondral allograft transplantation is shown.

Table 3. Technical Pearls

The addition of bone marrow concentrate will stimulate healing.
Precise measurement of the recipient site and sizing of the donor plug should be performed so that the plug is not loose and it sits flush with the articular surface.
The corresponding anatomic position on the allograft should be selected so that the contour of the donor plug closely matches the recipient's native articular surface.
The microfracture technique should be performed on both the recipient site and the donor plug to facilitate incorporation into the knee and reduce the risk of allograft failure.
The allograft plug should be tamped so that it advances evenly into the recipient socket.

to MF in treating OCD in elite athletes at 10 years' follow-up as determined by multiple validated modalities. In a meta-analysis of 20 studies on OCD treatment with MF, autologous chondrocyte implantation, mosaic OAT, and OCA transplantation, Mithoefer and Della Villa[13] found that mosaic OAT produced the best results, with a 91% rate of return to sport, followed by OCA transplantation, at 84%. One systematic review of long-term prognoses after OCA transplantation noted a relatively high failure and reoperation rate of 20% at 12 years for femoral condylar lesions.[14] A recent case series following up patients who underwent OCA transplantation as a salvage cartilage procedure showed only a 5.1% failure rate.[9] Overall, the literature supports OCA transplantation as a viable treatment for large primary and revision OCD lesions, with most patients having good satisfaction scores, rates of return to sport and/or activity, and allograft survival.[9,13-18]

OCA transplantation is not without limitations. The use of an allograft comes with the risk of rejection, albeit very low given the relatively innate nature of bone and cartilage. The need to perform a large open arthrotomy places patients at greater risk of iatrogenic injury and infection risk compared with arthroscopic MF or mosaic OAT. Given the technical difficulty of this procedure and precision required for optimal outcomes, results may vary between patients based on surgeon skill and experience (Table 4).[8,15]

We believe the orthobiologic augmentation and MF described in our Technical Note may improve allograft incorporation and decrease revision rates. To our knowledge, no studies have described the procedure with MF of the donor plug as well. We believe the micropores augment the osteoconductive and osteoinductive properties of the allograft and aid in the incorporation of the allograft plug by improving angiogenesis, enhancing clot formation in the allograft, and providing a homogeneous environment for remodeling.[19] By combining these methods into a single refined procedure, we hope to create a blueprint that consistently yields excellent outcomes for patients.

Table 4. Advantages and Disadvantages[15,19]

Advantages
Repair of bone and cartilage damage
Ability to repair large defects
Restoration of native joint environment (articular cartilage vs fibrocartilage)
Disadvantages
Limited supply of donor grafts
Risk of disease transmission
Possibility of immunogenic response
Fresh allograft needed for viable chondrocytes

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