Technical Note

Arthroscopic Osteochondral Autograft Transfer System Procedure of the Lateral Femoral Condyle with Donor-Site Backfill Using Osteochondral Allograft Plug

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Abstract: The osteochondral autograft transfer system (OATS) procedure is at the forefront of cartilage restoration surgeries of the knee, offering superior return to sport rates and long-term functionality. This technique reports an arthroscopic OATS procedure of the lateral femoral condyle with donor-site backfill using an osteochondral allograft plug. Potential complications from unfilled donor site sockets are eliminated through donor site backfill with an allograft plug.

Within diarthrodial joints like the knee, articular cartilage covers the ends of each bone where they articulate to form the joint. The articular cartilage of the knee is a layer of specialized connective tissue whose principal function is to provide a smooth, frictionless surface within the knee joint for articulation and transmission of load and shear forces.[1] Chondral defects are common injuries of knee musculoskeletal pathology, with a prevalence of full-thickness chondral defects at nearly 36% in athletes and 63% in the general population, and medial condyle defects more common than the lateral condyle at 68% versus 32%, respectively.[2] Additionally, articular cartilage defects have been identified in roughly 60% of knees undergoing arthroscopic surgery.[3] Without purposeful intervention, chondral lesions within the knee joint can be functionally debilitating, predispose to early osteoarthritis, and limit return to sports and daily activities.[4-7] The osteochondral autograft transfer system (OATS) has demonstrated favorable outcomes in patient satisfaction and function restoration when treating chondral lesions, proving to be at the forefront of surgical articular cartilage restoration techniques for the knee.[4-13]

Traditionally, OATS has been performed through an open approach, with several studies reporting good to excellent outcomes in patient satisfaction, pain relief, return to sport rate, and long-term functionality.[4-13] Given that OATS is a reliable surgical option for treating chondral defects of the knee, the advancement of an arthroscopic approach has been shown to achieve positive patient outcomes, displaying all the beneficial results of an open technique but through a minimally invasive manner.[15,16] The purpose of this Technical Note and video is both to present and highlight the efficacy of an entirely arthroscopic OATS procedure of the lateral femoral condyle using allograft donor site backfill. This proposed technique is reproducible and reliable, requires only minimal surgical tools, and offers patient functional and subjective outcomes.

Indications and Contraindications

Indications for OATS procedure are typically the following: active younger patients with persistent symptoms, unifocal osteochondral defects (OCD) of the

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Table 1. Pearls and Pitfalls of Arthroscopic Osteochondral Autograft Transfer System Procedure

Pearls
Orient the harvester perpendicular to the articular cartilage surface to ensure the same angulation difference for recipient and donor graft harvest
Once the harvester is positioned perpendicular, reassess alignment to ensure exact perpendicular orientation in all planes
Mallet the harvester to a depth of 15 mm within subchondral bone for preparation of the donor site
When 15 mm of depth is reached within the donor site, rotate the harvester 90° clockwise then 90° counterclockwise to disengage the donor plug from subchondral bone
Pitfalls
The harvester must be perpendicular to articular cartilage surface for graft harvest and insertion to avoid differences in angulation and alignment
When identifying the location of donor site, harvest in medial and superior fashion to avoid the weightbearing zone of the medial femoral condyle
Limit the incision of the superomedial portal to 1cm or less to avoid disruption of the medial patellofemoral ligament
Flex the knee adequately to achieve perpendicularity and avoid angulation with harvester utilization

femoral condyle (≤2 cm), failed prior conservative and surgical treatment methods, and normal or correctable mechanical alignment, ligamentous stability, and meniscal integrity.[4-6,8,12-17] Additionally, magnetic resonance imaging (MRI) is imperative to confirm a unifocal grade III to IV osteochondral defect of the femoral condyle. Contraindications for OATS procedure include obesity, active infection, bone cancer, osteonecrosis, generalized osteoarthritis, severe obesity, bipolar osteochondral lesions of the tibia and femur, and uncorrectable mechanical alignment or meniscal deficiency.[6,8,9,12,15-17]

Surgical Technique

A demonstration of an arthroscopic assisted OATS procedure of the lateral femoral condyle (LFC) using an autograft plug from the medial femoral condyle (MFC) and allograft donor site backfill is available in Video 1. Pearls and pitfalls of our proposed surgical technique are highlighted in Table 1.

Preoperative Assessment

Preoperative assessment of knee pain consists of a detailed history, a comprehensive physical examination, and imaging studies. Physical examination may reveal an antalgic gait, pain with active and passive range of motion, and tenderness to palpation along the joint line. Plain radiographs are obtained to evaluate for any osseous abnormalities. If radiographs are unremarkable, MRI is indicated for diagnosis. Our patient's MRI revealed an 11 × 12 mm OCD of the lateral femoral condyle of the right knee (Fig 1), and 9 mm of bony edema was appreciated surrounding the lateral femoral condyle OCD of the right knee.

Patient Positioning

Once general anesthesia with a peripheral nerve block is administered, the patient is placed supine on a standard operating table with a lateral leg post. The head and bony prominences of the patient are well padded, and the lateral leg post is then attached to the bed. The operative leg is prepped and draped in standard sterile fashion before the anatomical landmarks of the superior and inferior pole of the patella and tibial tubercle of the operative leg are marked.

Arthroscopic Portal Placement and Diagnostic Arthroscopy

A standard anteromedial portal is established utilizing a no. 11 blade. A blunt trocar and scope sheath are used to enter the intra-articular space. Diagnostic arthroscopy is then performed after the insertion of a 30° 4.0 mm arthroscope into the operative knee joint to determine OCD lesion characteristics and assess for any concomitant intra-articular knee pathology. A notable OCD extending 10 mm over the posterior aspect of the lateral femoral condyle is identified through the anteromedial portal (Fig 2). This LFC defect will be the location of the recipient site for autograft plug transplantation. Using direct arthroscopic visualization, an 18-gauge spinal needle is used to needle-localize the anterolateral portal in the perpendicular trajectory to

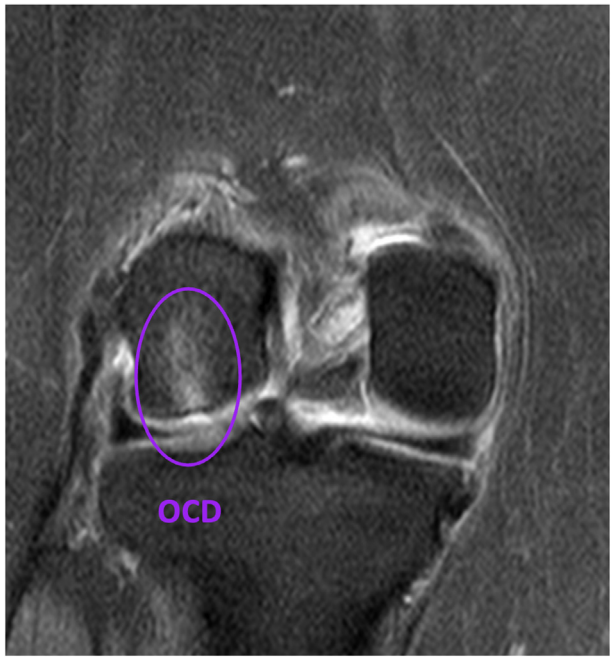

Fig 1. Magnetic resonance imaging of the right knee. T-2 fat-suppressed weighted imaging in the coronal plane depicts an osteochondral lesion measuring 11 × 12 mm with subchondral edema of the lateral femoral condyle.

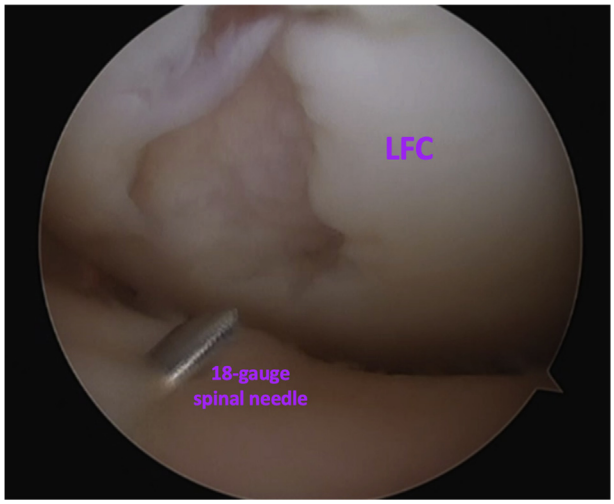

Fig 2. Intraoperative arthroscopic image of the right knee viewed through the anteromedial portal. Diagnostic arthroscopy with a 30° arthroscope confirms an osteochondral defect (OCD) of the lateral femoral condyle. A spinal needle is inserted perpendicular to the OCD lesion and is used for needle-localization of the anterolateral portal.

the lesion. The anterolateral portal is subsequently created with a no. 11 blade. A probe is then placed to further evaluate the chondral defect, noting the extent of the OCD posterior and medial to the joint surface.

OATS Procedure: Medial Femoral Condyle Donor Site Preparation and Backfill Plug

After standard diagnostic arthroscopy of the operative knee, a no. 11 blade is used to create a superior anteromedial portal for improved access to the MFC. A shaver and electrocautery are then inserted into the portal to debride the fat pad for direct visualization of the MFC donor site. A disposable 10 mm single-use OATS harvester (Arthrex, Naples FL) is placed perpendicular to the surface of the non-weightbearing chondral surface of the MFC to initiate autograft plug harvest at the donor site (Fig 3). After the appropriate amount of knee flexion is administered, the harvester is flushed against the MFC surface and malleted to a depth of approximately 15 mm. Once adequate depth is reached, the harvester is rotated clockwise 90° and then counterclockwise 90° to disengage the autograft plug from the subchondral bone within the MFC (Fig 4). The harvested autograft is measured at 15 mm in depth, and a hollow core is visible at the donor site of the MFC (Fig 5). To backfill the MFC donor site, a precut osteochondral allograft plug (Arthrex) is contoured to the appropriate size with a rongeur. The allograft is introduced back into the hollowed donor site with the harvester through a delivery tube and then malleted into place with correct alignment (Fig 6), followed by closing of the superomedial portal with a 3-0 nylon suture.

OATS Procedure: Lateral Femoral Condyle Recipient Site Preparation

Through the anterolateral portal, a cannulated guide (Arthrex) is placed on the articular cartilage surface of the OCD, and the proper amount of knee flexion is administered to ensure the guide is placed perpendicular to the lesion. Once directly perpendicular over the recipient site, a guide pin is fired into the center of the defect. A 10 × 13 mm cannulated recipient cannulated reamer is placed over the guide pin and is used to advance to a depth of 13 mm into the defect, preparing the recipient site for graft introduction (Fig 7). A cored

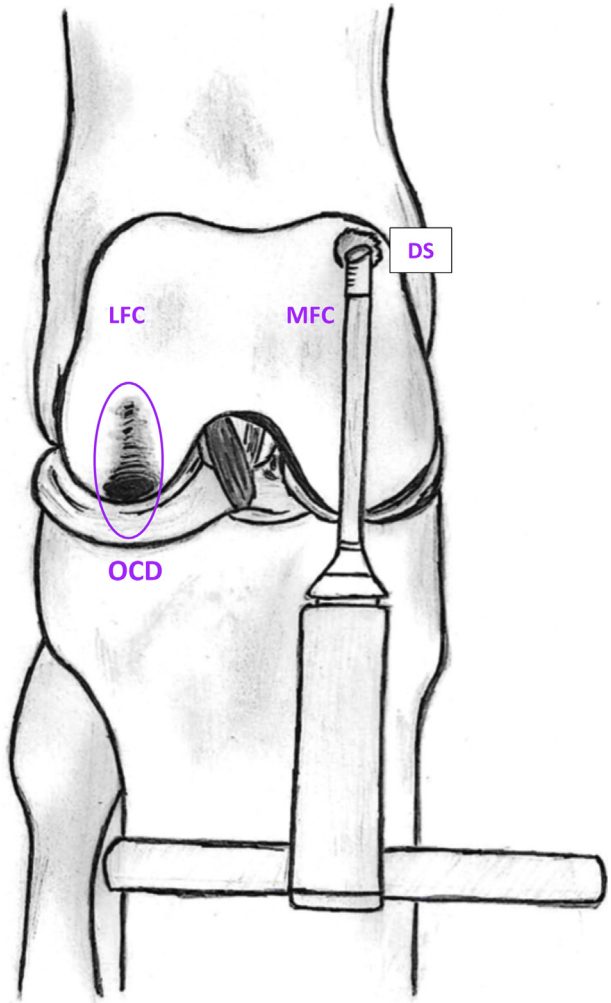

Fig 3. Illustration of osteochondral autograft transfer system (OATS) procedure of the lateral femoral condyle using allograft donor site backfill. Osteochondral defect (OCD) is present on the lateral femoral condyle (LFC), and position of the harvester is shown in the illustration below. Harvester is inserted through the superomedial portal and is placed perpendicular on a non-weight bearing surface of medial femoral condyle (MFC). Harvest of the autograft donor plug creates a donor site (DS) which is filled with an allograft osteochondral plug.

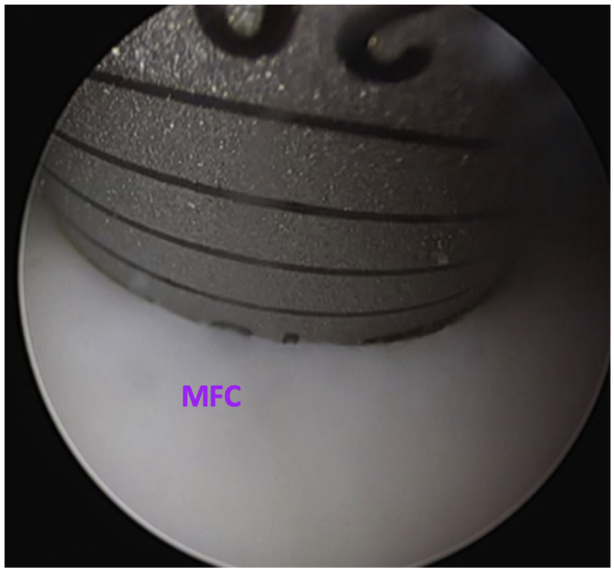

Fig 4. Intraoperative arthroscopic image of the right knee viewed through the anterolateral portal. Osteochondral autograft transfer system (OATS) harvester is inserted through the superomedial portal, perpendicular to the chondral surface of the medial femoral condyle, and the harvester is malleted on a non-weightbearing surface to a depth of 15 mm. The harvester is rotated 90° clockwise then counterclockwise, disengaging the graft from bone.

recipient site is now visible on the LFC where graft insertion will then take place.

OATS Procedure: Autograft Insertion Into the LFC Recipient Site

A rongeur is used to prepare the donor plug, shaping the bone graft to the appropriate dimensions and angulation for a depth of 13 mm. The harvester loaded with the graft is then placed into the joint perpendicular to the recipient site, advanced through the delivery tube into the recipient socket, and gently tapped into place with a bone tamp (Fig 8). The OATS procedure is now completed with the harvested autograft from the MFC donor site inserted into the LFC recipient socket and flushed adequately into surface (Fig 9).

Final Examination and Postoperative Care

Portal-site closure commences to end the OATs procedure. The incision sites are copiously irrigated, and excess fluid is suctioned from the knee joint. All portals are closed in standard fashion with a 3-0 nylon, and dressings are applied. Local anesthetic is injected superolaterally into the knee, and the patient is placed in a knee extension brace locked in full extension to aid in postoperative rehabilitation.

Immediate postoperative rehabilitation goals (Phase 0; 0-2 weeks) are aimed at promoting pain and swelling control of the affected knee while optimizing graft incorporation. The patient is non-weightbearing with the operative extremity for 8 weeks after the procedure. They will progress their range of motion (ROM) to 90° of flexion by the first postoperative visit with the orthopaedic surgeon. Physical therapy will begin after the first operative visit. Phase 1 (2-6 weeks) is geared toward increasing ROM to 120° of knee flexion. A continuous passive range of motion machine may aid during phase I in restoration of full range of motion. Phase II (6-12 weeks) focuses on establishing ROM to normal, gait normalization, and patellar mobility. Phase III (12-20 weeks) is the maturation phase where light strengthening exercises and agility work commence. Phase IV (>20 weeks) is where sport-specific activities are resumed. Running is suggested at 5 to 8 months after operation.

Discussion

OATS offers excellent functional outcomes and a relatively rapid return to sport. A systematic review by Krych et al.[18] of 2549 athletes who underwent cartilage restoration surgery demonstrated that OATS offered the highest return to sport rate within a minimum 2-year postoperative timeframe at 93%, followed by osteochondral allograft transplantation at 88%, autologous chondrocyte implantation at 82%, and microfracture (MFX) at 58%. Of note, the same systematic review revealed a 76% return to sport rate for all cartilage restoration surgeries at mid-term follow-up—thus the superior return to sport rate displayed by OATS highlights a surgical option ideal for faster recovery, and return to preinjury level activity.[18] Additionally, in comparison to MFX, patients undergoing OATS exhibit increased physical fitness and higher subjective satisfaction scores 5, 10, and 15 years after surgery.[6,19] Several other short- and long-term studies have also

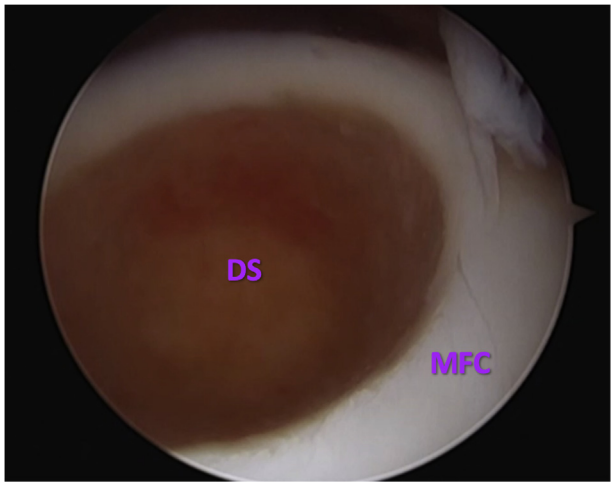

Fig 5. Intraoperative arthroscopic image of the right knee viewed through the anterolateral portal. After autograft harvest from the medial femoral condyle, the donor site is observed, confirming complete evacuation of the donor plug.

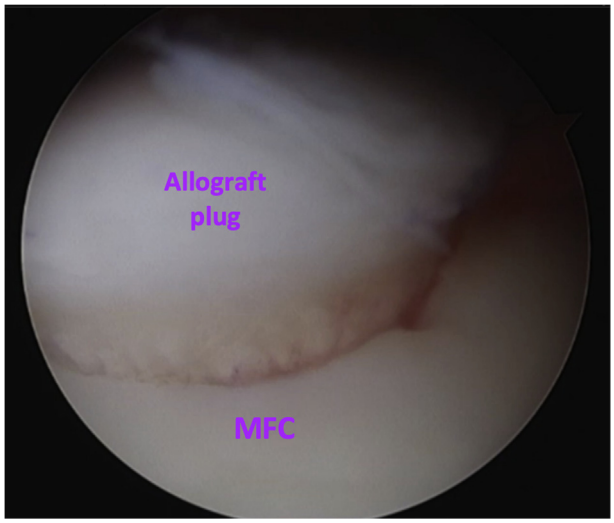

Fig 6. Intraoperative arthroscopic image of the right knee viewed through the anterolateral portal. An allograft osteochondral plug is advanced into the medial femoral condyle donor socket before being tamped into place with a mallet. This allograft plug tamped further and will be flush to the chondral surface of the medial femoral condyle.

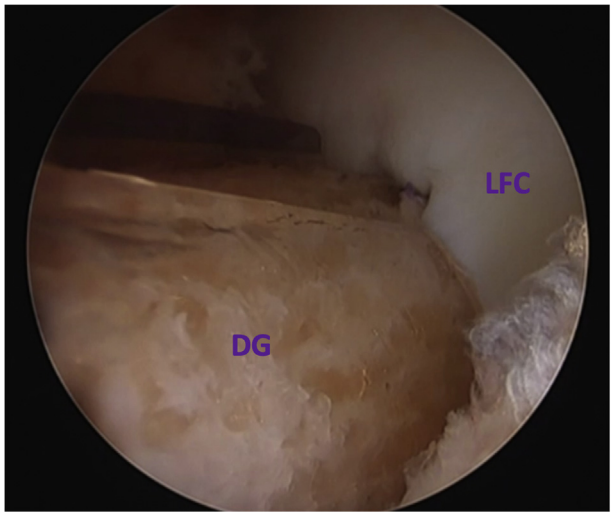

Fig 8. Intraoperative arthroscopic image of the right knee viewed through the anteromedial portal. Autograft donor plug is advanced into the recipient socket through a clear plastic delivery tube. Proper placement and angle approach is confirmed with visual confirmation.

proven that OATS consistently produces significantly greater functional, athletic, and subjective patient outcomes versus MFX and is thus the superior procedure for treating OCD of the knee.[4,6,13]

Arthroscopic OATS procedures have been published with satisfactory results and patient outcomes; however, these techniques have all focused on the osteochondral lesions of the medial femoral condyle using an autograft donor plug from the lateral femoral condyle.[15,16] A primary advantage of our technique is the procedure is done arthroscopically, offering a less-invasive, similar quality repair to traditional open OATS procedures. Thus the potential for neurovascular injury, iatrogenic damage, recovery time, and postoperative infection is substantially reduced through an arthroscopic approach. A systematic review by Kizaki et al.[20] of 1139 patients who underwent either open or arthroscopic OATS procedures of the knee

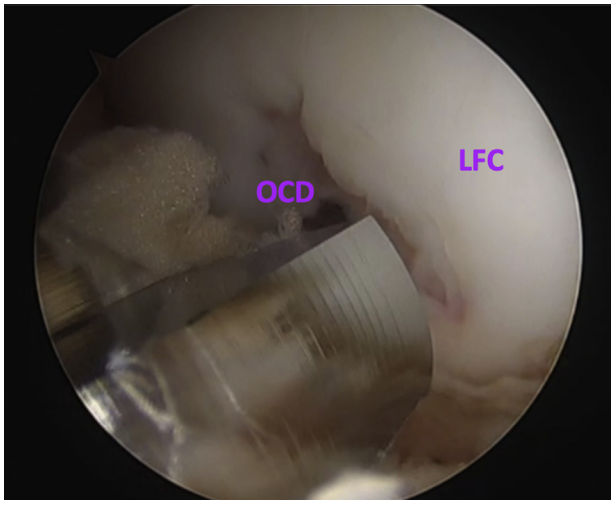

Fig 7. Intraoperative arthroscopic image of the right knee viewed through the anteromedial portal. After placement of the guide pin perpendicular to the osteochondral defect on the lateral femoral condyle, a cannulated recipient reamer is placed over the guide pin and reamed to a depth of 13 mm.

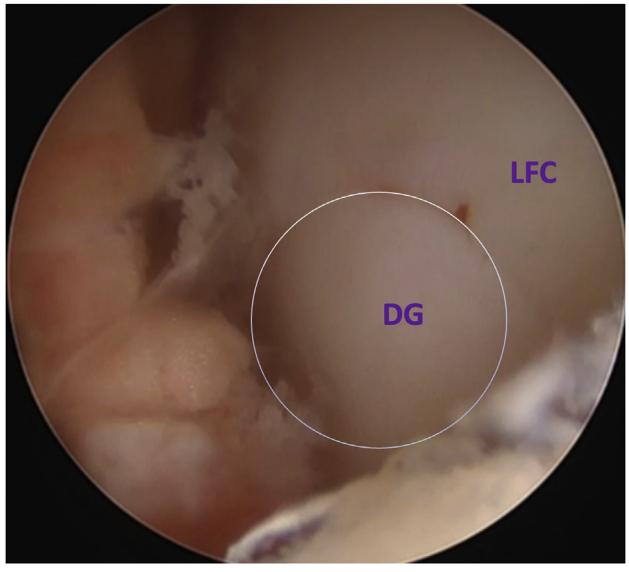

Fig 9. Intraoperative arthroscopic image of the right knee viewed through the anteromedial portal. After the donor graft is firmly impacted perpendicular into the recipient site of the lateral femoral condyle, the autograft plug is confirmed to be flush with the surrounding cartilage, with a well-contoured appearance.

Table 2. Advantages and Disadvantages of Arthroscopic OATS Procedure

Advantages
Performed arthroscopically. Less invasive relative to open procedure.
Decreased potential for neurovascular injury, postoperative infection and iatrogenic damage
Reduced postoperative recovery time
Potential complications associated with unfilled donor sites are eliminated through donor site backfill with an allograft plug
Single-use OATS instrument used for both graft harvesting and insertion
Disadvantages
Increased operative time due to decreased visualization of OATS plug, donor site, and recipient site
Theoretical risk of infectious disease transmission and limited shelf life viability of osteochondral allograft
Due to arthroscopic approach, can be more challenging to place harvester perpendicular to articular cartilage surface
Lack of recipient bone core to use as a template for the autograft bone plug increases risk of donor plug being "proud" after transplantation

OATS, osteochondral autograft transfer system.

demonstrated favorable postoperative clinical outcomes for either procedure; however, those who underwent an open procedure were more likely to develop postoperative hemarthrosis.[20] A large concern with OATS procedures is the potential for complications when the donor site socket is not backfilled, leaving the subchondral bone of the femoral condyle hollowed. By backfilling the donor site with an allograft plug, we effectively reduce potential complications such as mechanical irritation, patellar maltracking, locking of the knee joint, anterior knee pain, and fibrocartilage hypertrophy.[21-23] Last, through the use of a single OATS instrument for both graft harvest and insertion, our technique reduces overall steps, implants, and tools traditionally used in open procedures and differing arthroscopic techniques.

Because of our technique being an entirely arthroscopic procedure, a potential disadvantage in visualization exists because of innate differences in working surface area between arthroscopy and arthrotomy. As such, positioning of the harvester perpendicular to the articular surface can be more challenging, and issues of misalignment, angulation, and decreased visualization with a limited surface area arise. However, cadaveric studies have revealed that, in comparison to an open approach, an arthroscopic approach demonstrates nearly identical precision in graft harvesting, perpendicularity, plug placement, and site preparation.[24,25] Although potential complications of an unfilled donor site are eliminated with allograft plug backfill, theoretical concerns of infectious disease transmission are inherent in addition to the limited shelf life of osteochondral allograft viability.[13,26] Additionally, it is imperative to limit the size of the anteromedial incision to 1 cm or less to avoid disruption of the medial patellofemoral ligament and any concurrent iatrogenic damage. A complete list of advantages and disadvantages of our technique are listed in Table 2.

To the current literature of arthroscopic OATS of the knee, we add an arthroscopic OATS procedure of the lateral femoral condyle using an autograft donor plug from the medial femoral condyle with donor site backfill using an osteochondral allograft plug. In this surgery we chose to use autograft to fill the osteochondral defect with allograft backfill rather than allograft of the primary lesion because of the evidence of superior outcomes of autograft for osteochondral defects, whereas we backfilled to minimize complications associated with an empty donor site. The prevalence of articular cartilage defects of the knee is becoming increasingly common and can have dire functional and physical consequences in return to sport rate, active daily living activities, and athletic performance. Our proposed Technical Note offers a reproducible, efficient, and reliable method for articular cartilage restoration of the knee performed in minimally invasive, arthroscopic fashion.

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