Technical Note

Lateral Femoral Condyle Osteochondral Allograft and Concomitant Lateral Opening-Wedge Distal Femoral Osteotomy in the Setting of Failed Osteochondritis Dissecans Fixation

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Abstract: Osteochondritis dissecans (OCD) is a subchondral bone and articular cartilage abnormality that can lead to detachment of a bone fragment and eventually osteoarthritis. Juvenile OCD typically presents in male patients, with the most common presenting symptom being pain with weight-bearing. When conservative measures are not effective, OCDs are treated surgically with subchondral drilling, fixation, or autologous chondrocyte implantation, depending on the severity of the lesion and whether it has detached. Fragment fixation of the bone fragment may be attempted for high-grade OCD with subchondral bone to try and restore the native cartilage. When fixation of an unstable OCD lesion is unsuccessful, osteochondral allograft transplantation and an offloading osteotomy may be considered. This Technical Note describes a lateral opening-wedge distal femoral osteotomy and osteochondral allograft transplantation for a failed OCD fixation of the lateral femoral condyle.

Osteochondritis dissecans (OCD) of the knee is characterized by a subchondral bone abnormality that may detach from the surrounding bone, leading to pain, instability, and eventually osteoarthritis.[1,2] The incidence ranges from 9.5 to 29 per 100,000, with most patients aged 10 to 19 years old and male patients being 4 times more likely to be affected.[3,4] The exact etiology of OCD is unknown, but it is likely multifactorial with genetic risk factors, repetitive microtrauma, and/or undistributed axial loading with coronal malalignment, which can disrupt blood flow to the subchondral bone, playing a role in the pathogenesis.[1,4] Conservative treatment may be indicated for stable lesions or nonsurgical candidates with concomitant degenerative joint disease.[5] When lesions become unstable, generating pain, mechanical locking, and swelling, surgical treatment is indicated. Initial surgical intervention may include fragment refixation and bone grafting, chondroplasty/debridement, microfracture, or autologous chondrocyte implantation.[3-5] Procedural success is variable depending on the location, with lateral femoral condyle lesions being an independent risk factor for failure because of their generally larger size than medial femoral condyle OCD lesions, especially in patients with valgus malalignment. If failure of the initial surgical treatment occurs, osteochondral transplantation either with osteochondral allograft transplantation (OCA) or osteochondral autograft transfer may be indicated, but a complete workup and concomitant management of coronal malalignment should be considered to optimize the long-term healing potential.[2,5,6] In this Technical Note, we describe a failed treatment of an OCD fixation in a patient with valgus alignment that was treated with a lateral femoral condyle OCA and a concomitant lateral opening-wedge distal femoral osteotomy (DFO).

Surgical Technique

Video 1 details our technique from the approach, debridement, lateral femoral condyle OCA, concomitant

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Investigation performed at Twin Cities Orthopedics, Edina, Minnesota, U.S.A.

Received April 2, 2025; accepted May 2, 2025.

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2212-6287/25659

https://doi.org/10.1016/j.eats.2025.103678

Table 1. Step-by-Step Guide and Surgical Pearls for a Lateral Femoral Condyle Osteochondral Allograft and Concomitant Distal Femoral Osteotomy in the Setting of Failed Osteochondritis Dissecans Fixation

Step-by-Step Guide	Surgical Pearls
Lateral and anterior incisions are made.	An 8-cm lateral incision is made over the midline distal lateral femur for the distal femoral osteotomy. An anterior incision is made from 6 cm above the superior pole of the patella to the tibial tubercle. This can follow the incision from the patient's previous operation to minimize scarring and tissue damage.
The iliotibial band is split at the inferior third through the lateral incision.	The vastus lateralis must be elevated to access the femur.
Dissection is performed to create a lateral parapatellar arthrotomy.	This allows the osteochondral defect to be identified and measured.
The defect margins are scored and then the defect is reamed.	Copious irrigation is used to prevent iatrogenic heat necrosis.
The fresh donor graft is measured.	The donor graft is measured to the exact size of the recipient site using an allograft workstation. The graft should attempt to match the natural contour of the condyle. Once harvested, the depth of the graft is cut to match the recipient site depth. Pulsatile lavage must be used to remove the blood products from the subchondral bone of the donor graft.
The donor graft is inserted into the recipient site.	Several osteochondral plugs may be used to ensure that the transplant cartilage margins match the native articular surface. Smaller plugs can be placed using the snowman technique.
Two guide pins are placed along the lateral femoral cortex.	The guide pins are placed at a 45° angle to the adductor tubercle and are driven medially.
A saw blade is used to cut to a depth of 5 mm and osteotomes are used for the osteotomy.	The guidewire plate may be used as a guide when sawing. A finger may be used to protect the posterior cortex of the knee. A 1-cm medial cortical hinge should be maintained.
An opening spreader device is placed into the osteotomy cut.	The opening spreader is kept in place for five minutes to allow for stress relaxation of the medial cortical hinge.
A Puddu plate is placed to fix the osteotomy cut.	Four 4.5-mm cortical screws are used proximally and three 6.5-mm cancellous screws are used distally to secure the plate.
The deep and superficial tissues are closed.	Closure of the deep tissues reduces the risk of postoperative hematoma.

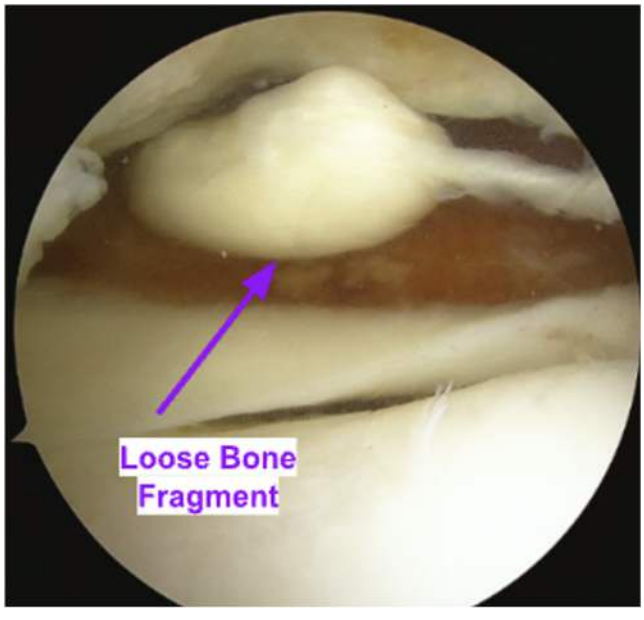

Fig 1. Arthroscopic view of a right knee lateral femoral condyle from the anterolateral portal. A first-stage arthroscopy is performed to validate that the osteochondritis dissecans fixation has failed, to remove loose bodies or bone fragments, and to measure the size of the defect so that the fresh graft can be ordered. In this case, the defect was measured at 22 mm anterior to posterior and 20 mm medial to lateral.

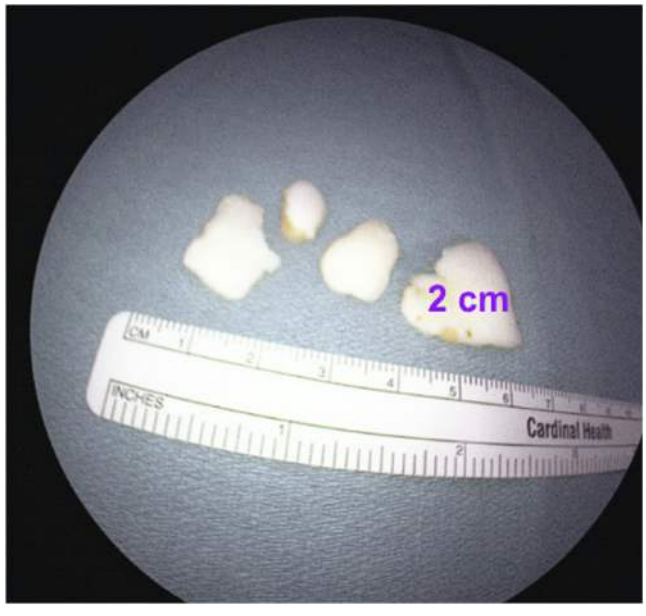

Fig 2. Image of the bone fragments removed during the first stage arthroscopy of a right knee. Osteochondritis dissecans is a subchondral bone and articular cartilage abnormality that can result in the detachment of bone fragments. An arthroscopy must be performed before osteochondral allograft transplantation to remove any bone fragments, measure the size of the defect, and validate the intact status of the lateral meniscus and the opposing lateral tibial plateau articular cartilage surface. This patient had 4 loose bone fragments removed, with the largest piece of bone measuring about 2 cm.

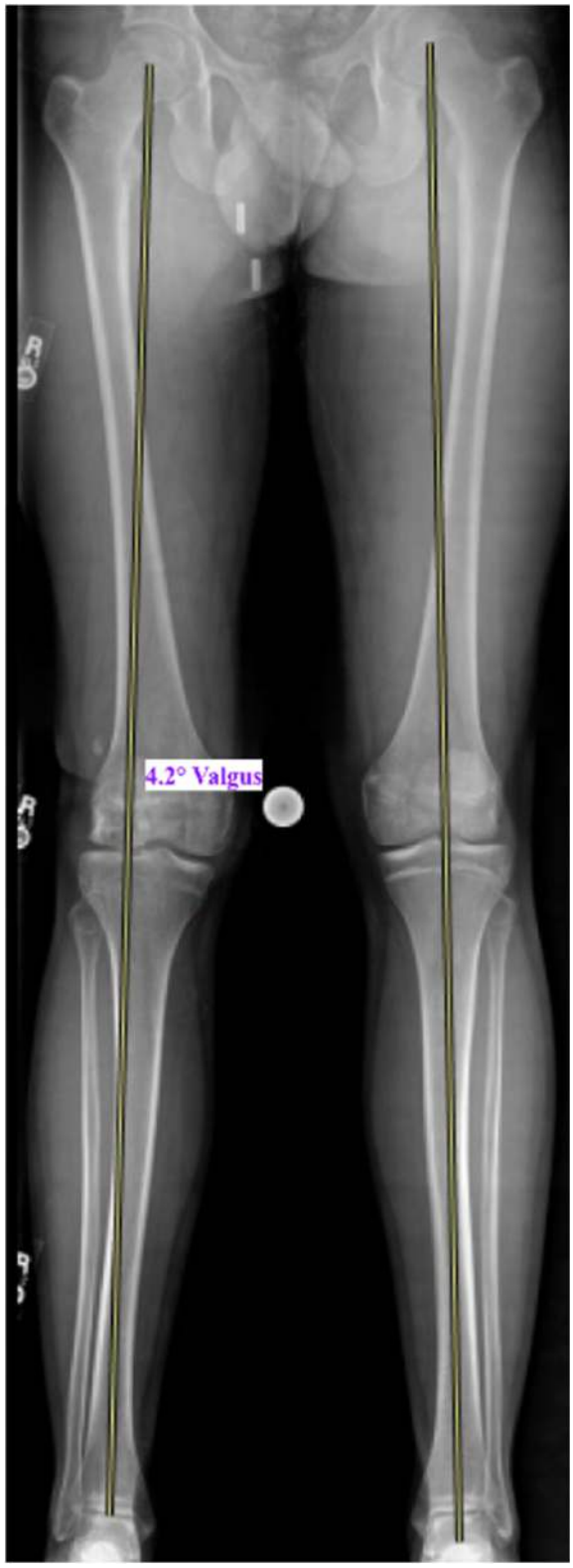

Fig 3. Standing long-leg anteroposterior radiographs. Undistributed axial loading is a risk factor for osteochondritis dissecans. Lateral femoral condyle lesions are also a risk factor, especially in patients with valgus malalignment. Because of these known risk factors, concomitant management of coronal malalignment should be considered to optimize healing. Standing long leg anteroposterior view radiographs allow for measurement of the patient's mechanical weightbeairng axis and hip-knee-angle (HKA), which tells us whether the patient has varus or valgus malalignment. For this patient, a line is drawn from the center of the femoral head to the center of the tibiotalar joint to find the mechanical weightbearing axis. In healthy adults, the HKA is between 1° valgus and 3.2° varus. In this patient, the HKA is 4.2° valgus, indicating that the patient is in valgus malalignment and bears weight through the lateral compartment of the knee. Therefore, management of the patient's malalignment with distal femoral osteotomy should be considered.

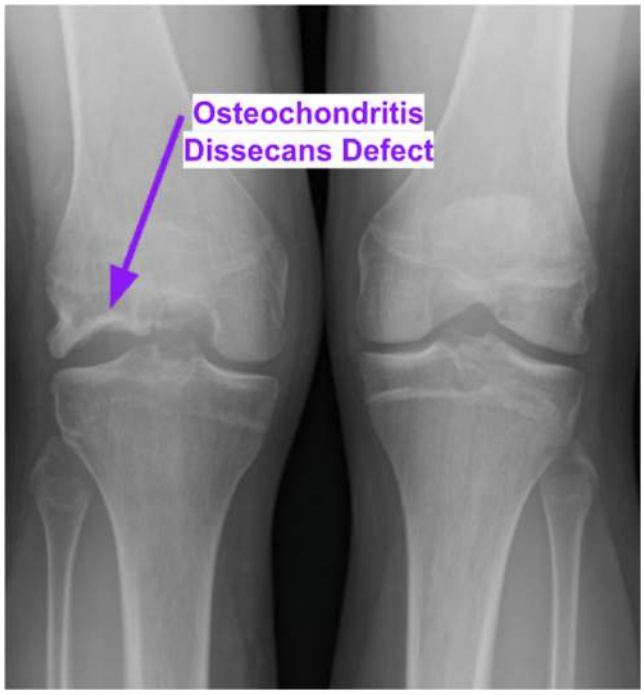

Fig 4. Rosenberg radiograph with bilateral knees bent at 45°. A failed osteochondritis dissecans fixation can lead to loose bodies and eventually osteoarthritis. The degree of osteoarthritis should be evaluated before surgery. Rosenberg radiographs require the knees to be partially flexed, allowing for better visualization of the joint space and assessment of osteoarthritis. In this patient, Rosenberg radiographs show an obvious osteochondral defect of the right lateral femoral condyle.

DFO, and closure. The step-by-step guide and surgical pearls are in Table 1.

Preoperative Evaluation

Clinical examination, diagnostic imaging, and radiographic assessment should be obtained to comprehensively evaluate the patient's condition and history. A first-stage arthroscopy is performed to validate that the OCD fixation has failed, remove loose bodies, and measure the size of the defect so that the fresh graft can be ordered (Figs 1 and 2). Long-leg anteroposterior radiographs are necessary to determine the weight-bearing axis and degree of correction for a potential osteotomy (Fig 3). Anteroposterior, lateral, and Rosenberg radiographs are used to visualize the joint space height (Fig 4).

Anesthesia and Positioning

The patient is positioned in the supine position on the operating table and induced under general anesthesia. A bilateral knee examination is performed to validate the clinical examination findings. A well-padded high thigh tourniquet is placed on the surgical leg. A sandbag is taped to the foot of the operating bed to allow the knee to be flexed to 115°. This allows for better visualization of and access to the joint space during preparation and insertion of the lateral femoral condyle OCA.

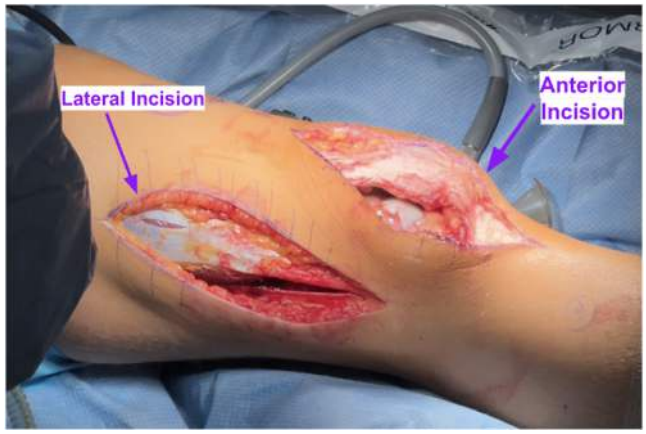

Fig 5. Right knee incisions for osteochondral allograft transplantation and concomitant distal femoral osteotomy (DFO) with the patient in the supine position. In a patient with osteochondritis dissecans (OCD) and coronal malalignment, concomitant fixation of the malalignment should be considered to optimize healing. This patient had a right lateral femoral condyle OCD lesion with several detached bone fragments and valgus malalignment; therefore, they underwent an osteochondral allograft transplantation as well as DFO. An anterior incision is made for the arthrotomy, and a lateral incision is performed for the DFO. Any existing incisions may be used to reduce scar tissue formation.

Fig 6. Image of the osteochondral dissecans (OCD) defect with the patient in supine position and the knee flexed to 115°. Osteochondral allograft transplantation is a suitable option for young, healthy patients who have failed OCD fixation. To begin the osteochondral allograft transplantation, an anterior incision is made, and careful dissection is performed to create a lateral parapatellar arthrotomy. The subchondral bone and articular cartilage defect must be measured for a proper graft to be sized. The knee is flexed to 115° to visualize the defect, and a cylindrical sizer is used to measure the defect. This patient has a full-thickness cartilage defect of the right lateral femoral condyle measuring 27.5 mm in diameter.

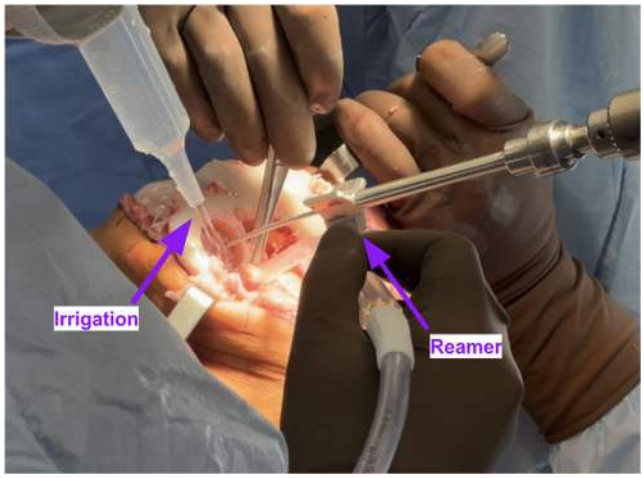

Fig 7. Image of the osteochondral dissecans (OCD) defect being reamed with the patient in the supine position and the knee flexed to 115°. After the defect has been measured, the site is reamed to prepare the recipient site for the graft. A guidewire is placed in the center of the defect, perpendicular to the articular surface. A reamer is inserted, and the defect is drilled to a depth of 7 mm. During reaming, copious irrigation is used to prevent iatrogenic heat necrosis. The depth of the lesion is measured at the 12-, 3-, 6-, and 9-o'clock positions so that the graft can be measured to fit properly.

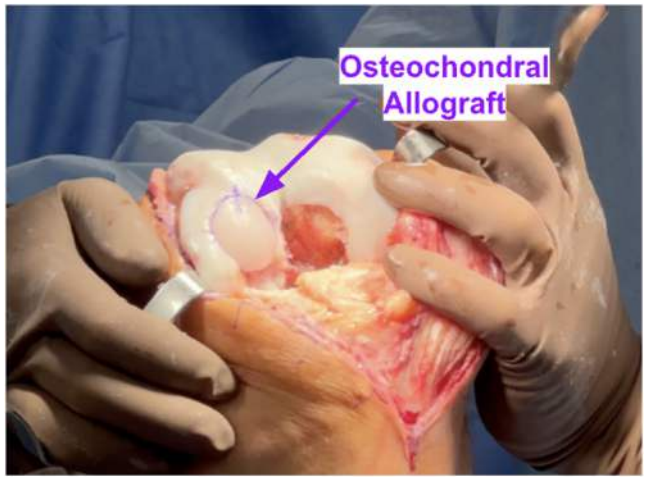

Fig 9. Final placement of the osteochondral allograft. Osteochondral allograft transplantation uses a donor graft to replace a subchondral and articular cartilage defect. This procedure is especially useful for large defects because it eliminates autograft harvest-site morbidity. After a donor graft has been measured to fit the patient's defect, it is inserted into the recipient site using gentle pressure. Excessive force must be avoided to prevent damage to the chondrocytes. In cases in which the defect is particularly large or the graft does not fill the defect, additional grafts may be inserted to completely fill the defect. The grafts must be the same height as the surrounding cartilage to avoid catching or abrasion of the graft.

Fig 8. Image of the allograft workstation with the allograft being measured to match the patient's defect. Osteochondral allograft transplantation is suitable for large osteochondral defects because of the use of an allograft, which eliminates the risk of donor-site morbidity. As the patient's defect is being reamed and measured, the allograft is immersed in saline. After the defect has been measured, the graft is moved to an allograft workstation where it is harvested and measured to perfectly fit the patient's defect. The graft should be harvested in an area that matches the curve of the native cartilage. Pulsatile lavage must be used on the subchondral bone to remove any blood products and minimize graft rejection.

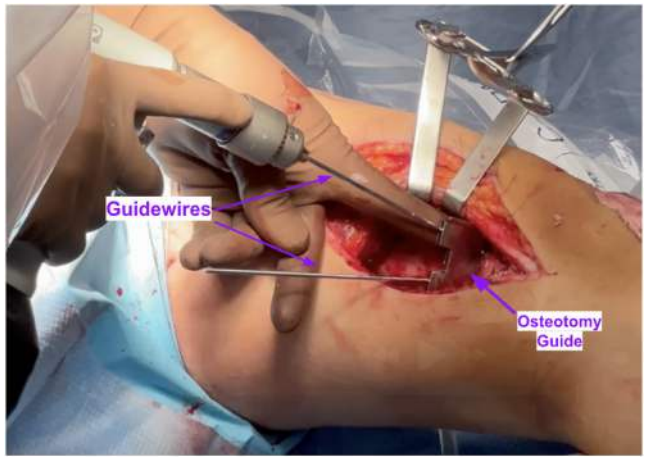

Fig 10. Guidewire placement for right knee distal femoral osteotomy (DFO) with the patient in supine position. In patients with osteochondritis dissecans and coronal malalignment, an offloading osteotomy should be considered to promote the healing of the graft and prevent further trauma. A lateral incision is used for a lateral opening-wedge DFO. The iliotibial band is split, and the vastus lateralis is elevated in order to visualize the femur. Two guide pins are placed at a 45° angle to the adductor tubercle along the lateral femoral cortex. An osteotomy guide is placed between the pins and an oscillating saw blade is used to drill while following the trajectory of the guide pins.

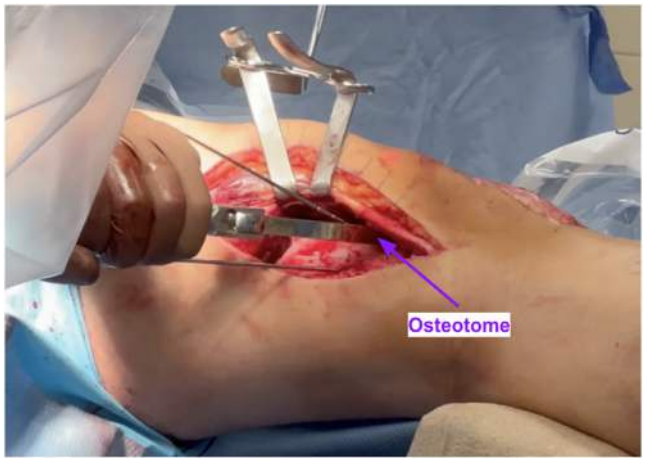

Fig 11. Right knee lateral incision for distal femoral osteotomy with guidewires placed and an osteotome being used to cut the femur with the patient in supine position. In patients with osteochondritis dissecans and coronal malalignment, an offloading osteotomy should be considered to promote healing of the osteochondral allograft transplantation graft. After the desired osteotomy has been outlined following the trajectory of two guidewires, a 5-mm deep sawcut is performed and osteotomes are then used to complete the osteotomy. A small osteotome is used anteriorly and posteriorly, whereas a medium osteotome is used for the midportion of the femur. The smaller osteotome allows for more precision. During the osteotomy, a finger should be used to protect the neurovascular bundle while the osteotome is being advanced in the posterior aspect of the knee.

Two grams of perioperative cefazolin is administered for infection prophylaxis.

Surgical Approach and OCD Isolation

An 8-cm lateral incision is made over the midline distal lateral femur for the DFO, the iliotibial band is split, and the vastus lateralis musculature is elevated to visualize the femur. An anterior incision is made from 6 cm above the superior pole of the patella to the tibial tubercle (Fig 5). If the patient has undergone a previous arthrotomy, the existing incision may be used. Careful dissection to create a lateral parapatellar arthrotomy is performed. The knee is flexed to improve visualization, the patella is retracted medially and held in place with Z retractors, and the osteochondral defect is identified and measured (Fig 6).

OCA Site Preparation and Implantation

The identified defect margins are first scored. Copious irrigation is used while the osteochondral defect is reamed to prevent iatrogenic heat necrosis (Fig 7). The depth of the recipient site is measured along the points of a compass. The fresh donor graft is measured to the exact size of the recipient site (Fig 8). Care should be taken to attempt to match the expected contour (anticipated radius of curvature) of the recipient site. Once the donor graft is harvested, the depth should be cut to match the recipient site. Before implantation of the graft, pulsatile lavage is used to remove the blood products from the subchondral bone of the donor graft. The donor graft is inserted into the recipient site, ensuring the transplant cartilage margins match the level of the native articular surface. Because of the odd shapes of osteochondral defects, several osteochondral plugs may be required to optimize the osteochondral allograft resurfacing. Smaller plugs can be placed using a snowman technique (Fig 9). The arthrotomy is then closed with ORTHOCORD (DePuy Synthes Inc, Warsaw, IN).

Lateral Opening-Wedge DFO

The previous distal lateral femur incision is used for the lateral opening-wedge DFO. Two guide pins are placed at a 45° angle to the adductor tubercle and perpendicular to the femoral diaphysis along the lateral femoral cortex (Fig 10). An osteotomy guide (Arthrex, Naples, FL) is placed between the pins, and an oscillating saw blade is used to drill to a depth of 5 mm, following the trajectory of the guide pins. Osteotomes are then used to cut the bone to the medial cortex where a 1-cm cortical hinge should be maintained (Fig 11). A finger should be used posteriorly while the small osteotome is being advanced to protect the neurovasculature of the knee.

Osteotomy Fixation

An opening spreader device (Arthrex) is placed into the osteotomy cut and held in place for five minutes to

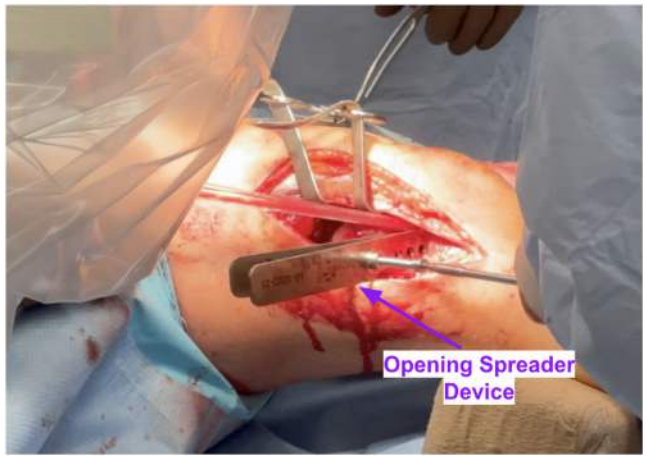

Fig 12. Opening spreader device in a right knee during a distal femoral osteotomy with the patient in supine position. Offloading osteotomies should be considered in patients with osteochondritis dissecans and coronal malalignment. This will shift the patient's weight-bearing axis away from the defect to promote healing of the osteochondral allograft transplantation graft. After the femoral osteotomy cut has been performed, an opening spreader device is placed in the bone and opened to the desired alignment. The device is left in place for 5 minutes to allow for relaxation of the 1-cm medial cortical hinge.

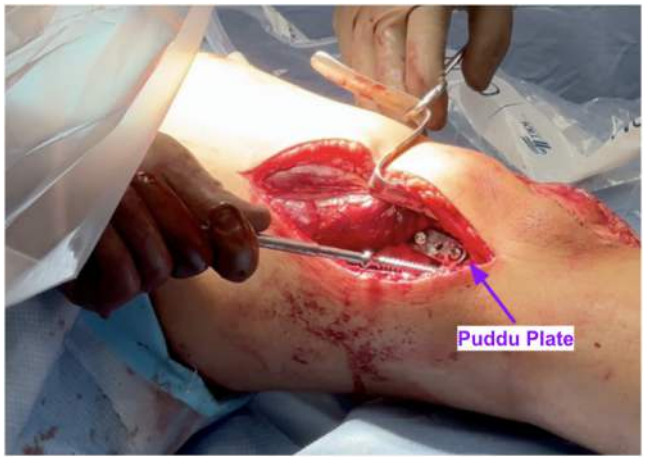

Fig 13. Puddu place fixation in a right distal femoral osteotomy with the patient in supine position. A lateral opening-wedge distal femoral osteotomy should be considered in a patient with coronal malignment complicating osteochondritis dissecans. After the femoral osteotomy cut has been performed, and the opening spreader device has been in place for several minutes to allow for relaxation, the osteotomy is fixed using a Puddu plate (Arthrex, Naples, FL). The plate is fixed with four 4.5-mm cortical screws proximally and three 6.5 cancellous screws distally. Fluoroscopy is used during the procedure to confirm the desired screw trajectory and plate fixation of the osteotomy.

allow for stress relaxation of the medial cortical hinge (Fig 12). A distal femoral Puddu plate (Arthrex) sized to fit the desired osteotomy correction is placed with four 4.5-mm cortical screws proximally and three 6.5-mm cancellous screws distally (Fig 13). Fluoroscopy is used to confirm the desired screw trajectory and plate fixation opening of the osteotomy.

Closure

The tourniquet is let down. The deep and superficial tissues are closed with sutures. The knee is placed in an immobilizer in full extension.

Postoperative Rehabilitation

The patient will be non−weight-bearing on the surgical extremity for 8 weeks. If radiographs at 8 weeks postoperatively have early evidence of healing, the patient may initiate weight bearing at one quarter of body weight per week until becoming fully weight-bearing.

Discussion

Significant cartilage defects in the knee are debilitating injuries that result in limited function, significant pain, and progression of osteoarthritis. When reparative failure of a large OCD lesion occurs, an OCA can be used to replace the damaged cartilage and subchondral bone. An OCA is advantageous for large osteochondral defects because it can replace the whole osteochondral unit and there is no donor site morbidity.[7]

A systematic review by Familiari et al.[8] identified 19 studies with 1,036 patients evaluating the long-term clinical outcomes and failure rates of a single-stage OCA procedure. The mean survival rate for 5, 10, 15, and 20 years postoperatively was 86.7%, 78.7%, 72.8%, and 67.5%, respectively. Outcome measures showed significant improvement from pre- to postoperative assessment. The weighted mean for failure was 18.2%, noting that revision cases and patients with concomitant lesions had worse outcomes.[8] Coronal malalignment is a known risk factor for requiring a revision OCA procedure, and it has been reported that a concomitant osteotomy at the time of cartilage restoration decreases the rate of reoperation.[9] A retrospective study of 1,113 patients with a mean follow-up of 3.25 years investigated the outcomes of osteochondral restorative procedures with and without a concomitant osteotomy and reported a significant decrease in reoperation rates in the group with concomitant osteotomy compared with isolated osteochondral replacement (OCA 34.8% vs OCA and osteotomy 16.3%).[9] Furthermore, a prospective study reported positive postoperative outcomes of lateral femoral condyle OCA with concomitant DFO. Significant improvements were observed in patient-reported outcomes and of the 24 patients included, 2 were considered treatment failures (at a mean 1.48 years).[10]

Through the structural restoration of the osteochondral defect and the simultaneous correction of coronal

Table 2. Advantages and Disadvantages of a Lateral Femoral Condyle Osteochondral Allograft and Concomitant Distal Femoral Osteotomy in the Setting of Failed Osteochondritis Dissecans Fixation

Advantages	Disadvantages
An anterior incision for the arthrotomy allows for direct visualization of the osteochondral defect.	There is risk of heat necrosis with reaming of the osteochondral defect.
Osteochondral allograft transplantation may be used to replace large osteochondral defects of the knee.	There is risk of damage to the posterior neurovasculature of the knee during the osteotomy.
Distal femoral osteotomy allows for correction of valgus malalignment of the knee and reduced loading on the osteochondral allograft transplantation.	No autograft harvest site morbidity because of the use of an allograft for the osteochondral transplantation.
Smaller donor plugs can help fill additional areas of the cartilage defect that the initial plug cannot dill.	Potential for mismatch between osteochondral allograft and native cartilage.
Osteotomy and osteochondral allograft transplantation in a single-stage procedure.	

malalignment, this surgical technique provides a viable reparative surgical procedure for patients with complex OCD defects. Advantages and disadvantages of the surgical techniques are listed in Table 2.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R.F.L. reports consulting or advisory and funding grants from Össur; consulting or advisory, funding grants, and travel reimbursement from Smith & Nephew; consulting or advisory with Responsive Arthroscopy; funding grants from the Arthroscopy Association of North America and the American Orthopaedic Society for Sports Medicine; speaking and lecture fees from Foundation Medical, LLC, and patent with royalties paid to Ossur. All other authors (G.E.G., L.V.T., E.P.S., M.T.R., D.R.L.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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