Technical Note

Treatment of Malalignment and Cartilage Injury: High Tibial Osteotomy With a Concomitant Osteochondral Allograft to the Medial Femoral Condyle and Lateral and Medial Partial Meniscectomy

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Abstract: In patients with full-thickness focal cartilage defects, osteochondral allograft is a technique for restoration of hyaline cartilage; however, in patients with genu varum, the diseased compartment of the knee is generally offloaded as well. A high tibial osteotomy presents a biomechanical solution to malalignment of the knee and offloading of the diseased compartment of the knee. The purpose of this Technical Note is to present our preferred technique to treat focal cartilage damage in a varus misaligned knee coupling a high tibial osteotomy with an osteochondral allograft to the medial femoral condyle, along with partial medial and lateral meniscectomy.

Large focal cartilage defects remain a challenging problem, particularly in young, higher-demand patients with coronal or sagittal deformities. For patients with early osteoarthritis or malalignment of the knees causing early arthritis, a high tibial osteotomy (HTO) presents a viable alternative treatment to a joint-sacrificing arthroplasty. Biomechanically, HTO offloads the diseased compartment of the knee by redistributing the weight-bearing forces, which can contribute to slowing the progression of degenerative joint disease and relieving pain.[1,2] In patients with baseline varus malalignment, an HTO can additionally aid in restoring a more sustainable mechanical axis of the knee. It is important to note that the survivorship rate of HTO is greater than 75% at 10 years, and this procedure does not preclude a patient from receiving a total joint arthroplasty later in life.[3-5]

For patients with an associated chondral defect in the diseased compartment, an osteochondral allograft (OCA) transplantation enables a pronged approach to joint preservation. Similarly to HTO, the long-term survivorship rate of OCA has been shown to be greater than 75% at 15 years.[6] By coupling HTO and OCA transplantation, the biomechanics of the knee are optimized to protect the graft and offload the diseased compartment, with the OCA enabling some improvement of the cartilage in a diseased knee.[2] HTO and OCA transplantation have been shown to have good outcomes, both in patients with varus malalignment and in patients with post-traumatic arthritis, in addition to being effective at prolonging the survivorship of a patient's native knee prior to needing a total knee arthroplasty.[2,5]

The purpose of this Technical Note and Video 1 is to present our preferred method of correcting a contained medial femoral condyle cartilage lesion in a young patient with genu varum and meniscal tears by use of an HTO with OCA transplantation to the medial femoral condyle, along with partial medial and lateral meniscectomy. Through correction of the angular deformity and incorporation of cartilage restoration, this massive knee repair technique fosters a favorable mechanical environment to promote biological repair and improve the longevity of the joint.

Surgical Technique

Preoperative Evaluation

The preoperative evaluation should consist of a thorough history and physical examination. Radiographic imaging, including anteroposterior, lateral, and long-leg standing views, should be obtained to assess mechanical alignment and create a template of the desired amount of correction (Fig 1). Magnetic resonance imaging of the knee allows for evaluation of the size and severity of chondral lesions, as well as any concomitant ligamentous, meniscal, or other soft-tissue injuries (Fig 2).

Patient Positioning and Anesthesia

Video 1 provides an overview of the described surgical technique with narration. General endotracheal anesthesia is used for induction, and it may be combined with regional nerve blocks to maximize postoperative pain control. The patient is placed supine on the operative table, and a bump is placed underneath the knee to maintain 30° of resting flexion. A nonsterile tourniquet is placed high on the leg and is set to 300 mg Hg. Pearls and pitfalls associated with this procedure are listed in Table 1.

Meniscectomy and Medial Opening-Wedge Tibial Osteotomy

At case initiation, a routine diagnostic knee arthroscopy is performed to evaluate the meniscal and cartilage morphology. Medial and lateral meniscectomies are performed as indicated.

Next, a medial parapatellar incision is made, with careful consideration to avoid the anterior horn of the medial meniscus, to access the chondral lesion. The incision is extended distally midway between the tibial tubercle and the posteromedial border of the tibia. Z-retractors are used medially and laterally to maximize exposure.

Three guide pins (Arthrex, Naples, FL) are inserted parallel to the joint line, distal to the metaphyseal flare, angled slightly cephalad (Fig 3). These guide pins should approximate the desired post-osteotomy tibial slope. Approximately 1.5 cm of bone between the

articular cartilage and the osteotomy must be maintained to leave sufficient bone for later hardware and minimize the risk of intra-articular fracture. An osteotomy guide is inserted over the guide pins, which creates a template for performing the osteotomy.

An oscillating saw is used to begin the osteotomy on the medial cortex, and osteotomes are used to advance the osteotomy. Fluoroscopic imaging confirms the position and verifies that the integrity of the lateral bony hinge is maintained. A lamina spreader is used to slowly distract the medial cortex to achieve the desired correction, and a lateral fluoroscopic image is taken to assess and confirm the appropriate tibial slope (Fig 4). The surgeon should be sure that the fluoroscopic image is aligned to the joint line (sagittal balance) to ensure that the tibial slope is not changed. Once the desired correction is confirmed, the lateral cortex is again assessed, and if it is damaged, a staple can be placed to prevent fracture propagation.

After accommodation of the lateral cortex, the spreader is removed and 2 calibrated osteotomy tines are advanced into the osteotomy site. The handle of one of the tines is then removed, and an angled wedge plate (Arthrex) is secured along the medial cortex (Fig 5). The plate is affixed using two 4.5-mm bicortical screws distally and two 6.5-mm fully threaded cancellous screws proximally (Fig 6). Once a screw is secured proximally and distally, the remaining tine is removed. Once the plate is fixed to the medial cortex, the knee is placed into hyperextension and an additional angled wedge plate is placed anteriorly to secure the sagittal-plane correction. Opteform allograft (RTI Biologics, Alachua, FL) is inserted into the osteotomy site.

Osteochondral Allograft

Next, attention is turned to the osteochondral lesion. BioUni sizers (Arthrex) are used to determine the coverage of the lesion. An indelible marker is used to outline the sizer and confirm adequate osteochondral tissue quality circumferentially. The sizer used to establish the recipient defect site is placed over the allograft condyle and used to delineate the appropriate donor site. The allograft is outlined with indelible ink with careful consideration of the superior, inferior, medial, and lateral aspects of the donor graft. The allograft is mounted to the workstation using 2.8-mm guide pins.

The oblong cutter inserter is carefully positioned over the allograft, and a 2.8-mm guide pin is drilled through the guide pin hole and advanced through the allograft (Fig 7). The impactor handle is screwed into the oblong cutter, and a mallet is used to drive the cutter into the graft. The distractor tool is inserted into the driver handle and, subsequently, the oblong cutter. The 2.8-mm pin is removed, and the distractor is advanced to remove the oblong cutter.
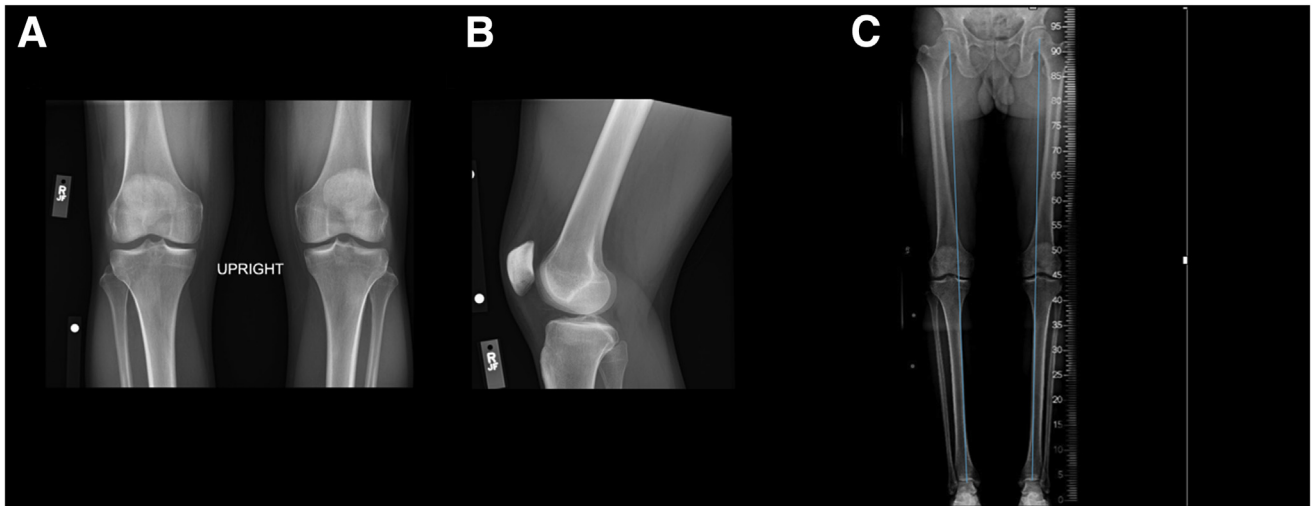
Fig 1. Preoperative radiographic films. (A, B) An anteroposterior weight-bearing view (A) and lateral view (B) of the right (R) knee show joint space narrowing and osteophytic changes (arrow) to the bilateral medial compartments in the setting of genu varum malalignment. (C) A full-length standing anteroposterior view shows bilateral genu varum malalignment.

The saw depth guide is assembled over the sagittal saw guide, and an impactor handle is screwed on. The assembly is placed onto the previously made cut, and the sagittal saw is inserted through the sagittal saw guide and advanced through the condyle to create the base of the graft. The impactor handle and sagittal saw attachments are removed, leaving the donor graft contained within the sagittal saw depth guide. The distractor tool is used to slowly extract the allograft implant. The marks denoting the cardinal coordinates of the graft should still be visible, and the graft undergoes pulse lavage to remove antigenic elements.

Attention is turned back to the chondral defect. A sizer is placed over the previously outlined recipient site, and confirmation is made that the sizer is flush on all sides and covers the defect (Fig 8A). Two 4-mm drill pins are placed into the drill holes. The sizer is removed, and the drill pins are kept in place. A scoring device is placed over the drill pins, and a 2- to 3-mm deep cut in the cartilage is created. An appropriately sized reamer is placed over the top drill pin and advanced until the reamer stops on the depth guide.

The box cutter is advanced over the drill pins until the tabs on the box cutter are abutting cancellous bone. The drill pins are removed, and remaining cartilage is removed with curettes. A dilator is used to dilate the recipient site and confirm the fit. Microfracture is performed in the recipient site with a 2.0-mm guide pin to prepare for graft implantation. The graft is press-fit into the recipient site by hand initially, and a tamp and mallet are used to complete the fit.

Closure and Postoperative Rehabilitation

The patient is placed in a knee immobilizer and is non−weight bearing for 8 weeks postoperatively. A supervised physical therapy program is initiated on
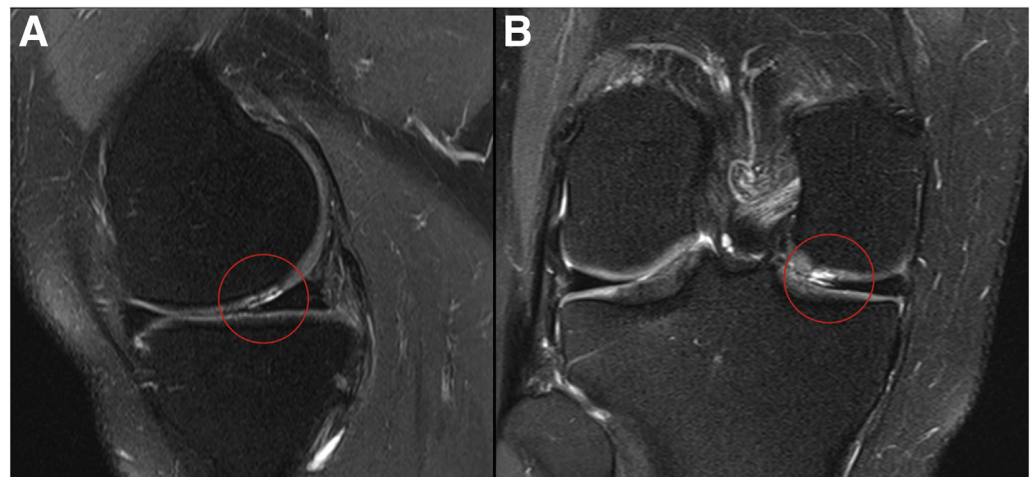

Fig 2. Sagittal (A) and coronal (B) magnetic resonance imaging views of a right knee show a grade 4 osteochondral lesion (circles) of the medial femoral condyle.

Table 1. Pearls and Pitfalls of High Tibial Osteotomy With Concomitant Osteochondral Allograft to Medial Femoral Condyle

Pearls
  Slow progression of the osteotomy should be performed using a lamina spreader, allowing for precise adjustments using intraoperative assessment.
  A large staple should be placed anteriorly to prevent sagittal-plane overcorrection.
  The tibial plate can be bent to allow for proper tibial conformity.
  A guide pin may be used to microfracture the recipient site to create a bleeding surface and maximize healing potential.
  Fluoroscopic imaging should be aligned with the joint line (sagittal balance) to ensure that the tibial slope is not changed.
Pitfalls
  Opening-wedge tibial osteotomy has been known to change the posterior tibial slope.
  Fracture of the lateral tibial cortex can occur.
  Bony consolidation of the opening-wedge osteotomy site can occur.
  Damage to the meniscus is possible during surgical exposure.

postoperative day 1, with particular emphasis on quadriceps activation. Passive range of motion should be limited from 0° to 90° of knee flexion during the first 2 weeks. After 8 weeks, weight bearing is gradually increased based on clinical and radiographic evidence of healing (Fig 9).

Discussion

This Technical Note describes our technique for HTO with concurrent OCA transplantation and partial medial and lateral meniscectomy in the setting of varus malalignment, unipolar focal full-thickness cartilage defects on the medial femoral condyle, and complex degenerative tears of the posterior horn of the medial and lateral menisci. Through correction of the angular deformity and incorporation of cartilage restoration, this massive knee repair technique fosters a favorable mechanical environment to promote biological repair and improve the longevity of the joint.

The combined procedure of HTO and OCA transplantation is a recently developed technique to correct angular deformity and normalize joint forces. Accordingly, there have been few studies investigating the outcomes of these patients. Hsu et al.[3] were the first authors to publish the outcomes of HTO and OCA transplantation in a case series of 17 patients who had significant improvements in functional scores and a mean survival period of 8.1 ± 3.3 years.[2] Recently, another group investigated 39 patients (average age, 36 ± 7.9 years) who underwent opening-wedge HTO and OCA transplantation of medial femoral condyle defects; the authors reported that 96.2% of patients were able to return to work by 3.5 ± 2.9 months and 79.2% were able to return to sport, with 41.7% able to return at the same level of competition postoperatively.[7,8] Together, these studies show the combination of HTO and OCA transplantation to be an effective and safe procedure in younger patients with unicompartmental osteoarthritis. Nonetheless, more studies with larger patient populations and longer-term follow-up are needed to further investigate functional outcomes and elucidate the limits of this procedure.

In the setting of varus malalignment, the medial meniscus is prone to greater contact pressures and extrusion, which has implications on the load distribution within the medial compartment and can eventually lead to accelerated progression of chondral defects, meniscal pathology, and ultimately, arthritis.[9]
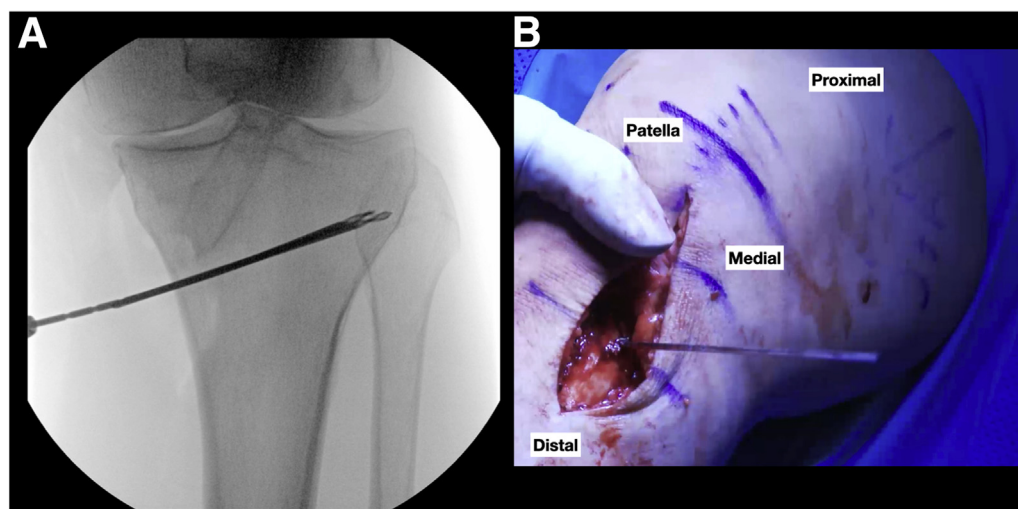

Fig 3. Using fluoroscopic imaging for guidance (A)*, 2 guide pins are inserted through the medial parapatellar incision of the right knee (B) parallel to the joint line of the knee with the patient in the supine position. The trajectory is from distal to the medial metaphyseal flare of the tibia toward the proximal superior-lateral aspect of the tibia at the level of the fibular head. These guide pins should approximate the desired post-osteotomy tibial slope. *Fluoroscopic imaging depicts a left knee and is included for readership reference. This is not the patient's fluoroscopic footage.

Fig 4. After an oscillating saw is used to perform osteotomy, a lamina spreader is inserted through the medial parapatellar incision of the right knee with the patient in the supine position. imaging (A)*, the lamina spreader is slowly opened (B) to the desired alignment correction of the limb using a 3.5-mm hex screwdriver. The degree of correction is planned using a template prior to surgery. *Fluoroscopic imaging depicts a left knee and is included for readership reference. This is not the patient's fluoroscopic footage.
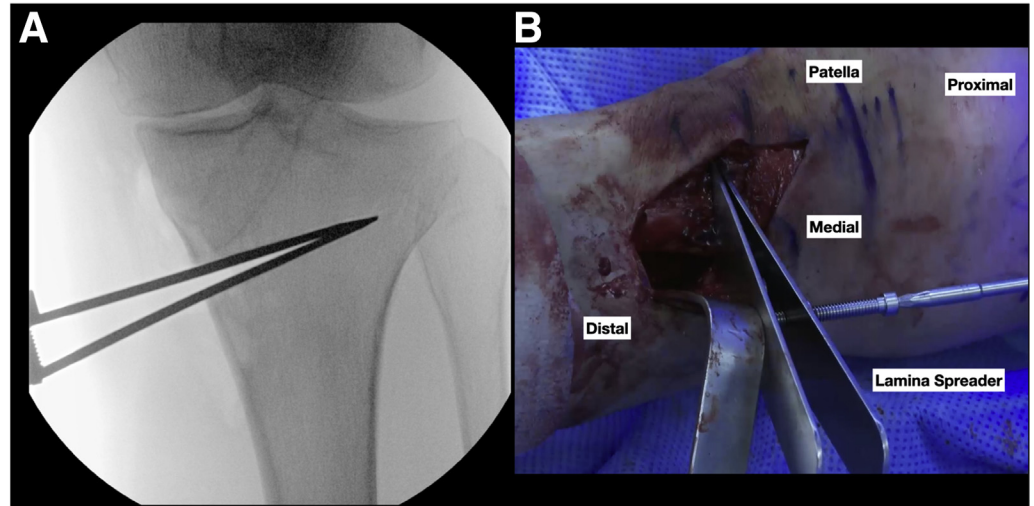

Fig 5. With the patient in the supine position, fixation of the osteotomy (A)* is achieved through placement of an angled wedge plate (B) along the medial cortex (arrow) of the right knee using the medial parapatellar incision. Two calibrated osteotomy tines are used to guide placement of the plate and are removed prior to securing it. *Fluoroscopic imaging depicts a left knee and is included for readership reference. This is not the patient's fluoroscopic footage.
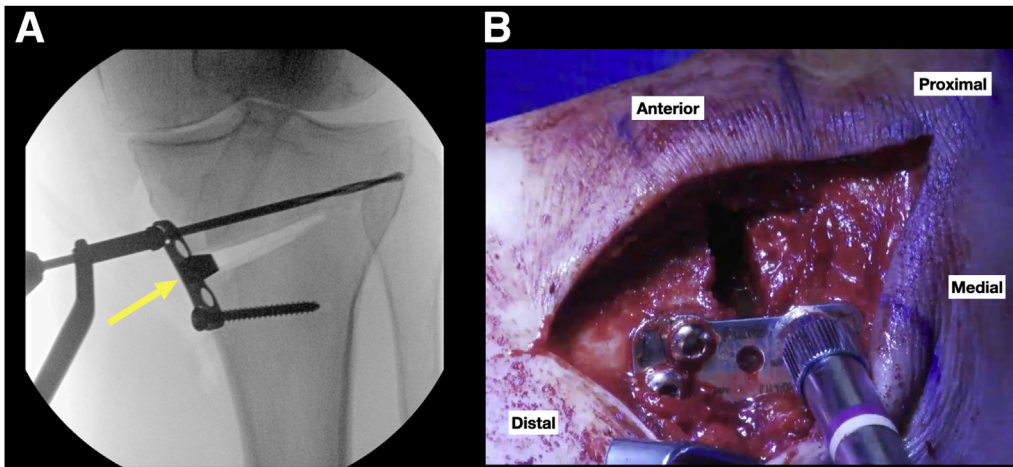

Fig 6. (A) Using the medial parapatellar incision in the right knee with the patient in the supine position, the plate is secured distally with two 4.5-mm cortical screws distally and two 6.5-mm fully threaded cancellous screws proximally. (B)* Fluoroscopic imaging shows secure fixation of the plate to the medial cortex. The lateral tibial cortex should be assessed for damage. *Fluoroscopic imaging depicts a left knee and is included for readership reference. This is not the patient's fluoroscopic footage.
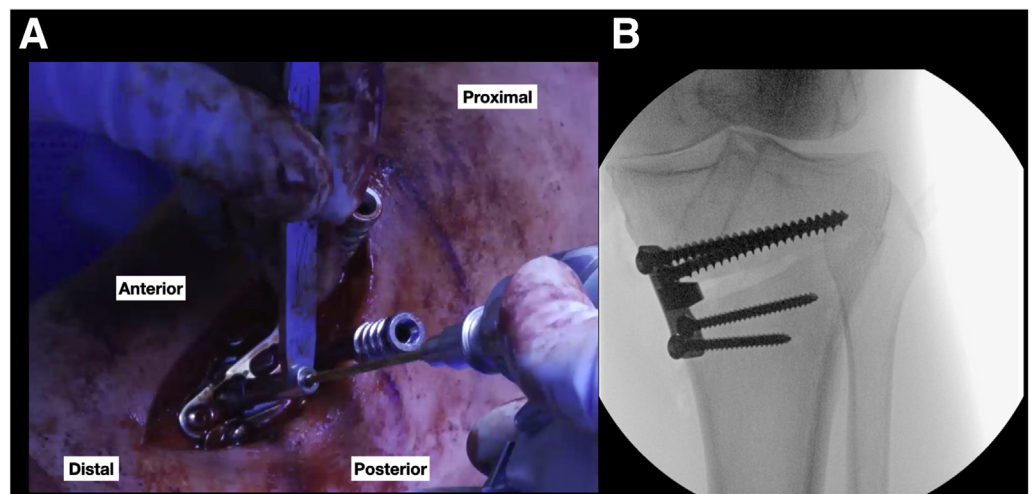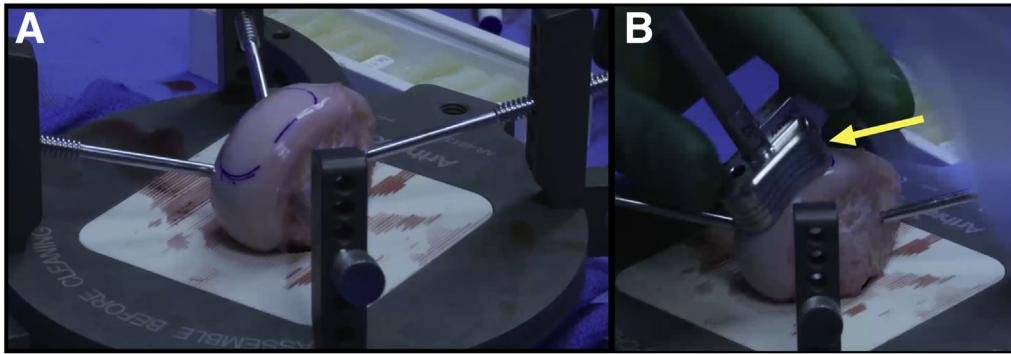
Fig 7. Preparation of the allograft condyle is performed on the allograft workstation. (A) The donor graft is sized and marked based on the dimensions of the recipient defect site. (B) A mallet is used to drive the carefully positioned oblong cutter (arrow) into the graft.

The management of medial meniscal posterior root tears with concomitant HTO is debated. The mechanism of meniscal remodeling remains unclear; however, it is established that HTO allows for decompression and optimization of the local environment for biological repair of meniscal tissue, similar to the mechanism for cartilage repair.[10] Additionally, degenerative meniscal tears have been associated with the osteoarthritic process. Therefore, meniscectomy may be the most appropriate treatment to provide relief of mechanical symptoms through mitigating posterior fallout and impingement.[11] Several studies have evaluated the outcomes of HTO combined with meniscal repair procedures, such as medial meniscal repair or transplantation with allograft or synthetic graft, and found improved meniscal healing rates (categorized as complete vs partial) but no difference in functional outcomes, patient-reported outcomes, or progression in osteoarthritis, based on the Kellgren-Lawrence grade and second-look arthroscopy, compared with unrepaired meniscal lesions with an average follow-up period ranging from 2 to 7 years.[11-15]

The ideal mechanical axis achievable by osteotomy to promote cartilage restoration has not been elucidated. Correction of the knee into slight valgus has previously been advocated when performing autologous chondrocyte implantation (ACI) or OCA transplantation in the medial femoral condyle. Conversely, Ackermann et al.[16] recently found a significantly improved graft 5-year survivorship rate after ACI (92% vs 55%, $P = .003$) and a trend toward improved survivorship of OCA ($P = .272$) in neutrally aligned knees compared with knees with slight valgus. Similarly, Hohloch et al.[17] found that HTO and concomitant ACI in patients with a larger postoperative valgus angle led to higher postoperative pain levels and lower functional outcome
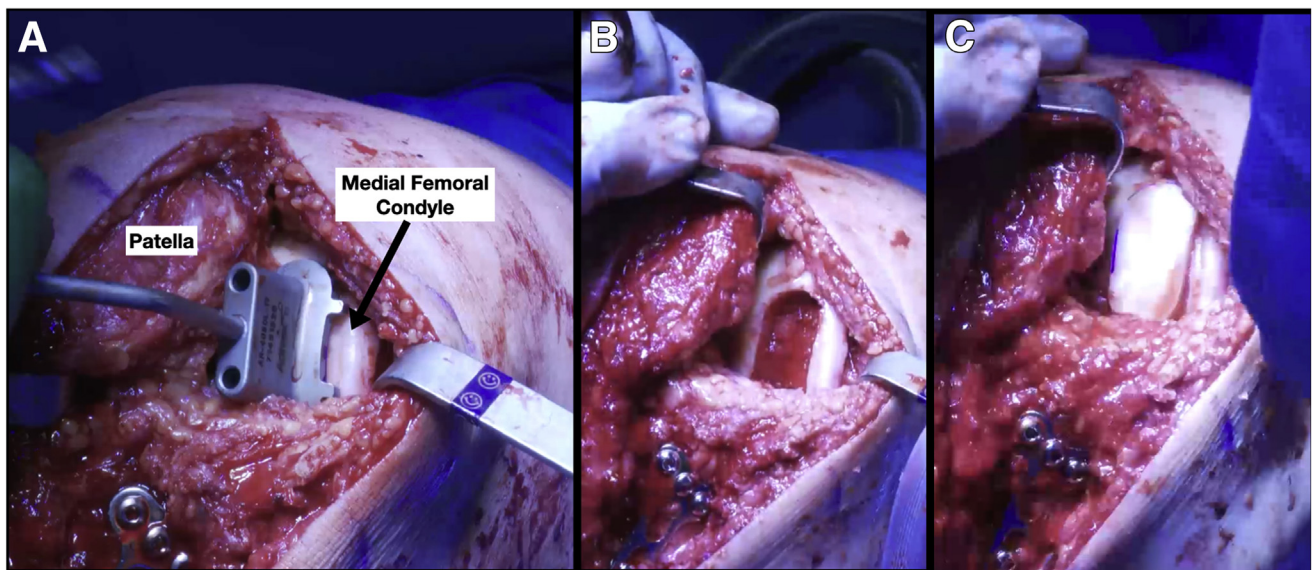

Fig 8. To prepare the recipient site for osteochondral allograft transplantation, the right knee is placed into flexion for good exposure of the distal medial femoral condyle. (A) The sizer is repositioned over the defect on the medial femoral condyle to place 2 drill pins. (B) A scoring device, followed by a box cutter, is used to remove the marked area of cartilage to the level of cancellous bone. (C) The donor allograft is placed into the recipient site and is fitted by hand, then with a tamp and mallet, until secure.

Fig 9. Postoperative anteroposterior and lateral radiographs of a right (R) knee. (A) The anteroposterior view shows a well-fixed plate and screws in the medial cortex with correction of the genu varum malalignment to neural alignment and offloading of the medial compartment. (B) The lateral view shows a well-fixed anterior plate and screws with sagittal-plane correction.
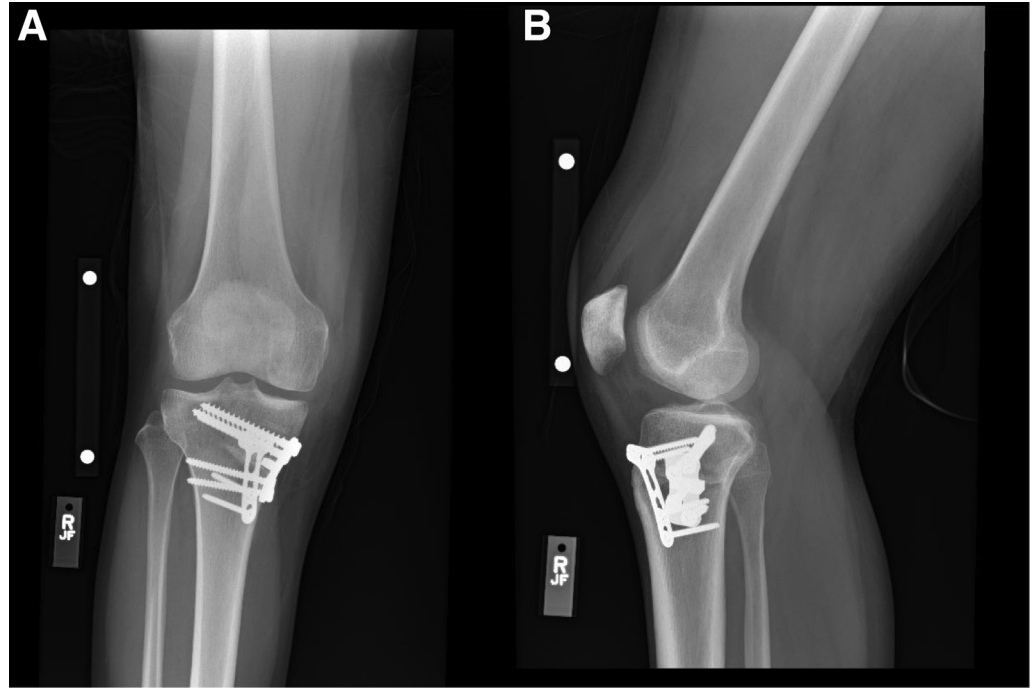
scores. Additional studies are required to determine the optimal mechanical environment to promote cartilage maturation or osseous integration. On the basis of the aforementioned studies, efforts should be made to achieve neutral alignment regardless of the type of graft used. Use of the opening-wedge osteotomy technique is a powerful tool for the surgeon because it allows for correction in both the sagittal plane and coronal plane.

In conclusion, we have presented our technique for an opening-wedge HTO with OCA transplantation to the medial femoral condyle to correct a unipolar cartilage lesion, along with medial and lateral partial meniscectomy. The benefits of this technique include precise multiplanar correction of the deformity, equalization of joint pressure, and optimization of the environment for cartilage repair.

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