Technical Note

Patient-Specific Instrumentation for Medial Closing Wedge Distal Femoral Osteotomy With Patellar Osteochondral Allograft

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Abstract: The primary indications for performing a medial closing wedge distal femoral osteotomy are valgus knee malalignment, lateral knee compartment overload, lateral meniscus insufficiency, and/or lateral compartment osteoarthritis or cartilage damage. Without correction of this malalignment, there is an increased risk for chondral damage in the lateral and patellofemoral compartment of the knee. The optimal candidates for this procedure are young, active individuals with moderate to severe arthritis in the lateral compartment. Recently, preoperative planning for high tibial and distal femoral osteotomies (HTOs and DFOs) using 3-dimensional (3D) patient-specific instrumentation (PSI) has increased in popularity. Successful patient outcomes have been reported using this technique. This Technical Note illustrates our preferred technique that uses 3D PSI in addition to a patellar OCA transplant when treating a symptomatic cartilage lesion associated with genu valgum.

Introduction

Valgus malalignment has been shown to be a risk factor for the progression of osteoarthritis.[1] A medial closing wedge distal femoral osteotomy (DFO) is a procedure that can be considered when a patient has a valgus alignment, and arthritis in the lateral and patellofemoral compartments is present.[2,3,4] An increased quadriceps (Q) angle may occur with valgus malalignment, contributing to patellar lateralization and maltracking.[5,6] A DFO unloads the patellofemoral compartment laterally by medializing the anterior tibial tubercle and reducing the Q angle.[4] A patellar focal chondral lesion may still exist. An osteochondral allograft (OCA) transplantation is a viable treatment option with good outcomes for the chondral lesion.[7-11]

Surgeons may use 3-dimensional, patient-specific instrumentation (3D-PSI) to assist with the DFO. 3D-PSI cutting guides have yielded accurate alignments, while decreasing operative time and intraoperative fluoroscopy during a DFO.[12] Studies have also shown good short-term outcomes and accurate alignment with osteotomies when using 3D-PSI.[13-15] The purpose of this Technical Note is to demonstrate our preferred technique of performing a DFO, using 3D-PSI with a patellar OCA transplant to treat a full-thickness cartilage lesion with subchondral edema.

Surgical Technique

Indications

A combined patellar OCA/DFO is indicated when a patient has symptomatic valgus malalignment and focal subchondral cartilage defects of the medial facet of the patella in the setting of a relatively normal TT-TG distance (≤13 mm). A patient must

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also have failed at least 3-6 months of conservative treatment. Preoperative anteroposterior (AP) long-standing films, computed tomography (CT), and magnetic resonance imaging (MRI) must be obtained if using 3D-PSI (Fig 1).

Patient Setup

Platelet-rich plasma (PRP) is harvested from the patient's peripheral blood, general anesthesia is given, and examination is performed to assess ligamentous stability and range of motion. A tourniquet is placed on the ipsilateral thigh. An adjustable abduction post is applied for diagnostic arthroscopy. The lower extremity is prepped and draped in standard orthopedic fashion. Timeout is performed and intravenous antibiotics are administered prior to incision.

Diagnostic Arthroscopy

A standard diagnostic arthroscopy using anterior-lateral and anterior-medial portals is performed (Video 1). A probe is used to assess the integrity of the anterior cruciate ligament, posterior cruciate ligament, menisci, and cartilage in other compartments. The patellar cartilage lesion is reexamined and sized arthroscopically.

Approach

A 12-cm semi-S curved incision is made using sharp dissection to incorporate both the medial distal femoral and medial parapatellar approach. Electrocautery is used to make full-thickness skin flaps and dissect through the subcutaneous layer. The distal femur is exposed by dissecting through the intermuscular interval between the sartorius and vastus medialis oblique (VMO) (Fig 2). The fascial layer of the VMO is evaluated off the anterior portal of the distal femur subperiostally. For posterior exposure, blunt dissection is used to help make an interval between the distal femoral posterior cortex and the posterior neurovascular structures. A radiolucent retractor (Arthrex, Naples, FL) is placed to help protect posterior

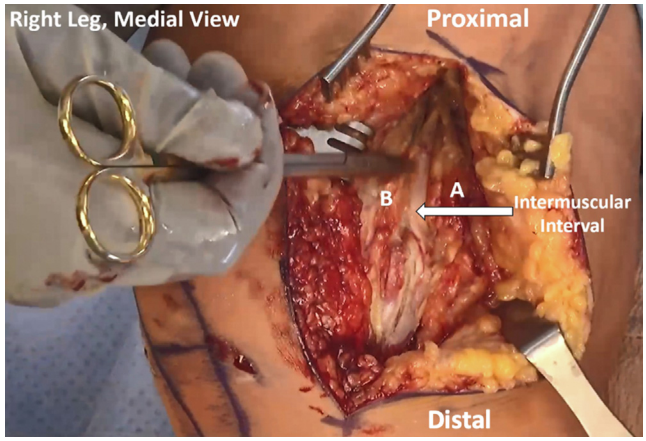

Fig 2. Medial view of the right leg. The approach to expose the distal femur consisted of dissecting through the intermuscular interval between the sartorius (A) and vastus medialis oblique (B).

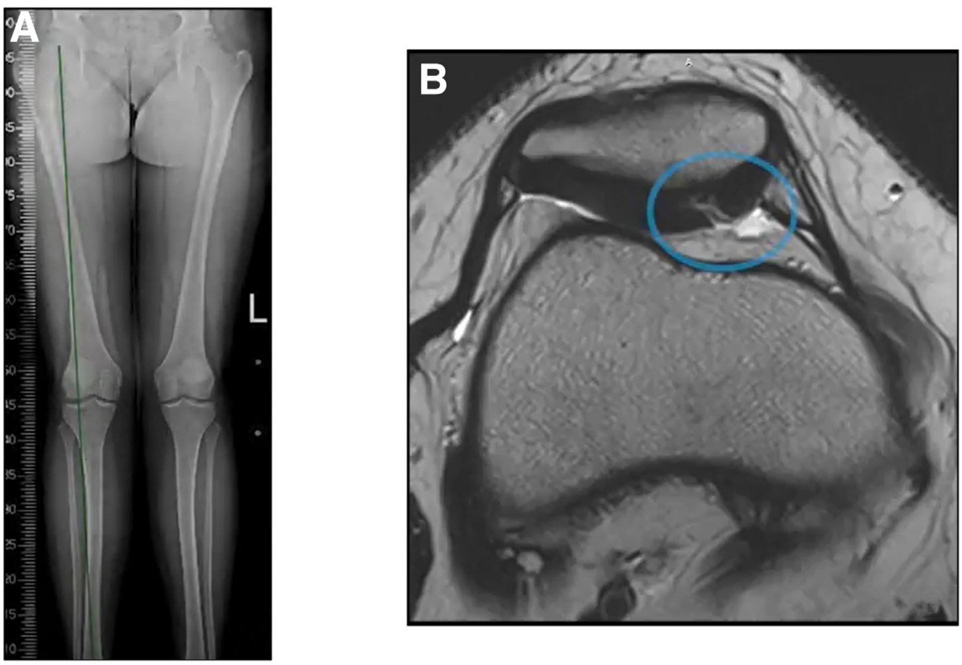

Fig 1. (A) Preoperative full-length alignment films reveal a mechanical axis that is centering on the lateral compartment of the knee. (B) Preoperative magnetic resonance imaging reveals a large chondral fissue along the medial patellar facet.

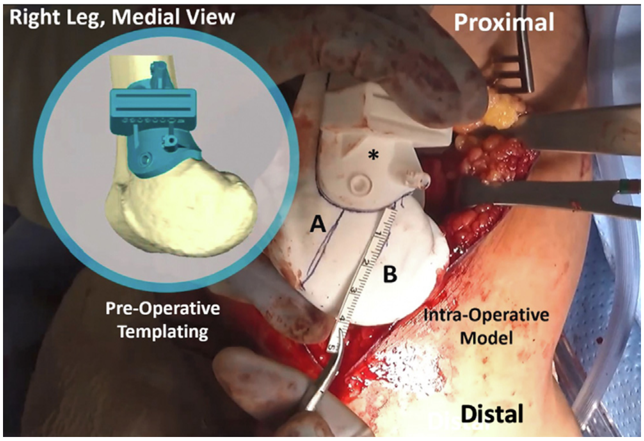

Fig 3. Medial view of the right leg displaying the preoperative templating for the right medial closing distal femoral osteotomy once the distal femur is adequately exposed. The patient-specific three-dimensional (3D) templating is shown with the 3D-printed model of the distal femur, and the intraoperative custom cutting jig (*) is viewed being used intraoperatively. The 3D model is used to measure the distance between the plate and the medial joint line (A and B). Once the measurements are made, the cutting jig can be placed on the distal femur model, and bony landmarks can be used as reference points on the patient and compared to the custom model.

neurovascular structures during the DFO. Care must be taken to avoid disruption of the proximal attachment of the MCL.

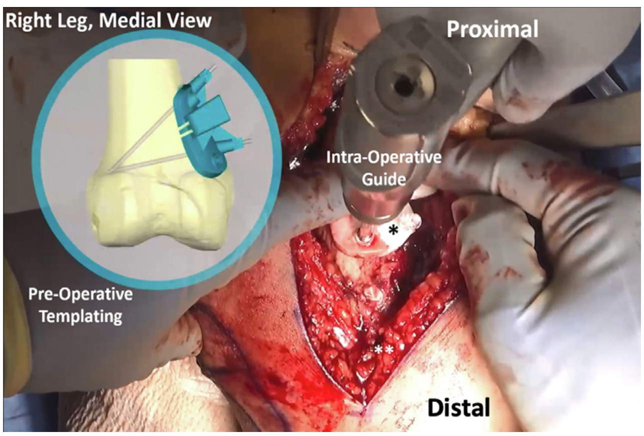

Fig 4. Medial view of the right leg displaying the preoperative templating for the right medial closing distal femoral osteotomy. The patient-specific three-dimensional templating is shown, and the intraoperative custom cutting jig (*) is viewed being used intraoperatively. Once the distance between the plate and the medial joint line is measured, the custom cutting jig is placed on the medial distal femur at this point and secured with converging K-wires to a predetermined lateral hinge distance. To confirm accurate placement, the surgeon compares the intraoperative fluoroscopy to the preoperative template.

Distal Femoral Osteotomy

Using the 3D-patient preoperative template and 3D-printed model, the distance between the plate and the medial joint line is measured (Fig 3). Following adequate exposure, the 3D-patient specific guide is placed using this previously measured distance to the medial joint line and two 2.4-mm K-wires are placed to fixate the guide to the distal femur (Fig 4). The two pins converge toward the lateral cortex, leaving ∼10.2 mm (pretemplated value) for the lateral hinge that was planned preoperatively. Intraoperative fluoroscopy image is obtained to compare to the preoperative template to confirm accurate placement for the 3D-specific osteotomy guide. Unicortical screws are placed through the guide for additional fixation. The varus producing closing wedge osteotomy is made with an oscillating saw (Fig 5, A-C). A 6.2-mm bony wedge is resected (pretemplated value), and the patient-specific guide is subsequently removed (Fig 6). Upon removing the guide, motion of the osteotomy site is assessed while avoiding disrupting the lateral hinge of the osteotomy to prevent destabilization (Table 1). The osteotomy is closed, and the custom drilling guide is placed and secured on the medial cortex. The screw holes are drilled to the appropriate depth, set by the guide, and referenced against preoperatively determined screw type and length (Fig 7, A-C). The 4.5-mm patient-specific distal femoral plate (Bodycad, Quebec, Canada) is placed and position is confirmed with fluoroscopy. A cortical screw is then placed proximally to the osteotomy, and additional locking screws are placed (Fig 8). Intraoperative fluoroscopy is used to assess the osteotomy correction and hardware placement, as predicted by the preoperative template.

Patella Osteochondral Allograft

The incision is extended distally for the medial parapatellar approach. An arthrotomy is performed while being mindful to leave a cuff of tissue on the patella for later repair of the arthrotomy. The patella is everted, and the cartilage defect is identified and sized (Fig 9). The lesion demonstrates a stellate pattern and was 2 × 2 cm in size. Using the appropriately sized centering guide (Arthrex), the surgeon places a guide pin in the center of the lesion using the circular centering guide (Fig 10). Using the cannulated, adjustable counterbore reamer (Arthrex), the lesion is reamed to a depth of 9 mm (Fig 11). The depth of the lesion is then measured at the 12, 3, 6, and 9 o'clock positions for later preparation of the OCA. The bed of the lesion is micofractured with a .045 K-wire to stimulate healing and integration of the later OCA. A dilator (Arthrex) is used to assist with placement of the OCA.

Using the OCA guide (Arthrex), the surgeon carefully sizes and contours the patella allograft to the native anatomy to ensure optimal final fixation. Using the

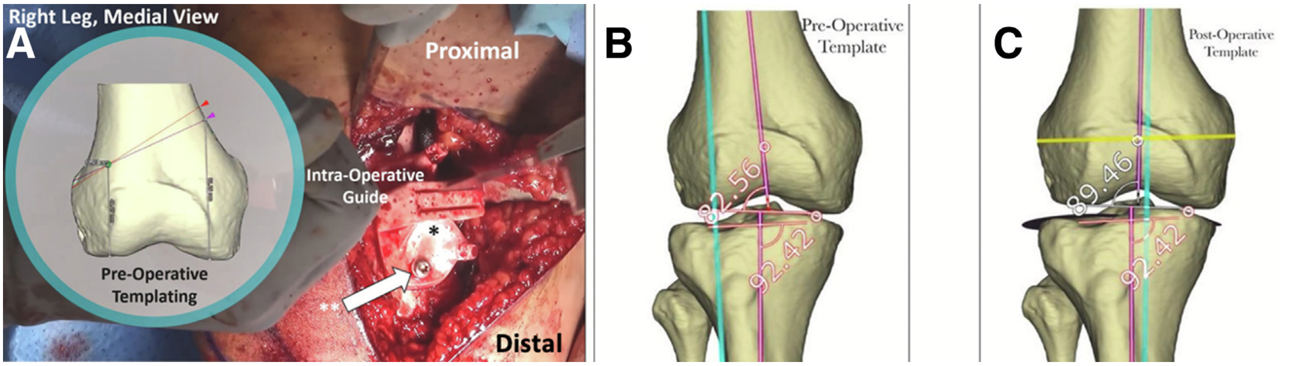

Fig 5. (A) Medial view of the right leg displaying the preoperative templating for the right medial closing distal femoral osteotomy. The patient-specific three-dimensional (3D) templating is shown, and the intraoperative custom cutting jig (*) is viewed as it is used intraoperatively. Once accurate placement of the patient-specific 3D guide is confirmed, unicortical screws (**) are used for additional fixation. Preoperative templating shows preosteotomy mechanical axis (green line) and mechanical lateral distal femoral angle in preoperative state (B) and planned postoperative state (C). The planned osteotomy is visualized (A), with a planned preserved lateral hinge of 10.23 mm. The depth of saw is built into the intraoperative guide.

same sizer guide for the patella lesion, the area of harvest is marked with a skin marker. The 12 o'clock position is marked for later understanding of graft orientation. Following harvest, the depth of the lesion is marked to the premeasured lesion depth at the 12, 3, 6, and 9 o'clock positions. A 10-mm oscillating saw is used to cut the depth of the allograft. After appropriate sizing, the subchondral bone edges are bulletized with a rongeur to optimize graft placement. The graft is irrigated with saline for 10 minutes and soaked with PRP for an additional 10 minutes. The graft is placed in the orientation of the previously marked 12 o'clock position. A lap is placed over the graft, and a tamp is fixated into the native bed of the lesion until complete conquer

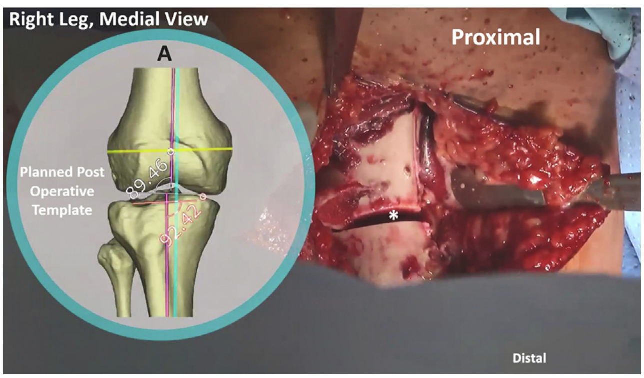

Fig 6. Medial view of the right leg displaying the completed varus-producing closing wedge osteotomy (*). Once the osteotomy is completed with the oscillating saw and the bony wedge is resected, motion of the osteotomy site is assessed while avoiding disrupting the lateral hinge of the osteotomy to prevent destabilization. The planned postoperative template is also shown (A).

of the native cartilage to the OCA cartilage. Two additional 2.5-mm headless compression screws (Arthrex) are placed through the graft (Fig 12). After fixation, the knee is brought through a range of motion to ensure the patella glides through the trochlea without catching. The tourniquet is released, the wound is irrigated, and hemostasis is achieved with electrocautery. The arthrotomy and overlying tissue are closed in a layered fashion.

Postoperative Rehabilitation

The patient is instructed to do toe-touch weight bearing for 6 weeks, limited to 0 to 30° of range of motion for the first 4 weeks, and then advancing to full range of motion. For deep vein thrombosis prophylaxis, the patient is started on Apixaban 2.5 mg twice a day for the first 2 weeks postoperatively and transitioned to

Table 1. Pearls and Pitfalls for our Proposed Technique that Uses 3D PSI in Addition to a Patellar OCA Transplant When Treating a Symptomatic Cartilage Lesion Associated with Genu Valgum

Pearls	Pitfalls
Adequate distal femoral exposure to place the 3D PSI osteotomy guide at the appropriate location	Not adequately exposing the posterior cortex of the distal femur and protecting the neurovascular structures with a retractor while performing the osteotomy
Confirming with intraoperative fluoroscopy appropriate location of the osteotomy guide	Closing the osteotomy guide in a technically controlled manner in order to avoid disturbing the lateral hinge

OCA, osteochondral allograft; PSI, patient-specific instrumentation; 3D, three-dimensional.

Table 2. Advantages and Disadvantages for our Proposed Technique that Uses Three-Dimensional PSI in Addition to a Patellar OCA Transplant When Treating a Symptomatic Cartilage Lesion Associated With Genu Valgum

Advantages	Disadvantages
Utilizing a 3D patient-specific osteotomy system can help to decrease operation time and intraoperative fluoroscopy	Risk of arthrofibrosis with the combined DFO and OCA
Performing the varus producing osteotomy and correcting the alignment helps to alleviate the abnormal mechanical force over the medial facet of the patella.	Risk of delayed healing and/or nonunion
Performing a medial distal femoral closing wedge may decrease the malunion rate and potentially decrease a patient's time for non-weight bearing.	

DFO, distal femoral osteotomies; OCA, osteochondral allograft; PSI, patient-specific instrumentation; 3D, three-dimensional.

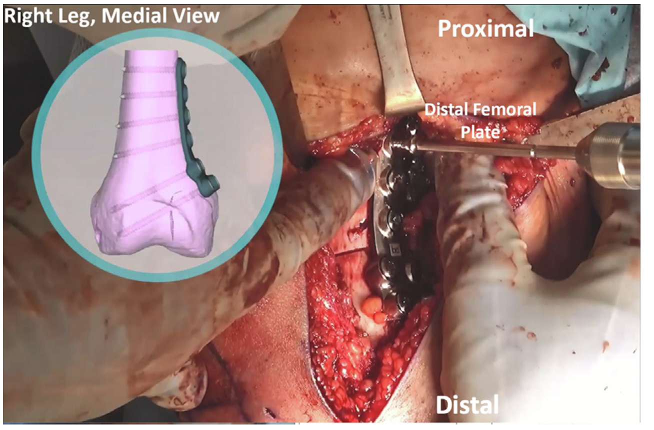

Fig 8. Medial view of the right leg displaying the patient-specific distal femoral plate (Bodycad, Quebec, CA) being placed. Position is first confirmed with fluoroscopy before a cortical screw is placed proximally to the osteotomy, and then additional locking screws are placed. Intraoperative fluoroscopy is then used to assess the osteotomy correction and adequate hardware placement.

aspirin 325 mg daily until full weight bearing. Postoperative imaging was taken immediately and at 6 week follow-up (Fig 13).

Discussion

There is a paucity of research published regarding optimal techniques for varus causing DFOs. Diaz et al. found no significant patient-reported outcome differences between medial closing wedge and lateral opening-wedge DFOs.[16] 3D-PSIs have emerged as an alternative technique to conventional methods due to their ability to mold to patient-specific anatomy and have shown high accuracy and consistency in pathologies.[17-19] Previous systematic reviews have found that 3D-PSIs have accurate coronal plane alignment with decreased operative times and intraoperative fluoroscopy for osteotomies.[12,14] This technique has demonstrated good short-term outcomes

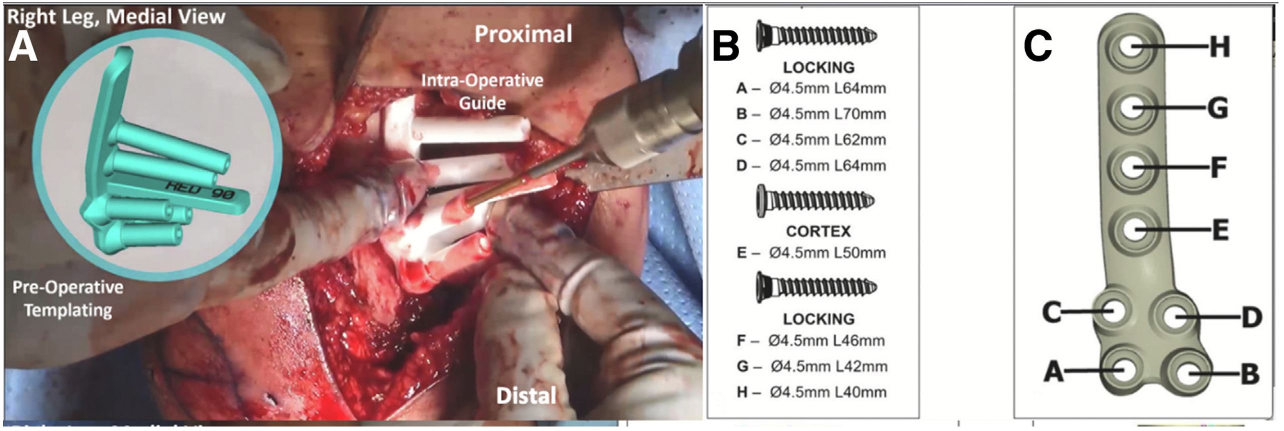

Fig 7. (A) Medial view of the right leg displaying the patient-specific three-dimensional preoperative templating with the intraoperative custom drilling guide, as viewed after completion of the osteotomy. The custom drill guide can be placed on the distal femur model, and bony landmarks can be used as reference points on the patient and compared to the custom model. The drill guide is designed so that the appropriate drilling depth for screw insertion can be built into the guide. Preoperative templating is used to determine screw types and length (B) and can be referenced intraoperatively with templated plate holes (C).

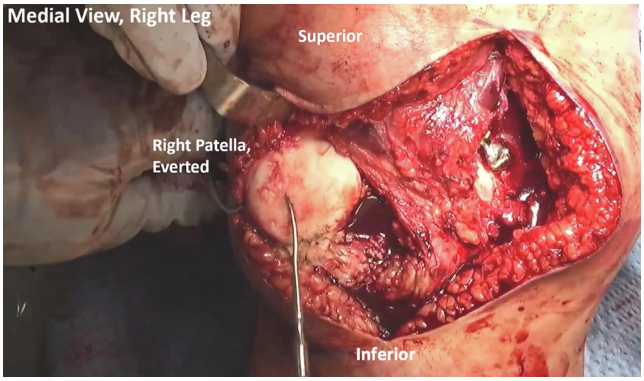

Fig 9. Medial view of the right leg displaying an everted patella. Once the initial incision is extended distally for the medial parapatellar approach, an arthrotomy is performed. Intraoperative evaluation of the patellar chondral lesion can be seen here. There is a 2 cm × 2 cm stellate pattern area of grade 3 chondromalacia with focal, full-thickness fissuring.

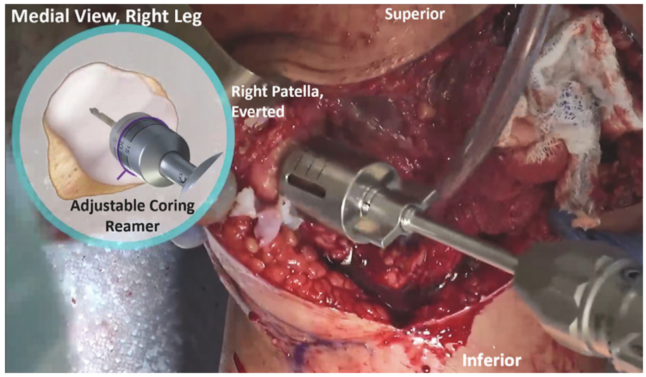

Fig 11. Medial view of the right leg displaying an everted patella. Following the placement of the guidepin and counterbore reamer being set to the appropriate depth for resection, the reamer is used to concentrically ream the patella to the appropriate depth.

postoperatively.[13] In addition, valgus malalignment has been shown to decrease the quadriceps tendon length, thus changing the Q angle and accelerating the onset of osteoarthritis and/or chondral lesions.[20-23] Even after a varus DFO reduces the lateral subluxation of the patella, chondral lesions can still be present. A patellar OCA transplantation has shown good outcomes for these symptomatic chondral lesions (Table 2).[7-9,11]

Valgus knee malalignment without correction increases risk for chondral damage in the lateral and patellofemoral compartments.[1,20] This Technical Note illustrates our technique that uses 3D-PSI and a patellar OCA when treating a symptomatic cartilage lesion associated with genu valgum. Limitations include risk of arthrofibrosis when combining osteotomy and OCA, and delayed healing and nonunion. This technique can help decrease operation time, intraoperative fluoroscopy, malunion rate, and the patient's period of non-weight bearing. Future long-term studies are needed to confirm efficacy and explore complications.

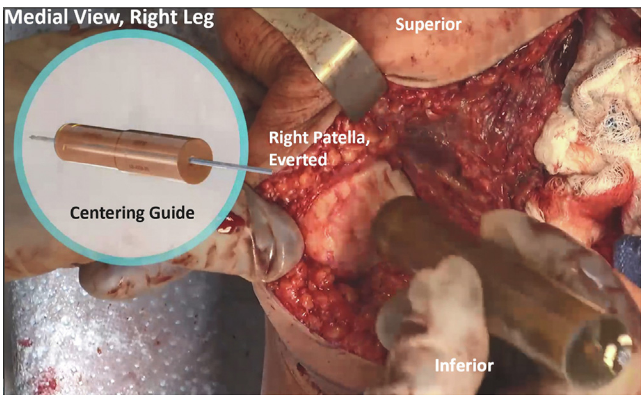

Fig 10. Medial view of the right leg displaying an everted patella. Following intraoperative evaluation of the patellar chondral lesion, the defect is sized, and an appropriately selected centering guide is used to place a guidepin in the center of the defect. The counterbore reamer (Arthrex), is then set to an appropriate depth of resection.

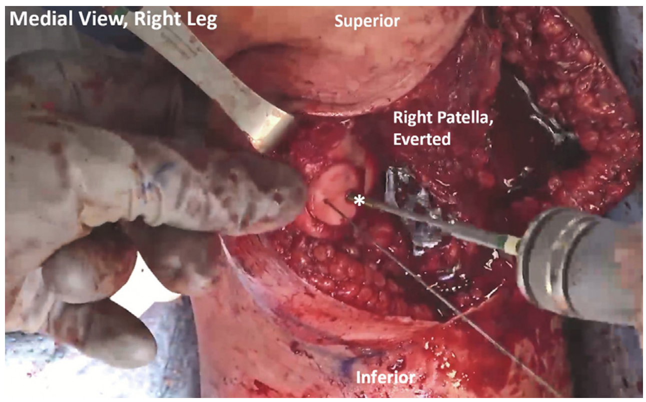

Fig 12. Medial view of the right leg displaying an everted patella. Following the removal of the lesion, the depth is measured at the 12, 3, 6, and 9 o'clock positions. The allograft is prepared in the standard fashion, and the measured lesion depth is used for a 10-mm oscillating saw to cut the depth of the allograft. The subchondral bone edges are bulletized with a rongeur to optimize graft placement. A lap is placed over the graft, and a tamp is fixated to the native bed of the lesion until complete conquer of the native cartilage to the osteochondral allograft cartilage. Two additional 2.5-mm headless compression screws (*) are placed through the graft.

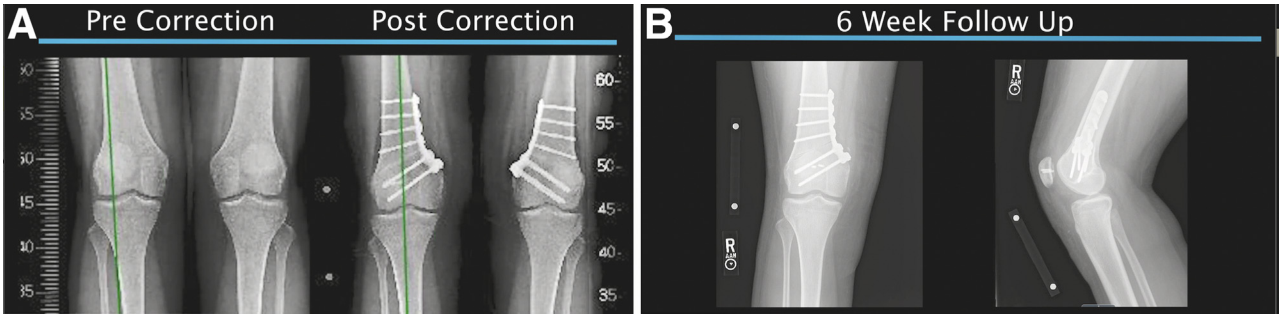

Fig 13. (A) Full-length alignment films are shown zoomed in at the knee joint, comparing precorrection to postcorrection of the right leg. (B) Anteroposterior and lateral radiograph imaging is shown taken at 6 weeks follow-up of the right knee.

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