Combined Particulated Juvenile Cartilage Allograft Transplantation and Medial Patellofemoral Ligament Reconstruction for Symptomatic Chondral Defects in the Setting of Recurrent Patellar Instability

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Abstract: Successful management of patellar osteochondral lesions has proved difficult, with unreliable outcomes reported using traditional cartilage repair and restoration procedures. Unique considerations for this type of defect include the multiplanar contours of the articular surface of the patella, high compressive and shear forces with knee range of motion that may disrupt graft healing, and the potential need for concomitant surgery to address patellar malalignment and instability. We describe our preferred method for treatment of a symptomatic chondral defect in the setting of recurrent patellar instability using particulated juvenile articular cartilage allograft transplantation and medial patellofemoral ligament reconstruction with semitendinosus allograft. Distinct advantages of this cartilage restoration technique include single-stage restoration of relevant cartilage pathology and the ability to easily contour the graft to the size and shape of the chondral defect.

Articular cartilage defects of the knee are a significant source of pain and disability. Studies have estimated that up to 100,000 articular cartilage procedures are performed each year in the United States.[1] Although numerous techniques have been developed to address cartilage defects, no technique has been proved to be clearly superior and without limitations, which has encouraged research to develop methods for replacing and regenerating cartilage with both endogenous and exogenous sources. Particulated juvenile articular cartilage (PJAC) allograft is one such emerging technology that is now in clinical use under the proprietary name of DeNovo NT (Zimmer, Warsaw, IN). The principle behind its form and function is that mechanical mincing of juvenile cartilage harvested from young donors (aged 0 to 13 years) into small 1-mm^3 pieces allows successful infiltration of nascent chondrocytes into chondral defects to form a hyaline-like matrix.[2] The proposed advantages of this type of allograft source include favorable gene expression and metabolic profiles compared with adult chondrocytes, availability as a fresh graft for a single-stage operative procedure, and the ability to easily contour to the size and shape of the chondral defect.[1]

Despite encouraging in vitro data[2] and the use of PJAC allograft in over 8,000 surgical procedures in the shoulder, knee, and talus since it became available in 2007, prospective clinical data on PJAC allograft have been limited.[1,3,4] Although indicated for the treatment of symptomatic chondral defects in both tibiofemoral and patellofemoral compartments, PJAC allograft may be particularly suitable for patellar defects where the ability to restore a complex defect with multiplanar contours in a single-stage procedure may be preferable to alternative procedures such as osteochondral autograft transplantation (OATS) or autologous chondrocyte implantation. We describe combined PJAC allograft transplantation and medial patellofemoral ligament (MPFL) reconstruction for a patient with a

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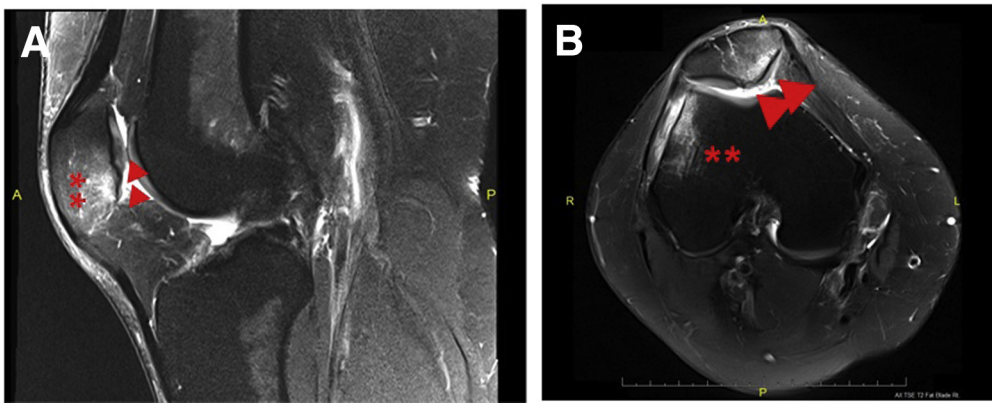

Fig 1. Preoperative magnetic resonance imaging in the illustrated case shows a full-thickness chondral defect of the medial patellar facet (arrowheads) on the sagittal (A) and axial (B) views with visible edema of the inferomedial patella and condyle (asterisks) indicative of recent dislocation.

symptomatic chondral defect in the setting of recurrent patellar instability.

Technique

Diagnostic Arthroscopy and Chondroplasty

The patient is positioned supine on the table with a post secured at the level of the upper thigh on the operative side. A combination of general and regional anesthesia (adductor canal block) is used for postoperative pain control. In this case, preoperative magnetic resonance imaging showed an 18 × 20—mm grade 4 chondral lesion involving the inferomedial patellar facet (Fig 1). To begin, a diagnostic arthroscopy using a standard 30° arthroscope through the anterolateral and anteromedial portals is always performed to investigate for concomitant pathology and lesion characteristics that would preclude the use of DeNovo NT allograft (Video 1). Using these standard portals, we confirm the lesion location and characteristics (Fig 2A), and a No. 4-5 shaver is used to perform a chondroplasty (Fig 2B). The lesion is further inspected to ensure there is no significant bone loss, which would be a relative contraindication for the use of DeNovo NT (Table 1).

DeNovo NT Allograft Transplantation

After confirmation of the lesion characteristics, we move forward with open surgical reconstruction (Video 1). An 8-cm incision is made along the anterior knee, and a medial parapatellar arthrotomy is performed. The patella is everted with the aid of traction sutures, and the chondral defect is identified and prepared using standard principles of cell-based cartilage procedures. The edges of the defect are sharply delineated with a No. 15 scalpel to create stable vertical margins (Fig 3A). The base of the defect is carefully debrided with ring curettes to completely remove the calcified cartilage layer without violating the subchondral bone (Fig 3B). We recommend not using the tourniquet during this part of the procedure to ensure there is no significant bleeding at the base of the lesion. If significant bleeding is encountered during this aspect of the procedure, it can be controlled with an epinephrine-soaked gauze pad and manual pressure applied to the area. We prefer to apply the DeNovo NT graft directly to the defect for appropriate

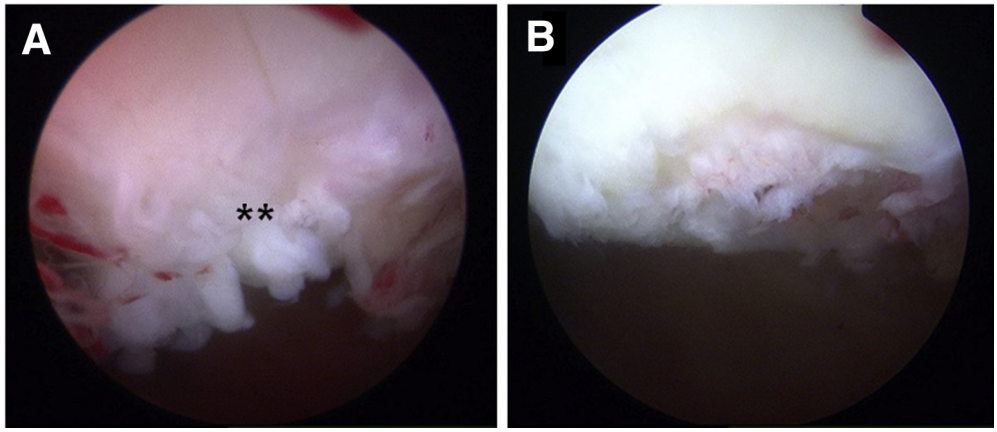

Fig 2. (A) Diagnostic arthroscopy through standard viewing portals shows a chondral lesion (asterisks) on the inferior aspect of the medial facet of the patella. (B) By use of a No. 4-5 shaver, a chondroplasty is performed with thorough debridement before open surgical reconstruction.

Table 1. Indications, Advantages, Risks, and Limitations of Combined PJAC Allograft and MPFL Reconstruction for Symptomatic Patellar Chondral Defect With Patellofemoral Instability

Indications
Symptomatic chondral lesion (ICRS grade 3 or higher) with MRI findings
Isolated lesion of patella
Recurrent patellofemoral instability with or without MRI findings of MPFL disruption
Lesion size <5 cm
Patient age <55 yr
BMI <35
Contraindications
Active or recent infection in affected knee
Extensive subchondral bone edema or bone loss >6 mm
Uncorrected ligamentous instability
Bipolar lesions
Evidence of diffuse patellofemoral chondral wear or osteoarthritis
Advantages
Cartilage restoration can be performed in a single-stage procedure.
The procedure can be combined with other stabilization procedures (e.g., tibial tubercle osteotomy).
The construct can be molded to the shape and size of the defect ad hoc.
Risks
Mild graft hypertrophy
Patellar fracture (1%-3%)
Loss of knee range of motion, possibly necessitating manipulation under anesthesia (3%-5%)
Recurrent instability (5%-28%)
Infection (1%)
Iatrogenic saphenous nerve injury
Limitations
Limited long-term clinical data on use of PJAC allograft for patellar chondral defects

BMI, body mass index; ICRS, International Cartilage Repair Society; MPFL, medial patellofemoral ligament; MRI, magnetic resonance imaging; PJAC, particulated juvenile articular cartilage.

surface contouring. To do this, it is important to be able to maximally evert the patella and position the base of the defect as close to horizontal as possible. If adequate patellar eversion is not possible for graft application with the standard parapatellar exposure, external rotation at the hip can be used to achieve a more horizontal position of the patella.

After the DeNovo NT graft package is opened, the excess medium is removed with an 18-gauge needle or angiocatheter and the plastic package is cut at the corners to create a funnel-shaped delivery container. Each package contains sufficient graft quantity to treat a 2.5-cm^2 defect, and additional packages should be obtained based on preoperative planning. The fibrin glue is added to the minced cartilage pieces, and a freer elevator is used to directly apply the graft-glue mixture to the defect. The mixture is distributed across the defect with the elevator to create an even monolayer scaffold (Fig 3C). It is important to ensure the graft is not proud to avoid graft hypertrophy and excessive shear loads that may compromise stability (Table 2). The scaffold is allowed to set for 5 to 10 minutes, and stability is checked under direct visualization (Fig 3D).

MPFL Reconstruction Using Semitendinosus Allograft

The upper half of the medial patella is exposed and debrided to facilitate subsequent graft healing (Video 1). Two 3.0-mm PEEK (polyether ether ketone) SutureTak suture anchors (Arthrex, Naples, FL) are then inserted (Fig 4A). The inferior anchor is placed at the patellar equator, and the superior anchor is placed 10 mm proximally. The semitendinosus allograft (>26 cm) is folded in half, and the looped end is secured to the patella with FiberWire suture (Arthrex) (Fig 4B). Next, the capsular layer is identified and isolated to create access for extracapsular graft passage and ensure the final graft construct lies above the capsular layer (Fig 4C). This space lies between anatomic layers 2 and 3 of the medial knee.

A small 3- to 4-cm longitudinal incision is centered over the medial epicondyle, and blunt dissection is used to expose the deep fascia. The "saddle" between the adductor tubercle and medial epicondyle is palpated and exposed by electrocautery (Fig 4D). A 2.4-mm Beath pin is provisionally placed at this location and checked with fluoroscopy to ensure it lies near the radiographic parameters of the Schottle's point (Fig 4E). The guide pin is drilled through the lateral femoral condyle, aiming anterosuperiorly (Fig 4F). The limbs of the graft are then passed between layers 2 and 3 and subsequently wrapped around the guide pin (Fig 5A). The knee is brought through a gentle range of motion to check isometry (Video 1). The limbs should become lax with increasing knee flexion and minimally change or only slightly tighten with terminal knee extension. After confirmation of appropriate femoral tunnel placement, the graft is marked at the point of attachment around the guide pin. A second mark approximately 25 mm distal to the first one is created, and all the excess graft is trimmed beyond this point. The 2 limbs are then secured to each other with a No. 2 FiberLoop suture (Arthrex) (Fig 5B). The graft diameter is measured, and an appropriately sized low-profile reamer is used to over-ream the guide pin to a depth of at least 30 mm to ensure the graft does not bottom out during graft passage. The graft is tunneled between layers 2 and 3 once again, and the sutures are secured to the guide pin to pass them laterally through the femur. With the graft secured in the femoral tunnel, tension is applied by the lateral passing sutures, and an appropriately sized Bio-Interference Screw (Arthrex) is inserted over a nitinol wire with the knee at 45° of flexion (Fig 5C). The tension is checked, and the graft is once again inspected before wound closure in layers (Fig 5D).

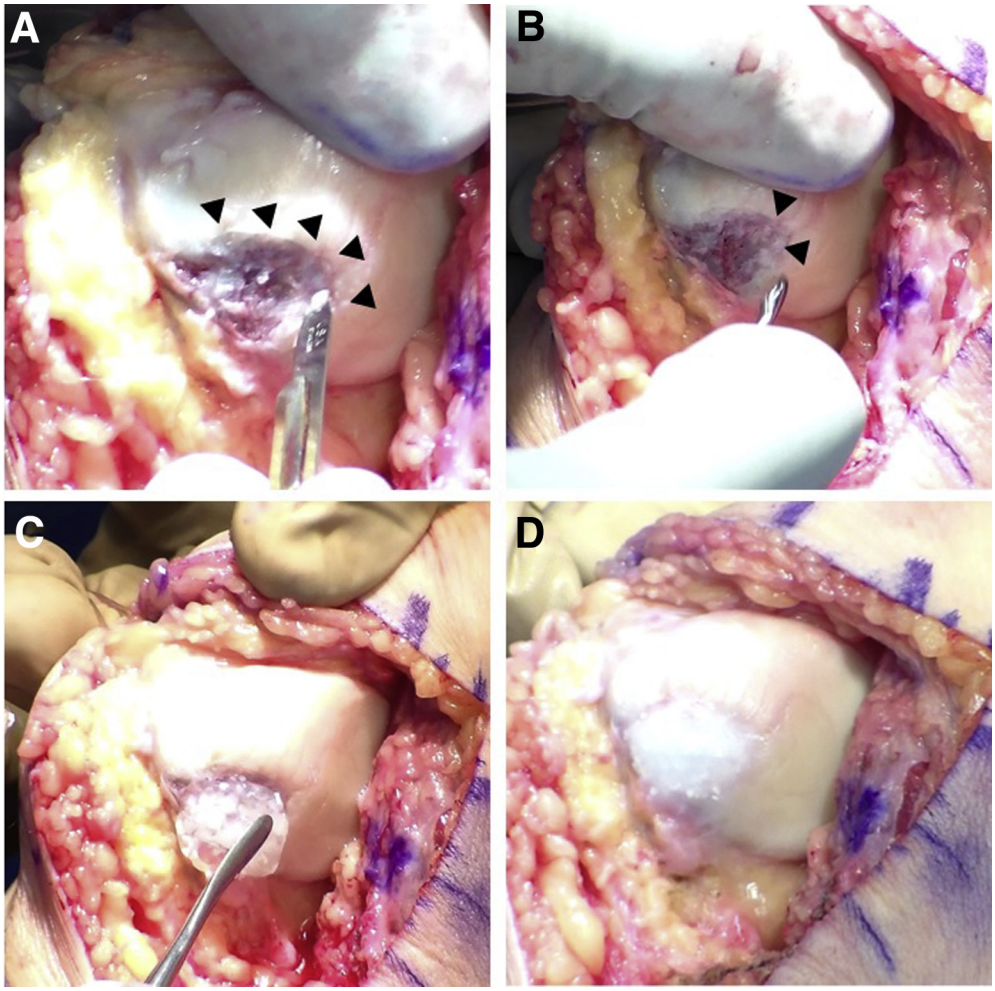

Fig 3. (A) After exposure by a medial parapatellar arthrotomy and eversion with traction sutures, the chondral defect is visible and a No. 15 scalpel is used to define the edge and leave an intact border of healthy cartilage with stable margins (arrowheads). (B) A curette is then used to remove the underlying calcified cartilage layer (arrowheads). (C) After creation of the fibrin glue and particulated juvenile articular cartilage allograft mixture in its package, it is applied directly to the defect to create an even monolayer scaffold without proud edges. (D) The construct is allowed to dry for 5 to 10 minutes.

Discussion

In general, chondral lesions of the patella have proved difficult to treat using traditional cartilage restoration procedures because the unique anatomy and biomechanics pose special challenges. Whereas OATS and fresh osteochondral allografts can be used for large symptomatic defects, these methods are technically challenging when applied to the patella because of the limited ability to match the size of the graft to the native contour of the articular surface. Specifically, OATS may not be an optimal method for patellar lesions given the differential thickness between donor plugs and the recipient patellar cartilage, which is significantly thicker than other areas of the knee. Ultimately, it is this mismatch that may compromise clinical outcomes.[5] The use of autologous chondrocyte implantation in the patella remains off label despite promising results from large-scale studies that have shown a high rate of good to excellent outcomes; however, this technique necessitates a minimum of 2 procedures. The transplantation of particulated juvenile cartilage allograft appears to be a promising treatment option for patients with symptomatic cartilage lesions. Distinct advantages of this technique include the fact that it is a single-stage procedure with no donor-site morbidity (Table 1). For chondral defects of the patella, we have observed that the unique graft form (small minced pieces) and delivery application facilitate even monolayer graft application to precisely restore the complex chondral surface.

Table 2. Pearls of Combined PJAC Allograft and MPFL Reconstruction

Perform a thorough diagnostic arthroscopy to evaluate for concomitant pathology or subchondral bone loss.
Completely debride the calcified cartilage layer before PJAC allograft implantation.
Avoid using the tourniquet during PJAC allograft implantation to ensure there is no significant bleeding at the base of the lesion.
Bear in mind that each DeNovo NT package contains sufficient graft quantity to treat a 2.5-cm^2 defect; plan accordingly to obtain additional packages based on the defect size.
Ensure that the applied mixture is not proud to avoid graft hypertrophy.

MPFL, medial patellofemoral ligament; PJAC, particulated juvenile articular cartilage.

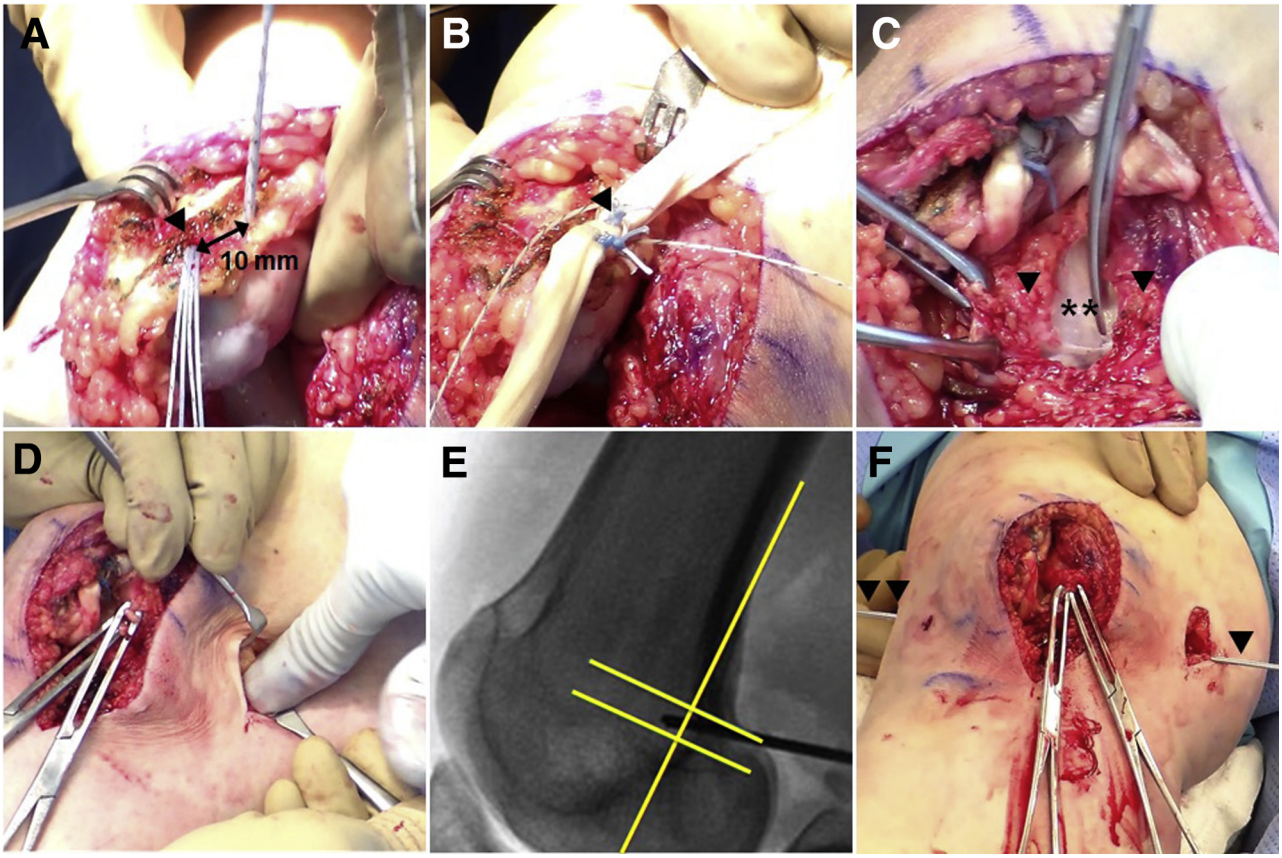

Fig 4. (A) After exposure and debridement of the upper half of the medial patella, two 3.0-mm PEEK SutureTak suture anchors (Arthrex) are inserted with the inferior anchor at the patellar equator (arrowhead) and the superior anchor 10 mm proximal. (B) The semitendinosus allograft is folded in half, and its looped end is secured with FiberWire suture (arrowhead). (C) After security is checked, the capsular layer between layers 2 and 3 (arrowheads) of the medial knee (asterisks) is dissected for graft passage. (D) The saddle between the adductor tubercle and medial epicondyle is exposed, palpated, and marked with a Beath pin. (E) Intraoperative fluoroscopy verifies the pin's position near the radiographic parameters of the Schottle's point (yellow lines). (F) The pin is then drilled (arrowheads) anterosuperiorly through the lateral femur.

In the past few years, there have been 2 series reporting on outcomes after the use of PJAC allograft for the treatment of patellar chondral defects.[6,7] In their case series of 13 patients (15 knees), Tompkins et al.[6] reported that 73% of patients had normal or nearly normal cartilage repair on magnetic resonance imaging with mean defect coverage of 89% after PJAC grafting for grade 4 patellar chondral lesions (mean size, 2.4 cm^2). On average, they reported good to excellent functional outcome scores at a mean follow-up of 28.8 months, although no baseline scores were reported for comparison. The most common complications were symptomatic graft hypertrophy in 2 patients and incomplete defect filling in another patient. In 2014 Buckwalter et al.[7] reported significant improvement in the global Knee Injury and Osteoarthritis Outcome Score of 13 patients undergoing PJAC grafting for high-grade chondral defects of the patella (mean size, 2.3 cm^2). It should be noted that 6 of the 13 patients underwent a concomitant Fulkerson osteotomy to unload the lesion. Although their series averaged only 8 months of follow-up, Buckwalter et al. reported no complications related to the PJAC allograft.

Chondral damage after patellofemoral dislocation has been reported in up to 95% of first-time dislocations, with the central and medial areas most commonly affected. Progressive cartilage damage may result from altered joint loading caused by persistent instability and pre-existing anatomic abnormalities.[8] Currently, data investigating the use of PJAC allograft for cartilage restoration in the setting of patellar stabilization are lacking; however, the aforementioned studies do lend support to the use of PJAC allograft as a viable treatment option with distinct advantages for patients with focal chondral defects of the patella. We have used this technique in a pilot cohort of 8 patients with symptoms of pain and instability in the setting of recurrent patellar instability solely attributed to ligamentous (MPFL) deficiency (i.e., normal tibial tubercle−trochlear groove distance and patellar height). Future studies investigating outcomes of PJAC allograft in the setting of

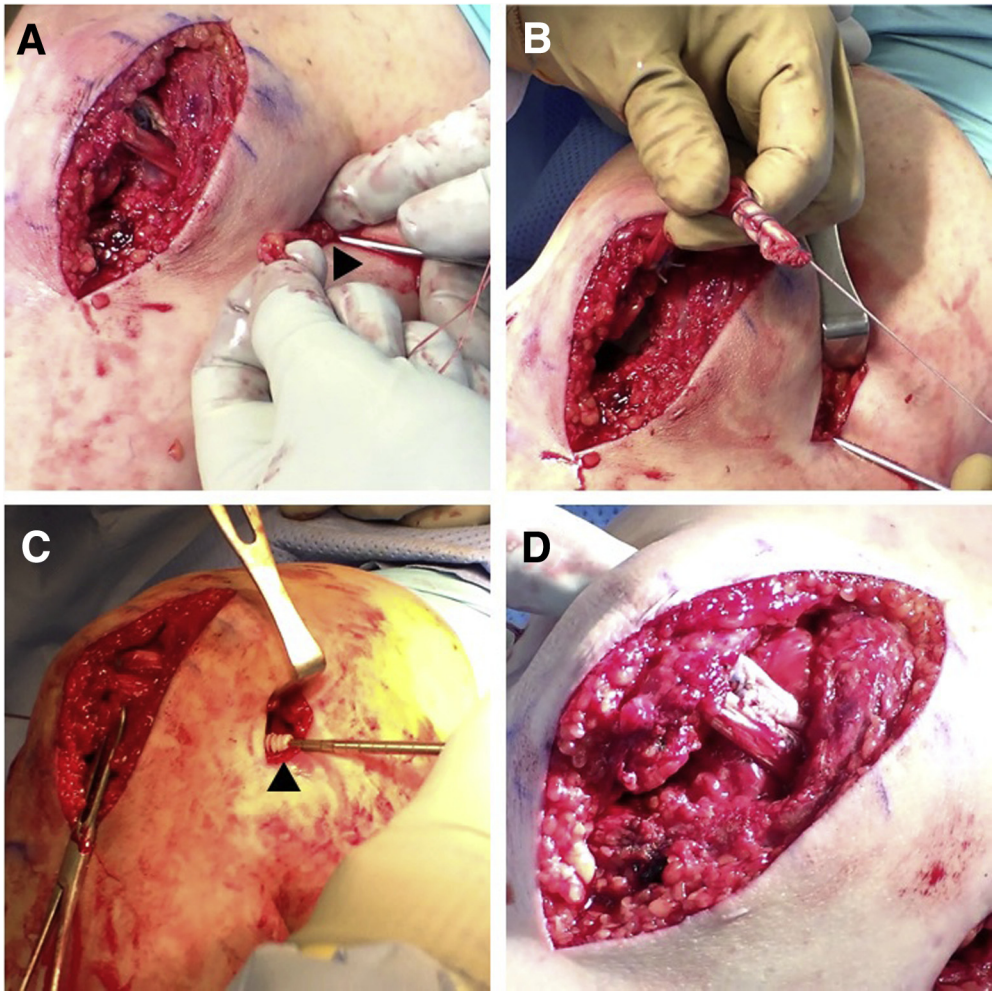

Fig 5. (A) After guide pin placement (arrowhead), graft limbs are passed and wrapped around the guide pin and knee range of motion is assessed for isometry. (B) The graft limbs are then secured to each other using No. 2 FiberLoop suture (Arthrex), and excess graft is trimmed. (C) After the guide pin is reamed to 30 mm and the graft is passed laterally, it is secured in place using a 7 × 23—mm bioabsorbable interference screw (Arthrex) (arrowhead) over a nitinol wire at 45° of knee flexion. (D) Graft tension is assessed in the final construct before closure.

MPFL reconstruction are warranted to establish treatment guidelines.

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