

Revision Anterior Cruciate Ligament Reconstruction in Combination With Meniscal and Osteochondral Allograft Transplantation for Complex Knee Injury



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Abstract: Revision anterior cruciate ligament reconstruction (ACLR) may present a challenge as a result of several factors, including malpositioned bone tunnels, tunnel osteolysis, and the presence of previous hardware. In addition, concomitant pathology, specifically meniscal and cartilaginous injuries, may be present and should be addressed to minimize the risk of re-rupture. Revision ACLR and treatment of accompanying injuries can be performed either as a 1-stage or 2-stage procedure, yet the latter may increase surgical risk for the patient and extend recovery time. The over-the-top technique serves as a good option for revision ACLR and can be performed with careful consideration of patient-specific anatomy and with proper surgical planning. Therefore, this Technical Note aims to present our 1-stage surgical technique for revision ACLR using over-the-top technique with an Achilles tendon allograft, along with concomitant treatment for meniscal deficiency and a medial femoral condyle chondral defect using meniscal and osteochondral allografts, respectively.

The main goal of anterior cruciate ligament reconstruction (ACLR) is to restore knee stability, leading to favorable results in up to 90% of patients.^{1,2} In the case of ACLR failure, revision ACLR may represent a challenge for even the most experienced orthopaedic surgeon as a result of a myriad of issues, including malpositioned femoral and tibial tunnels, tunnel osteolysis, and the presence of previous hardware.^{3,4} In addition, concomitant pathology, specifically meniscal

and cartilaginous injuries, is crucial to address to confer the greatest stability and minimize the risk of re-rupture.⁵ Meniscal and articular cartilaginous injuries can further contribute to knee instability, rapid osteoarthritis development, and poor clinical outcomes.^{6,7} Previous literature has demonstrated that meniscal deficiency decreases the stability of the knee, subsequently increasing the risk of secondary ACLR failure.^{8,9} Meniscal allograft transplantation (MAT) is a well-studied procedure that has produced reliably positive results¹⁰⁻¹³; however, the restoration of the biomechanical function of the knee (via concomitant ligamentous reconstruction) is recommended to promote allograft durability.¹⁴

Revision ACLR and treatment of concomitant injuries can be performed either as a 1-stage or 2-stage procedure, yet the latter may increase surgical risk for the patient and extend recovery time.¹⁵ The over-the-top technique (OTT)¹⁶ bypasses some of the challenges encountered in the ACL revision setting, such as the need for hardware removal, malpositioned tunnels, and tunnel osteolysis. The OTT is a good option for revision ACLR and can be performed with careful consideration of patient-specific anatomy and with proper surgical planning.¹⁷ The aim of this Technical Note is to present our 1-stage technique for

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revision ACLR using OTT with an Achilles tendon allograft, along with simultaneous treatment for medial meniscal deficiency and a chondral defect of the medial femoral condyle using MAT and osteochondral allograft (OCA), respectively.

Surgical Technique

Video 1 shows our surgical technique.

Positioning and Intraoperative Examination

The patient is placed in the supine position (**Fig 1**). After induction of anesthesia, the operative knee is prepped and draped in a standard sterile fashion. Before making a skin incision, the knee is examined with both the Lachman and pivot shift tests for evaluation of anteroposterior and rotational knee stability.

Anterior Cruciate Ligament Reconstruction

After establishing a standard anterolateral arthroscopic portal, a 2-inch anteromedial skin incision is made along the planned arthrotomy incision, sharp to skin and subcutaneous tissues, followed by the elevation of soft-tissue flaps. A 1.5-inch additional superolateral incision is made proximal to the lateral epicondyle, centered over the posterior iliotibial band.

After accessing the knee joint through both incisions, a suture is passed with curved Kelly forceps through the notch, and the lateral wall of the lateral condyle is decorticated for the over-the-top graft location. Subsequently, the ACL tibial tunnel is prepared with a width of 9 mm and dilated to 10 mm in the anatomic footprint (**Fig 2**). The suture that was previously placed through the anteromedial incision is retrieved through the tibial tunnel for later graft passage.

On the back table, an Achilles tendon allograft is prepared with a 10- × 20-mm calcaneal bone block (to be placed in the tibial tunnel) (**Fig 3**). Two drill holes are created in the bone block and 2 draw sutures are passed, and the tendon end is prepared with a No. 2 nonabsorbable suture in whipstitch fashion. The graft is then passed transtibially. The femoral fixation is performed first, using 2 small staples in the metaphyseal flare to fix the ACL in an over-the-top position. The graft is then cycled for an impingement-free full range of motion 10 times for stress relaxation and tibial fixation is delayed until after the remainder of the procedure is completed.

Medial MAT

The medial meniscal allograft is prepared on the back table using a No. 5 braided suture to secure the

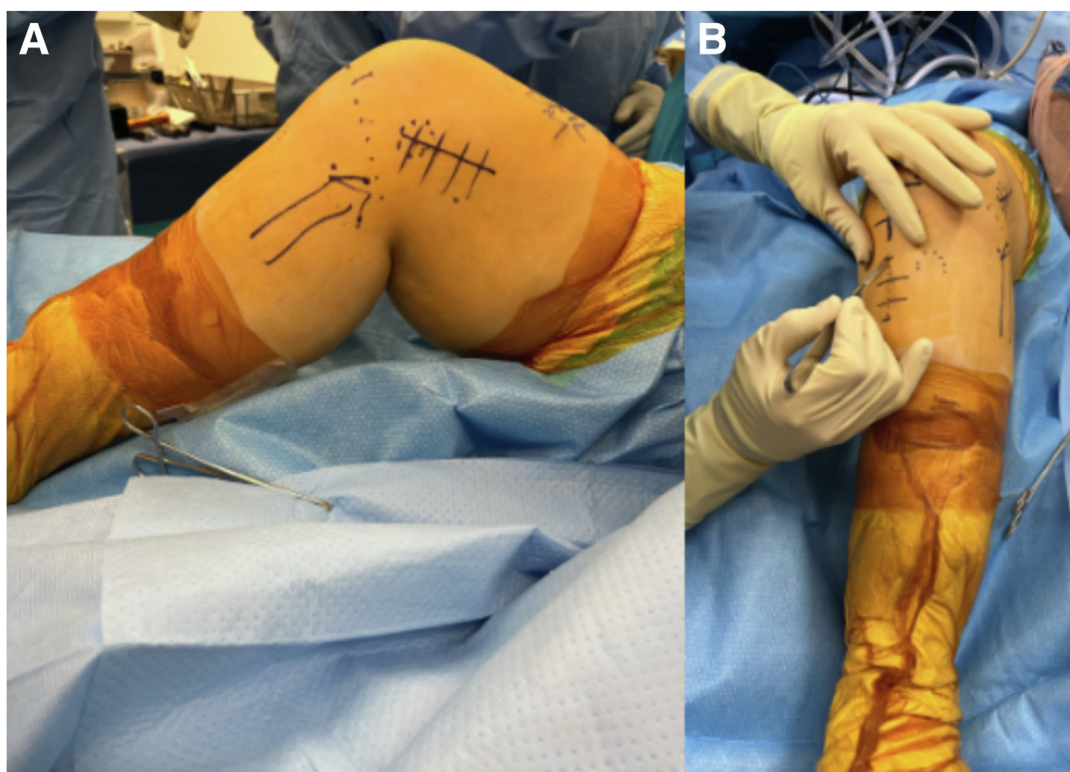


Fig 1. The supine positioning of the operative left knee is shown. (A) The lateral planned incision site for the over-the-top ACLR. (B) The planned anterolateral and anteromedial incisions needed for the ACLR. (ACLR, anterior cruciate ligament reconstruction.)

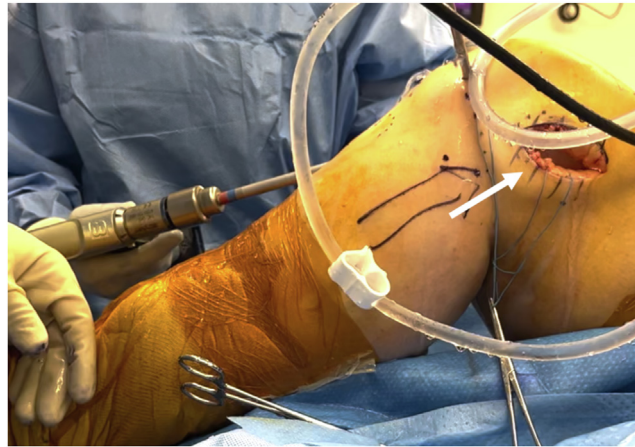


Fig 2. The medial side of the operative left knee in a supine position. A suture is passed with a curved Kelly forceps through the notch, and the lateral wall of the lateral condyle is decorticated for the over-the-top graft location (arrow). The anterior cruciate ligament tibial tunnel is prepared with a width of 9 mm and dilated to 10 mm in the anatomic footprint

posterior and anterior roots in a modified Bunnel fashion (Fig 3). In addition, the top side of the allograft is marked to help guide placement and later fixation within the medial compartment of the knee. Tunnels are drilled at the anterior and posterior roots, with care taken to avoid the previous ACLR tibial tunnel, and draw sutures are left in place to assist with graft passage and fixation. The graft is then inserted through the dilated anteromedial portal and positioned posteriorly,

passing the posterior root sutures through the posterior root tunnel (Fig 4). It is secured peripherally using all-inside meniscal fixation devices (Smith & Nephew, Watford, England). Specifically, 5 devices are placed on the upper surface to the anterior horn and midbody junction, and 3 additional devices on the lower surface in a horizontal mattress fashion, alternating with the upper sutures in a vertical mattress fashion. The anterior root suture is then passed down the anterior root

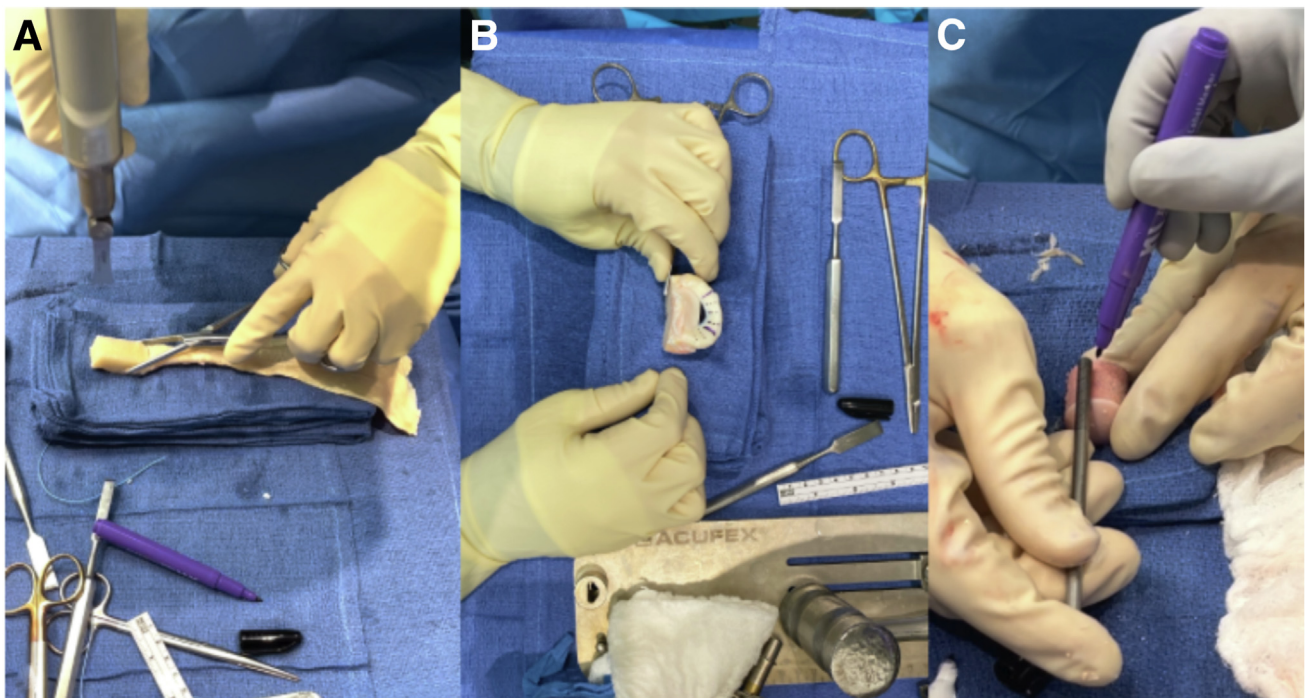


Fig 3. The 3 different allografts used in the surgery described in this article. (A) The Achilles tendon allograft used in the over-the-top anterior cruciate ligament reconstruction. (B) The medial meniscal allograft. (C) The osteochondral allograft that is used for the medial femoral condyle chondral defect.

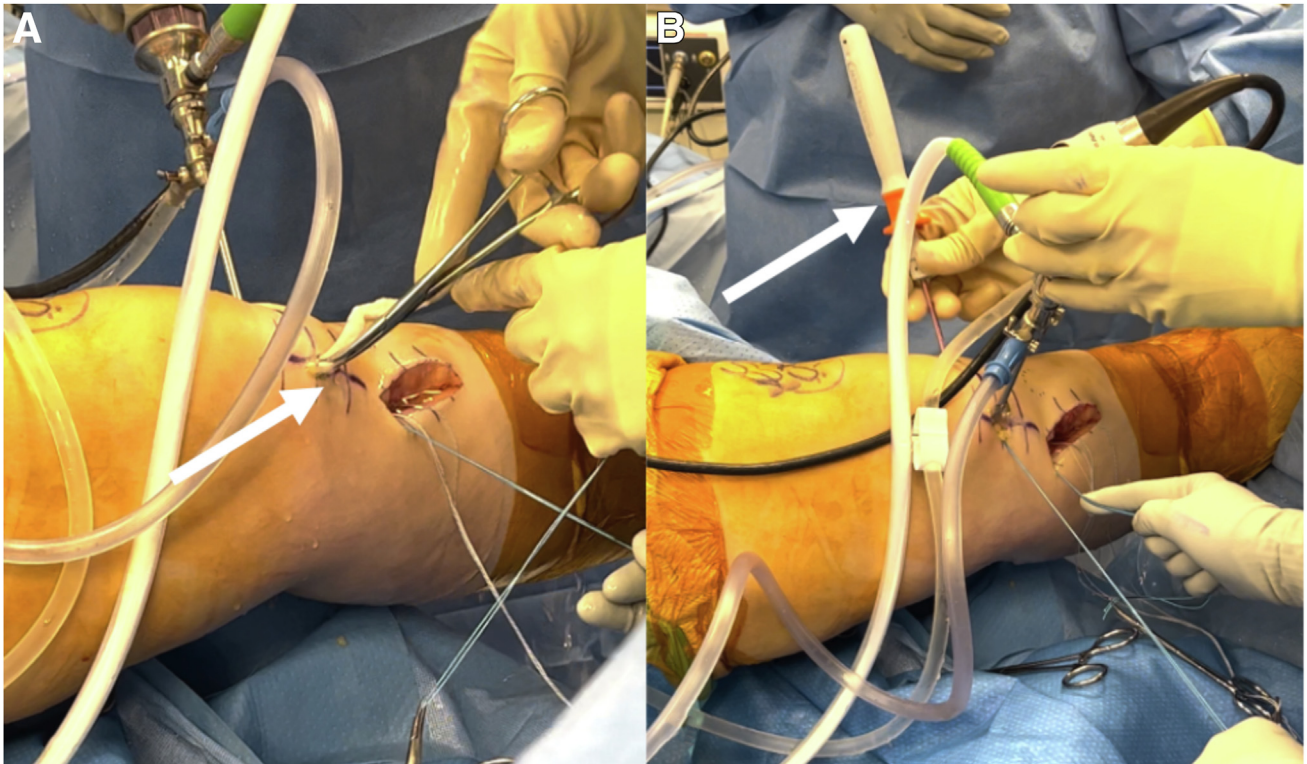


Fig 4. The medial side of the operative left knee. (A) The insertion of the meniscal allograft through the dilated anteromedial portal (arrow). (B) How the allograft is peripherally secured using all-inside meniscal fixation devices (arrow).

tunnel with proper tension for a secure fit. Final fixation is deferred until the remainder of the procedure is completed.

Medial Femoral Condyle OCA Transplantation

A 3-inch arthrotomy incision is made over the medial femoral condyle, encompassing the previously made portal. The incision is made sharply through the skin and subcutaneous tissue, followed by the incision of the portal to visualize and protect the vastus medialis. The knee is now flexed at 120° to visualize the cartilaginous lesion. A central guide pin is placed, and a 20-mm sizer is chosen as appropriate in this case, as it adequately covers the lesion, encompassing it completely posteriorly, laterally, and medially, with only a small amount of grade II cartilaginous change remaining in the anterior non-weight-bearing zone. This is reamed to 15 mm depth. At the back table, an OCA is prepared with a corresponding 20-mm plug. Subsequently, the press-fit plug (20.5 mm) is inserted, and the knee is ranged to ensure that the graft is adequately positioned (Fig 5).

Final Fixation

The tibial fixation of the ACL graft is performed using an 11- × 25-mm interference screw with the knee near full extension and axial tension applied on draw sutures while placing a posterior drawer force on the knee

(Fig 6). The graft is confirmed to be stable. The meniscal root sutures are tied over a cortical button (Smith & Nephew) at 60° of flexion, ensuring adequate positioning and fixation of the meniscus. The incisions are irrigated copiously, then the tourniquet is released, and after adequate hemostasis, the incisions are closed in standard fashion.

Postoperative Rehabilitation

Postoperatively, the patient will be non-weight-bearing for 6 weeks with crutches and restricted to 0° to 60° of motion. After the initial 6-week postoperative period, a gradual increase in the range of motion is allowed.

Discussion

This Technical Note describes a 1-stage surgical technique for revision ACLR, MAT, and OCA. Revision ACLR is a challenging surgical procedure, and meniscal and cartilaginous deficiencies may further complicate surgery if a 1-stage approach is used. Consequently, some surgeons prefer a 2-stage surgery for revision ACLR to address concomitant injuries or malposition or enlargement of the femoral or tibial tunnels with the use of bone grafting.¹⁸ However, because of the increased surgical risk and prolonged recovery time associated with a staged approach, a



Fig 5. An anterior view of the anterior left knee and the medial femoral condyle with transplanted osteochondral allograft (arrow).



Fig 6. An anterior view of the operative left knee. The tibial fixation of the anterior cruciate ligament graft is performed using an 11- x 25-mm interference screw (Smith & Nephew, Watford, England) with the knee near full extension and axial tension applied on draw sutures while placing a posterior drawer force upon the knee.

1-stage technique using OTT serves as a good alternative for revision ACLR with meniscal and cartilaginous deficiencies and circumvents the need for tunnel management.¹⁷

Meniscal deficiency and cartilaginous defects often accompany ACL injury.^{5,19} Meniscal injuries and the presence of full-thickness cartilaginous lesions at the time of ACLR have been shown to lead to worse patient-reported outcomes, subsequent injuries, and early development of osteoarthritis.^{5-7,20} Transplanted OCAs aim to add mature hyaline cartilage and subchondral bone to areas of cartilage loss and intra-articular osteochondral defects and have been associated with favorable long-term results.²¹⁻²³ In addition, studies have shown that OCA can be performed concurrently with MAT without adversely affecting its clinical outcomes.^{12,14}

In the revision ACLR setting, it is paramount to identify and address all factors that may increase the risk of graft failure, such as previously malpositioned tunnels and concomitant meniscal injuries.^{1,5} Medial meniscal deficiency has been shown to increase the forces on the ACL graft, leading to ACLR failure.^{9,19} The importance of the medial meniscus in restraining anteroposterior tibial translation is also well documented.^{8,24} Combined MAT and ACLR have been shown to increase stability and have good long-term clinical outcomes, making it an optimal procedure for patients with concurrent ACL injuries with irreparable meniscal injuries.²⁵ Thus, simultaneous MAT and OCA may be combined with 1-stage OTT revision ACLR, wherein the OTT serves as a good alternative technique, overcoming challenges associated with revision ACLR, such as widened and misplaced femoral tunnels and hardware removal (Table 1).¹⁶

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: V.M. received consulting fees from Smith & Nephew and Newclip; educational fees from Arthrex, DePuy Synthesis, and Conmed; is a board member of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS), and is the Assistant Editor-in-Chief of *Knee Surgery, Sports Traumatology, Arthroscopy* (KSSTA). Also, V.M. has a patent, U.S. Patent No. 9,949,684, issued on April 24, 2018, to the University of Pittsburgh. All other authors (D.L., J.K., S.E.M., E.M.N., C.J.C., Z.J.H., L.M.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.

Table 1. Pearls and Pitfalls of Combined Revision ACLR, MAT, and OCA

Pearls	Pitfalls
<ul style="list-style-type: none"> • When performing concomitant procedures, careful patient selection is paramount (i.e., the patient must have all the indications for MAT, OTT, and OCA, not just 1 or 2 of these) • Perform a quality check of all grafts (i.e., OCAs, MAT, and the Achilles tendon allograft) before intubation to avoid unnecessary anesthesia risk if the surgery needs to be aborted as a result of poor-quality tissue • Start with the ACLR preparation first but do not complete tibial fixation until the end of the procedure • Match the Achilles tendon bone block to the width of the tibial tunnel • Remove previously placed hardware to prevent compromising on tunnel positioning • During MAT, avoid redundancy of meniscus by placing 1 suture for balance and another underneath the meniscus • Consider medialization of the capsule after MAT to avoid extrusion, especially if visible on preoperative MRI • Ensure that the cannulated guide for sizing the OCA and implantation onto the host lesion are oriented perpendicularly to maximize sizing accuracy 	<ul style="list-style-type: none"> • Performing combined revision ACLR without properly assessing limb alignment may result in increased failure rates. Osteotomies should be considered to optimize knee biomechanics • Using previously placed tunnels or avoiding removal of hardware may prevent a more optimal OTT graft placement and increase the risk of revision ACLR failure • Failing to match attachment sites of the meniscal allograft to the native meniscal footprints (i.e., anterior and posterior horn) may result in under- or over-tensioning, increasing risk of failure • Infrequent pulse lavage of the host lesion and donor OCA may result in remnant marrow elements and impeding of host incorporation of graft • Implementing an accelerated weight-bearing protocol for post-operative rehabilitation will compromise the healing of all components of the revision ACLR, especially the OCA and MAT

ACLR, anterior cruciate ligament reconstruction; MAT, meniscal allograft transplantation; MRI, magnetic resonance imaging; OCA, osteochondral allograft; OTT, over-the-top technique.

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