Technical Note

Revision Anterior Cruciate Ligament, Posterior Cruciate Ligament, and Medial Collateral Ligament Reconstructions With Primary Fibular Collateral Ligament Reconstruction After First-Stage Bone Grafting Procedure

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Abstract: Revision multiligament knee injuries are rare but can occur due to unaddressed injuries in the primary reconstruction, poor tunnel placement, or a new injury. A thorough examination via physical examination and imaging must be performed in a revision multiligament case, and occasionally, 2-stage procedures are required. This technical note describes revision anterior cruciate ligament, posterior cruciate ligament, and medical collateral ligament reconstructions after a first-stage bone grafting procedure with primary fibular collateral ligament reconstruction.

Multiligament knee injuries involve 2 or more of the 4 major knee ligament complexes. The anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL)—the 2 main intra-articular structures—are the main restraints to anterior and posterior translation of the knee, respectively.[1,2] The medial collateral ligament (MCL) and fibular collateral ligament (FCL)—the 2 main extra-articular structures—are the main restraints to valgus and varus gapping, respectively.[3,4]

Revision cases of multiligament knee injuries are rare but can occur due to new injuries, untreated initial injuries, or nonanatomic primary reconstructions.[5] In revision cases, various factors including previous autografts used, previous tunnel placement, and bony alignment should be considered.[5,6] This technical note describes revision ACL, PCL, and MCL reconstructions after a first-stage bone grafting procedure with primary FCL reconstruction.

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Surgical Technique

The technique is shown in detail in Video 1. A step-by-step guide and surgical pearls are presented in Table 1.

Anesthesia and Positioning

The patient is positioned in the supine position and induced under general anesthesia. A knee examination, including Lachman, pivot-shift, posterior drawer, dial, and varus and valgus stress testing, is performed to validate clinical examination findings. A high thigh tourniquet is placed on the surgical leg. The surgical leg is placed in a leg holder (Mizho OSI, Union City, CA) and the nonsurgical leg, into an abduction stirrup (Birkova Product, Gothenburg, NE).

Posterolateral Knee Approach

The posterolateral corner is approached first with a 10-cm lateral hockey-stick incision centered over the midportion of the iliotibial band (ITB) (Fig 1). Dissection is carried down to the superficial ITB and biceps femoris tendon, and a common peroneal nerve neurolysis is performed. The biceps bursa is entered via a small horizontal incision to locate the distal attachment of the FCL, and a tag stitch is placed. A fibular head guide (Smith & Nephew, London, England) is used to

Table 1. Step-by-Step Guide and Surgical Pearls for Revision ACL, PCL, and MCL Reconstructions With Primary FCL Reconstruction After First-Stage Bone Grafting Procedure

Step-by-Step Guide	Surgical Pearls
The posterolateral corner is approached first with a 10-cm lateral hockey-stick incision down to the Gerdy tubercle.	The incision should be centered over the midportion of the ITB.
Dissection is carried down to the superficial ITB and biceps femoris tendon, and a common peroneal nerve neurolysis is performed.	The nerve should be released about 6 cm proximally and all the way to the peroneus longus fascia distally.
The biceps bursa is entered via a small horizontal incision to locate the distal attachment of the FCL.	A tag stitch should be placed in the FCL to help identify the femoral attachment of the FCL.
A fibular head guide (Smith & Nephew) is used to drill a guide pin through the FCL fibular head attachment, about 8 mm posterior to the anterior margin of the fibular head.	Prior to drilling, the soleus musculature should be elevated off the posterior aspect of the fibular head.
The guide pin is over-reamed with a 6-mm reamer, and a passing stitch is placed.	The loop of the passing stitch should be lateral to allow passage of the FCL graft from lateral to medial later in the case.
The ITB is split horizontally 3-4 mm proximal to the femoral FCL attachment.	The tag stitch can be used to tension the FCL and determine its femoral attachment location.
A guide pin is drilled through the FCL femoral attachment. This is over-reamed with a 6-mm reamer, followed by a 7-mm tap, and a passing stitch is placed.	The femoral attachment is located just posterior and proximal to the lateral epicondyle. The guide pin should be aimed 35° anteriorly to avoid convergence with the ACL tunnel.
A channel under the superficial ITB is created to later pass the FCL graft.	This channel should run from the FCL femoral tunnel to the FCL fibular head tunnel.
The medial side is approached next with an anteromedial incision. Dissection is started over the vastus medialis oblique musculature and carried down to the hamstring tibial attachments.	The anteromedial incision should start over the vastus medialis oblique musculature and proceed distally past the tibial tubercle.
Both the semitendinosus and gracilis tendons are harvested using an open hamstring harvester. Both tendons are left attached to the tibia.	Adhesions around the tendons should be removed first using a Cobb elevator, Metzenbaum scissors, and a physician's finger to prevent graft amputation.
Two Q-Fix anchors are placed at the anatomic distal tibial attachment of the MCL, at a point 6 cm distal to the joint line. Both grafts are sutured to the tibia with the Q-Fix anchors.	A spinal needle placed at the medial joint line can help to measure 6 cm distally.
On the femur, the MCL attachment, directly posterior and proximal to the medial epicondyle, is identified.	From the adductor magnus tendon, the adductor tubercle can be located. The medial epicondyle is located 12 mm distal and 8 mm anterior to the adductor tubercle.
A guide is placed in the center of the MCL femoral attachment, and a guide pin is drilled anterolaterally across the thigh. The guide pin is over-reamed with a 7-mm reamer to a depth of 35-40 mm.	The guide pin should be aimed 40° anteriorly and proximally to avoid convergence with the PCL tunnels.
The hamstring autografts are passed through a soft-tissue channel created under the sartorial fascia and are cut and whipstitched.	The grafts should be cut so that 30 mm of graft will fit into the femoral tunnel.
Via the same incision, a central-third BPTB autograft is harvested with a 10 × 20-mm bone plug off the patella and a 10 × 25-mm bone plug off the tibia.	A shorter patellar bone plug and a longer tibial tubercle bone plug should be harvested. Both harvest sites should be bone grafted prior to closure.
For the PCL, an Achilles tendon allograft is prepared for the ALB graft, and a tibialis anterior allograft is sized to fit through a 7-mm tunnel for the PMB graft.	The ALB graft should have an 11 × 20-mm bone plug on one end, and the other end should be whipstitched. Both ends of the PMB graft should be whipstitched.
A semitendinosus allograft is prepared to fit through a 6-mm tunnel for the FCL graft.	The graft should be whipstitched at both ends.
The BPTB graft is sized to fit through 10-mm tunnels with 2 passing sutures in each bone plug.	The distal end of the patellar side should be marked with a methylene blue marker for visualization while dunking the bone plug in the femoral tunnel.
Medial and lateral parapatellar portals are made. A notchplasty should be performed to remove any intercondylar notch osteophytes.	The healing from the previous bone grafting procedure should be evident. Near normal anatomic margins should be established.
The PCL femoral tunnel anatomic locations are identified, the ALB is over-reamed with an 11-mm reamer and the PMB is over-reamed with a 7-mm reamer to a depth of 25 mm, and passing stitches are placed.	The reamers should be used as guides for the guide pins prior to reaming the tunnels. The inferior aspect of the PMB tunnel should be notched.
The ACL femoral tunnel guide pin is drilled at the anatomic attachment using an over-the-top guide placed through an accessory anteromedial portal. This is over-reamed with a 10-mm reamer to a depth of 25 mm.	The posterior cartilage margin can be used as an anatomic landmark because the other landmarks in the lateral notch may be gone after bone grafting.
A posteromedial portal is made to prepare for the PCL tibial tunnel placement. The guide pin is drilled at the bundle ridge for the PCL tibial tunnel.	After the guide pin is drilled, intraoperative fluoroscopic imaging confirms that it is in the desired position.

Step-by-Step Guide	Surgical Pearls
The PCL tibial tunnel is over-reamed with a 12-mm acorn reamer. A Gore smoother (Smith & Nephew) is passed up the tunnel to smooth off the intra-articular tunnel aperture, and the end is pulled out the anterolateral portal.	Reaming should be completed by hand to protect the posterior neurovasculature.
The ACL tibial tunnel is identified next, adjacent to the anterior horn of the lateral meniscus. A guide pin is drilled and over-reamed with a 10-mm reamer.	Previous proud bone grafting must be addressed by thorough debridement.
The PMB graft is fixed in the femur with a 7 × 20-mm bioabsorbable screw, and the ALB is fixed with a 7 × 20-mm titanium screw. The sutures in the opposite ends of the PCL grafts are passed through the ends of the Gore smoother and shuttled down the tibial tunnel.	The ALB bone plug should be passed into the femoral tunnel with the cortical side up.
The ACL graft is passed into the femur and fixed with a 7 × 20-mm titanium screw.	The methylene blue mark should be visualized as fully in the tunnel to ensure no part of the bone plug is sticking out of the femoral tunnel.
The FCL graft is passed into the femoral tunnel and fixed with a 7 × 20-mm bioabsorbable screw. Then, the graft is passed distally to the fibular head.	The screw should be placed at the anterior aspect of the tunnel.
Final fixation of the PCL is performed first with two 6.5-mm screws and spiked washers. The ALB is fixed first at 90°, followed by the PMB at 0°.	Pilot holes should be drilled, measured, and tapped for the PCL screws to ensure optimal screw depth and fixation.
The ACL is then fixed in the tibia with a 9 × 20-mm titanium screw in extension.	The knee should be cycled several times before final fixation.
The FCL is fixed in the fibular head with a 7 × 20-mm bioabsorbable screw with the knee at 20° of flexion with a slight valgus reduction force.	The excess graft should be cut on the posterior side of the fibular head.
Finally, the MCL is fixed in the femoral tunnel with a 7 × 20-mm bioabsorbable screw at 20° of flexion with a slight varus reduction force.	The screw should be placed at the anterior aspect of the tunnel.
A final Q-Fix anchor is placed 15 mm distal to the joint line to re-create the proximal tibial attachment of the MCL.	The knee should be in 20° of flexion for final fixation.
The deep and superficial sutures are closed with suture.	The bone trough sites of the BPTB harvest should be bone grafted.

ACL, anterior cruciate ligament; ALB, anterolateral bundle; BPTB, bone–patellar tendon–bone; FCL, fibular collateral ligament; ITB, iliotibial band; MCL, medial collateral ligament; PCL, posterior cruciate ligament; PMB, posteromedial bundle.

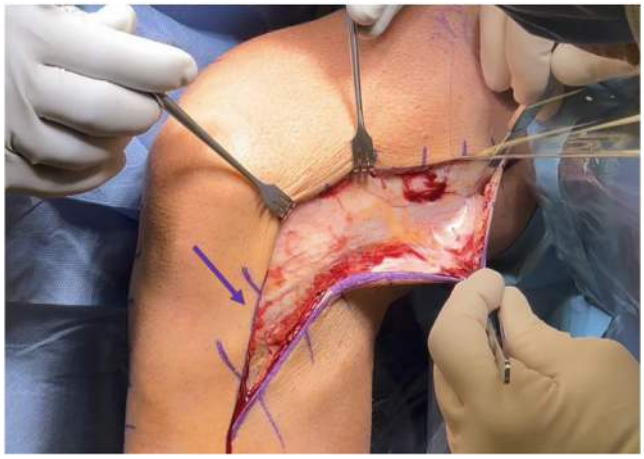

Fig 1. Lateral incision for fibular collateral ligament reconstruction in a left knee with the patient in the supine position. A 10-cm lateral hockey-stick incision (purple arrow) is created, centered over the midportion of the iliotibial band and splitting the distance between the Gerdy tubercle and the fibular head. Careful dissection should be carried down to the iliotibial band and long head of the biceps femoris tendon. A common peroneal nerve neurolysis should be performed.

Fig 2. Fibular head tunnel for fibular collateral ligament (FCL) reconstruction in a left knee with the patient in the supine position. The biceps bursa is entered via a small horizontal incision to locate the native distal attachment of the FCL. The soleus musculature is elevated off the posteromedial aspect of the fibular head. A fibular head guide (Smith & Nephew) (white arrow) is used to drill a guide pin through the FCL fibular head attachment, about 8 mm posterior to the anterior margin of the fibular head. This guide pin is over-reamed with a 6-mm reamer, and a passing stitch is placed.

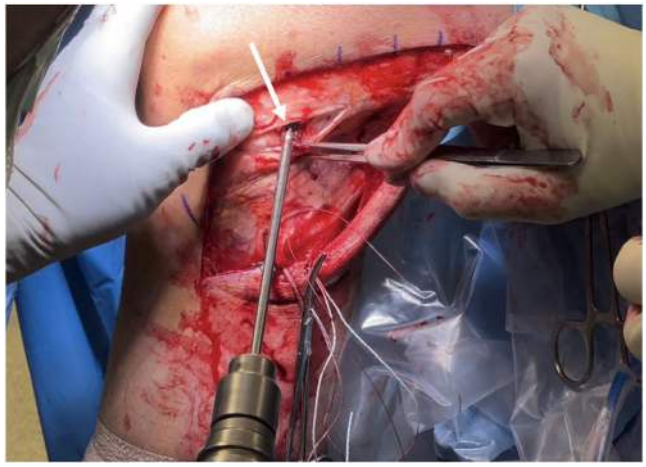

Fig 3. Femoral tunnel for fibular collateral ligament (FCL) reconstruction in a left knee with the patient in the supine position. By pulling on the tag stitch previously placed in the distal FCL, the proximal attachment of the FCL can be found in a sulcus just posterior and proximal to the lateral epicondyle. A horizontal incision, in line with the fibers of the iliotibial band, should be created above the FCL proximal attachment. A guide pin is drilled across the femur using a femoral guide (Smith & Nephew) and should be aimed about 35° anteriorly to avoid convergence with the revision anterior cruciate ligament reconstruction tunnel. This guide pin is over-reamed with a 6-mm reamer (white arrow). A 7-mm tap is used, and a passing stitch is placed.

drill a guide pin through the FCL fibular head attachment, about 8 mm posterior to the anterior margin of the fibular head (Fig 2). This is over-reamed with a 6-mm reamer, and a passing stitch is placed.

The ITB is split 3 to 4 mm proximal to the femoral FCL attachment, using the tag stitch to tension the FCL and determine its femoral attachment location. A guide pin is drilled through the FCL femoral attachment. This is over-reamed with a 6-mm reamer, followed by a 7-mm tap, and a passing stitch is placed (Fig 3). A channel under the superficial ITB is created to later pass the FCL graft.

Anteromedial Knee Approach

The medial side is approached next with an anteromedial incision (Fig 4). Dissection starts over the vastus medialis oblique musculature and is carried down to the hamstring tibial attachments. Both the semitendinosus and gracilis tendons are harvested using an open hamstring harvester (Fig 5) and are left attached to the tibia. Two Q-Fix anchors (Smith & Nephew) are placed at the anatomic distal tibial attachment of the MCL, at a point 6 cm distal to the joint line. Both grafts are sutured to the tibia with the Q-Fix anchors (Fig 6).

Fig 4. Anteromedial incision for anterior cruciate ligament and medial collateral ligament graft harvest and medial collateral ligament reconstruction in a left knee with the patient in the supine position. The medial side is approached with an anteromedial incision that extends from the vastus medialis oblique musculature to a location distal to the tibial tubercle (purple arrow). Dissection starts over the vastus medialis oblique musculature and is carried down to the hamstring tibial attachments. Dissection is also carried laterally for a bone–patellar tendon–bone graft harvest for revision anterior cruciate ligament reconstruction.

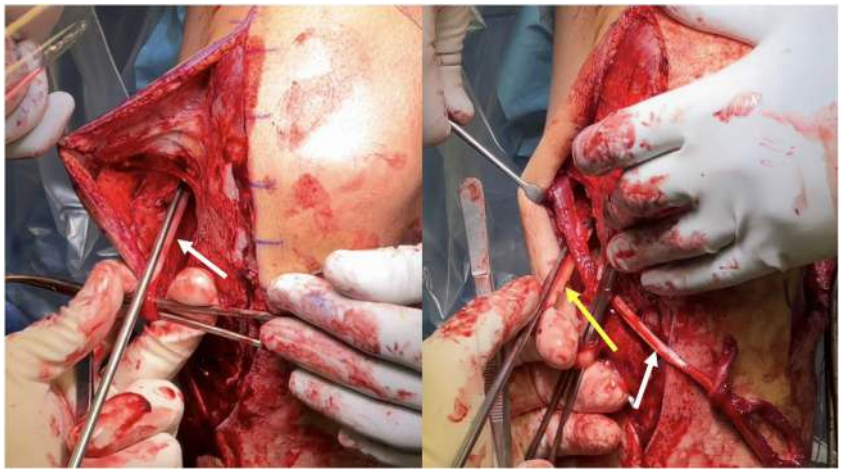

Fig 5. Hamstring autograft harvest for use in medial collateral ligament reconstruction in a left knee with the patient in the supine position. Both the gracilis (white arrows) and semitendinosus (yellow arrow) hamstring tendons are harvested to be used in medial collateral ligament reconstruction. Prior to harvest, adhesions around the tendons are removed using a combination of a Cobb elevator, Metzenbaum scissors, and the physician's fingers. An open hamstring harvester (Arthrex, Naples, FL) is used to harvest the hamstrings, with care taken not to amputate the grafts. The grafts are left attached to the tibia.

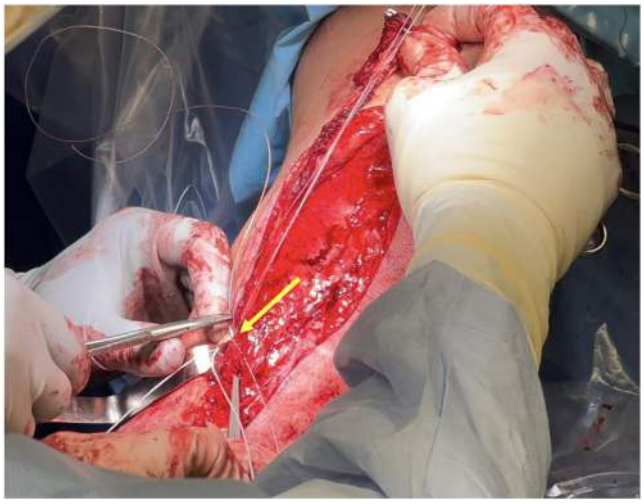

Fig 6. Distal fixation for medial collateral ligament reconstruction using hamstring tendon autografts in a left knee with the patient in the supine position. The previously harvested gracilis and semitendinosus tendons are left attached to the tibia. A spinal needle is placed at the medial joint line, and the native distal attachment of the medial collateral ligament is located 6 cm distal to the joint line. At this location, 2 Q-Fix anchors (Smith & Nephew) are placed at the anatomic distal tibial attachment (yellow arrow). Both hamstring autografts are sutured to the tibia with the Q-Fix anchors.

Fig 7. Location of the femoral attachment of the medial collateral ligament (MCL) and tunnel drilling for the MCL reconstruction in a left knee with the patient in the supine position. When one is approaching the femur, the adductor magnus tendon should be identified first. From the adductor magnus tendon, the adductor tubercle can be located. The medial epicondyle is located 12 mm distal and 8 mm anterior to the adductor tubercle. The MCL femoral attachment is located directly posterior and proximal to the medial epicondyle. A femoral aiming guide (Smith & Nephew) is placed in the center of the MCL femoral attachment, and a guide pin (white arrow) is drilled anterolaterally across the thigh, aimed 40° anterior and proximal. The guide pin is over-reamed with a 7-mm reamer to a depth of 35 to 40 mm, and a passing stitch is placed. The hamstring autografts previously harvested and fixated to the distal tibial attachment are passed under the sartorial fascia and are trimmed and whipstitched so that 30 mm of graft will fit into the femoral tunnel.

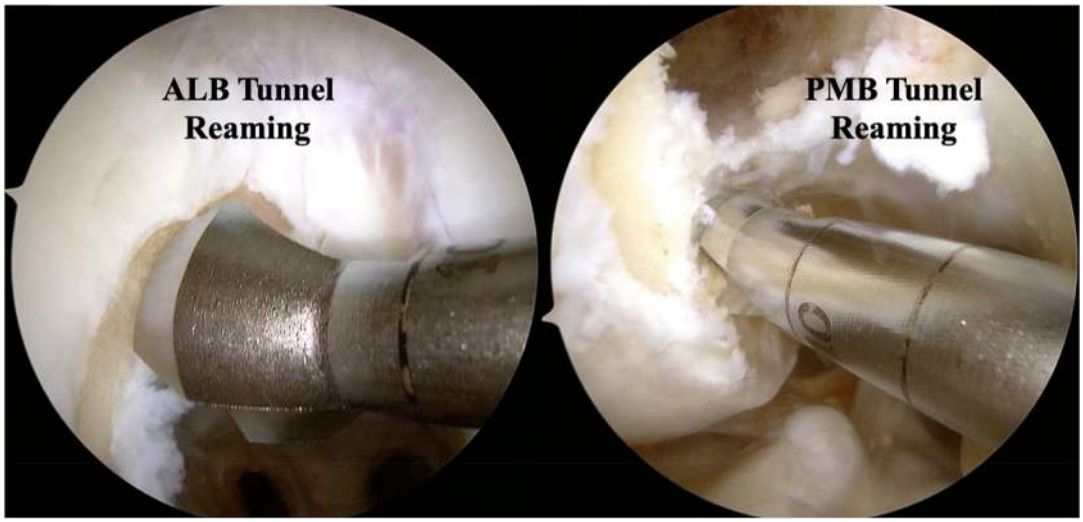

Fig 8. Drilling of the posterior cruciate ligament femoral tunnels to reconstruct the anterolateral bundle (ALB) and posteromedial bundle (PMB) for posterior cruciate ligament reconstruction after bone grafting. This is an arthroscopic view from the anteromedial portal in a left knee. An 11-mm reamer is used as a guide for the ALB tunnel location. The reamer should be positioned so that it is midway between the trochlear point and the medial arch point, and the edge of the reamer should touch the cartilage margin. After the guide pin is drilled, the 11-mm reamer is used to over-ream the tunnel to a depth of 25 mm. A 7-mm reamer is used as a guide for the PMB tunnel location. The reamer should be positioned so that it is midway between the medial arch point and the posterior point, and the edge of the reamer should be about 5 mm from the cartilage margin. A 2-mm bone bridge should remain between the tunnels. After the guide pin is drilled, the 7-mm reamer is used to over-ream the tunnel to a depth of 25 mm. Passing stitches are placed through both tunnels.

On the femur, the MCL attachment, directly posterior and proximal to the medial epicondyle, is identified. A guide is placed in the center of the MCL femoral attachment, and a guide pin is drilled anterolaterally across the thigh (Fig 7). The guide pin is over-reamed with a 7-mm reamer to a depth of 35 to 40 mm. The hamstring autografts are passed through a soft-tissue channel under the sartorial fascia and are cut and whipstitched so that 30 mm of the graft will fit into the tunnel. Via the same incision, a central-third bone—patellar tendon—bone autograft is harvested with a 10 × 20-mm bone plug off the patella and a 10 × 25-mm bone plug off the tibia.

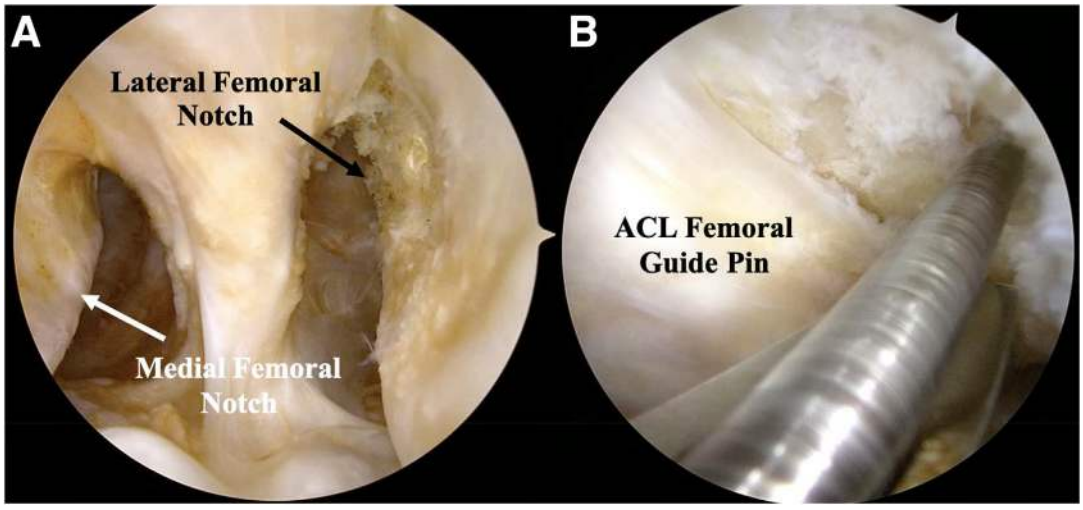

Fig 9. Drilling of the anterior cruciate ligament (ACL) femoral tunnel for ACL reconstruction after healed bone grafting. This is an arthroscopic view from the anterolateral portal in a left knee. A notchplasty is performed on the roof and the lateral edge of the femoral notch prior to drilling of the ACL tunnel. The ACL femoral guide pin is drilled using an over-the-top guide (Arthrex) with a 7-mm offset. After bone grafting, the normal anatomic landmarks are gone. The tunnel should be in line with the posterior cartilage margin, and a 2-mm back wall should remain after reaming a 10-mm tunnel to a depth of 25 mm. A passing stitch is placed through this tunnel.

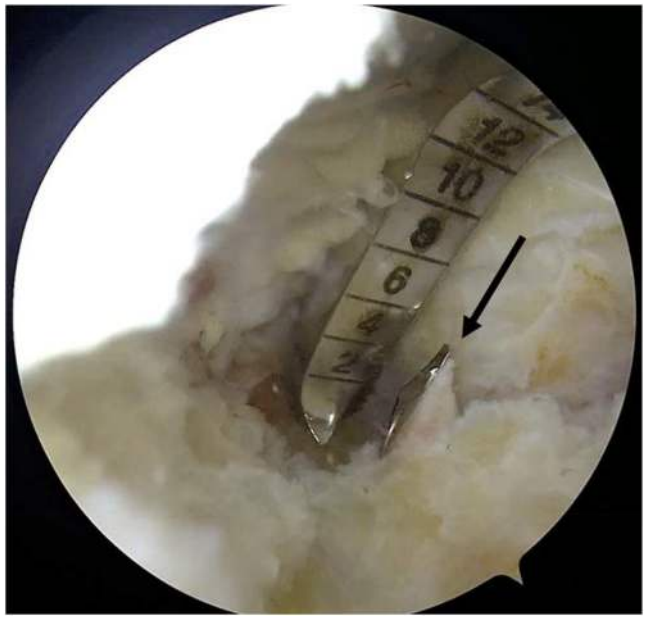

Fig 10. Drilling of the posterior cruciate ligament (PCL) tibial tunnel for PCL reconstruction after bone grafting. This is an arthroscopic transnotch view from the anteromedial portal in a left knee. The posterior soft tissues and any extra bone from the bone grafting are removed prior to drilling the tunnel using an accessory posteromedial portal. The guide pin is drilled using a PCL guide (Arthrex) at the bundle ridge for the PCL tibial tunnel (black arrow). After the guide pin is drilled, intraoperative fluoroscopic imaging confirms that it is in the desired position. Any meniscus work should be performed prior to over-reaming the PCL tibial tunnel. The PCL tibial guide pin is over-reamed with a 12-mm reamer, and the last portion of reaming is performed by hand to protect the posterior neurovascular structures. A Gore smoother (Smith & Nephew) is passed up the tunnel to smooth out the tunnel and aperture and help with graft passage later in the case.

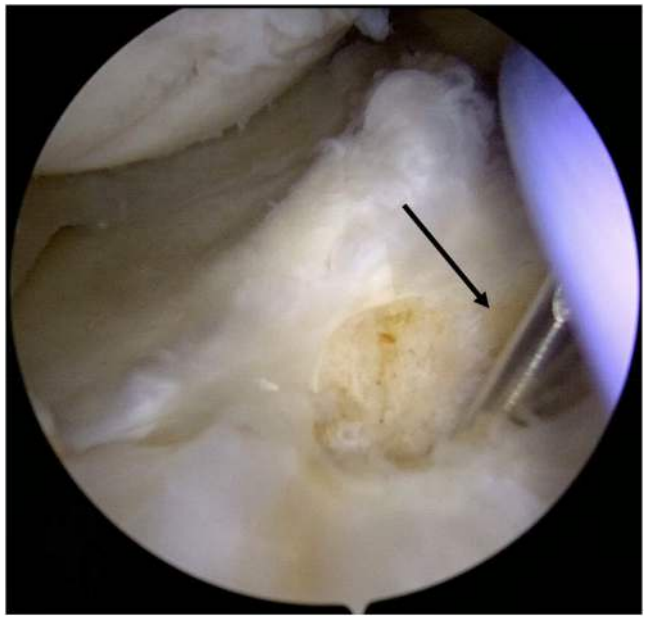

Fig 11. Drilling of the anterior cruciate ligament (ACL) tibial tunnel for ACL reconstruction after bone grafting. This is an arthroscopic view from the anterolateral portal in a left knee. The guide pin (black arrow) should be aimed to be in line with the anterior root attachment of the lateral meniscus. The guide pin is over-reamed with a 10-mm reamer. Any bony fragments and soft tissue should be cleared from the tunnel aperture. The previously placed passing stitch through the ACL femoral tunnel is pulled down the tibial tunnel.

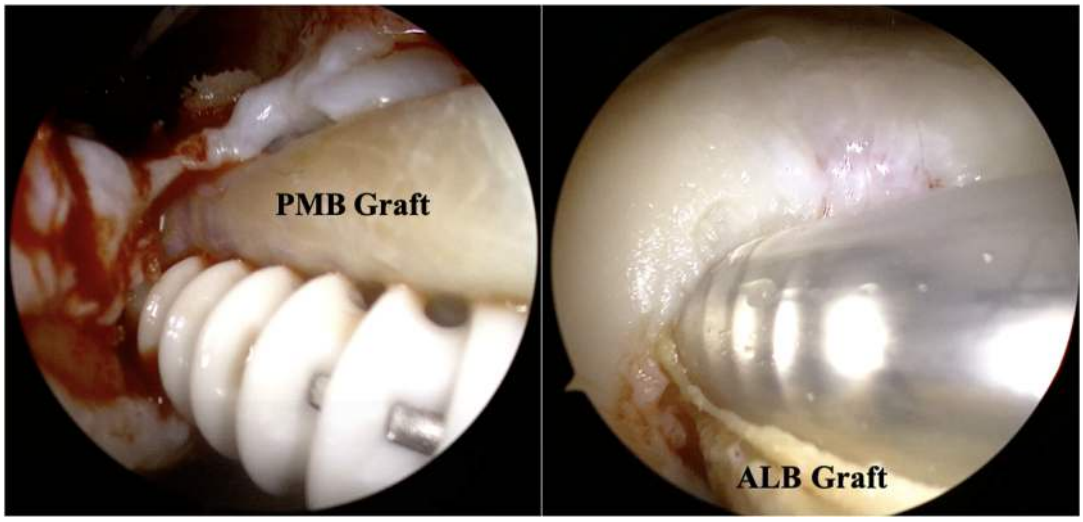

Fig 12. Fixation of the posterior cruciate ligament anterolateral bundle (ALB) and posteromedial bundle (PMB) in the femur during multiligament knee reconstruction. This is an arthroscopic view from the anterolateral portal in a left knee. The PMB graft is a tibialis anterior allograft that has been whipstitched at both ends. The ALB graft is an Achilles allograft that has an 11 × 20-mm calcaneal bone plug at one end and is whipstitched at the other end. The PMB graft is passed first into the femur and fixed with a 7 × 20-mm bioabsorbable screw. The ALB graft bone plug, cortical side up, is passed into the femur and fixed with a 7 × 20-mm titanium screw. The grafts are then passed down the tibial tunnel using the Gore smoother (Smith & Nephew).

Graft Preparation

The ACL, PCL, and FCL grafts are prepared and sized on the back table. An Achilles tendon allograft is prepared with an 11 × 20-mm bone plug on one end and whipstitched on the other end for the anterolateral bundle (ALB) graft, and a tibialis anterior allograft is whipstitched at each end for the posteromedial bundle (PMB) graft. A semitendinosus allograft is whipstitched and prepared to fit through a 6-mm tunnel for the FCL graft. The bone–patellar tendon–bone graft is sized to

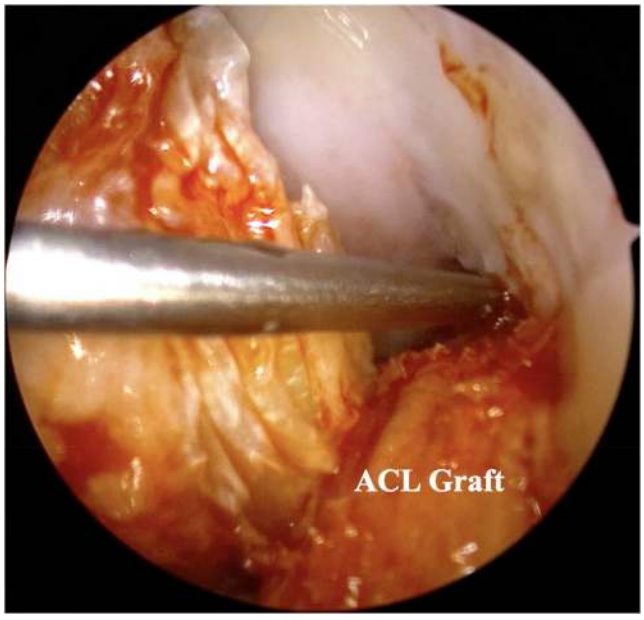

Fig 13. Fixation of the anterior cruciate ligament (ACL) graft in the femur during multiligament knee reconstruction. This is an arthroscopic view from the anterolateral portal in a left knee. The ACL autograft is a bone–patellar tendon–bone autograft that is prepared to fit through a 10-mm-diameter tunnel. The ACL graft is passed up the tibial tunnel and seated into the femoral tunnel with the cortical side of the bone plug aligning with the posterior margin of the tunnel. A 7 × 20-mm titanium screw is used to fixate the graft in the femoral tunnel.

Fig 14. Femoral fixation of the fibular collateral ligament (FCL) graft during multiligament knee reconstruction in a left knee. The FCL graft is prepared using a semitendinosus allograft that is whipstitched at both ends. The graft is pulled into the femoral tunnel using the previously placed passing stitch. A 7 × 20-mm bioabsorbable screw (white arrow) at the anterior aspect of the tunnel is used to fixate the graft in the femur.

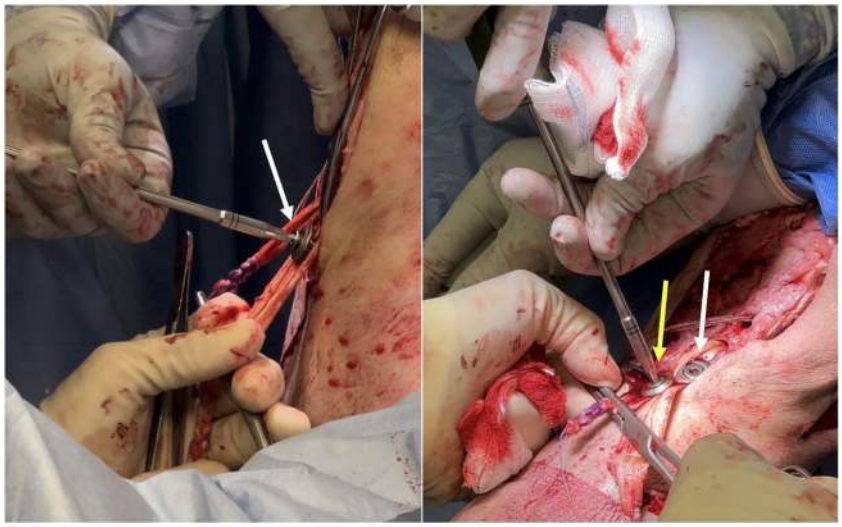

Fig 15. Tibial fixation of the anterolateral and posteromedial bundles of the posterior cruciate ligament during multiligament knee reconstruction in a left knee. Via the previous anteromedial incision, final fixation of the anterolateral bundle at 90° is performed first with a 6.5-mm screw and spiked washer (white arrows). The posteromedial bundle is fixed in the same fashion at 0° (yellow arrow). Both screws should have pilot holes drilled first, and the bicortical distance should be measured to ensure proper screw length.

fit through 10-mm tunnels with 2 passing sutures in each bone plug.

Arthroscopy and Intra-articular Work

Medial and lateral parapatellar portals are made. Healing of first-stage bone grafting should be evident. A notchplasty should be performed to remove any intercondylar notch osteophytes. The PCL femoral tunnel anatomic locations are identified, and the reamers are used as guides for the guide pins, which are drilled through the anterolateral portal (Fig 8). The ALB is over-reamed with an 11-mm reamer and the PMB is over-reamed with a 7-mm reamer to a depth of 25 mm, and passing stitches are placed. The inferior aspect of the PMB tunnel is notched.

The ACL femoral tunnel guide pin is now drilled at the anatomic attachment using an over-the-top guide placed through an accessory anteromedial portal (Fig 9). This is over-reamed with a 10-mm reamer to a depth of 25 mm.

A posteromedial portal is now made to prepare for the PCL tibial tunnel placement. The guide pin is drilled at the bundle ridge for the PCL tibial tunnel (Fig 10). After the guide pin is drilled, intraoperative fluoroscopic imaging confirms that it is in the desired position.

After meniscal assessment and repair (if necessary), the PCL tibial tunnel is over-reamed with a 12-mm acorn reamer. Reaming should be completed by hand to protect the neurovascular structures. A Gore smoother (Smith & Nephew) is passed up the tunnel to

Fig 16. Tibial fixation of the anterior cruciate ligament during multiligament knee reconstruction in a left knee. Via the previous anteromedial incision, the anterior cruciate ligament is pulled into tension, and the knee is cycled several times. With the graft pulled taut, the knee is placed in extension and the ACL is fixed in the tibia with a 9 × 20-mm titanium interference screw (white arrow).

Fig 17. Fibular head fixation of the fibular collateral ligament graft during multiligament knee reconstruction in a left knee. The graft is pulled into the fibular head tunnel using the previously placed passing stitch. A 7 × 20-mm bioabsorbable screw (white arrow) at the distal aspect of the tunnel is used to fixate the graft in the fibular head. This should be achieved at 20° of flexion with a slight valgus force.

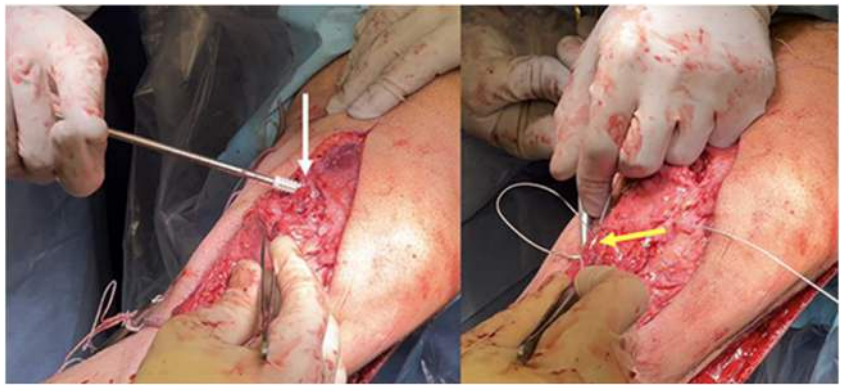

Fig 18. Femoral fixation of the medial collateral ligament (MCL) graft during multiligament knee reconstruction in a left knee. The MCL graft is passed under the sartorius fascia up to the femoral tunnel. The MCL is fixed in the femoral tunnel with a 7 × 20-mm bioabsorbable screw (white arrow) at 20° of flexion with a slight varus reduction force. Next, another Q-Fix anchor (Smith & Nephew) (yellow arrow) is placed 15 mm distal to the joint line to re-create the proximal tibial attachment of the MCL. The MCL graft is fixated to the Q-Fix anchor using simple knots.

smooth off the intra-articular tunnel aperture, and the end is pulled out the anterolateral portal.

The ACL tibial tunnel is identified next, adjacent to the anterior horn of the lateral meniscus. Previous proud bone grafting must be addressed by thorough debridement. A guide pin is drilled and over-reamed with a 10-mm reamer (Fig 11).

Graft Passage and Fixation

The PMB graft is passed into the femur and fixed with a 7 × 20-mm bioabsorbable screw, and the ALB graft bone plug, cortical side up, is passed into the femur and fixed with a 7 × 20-mm titanium screw (Fig 12). The sutures in the opposite ends of the PCL grafts are passed through the ends of the Gore smoother and shuttled down the tibial tunnel. The ACL graft is passed into the femur and fixed with a 7 × 20-mm titanium screw (Fig 13). The FCL graft is passed into the femoral tunnel and fixed with a 7 × 20 mm bioabsorbable screw and is then passed down to the fibular head tunnel (Fig 14).

Final fixation of the PCL is performed first, with two 6.5-mm screws and spiked washers. The ALB is fixed first at 90°, followed by the PMB at 0° (Fig 15). The ACL is then fixed in the tibia with a 9 × 20-mm titanium screw in extension (Fig 16). The FCL is fixed in the fibular head with a 7 × 20-mm bioabsorbable screw with the knee at 20° of flexion with a slight valgus reduction force (Fig 17). Finally, the MCL is fixed in the femoral tunnel with a 7 × 20-mm bioabsorbable screw at 20° of flexion with a slight varus reduction force, followed by fixation to a new Q-Fix anchor that is placed 15 mm distal to the joint line to re-create the proximal tibial attachment of the MCL (Fig 18). The deep and superficial tissues are closed with sutures.

Table 2. Advantages and Disadvantages of Revision ACL, PCL, and MCL Reconstructions With Primary FCL Reconstruction After First-Stage Bone Grafting Procedure

Advantages
Combination of allograft and autograft to avoid graft harvest from contralateral limb
Reconstructions of all affected structures to ensure knee stability
Bone grafting in first stage allows for new anatomic tunnels for all ligaments
Double-bundle PCL reconstruction restores native knee stability better than single-bundle PCL reconstruction
Large incisions allow for optimal visualization of all structures, especially in revision cases
Disadvantages
Higher cost because of use of allograft
Iatrogenic damage to hamstring tendons and patellar tendon with graft harvest
Potential iatrogenic damage to posterior neurovasculature when performing revision PCL reconstruction
Potential progression of osteoarthritis and cartilage damage by bone grafting in first stage

ACL, anterior cruciate ligament; FCL, fibular collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.

Postoperative Rehabilitation

Patients are non–weight bearing for 6 weeks. Prone knee flexion is initiated at 0° to 90° for the first 2 weeks and increased as tolerated. Patients are placed into a dynamic PCL brace once their incisions and swelling allow its use.

Discussion

Revision multiligament knee injuries are rare but require careful assessment to ensure optimal postoperative outcomes.[7] Concomitant injuries, bony alignment including sagittal and coronal alignment, and previous tunnel locations and sizes must be considered.[5,6] Typically, revision multiligament cases will require a 2-step approach, with the first step being bone grafting and corrective osteotomy (if required), followed by ligament and meniscal repairs and/or reconstructions and chondral procedures in the second stage.

Very few studies have reported on outcomes after revision multiligament knee injuries; however, a study by Woodmass et al.[5] of 23 patients who underwent revision multiligament knee reconstruction reported improved postoperative Lysholm and International Knee Documentation Committee scores of 79.4 and 74.5, respectively. Multiligament reconstructions, even revision cases, should be performed to restore knee stability and improve patient function and outcomes.[8] The advantages and disadvantages of our technique 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 a consulting or advisory relationship with Ossur, Smith & Nephew, and Responsive Arthroscopy; receives funding grants from Ossur, Smith & Nephew, Arthroscopy Association of North America, and American Orthopaedic Society for Sports Medicine; receives travel reimbursement from Smith & Nephew; receives speaking and lecture fees from Foundation Medical; and has a patent with royalties paid to Ossur. All other authors (L.V.T., E.P.S., D.R.L., M.T.R.) 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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