Technical Note

Arthroscopic-Assisted Lateral Extra-Articular Tenodesis With Knotless Anchor Fixation

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Abstract: Recent studies have reported the biomechanical and clinical advantages of lateral extraarticular augmentation procedures including the modified lateral extra-articular tenodesis (LET) in the setting of anterior cruciate ligament reconstruction. LET has been shown to significantly decrease re-rupture rates in high-risk patients and decrease anterior cruciate ligament graft forces during pivoting loads and instrumented anterior laxity testing. Many variations of the modified LET approaches have been described. However, concerns including lateral hematoma, wound-healing complications, and increased operative time exist. This minimally invasive, arthroscopic-assisted approach using a knotless, all-suture anchor allows for direct visualization through a 2-cm incision and inherently decreases the morbidity associated with traditional LET techniques.

Introduction

Anterior cruciate ligament (ACL) injuries are routinely treated with reconstruction using a graft but have relatively high failure rates, especially in young, athletic populations.[1] Certain characteristics such as younger age, female sex, sport, and knee hyperlaxity place certain patients at greater risk of failure.[2] This may partially be attributable to the inability of intra-articular procedures, such as anterior cruciate ligament reconstruction (ACLR) and meniscus repair, when necessary, to restore the rotatory instability associated with concomitant anterolateral complex disruption.[3] To minimize subsequent failure, Noyes and Barber[4] described an additional extra-articular procedure involving tenodesis of the iliotibial band (ITB) for treatment of chronic rupture of the ACL, reporting a decrease in graft rupture from 16% without tenodesis to 3% with the addition of concomitant tenodesis.

Recent studies have found that the addition of lateral extra-articular tenodesis (LET) to isolated ACLR confers a biomechanical advantage compared with isolated ACLR and decreases ACL graft force by 70% during simulated tests of anterior laxity.[3,5] In addition, LET combined with ACLR reduced anterior tibial translation with pivoting loads.[5] Clinically, the addition of an LET has been shown to better restore knee stability and significantly reduce failure rates in skeletally immature patients,[6] high-risk young patients, and elite athletes.[7] Downsides to the technique include increased surgical morbidity and a lateral incision that is reportedly prone to hematoma and wound complications.[8,9]

This article describes our minimally invasive technique performing an arthroscopic-assisted LET with knotless anchor fixation, which may decrease the added surgical morbidity of this procedure that is increasingly being performed concomitantly with ACLR.[7,10]

Surgical Technique (With Video Illustration)

A video of this technique is available (Video 1). Pearls and pitfalls are shown in Table 1.

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Table 1. Pearls and Pitfalls of Arthroscopic-Assisted LET With Knotless Anchor Fixation: Pearls and Pitfalls of the Procedure

Pearls	Pitfalls
○ Harvest the ITB and pass graft under FCL before ACLR. This gives the best visibility and avoids fluid extravasation into the soft tissues.	○ If the skin incision is anterior to the mid portion of the ITB or LE, visualization will be compromised, and the incision will have to be extended.
○ Free the undersurface of the ITB from the underlying lateral musculature with a Cobb elevator before cutting the ITB graft proximally.	○ Unequal pressure on the blades of the parallel knife may cause damage to the musculature underlying the ITB or FCL more distally.
○ Determine the anchor point of the ITB on the femur. Hold the graft in place and take the knee through complete range of motion to ensure the graft is long enough. If the graft is not long enough, then you must move the anchor position closer to the epicondyle.	○ Do not move the drill guide before anchor insertion following drilling or it can be difficult to find your drill hole.
○ Extend distal end of incision slightly toward Gerdy's in order to palpate and pass deep to the FCL	
○ If the all-suture anchor pulls out, it can generally be replaced with a larger solid anchor. If the solid anchor pulls out, move to a more proximal location where cortical bone quality is generally better. Ensure graft is adequate length.	

ACLR, anterior cruciate ligament reconstruction; FCL, fibular collateral ligament; ITB, iliotibial band; LE, lateral epicondyle.

Indications

LET is considered in patients undergoing ACLR who are considered high-risk for failure. High-risk patients have been described as those who meet 2 of the 3 following criteria: (1) grade 2 pivot shift or greater, (2) a desire to return to high-risk/pivoting sports, (3) and generalized ligamentous laxity or knee hyperextension >10°.[11] LET is also considered for patients with a history of ACL graft failure on the ipsilateral or contralateral extremity, generally without a known technical cause for failure such as inappropriate tunnel placement or allograft use.

Patient Positioning and Examination Under Anesthesia

The patient is positioned supine. A pivot shift test is performed to assess for rotatory laxity and compared with the contralateral extremity to assess whether the laxity is physiologic. After examination under anesthesia, the nonoperative leg is placed into the lithotomy position in a well-padded leg holder, the operative extremity is placed in a well-padded c-clamp holder and the foot of the bed is dropped. Alternatively, the patient may be positioned supine with a leg post and foot roll to maintain the leg at 90° of flexion.

Surgical Approach

The ITB graft is harvested before ACLR to allow for easy definition of anatomy without extravasation of arthroscopic fluid into the soft tissue. The ITB harvest can performed with the tourniquet inflated or without torniquet according to surgeon preference.

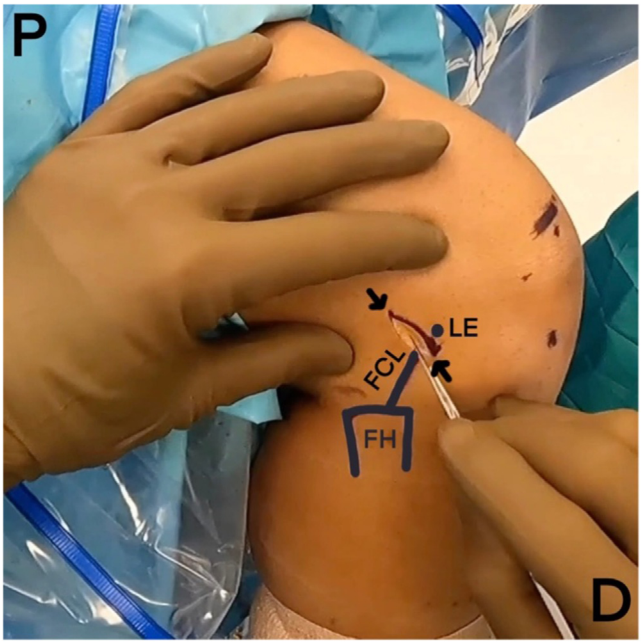

Fig 1. Landmarks and incision. Shown is the right knee in 90° flexion and neutral rotation on a supine patient. Before primary anterior cruciate ligament repair, anatomy is defined, landmarks are marked, and a small 2-cm skin incision (proximal and distal edges indicated by arrows) is created proximally from the lateral epicondyle. The surgeon is demonstrating the posterior and anterior borders of the iliotibial band with the first and second digits of his left hand respectively. (D, distal side; FCL, fibular collateral ligament; FH, fibular head; LE, lateral epicondyle; P, proximal side.)

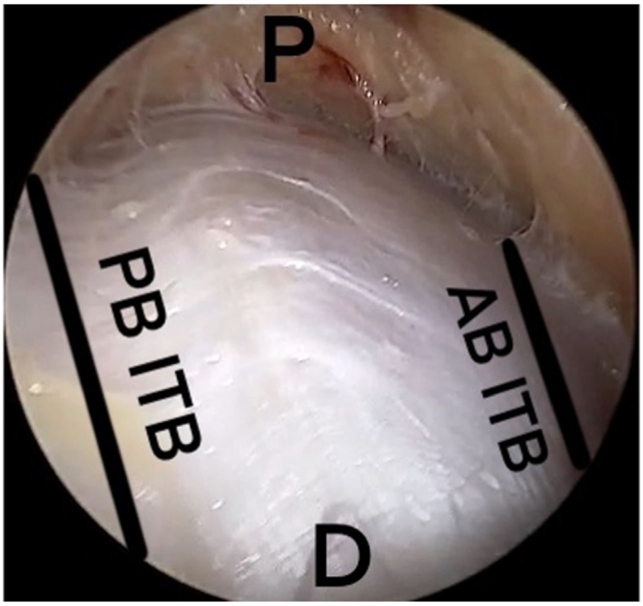

Fig 2. Arthroscopic view of the ITB. Shown is the arthroscopic view of the right ITB of a supine patient with knee in 90° flexion and neutral rotation. After subcutaneous dissection, an arthroscope is directed proximally and placed through the lateral skin incision into the potential space just superficial to the ITB. This allows the surgeon to directly visualize the anterior and posterior borders of the ITB and identify any superficial vessels. (AB ITB, anterior border of iliotibial band; D, distal side; ITB, iliotibial band; P, proximal side; PB ITB, posterior border of iliotibial band.)

The fibular head, fibular collateral ligament (FCL), and lateral epicondyle (LE) are palpated and marked on the skin. A 2-cm skin incision is made along the posterior aspect of the LE and directly in line with the ITB, starting 0.5 cm distal to the LE traveling proximal (Fig 1). The subcutaneous tissues are sharply divided down to the level of the ITB. Care is taken not to damage deeper structures including the FCL. The ITB fascia is incised distally 1 cm toward Gerdy's tubercle beneath the skin. A sponge is inserted between the ITB and subcutaneous fat to further expose the ITB when removed. A key elevator is used to elevate the remaining proximal and distal adhesions along the ITB. A skin marker is used to place a mark 5-cm proximal to the lateral epicondyle in-line with the skin incision to identify the proximal extent of the ITB harvest. This will ensure a sufficient length of ITB graft to pass beneath the FCL and attach to an isometric position on the femur.

Graft Harvest

Place the arthroscope into the potential space superficial to the ITB, allowing for visualization of its anterior and posterior borders (Fig 2). A 10-mm Parallel Graft Knife Blade (Arthrex, Naples, FL) is used to incise the ITB posterior to its midline along the length of the desired harvest (Fig 3). Ensure that the superior blade of the parallel knife is at or slightly posterior to the level of the mid-point of the LE. Arthroscopic scissors can be placed in-line with the arthroscope and used to extend the ITB incision proximally as needed. Ensure that the ITB is completely incised to the appropriate depth by visualizing the lateral compartment musculature deep to the ITB, taking care not to incise the underlying FCL distally (Fig 4). A Cobb elevator is placed between the 10-mm strip of ITB and underlying lateral compartment musculature to separate the 2 planes. With an 11 blade, create a small poke hole just anterior to the proximal extent of the harvest. Place arthroscopic scissors through the poke hole (Fig 5) and complete the harvest with a transverse cut of the ITB graft under direct visualization (Fig 6). This less-invasive harvest technique under direct visualization and before ACLR may in part decrease the risk of hematoma formation and allows surgeons to minimize their incision.

Remove the proximal end of the graft from the wound with its distal attachment still intact using curved-tip forceps. Grasp the proximal end of the graft with an Allis clamp and dissect away distal adhesions with Metzenbaum scissors to maximize excursion of the harvested tendon.

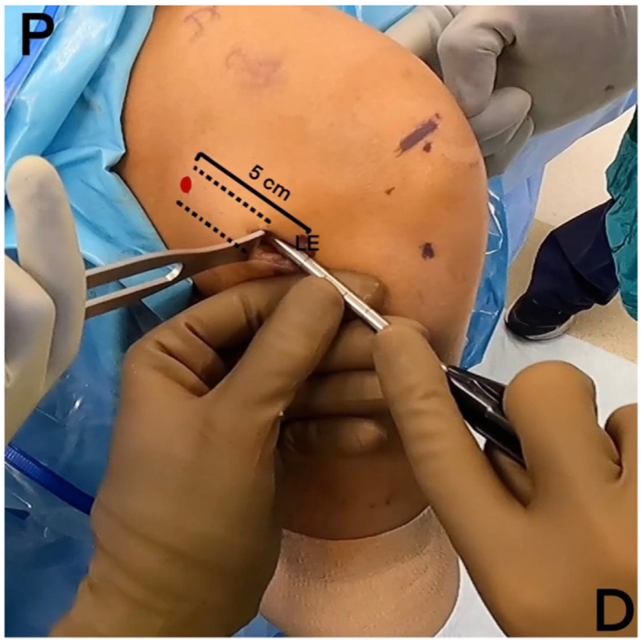

Fig 3. Parallel blade harvesting tendon. Shown is the right knee in 90° flexion and neutral rotation on a supine patient. A mark (red dot) is placed 5 cm proximal to the lateral epicondyle. A 10-mm Parallel Graft Knife Blade (Arthrex) is used to incise the ITB posterior to its midline for approximately 5 cm along the trajectory marked by the dotted line directly in line with the ITB fibers. The superior blade of the knife should be at or slightly posterior to the level of mid-point of the LE. (D, distal side; ITB, iliotibial band; LE, lateral epicondyle; P, proximal side.)

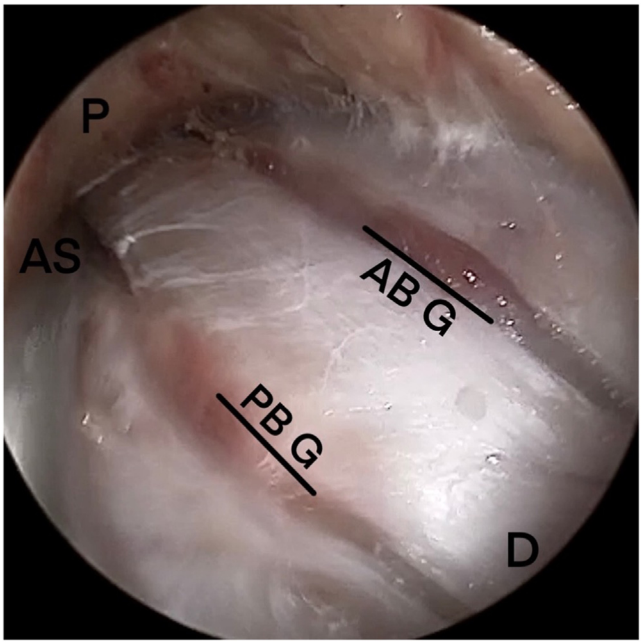

Fig 4. Arthroscopic view of the incised ITB. Shown is the arthroscopic view of the right ITB of a supine patient with knee in 90° flexion and neutral rotation. The anterior and posterior borders of the incised ITB are directly visualized. (AB G, anterior border of graft; D, distal aspect; ITB, iliotibial band; P, proximal aspect; PB G, posterior border of graft.)

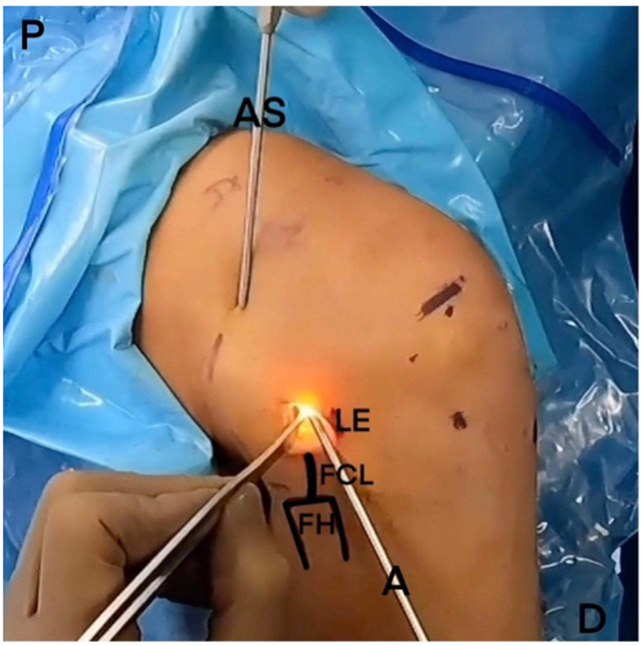

Fig 5. Portal for proximal graft harvest. Shown is the right knee in 90° flexion and neutral rotation on a supine patient. After a small incision is made just anterior to the proximal extent of the harvest, arthroscopic scissors can be placed anteriorly to posteriorly in preparation to complete the tendon harvest. (A, arthroscope; AS, arthroscopic scissors; D, distal aspect; FCL, fibular collateral ligament; FH, fibular head; LE, lateral epicondyle; P, proximal aspect.)

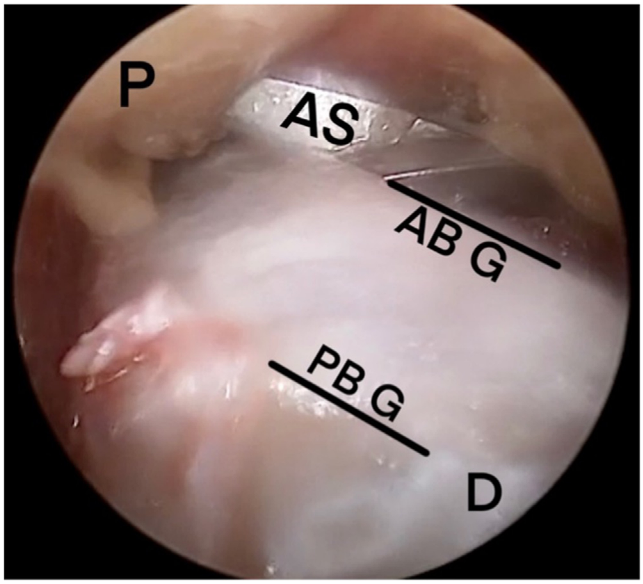

Fig 6. Arthroscopic view of scissors incising proximal edge of graft. Shown is the right ITB as viewed through the arthroscope in 90° flexion and neutral rotation on a supine patient. The arthroscopic scissors are used to incise the proximal end of the ITB strip under direct visualization. (AB G, anterior border of graft; AS, arthroscopic scissors; D, distal aspect; ITB, iliotibial band; P, proximal aspect; PB G, posterior border of graft.)

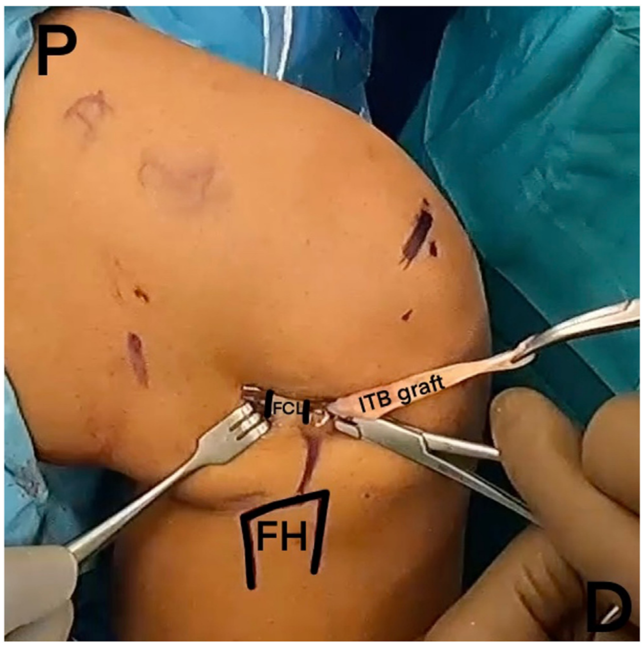

Fig 7. FCL is defined. Shown is the right knee in 90° flexion and neutral rotation on a supine patient. The ITB graft is pulled distally allowing the surgeon to visualize the underlying FCL and define its anterior and posterior borders. Curved-tip forceps are then placed to create a passage deep to the FCL from anterior to posterior and used to pull a passing suture through this passage. (D, distal aspect; FCL, fibular collateral ligament; FH, fibular head; ITB, iliotibial band; P, proximal aspect.)

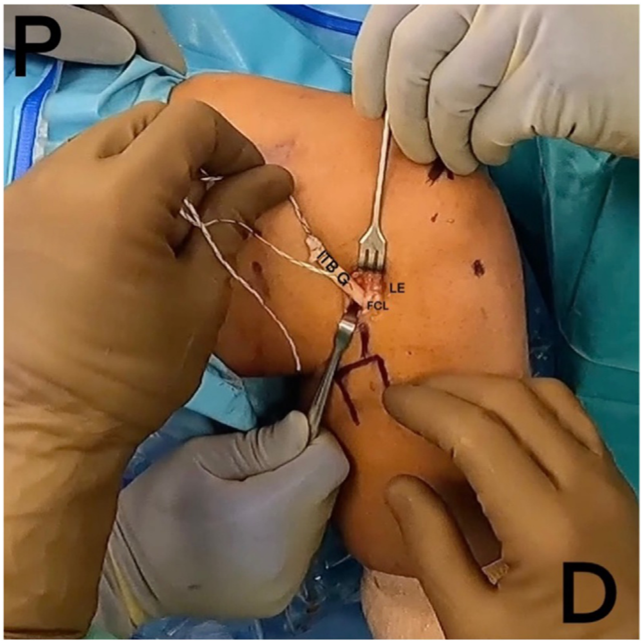

Fig 8. Graft shuttled deep to FCL. Shown is the right knee in 90° flexion and neutral rotation on a supine patient. The prepared ITB graft has been shuttled proximally deep to the FCL. At this point, the graft can be wrapped in vancomycin-soaked gauze and stored in the wound. The femoral tunnel for anterior cruciate ligament reconstruction is then drilled. (D, distal aspect; FCL, fibular collateral ligament; ITB, iliotibial band; LE, lateral epicondyle; P, proximal aspect.)

Passing Suture Shuttled Beneath FCL

While pulling the ITB graft distally, identify the anterior and posterior borders of the femoral attachment of the FCL. Slight varus stress can be applied to the knee to assist with identification of the FCL. Define the edges of the FCL using a bovie or knife and create a passage deep to the FCL. Place curved-tip forceps from anterior to posterior through this passage (Fig 7). Pull a passing suture through the passage and clamp the ends for later use.

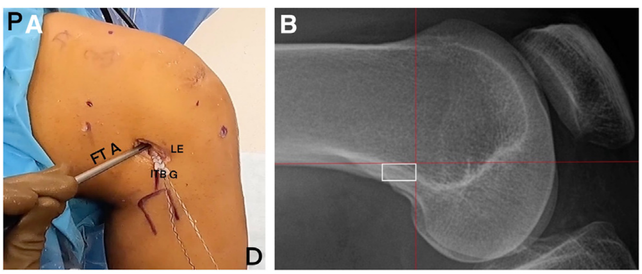

Fig 9. Anchor placement. (A) Depicts the right knee in 90° flexion and neutral rotation on a supine patient. The ACL femoral tunnel has been completed, but the ACL graft has not been pulled into the tunnel. A single-loaded Arthrex FiberTak knotless all-suture anchor is placed at the metaphyseal flare, 10 mm proximal to the lateral epicondyle and 5 mm posterior. A passing suture exiting from the ACL femoral tunnel is used to identify the location of the tunnel and avoid collision with the suture anchor. (B) The location of ideal placement of graft fixation is indicated by the white box. After the anchor is placed and set, the ACLR is completed. (ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament; rehabilitation; D, distal side; FT A, FiberTak anchor; ITB G, iliotibial band graft; LE, lateral epicondyle; P, proximal side.)

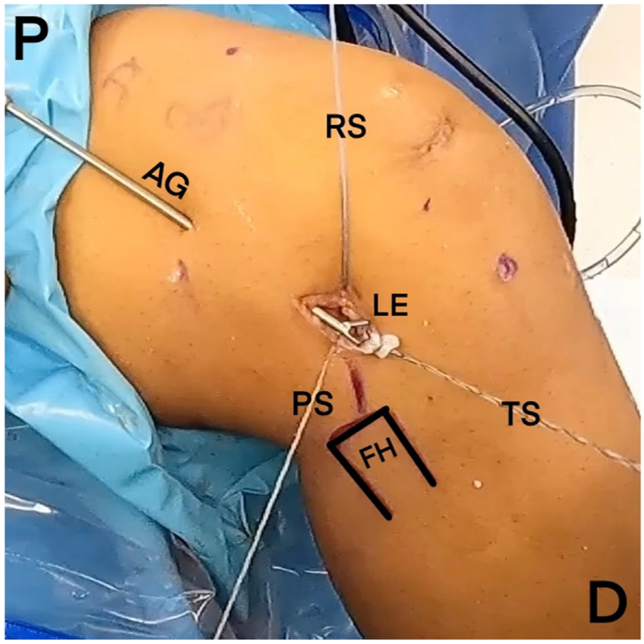

Fig 10. Reducing graft proximally after ACLR is complete. Shown is the right knee in <90° flexion and neutral rotation on a supine patient. After completion of the ACLR, the repair suture from the anchor is held over the anterior thigh, the looped "pull" suture is held posteriorly, and the tag suture is held distally. An arthroscopic grasper is placed through the previously created proximal incision and used to grasp the tag suture and pull it proximally, reducing the graft. (ACLR, anterior cruciate ligament; rehabilitation; AG, arthroscopic grasper; D, distal side; FH, fibular head; ITB, iliotibial band; LE, lateral epicondyle; P, proximal side; PS, pull suture; RS, repair suture; TS, tag suture.)

ITB Graft Preparation

The proximal 2 cm of the graft is whipstitched using a #2 SutureTape Loop suture (Arthrex). Use the previously shuttled passing suture to shuttle the prepared ITB graft proximally deep to the FCL (Fig 8). Wrap the suture and graft in a vancomycin-soaked 4 × 4 (5 mg/mL solution) and store the graft in the subcutaneous tissue for later fixation.[12]

Anchor Placement Before ACL Graft Passage and Fixation

Drill the ACL femoral tunnel and leave a passing suture exiting the femoral cortex to mark the ACL tunnel location. A single-loaded FiberTak knotless all-suture anchor (Arthrex) is placed at the metaphyseal flare, directly proximal or slightly posterior to the lateral

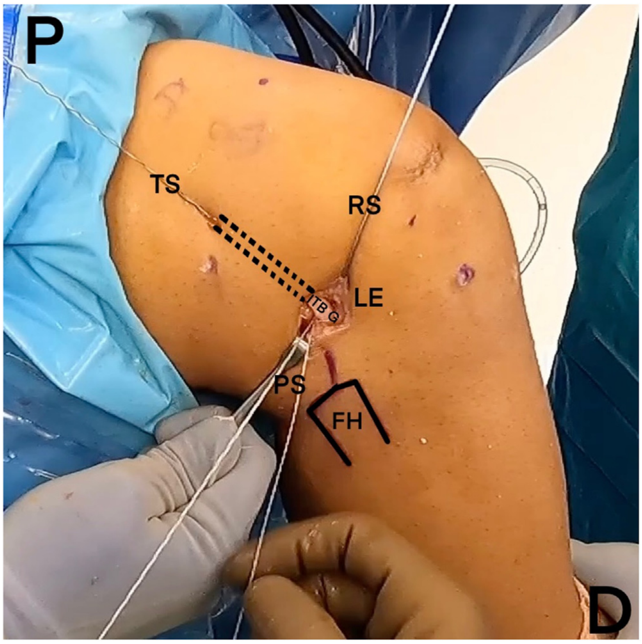

Fig 11. Reduced graft. Shown is the right knee in 90° flexion and neutral rotation on a supine patient. The graft is now reduced over the desired fixation point with its trajectory outlined (dotted lines). Gentle proximal traction is applied to the tag suture being careful to avoid over tensioning of the ITB graft. The repair suture is still over anterior thigh and the looped "pull" suture is still posterior to thigh. (D, distal side; FH, fibular head; ITB, iliotibial band; LE, lateral epicondyle; P, proximal side; PS, pull suture; RS, repair suture; TS, tag suture.)

epicondyle[13] (Fig 9A). Placement within an isometric area is demonstrated on radiograph (Fig 9B). Placing the suture anchor before the ACL graft being shuttled into the femoral tunnel obviates potential damage that the anchor drill could cause to the ACL graft or fixation device. After the anchor is inserted and pulled such that it balls up onto the femoral cortex, proceed with ACL reconstruction.

Graft Fixation and Wound Closure

After the ACL is fixed on both the femoral and tibial sides. Place an arthroscopic grasper through the proximal incision in line with the ITB graft. Grasp the tag suture of the ITB graft (Fig 10) and pull it proximally through the portal (Fig 11). The graft is now reduced over the desired fixation point. Hold gentle traction on the tag suture to remove laxity but avoid over-tensioning of the ITB graft. Place the repair suture through the looped end of the pull suture and pull the looped suture to bring the repair suture over the top of the tendon. Do not fully tighten the repair suture. Before fully tensioning the construct, bring the knee to neutral rotation and 30° of flexion to avoid over constraining the lateral compartment. After fully tensioning the construct, the tag sutures and remaining repair sutures are removed (Fig 12). The defect from ITB graft harvest can be closed or left open according to surgeon preference. If used, the tourniquet is released before wound closure. The subcutaneous tissue is then closed with 2-0 VICRYL suture and the skin is closed according to surgeon preference (Fig 13).

Postoperative Rehabilitation

Augmentation of ACLR with LET does not alter the postoperative rehabilitation protocol.

Discussion

Recent studies suggest that lateral knee augmentation (LA), such as LET, reduces stresses on the ACL graft during ligamentization, which supports graft strength and maturation.[14,15] The addition of LA to primary ACLR has also been shown to significantly reduce graft failure rates and persistent rotatory laxity without

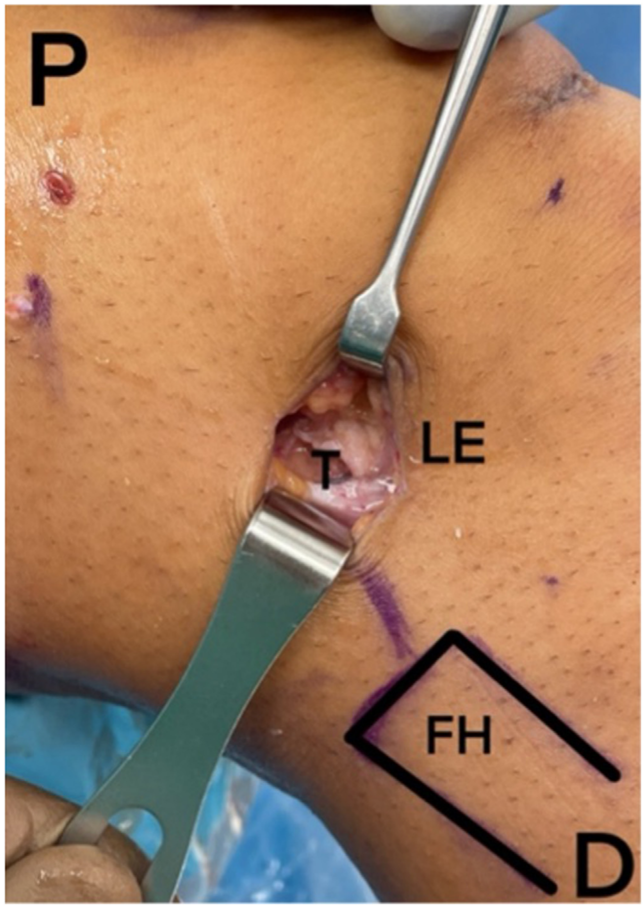

Fig 12. Fixed ITB graft with sutures removed. Shown is the right knee in 30° flexion and neutral rotation on a supine patient. After using the looped pull suture to bring the repair suture over the top of the tendon, the knee is brought to 30° flexion and neutral rotation. The construct is then fully tightened resulting in a reconstructed ALC. (AD, distal side; ALC, anterolateral complex; FH, fibular head; LE, lateral epicondyle; P, proximal side; T, tenodesis.)

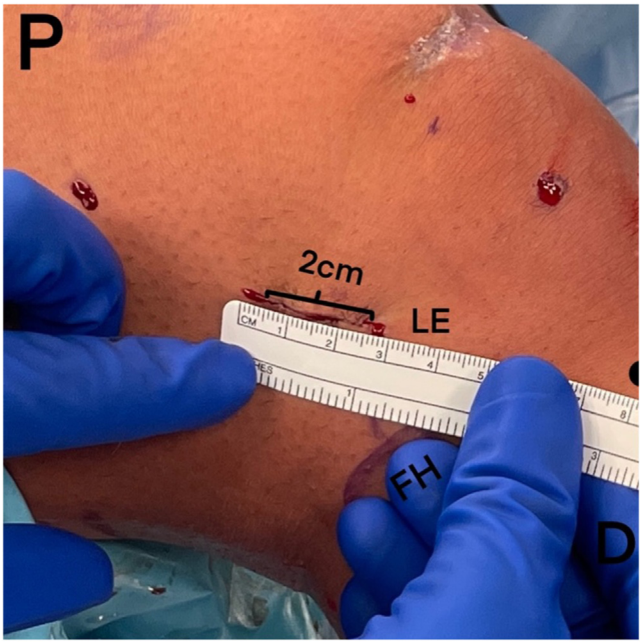

Fig 13. Closed incisions. Shown is the right knee in 30° flexion and neutral rotation on a supine patient. The 2-cm incision is closed. (D, distal side; FH, fibular head; LE, lateral epicondyle; P, proximal side.)

jeopardizing patient-reported outcomes at a minimum of 2 years' postoperatively.[3] Getgood[16] suggested the addition of an LA procedure for patients with 2 or more of the following risk factors: Returning to contact pivoting sports; high-grade anterolateral rotatory laxity; and generalized ligamentous laxity. A recent publication from Borque asserts that all elite athletes undergoing ACLR may be candidates for LET, as failure rates were markedly reduced with concomitant LET.[7]

We prefer to fully tension our construct after bringing the knee to neutral rotation and 30° of flexion. Inderhaug et al.[17] investigated tibiofemoral joint contact pressures and kinematics in the setting of a MacIntosh tenodesis while varying graft tension and tibial rotation during graft fixation. In this cadaveric study, the authors found that controlling tibial position while tensioning only produced subtle changes that may not be clinically significant in a fully loaded knee. However, the authors found that native knee laxity was successfully restored by ACLR and the modified LET whether the graft was tensioned at 0, 30, or 60° of flexion.[18] Kittl et al.[19] reported that all femoral positions for LET between the distal Kaplan's fibers, which is the location for a MacIntosh tenodesis and the lateral epicondyle, are isometric for grafts passed beneath the FCL. Jaecker et al.[13] subsequently reported a safe isometric area for femoral attachment of LET at or proximal to the metaphyseal flare and on or posterior to the posterior cortical extension line. We aim to place our anchor within this isometric attachment area, and as such, degree of flexion at which the LET is fixed may be less relevant due to isometry.

Reported LA complications include increased pain and delayed recovery in quadriceps strength that has only been reported to persist for 6 months.[10] In addition, drilling an additional tunnel in the lateral femoral condyle may lead to converging with the ACL tunnel or implant. The morbidity associated with an additional procedure also raises potential concerns. To mitigate these, other minimally invasive approaches have been described allowing surgeons to operate through 3- or 4-cm incisions.[20,21] Our proposed arthroscopic-assisted surgical technique requires only a 2-cm skin incision and an accessory nick incision and allows for direct visualization throughout the procedure. In conclusion, this technique allows surgeons to closely restore native knee kinematics while minimizing morbidity and graft or implant compromise.

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