

Combined Anterior Cruciate Ligament Reconstruction and Lateral Extra-Articular Tenodesis in Skeletally Immature Patients: Surgical Technique



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Abstract: Pediatric anterior cruciate ligament (ACL) reconstructions have a relatively high risk for re-rupture, and a low proportion of these patients report a successful return to sport. With an increasing emphasis on youth participation in pivoting sports, the incidence of these injuries has increased in recent years. A reappreciation of lateral extra-articular stabilizing procedures in high-risk adult populations who undergo ACL reconstruction has demonstrated potential improved outcomes for vulnerable ACL reconstructions. However, the open status of the pediatric physes makes the use of these procedures more challenging. Therefore, the purpose of this Technical Note is to describe the current authors' surgical technique for a combined ACL reconstruction with a lateral extra-articular tenodesis for these high-risk patients with open physes.

Return to high-level sports and the rate of re-rupture following anterior cruciate ligament (ACL) reconstruction in high-risk patient populations remain unsatisfactory; thus, lateral extra-articular augmentation procedures have recently generated increased focus regarding their ability to augment an ACL reconstruction.¹⁻⁶ Both lateral extra-articular tenodesis (LET) procedures and anterolateral ligament reconstructions help prevent increased/residual anterolateral rotary instability of the knee, which has been

shown to decrease tension on the ACL reconstruction graft.^{7,8} A variety of specific surgical techniques have been described for both procedures, but generally, anterolateral ligament reconstructions use a graft spanning the joint line with either 2 or 3 separate bony fixation points, and LET procedures anchor a surgically mobilized segment of the iliotibial band (ITB) to the lateral femoral condyle.^{4,9} Although the specific indications for the use of these procedures are controversial, recent literature has reported that this surgical augmentation significantly reduces the risk of ACL reconstruction failure.^{10,11} In a randomized control trial, primary ACL reconstructions with a hamstring autograft had a 2-year failure rate of 11%, whereas ACL reconstructions with a combined LET (modified Lemaire technique) had a 4.5% failure rate without any difference in subjective patient-reported outcomes.¹⁰

Biomechanical studies have shown that both of these anterolateral complex procedures significantly reduce internal tibial rotation and anterolateral rotary instability, and when combined with ACL reconstructions, are able to restore anterior tibial translation to comparable amounts seen in native, healthy knees.¹ Because of the anatomic location of the anterolateral ligament and its proximity to the epiphyseal growth plates, an ALL reconstruction, in particular with larger transosseous tunnel/interference screw fixation, is not

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Table 1. Pearls and Pitfalls for the Surgical Technique of Combined ACL Reconstruction With a Lateral Extra-Articular Tenodesis for Patients With Open Physes

Pearls	Pitfalls
Dissect and expose the ITB autograft before detaching the graft proximally, as it can be more difficult to clean once the graft is mobilized	Disrupting the femoral physes may result in physeal arrest and intraoperative fluoroscopy is invaluable
Carefully clear the soft tissue deep to the fibular collateral ligament, to ease the passage of the iliotibial band: The FCL can be palpated with varus stress or figure 4 positioning	Failure to provide lateral extra-articular stabilization may put increased tension on the reconstructed ACL graft in these high-risk individuals
Use intraoperative fluoroscopy before LET graft fixation to ensure that femoral fixation does not violate the femoral physis.	Avoid placing the suture anchor or staple-fixation device across the open physis
Aim the fixation device distally (suture anchor) or proximally (staple) to avoid violating the open physis	Not ensuring that the tibia is in neutral rotation during tensioning and fixation of the LET graft may result in under- or overconstraint of knee internal rotation or prevent adequate protective effects of the LET
When staple fixation is used, suture the LET graft back onto itself	Harvesting the ITB graft too posteriorly could disrupt the remaining Kaplan's fibers

ACL, anterior cruciate ligament; FCL, fibular collateral ligament; ITB, iliotibial band; LET, lateral extra-articular tenodesis.

recommended in the pediatric population. Conversely, a modified Lemaire LET requires only one surgical femoral fixation point, making this procedure a more promising and potentially safer option for patients with open physes.

Table 2. Advantages and Disadvantages of the Approach of Combined ACL Reconstruction With a Lateral Extra-Articular Tenodesis for High-Risk Patients With Open Physes

Advantages	Disadvantages
Does not violate the tibial physis, as it does not require fixation on the tibial side	Nonanatomic iliotibial graft placement on the lateral distal femur when using a staple
Use of intraoperative fluoroscopy allows the surgeon to identify the physes and appropriate fixation site on the femur	Lateral incision and dissection, which can increase postoperative pain
Provides lateral extra-articular stabilization/additional anterolateral rotatory stability in an inherently high-risk patient population	Potential for overconstraint of the knee and restriction of tibial rotatory motion

Surgical Technique (With Video Illustration)

A detailed video of the technique is shown in [Video 1](#). Pearls and pitfalls of this technique and the advantages and disadvantages for this approach are described in [Tables 1](#) and [2](#), respectively.

Indications and Contraindications

The current authors' primary indications for ACL reconstruction combined with LET in a patient with open physes ([Fig 1](#)) are revision ACL reconstruction, a high-grade pivot shift on clinical examination, generalized ligamentous hyperlaxity, and primary ACL reconstruction in patients with increased posterior tibial slope ($>12^\circ$). Secondary indications include chronic ACL insufficiency, meniscus insufficiency, depression of the lateral femoral condyle observed on preoperative radiographs (notch sign), and high-level athletes participating in a sport that requires pivoting. Potential contraindications to LET include lateral compartment arthritis or injury to the posterolateral corner requiring posterolateral corner reconstruction.

Patient Positioning and Anesthesia

The patient is placed in the supine position on the operating table. After the induction of general anesthesia, a bilateral clinical knee examination is performed to evaluate for concurrent ligamentous instability patterns, generalized ligamentous laxity, to assess knee range of motion, and to reassess the pivot shift. A well-padded high-thigh tourniquet is subsequently placed on the operative leg, which is then placed into a leg holder (Mizuho OSI, Union City), whereas the contralateral knee is placed into an

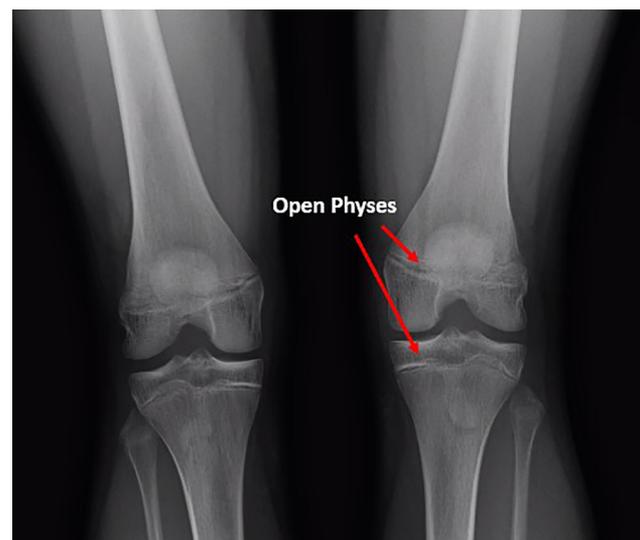
**Fig 1.** Preoperative bilateral Rosenberg radiographic views demonstrating the physeal status of the patient. One can identify the open physes for this patient.



Fig 2. Image of a left knee demonstrating limb positioning for the procedure. The patient is placed in a supine position and the surgical limb is sterilized and draped in a free hanging position.

abduction stirrup (Birkova Product LLC, Gothenburg, NE) or soft padded well leg holder (Fig 2).

Transphyseal ACL Reconstruction

Standard anterolateral and anteromedial portals are established adjacent to the patellar tendon. The joint is insufflated with normal saline and visualized with a 30° arthroscopic camera (Smith & Nephew, Andover, MA). A complete diagnostic arthroscopy is performed to assess for any concomitant intra-articular pathologies. Any meniscal tears or cartilage lesions should be repaired or appropriately managed at this time. An arthroscopic shaver (Smith & Nephew) is inserted into the knee and the ACL remnant is debrided, leaving the femoral and tibial footprints intact to allow for anatomic single bundle reconstruction. A 2- to 3-cm incision is made over the superolateral aspect of the knee and careful sharp dissection is carried down through the subcutaneous tissue to the ITB.

The ITB is split, the vastus lateralis is elevated, and the femoral tunnel outside-in technique is used with a rear entry guide (Acufex; Smith & Nephew). The tibial tunnel is drilled with a Howell tibial guide (Biomet Sports Medicine, Warsaw, IN), or any available ACL

tibial guide, and repositioned as necessary to recreate the anatomic tibial footprint. Intraoperative fluoroscopy can be used at this point to confirm an extraphyseal position for both the tibial and femoral tunnel fixation. A quadrupled hamstring autograft was used for the ACL reconstruction in this particular case.¹²

Lateral Extraarticular Tenodesis

Anatomical landmarks on the lateral aspect of the knee are marked, including the head of the fibula, the fibular collateral ligament (FCL), and the distal ITB and its insertion at Gerdy's tubercle (Fig 3). A 3-cm superficial skin incision is made over the FCL origin. Alternatively, a larger incision can be made to allow for

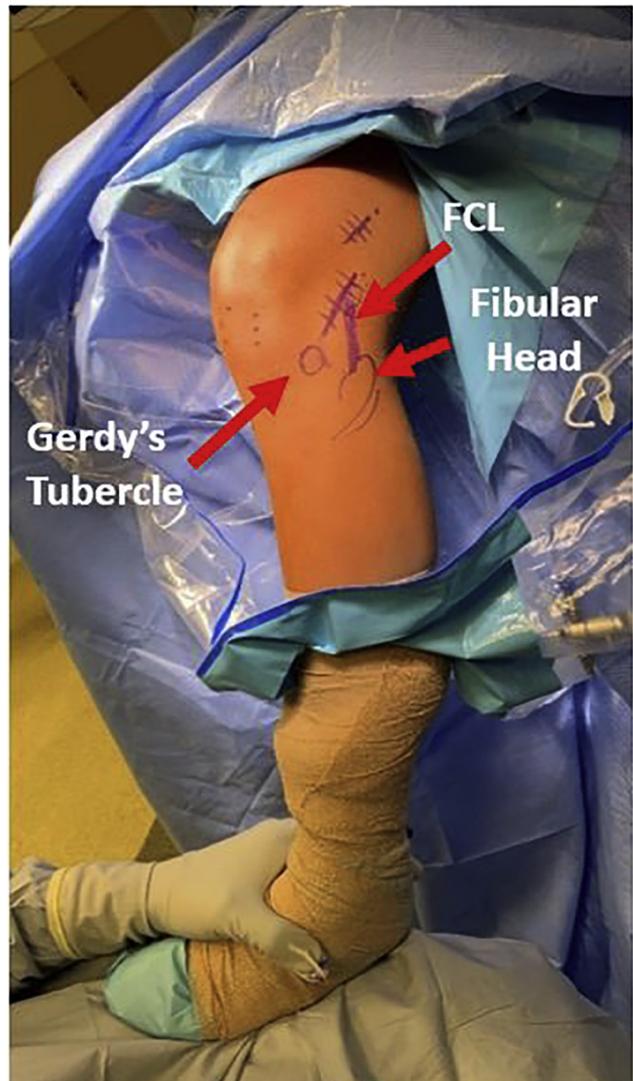


Fig 3. Image of a left knee demonstrating the anatomical landmarks that are identified before making the initial lateral skin incision. Gerdy's tubercle, the fibular head, and the FCL are each identified. In addition, the lateral extra-articular tenodesis at the lateral epicondyle and the lateral incision for the anterior cruciate ligament reconstruction are marked. (FCL, fibular collateral ligament.)



Fig 4. Intraoperative image from a lateral viewpoint in a left knee. This image shows the ITB graft after preparation and mobilization. The graft was taken from the posterior third of the distal ITB and is 7 cm in length and 1 cm in width. The Gore Smoother is kept in the anterior cruciate ligament tunnels that have already been drilled. (ITB, iliotibial band.)

femoral tunnel and ITB preparation through the same incision. Sharp dissection is carried down until reaching the ITB. Care should be taken to expose the posterior third of the ITB that will be used as the LET graft. Using Metzenbaum scissors, an incision is made along the posterior one-third of the ITB beginning just proximal to Gerdy's tubercle and continuing proximally; the strip should be 1 cm in width and approximately 7 to 9 cm in length, making sure to leave a portion of the posterior ITB with Kaplan's fibers intact (Fig 4).

The FCL is then identified by providing a varus stress to the knee and by direct palpation. Through dissection of soft tissue, with care taken not to disrupt the ligament or the underlying capsular structures, a tunnel deep to the FCL is then prepared. Using a passing stitch and a grasping device, the ITB graft is passed deep to the FCL through the channel created in the previous step (Fig 5). Prior to LET femoral fixation preparation, a Gore Smoother (Smith & Nephew) is placed in the

femoral and tibial tunnels and can be used to verify that femoral LET fixation does not converge with the ACL femoral tunnel. Alternatively, the arthroscope can be placed down the femoral tunnel if a suture anchor or tunnel is reamed in order to verify tunnel non-convergence. The proximal site of the LET fixation is then identified and prepared using an osteotome or curette. In the pediatric population, intraoperative fluoroscopy is used to identify a fixation point that is adjacent to the distal Kaplan fiber attachment and that does not violate the open physis (Fig 6).¹³ Our preferred fixation method is a double-armed Q-Fix suture anchor (Q-fix, Smith & Nephew). When placing the anchor distal to the femoral physis, the device is aimed distally to ensure that the growth plates are not disturbed while also allowing for anatomic graft fixation (Fig 7). Alternatively, if a tunnel or staple are used, or the growth place is in line with the anatomic ALL femoral origin, fixation can be placed proximal to the femoral physis when the ITB is routed deep to the FCL. The ACL graft is then passed and the femoral side is fixed with a large ENDOBUTTON (Smith & Nephew) and the tibial side is secured below the tibial physis with a WasherLoc (Biomet, Warsaw, IN) or screw and soft-tissue washer with the knee in full extension (Fig 8). Attention is then paid to securing the LET. Although

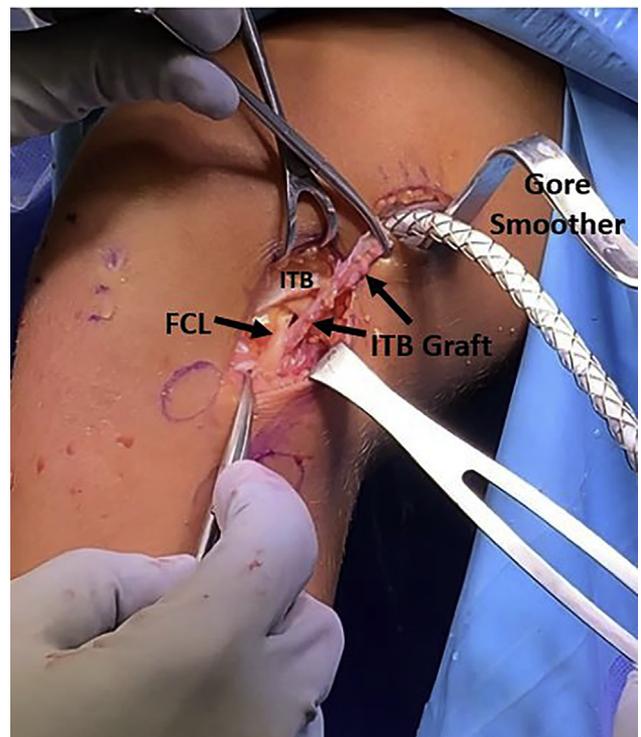


Fig 5. Intraoperative image from a lateral viewpoint in a left knee. This image shows the ITB graft after it was passed deep to the FCL. The Gore Smoother is kept in place of the anterior cruciate ligament tunnels. (FCL, fibular collateral ligament; ITB, iliotibial band.)

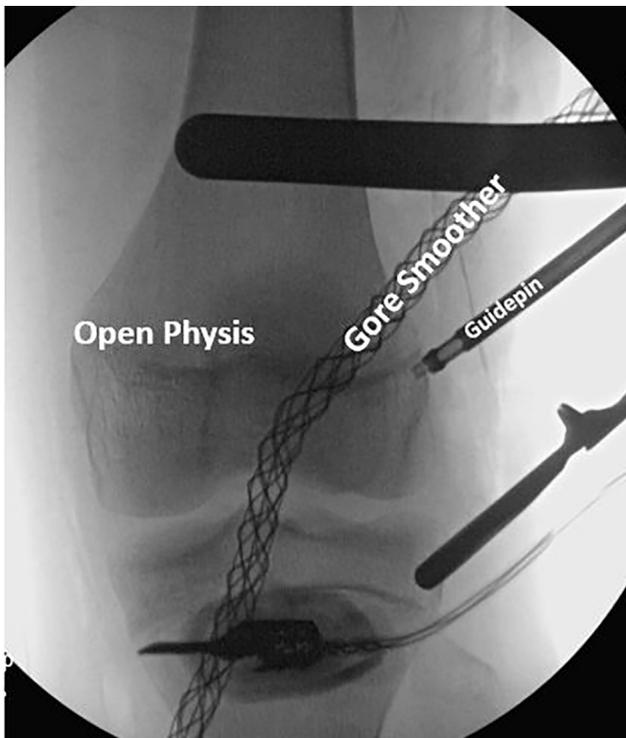


Fig 6. Intraoperative anterior posterior left knee fluoroscopic image allows for identification of the open femoral physis. It is important to identify the physis to place the guide pin/lateral extra-articular tenodesis fixation point distal to the physis when using a suture anchor. In addition, this image shows the Gore Smoother in the anterior cruciate ligament tunnels; note the transphyseal surgical technique.

controversial, in the current authors' practice, LET fixation is performed with the knee at 30° of flexion and with the tibia in neutral rotation. The femoral side of the LET graft is then secured to the femur using the previously placed double-armed Q-fix suture anchor or staple placed proximal to the femoral physis. The isometry of the graft is then observed from 90° of knee flexion to full extension. The LET graft is observed becoming taut with internal tibial rotation. Finally, the ITB is closed with #0 VICRYL sutures and the incisions are closed in the standard fashion.

Postoperative Protocol

After the procedure, the patient is weightbearing as tolerated with the use of crutches for a minimum of 2 weeks. Patients may discontinue crutches once they can walk without a limp. The patient is placed into a functional hinge brace (T Scope Premier, Breg, Carlsbad, CA; or CTi, Ossur, Foothill Ranch, CA) postoperatively. Physical therapy begins on postoperative day 1 with a focus on pain control, reducing swelling, and early knee range of motion. There are no restrictions for knee motion, but a gradual progression is essential. There are no additional restrictions based

upon the concurrent LET in the setting of ACL reconstruction. Stationary cycling begins around 3 to 4 weeks postoperatively, and a generalized strengthening progression is initiated at this time. Running and straight-line functional activities may begin at 4 to 5 months postoperatively once sufficient core strength is obtained and the patient has been meeting progressive milestones. At 6 months postoperatively, clinical/functional sports testing is performed to ensure adequate stability, and patients may begin a gradual return to sport progression at this time. Clearance for full activities with no restrictions is allowed following a functional sports test between 7 and 9 months postoperatively. In this high-risk patient population, the current authors are typically more conservative regarding return to sports timelines.

Discussion

This Technical Note describes our surgical technique for performing a combined ACL reconstruction and LET in a patient with open physes and an inherently high risk for ACL reinjury. A detailed understanding of the anterolateral knee anatomy, and use of intraoperative fluoroscopy, are integral for a successful lateral extra-articular augmentation. Skeletal maturity should be assessed both clinically and radiographically before surgery, and when indicated in a high-risk patient

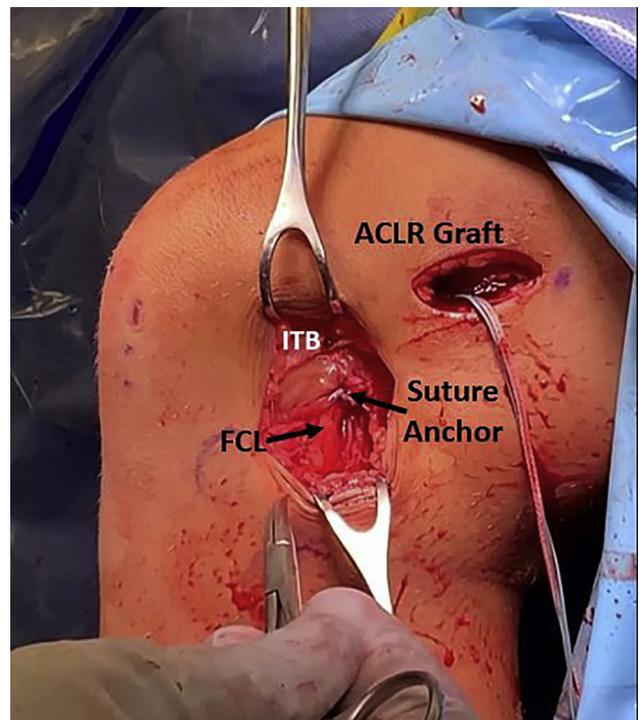


Fig 7. Intraoperative image from a lateral viewpoint in a left knee. This image shows the lateral extra-articular tenodesis after fixation with a suture anchor. The ITB graft courses deep to the FCL. (ACLR, anterior cruciate ligament reconstruction; FCL, fibular collateral ligament; ITB, iliotibial band.)



Fig 8. Postoperative left knee AP radiograph demonstrating the anterior cruciate ligament hardware positioning with screw and washer fixation in tibia and XTENDOBUTTON (Smith & Nephew) on the femur.

presenting with ACL tear, a combined ACL reconstruction and LET can be successfully performed with careful presurgical and intraoperative planning.^{14,15} Use of intraoperative fluoroscopy is crucial to avoid placing the suture anchor or staple fixation through or across the femoral physis that may compromise future growth. Potential complications include growth arrest with subsequent angular deformity and or limb length discrepancy, tunnel convergence with the ALL reconstruction or LET and the concurrent ACL reconstruction, creating an ALL or LET graft that is inappropriately sized, and overconstraint of the knee; however, these risks are decreased with intraoperative fluoroscopy and direct visualization during fixation, and fixation with the knee in neutral rotation.

The addition of lateral extra-articular augmentation procedures in combination with ACL reconstructions have yielded encouraging early results in adults, including significantly lower graft failure rates without compromising subjective patient outcomes.^{10,16} These procedures have garnered particular interest in high-risk patient populations, including pediatric patients,

those with a high grade pivot shift, patients with soft-tissue grafts with open physes, generalized ligamentous laxity, those undergoing revision ACL reconstruction, and high-level athletes participating in a sport that requires pivoting. Recent studies have reported that isolated ACL reconstructions in pediatric athletes have a 10% to 25% graft re-rupture rate, with less than 70% of patients reported to return to sport.^{12,17-20} In addition, patients with generalized hypermobility and increased heel height/knee hyperextension have reported high ACL reinjury rates.²¹⁻²³ Recent systematic reviews have reported that extra-articular procedures reduce knee instability observed on the pivot shift maneuver and subsequently decrease the forces on the ACL graft.²⁴⁻²⁷ It is unclear whether the addition of an LET in a skeletally immature patient might increase the risk for growth disturbances secondary to the forces placed across the developing physes. This has not been observed by the current authors. Therefore, the potential utility of LET to augment ACL reconstructions in a high-risk pediatric patient population is encouraging.

This Technical Note describes an approach for a LET combined with ACL reconstruction in patients with ACL deficiency and open physes. The use of intraoperative fluoroscopy aids in the avoidance of the femoral physis during the LET. Further clinical studies are needed to assess subjective and objective clinical outcomes and the potential risks of concurrent ACL reconstruction and LET in skeletally immature patients.

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