Technical Note

Modified Lemaire Lateral Extra-Articular Tenodesis Using an Inlay Technique and All-Suture Knotless Anchor Fixation

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Abstract: Appreciation of persistent anterolateral rotatory instability and graft failure after anterior cruciate ligament (ACL) reconstruction procedures has led surgeons to adopt the addition of lateral extra-articular tenodesis (LET) in both the revision and primary setting. Multiple techniques have been shown to eliminate anterolateral rotatory instability and reduce forces on the ACL graft, which has translated to lower re-rupture rates and improved patient outcomes. The risk of ACL/LET tunnel convergence can potentially compromise the fixation of one or both graft reconstructions. This article describes a technique for LET fixation which minimizes the depth of the LET femoral bone socket and utilizes low-profile implants thus mitigating this risk.

Lateral extra-articular tenodesis (LET) recently has received renewed interest within the orthopaedic community for the purposes of augmenting anatomic anterior cruciate ligament (ACL) reconstruction in both the primary and revision setting. Since the first description by Lemaire in 1967,[1] reconstruction of the LET construct was recognized to reduce anterior tibial rotatory instability and eliminate the pivot shift. The pursuit of the "anatomic" ACL reconstruction led many surgeons to abandon extra-articular procedures; however, evidence over the last couple of decades have highlighted shortcomings of isolated ACL reconstruction.

Several biomechanical and clinical studies have demonstrated isolated ACL reconstruction often does not fully restore rotational stability to the knee.[2-5] Persistent pivot shift and rotational instability have been correlated with poorer patient-reported outcome measures, lower rates of return to sport, greater re-rupture rates, and potentially earlier progression of degenerative knee changes.[6-8]

Mounting biomechanical and clinical evidence demonstrates the addition of LET is more effective in reducing the pivot shift and restoring rotational stability to near-normal knee biomechanics[9] and can be performed without overconstraining the lateral compartment.[10-12] Addition of LET in adolescents, high-risk and/or contact athletes, and those with high-grade pivot shift has demonstrated excellent clinical results

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Fig 1. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. A 3- to 5-mm longitudinal incision is made beginning 1 cm proximal to the lateral epicondyle and extending toward Gerdy's tubercle.

and significant decreases in the relative risk of re-rupture by as much as 30% to 58%.[13,14] Several randomized controlled trials comparing isolated ACL reconstruction versus ACL with LET have demonstrated equivalent or improved clinical outcome scores with the addition of LET and significantly reduced re-rupture rates without significant additional morbidity.[15,16] A recent meta-analysis and systematic review of seven randomized controlled trials found addition of LET reduced the re-rupture rate by 3 times.[13]

There are many described techniques for LET that have been shown to effectively restore rotational stability in the setting of ACL reconstruction.[17] One major technical concern while performing LET in conjunction with ACL reconstruction is the high risk of tunnel convergence with the ACL femoral tunnel.[18,19] Here, we will describe a modified Lemaire LET using a technique for proximal fixation of the iliotibial band autograft, which mitigates this risk.

Surgical Technique (With Video Illustration)

Graft Harvest/Preparation

The iliotibial band (ITB) graft can be harvested before or after ACL reconstruction. Based on the patient's habitus, a 3-cm to 5-cm incision is created, beginning 1 cm to 2 cm proximal to the lateral epicondyle and carried toward Gerdy's tubercle (Fig 1). The ITB fibers should be clearly exposed proximally and distally. The center of the lateral epicondyle is palpated and marked, and a 10-mm to 12-mm strip of the ITB is created, centered over this point, and carried distally to the insertion at Gerdy's, where it is left attached (Fig 2).The strip is then continued proximally to a point 2 cm proximal to the lateral epicondyle, where the strip is detached from the proximal ITB and dissected from the underlying investments (Fig 3).The proximal 15 mm of the tail of the ITB autograft is then prepared using a nonabsorbable #0 braided suture in a Krakow or whip-stitch configuration (Fig 4).

Sub-Fibular Collateral Ligament (FCL) Graft Passage

It is critical to shuttle the ITB tenodesis beneath the FCL, as this ensures a graft trajectory will best control excessive anterolateral internal rotation in both knee flexion and extension. Sub-FCL passage also eliminates mechanical subluxation of the graft across the epicondyle. After resecting the overlying bursa, the FCL can be easily palpated. Using a blade or electrocautery, make small, 15-mm incisions in the capsule parallel to the FCL immediately anterior and posterior to it, just distal to the FCL origin on the epicondyle (Fig 5). Keeping these parallel incisions adjacent to the proximal FCL will minimize the risk of injury to the lateral geniculate vessels. A blunt Kelly clamp can then be used to develop and slightly widen a plane just deep to the FCL (Fig 6). Place a shuttle suture loop from posterior to anterior and shuttle the ITB graft from anterior to posterior beneath the FCL (Fig 7).

Confirmation of Femoral Insertion Isometry

An isometric position for femoral insertion of the ITB graft is critical so the graft will not overconstrain

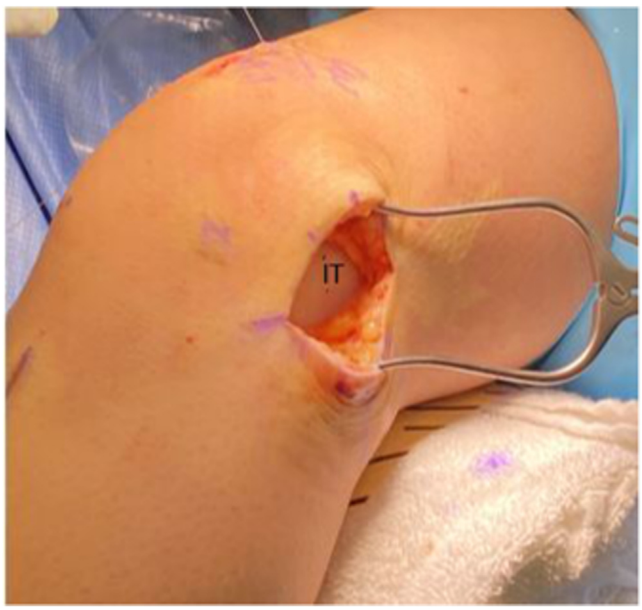

Fig 2. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. After exposure of the IT, a 10-mm wide strip of IT is marked centered over the lateral epicondyle and directed towards Gerdy's tubercle. (IT, iliotibial band.)

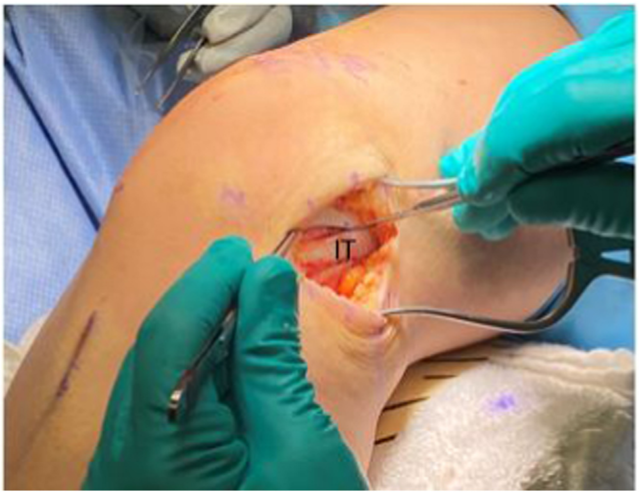

Fig 3. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. A 10-mm strip of IT is then created extending distally to Gerdy's tubercle and proximally 2 to 2.5 cm beyond the lateral epicondyle. (IT, iliotibial band.)

rotational motion in flexion or extension. This isometric position is reliably located about 1 cm proximal and 1 cm posterior to the center of the FCL origin on the epicondyle (at the base of its rounded protuberance). A long 3.2-mm reamer guide pin is placed at this point, directed slightly proximally and anteriorly or away from the common trajectory of the ACL tunnel in the femur, and inserted to a depth of 25 mm (Fig 8).The prepared tail of the ITB graft can now be looped over the reamer guide pin and the knee is taken through a full range of flexion and extension. If correctly placed, there should be no graft excursion throughout a full range of motion.

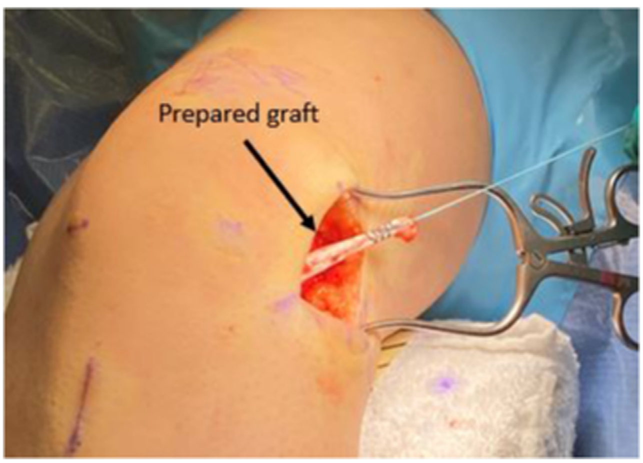

Fig 4. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. The proximal portion is then sharply incised transversely while leaving the distal attachment intact. Deep investing attachments are released, and the proximal 15 mm is sutured using a locking stitch configuration with nonabsorbable braided suture.

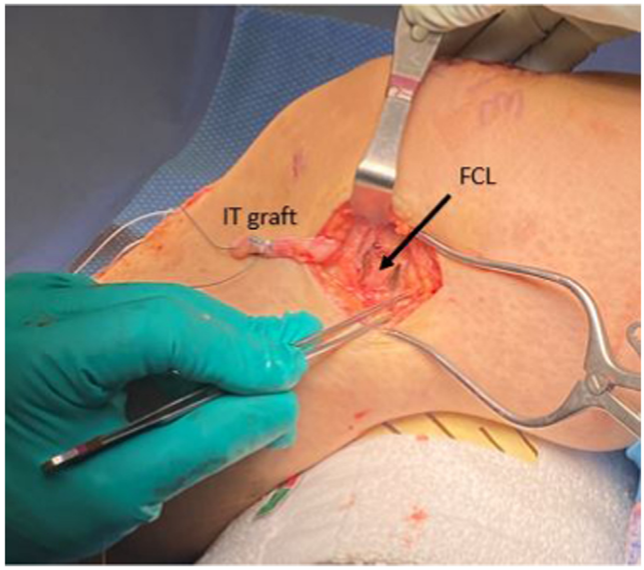

Fig 5. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. The FCL origin at the lateral epicondyle is identified. Incisions are made anterior and posterior to the ligament to allow for graft passage deep to the FCL. (FCL, fibular collateral ligament; (IT, iliotibial band.)

Femoral Socket Creation and Anchor Insertion

After confirming the ideal isometric point clear of the FCL origin, a 6-mm or 7-mm reamer is placed over the reamer guide pin and the outer cortex of the bone is reamed to a depth of 10 mm to 15 mm maximum (Fig 9). Drilling a shallow socket to this reaming depth creates a healing bed for the graft yet minimizes the risk of intersection with a normally positioned anatomic ACL femoral tunnel. For this procedure, the authors prefer to use a 2.6-mm Knotless FiberTak (KFT) Anchor (Knotless FiberTak; Arthrex, Naples FL). Because the 3.2-mm

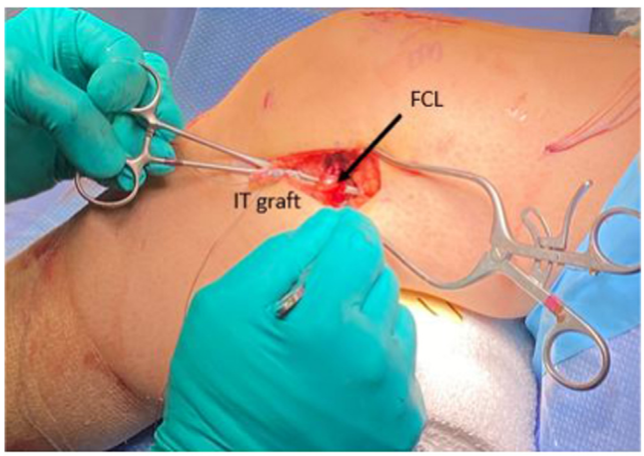

Fig 6. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. A hemostat is used to develop the plane deep to the FCL and just distal to the epicondyle in preparation for passage of the IT graft deep to the FCL. (FCL, fibular collateral ligament; (IT, iliotibial band.)

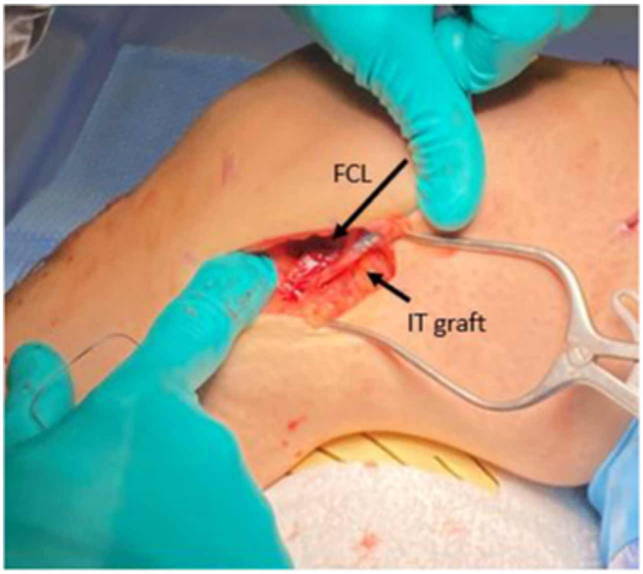

Fig 7. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. IT graft has been passed deep to the FCL to the insertion point which is approximately 1 cm proximal and posterior to the center of the FCL origin at the lateral epicondyle. (FCL, fibular collateral ligament; IT, iliotibial band.)

reamer guide pin is very close to the 3.5-mm diameter of the pilot drill for the KFT, there is no need to re-drill. The drill guide for the KFT is placed over the reamer guide pin into the base of the femoral socket, and the reamer guide pin is removed (Fig 10).The suture anchor is then inserted and deployed by tugging the anchor against the cortex. Setting the anchor in this way will reduce the risk of anchor pull out due to the design of the all-suture anchor (Fig 11).

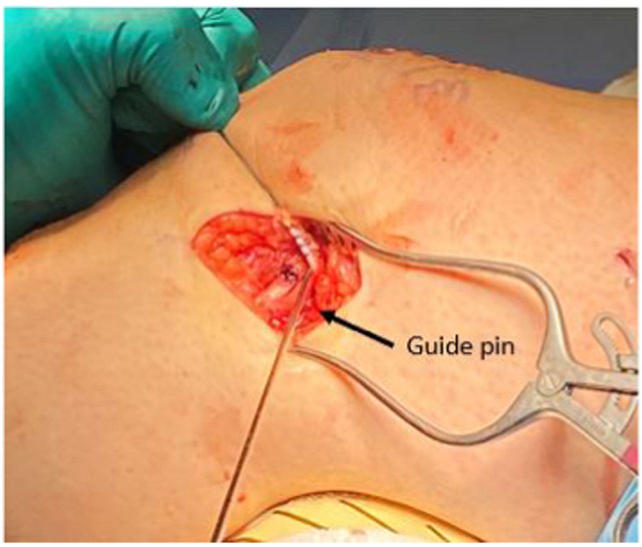

Fig 8. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. A guide pin is placed at the femoral attachment site aiming proximal and anterior to avoid penetration of the ACL femoral tunnel. Graft isometry is evaluated by wrapping the graft around the guide pin and taking the knee through a range of motion. (ACL, anterior cruciate ligament.)

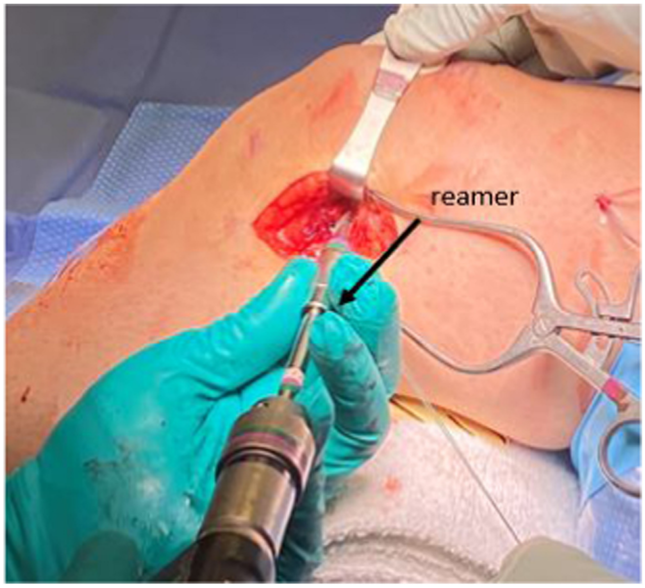

Fig 9. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. A shallow, 10 to 15 mm socket is drilled over the guide pin using a 6- or 7-mm reamer. This ensures an adequate biologic environment for graft healing while minimizing risk of ACL tunnel intersection. The graft is retracted out of the way by an assistant. (ACL, anterior cruciate ligament.)

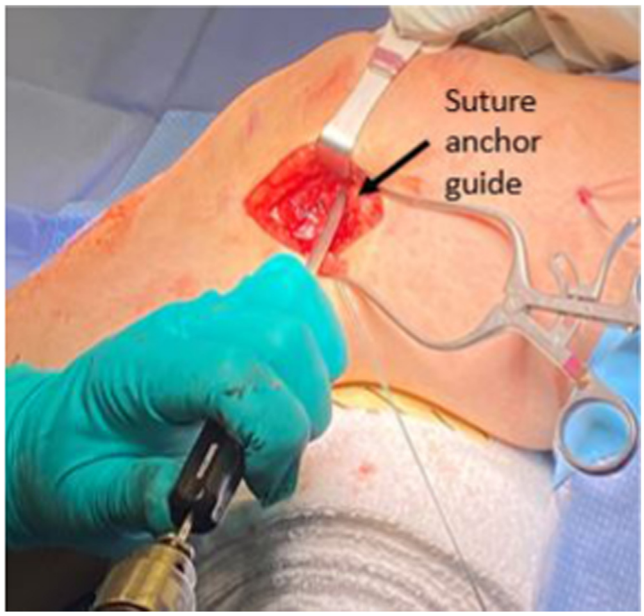

Fig 10. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. The anchor guide is placed over the guide pin and held stable while the guide pin is removed. The surgeon may then overdrill with the stepped drill bit for the suture anchor or simply place the anchor within the hole created by the guide pin.

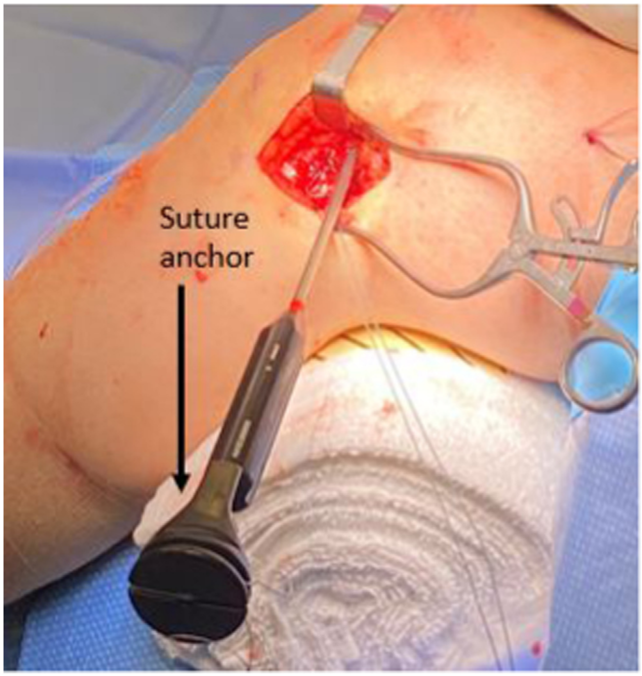

Fig 11. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. The anchor is then inserted and fully seated within the guide.

Tensioning/Securing the Tenodesis

The ITB graft tail is positioned between the "shuttle" and "locking" sutures and the anchor locking suture looped around the body of the graft. The knee is held in neutral rotation and 70 degrees to 90 degrees of flexion. The ITB graft tail is lightly tensioned, and the locking suture is secured, pulling a shallow loop of the graft body into the prepared femoral socket (Fig 12).To augment the femoral fixation and de-tension stress on the anchor, the residual graft tail is secondarily secured to the ITB graft and the periosteum of the lateral epicondyle using the previously placed #0 nonabsorbable suture and #0 or #1 absorbable braided sutures. The ITB is reapproximated anatomically using braided absorbable suture.

The complete technique is illustrated in a right knee in Video 1.

Postoperative Rehabilitation

A standard postoperative rehabilitation protocol is used, dependent upon concomitant procedures performed. We do not limit weight-bearing or range of motion because of the addition of the LET after ACL reconstruction. Full range of motion should be achieved by 6 weeks with strengthening to begin around 12 weeks postoperatively. Return to sport occurs between 9 and 12 months postoperatively based on patient specific factors and return to sport testing. Table 1 reviews the pearls and pitfalls applicable to the procedure. Table 2 indicates advantages and disadvantages of this technique.

Discussion

This Technical Note details a modification of proximal fixation for modified Lemaire extra-articular tenodesis, which significantly reduces the risk of convergence with the ACL femoral tunnel, is bone-sparing, and maintains a low intra- and extraosseous profile. Biomechanical, as well as clinical studies, continue to emerge highlighting the benefits of LET in the setting of ACL reconstruction, particularly when treating patients deemed to be at high risk of re-rupture. Clinical studies continue to demonstrate a trend of improved clinical outcomes, reduced re-rupture rates, and minimal added morbidity to the procedure.[12-16,20] A recent meta-analysis and systematic review of 7 randomized controlled trials found addition of LET reduced the re-rupture rate by three times.[13] When applied to an extremely high-risk population of young, elite alpine skiers on the French national team, the addition of LET reduced re-rupture rates from 34% in isolated ACL reconstruction to 6.5% when LET was added.[20]

The major concern when performing lateral extra-articular procedures remains the risk of tunnel convergence with the ACL femoral tunnel. In a

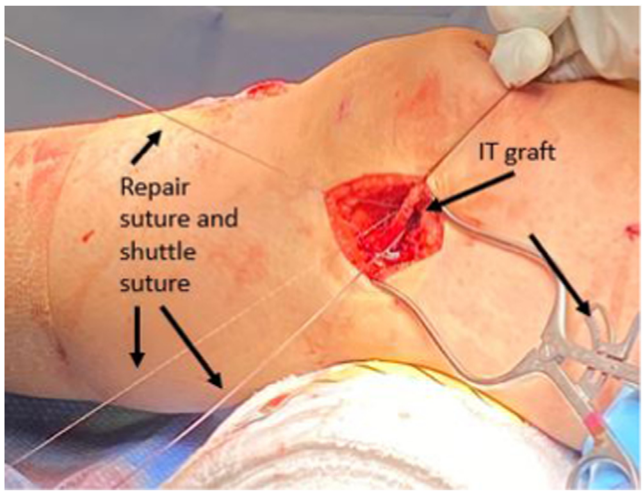

Fig 12. Left knee, open view demonstrating the lateral knee with the knee flexed to 30°. The shuttle sutures from the anchor are then used to pass the locking sutures from the anchor around the IT graft while an assistant maintains tension on the graft while the knee is in neutral rotation. The remaining free end of the graft is folded over and oversewn to the FCL origin and surrounding periosteal tissue. (FCL, fibular collateral ligament; IT, iliotibial band.)

Table 1. Pearls and Pitfalls

Pearls
- The ITB graft should be at minimum 10 mm in width to assure adequate strength. With the incision over the lateral epicondyle, the strip can be easily extended distally with skin retraction, but adequate proximal exposure is critical for graft passage, isometry, and tunnel placement.
- The capsular incisions anterior and posterior to the FCL should be kept proximal (just distal to the epicondyle) to minimize risk to the lateral geniculate vascular bundle.
- Direct the 3.2-mm reamer guide pin proximally and slightly anterior or to avoid intersection with the ACL femoral tunnel.
- The femoral socket need not be reamed to a diameter greater than 7 mm or a depth greater than 15 mm. This allows adequate room for tensioning and minimizes damage to the ACL graft or fibular collateral ligament at the epicondyle.

Pitfalls
- Do not overtension the graft or secure it in external rotation as this could over-constrain normal motion of the knee. Ensure graft fixation in neutral rotation and 70-90° of flexion.
- One reason for anisometry of the graft is failure to direct the ITB harvest toward Gerdy's tubercle. Palpation or direct visualization should be used to ensure proper trajectory of the graft harvest.
- Secure the residual tail of the graft to itself and the periosteum of the lateral epicondyle to share/unload tension on the suture anchor.
- Failure to set the anchor before graft fixation can result in suture anchor pull out. If the all-suture anchor pulls out of the bone, there are 2 salvage options. (1) A standard screw-type suture anchor can be placed into the base of the socket and utilized to dock the graft, or (2) the reamer guide pin can be replaced into the socket base and drilled across the femur to the distal medial metaphyseal region, aimed to avoid the path of the femoral ACL tunnel. The socket is then reamed to a depth of 25 mm to accommodate the graft tail. The #0 prep sutures used to dock the graft tail into the socket and secured using a 6- or 7-mm interference screw.
- Tension and security of the ACL graft fixation should be assessed after final tensioning of the LET graft to ensure the primary ACL graft was not compromised.

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

cadaveric study, Jaecker et al.[18] demonstrated with computed tomography imaging a 70% incidence of tunnel convergence with the combination of anteromedial portal drilling for the ACL femoral tunnel and a modified Lemaire technique. Of note, in this study, the femoral socket for the LET was directed 30° proximal, but in the mid-axial plane. Another study evaluating tunnel convergence in modified Lemaire tenodesis found directing the femoral socket 30° proximal and at least 20° anterior prevented tunnel convergence, although, the tunnels often came within 5 mm.[19]

One advantage of the described technique is that it mitigates the risk of convergence as no additional femoral socket is required. The all-suture, knotless anchor is small and seated immediately below the lateral cortex therefore, the only opportunity for convergence is directly at the lateral cortex. With the modified Lemaire technique, the position of the LET graft is immediately proximal and posterior to the lateral epicondyle which is distal to typical ACL femoral tunnel trajectory whether the surgeon is using anteromedial portal drilling, outside-in, or all-inside techniques. Another advantage is the use of autograft tissue without detachment of the iliotibial band from Gerdy's tubercle. This reduces fixation points requiring implants as is required in anterolateral ligament reconstruction and simplifies the technique in addition to minimizing the need for distal dissection and additional morbidity to the patient. One risk is loss of fixation of the graft by failure of the knotless anchor. Care should be taken to prevent excessive reaming that compromises the lateral cortex. This is critical to the use of all-suture anchors in any setting. Failure of the knotless anchor can be salvaged by conversion to a forked tenodesis screw (SwiveLock; Arthrex). Use of this anchor does require additional reaming and increases the risk of tunnel convergence and compromise of the ACL reconstruction tunnel. Another consideration in the case of failure is to convert to all soft-tissue fixation by sewing the graft to the LCL and subsequently to itself. In general, this technique allows the surgeon to easily and reproducibly incorporate the addition of LET to ACL reconstruction without

Table 2. Advantages and Disadvantages

Advantages
- Use of 2.6-mm knotless anchors reduces risk of tunnel convergence, which is common in combined ACL/LET reconstruction
- Passage of the graft under the LCL improves the force vector for stabilization of the knee while the isometric position reduces the risk of overconstraint and postoperative stiffness.
- Harvest of autograft iliotibial band reduces the need for additional graft material and an additional fixation point which is required with anterolateral ligament reconstruction.

Disadvantages
- Use of knotless anchors risks blowout of the lateral cortical wall and the need for salvage techniques—conversion to a tenodesis anchor or all soft tissue fixation to the LCL or the graft itself.
- Harvest of autograft increases the length and technical complexity of the procedure
- LET carries a risk of overconstraint and non-anatomic rotation of the lateral compartment.

ACL, anterior cruciate ligament; LCL, lateral collateral ligament; LET, lateral extra-articular tenodesis.

risking tunnel or graft compromise while minimizing dissection and patient morbidity.

Conclusions

This article describes a technique for LET fixation, which minimizes the depth of the LET femoral bone socket and utilizes low-profile implants thus mitigating this risk. This has advantages for surgeons who routinely perform ACL reconstruction and revision ACL reconstruction in high-risk populations.

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