Technical Note

Lateral Extra-articular Tenodesis With Cortical Suspensory Femoral Fixation and Suture Tape Augmentation

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Abstract: This article aims to provide a new surgical technique for rotational instability in the setting of anterior cruciate ligament rupture. Two main groups of surgical procedures can be identified in the treatment of anterolateral knee instability: lateral extra-articular tenodesis and anterolateral ligament reconstruction. Although the importance of anterior cruciate ligament reconstruction in anterolateral complex injuries is well known, the superiority of lateral extra-articular tenodesis over anterolateral ligament reconstruction or vice versa has not yet been shown. Both techniques show improved outcomes and reduced graft failure rates. The presented procedure can be considered a modification of the technique first described by Lemaire. Better tensioning can be achieved through cortical suspension by identifying the anisometric point on the lateral femur and performing a medial pullout on the femoral side. The advantages of this technique are better fine-tuning and tensioning, less invasiveness, and adjustable cortical fixation, which allows for a precise, incremental tensioning of the graft, ensuring circumferential healing of the graft within the socket and reducing the risk of graft laceration, which may happen with interference screws. Internal bracing provides excellent contact pressure between the femoral button and femoral cortex, ensuring that adequate tensioning is applied to the graft.

Anterior cruciate ligament (ACL) injuries are a widespread type of injury, especially in young people. ACL reconstruction (ACLR) aims to restore native knee kinematics and biomechanics.

The anterolateral complex (ALC) and the techniques for its reconstruction are debated topics in the sports medicine community. Indications and treatment options for ACLR and ACL revision and ALC procedures have been identified by the International ALC Consensus Group Meeting.[1] If ACL and ALC injuries coexist, normal knee function is restored when ACLR and extra-articular procedures are combined.

ALC surgery includes anatomic techniques such as anterolateral ligament reconstruction and nonanatomic techniques such as lateral extra-articular tenodesis (LET). No superiority of one over the other has been established.[2] The association of LET and ACLR reduces postoperative pivot shift and lowers the risk of graft failure.[3] Although our technique is considered a LET procedure, it has the advantage of fine tensioning of the proximal fixation, which also makes it similar to an anterolateral ligament reconstruction. This article provides a step-by-step guide to our surgical technique of choice for LET.

Surgical Technique

Patient Positioning and Clinical Evaluation

The patient is positioned supine with a leg post at the thigh and a foot holder that maintains 90° of flexion and aids extension. A tourniquet is placed at the level of the upper thigh. Clinical examination, including pivot shift test, is performed under anesthesia. LET is performed in cases of grade 3 Lachman test, pivot shift

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grade 2 or higher, and ACLR combined with meniscal repair.

Preferred Technique for Primary ACLR

Our preferred procedure for primary ACL reconstruction is the all-inside technique.[4] Autologous semitendinosus or quadriceps tendons are usually the grafts of choice. Any concomitant meniscal or ligamentous injuries are addressed and treated accordingly before performing LET.

Surgical Approach

Anatomic landmarks on the lateral aspect of the knee are marked (Fig 1). A 4-cm skin incision is performed centered on the lateral femoral epicondyle and directed toward Gerdy tubercle. Dissection is carried out to the superficial layer of the iliotibial band (ITB). The posterior margin of the ITB and the interval between the ITB and lateral tendon of the biceps femoris are identified.

Fig 1. Right knee. Anatomic landmarks for lateral approach. Black dashed line indicates joint line. Red arrow indicates Gerdy tubercle. Blue arrow indicates fibular head. Black arrow indicates lateral femoral epicondyle. Green star indicates ACL femoral tunnel button. Green dot indicates patella. (ACL, anterior cruciate ligament.)

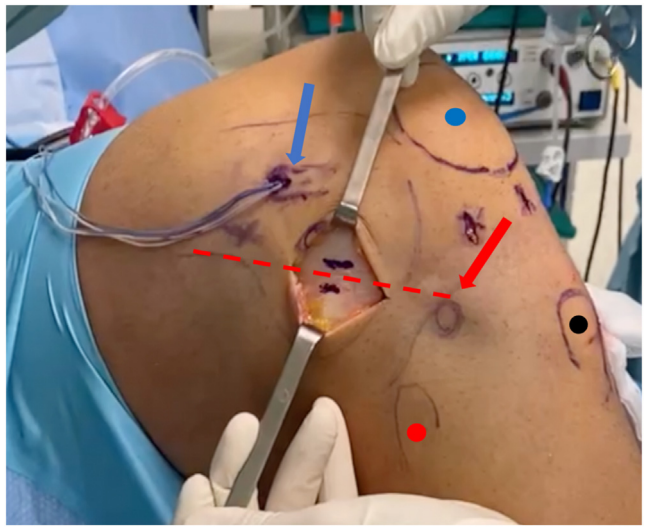

Fig 2. Right knee. The ITB is exposed, and the fascial flap is marked in line with the incision. The direction should be toward Gerdy tubercle, with a total width of approximately 1 cm. Red dotted line indicates ITB. Red arrow indicates Gerdy tubercle. Red dot indicates fibular head. Black dot indicates tibial tuberosity. Blue arrow indicates femoral tunnel exit point. Blue dot indicates patella. (ITB, iliotibial band.)

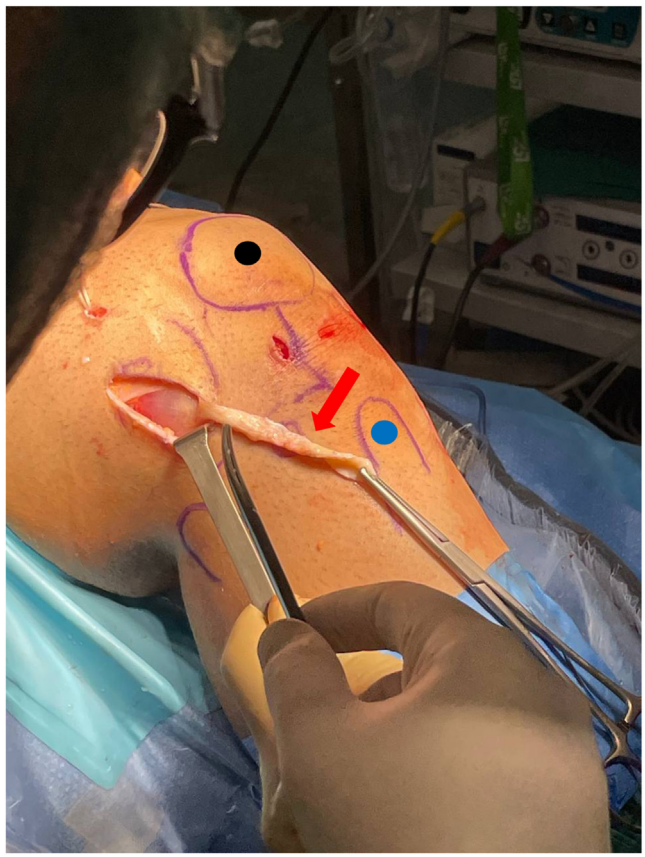

Fig 3. Right knee. The ITB strip (red arrow) has been harvested, and its distal insertion is left intact. A total of 2 cm of the ITB should be left in place between the graft and Gerdy tubercle to provide sufficient strength. Black dot indicates patella. Blue dot indicates tibial tuberosity. (ITB, iliotibial band.)

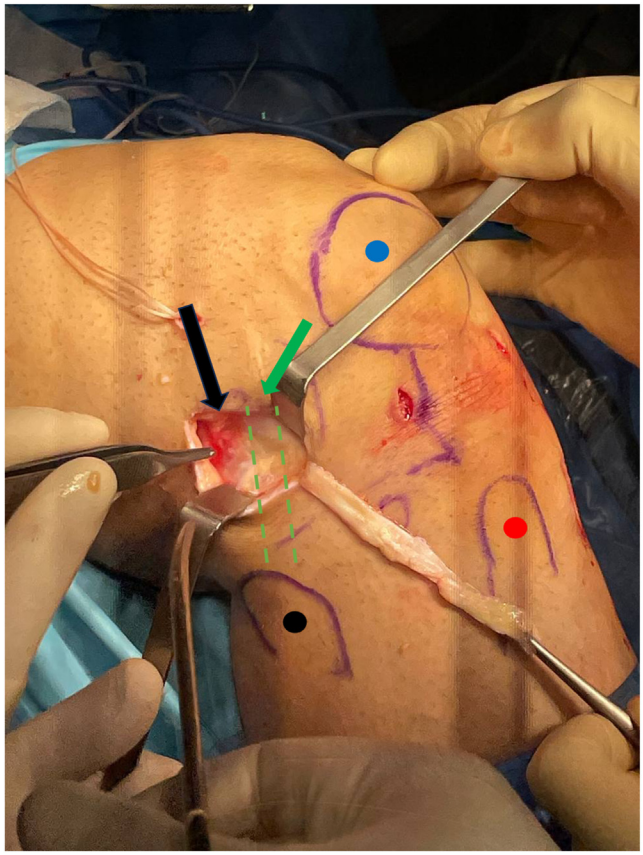

Fig 4. Right knee. The anisometric point is identified. This point is located 5 mm posterior and 5 mm proximal to the lateral femoral epicondyle. This point marks the entry site for the femoral tunnel. Green dashed line indicates fibular collateral ligament. Green arrow indicates lateral femoral epicondyle. Black arrow indicates anisometric point (approximate femoral origin of ALL). Black dot indicates fibular head. Red dot indicates tibial tuberosity. Blue dot indicates patella. (ALL, anterolateral ligament.)

Fig 5. Right knee. Direction of the guide wire is shown. It is directed 15° to 20° proximally on the frontal plane and 20° to 30° anteriorly on the sagittal plane. This is done to avoid femoral ACL tunnel convergence. Blue arrow indicates guide wire. Black arrow indicates Gerdy tubercle. Red arrow indicates tibial tuberosity. Blue dot indicates patella. Red dot indicates fibular head. (ACL, anterior cruciate ligament.)

ITB Graft Harvesting

The ITB is divided into three thirds longitudinally (Fig 2). A 1-cm graft is marked with a sterile marker at the junction between the posterior and middle third. Another mark is made 1 cm anterior and parallel to the previous mark. A No. 15 blade and scissors are used to carve the graft following the direction of the fibers while maintaining constant width. The dissection stops at 2 cm from Gerdy tubercle, and the distal insertion is preserved. Graft length is measured, and the proximal end is cut free at 8 cm from Gerdy tubercle (Fig 3).

Identification of Anisometric Point and Tunnel Placement

The anisometric point is identified 5 mm posterior and 5 mm proximal to the lateral femoral epicondyle (Fig 4). This point roughly corresponds to the femoral anterolateral ligament origin. A 2.4-mm guide wire is passed from lateral to medial, directed 20° proximally on the frontal plane and 30° anteriorly on the sagittal plane (Fig 5) to avoid ACL tunnel convergence. Identify the femoral origin and the fibers of the lateral collateral ligament to avoid incorrect entry. Gentle varus stress can aid this maneuver. A suture passer is passed in a proximodistal fashion beneath the lateral collateral ligament, and a cotton loop is used to retrieve the free end of the graft (Video 1).

The knee is extended, and the ITB strip is presented at the femoral tunnel entry point. This level is marked on the ITB flap. At 3 cm proximally, another mark is added to the graft (Fig 6). The flap is tensioned, and the knee is cycled to test anisometry. Any excess ITB strip beyond 3 cm is removed.

Graft Preparation

At 90° of flexion, the graft is prepared for medial pullout. A FiberTag suture system (Arthrex) is used. If

Fig 6. Right knee viewed from the lateral side. The ITB strip is measured and the length of the entry point into the femoral tunnel is marked. The proximal intraosseous portion of the graft should be 3 cm. Any excess is cut. Orange arrow indicates femoral tunnel entry point marked on the graft. Blue dotted line indicates ITB graft. Blue star indicates Gerdy tubercle. Black star indicates ACL femoral tunnel exit. Red star indicates patella. (ACL, anterior cruciate ligament; ITB, iliotibial band.)

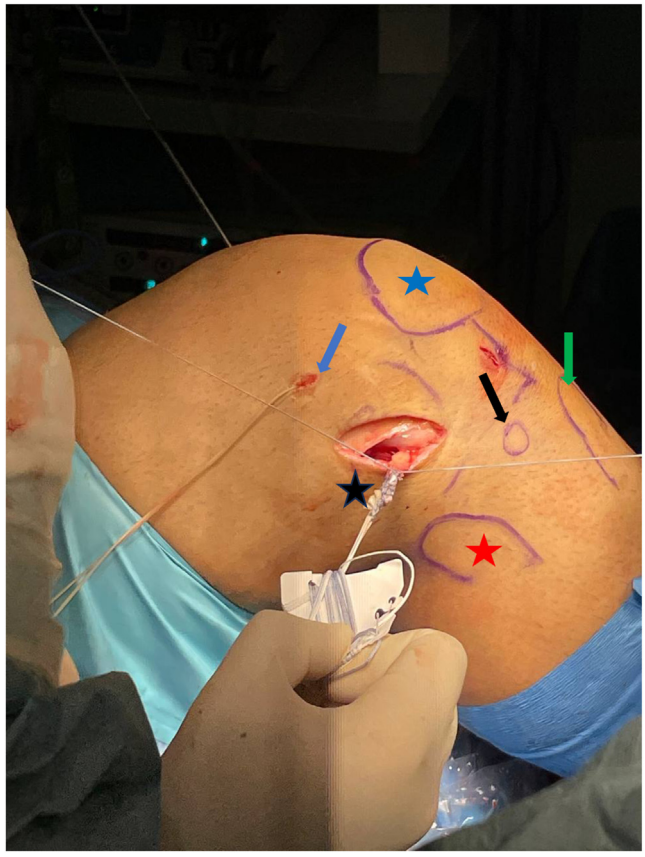

Fig 7. Lateral aspect of the right knee. An ACL FiberTag TightRope is assembled on the free end of the graft (black star). The construct is assembled using the standard technique provided by the manufacturer. At least 2 cm of the graft must be stitched to provide good resistance. Note that 2 cm corresponds to the length of the FiberTag loop. It should, when possible, be all intraosseous. Blue arrow indicates femoral ACL tunnel exit point. Red star indicates fibular head. Blue star indicates patella. Green arrow indicates tibial tuberosity. Black arrow indicates Gerdy tubercle. (ACL, anterior cruciate ligament.)

available, our preference is the ACL FiberTag TightRope implant (Arthrex), which eliminates the step of having to assemble a FiberLoop with FiberTag on an ACL TightRope RT (Arthrex) (Fig 7). The system is constructed from the free end to the distal end by following the standard technique provided by the manufacturer of the implants. A standard sizing block is used to establish the diameter. At this stage, we also assemble a provisional leading string, henceforth termed "fake brace" (Fig 8), on the TightRope button (Arthrex). A 0 Vicryl suture (Ethicon) is sufficient (Video 1). Once the button has been flipped, the surgeon applies constant traction on the free tails of the fake brace while the assistant progressively shortens the adjustable loop. This is useful when constant countertraction on the graft cannot be ensured during the tensioning phase because of tunnel placement and surrounding tissues.

Femoral Tunnel Completion

The 2.4-mm guide wire is inserted to the lateral side a few centimeters, and a cannulated reamer drill the same diameter of the graft (usually 5 or 6 mm) is used to create a femoral socket measuring 35 mm (Fig 9). The reamer is removed while the guide wire is still in place, and a cannula from the all-inside ACL reconstruction kit (3.5 mm in diameter) (Arthrex) is placed in the slot to maintain tunnel direction. A 3.5-mm noncannulated drill, usually a FlipCutter II (Arthrex), is used to drill through the medial cortex. This allows button passage for medial cortical suspension (Table 1). A No. 2 suture is used as a shuttle in the 2.4-mm guide wire from lateral to medial. The free ends of the TightRope are pulled medially through the tunnel, and the No. 0 Vicryl fake brace free ends stay on the lateral side (Fig 10).

Graft Transportation and Tensioning

The TightRope button is pulled onto the medial side and flipped. Gentle traction must be exerted in this phase to have proper tactile feeling of both the button traveling along the tunnel and the button exiting the

Fig 8. Lateral view of right knee. A temporary "fake brace" made of a No. 0 Vicryl suture is inserted into the button of the FiberTag. This is inserted by using the needle at the end of the Vicryl suture. Note that the loop must be seated on the button and the free ends of the Vicryl must exit on the lateral side of the femur. Blue arrow indicates TightRope button and Vicryl. Black arrow indicates ITB prepared with the FiberTag suture. Blue star indicates Gerdy tubercle. Black star indicates fibular head. Red star indicates patella. (ITB, iliotibial band.)

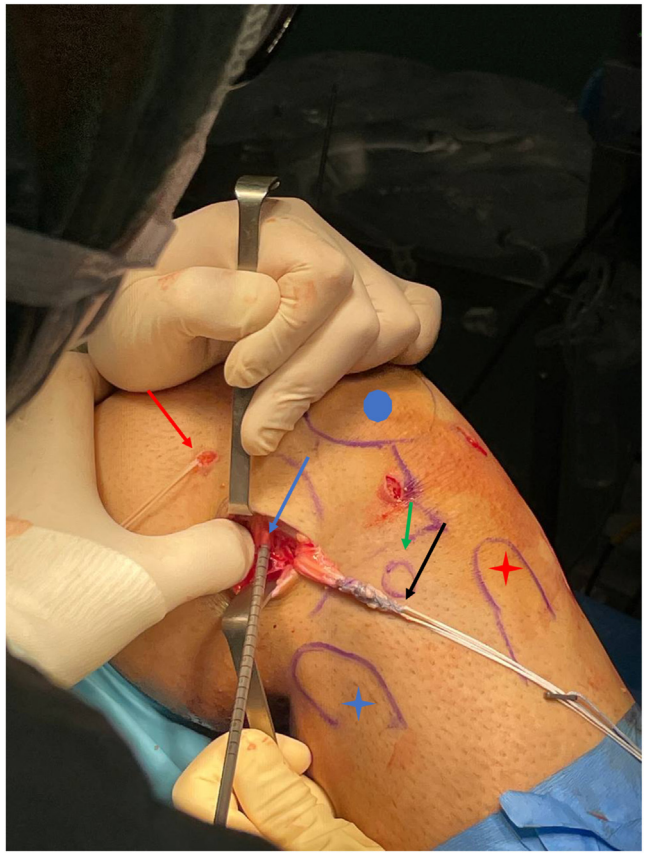

Fig 9. Lateral aspect of the right knee. Once the FiberTag has been armed, it is time to prepare the femoral socket (blue arrow). This is done using a cannulated reamer of the appropriate diameter. The graft is passed into a standard sizing block to establish diameter and the first 3 cm of the femoral tunnel is reamed. Black arrow indicates ITB with FiberTag suture. Red arrow indicates femoral tunnel ACL TightRope RT sutures. Blue dot indicates patella. Green arrow indicates Gerdy tubercle. Red star indicates tibial tuberosity. Blue star indicates fibular head. (ITB, iliotibial band.)

medial cortex. The surgeon can achieve this by applying constant tension and counter tension on both ends of the button sutures. If the button is correctly seated on the medial cortex, pulling the brace should return no elasticity and no bouncing of soft tissues, as seen in cases of button entrapment beneath the vastus medialis. Once the button is seated, the TightRope sutures are tensioned at 0.5-cm increments on each strand. Maximum tension on the fake brace is always kept during tensioning of the graft (Table 2). Once the free end of the graft engages the socket, the knee is placed in full extension and a surgical clamp is laid between the graft and the femur as a pulley (Fig 10). The knee is cycled through full range of motion, and anisometry is assessed, pivot shift is tested, and the fake brace is removed. The graft should be tight in full extension and slightly loose in flexion (Fig 11). This avoids constraint of the lateral compartment.

Internal Bracing

In case of grade 3 pivot shift test and grade 3 Lachman with grade 2 pivot shift or higher, we position a high resistance multistrand tape as a permanent internal brace. A No. 2 FiberTape (Arthrex) is used, inserted in the TightRope button in the same way as the fake brace. A stab incision is performed on the Gerdy's tubercle then a suture passer is used to identify the plane beneath the fascia, and the brace is passed distally and inserted in proximity to the tubercle in full extension. A FOOTPRINT PK 4.5-mm anchor (Smith & Nephew) is our preferred fixation method.

Postoperative Protocol

Full range of motion and full weight-bearing are encouraged as tolerated by the patient. In case of meniscus repair procedures, weight-bearing and flexion

Table 1. Highlights of the Surgical Technique

- Expose the most posterior portion of ITB to distinguish between ITB and lateral head of biceps tendon.
- Ensure that graft width is constant; convergence or divergence of flap can cause loci of minor resistance.
- Graft length should be 8 cm: 5 cm extraosseous and 3 cm in the bone tunnel.
- Identify anisometric point (roughly at origin of ALL): 5 mm posterior and 5 mm proximal to the lateral femoral epicondyle.
- Tunnel trajectory is paramount to avoid tunnel convergence with femoral ACL tunnel: 15-20° proximally on the frontal plane and 20-30° anteriorly on the sagittal plane.
- Keep in mind the right sequence for tunnel and half-tunnel preparation: (1) insert slotted 2.4-mm guide wire, (2) ream half-tunnel after size of ITB graft is established, (3) insert 3.5-mm cannula from ACL all-inside reconstruction kit into half-tunnel (this will give right direction to remaining part of tunnel), (4) use FlipCutter to ream all the way to medial cortex, and (5) use a slotted wire to place a shuttle suture for future use.
- Remember that you only need a half-tunnel for graft entry; the entirety of your tunnel is 3.5 mm (diameter of FlipCutter). Therefore, you have a half-tunnel that fits your ITB graft perfectly and a smaller tunnel that the TightRope button can traverse.
- Countertraction on the fake brace must be kept at all times while tensioning.
- Start tensioning the graft at 90° of flexion until the ITB strip engages the femoral socket, then move the knee in full extension and tighten the graft until all femoral socket is occupied.
- The graft and permanent internal brace (when present) should be loose in flexion and tight in extension.

ACL, anterior cruciate ligament; ALL, anterolateral ligament; ITB, iliotibial band.

beyond 90° can be delayed up to 40 days. Early rehabilitation is encouraged, and maximum passive and active knee extension must be achieved within 30 days. Pivoting sport is resumed after 7 months following adequate neuromuscular recovery.

Discussion

Many techniques have been described for LET in association with ACLR.[5,6] The Coker-Arnold technique is one of the most performed LET techniques.[7] Other variants include several modifications of the Lemaire technique, such as the Williams modification,[8] in which a 1-cm-wide strip of ITB is harvested with the distal insertion intact and then passed under the fibular collateral ligament and fixed with a suture anchor to the lateral femoral epicondyle with the knee in 30° of flexion and neutral rotation, and the similar Jesani-Getgood modification.[9] In the Marcacci technique, hamstring tendons are harvested and sutured together and then used for both ACLR and LET in an over-the-top fixation technique.[10,11]

A recent systematic review compared the postoperative stability of LET procedures based on the fixation type.[10] Proximal bony and soft tissue fixation methods result in lower residual rotational and anterior instability, as measured through different parameters, compared with distal bony fixation techniques.[12]

Hurley et al.[13] compared knee stability with various LET techniques. Rates of ACL re-rupture and residual pivot shift were significally lower when LET was performed. One of the main concerns is the risk of tunnel collision. Mitrousias et al.[14] suggested the use of arthroscopy through the anteromedial portal for safe femoral tunnel creation. Stordeur et al.[15] showed that femoral tunnels positioned with specific orientations present a lower risk of tunnel collision. In a study comparing tunnel collision in Lemaire and Macintosh LET, convergence occurred in 70% of cases with the Lemaire procedure and no cases with the Macintosh technique.[16] In our experience, the femoral tunnel placement achieved during all-inside ACLR (with less

Table 2. Pearls and Pitfalls

Pearls
- At least 2 cm of ITB should be left intact distally from Gerdy tubercle to allow good resistance and avoid avulsion at the distal insertion.
- Present the graft at the tunnel entry and mark this level; by doing so you ensure that proper tensioning can be applied to the graft once the femoral socket is created. Once you have decided how deep your socket will be, make another mark on the free end of the graft and remove any excess tissue.
- When shuttling the FiberTag suture, ensure that the button is seated on the medial cortex and that no soft tissue stands between the button and the femoral cortex. Gentle traction must be applied, as the surgeon must have tactile feedback. This may require some experience.
- The use of the "fake brace" loaded on the TightRope button is helpful for countertraction on the graft while the button is seated on the medial femoral cortex, avoiding the interposition of soft tissue between the button and the bone.
- Tension the graft starting at 90° of flexion, and when the proximal part of the ITB strip is brought near the tunnel, continue tensioning in full extension.
- In cases requiring a permanent internal brace, remember to tighten the brace in full extension distally to Gerdy tubercle.

Pitfalls
- Harvest a short (less than 6-8 cm) or thin (less than 1 cm) ITB graft.
- Having extra tissue can make the graft loose, as it will not be able to fully occupy the femoral socket.
- Aggressive shuttling of the FiberTag from lateral to medial could pull the button over the bone in the soft tissue.
- If there is interposition of soft tissue, tensioning may not be adequate.
- Performing the tensioning in flexion may result in excess tension of the graft and a risk of extension deficit.

ITB, iliotibial band.

Fig 10. Right knee. The button is seated on the medial femoral cortex and the graft (black arrow) is pulled to the socket at 90° of flexion. While doing so it is imperative that the internal brace (blue arrow) is pulled tightly to ensure good contact pressure between the TightRope button and the medial femoral cortex. Once the tip of the graft engages the femoral tunnel, the knee is placed in full extension and further tensioning is applied to the graft. Red arrow indicates fibular head. Green arrow indicates Gerdy tubercle.

Fig 11. Right knee. In cases of high-grade pivot shift, a permanent internal brace is preferred. This is done using FiberTape instead of Vicryl (blue arrow). A stab incision is made on the Gerdy's tubercle (black arrow), and the brace is tensioned in full extension and put in place using a suture anchor (4.5-mm FOOTPRINT). The internal brace follows the same anisometry of the ITB graft. It is loose in flexion, as shown, and tight in extension. Red arrow indicates fibular head. (ITB, iliotibial band.)

vertical tunnel drilling) reduces the risk of femoral tunnel conflict.

Internal bracing augments a ligament repair with high-strength suture tape, which acts as a secondary stabilizer.[17] Recent studies associate suture augmentation with better patient-reported outcome measures, less pain, and earlier percentage of return to preinjury activity level.[16,18] No data are available to date for augmentation in the setting of LET.

Our technique provides a safe and reproducible alternative for treating rotatory instability in ACLR. The advantages of this procedure are the possibility of fine-tuning thanks to the gradual tensioning achievable with suspension devices, circumferential healing, and less risk of graft laceration. Disadvantages may include the cost of the implant and longer surgical time compared with standard techniques. Identifying the correct point for the femoral socket and the right direction avoids any tunnel conflict with the ACL graft.

Disclosures

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

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