Technical Note

Anatomical Landmark Technique for Femoral Tunnel Placement of Lateral Extra-Articular Tenodesis

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Abstract: The anterolateral ligament is a crucial part of the anterolateral complex of the knee, providing rotator stability to the knee and being a primary restraint to tibial internal rotation. Lateral extra-articular tenodesis added to anterior cruciate ligament reconstruction can reduce pivot shift without sacrificing the range of motion or increasing the risk of osteoarthritis. A 7- to 8-cm longitudinal skin incision is made and a 9.5- to 10-cm × 1- cm wide iliotibial band graft is dissected, leaving the distal attachment intact. The free end is whip stitched. One of the most important steps during the procedure is the identification of the site of attachment of the iliotibial band graft. The leash of vessels, fat pad, lateral supracondylar ridge, and fibular collateral ligament serve as important landmarks. The tunnel is drilled from the lateral femoral cortex with a guide pin and reamer pointing 20 to 30° anteriorly and proximally while the arthroscope visualizes the femoral anterior cruciate ligament tunnel. The graft is routed under the fibular collateral ligament. The graft is fixed with a bioscrew while the knee is kept in 30° flexion and the tibia is kept in neutral rotation. We believe that lateral extra-articular tenodesis gives the anterior cruciate ligament graft a good chance for faster healing along with addressing anterolateral rotatory instability. Choosing a correct fixation point is very important to restore normal knee biomechanics.

Lateral extra-articular tenodesis (LET) has made a comeback in the field of orthopaedic surgery after Claes et al.[1] reported that the anterolateral ligament is a crucial part of the anterolateral complex of the knee, providing rotator stability to the knee and being a primary restraint to tibial internal rotation. There is evidence that LET can reduce pivot-shift without sacrificing the range of motion[2] or increasing the risk of osteoarthritis.[3] There are multiple landmarks that can help us identify the same as described in our technique.

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Indications and Contraindications

LET with anterior cruciate ligament reconstruction (ACLR) is indicated in high-risk, pivot-demanding contact sports like football and kabaddi, female athletes, inherent ligamentous laxity, genu recurvatum >10°, high-grade (grade ≥2) pivot shift under anesthesia, after a failed "well-performed" ACLR, revision ACLR, chronic ACL injuries, concurrent medial meniscus tears, increased posterior tibial slope >12°, potential ramp lesions, or in patients with anterolateral complex injury on MRI respectively.[4,5] Relative contraindications are posterolateral corner injury and lateral compartment osteoarthritis of the knee.[6]

Surgical Technique (With Video Illustration)

Preoperative Evaluation, Patient Positioning, and Examination

Preoperative evaluation of the patient includes a clinical examination of the bilateral knee, hip, spine, and ankle followed by hematologic and radiologic investigations. A radiograph of the knee is taken, especially to check the slope of the tibial condyle. Magnetic resonance imaging is done to assess other soft-tissue injuries. The patient is positioned supine on the surgery table. Bilateral knee examination is done before and after the administration of spinal/epidural/general

Fig 1. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° of flexion. The Gerdys Tubercle, lateral epicondyle, fibular head, fibular collateral ligament and skin incision are marked over the skin with a skin marker. A 7- to 8-cm longitudinal incision is made, starting posterior to the lateral epicondyle of the femur.

anesthesia, with care taken to note the grade of pivot shift. A pivot shift of grade 2 or greater is considered a provisional indication of LET. A well-padded high tourniquet is applied to the operating limb. The knee is kept in 90° flexion with help of a sandbag as a foot support. Lateral thigh support is kept, making sure that it allows the limb to be positioned in a figure-of-4 position. The patella, patellar tendon, tibial tuberosity, Gerdy tubercle, femoral epicondyle, posteromedial border of tibia, and fibular collateral ligament (FCL) are marked with a skin marker.

Graft Harvest, Diagnostic Arthroscopy, and Preparation of Tunnels

The graft is harvested according to the requirement of the patient and the sport he/she plays. A full round of

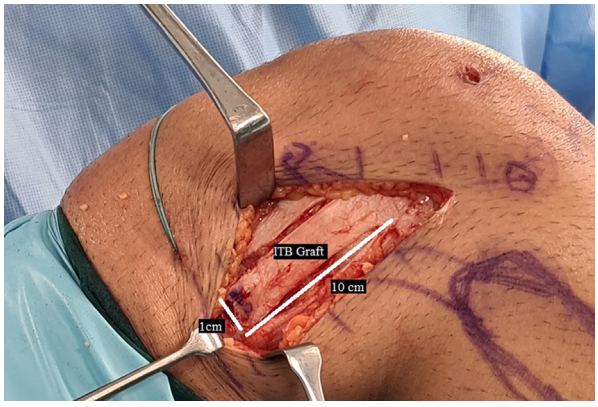

Fig 2. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. A 10-cm long and 1-cm wide middle part of the ITB graft is dissected, keeping the distal attachment to the Gerdy tubercle intact. (ITB, iliotibial band.)

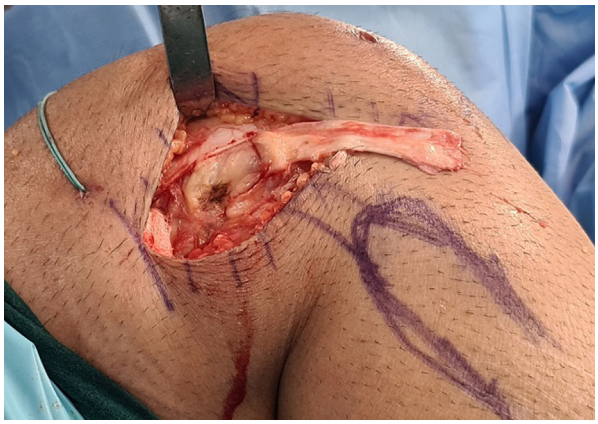

Fig 3. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion, with the dissected iliotibial band after clearing the undersurface fat and vastus lateralis attachments.

diagnostic arthroscopy is completed to make sure that the other injuries such as lateral meniscus posterior horn tear, which could create a positive pivot shift, are excluded. Standard tibial and femoral tunnels are prepared.

Skin Incision

The knee is kept in 80° of flexion. A 7- to 8-cm longitudinal incision is made, starting 1 cm posterior to the femoral epicondyle to the Gerdy tubercle (Fig 1 and Video 1). Subcutaneous fat is dissected to reach the iliotibial band (ITB). Insertion of ITB over the Gerdy tubercle is visualized and palpated.

Harvesting the ITB

A 9.5- to 10-cm long and 1-cm wide middle part of the ITB is identified and marked for harvesting, leaving the distal attachment of ITB to the Gerdy tubercle intact (Video 1). Attachments of vastus lateralis to the

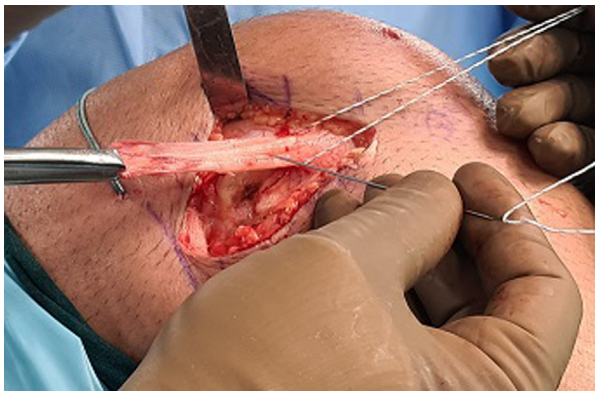

Fig 4. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. The free end of the iliotibial band graft is whip-stiched with high strength No. 2 multifilament loop suture (Healthium Pvt. Ltd., Peenya, BLR) holding the graft with Allis forceps.

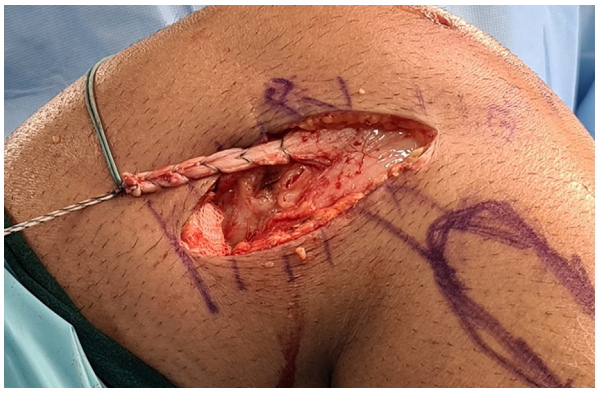

Fig 5. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion with the final whip-stitched iliotibial band graft.

underside of the ITB are dissected off along with some of the fat that tags along (Figs 2 and 3). The free end is whip stitched with high-strength No. 2 multifilament suture (Healthium Pvt. Ltd., Peenya, BLR) (Figs 4 and 5).

Identification of Landmarks for Fixation of ITB to the Femur

This is the key step in this procedure to gain desired results by this procedure. This is the point where distal Kaplan fibers of the ITB insert into the femur. We have identified 4 ways to find this landmark (Video 1).

1. 1.5 cm proximal and anterior to a "leash of vessels" over the lateral epicondyle (Fig 6).

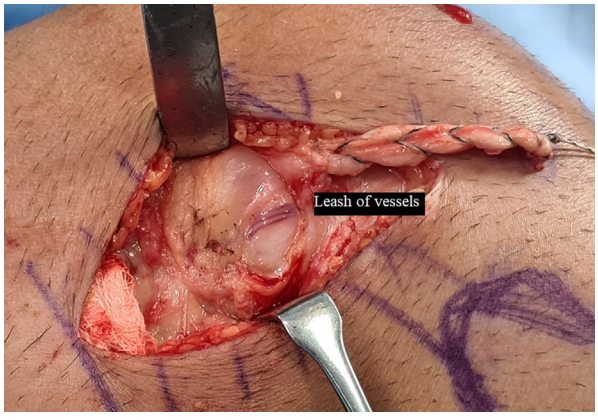

Fig 6. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. The "leash of vessels" over the lateral epicondyle can be used as a landmark for identifying the iliotibial band graft fixation point. Three to four venules run close to the lateral epicondyle and are easy to identify when careful dissection is done. The graft fixation point is 1.5 cm proximal and anterior to the "leash of vessels."

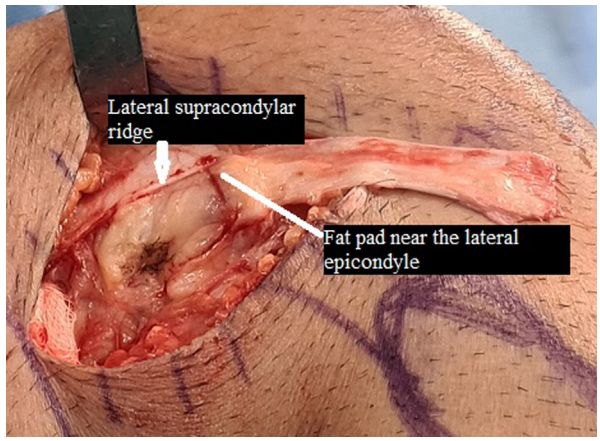

Fig 7. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. Once the ITB graft is dissected, the underlying fat pad and supracondylar ridge can be identified, which also act as landmarks for the ITB graft fixation point. The fat pad is 1.5 to 2 cm proximal and posterior to the lateral epicondyle. The lateral supracondylar ridge is a bony prominence where the Kaplan fibers insert, which is usually approximately 2 cm proximal and 1 cm posterior to the lateral epicondyle. (ITB, iliotibial band.)

2. Identify a small area of the fat pad around 1.5 to 2 cm proximal and posterior to the lateral epicondyle (Fig 7).
3. A bony prominence over the lateral supracondylar ridge of the distal femur where distal Kaplan fibers insert, which is usually approximately 2 cm proximal and 1 cm posterior to the lateral epicondyle (Fig 7).
4. 8 mm proximal and 4 mm posterior to the femoral attachment of the FCL, which becomes taut in the figure-of-4 position (Fig 8).

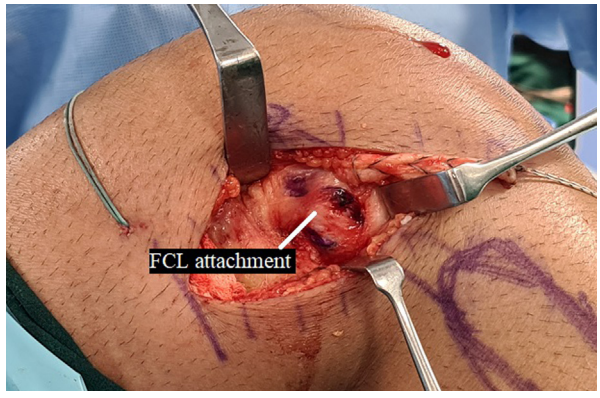

Fig 8. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. The FCL can be identified proximally attached to the lateral epicondyle and acts as a landmark for identifying the iliotibial band graft fixation point, which is 8 mm proximal and 4 mm posterior to the femoral attachment of the FCL. (FCL, fibular collateral ligament.)

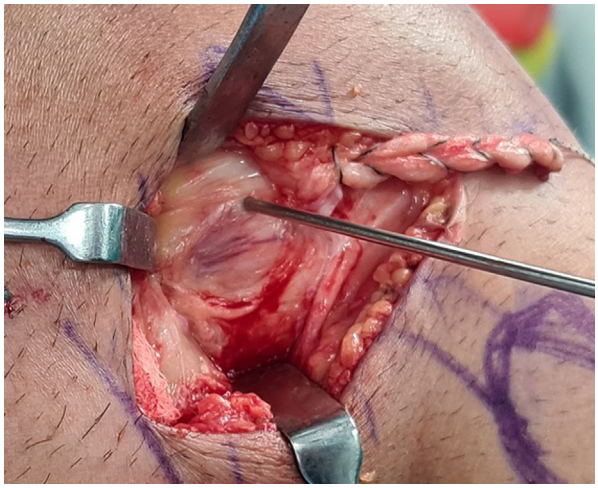

Fig 9. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. The final point of fixation of the iliotibial band graft as depicted by the 2.4 mm guide pin placed at the exact point after identifying all the mentioned landmarks.

Usually, all these landmarks coincide with each other and the final point of fixation is marked with electrocautery.

Drilling the Tunnel for ITB Fixation

The tunnel is drilled from the lateral femoral cortex with a 2.4-mm guide pinpointing 20 to 30° anteriorly and proximally (Figs 9 and 10) and exiting from the medial femoral cortex. Over-reaming is done with a 6-mm reamer to a depth of 25 mm. While guide pin introduction and reaming are performed, the arthroscope is used to visualize the femoral ACL tunnel (Video 1) to look for any violation of the ACL tunnel, as they are in very close proximity to each other. An

Fig 10. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. A 2.4-mm guide pin is placed pointing it 20 to 30° anteriorly and proximally and exiting through the medial femoral cortex as seen in the figure. Over-reaming is done over the guide pin with a 6-mm reamer to a depth of 25 mm.

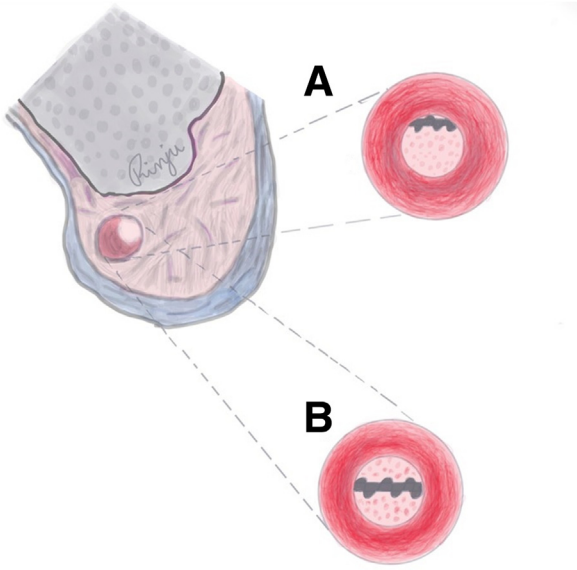

Fig 11. A Picture showing the medial wall of the lateral femoral condyle with zoomed in images of the femoral tunnel as viewed from the antero-medial portal with a 30° scope to look for any tunnel violation, while doing guide pin insertion and over reaming for the LET femoral tunnel. An eccentric superior violation of the ACL tunnel can be accepted if a soft-tissue ACL graft is being fixed by a suspensory fixation on the femur side, as shown in (A). Violation of the ACL tunnel at its center is not acceptable, as shown in (B). (ACL, Anterior cruciate ligament.)

eccentric superior violation of the ACL tunnel can be accepted if a soft-tissue ACL graft is being fixed by a suspensory fixation on the femur side (Figs 11A and

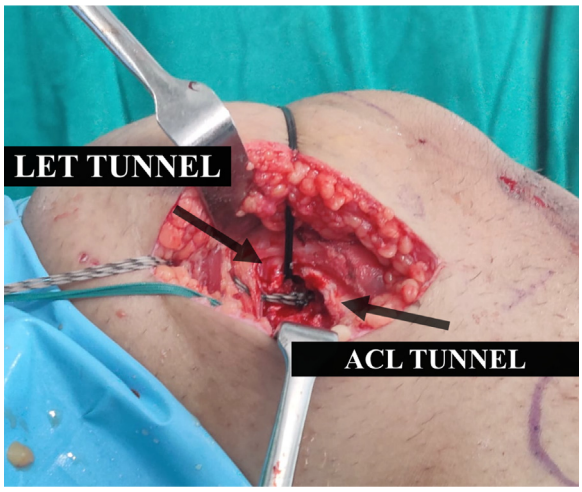

Fig 12. AThe figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. An eccentric superior violation of the ACL tunnel is shown, as visualized from the anteromedial portal by arthroscope, which is acceptable while soft-tissue ACL graft is being fixed by suspensory fixation. (ACL, anterior cruciate ligament; LET, lateral extra-articular tenodesis.)

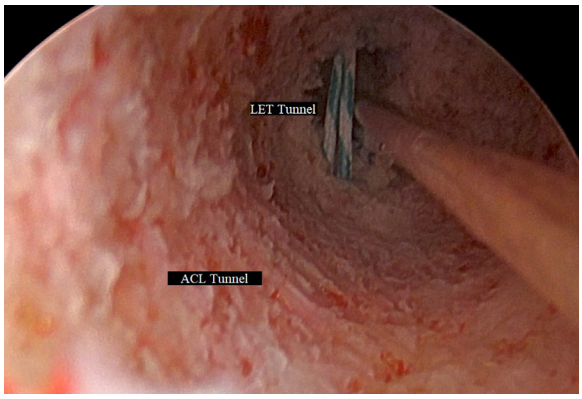

Fig 13. Arthroscopic Image as visualized from the anteromedial medial portal with a 30° scope showing the central violation of the ACL femoral tunnel by the LET tunnel, which isn't acceptable. In this case, the direction of the guide pin has to be changed to avoid any violation. (ACL, anterior cruciate ligament; LET, lateral extra-articular tenodesis.)

12). Violation of the ACL tunnel at its center is not acceptable (Figs 11B and 13).

Completion of ACLR

The ACL graft is fixed using appropriate implants in standard fashion into the femoral and tibial tunnels after cycling the graft for 30 cycles.

ITB Graft Passage and Fixation

The FCL is identified and is carefully dissected from the lateral joint capsule with 2 small rents anterior and posterior parallel to the FCL for passage of the graft (Fig 8). Using Spencer-Wells artery forceps, the ITB graft is routed under FCL using a loop suture from distal to proximal (Figs 14 and 15). Spencer-Wells artery

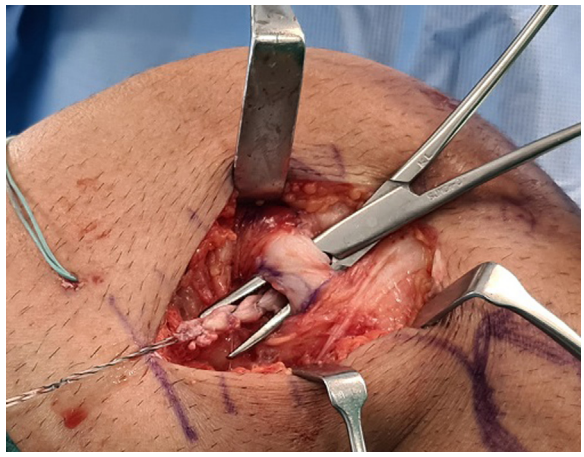

Fig 15. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. Spencer-Wells artery forceps are passed under FCL to create and dilate the path for easy retrieval of ITB graft to avoid crumpling (bunching) of graft. This is an important step, as bunching prevents the proper fixation of the graft into the desired LET tunnel. (FCL, fibular collateral ligament; ITB, iliotibial band; LET, lateral extra-articular tenodesis.)

forceps under FCL are used to create and dilate the path for easy retrieval of the ITB graft (Video 1). This step is important to allow easy passage of the ITB graft under the FCL. If not done adequately, crumpling (bunching) of the graft at the FCL attachment site prevents the proper fixation of the graft into the desired LET tunnel. The whipstitch of the graft is passed from the lateral to the medial femoral cortex over a shuttling suture (Fig 16). A nitinol wire is passed into the bony tunnel before the graft is shuttled (Fig 16). The graft shouldn't be tensioned more than 20 N while fixing it with a 7 × 25 mm bioscrew (Healthium Pvt. Ltd.) (Fig 17).

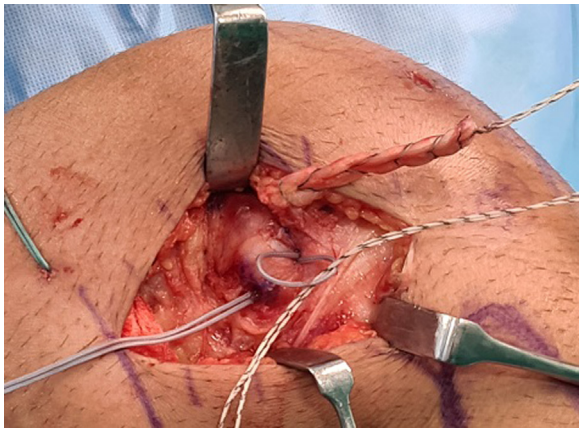

Fig 14. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. Two small rents are made anterior and posterior parallel to the FCL for passage of the graft. Iliotibial band graft is routed under the FCL using a loop suture from distal to proximal. (FCL, fibular collateral ligament.)

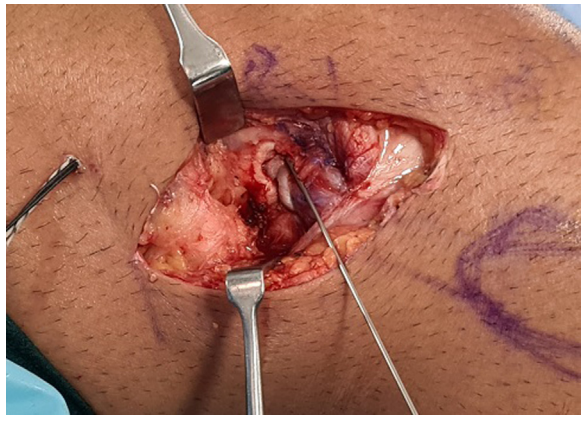

Fig 16. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 80° flexion. The mouth of the tunnel is cleaned with a basket punch. Nitinol wire is passed through the LET tunnel before passing the graft and whipstitched graft is exited from the medial femoral cortex. (LET, lateral extra-articular tenodesis.)

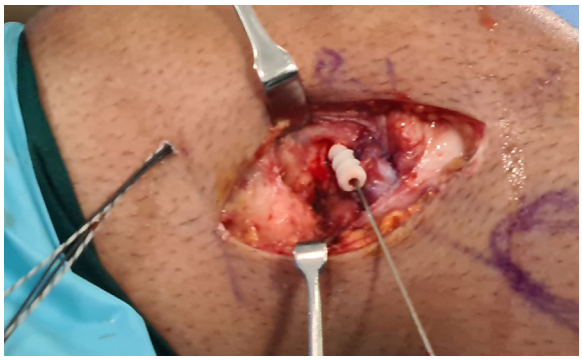

Fig 17. The figure shows the lateral aspect of the right side knee with patient in supine position and knee in 30° flexion. A bioscrew, 7 × 25 mm in size (Healthium Pvt Ltd, Peenya, BLR), is inserted with the lower limb in 30° flexion and tibia in neutral rotation to secure the graft.

During this whole process, the knee is kept in 30° flexion and the tibia is kept in neutral rotation (Fig 18). Other fixation devices such as staples also can be used if the ACL and LET tunnels coalesce. After fixation, it should be ensured that the knee can obtain full extension and flexion. The graft should become taut with internal rotation. The whipstitch is cut from the medial end. Partial closure of the ITB is done with continuous sutures to avoid overconstraining the knee. The wound is closed in layers. Clean dressing is done followed by Robert Jones compression bandaging.

Postoperative Rehabilitation

After the surgery, the functional hinged knee brace is applied. The patient is allowed to bear weight as tolerated with crutches for a minimum of 2 weeks before discontinuing crutches when the patient can walk without a limp. The brace is kept for 3 months for all activities. Physical therapy begins on the first postoperative day, with an emphasis on pain management, edema reduction, and knee motion. There are no limitations when it comes to the range of motion in the knees, with a focus on progressive improvement

Fig 18. The figure shows position of lower limb during bioscrew insertion. It should be 30° of knee flexion and tibia in neutral rotation.

Table 1. Pearls and Pitfalls

Pearls
1. The decision to perform LET is essentially preoperative, depending on the grade of the pivot shift and patient-specific requirement.
2. Ensure proper surface marking of lateral epicondyle, fibula head, Gerdy tubercle, and FCL before the skin incision.
3. Prepare ACL reconstruction femoral tunnel before LET.
4. The width of the harvested ITB should be a minimum 1 cm.
5. Underlying attachments of the ITB, i.e., vast lateralis and fat pad, must be cleared off the graft.
6. Ensure proper identification of 4 landmarks: "leash of vessels," fat pad, lateral supracondylar ridge, and lateral epicondyle.
7. Mark the final point of fixation with electro-cautery and clear it of any soft tissue.
8. Guide pin for the ITB fixation tunnel points 20-30° anteriorly and proximally
9. Ensure good arthroscopic visualization of the ACL femoral tunnel through anteromedial portal while drilling and reaming the ITB fixation tunnel. Any violation of the tunnel has to be identified, whether it is eccentric or central. An eccentric superior violation of the ACL tunnel can be accepted if a soft-tissue ACL graft is being fixed by a suspensory fixation on the femur side. Violation of the ACL tunnel at its center is not acceptable.
10. Avoid crumpling (bunching) of the graft by using Spencer-Wells artery forceps passed under FCL to create and dilate the path for easy retrieval of the graft.
11. Clear the mouth of the tunnel and pass nitinol wire before passing the whip-stitched graft.
12. Ensure proper position of the lower limb while fixation with the bio-screw: 30° knee flexion with the tibia in neutral rotation.
Pitfalls
1. Crumpling (bunching) of graft if the adequate passage isn't created under the FCL.
2. Inadequate visualization of the ACL femoral tunnel due to bony bleeding and failure to identify a violation of the tunnel.
3. Tensioning the graft more than 20 N leads to overconstraint of the lateral compartment of the knee.
4. Tight closure of the ITB leading to overconstraint of the knee and abnormal patellar tracking.

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

progression. At approximately 3 to 4 weeks, stationary cycling is started. Generalized strengthening progression is initiated at this time, along with core strengthening. Jogging and straight-line functional activities can start as early as 4 months once sufficient core strength has been achieved and the patient can demonstrate a single leg squat without valgus collapse. If a meniscal tear accompanies an ACL tear, the physiotherapy is gradual and biased towards protecting the meniscal repair.

Discussion

The anterolateral corner of the knee is made up of the anterolateral capsular ligament and ITB, which inserts onto the lateral meniscus, distal femur, and joint capsule through Kaplan fibers.[7] When combined with ACLR, LET has been shown to minimize anterior tibial translation and internal tibial rotation in addition to improving knee stability by lowering

Table 2. Advantages and Limitations of the Procedure

Advantages
1. LET provides rotatory stability to the knee essentially reducing the pivot shift, especially in pivot-demanding contact sports.
2. It reduces stress on the ACL graft during rehabilitation and ensures better graft healing.
3. Range of motion or increased risk of osteoarthritis remains unaffected by the procedure.
4. The procedure is relatively fast and simple with an easy learning curve.
5. Rehabilitation remains the same as with an ACLR without LET.
Limitations
1. LET is relatively contraindicated in posterolateral corner injuries and lateral compartment osteoarthritis.
2. The procedure creates a scar on the lateral side of the knee, which might have cosmetic implications, especially in female patients.
3. Overtensioning the graft might lead to overconstraint of the lateral compartment of the knee.
4. Tight closure of the ITB might lead to patellar maltracking.
5. An extra bioscrew in addition to the ACLR implants has financial implications.

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

anterolateral rotary instability.[8-10] LET anteriorizes lateral compartment contact stress, which may help in knees with passive anterior subluxation of lateral tibia.[11] It also reduces the force exerted on the ACL graft and gives it a chance for early vascularization and ligamentization.[8-10] Anterolateral rotatory instability is one of the most common causes of ACLR failure, which in turn leads to a poor outcome for the patients. Limiting internal rotation of the tibia does overconstrain the knee, which can be minimized by not exerting more than 20 N force during fixation of the ITB to the lateral femoral cortex.[12,13] The knee is kept in 30° flexion and neutral rotation according to the original Lemaire description of the technique, which restores normal knee biomechanics.[14] Fixation of the ITB graft can be done by various techniques. Staple fixation has been commonly described in the literature in techniques by Kwapisz et al.[15] and Bernholt et al.[16] Abusleme et al.[17] described suturing the ITB graft onto itself without any implants. We use a bioscrew to secure the graft which, according to us, minimizes the chances of graft failure. Identification of the fixation point of the ITB graft is probably the most important step in the whole procedure. The fixation point should restore the normal knee biomechanics and, as described in our technique. The "leash of vessels," fat pad near the lateral epicondyle, and lateral supracondylar ridge have served us well to decide the fixation point and should help other surgeons to precisely locate the same. Pearls and pitfalls of the procedure are explained in Table 1. The advantages and limitations of the procedure are enumerated in Table 2.

Conclusions

LET is now being routinely used as an adjunct to ACLR in patients with grade 2 or greater pivot shift and high-risk pivot, demanding athletes. We believe that it gives the ACL graft a good chance for faster healing along with addressing anterolateral rotatory instability. Choosing a correct fixation point is very important, which restores normal knee biomechanics.

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