Technical Note

Double-Bundle Anterior Cruciate Ligament Repair and Augmentation With Lateral Extra-articular Tenodesis

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Abstract: The evidence to date still favors anterior cruciate ligament (ACL) reconstruction over anterior cruciate ligament repair because ACL repair has a higher failure rate. However, there has recently been a resurgence of interest in primary ACL repair that has the potential to preserve its native tissue and improve its function. This Technical Note describes a double-bundle arthroscopic ACL repair combined with a modified Lemaire procedure. The extra-articular tenodesis improves anterolateral stability to enhance the success of the repair.

Multiple enhancement techniques for anterior cruciate ligament (ACL) repair have been introduced over the past decade, the 2 most common of which are suture tape and dynamic intraligamentary stabilization. These reinforced systems have been used to reduce the chance of gap formation and load to failure and support the ACL while it heals. Research has shown that these augmentations appear to be safe, but failure rates are still around 7% and 11%.[1] Meanwhile, additional lateral extra-articular tenodesis improves rotational stability and lowers the failure risk of ACL reconstruction.[2] This remark led us to the idea of combining these 2 procedures so as to take advantages of the inherent benefits of ACL repair and at the same time minimize the failure rate.

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Surgical Technique (With Video Illustration)

Patient Selection

ACL repair is indicated mainly for those patients with acute injuries within the first 3 weeks, with proximal tear patterns Sherman classification type I or II, good tissue quality, and intact synovial sheath.

Position and Landmark

The patient is placed in the supine position with the knee in right-angle flexion. A tourniquet is wrapped around the thigh above the knee, and the operative leg is prepared and draped in a standard fashion. Gerdi tubercle, lateral epicondyle, skin incision, patella, and patellar tendon are all marked.

Arthroscopic ACL Inspection

Anterolateral, anteromedial, and accessory superior-anteromedial portals are created, and diagnostic arthroscopy is undertaken. An assessment of the ligament is made to confirm a proximal tear and good tissue quality, making it reasonable to attempt doing a repair (Fig 1A, Video 1).

The femoral footprint is exposed, and a small awl is introduced to create some bleeding. First, a No. 2 FiberWire (Arthrex) suture is placed roughly into the anteromedial bundle fibers of the ACL remnant with a suture passer (TRUEPASS Suture Passer; Smith & Nephew). The 2 free ends of the suture are pulled through the closed end and tensioned to create a loop on the anteromedial (AM) bundle.

Second, with the help of a Lasso suture passer (Conmed Livantec), a shuttle suture is placed into the

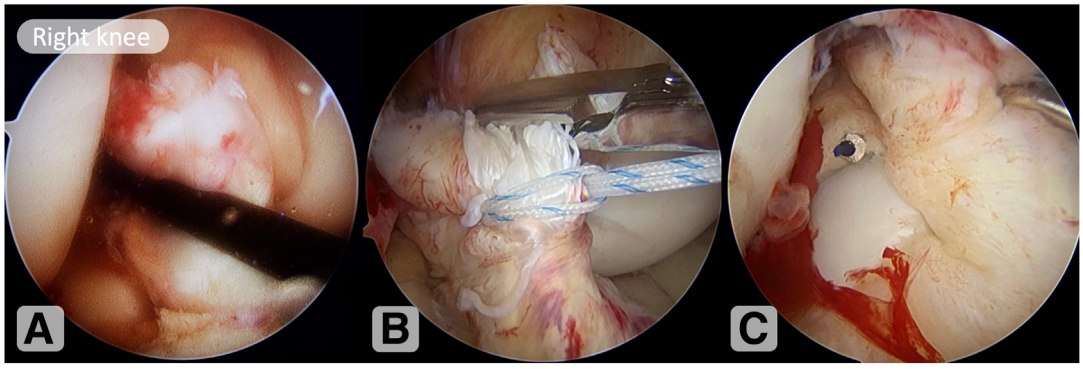

Fig 1. (A) Ligament investigation. (B) A looped suture around the anteromedial bundle. (C) An arthroscopic suture passer used to pass the suture around the posterolateral bundle (right side, supine position with knee in 90° of flexion, view from anterolateral portal).

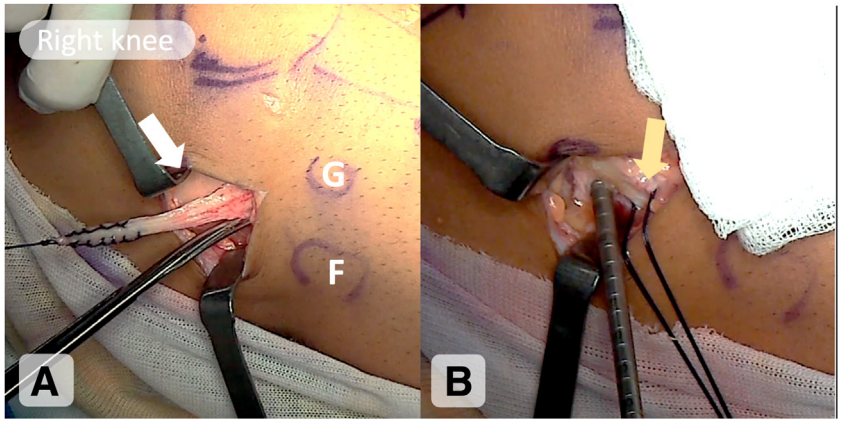

Fig 2. (A) Iliotibial band (ITB) graft harvesting (white arrow: ITB graft). (B) Femoral tunnel drilling for extra-articular tenodesis (yellow arrow: lateral collateral ligament) (right side, supine position with knee in 90° of flexion. (F, fibular head; G, Gerdi tubercle.)

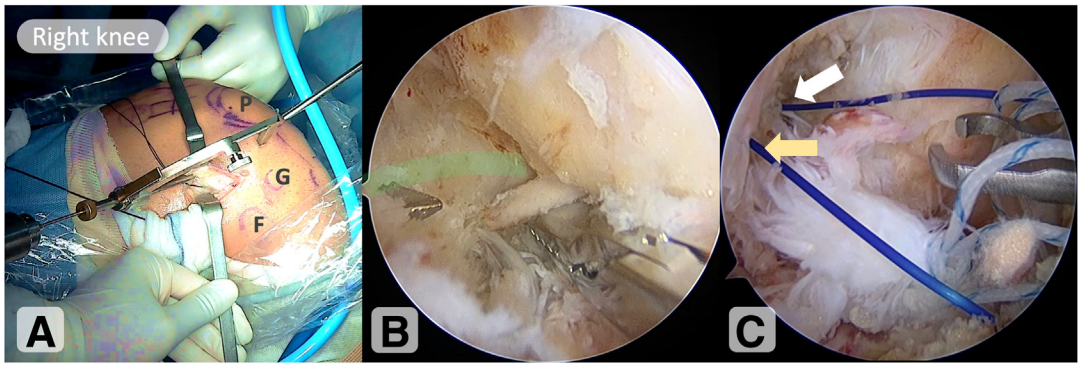

Fig 3. (A) Femoral tunnel drilling for anterior cruciate ligament repair (right side, supine position with knee in 90° of flexion). (B) Tip of the K-wire view from the accessory superior anteromedial portal (green line: intercondylar edge) (right side, supine position with knee in 90° of flexion). (C) Shuttle sutures for anterior cruciate ligament repair (white and yellow arrow: anteromedial and posterolateral bundles, respectively) (view from anterolateral portal, right side, supine position with knee in 90° of flexion). (F, fibular head; G, Gerdi tubercle; P, patella.)

posterolateral (PL) bundle, which is then used to draw a No. 2 FiberWire suture to make a second loop on the PL bundle (Fig 1 B and C, Video 1).

Bone Marrow Aspirate Clot Preparation

Approximately 20 mL of bone marrow is harvested from the proximal tibia and placed into a small basin. After approximately a 6- to 7-minute stirring, the bone marrow clot is carefully removed and put onto a sterile surgical sponge.

Lateral Extra-articular Tenodesis

A 4- to 5-cm skin incision is made posterior to the lateral epicondyle, toward the Gerdi tubercle. A 10-

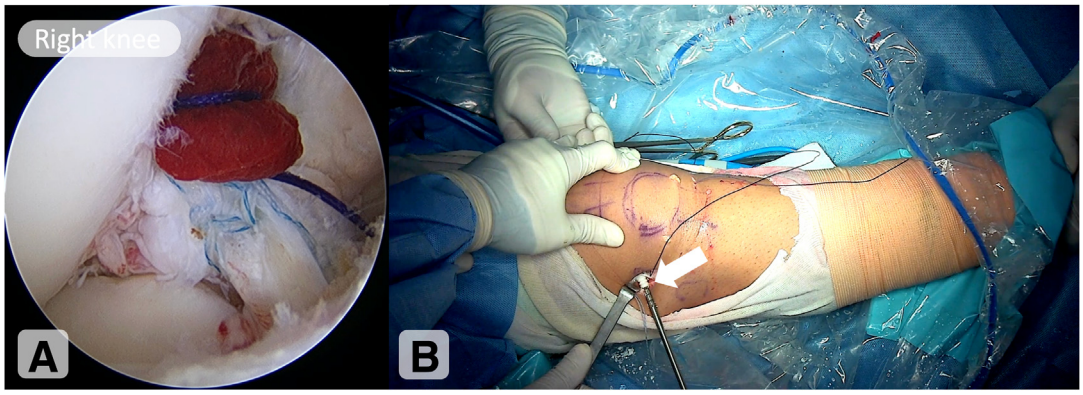

Fig 4. (A) Tensioning and tying the posterolateral bundle in 90° of flexion (right side, supine position with knee in 90° of flexion, view from anterolateral portal). (B) Fixing the anteromedial bundle and iliotibial band graft in full extension (white arrow: interference screw) (right side, supine position with knee in full extension).

mm-wide and approximately 8-cm-long strip of the posterior half of the iliotibial band (ITB) is harvested, leaving the distal insertion. The ITB graft is whip-stitched and then wrapped in a vancomycin sponge (Fig 2A, Video 1).

After identifying the lateral collateral ligament, a tunnel is created, and a passing suture is placed deep to the ligament.

The femoral insertion point for the extra-articular tenodesis, roughly 6 mm posterior and 4 mm posterior to the lateral epicondyle, is identified. A 6-mm drill is used to create a 25-mm tunnel at an angle of 30° anteriorly and proximally. A second suture is drawn through the tunnel for later use (Fig 2B, Video 1).

ACL Tunnel Creation

After passing the ITB graft beneath the lateral collateral ligament, the camera is switched to the superior AM portals. From this perspective, the native femoral ACL insertion can be easily identified and accessed. An ACL femoral guide is introduced via the anterolateral portal to help create 2 parallel 2.4 mm tunnels in an outside-in fashion. The first and the second guide pins are centered over the AM and PL insertion, respectively. The intra-articular entry point of the tunnels is higher than those for ACL reconstruction (right on or 1 mm posterior to the intercondylar edge). Two 1.0 polydioxanone sutures are placed in each tunnel for later FiberWire looped suture passing and a No. 1 Vicryl (Ethicon) suture to the AM tunnel for bone marrow clot placing (Fig 3, Video 1).

ACL Remnant and ITB Graft Fixation

Sutures from the 2 bundles are drawn through the respective tunnels to the lateral surface of the lateral condyle. The No. 1 Vicryl suture is used to draw a bone marrow clot to the medial wall of the lateral condyle, close to the insertion side of the ACL remnant. The FiberWire of the PL bundle is then tensioned and tied in 90° of flexion, and the suture of the AM bundle and the Vicryl suture are tied in full extension over an endobutton. The iliotibial band graft is pulled to the tunnel and fixed in full extension and neutral rotation with an interference screw (Fig 4, Video 1).

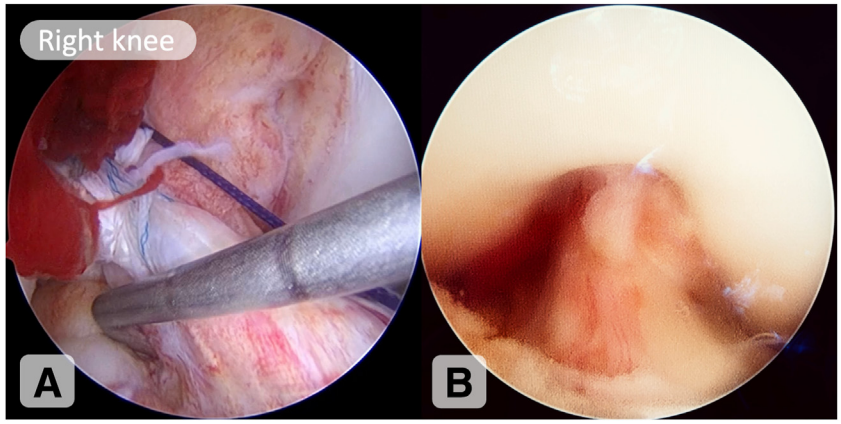

Fig 5. (A) Checking the stability in 90° of flexion. (B) Impingement in extension (right side, supine position with knee in 90° of flexion [A], and extension [B], view from anterolateral portal).

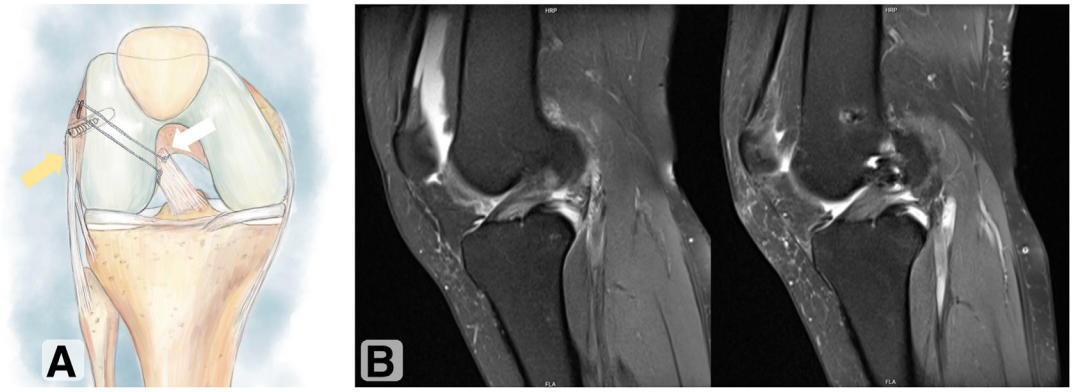

Fig 6. (A) A schematic technical illustration (yellow arrow: extra-articular tenodesis, white arrow: anterior cruciate ligament repair). (B) Magnetic resonance imaging of a patient before and 3 months after surgery.

Checking the Stability

The ACL remnant tension is confirmed with a probe. Range of motion confirms anatomic positioning without impingement, and manual laxity testing shows minimal translation with a firm end point on Lachman examination intraoperatively (Fig 5, Video 1).

Discussion

ACL tears can be repaired with a failure rate of 8% and good functional outcome.[3] The most common approach is passing sutures around the ACL stump and reapproximating these fibers to the ACL femoral footprint at a single point. An additional internal bracing is then used to minimize elongation of tissue and promote healing, which is found to be safe.[1] Nevertheless, long-term effects of suture tape incorporation in ACL repair are largely unknown. Moreover, suture anchor irritation has been reported.[4]

Our hypothesis that an extra-articular augmentation can minimize failure after ACL reconstruction provides us with a mechanism through which we can create a "safe belt" for the ACL repair (Fig 6). Therefore, it is possible to improve primary stability and lower the failure rate while avoiding complications of intra-articular implant. Besides, by not using a suture augmentation for ACL repair, this technique requires smaller tunnels and helps preserve bone on the femoral side in case of revision.

The benefit of double-bundle repair is restoring the natural anatomic and biomechanical properties of the ligament,[5] thus maximizing the contact area of the stump to the bone and stability of the whole repair structure, especially in combination with an extra-articular procedure.

Nguyen et al.[6] have proved that the proximal ACL has greater healing potential than the mid-substance of the ACL. Our indications narrow to only Sherman classification type I or II within 3 weeks of injury, with good tissue quality and intact synovial sheath.[7]

Biologically enhanced ACL repair achieves better outcomes than ACL repair alone.[8] Therefore, bone marrow clot is added between the ligament stump and bone in the hope of improving healing and outcomes. This is a simple technique and does not lead to an increase in surgery time or costs.

Other potential advantages of this technique include less pain, earlier return of range of motion, faster rehabilitation,[9] lower risk of post-traumatic

Table 1. Surgical Pearls and Pitfalls

Pearls	
1	Outside-in ACL and ALL tunnel drilling helps avoid collision
2	The tunnel for AM and PL bundles is placed close to the intercondylar edge (direct insertion)
3	View from anteromedial portal helps place tunnel precisely
4	Independent tightening the AM and PL bundles in extension and flexion, respectively
5	Fix IT band graft in full extension
Pitfalls	
1	The sutures too distal or too proximal on the stump
2	The femoral tunnels are too high (impingement) or too low (nonisometric)

ACL, anterior cruciate ligament; ALL, anterolateral ligament; AM, anteromedial; IT, iliotibial; PL, posterolateral.

Table 2. Advantages and Disadvantages of the Technique

Advantages	
1	Better primary stability during the healing process
2	No intra-articular implant complication
3	Larger contact area between graft and lateral wall
4	No need for tibial tunnel; less injury to ACL stump
5	Lower surgical costs
6	Potential improvement in healing and revascularization of the ACL with bone marrow clot
Disadvantages and Limitations	
1	Time-consuming procedure
2	Surgical skill requiring procedure
3	Not an all-arthroscopic procedure
4	Not applicable to complex tears or Sherman type III or IV
5	Unknown rate of failure

ACL, anterior cruciate ligament.

osteoarthritis, and, most obviously, no need for autograft harvest.[10]

In conclusion, double bundle with lateral extra-articular tenodesis is a safe and promising technique to repair the proximal ACL tears. Advantages, disadvantages, and surgical pearls and pitfalls of the technique are summarized in Tables 1 and 2.

Disclosures

All authors (N.Q.T.Q., D.M.H., V.T.H., P.N.T., T.H.N.A.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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