Technical Note

Anterior Cruciate Ligament Reconstruction and Double Extra-Articular Reinforcement

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Abstract: This study describes a technique for double extra-articular reinforcement associated with anterior cruciate ligament (ACL) reconstruction for patients with both internal and external rotational instability, using reinforcements from the hamstrings and the anterior half of the peroneus longus muscle. The technique involves using 2 reinforcements: one for anterolateral stabilization and the other for anteromedial stabilization. The procedure follows a detailed algorithm for diagnosing rotational instability through physical examination under anesthesia. This approach offers a solution for complex ACL injuries involving bidirectional rotational instability, aiming to optimize knee stability and reduce failure rates in ACL reconstruction.

Patients with anterior cruciate ligament (ACL) injury who have indications for extra-articular reinforcement without peripheral lesions requiring reconstruction undergo a physical examination under anesthesia, following the algorithm[1] represented by Figure 1. All cases should exhibit a positive Lachman test, indicating ACL injury. A positive pivot shift will indicate instability in internal rotation, necessitating anterolateral extra-articular reinforcement, along with anterolateral ligament (ALL) reconstruction. The medial compartment should be tested using the anterior drawer in external rotation test. A positive test denotes instability in external rotation, the anteromedial rotatory instability (AMRI). In this presence, medial reinforcement is also necessary to reconstruct the anterior oblique ligament (AOL). Therefore, we opt for double extra-articular reinforcement in external and internal rotational instability cases.

Surgical Technique

Patient Positioning

The patient is positioned supine on a standard operating room table with a nonsterile tourniquet applied at the proximal thigh.

Harvesting the Grafts

Harvesting of the tendons of the semitendinosus and gracilis (STG) muscles is preferentially performed in the injured limb. The grafts are harvested from the contralateral limb for patients in whom these grafts were used in the primary reconstruction. First, a longitudinal incision of approximately 3 cm is made 4 cm distal to the knee joint. The fascia of the sartorius muscle and the tendons of the STG muscles are identified. A new transverse incision is made in the fascia of

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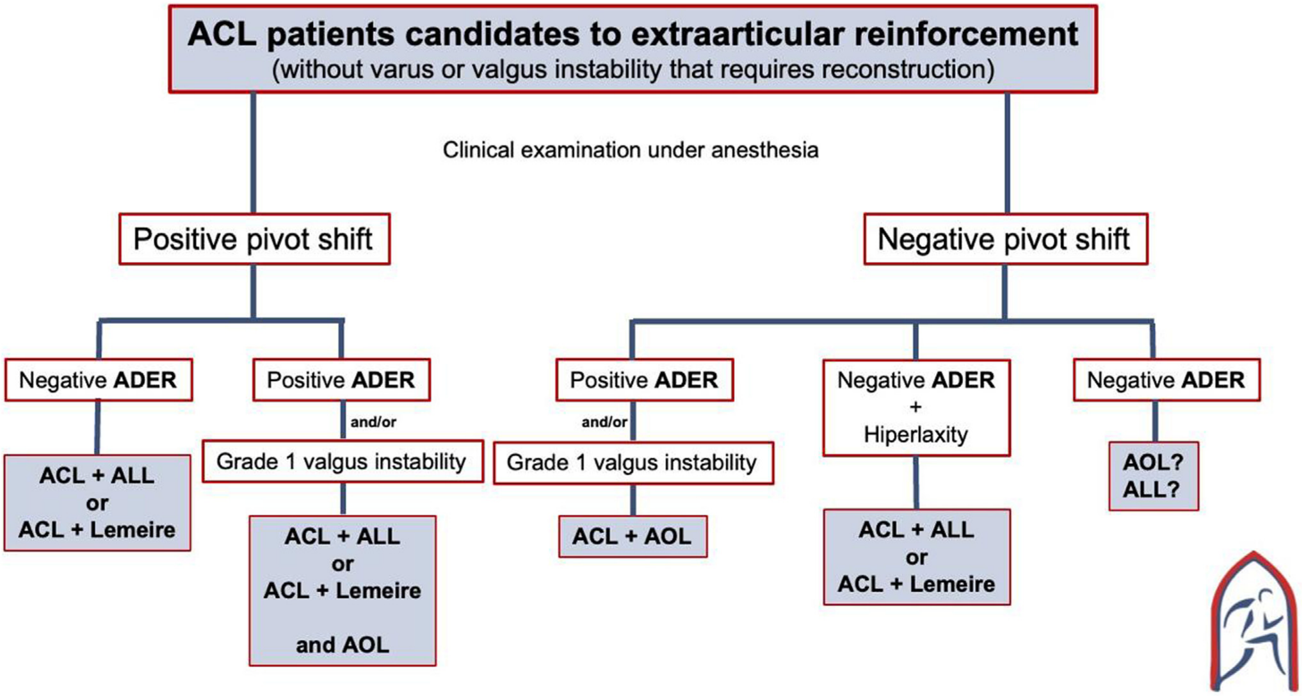

Fig 1. Decision-making algorithm for determining which patients with anterior cruciate ligament (ACL) injuries are candidates for extra-articular reinforcement. (ADER, anterior drawer in external rotation; ALL, anterolateral ligament; AOL, anterior oblique ligament).

the sartorius muscle, and the STG is visualized. The STG is then repaired with No. 1-0 VICRYL thread (Ethicon, Somerville, NJ) and harvested using a closed-loop tendon stripper.

For harvesting the anterior half of the peroneus longus (PL). a single longitudinal incision of 3 cm is made in the posterolateral region of the fibula (Fig 2). The incision is made starting 3 cm proximal to the most distal point of the lateral malleolus. The PL is identified and isolated (Fig 3). Using a scalpel blade, the tendon is divided in half and an L-shaped incision is made, separating the anterior half, which is removed using a closed-loop tendon stripper (Fig 4).

Graft Preparation

Usually, the longer graft is the anterior half of the PL. This is folded to make it triple, resulting in a graft about 8 to 10 cm in length. Alongside it, we lay the gracilis

Fig 2. Patient in supine position; left ankle. Posterolateral region of the fibula. The incision is made in a distal-to-proximal direction, starting 3 cm proximal to the most distal point of the lateral malleolus.

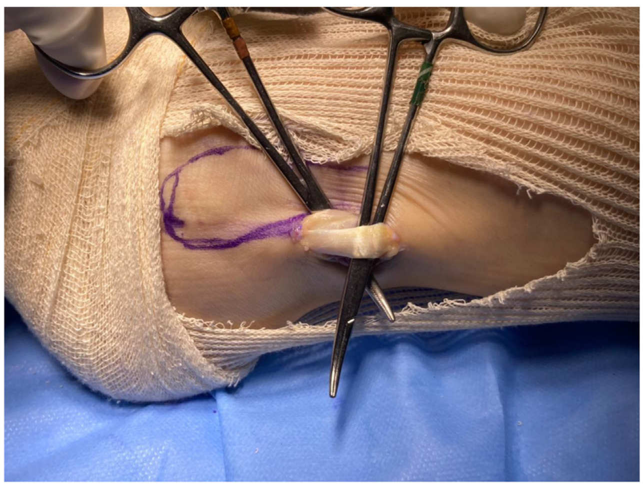

Fig 3. Patient in supine position; left ankle. Posterolateral region of the fibula. The peroneus longus is identified and isolated with hemostatic forceps (mosquito or Kelly) after distinguishing it from the peroneus brevis.

Fig 4. Patient in supine position; left ankle. Posterolateral region of the fibula. The anterior half is repaired with No. 1-0 VICRYL thread (Fig 5) and removed to its proximal insertion with a tenotome, up to approximately 5 cm from the fibular head.

tendon in a single manner, with its remaining portion forming an extra-articular reinforcement. Similarly, but in the opposite direction the semitendinosus is positioned, with its end forming the other extra-articular reinforcement. All the grafts are prepared with 1.0 VICRYL, at both ends of the ACL, and at one end of each extra-articular reinforcement (Table 1).

ACL Tunnels

Reconstruction is performed through anatomic positioning to create the femoral and tibial tunnels. The femoral tunnel is positioned in the anatomical functional position.[2] Guides (ACUFEX PINPOINT; Smith & Nephew, Andover, MA) are used to make the tunnels using the outside-in technique. The tibial tunnel should be made with the guide at a 60° opening angle and positioned 45° in the medial direction relative to the tibial crest.

AOL Femoral Tunnel

The medial epicondyle is identified in the lateral view with the aid of radioscopy. At this point, a guidewire (Smith & Nephew) is passed through the femur, starting at the medial epicondyle anterior portion, in the anterior and proximal direction, and a bone tunnel of approximately 40 to 45 mm is then constructed (Fig 5).

ALL Tibial Tunnel

The distance halfway between the Gerdy tubercle and the anterior eminence of the fibular head is found at approximately 1.5 cm from the articular surface. At this point, a guidewire (Smith & Nephew) is passed through the tibia in the anterior and slightly lateral direction, and a bone tunnel with a depth of 25 to 35 mm is constructed under radioscopic visualization. To avoid tunnel convergence, careful surgical planning, continuous radioscopic guidance during the procedure, and strategic placement of the tunnel's entry and exit points are essential.

Passage and Fixation

The graft is pulled through the tibial tunnel and passed through the femoral tunnel. The 2 unfolded distal an proximal portions of the graft remain out of the tibial tunnel and the femoral tunnel until the ACL 10-cm portion occupies both femoral and tibial tunnels. An interference screw (BIOSURE; Smith & Nephew) is fixed to the femur. The next step is to fix the inferior end of the ACL graft to the tibia after pretensioning. Fixation is performed with the graft tensioned and the knee in total extension and after the performance of the posterior drawer maneuver. After tibial fixation, the remaining PL is passed through the subcutaneous, on the medial side, and is passed through the AOL femoral tunnel. The lateral portion of the single graft, which emerges from the lateral femoral tunnel, is passed subcutaneously in a closely articular manner and through the tibial tunnel of the ALL. Both extra-articular ligaments are fixed under traction with interference screws, neutral rotation, and full extension.

Discussion

We describe an extra-articular solution for cases with ACL injury associated with complex rotational instabilities without peripheral injury that warrants complete reconstruction of both the medial and lateral structures. More accurate identification of all instabilities present in each patient and their treatment is the most suitable approach to achieve better outcomes.

Fig 5. A guidewire is passed through the femur, starting at the medial epicondyle anterior portion, in the anterior direction.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
It is important to suture the tendons of the peroneus longus and brevis muscles with knots that will not damage the superficial tissues to avoid the formation of granulomas.	Tightening the screw deeply past the cortical bone may cause loosening of the fixation, leading to failure.
Guiding the positioning of the femoral tunnel, in which the AOL will be fixed with fluoroscopy, is essential for a good result.	Performing the fixation in the femoral tunnel for the AOL in extension and neutral rotation is important for good results.
The positioning of the tunnels for ACL reconstruction with extra joint reinforcement is exactly the same as for ACL reconstruction combined with the AOL.	

ACL, anterior cruciate ligament; AOL, anterior oblique ligament.

Despite outcome studies after anterior cruciate ligament reconstruction (ACLR) in elite athletes showing a high return-to-sport rate, recent research has indicated that up to 35% of athletes specifically don't return to their previous levels of preinjury function within two years from ACLR.[3] Furthermore, reinjury to the same surgical knee after an ACL injury has been reported often.[4] Restoring knee stability is critical to obtaining better outcomes after ACLR. A residual pivot shift indicates anterolateral instability or external rotational instability and can cause poor results. Ueki et al.[5] reported that a residual anterolateral instability patient population may represent a group at an increased risk of poor results after ACLR. Kemler et al.[6] reported that patients who experience persistent rotatory instability in the setting of a reconstructed ACL have worse outcomes, as well as greater rates of graft failure and revision surgery. The pivot shift test is a complex clinical sign assessing internal rotation and anterior tibial translation. Despite the recent development of objective and standardized evaluation methods, clinical examination remains the gold standard.[7]

In contrast, residual anteromedial instability (AMRI) has been reported as a cause of failure in ACLRs. Miyaji et al.[8] reported that many medial collateral ligament (MCL) injuries occur in combination with ACL injuries, causing AMRI. These injuries may rupture the anteromedial capsule and deep MCL. Unaddressed MCL deficiency leads to an increased ACLR failure rate. Beel et al.[9] believe that it remains to be determined whether a medial extra-articular procedure designed to reduce AMRI will reduce the failure rate of ACLR. Behrendt et al.[10] reported that a flat MCL reconstruction or an additional anteromedial procedure better restored medial knee stability. These findings may have important implications for improving medial reconstructions and reducing the risk of ACL graft rupture.

However, since the studies of Jorge et al.,[3,11,12] the AOL has been described in the anteromedial quadrant of the knee. As the result of its positioning, similar to the in vitro reconstructions reported by Behrendt et al.[10] and Miyaji et al.,[8] it would help control primarily external tibial rotation, minimizing residual AMRI in patients with this type of instability.

Physical examination under anesthesia should be essential in evaluating the type of extra-articular reinforcement. When the pivot shift is positive, grade 2 or 3, the surgeon is undoubtedly dealing with internal rotational instability, and the need for reinforcement in the anterolateral compartment will be present. In cases in which the anterior drawer in external rotation (using the anterior drawer in external rotation test) is positive, the surgeon is dealing with external rotational instability, and the patient will likely benefit from extra-articular reinforcement in the anteromedial quadrant, with the reconstruction of the AOL).

Nevertheless, there are cases in which the physical examination under anesthesia shows bidirectional rotational instability. These patients may benefit from double extra-articular reinforcement, with the aim to control both external and internal rotation, protecting the ACL reconstruction in the central pivot.

The limitation of this study is the lack of a biomechanical analysis of the type of reconstruction proposed. However, we believe in the importance of rotational control to minimize the load on the ACL graft (Table 2). With a thorough and detailed physical examination, it is possible to identify the direction of the instability precisely. When bidirectional, the benefit of double reinforcement will likely be present.

Table 2. Advantages and Disadvantages of the PL-Removal Technique

Advantages	Disadvantages
The PL removal technique is not complicated.	More graft-fixation devices are needed compared with the traditional outside-in technique.
The availability of the PL graft is greater than that of allograft.	There is a need to remove the graft from another site.
Greater rotational stability occurs in the knee when extra-articular reinforcement is performed.	

PL, peroneus longus.

Disclosures

All authors (P.B.J., M.B.T., J.M.D.M., C.P.H., S.M.d.G.C., V.B.C.d.P., D.E.D.O.) 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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