Technical Note

Combined, Pedicled Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction - "PAAR" Technique

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Abstract: Despite constant development of surgical implants, instruments, and rehabilitation protocols, the outcomes of anterior cruciate ligament reconstruction remain unpredictable, and the failure rate of isolated procedures remains unacceptably high. Several factors possibly concerning suboptimal outcomes and risk of graft rerupture have been highlighted, among which are graft healing, tunnel position, and residual rotational instability. Recent studies have suggested that addressing anterolateral complex injury and enhancing graft healing properties might improve the outcomes of surgery. We propose a simple technique of combined anterior cruciate ligament and anterolateral ligament reconstruction using pedicled semitendinosus and gracilis tendons with a single femoral tunnel and no additional tibial tunnels.

Anterior cruciate ligament (ACL) reconstruction surgery is one of the most common orthopaedic procedures and is the subject of constant research. Despite surgical implant and rehabilitation protocol development, the outcomes of ACL reconstruction remain unpredictable. An unacceptably high rerupture rate—over 10%—and a low rate of return to preinjury sports level are still urgent problems.[1] For over a hundred years, we have observed many "revolutions" in surgical techniques including different grafts, fixation methods, and attempts to preserve graft and repair torn ligaments. Despite profound studies, some problems remain unresolved. Recent research has highlighted some factors that improve—or might improve—surgery outcomes[1,2]: lateral extra-articular procedure (LEAP), remnant preservation, and preservation of the hamstring tendon insertion to the pes anserinus. Regarding the first factor, large studies of 2 groups, SANTI and STABILITY, confirmed that LEAP, consisting of both anterolateral ligament (ALL) reconstruction and lateral extra-articular tenodesis (LET), significantly reduces the risk of ACL graft rupture and residual rotational instability.[3-5] Regarding the second factor, many authors have suggested that preservation of the ACL remnant offers multiple benefits, that is, preservation of mechanoreceptors, better vascularization, synovial coverage, and a faster ligamentization process.[6] Regarding the third factor, recent studies have suggested that leaving the insertions intact improves vascularization and ligamentization, enhancing graft healing.[7]

A significant number of techniques addressing the aforementioned factors have been described. The optimal LEAP method remains controversial. LET techniques require an extensive approach and harvesting of the iliotibial band. ALL reconstruction and modified Lemaire techniques are associated with the risk of tunnel convergence and implant conflict. Sonnery-Cottet et al.[8] presented a combined ACL-ALL reconstruction technique using a single femoral tunnel, with additional tibial tunnels for ALL reconstruction.

We describe a simple technique of combined ACL-ALL reconstruction, preserving both the semitendinosus and gracilis tendon insertions, using a single femoral tunnel and no additional tibial tunnels, as presented in Video 1. The name of technique - "PAAR" stands for "Pedicled ACL-ALL reconstruction". Graft preparation is significantly facilitated, leaving no sutures either in the joint or inside the ACL

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Table 1. Authors' Indications for Lateral Extra-articular Procedure

Significant pivot-shift test finding during examination
Young patient (aged < 21 yr)
High-demanding athlete who participates in pivoting sport
Revision case
Meniscal bucket-handle tear
Segond fracture
Chronic ACL tear

ACL, anterior cruciate ligament.

Table 2. Technique Advantages and Disadvantages

Advantages
A single femoral tunnel is used for ACL and ALL reconstruction; hence, there is no risk of tunnel convergence or implant conflict.
Preservation of the ACL remnant offers graft synovial coverage, vascularization, preservation of mechanoreceptors, and a potentially better healing process.
Preserving the hamstring graft's tibial insertion leaves its vascularization intact, supporting the healing process.
Graft preparation is easy and fast, with no suturing materials inside the joint or ACL reconstruction tunnels.
No additional tunnels are needed for ALL reconstruction.
There is no need to measure tunnel lengths.
The technique is less invasive, and there is no need for ITB harvesting compared with popular LET techniques.
The outside-in femoral tunnel allows for precise and repeatable positioning, as well as preservation of the ACL remnant, limiting the risk of iatrogenic cartilage injury.
Disadvantages
Remnant preservation reconstruction is more technically demanding because of worse visualization.
A doubled semitendinosus—single gracilis graft, in rare situations, might have a diameter <8 mm, causing the potential need for conversion to another technique.

ACL, anterior cruciate ligament; ALL, anterolateral ligament: ITB, iliotibial band; LET, lateral extra-articular tenodesis.

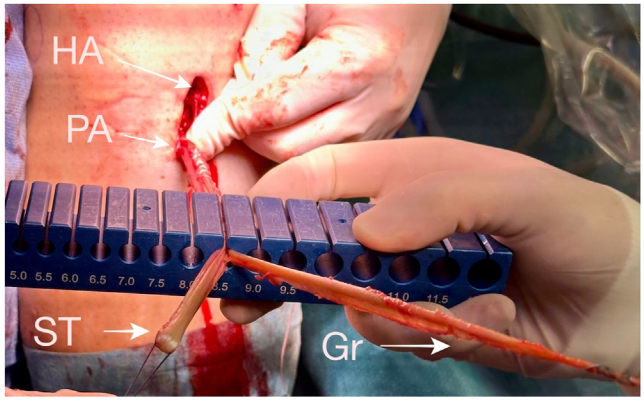

Fig 1. Graft preparation for pedicled anterior cruciate ligament—anterolateral ligament reconstruction. A right knee is shown, with a typical hamstring harvesting approach (HA). After harvesting of the semitendinosus and gracilis tendons, with a preserved insertion to the pes anserinus (PA), the free ends of the tendons are whipstitched. Then, the size of graft is measured with a single strand of gracilis (Gr) and doubled semitendinosus tendons (ST).

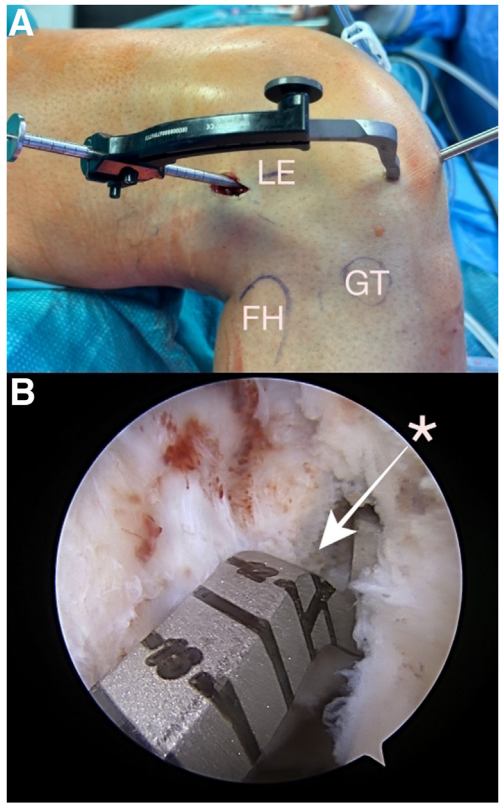

Fig 2. (A) Lateral side of right knee with orientation points marked on skin: lateral epicondyle (LE), Gerdy tubercle (GT), and fibular head (FH). The lateral femoral approach is performed slightly posterior and proximal to the lateral epicondyle. (B) Arthroscopic view from anteromedial portal. An outside-in femoral guide is introduced through the anterolateral portal and positioned on the proximal anterior cruciate ligament insertion (asterisk). The guide sleeve is pushed through the lateral femoral approach to the point of the anterolateral ligament insertion. A guidewire will be introduced into the anterior cruciate ligament footprint under arthroscopic visualization.

reconstruction tunnels. This technique was introduced as standard for authors in cases with indications for additional LEAP. Our indications for LEAP are highlighted in Table 1. Advantages and disadvantages of our technique are described in Table 2.

Surgical Technique

Setup and Approach

The patient undergoes the standard arthroscopic setup, with an Esmarch tourniquet installed. A high anterolateral portal for arthroscopy is created, and a camera is introduced into the joint. An anteromedial portal is created under arthroscopic visualization, and thorough joint inspection is performed. Any concomitant injuries requiring treatment are treated. A standard 1.5- to 2-cm incision is performed over the pes anserinus, and the semitendinosus and gracilis tendons are

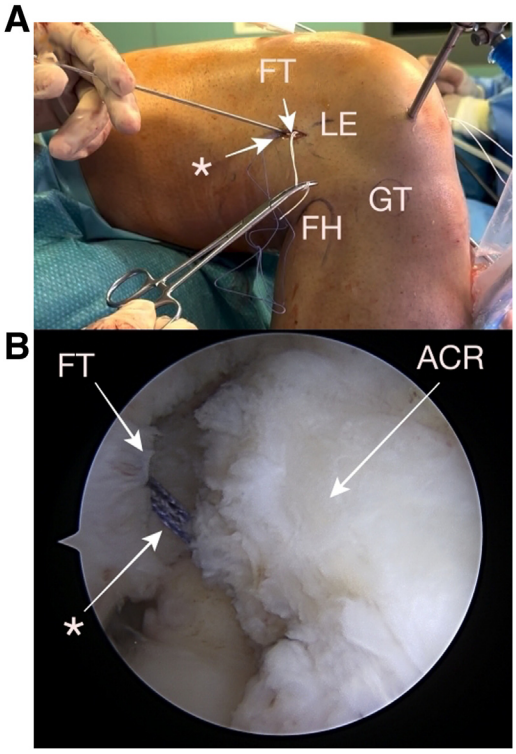

Fig 3. (A) Lateral side of right knee with orientation points marked on skin: lateral epicondyle (LE), Gerdy tubercle (GT), and fibular head (FH). A guidewire with a shuttling suture (asterisk) on the blunt end is inserted through the femoral tunnel (FT) into the joint. (B) Arthroscopic view from anterolateral portal. After retrieval of the shuttling suture (asterisk) from the femoral tunnel (FT), it is pulled underneath the anterior cruciate ligament remnant (ACR) through the tibial tunnel connecting the tibial hamstring harvesting approach with the lateral femoral approach. Later, the shuttling suture will be used to transfer the graft.

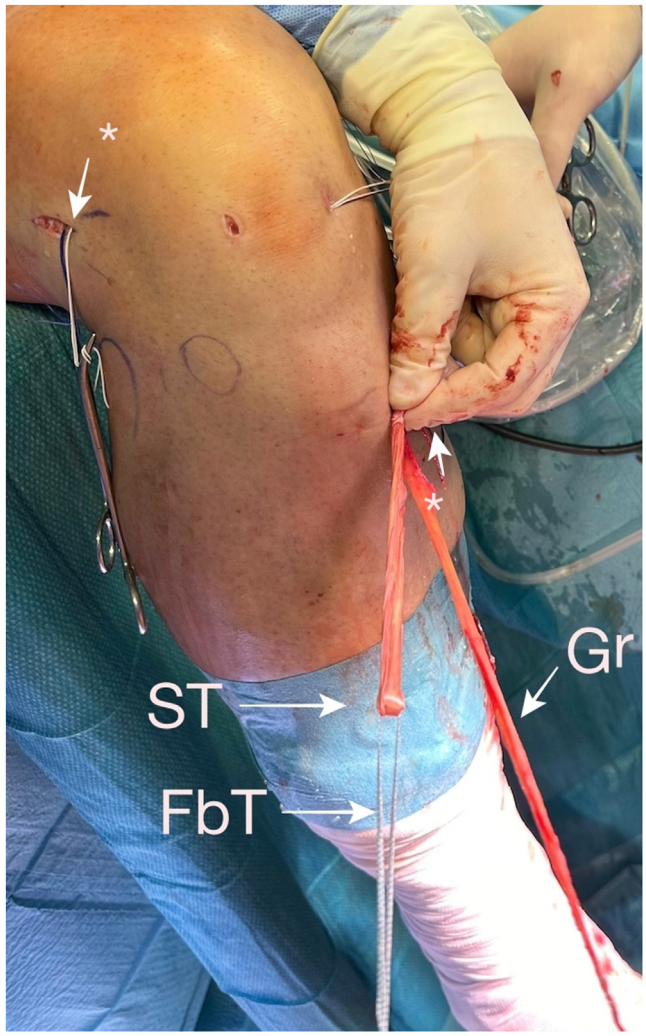

Fig 4. Anterolateral side of right knee with graft ready for reconstruction. The semitendinosus tendon (ST) is bent in half, hanging on the FiberTape suture (FbT), with 1 whipstitched free end. The gracilis tendon (Gr) also has a whipstitched free end. Next, the gracilis whipstitch suture and FiberTape suture will be pulled through the loop of the shuttling suture (asterisk).

harvested with a tendon stripper (Open Ended Tendon Stripper; Biomet, Warsaw, IN) without cutting of the tibial insertions. After preparation and removal of muscle tissue, the free ends are whipstitched (PremiCron, size 1; B Braun, Melsungen, Germany). The graft size is measured with doubled semitendinosus tendon and single-strand gracilis tendon (Fig 1).

Femoral Tunnel Preparation

Limited removal of scar tissue from the lateral femoral cortex is performed to uncover the ACL femoral footprint. An outside-in femoral aimer (Footprint Femoral ACL Guide; Arthrex, Naples, FL) is introduced through the anterolateral portal and pointed to the anatomic ACL footprint. A 1- to 1.5-cm skin cut is performed slightly proximal and posterior to the lateral femoral epicondyle. The drill guide system is connected. After the guide sleeve is pushed to the proximal ALL insertion point, a guidewire is introduced into the joint under arthroscopic visualization (Fig 2). After confirmation of proper wire position, femoral tunnel drilling is performed with the reamer size equal to the graft's measured diameter. The joint is debrided using a shaver.

Tibial Tunnel Preparation

A tibial aimer (Arthrex) is inserted into the joint through the anteromedial portal and placed in the proper position: inside the tibial ACL footprint with the knee in slight extension. The guide sleeve is connected, and a guidewire is introduced into the ACL remnant under arthroscopic visualization. After confirmation of proper position, the tibial tunnel is created with a reamer size equal to the graft diameter. The tibial tunnel and the joint are debrided with a shaver. A guidewire with a shuttling suture on the blunt end is inserted

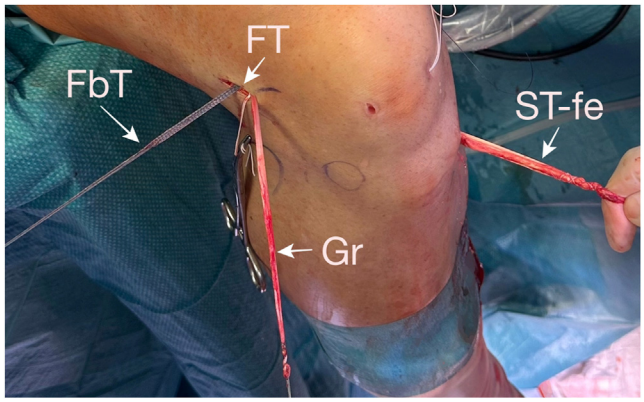

Fig 5. Anterolateral side of right knee after pulling shuttling suture. The FiberTape suture (FbT), on which the doubled semitendinosus graft is hanging, and the whipstitched end of the gracilis tendon (Gr) are transferred from the hamstring harvesting approach on the tibia to the lateral femoral approach (FT). The FiberTape is pulled with contra-tension on the whipstitched free end of the semitendinosus tendon (ST-fe) to position the graft, obtaining proper tension of the pedicled limb and placing the graft apex flush with the femoral tunnel exit.

through the femoral canal. The suture is retrieved by a grasper through the tibial canal to the hamstring harvesting approach (Fig 3).

Graft Preparation and Passage

The semitendinosus tendon is bent in half and hung on the central part of a FiberTape suture (length: 7 inches, diameter: 2 mm; Arthrex) (Fig 4). The free ends of the FiberTape and the free ends of the gracilis whipstitch suture are pulled by the shuttling suture to the lateral femoral approach. The gracilis tendon is passed through the tunnels, and using FiberTape with proper tension on the whipstitched free end, the semitendinosus graft is pulled through the tunnels until it shows up in the lateral aperture of the femoral tunnel (Fig 5). Then, using FiberTape and the whipstitched end, semitendinosus graft is positioned until proper tension on the second end (tibial insertion to the pes anserinus) is obtained and the apex of the graft is located flush with the tunnel aperture.

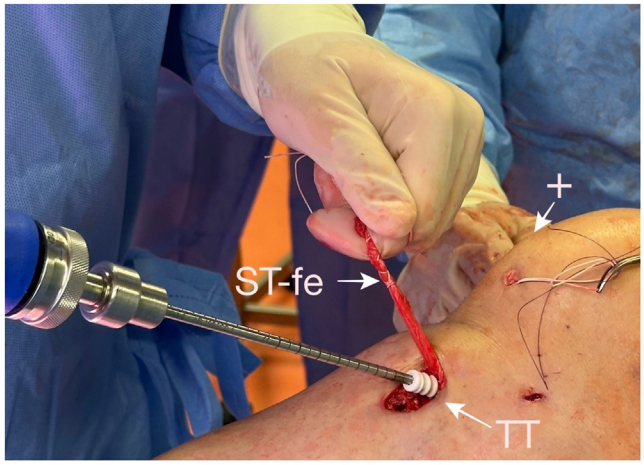

Fig 6. Anteromedial side of right knee showing anterior cruciate ligament reconstruction fixation in tibial tunnel (TT). After shuttling of grafts and proper positioning of the semitendinosus graft, blocking is performed in the tibial tunnel. With constant tension on the whipstitched free end of the gracilis, as well as the FiberTape suture on the lateral side (plus sign), and contra-tension on the whipstitched free end of the semitendinosus tendon (ST-fe), an interference screw of appropriate size is implanted in the tibial tunnel with the use of a nitinol guidewire.

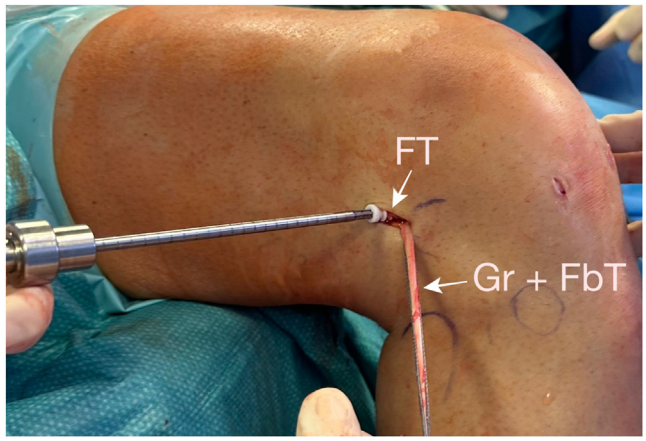

Fig 7. Lateral side of right knee showing anterior cruciate ligament reconstruction fixation in femoral tunnel. With constant tension on the FiberTape suture from the semitendinosus graft and the whipstitched gracilis free end (Gr+FbT), an interference screw of appropriate size is introduced in the aperture of the femoral tunnel (FT) with the use of nitinol guidewire. Then, the knee will be fully extended and positioned in neutral rotation, and a screw will be implanted, blocking the graft in the tunnel.

ACL Graft Fixation

With tension on the gracilis whipstitch and FiberTape sutures and with contra-tension on the semitendinosus whipstitch suture, the appropriately sized interference screw (FastThread; Arthrex) is introduced into the tibial tunnel using a nitinol guidewire (Fig 6). Then, the same step, without the contra-tension, is repeated at the femoral tunnel with the knee positioned in full extension and neutral rotation (Fig 7).

ALL Reconstruction

A stab incision is performed at the tibial ALL anatomic insertion point, between the Gerdy tubercle and the head of the fibula. The cortical layer of bone is refreshed, and a 2.6-mm Knotless FiberTak Soft Anchor (Arthrex) is implanted. After confirmation of stable implantation, the whipstitched end of the gracilis tendon is transferred subcutaneously, deep to the iliotibial band, to the tibial

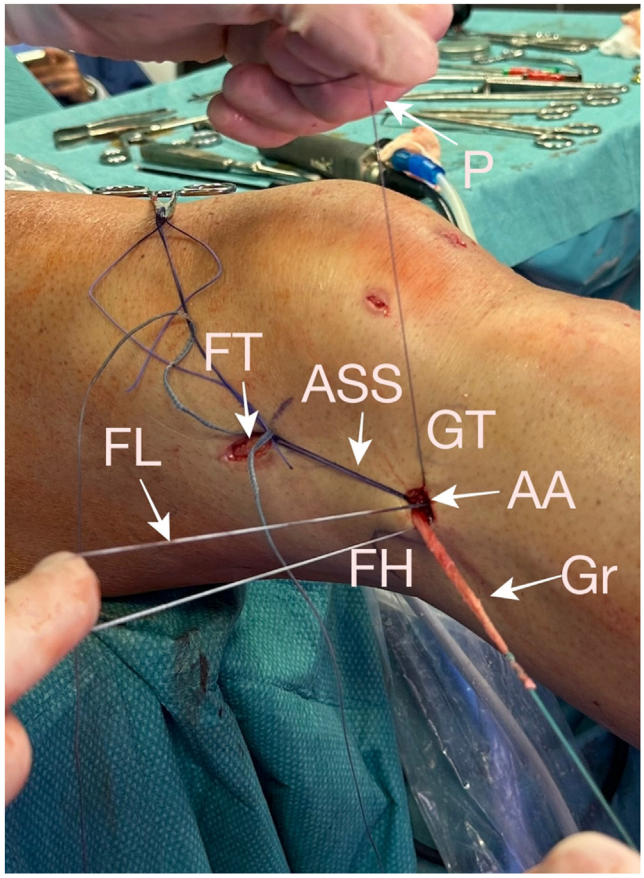

Fig 8. Lateral side of right knee in full extension and neutral rotation showing distal fixation of anterolateral ligament (ALL) reconstruction. After the ALL tibial insertion point is localized between the Gerdy tubercle (GT) and fibular head (FH), a stab incision is performed, creating an additional approach (AA). The cortical layer of the tibia is refreshed, and a 2.6-mm knotless suture anchor is implanted. The free end of the gracilis tendon (Gr) with the additional shuttle suture (ASS) is pulled subcutaneously and deep to the iliotibial band from the lateral femoral approach (FT) to the additional ALL approach (AA). Next, the free end of the gracilis (Gr) is tensioned through the implant suture loop (FL). Knotless tenodesis is performed by pulling the blocking suture (P), with the knee in full extension and neutral rotation, creating the distal ALL reconstruction fixation.

ALL approach, with an additional shuttling suture. By use of the FiberTak sutures, a self-tightening loop mechanism is created and the whipstitched end of the gracilis tendon is passed through it. Then, with the knee in full extension and neutral rotation, the FiberTak loop is tightened, blocking the graft on the tibial side (Fig 8).

Next, the whipstitched end of the gracilis is transferred back to the lateral femoral approach by the additional shuttling suture. Again, with the knee in full knee extension and neutral rotation, the gracilis graft is tensioned proximally and blocked by FiberTape suture limbs from ACL reconstruction, creating the second

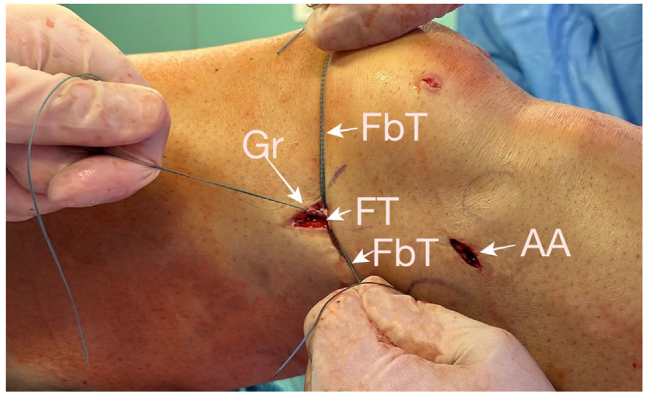

Fig 9. Lateral side of right knee in full extension and neutral rotation showing proximal fixation of anterolateral ligament reconstruction. By use of the additionally transferred shuttle suture, the free end of the gracilis tendon (Gr) is pulled back subcutaneously from the additional approach (AA) to the lateral femoral approach (FT). The tendon is fixed proximally by the limbs of FiberTape suture (FbT) from the anterior cruciate ligament reconstruction.

limb of the ALL reconstruction (Fig 9). The knee is finally examined for stability and range of motion. Final arthroscopic evaluation is performed, confirming proper graft position and tension and excluding conflict with other knee structures or implants (Fig 10). Then, an arthroscope and shaver are introduced into the suprapatellar pouch, and joint lavage is performed. The incisions are closed in the standard manner.

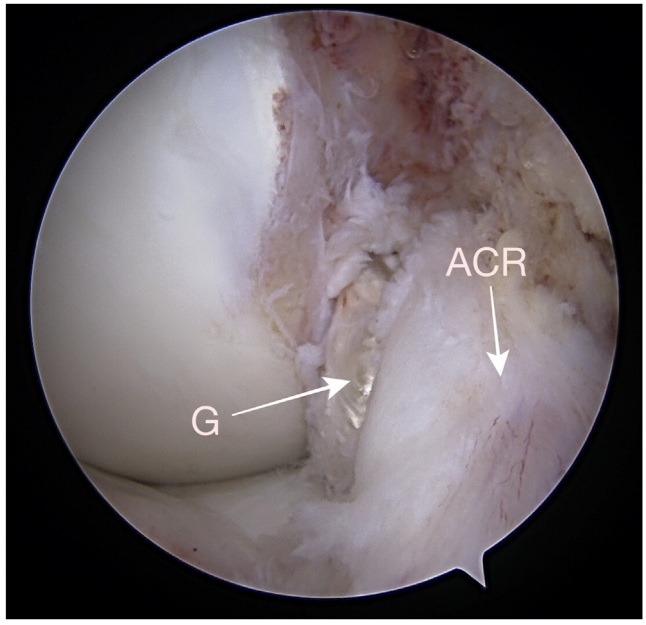

Fig 10. Arthroscopic view of right knee from anterolateral portal. The doubled semitendinosus and single gracilis graft (G) for anterior cruciate ligament reconstruction is covered by the preserved anterior cruciate ligament remnant (ACR).

Discussion

The described technique offers a simple solution to improve standard ACL reconstruction with potentially beneficial factors highlighted earlier in the article. Preservation of the tibial hamstring insertion and the ACL remnant enhances the biology of healing through better vascularization, synovial coverage, and preservation of the mechanoreceptors.[6,7] The proposed technique of ALL reconstruction has several advantages. Compared with LET techniques, it does not require an excessive approach or iliotibial band harvesting and it offers comparable effectiveness.[9] The single femoral tunnel eliminates the risk of tunnel convergence or implant conflict compared with most ALL reconstruction and modified Lemaire techniques.[10] Tibial fixation with no additional bone tunnels decreases the risk of fracture and tunnel-associated complications.[8] One limb of gracilis tendon is still used for ACL reconstruction, reinforcing the semitendinosus graft, unlike in most separate ALL reconstruction techniques.[11] A great advantage of our technique involves graft preparation: It is very simple and fast, limiting the risk of surgery time—associated complications. In addition, according to some authors, the lack of artificial suturing materials in both the joint and the ACL reconstruction tunnels may have a beneficial influence on graft healing and decrease the risk of infection.[12]

The main disadvantage of our technique—although rare in our experience—is the possibility of cases in which the diameter of the ACL graft (doubled semitendinosus and single gracilis) is smaller than 8 mm, given that some previous studies have suggested this might be a risk factor for graft rupture.[13] In such situations, we change techniques and use triple semitendinosus and single gracilis graft, as proposed by Sonnery-Cottet et al.[8] In situations in which the gracilis graft is too short to create the second, ascending limb of the ALL reconstruction—also rare in our experience—2 strands of FiberTape suture from the ACL reconstruction can be used to enhance the single gracilis graft.

Disclosures

All authors (P.W., T.Z., M.P.) 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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