Technical Note

Combined Anterior Cruciate Ligament and Anteromedial Oblique Ligament Reconstruction Using the Rectus Femoris Tendon: Description of Surgical Technique

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Abstract: We present a technique for combined anterior cruciate ligament and anteromedial oblique ligament reconstruction using the rectus femoris tendon graft. Anatomic anterior cruciate ligament reconstruction and anteromedial reinforcement are performed with a single rectus femoris graft. The rectus femoris tendon graft is harvested in a reproducible and minimally invasive approach. The surgical technique requires no special instruments and consists of 3 bone tunnels. Fixation is performed with interference screws.

Anterior cruciate ligament (ACL) injuries have doubled over the last 2 decades despite the efforts of researchers and clinicians to mitigate risk.[1] Even after ACL reconstruction and proper rehabilitation, the need for another surgical procedure can reach up to 15%.[2] In addition, in all levels of play, there is a significant reduction in playing level and a high rate of patients ending their careers,[3] which is why the role of concomitant extra-articular procedures in improving the outcome of ACL reconstruction have experienced a resurgence in interest.[4]

Most ACL lesions in sports occur without direct trauma. Several trauma mechanisms can lead to it, but valgus knee and foot external rotation are the most common biomechanical movements,[5] which may result in external rotation instability, described as anteromedial rotational instability (AMRI),[6] secondary to an anteromedial compartment lesion.[7,8] Unaddressed AMRI leads to an increased rate of ACL reconstruction failure,[9,10] but AMRI is not assessed by clinicians in a regular basis,[11] even though the anterior draw in external rotation (ADER) test described by Slocum and Larson[6] is simple and reproducible.

After the studies of Jorge et al.,[7,12] a ligamentous structure in the anteromedial knee quadrant and remarkably similar to the anterolateral ligament was meticulously described. Recent research described the anteromedial oblique ligament (AOL) in cadaveric dissections, confirming that its histological properties are those of ligament tissue, as well as on magnetic resonance imaging examination,[13] and a technique for combined ACL and AOL reconstruction surgery[14] was described for patients with ACL lesions and associated AMRI.[15] The goal is to control any external rotation instability, protecting the central pivot graft.

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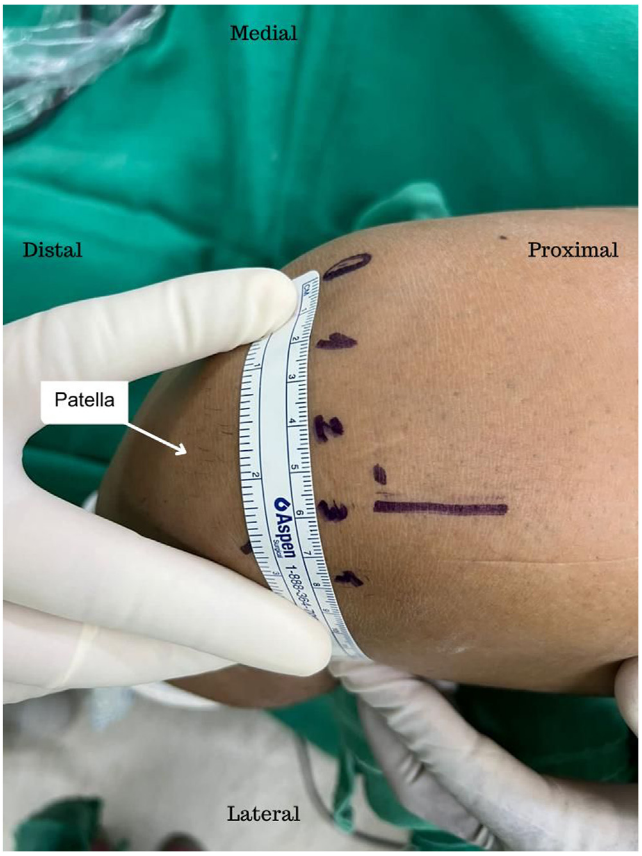

Fig 1. The left knee is shown, and the patient is in the supine position. A 3-cm longitudinal skin incision is made from the superior pole of the patella at the junction of the lateral and middle third.

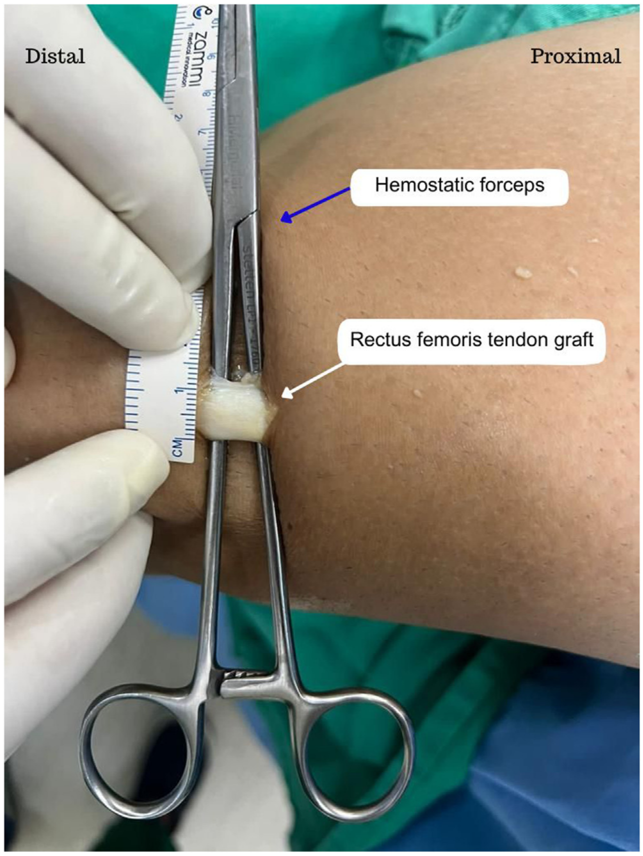

Fig 2. The left knee is shown. After 2 longitudinal incisions are made in the rectus femoris tendon, a 10-mm width graft is created. The rectus femoris tendon is elevated from the remaining quadriceps tendon with the aid of a hemostatic forceps.

The quadriceps tendon (QT) graft is becoming more popular in ACL primary[16] and revision[17] surgery. The QT graft is extremely versatile and can be harvested in different ways.[18-20] The harvest of the long-length rectus femoris (RF) tendon graft allows the surgeon to combine ACL reconstruction and anteromedial reinforcement using only 1 graft of adequate diameter and size, with no need for special instruments or high-cost materials, as it can be performed with only the use of interference screws. The purpose of this Technical Note is to present a combined ACL and AOL reconstruction technique using a RF tendon graft.

Surgical Technique

The procedure is performed with the patient in the supine position. A padded tourniquet is applied to the thigh. Examination under anesthesia should confirm the insufficiency of the ACL and associated AMRI with emphasis on the ADER test, which is performed with the patient in the supine position, knee flexed at 90°, and leg in 15° of external rotation The anatomical landmarks identified are the patella, the QT, and the medial epicondyle.

RF Tendon Graft Harvest

A 3-cm longitudinal skin incision is made from the superior pole of the patella, extending proximally (Fig 1). The graft is harvested from the lateral portion of the RF tendon, which is the superficial lamina of the QT. The surgical plane between the superficial and intermediate laminae is identified approximately 3 cm proximal to the patella. After 2 longitudinal incisions in the RF tendon, a 10-mm width graft is created (Fig 2). The RF tendon is elevated, and its distal end is detached from the patella. The distal free end of the graft is whipstitched with nonabsorbable sutures. The dissection of the RF tendon is extended proximally for 8 cm using scissors (Fig 3), ensuring that intermediate and deep layers of QT are preserved. A closed tendon stripper is pushed carefully with the knee in 20° of flexion, and the RF tendon graft is harvested (Fig 4). Paratenon, subcutaneous tissue, and the skin are closed.

Graft Preparation

The muscle fibers are removed and measured. The total length normally ranges from 28 to 35 cm. The

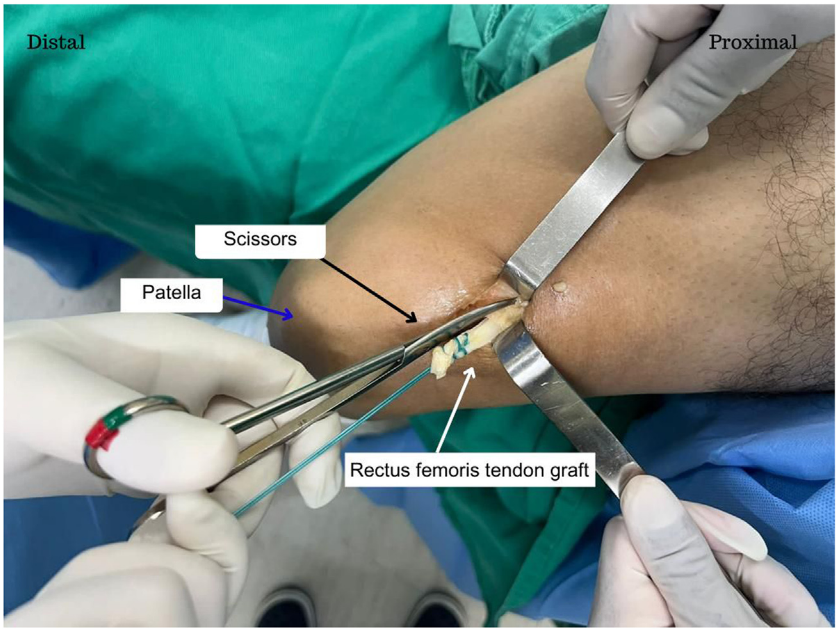

Fig 3. The left knee is shown. The distal free end of the graft is whipstitched with nonabsorbable sutures. The dissection of the rectus femoris tendon graft is extended proximally for 7 to 8 cm using scissors.

Fig 4. The right knee is shown. A closed tendon stripper is pushed carefully with the knee in 20° of flexion and the rectus femoris tendon graft is harvested. Usually, the total length ranges from 28 to 35 cm.

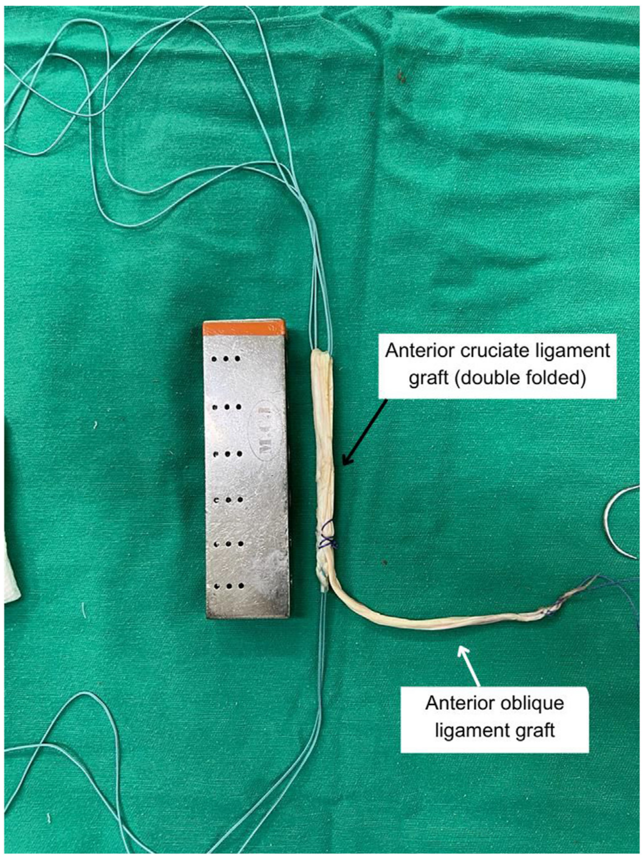

Fig 5. The muscle fibers are removed from the rectus femoris tendon graft. The distal portion is folded to form a double graft for the anterior cruciate ligament portion of the graft. The anteromedial oblique ligament portion of the graft is the proximal remainder without folding.

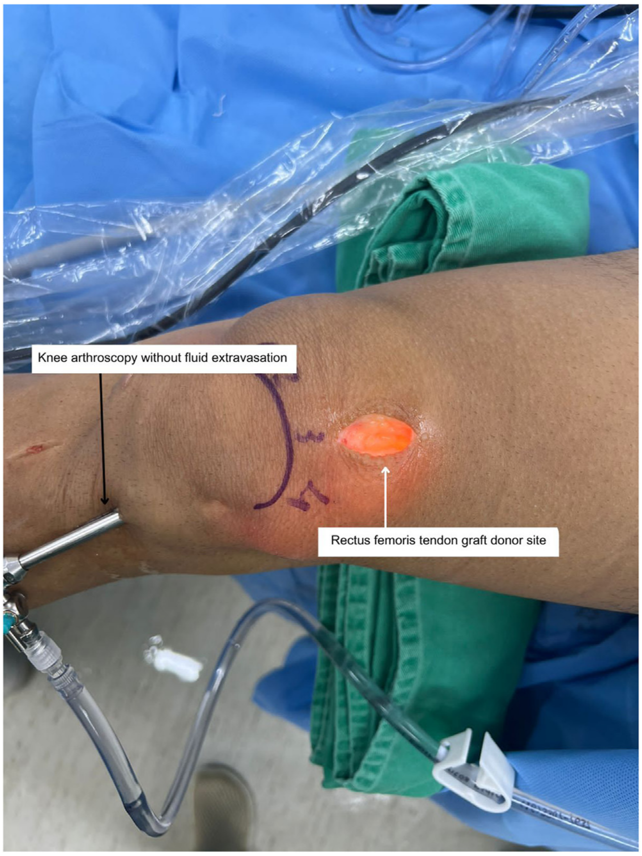

Fig 6. The left knee is shown. A high anterolateral portal is created first. The preservation of intermediate and deep laminae of the quadriceps tendon allows a knee arthroscopy without fluid leakage.

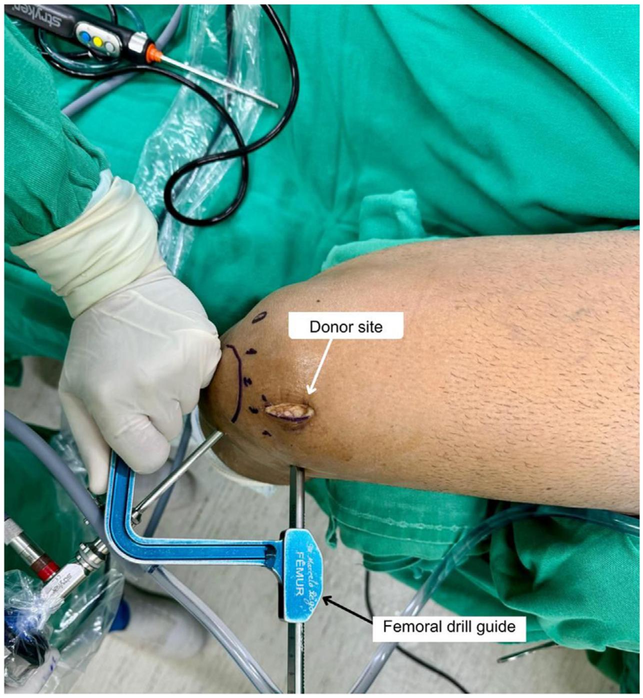

Fig 7. The left knee is shown. The anterior cruciate ligament (ACL) femoral tunnel is made using an outside-in technique. A lateral skin incision is made along the lateral aspect of the distal femur. The tip of the drill guide is placed at the femoral footprint of the ACL.

RF graft is folded asymmetrically. The distal portion is folded to form a double graft for the ACL portion of the graft. The AOL portion of the graft is the proximal remainder without folding (Fig 5). The ACL graft should be 10 cm long and 8 mm in diameter.

Arthroscopic Evaluation

A high anterolateral portal and a low anteromedial portal are created. Evaluation of the cruciate ligaments and possible associated lesions is performed (Fig 6).

ACL Reconstruction

The intercondylar area is prepared by shaving the inside wall of the lateral femoral condyle. The femoral tunnel is made using an outside-in technique. A lateral skin incision of 2 cm is made along the lateral aspect of the distal femur, and the iliotibial tract is split longitudinally. The tip of the drill guide (Sartori) is placed at the femoral footprint of the ACL (Fig 7). The tibial tunnel is made within the topography of the native ACL tibial footprint. The diameter of the tunnels is equal to the diameter of the previously prepared double-folded portion of RF graft. Using a suture shuttle, the graft is passed from the tibial to the femoral tunnel. The graft segment without folding exits through the tibial tunnel.

Femoral ACL graft fixation is performed in an outside-in manner using an interference screw (Fig 8). Tibial ACL graft fixation is performed with the graft tensioned and the knee at 20° of flexion with an interference screw one size greater than the tunnel diameter (Fig 9).

AOL Reconstruction

The medial epicondyle is identified by palpation (Fig 10). Fluoroscopy also can be used to aid in identification. A 3-cm medial skin incision is made over the medial epicondyle. A guidewire is drilled via free hand, starting at the medial epicondyle anterior portion and aimed slightly anterior and proximal (Fig 11). The femoral bone tunnel is created with a 6-mm drill. The remaining graft that exits the tibial tunnel is passed beneath subcutaneous tissue and shuttled with a suture in the AOL femoral tunnel in the medial side of the knee (Fig 12). AOL graft fixation is performed with an interference screw in neutral rotation and full extension (Fig 13). After reconstruction, closure in layers is

Fig 8. The left knee is shown. Femoral anterior cruciate ligament graft fixation is performed in an outside-in manner using an interference screw.

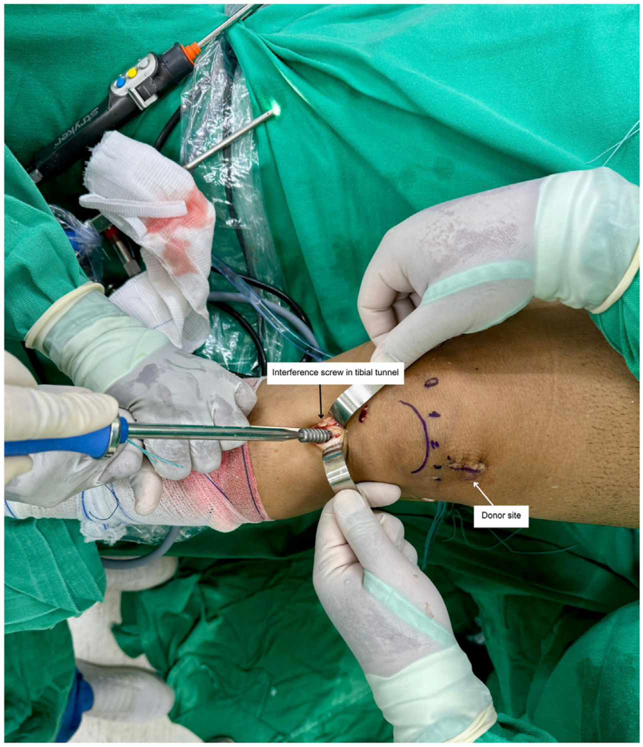

Fig 9. The left knee is shown. Tibial anterior cruciate ligament graft fixation is performed with the graft tensioned and the knee at 20° of flexion.

performed (Video 1). A routine ACL rehabilitation plan is instituted.

Discussion

In the United States, ACL injuries total between 100,000 and 200,000 yearly, making this the most common ligament injury.[15] Recent research has indicated that up to 35% of athletes don't return to their previous levels of preinjury function within 2 years from ACL reconstruction.[21] ACL re-rupture rates range from 4.5% to 11% but may be significantly greater within the first postoperative year.[22]

With the advances in studies of extra-articular reconstructions in patients with torn ACLs, the combined reconstruction presents decreased failure rate and better rotational control compared with isolated reconstruction.[4] In a recent study by the Santi Group, patients who underwent combined ACL and anterolateral ligament reconstruction experienced significantly better long-term ACL graft survivorship, lower overall reoperation rates, and no increase in complications compared with patients who underwent isolated ACL reconstruction. Further, patients who underwent isolated ACL reconstruction had a >5-fold increased risk of undergoing revision surgery at a mean follow-up of 104.3 months.[4]

The ACL trauma mechanism varies; it can occur in different ways, with different movements.[5] Certainly, the direction of knee injury will predict rotational instability. If the sprain is in internal rotation, there will be instability in internal rotation, with a positive pivot shift. If it occurs in external rotation, there will be instability in external rotation, with anteromedial rotational instability and a positive ADER. The valgus + external rotation traumas are the most common mechanism of ACL injuries,[5,23-26] which is why controlling the AMRI seems imperative. According to the theory of tibial quadrants,[7] the knee's anteromedial quadrant is responsible for valgus and external rotational control, and the reinforcement of this area shows, in vitro, improvement of the knee stability, controlling AMRI.[10] In this article, authors made superficial medial collateral ligament (MCL) and deep MCL reconstructions in cadaveric species. The deep MCL is positioned in the anteromedial quadrant, in the same position where the AOL was described, and the authors concluded that reconstruction of the superficial and deep bands of the MCL was able to restore native knee laxity measures related to AMRI in the face of complete transection of the MCL and posteromedial corner/posterior oblique ligament in a cadaveric model.[10] This increasing interest in the anteromedial

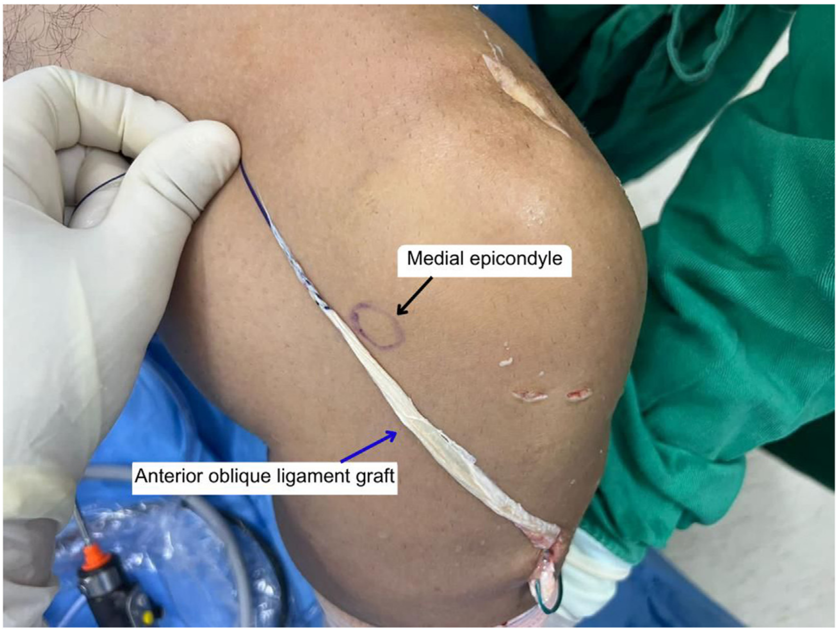

Fig 10. The left knee is shown. The medial epicondyle is identified by palpation.

region of the knee in the literature[27,28] indicates that there might be a role for not only an anterolateral extra-articular augmentation but also for an anteromedial augmentation procedure.

Even though there are studies showing a greater failure rate with the use of a QT graft, more recent studies demonstrate it can have similar clinical outcomes, knee objective stability, and failure rate compared with hamstrings and bone patellar tendon bone graft.[29,30] Clinical studies present similar outcomes between different QT graft preparations: partial or full thickness[31] and with or without bone block graft.[32] Considering the variability in QT anatomy,[33] it is possible to harvest the RF tendon before the layers

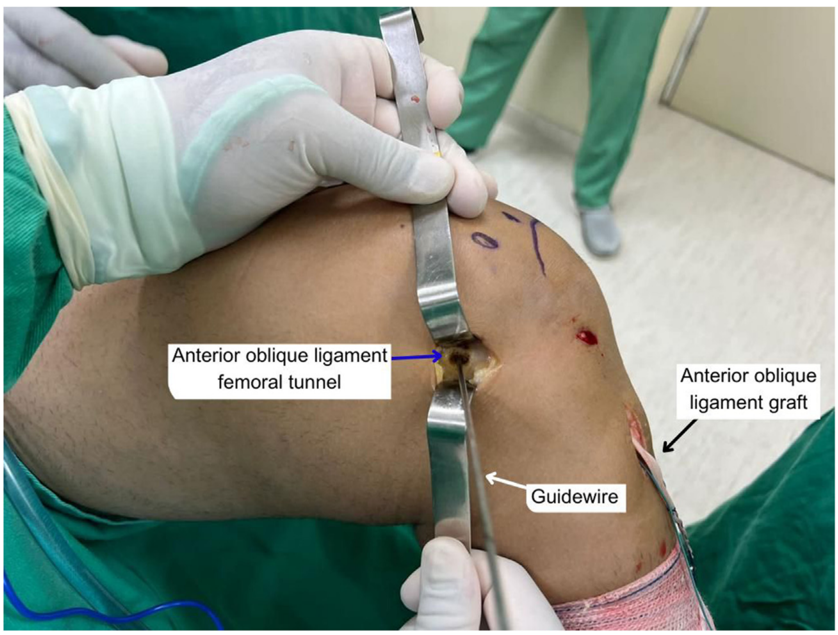

Fig 11. The left knee is shown. A guidewire is drilled via free hand, starting at the medial epicondyle anterior portion. The anteromedial oblique ligament femoral tunnel is created with a 6-mm drill.

Fig 12. The right knee is shown. The remaining graft, without folding that exits the tibial tunnel, is passed beneath subcutaneous tissue in the medial side.

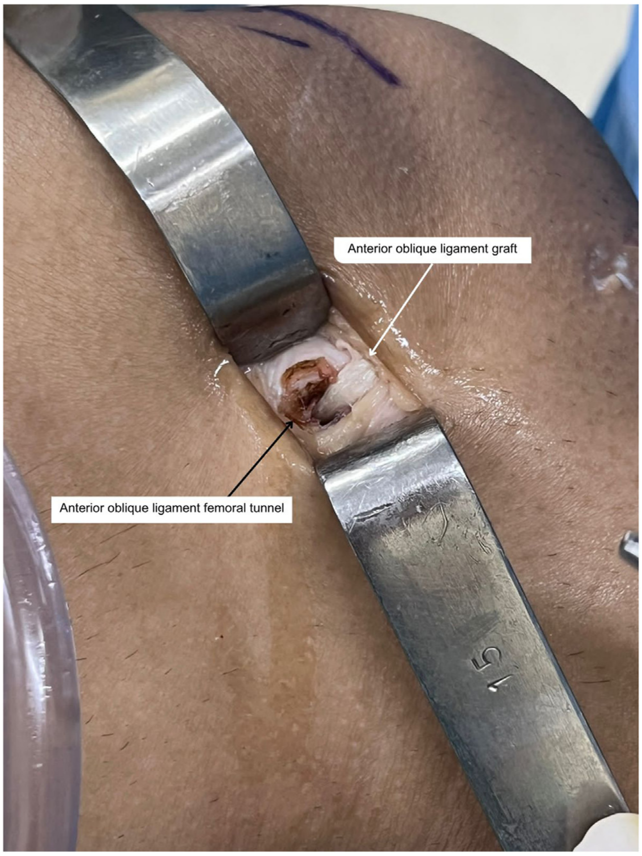

Fig 13. Anteromedial oblique ligament graft is fixed with an interference screw in neutral rotation and full extension in left knee.

Table 1. Advantages and Disadvantages of the Procedure

Advantages
Simple to perform and few steps are added to the typical anterior cruciate ligament reconstruction technique.
Greater rotational stability occurs in the knee when extra-articular reinforcement is performed.
Preservation of hamstring strength
Graft removal in a minimally invasive way using a conventional extractor.
Disadvantages
Risk of violating suprapatellar bursa when individualization of the rectus femoris tendon is not well performed.
Risk of graft amputation when satisfactory release is not performed proximally.
Anterior hematoma may occur.

Table 2. Pearls and Pitfalls

Pearls
It is important to identify the cleavage plane between the rectus femoris tendon and the vastus intermedius and perform a dissection of approximately 8 cm from distal to proximal using Metzenbaum scissors.
The knee should be place in 20° of flexion for graft harvest. Reasonable force can be used applying the tendon stripper.
Guiding the position of the femoral tunnel for anterior oblique ligament reconstruction is essential for a good result. Fluoroscopy can aid in this process.
The tibial tunnel must be made with 45° angulation in the coronal plane.
The positioning of the tunnels for ACL reconstruction with extra-articular reinforcement is the same as for anatomical ACL reconstruction without reinforcement.
Pitfalls
The surgical plane between the superficial and intermediate laminae is easier to identify at approximately 3 cm proximal to the patella.
Protrude screws can irritate the iliotibial tract.
Tightening the screw deeply past the cortical bone may cause loosening of the fixation causing failure.
Performing the fixation in the femoral tunnel for the AOL in extension and neutral rotation is important for good results.

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

merge. The described RF tendon graft harvest obtains a long length with adequate diameter graft for combined ligamentous reconstruction and does not violate the knee capsule.

The described technique using the RF graft harvested in a minimally invasive approach is a reasonable alternative to combined ACL reconstruction and anteromedial reinforcement in primary and revision surgery (Tables 1 and 2). Clinical studies are required to demonstrate the efficiency of this surgical technique.

Disclosures

All authors (Márcio C.F.R., B.G.B, C.P.H., Marcelo C.F.R., S.M.d.G.C., D.E.d.O., P.B.J.) 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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