MENTORS IN ORTHOPEDICS

SECOND INJURIES AFTER ACL RECONSTRUCTION AND LATERAL TENODESIS WITH HAMSTRINGS

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SUMMARY

Background: Anterior cruciate ligament (ACL) injuries frequently result in rotatory instability, necessitating surgical interventions that restore both translational and rotational knee mechanics. While various reconstruction techniques exist, the integration of lateral extra-articular tenodesis (LET) has emerged as a strategy to address residual laxity and reduce graft failure rates, particularly in high-demand populations.

Objective: This article describes the surgical methodology of the over-the-top single-bundle ACL reconstruction combined with a hamstring-based lateral plasty and evaluates its long-term clinical efficacy, safety, and survivorship.

Key Points: The procedure utilizes harvested gracilis and semitendinosus autografts, preserved at their tibial insertions. A vertical tibial tunnel is created freehand, and the graft is routed through an over-the-top femoral passage, bypassing traditional femoral tunneling. Fixation is achieved using metallic staples at the lateral femoral condyle and below Gerdy's tubercle for the LET component. Clinical data spanning up to 24 years demonstrate high International Knee Documentation Committee (IKDC) scores, with over 90% of patients achieving normal or nearly normal knee function. Comparative studies indicate superior rotatory control and faster return-to-sport intervals compared to isolated intra-articular reconstructions. The technique is associated with a low 10-year revision rate of 3.7% and a 90-day readmission rate of 2.3%, primarily due to minor perioperative complications such as joint swelling or superficial infection.

Conclusion: The combined over-the-top and lateral extra-articular tenodesis technique provides durable knee stability and favorable functional outcomes. This approach effectively mitigates rotatory laxity with a low incidence of long-term graft failure or significant complications.

KEYWORDS

Anterior Cruciate Ligament Reconstruction; Tenodesis; Hamstring Muscles; Knee Joint; Autografts

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are among the most prevalent knee injuries, particularly in active individuals engaged in sports [5]. Surgical reconstruction of the ACL aims to restore the anteroposterior and rotational stability of the knee, allowing the individual to return to the physical activities they were engaged in before the injury. In the last decades, different surgical techniques have been developed aimed at optimizing patient outcomes and reducing the risk of re-injury. One technique that gained popularity is the combined approach of ACL reconstruction with hamstring autografts and lateral extra-articular tenodesis (LET) [8].

The identification of the anterolateral ligament (ALL) and its function in limiting the pivot shift has suggested supplementary surgical interventions on the anterolateral aspect of the knee to improve the surgical results [1]. Indeed, the LET in addition to ACL reconstruction has been shown to be effective in controlling residual knee rotatory instability; the recent literature has demonstrated promising results regarding the efficacy and safety of lateral external tenodesis in reducing graft failure rates and improving functional outcomes [2]. The Over-the-top Single-Bundle with Lateral Plasty (SBLP) surgical technique has been developed to enhance stability by integrating an intra-articular reconstruction with a lateral tenodesis [6],[8]. This article provides an overview of this surgical technique, discussing its biomechanical rationale, surgical procedure, and rate of ACL re-injury. Additionally, it explores the evolving evidence base supporting the efficacy and safety of this combined approach in restoring knee stability and function, helping orthopedic surgeons in optimizing surgical treatment and patient outcomes.

SURGICAL TECHNIQUE

The surgical technique was first described by Marcacci et al. in 1998 [8]. The patient is positioned supine, with a specialized leg support on the outer side of the lower femur. A tourniquet is applied, and a diagnostic arthroscopy is conducted to address potential meniscal or cartilage issues and to clear the ACL femoral attachment site. Due to the graft's small diameter, extensive debridement of the tibial stump is unnecessary.

An oblique incision of 2 to 3 cm is created above the pes-anserinus, beginning 2 fingers distal and 1 finger medial to the Tibial Tuberosity and directed proximally and medially. This incision design aims to minimize the risk of damaging the Infrapatellar branch of the Saphenous Nerve [4] and to facilitate proper placement of the tibial tunnel via the same incision site (Figure 1a). The fascia of the Sartorius muscle is incised between the two tendons, and both the Gracilis and Semitendinosus tendons are harvested preserving their tibial attachment. Due to potential anatomical variations in the pes-anserinus insertion, caution is necessary when releasing the numerous expansions to the medial gastrocnemius. Tendon harvesting is performed with an open tendon stripper only after complete release of the gastrocnemius from the hamstrings, aiming to prevent tendon injury and optimize graft length. Once both the Gracilis and Semitendinosus tendons are stripped, muscle fibers are excised, and a gentle release at their tibial insertion is performed with scissors to achieve tendon approximation and consistent tension when both tendons are simultaneously pulled. The two tendons are then sutured together at 5 to 8 cm from their free end using two No. 2 non-absorbable sutures employing Krakow stitches (Figure 1b).

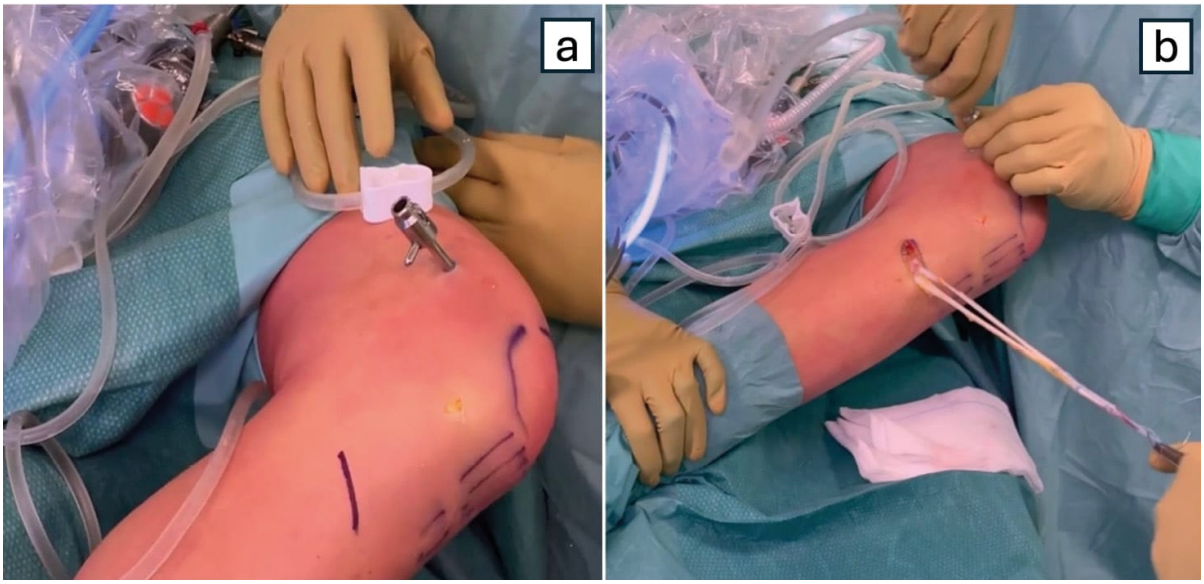

Figure 1. Hamstrings harvesting is performed through a 3 cm oblique incision above the Pes Anserinus (a); Both tendons (Gracilis and Semitendinosus) are harvested preserving the tibial insertion and sutured together with the same tension (b).

The position of the tibial tunnel is crucial in this technique. The tunnel's entry point should be positioned 1-2 cm proximal to the tendon insertion and anterior to the MCL. A 2.4 mm guide-wire is directed freehand towards the postero-lateral segment of the tibial stump, without the use of ACL guides, aiming towards the tip of the arthroscope with the knee flexed at 45° and internally rotated. However, ACL guides could also be employed. Once the optimal tibial insertion is identified, the guide-wire is enlarged using a 7 mm in most cases. An 8 mm tunnel is reserved for exceptional cases. This technique results in a small, elongated, and vertical tunnel that allows minimal angulation at the tunnel-graft interface, minimal damage to the cancellous bone since no hardware is placed inside the tunnel, and a large area for tunnel-graft healing with complete tunnel filling. After the tibial tunnel is performed, a wire-loop is passed through it and finally inserted through the Antero-Medial Portal.

To perform the Lateral approach to the Over-The-Top, with the knee bent at a 90° angle, a 3 cm longitudinal incision is created aligned with the proximal projection of the lateral epicondyle, proximal to the fibula, and running parallel to the posterior border of the ITB. It is crucial at this stage to identify the posterior margin of the ITB and to perform a longitudinal split of the ITB in line with its fibers and between 1 to 2 cm from its posterior margin (Figure 2a). If the incision is made too anterior, it might be hard to reach the back of the joint capsule because of the tightness of the ITB band. The split in the ITB can be extended proximally and distally to facilitate exposure using retractors employing the "mobile window" technique. Following completion of the split, the anterior portion of the ITB is retracted superiorly while the posterior portion is retracted towards the surgeon, thereby tensioning the intermuscular septum. An electrocautery angled at 45° is utilized to gently section the intermuscular septum (Figure 2b). This kind of positioning and technique is aimed to minimize the risk of penetration into the neurovascular structures posterior to the femur. With adequate exposure, minimal dissection is required to access the posterior aspect of the knee joint, after the removal of the inferior retractor, a digital exploration is performed in blunt fashion. At this stage it is possible to palpate the medial margin of the lateral femoral condyle.

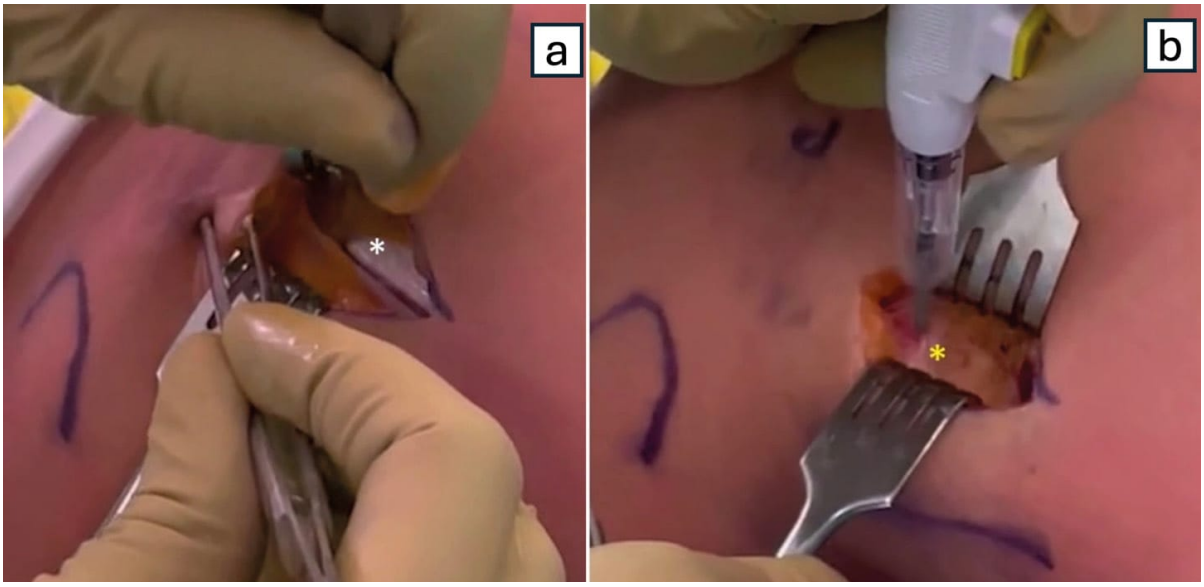

Figure 2. After a 3-4 cm skin incision proximal to the lateral epicondyle, the ITB is split (white asterisk) 1.5 cm from its posterior border (a); After retracting the ITB flaps, the intermuscular septum (yellow asterisk) is opened with electrocautery (b).

A long, blunt, curved Kelly clamp is inserted through the Antero-Medial portal, aimed towards the notch, with the curve directed medially. The positioning of the clamp should be adjusted, and knee flexion increased to approximately 100° until the tip of the clamp can be felt with the index finger through the lateral incision. Arthroscopic monitoring can be useful to ensure correct placement (Figure 3a). The Kelly clamp is then rotated (clockwise in left knees and anticlockwise in right knees) and carefully pushed through the capsule while shielding the tip with the index finger in order to minimize the risk of neurovascular injuries. Depending on the patient's anatomy and muscle tone, significant pressure may be necessary during this passage due to potential impingement with the lateral gastrocnemius tendon. Once the clamp's tip has passed the capsule, a long, narrow retractor is positioned beneath the tip, and a suture loop is attached to the clamp by the assistant (see Figure 3b). After securing the suture loop, the clamp is removed from the Antero-Medial portal, and the loop is threaded onto the medial wire previously passed through the tibial tunnel. By pulling the wire from the tunnel, the suture is guided from the lateral incision to the tibial incision. The suture loop is then moved back and forth with a saw-like motion to disrupt any adhesions and ensure smooth passage of the graft. Finally, the suture end of the graft is attached to the suture loop and pulled into the tibial tunnel, through the joint, and outside the lateral approach.

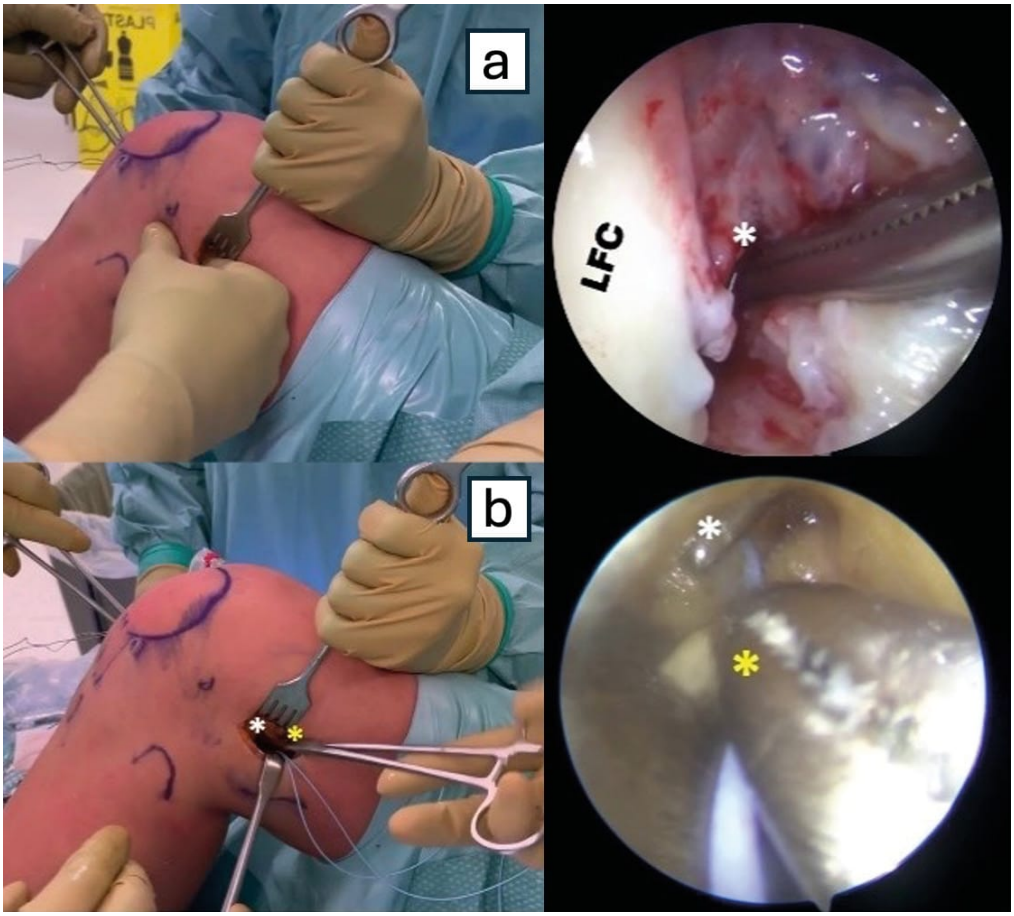

Figure 3. To create the passage to the “over-the-top”, a curved Kelly clamp is inserted through the Antero-Medial portal and directed through the notch, feeling its tip with the index finger from the lateral incision; arthroscopic monitoring can be useful to ensure correct placement of the clamp (white asterisk) (a); A passing suture loaded in a small clamp (yellow asterisk) is grabbed extra-articularly with the tip of the Kelly clamp (white asterisk) inserted through the notch; with the scope in the lateral incision is possible do see the passage (b).

Once the graft has been pulled out of the joint, the femoral insertion site needs to be prepared. It may be prudent to release the tourniquet and perform an accurate hemostasis because of the proximity of the superolateral geniculate artery.

When the graft is pulled directed to the ceiling, it is possible to note some fibers of the intermuscular septum that should be carefully released in order to obtain a good adhesion of the graft with the femoral cortex. The femoral cortex must be cleaned at the base of the lateral femoral condyle using electrocautery. To identify the correct position in the anteroposterior view, either a finger or forceps are utilized to locate the femur’s posterior border, where fixation should occur at least 1 cm away. Once the appropriate spot is identified, the graft is secured to the femur using two horizontally placed 8 mm barbed metal staples. Fixation is performed with a knee flexion of approximately 70°, with the foot positioned in a neutral to externally rotated position based on pre-operative laxity and risk factors.

Finally, differently from the classic one with the ITB, the Lateral Extra-Articular Tenodesis is with the residual part of the hamstring graft and without the passage under the lateral collateral ligament (LCL). After palpation of the Gerdy’s tubercle, a 1 cm skin incision is performed just below it, arriving to the bone surface.

The route for the graft is prepared by pushing the index finger under the ITB and directing it distally. A small, curved Kelly clamp is inserted in the tibial incision and guided under the ITB towards the lateral incision. It is

crucial to verify that the clamp is positioned under the ITB and not within the subcutaneous tissue. Following this, the sutures from the free end of the graft are attached to the clamp's tip and pulled out from the lateral tibial incision. Subsequently, the graft is secured with a 6 mm staple below Gerdy's tubercle. Both tips of the staples must be in contact with the bone before hammering. The tenodesis fixation is performed in the same position as ACL fixation.

At the end of the procedure an intra-operative evaluation of the knee range of motion and stability is performed by checking flexion-extension, Anterior Drawer test, Pivot Shift test, and Lachman test.

No brace is used, unless complex meniscal sutures.

RESULTS OF THE "OVER-THE-TOP" TECHNIQUE

Marcacci et al. [8] evaluated the first group of patients undergone ACL-reconstruction with over the top technique and lateral plasty in 1998 at a minimum 2-year follow-up. Satisfactory clinical results were shown with 92.5% normal and fairly normal knees according to IKDC score and only 7.5% abnormal knees. The mean Lysholm and Tegner scores were 95 and 7.2 respectively. Excellent knee stability was reported with a mean injured/uninjured difference of 2.1 mm at KT-2000. Finally, 90% of patients resumed sports at the same level, 67.5% in 3-4 months and 27.5% in 4-6 months. Similar results have been reported in 2003 by the same authors in a prospective study that involved 50 patients at a mean follow-up of 6.4 years [9].

An interesting, randomized study that compared three different techniques performed in 75 patients at 5 years of follow-up, showed higher subjective scores and faster return to sport when treated with over-the-top and lateral plasty technique in respect to four-strand hamstrings and patellar tendon grafts. Furthermore, a lower rate of positive pivot shift was found compared to four-strand hamstrings, and fewer cases of anterior knee pain or ROM limitations were reported compared to the patellar tendon [10].

The same authors decided to prospectively analyze, at a mean 11-year follow-up, the clinical and radiographic outcomes in patients undergoing ACL reconstruction with over-the-top and lateral plasty technique comparing results with those at 5-year follow-up [7]. The International Knee Documentation Committee score demonstrated good or excellent results in 90.7% of patients and objective knee laxity evaluated with KT-2000 arthrometer demonstrated that only 2 patients had >5 mm manual maximum side-to-side difference in laxity. The mean Tegner activity score was 4.5, while the mean Lysholm score was 97.3 and the mean subjective score was 90.0%. The radiographic evaluation showed progressive joint narrowing only for the 20 patients having concomitant medial meniscal surgery.

The revision rate of the over-the-top and lateral plasty technique was analyzed and stratified in a review of 267 consecutive patients with a minimum follow-up of 10 years [3]. The study allowed to determine a revision rate of 1.1% at 2 years, 1.9% at 5 years, and 3.7% at 10 years with a total of 13% of patients undergoing reoperation that were mainly staples removal. Patient Reported Outcome Measures (PROMs) evaluated with the KOOS Score were substantially comparable with the 10-year results of the Multicenter Orthopaedic Outcome Network (MOON) ACL registry.

Moreover, the authors published in 2017 a very long-term clinical and radiographic results in 29 patients at a mean follow-up of 24 years [11]. Of this group of patients, 2% experienced graft rupture and 5,8% had contralateral ACL injury. Only 12% had >5-mm manual maximum KT-2000 side-to-side difference and a positive pivot-shift documented with KiRA system. The radiographic evaluation demonstrated a significant difference of

the medial joint space between injured and healthy knees in patients with concomitant medial meniscectomy, while no significant differences were reported regarding lateral or patellofemoral joint space.

To evaluate the safety of adding an extra-articular procedure to intra-articular over-the-top reconstruction, the medical records of 2559 consecutive ACL reconstructions conducted over 7 years were examined in a study that aimed to determine the rate of re-admission within 90 days post-ACL reconstruction [3]. Results showed that 2.3% of patients were re-admitted within the initial 3 months following ACL reconstruction, primarily due to knee swelling (0.78%), superficial infection (0.63%), deep infection (0.55%), or joint stiffness (0.23%) These findings affirm the over-the-top plus lateral extra-articular plasty as a safe technique associated with a low incidence of peri-operative complications.

CONCLUSIONS

In conclusion, the over-the-top combined with lateral extra-articular tenodesis technique for ACL reconstruction" has proven to be a valid approach, offering excellent subjective and objective clinical outcomes even at ultra-long-term follow-ups. The use of hamstrings as autografts showed a low re-rupture rate of the ACL and satisfactory objective knee stability, even when compared to other techniques performed with the patellar tendon. The addition of lateral extra-articular tenodesis has been shown to be a protective factor against surgical failure of the ACL, with a low rate of postoperative complications.

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