Technical Note

Combined All-Inside Anterior Cruciate Ligament Reconstruction With Semitendinosus Plus Anterolateral Ligament Reconstruction With Intact Gracilis Tibial Insertion and Transtibial Passage

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Abstract: The indications for combining anterior cruciate ligament reconstruction with anterolateral ligament reconstruction have increased considerably in recent years since several anatomical, clinical, and biomechanical studies have proven the importance of the anterolateral periphery in knee rotational stability. Much is still being discussed on how to combine these techniques in terms of which grafts and fixation options to use, as well as avoiding tunnel convergence. This study aims to describe anterior cruciate ligament reconstruction with a triple-bundle semitendinosus tendon graft all-inside technique combined with an anterolateral ligament reconstruction maintaining the gracilis tendon insertion on the tibia, using independent anatomical tunnels. With this, we were able to reconstruct both using only hamstring autografts, reducing morbidity in other possible donor areas, in addition to allowing stable fixation of both grafts without tunnel convergence.

The anterior cruciate ligament (ACL) is one of the most commonly injured structures of the knee joint.[1] The gold standard treatment is ligament reconstruction using autografts, with both the hamstrings and patellar tendon being the most used.[2] Despite approximately 90% of patients having normal or very close to normal postrehabilitation function,[3] the return-to-sport rates at the same preinjury level are only approximately 65%.[3]

The re-rupture or clinical failure rates caused by instability after ACL reconstruction can reach up to 18% of cases.[4-6] Several studies attribute this to an associated anterolateral ligament (ALL) injury. In the last decade, several publications have demonstrated the important role of this structure in rotational stability of the knee.[7] Anatomical, biomechanical, and clinical studies report that ACL reconstruction associated with ALL reconstruction or lateral extra-articular

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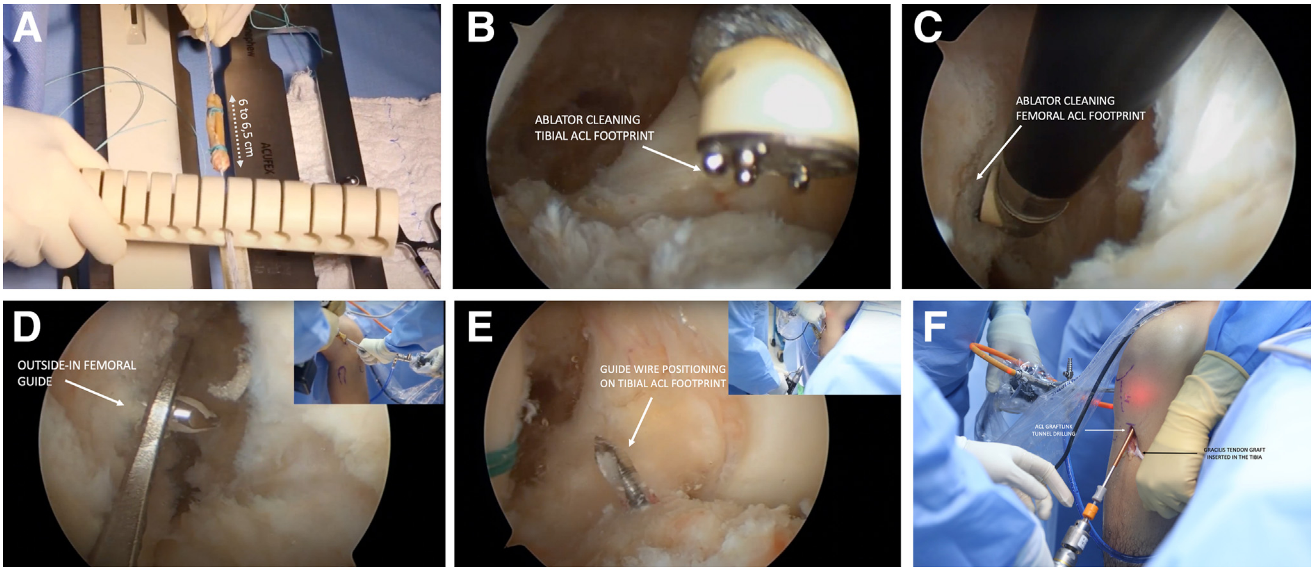

Fig 1. (A) The semitendinosus graft is prepared by folding it over itself 3 times, forming a triple graft. The graft length must be between 6.0 and 6.5 cm (white arrow); after that, the diameter is measured to know the appropriate thickness of the femoral and tibial tunnels. (B, C) An arthroscopic ablator is used to clean the tibial and femoral ACL footprint. (D) An outside-in femoral ACL guide is used to introduce the guidewire. After that, a TRUNAV drill is used to create the femoral tunnel. (E, F) A conventional tibial ACL guide is used to create the tibial tunnel along with the TRUNAV drill. Right knee is flexed on the side of the operating room table. The camera is positioned at the lateral portal in Figures B, C, E, and F. In Figure D, the camera is positioned at the medial portal. (ACL, anterior cruciate ligament.)

tenodesis can significantly decrease the rates of reinjury and postoperative rotational instability.[8-10]

Among the different ways to reconstruct the ACL, one that has become quite popular is the surgical technique that uses a femoral and tibial fixation with adjustable buttons, known as the all-inside. This technique has the advantage of using only one autologous hamstring tendon to prepare a graft with adequate diameter, in addition to allowing adjustments in graft tension after initial fixation and using minimally invasive incisions.[11]

Many techniques of anterolateral periphery reinforcement or reconstruction also have been described. Many of them require large incisions on the lateral aspect of the knee, incising the iliotibial band, dissection around or under the lateral (fibular) collateral ligament, and tunnel convergence, limiting independent graft fixation.[12]

We use an ALL reconstruction while maintaining the gracilis graft attachment on the tibia, using anatomic and independent tunnels and with a minimally invasive technique (Video 1). The idea of preserving the bony graft insertion during ligament reconstruction has been around for many years. Bahlau et al.[13] confirmed that preserving the tibial insertion of hamstring tendons intended for ACL reconstruction increases the maximum load to failure at the tibial tunnel. In addition, leaving the hamstring tendons pedicled allows faster ligamentization of the transplant while preserving its vascularity and innervation.[14] For this reason, we believe that these principles could be useful in the technique of ALL reconstruction.

In this Technical Note, we describe ACL reconstruction with a triple-bundle semitendinosus tendon graft all-inside technique combined with an ALL reconstruction maintaining the gracilis tendon insertion on the tibia, using independent anatomical tunnels (Video 1).

Technical Note (With Video Illustration)

The patient, in the supine position, is administered spinal anesthesia. Asepsis is performed with a 2.0% degerming chlorhexidine solution, followed by antisepsis with a 0.5% chlorhexidine alcohol solution. After placement of the surgical drapes, ischemia is performed with exsanguination of the limb. The tourniquet was previously positioned on the proximal third of the thigh and was inflated to 300 mm Hg.

We start the surgical procedure with an anteromedial approach directly over the hamstring tendons, followed by dissection of tissue planes, identification, and harvesting of the semitendinosus graft using the standard technique. Next, using an open stripper, the gracilis tendon is isolated, releasing it proximally and maintaining its distal insertion preserved in the tibia. The semitendinosus graft is prepared with Krackow sutures at its ends with a No. 2 ETHIBOND nonabsorbable thread (Ethicon, Somerville, NJ) and then folded over itself 3 times, forming a triple-length graft. The graft

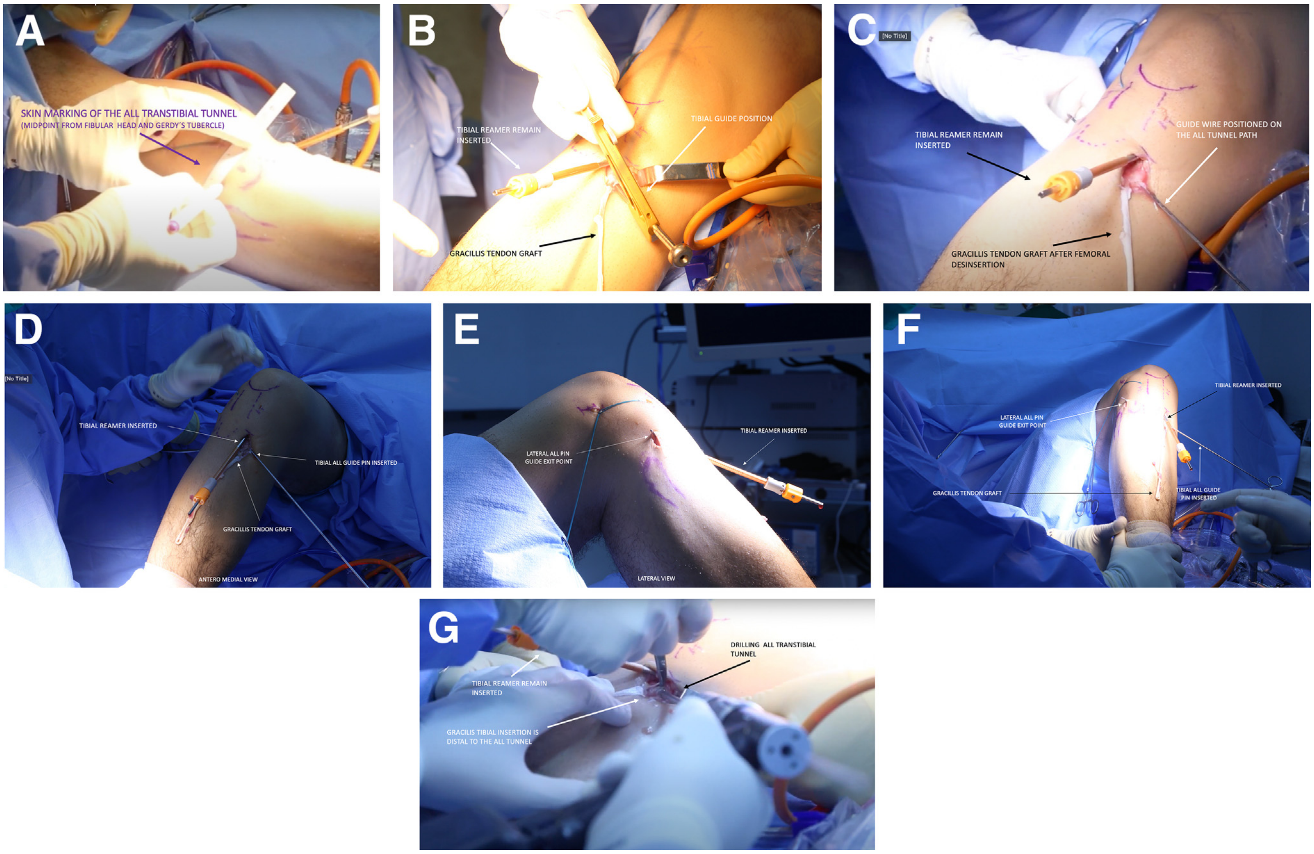

Fig 2. (A) We begin preparation of the ALL transtibial tunnel by marking on the skin the correct place to introduce the guidewire (midpoint from fibular head and Gerdy's tubercle). (B-F) We position the tibial guide in a position that does not conflict with the tibial ACL tunnel and the tibial insertion of the gracilis tendon, and after that, we introduce the guidewire. To ensure the absence of tunnel conflict, we keep the TRUNAV drill inserted. (G) The transtibial ALL tunnel is drilled with a 6-mm drill. (A-C) The right knee is extended on the operating room table. (D-F) The right knee is flexed on the operating room table. (ACL, anterior cruciate ligament; ALL, anterolateral ligament.)

length must be between 6.0 and 6.5 cm, and the diameter is then measured to identify the appropriate diameter of the femoral and tibial tunnels (Fig 1A). The graft is prepared for fixation by a suspensory mechanism with an ULTRABUTTON (Smith & Nephew, Andover, MA) at both ends using an all-inside technique.

We create the anterolateral and anteromedial standard arthroscopic portals, and an inventory of the joint cavity is performed. The remaining ACL is removed, and the sites for the femoral and tibial ACL tunnels are prepared (Fig 1 B and C). A detail at this point is to leave the tibial bone bed without any previous ACL tissue, as this remaining ACL tissue can interfere with the passage of the graft through the tibial tunnel.

With the knee at 90°, the femoral tunnel is created using an outside-in technique using a guide with a 105° angle (Fig 1D), inserted through the anterolateral portal (while the camera is placed in the anteromedial portal) with retrograde drilling of 20 mm in depth with a TRUNAV drill (Smith & Nephew) in its native footprint, preserving 3 mm of the posterior cortex. It is crucial, at this point, to tilt the guide slightly in the anterior direction so that later convergence is avoided when making the ALL femoral tunnel. Then, inside the TRUNAV guidewire, the transport wire is passed and retrieved through the medial portal.

To perform the tibial tunnel, the 65° tibial guide is positioned through the medial portal (Fig 1E), immediately posterior to the anterior horn of the lateral meniscus and approximately 7 mm anterior to the posterior cruciate ligament, followed by the passage of the guidewire. Knee extension is then performed to confirm the anatomical location and avoid possible tunnel positioning errors. After confirming the position, drilling is performed with a retrograde drill type (TRUNAV) of the graft diameter and to a 30-mm depth. At this point, the drill is left inside the tunnel to serve as a parameter for the ALL tunnel, avoiding confluence of the tunnels (Fig 1F).

With the retrograde drill still in the tibial tunnel, a guide at 65° is positioned with the medial entrance immediately anterior and proximal to the insertion of the gracilis tendon, 1.5 cm from it. The other end is

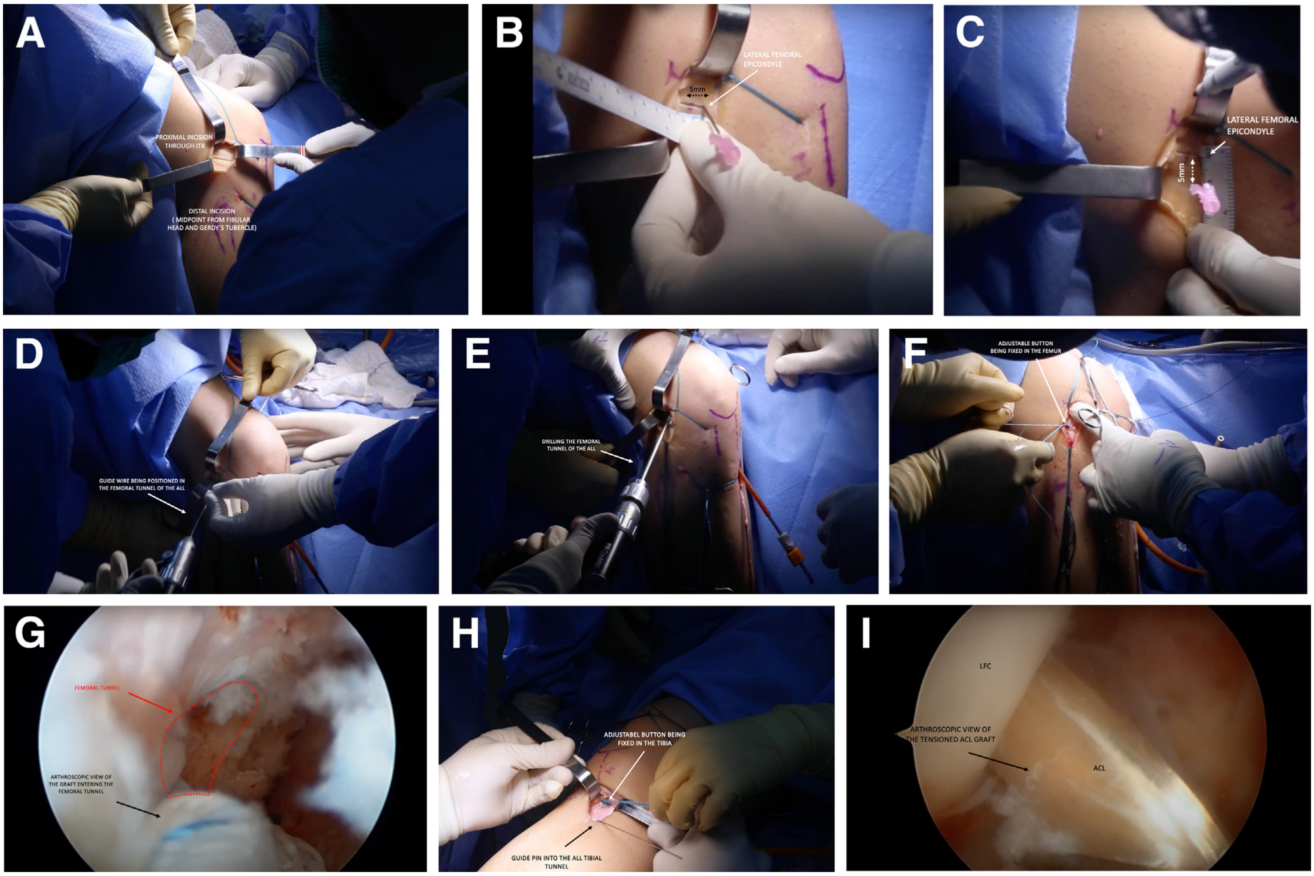

Fig 3. (A) A lateral incision is created on the femur, and a longitudinal incision is created in the same way of the ITB fibers. (B, C) We identify the correct place to create the ALL femoral tunnel, 5 mm proximal and posterior of the lateral femoral epicondyle. (D) The guidewire is positioned in the ALL femoral tunnel. (E) Drilling of the ALL femoral tunnel. (F) An adjustable button is fixed in the femur. (G) Arthroscopic view of the ACL graft entering the femoral tunnel. (H) Adjustable button is fixed in the tibia. (I) Arthroscopic view of the tensioned ACL graft. (A-G) Right knee is flexed on the side of the operating room table. (H) Right knee is extended on the operating room table. (I) Right knee is flexed on the side of the operating room table. (ACL, anterior cruciate ligament; ALL, anterolateral ligament; ITB, iliotibial band.)

placed at the insertion of the ALL, midway between the fibular head and Gerdy's tubercle (Fig 2A). After confirming the position of the guide, a 2.4-mm wire is passed from medial to lateral in the tibia, and the position is rechecked, with attention paid to the possibility of collision between the 2 tunnels (Fig 2B). After confirming the ideal position, a 1-cm direct access over the wire tip's exit in the proximal tibia's lateral portion is performed (Fig 2C-F). Next, an oblique tunnel is created with a 6-mm tibia drill from distal and medial to proximal and lateral (Fig 2G). Then, a transport wire is passed, leaving a loop medially at the tunnel's entrance and appearing on the side of the tibia.

Under fluoroscopy, a guidewire is positioned posterior and proximal to the lateral epicondyle, respecting the anatomical origin of the ALL (Fig 3 B and C). Fluoroscopy can be used in case of any doubt regarding the correct position.[15] Then, the femur is drilled with proximal and posterior inclination to avoid convergence of the tunnels (Fig 3D). After checking the position, a direct approach to the insertion of the ALL of 1.5 cm is performed, respecting the dissection by planes until the lateral cortex of the femur is found, and perforation of the femur is made, breaking the 2 cortices (Fig 3E). Next, a #2 ETHIBOND transport thread wire is positioned with the loop in the lateral region of the femur.

Once this is done, the ULTRABUTTON traction wires are positioned inside the loop of the ETHIBOND, which is positioned inside the femoral tunnel of the ACL, exiting through the arthroscopic portal. Next, the ETHIBOND wire is pulled, transporting the ULTRABUTTON inside the femoral tunnel, exiting in the lateral cortex of the femur. Finally, it is laid down in this location, functioning as the femoral fixation of the ACL graft (Fig 3F). After that, the traction wires of the femoral ULTRABUTTON are pulled, bringing the ACL graft to the interior of the femoral tunnel (Fig 3G). The same process is performed on the tibia, retrieving the fixation device on the anteromedial cortex of the tibia

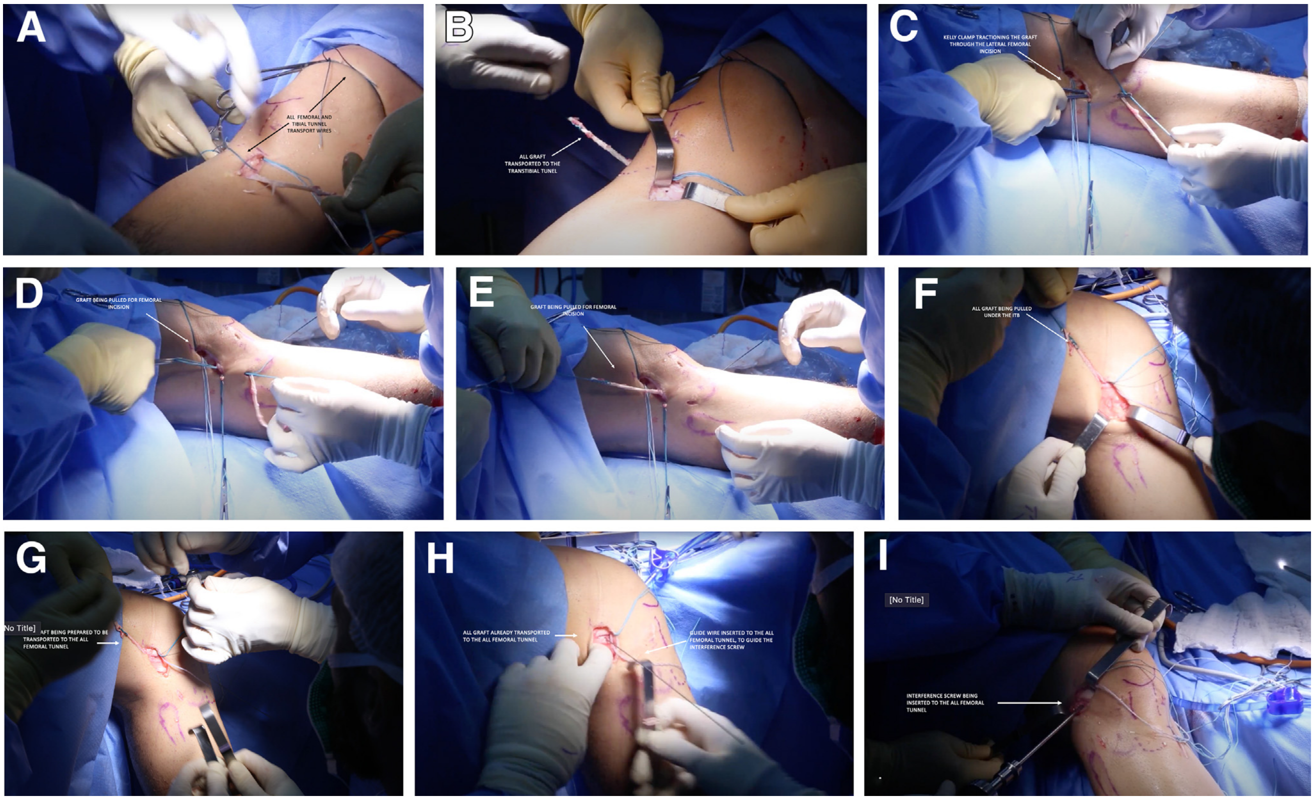

Fig 4. (A) Front view of the ALL femoral and tibial tunnels transport wires. (B) ALL graft transported to the transtibial ALL tunnel. (C) Kelly clamp is shown tractioning the graft through the lateral femoral incision. (D, E) Graft being pulled for femoral incision. (F) ALL graft being pulled under the ITB. (G) ALL graft being prepared to be transported to the ALL femoral tunnel. (H) ALL graft already transported to the ALL femoral tunnel; guidewire is inserted into the ALL femoral tunnel to guide the interference screw. (I) Interference screw is inserted into the ALL femoral tunnel. (A-E) Right knee extended on the operating room table. (F-I) Right knee flexed on the side of the operating room table. (ALL, anterolateral ligament; ITB, iliotibial band.)

(Fig 3H), followed by final tensioning of the anterior cruciate ligament graft at 20° of knee flexion and performing active posteriorization of the tibia (Fig 3I), following the standard reconstruction technique of the ACL using the all-inside method described by Lubowitz et al.[16,17]

Next, the end of the gracilis graft, repaired with no. 2 ETHIBOND, is placed in the loop and transported laterally with the graft crossing the tibia and remaining free in the lateral portion of it (Fig 4 A and B). With the aid of forceps positioned by the direct approach to the lateral epicondyle, the tip of this is presented, passing above the lateral collateral ligament and deep to the iliotibial band until it comes out through the approach in the tibial insertion of the ALL, where the repaired tip of the gracilis graft is transported above the lateral collateral ligament to the lateral approach of the femur (Fig 4C-F). The graft is then placed in the loop of the transport wire (Fig 4G) and tensioned medially until it is entirely inside the socket and tensioned. Next, with the aid of a 1.2-mm guidewire (Fig 4H), the graft is fixed in full extension and neutral rotation of the tibia with a 7- × 25-mm bioabsorbable screw (Fig 4I).

Discussion

We present a technique for combined ACL and ALL reconstruction without the need to remove additional grafts beyond those commonly used for a hamstring tendon harvest. Furthermore, we do not disturb the iliotibial band and Kaplan fibers, which are important rotational knee stabilizers, which are necessary for most anterolateral tenodesis techniques, preventing adding morbidity to the procedure.

Although historically, the existence of the ALL has been a matter of debate, nowadays, despite constant discussion, there is much knowledge in the literature about its anatomy, function, biomechanics, and surgical-reconstruction techniques.[4-6,18-21] Located on the anterolateral aspect of the knee, its femoral insertion is posterior and proximal to the lateral epicondyle, and in the tibia, it is located between Gerdy's tubercle and the fibular head.[9] Regarding biomechanics, the ALL resists the tibial internal rotation, with a minimal role in the anteroposterior stability.[22] When injured, it affects the outcome of the pivot shift in knees with ACL rupture, increasing rotational instability.[23]

Table 1. Pearls and Pitfalls

Pearls	
	When removing the flexor graft, it is essential to keep the gracilis tendon inserted distally using an open stripper.
	Tilt the femoral guide slightly anteriorly while constructing the ACL tunnel to avoid confluence of the tunnels.
	To reduce the risk of confluence of the tunnels, keep the tibial perforation drill of the ACL tunnel inside this so that it serves as a guide.
	Use the same ACL drill guide at 65° to perform the tibial ALL tunnel from medial to lateral in the tibia, 1.5 cm proximal and anterior to the insertion of the gracilis.
	Make a 1-cm skin incision and confirm the guidewire exit point laterally on the tibia midway between the fibular head and Gerdy's tubercle.
	Drill the femoral tunnel immediately posterior and proximal to the lateral epicondyle directed perpendicular to the ground and with proximal inclination to avoid tunnel confluence.
	Perform ALL fixation in full extension and neutral rotation.
Pitfalls	
	Do not pass the ALL under the LCL

Table 2. Advantages and Disadvantages

Advantages	
	Greater rotational stability
	Gracilis remains attached to the tibia, preventing devascularization and allowing faster ligamentization of the ALL
	Nonviolation of the iliotibial tract, thus not harming a restrictor of internal rotation of the tibia
	Preservation of Kaplan fibers
	Technically easy to perform
	Does not require fixation material on the tibia (lower cost)
	Better proprioception (potentially)
Disadvantages	
	Technique only applicable with the use of hamstring grafts
	Need to preserve the insertion of the gracilis tendon makes graft harvesting more difficult
	Retractable drill devices are required
	The use of 2 adjustable-loop buttons and an interference screw increases the cost

ALL, anterolateral ligament.

The study group of LaPrade carried out a series of in vitro and biomechanical studies, demonstrating the importance of the ALL as a structure that provides rotational stability in the knee.[24-27] The same authors demonstrated that ACL reconstruction associated with ALL reconstruction improves rotational stability, comparing ACL reconstruction alone in scenarios in which the ACL and ALL were deficient.[24]

Combined ACL and ALL reconstruction is indicated in patients with chronic ACL tears; in postfailure reconstruction reviews; in practitioners of high-intensity sports with change of direction; in explosive pivot shift (grades 2 and 3); femoral lateral deep notch sign; Segond fracture; contralateral Lachman difference greater than 7 mm; ligament hyperlaxity; and age younger than 25 years or contralateral ACL tear.[25]

Many techniques have been proposed for anterolateral reinforcement. The modified Lemaire technique, which consists of using the central third of the iliotibial band, disinserted proximally, and fixed in the femoral anatomical position, is technically easy to perform but can be criticized for adding morbidity to stabilizing structures of the knee anterolateral aspect, such as the iliotibial band and Kaplan fibers, in addition to the need for more extensive lateral access.[26]

Sonnery-Cottet et al.[27] reported, in a large number of cases, lower re-rupture rates with ALL associated with ACL reconstruction compared with isolated ACL reconstruction. His technique uses hamstring tendons with a semitendinosus triple graft (preserving distal insertion) associated with the gracilis (disinserted from the tibia). After passing through the tibial tunnel, joint and femoral tunnel, the graft that reconstructs the ALL emerges proximal and posterior to the medial femoral epicondyle, runs distally over the lateral collateral ligament, and is fixed in the tibia in an anatomical position.[28] It demands some experience for adequate reproducibility, and because the same femoral tunnel is used for both reconstructions, the imperfect positioning of a single tunnel can impair the results of 2 reconstructions.

Helito et al.[10] recently published a study that evaluated patients undergoing ACL reconstruction associated with ALL reconstruction. Patients were divided into 2 groups; group 1 was composed of patients who underwent the aforementioned procedure less than 8 weeks after injury, and group 2 was composed of patients more than 8 weeks after injury also undergoing the same surgical procedure. The patients had similar functional scores between the groups, with no differences in the assessment with KT-1000 pre- and postoperatively. There were also a similar number of complications between the 2 groups. Helito et al.[10] concluded that patients with ACL injuries associated with ALL undergoing surgical treatment in the acute or chronic phase present similar clinical results.

In cases of revision ACL reconstruction, both iliotibial tract tenodesis and ALL reconstruction can be performed. Recent literature supports the fact that these procedures should be performed routinely in patients who will undergo surgery after a failed ACL reconstruction.[29,30] In another recent study published by Helito et al.,[29] the authors showed that extra-articular reinforcement generated less postoperative laxity and reduced the number of failures after revision surgery. No benefit from iliotibial tenodesis regarding ALL reconstruction was observed.[29] Pavão et al.[30] demonstrated good results in a series of patients who underwent an ACL revision with extra-articular reinforcement with an iliotibial band tenodesis. These studies reinforce the indication of associated procedures in ACL revision surgeries.[29,30]

As for ACL reconstruction with only one graft, quadruple or triple looped, fixed with adjustable buttons, the technique is already well described and provides good results.[31]

In this article, we propose a technique for ALL reconstruction that, compared with other techniques, has the advantages of not harming the stabilizing structures of the iliotibial band and Kaplan fibers in the anterolateral region of the knee; does not require additional grafts other than those commonly used; favors the ligamentization of the gracilis graft, with a potential maintenance of proprioception; dismisses the need for tibial fixation material, reducing the cost of reconstruction; and it presents a technical ease of execution (Table 1). However, this technique is only applicable with the use of hamstring grafts and involves the need to preserve the insertion of the gracilis tendon, which makes graft harvesting more difficult. The technique cost also increases due to the need of retractable drill devices and the 2 adjustable loop buttons for ACL graft fixation and an interference screw for the femoral ALL fixation (Table 2).

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