Technical Note

Autologous Single Semitendinosus Anatomical Posterolateral Corner Reconstruction With Adjustable-Loop Cortical Suspension Devices

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Abstract: We present our surgical technique for the reconstruction of the posterolateral corner of the knee. It is a tibia- and fibular-based reconstruction technique. Most of these procedures require the use of 2 tendons (autograft or allograft). In our technique, a single semitendinosus tendon is required, making the procedure more suitable if the surgeon prefers the use of autograft or when there is no access to a tissue bank. This is even more important in the setting of multiligament knee injuries. The most defining feature of this modification is the possibility of achieving the desired graft tension in a progressive and independent way, due to the use of 3 adjustable-loop cortical suspension devices.

Several authors have established the correlation between clinical findings and the presence of an injury to the posterolateral corner (PLC) of the knee.[1] Rarely seen in isolation, most high-grade PLC injuries are associated with concomitant cruciate ligament tears, as well as meniscal tears and injuries to the medial ligamentous structures.[2] An instability pattern may sometimes obscure the PLC injury; therefore, the physician must maintain a high index of suspicion based on the mechanism of injury and symptoms.[3]

Different techniques have been described to repair, augment, or reconstruct the posterolateral structures, such as femoral osteotomy and advancement with a lax ligament, a biceps tenodesis by the Clancy method, a fibula-based reconstruction as described by Larson, and combined fibula and tibia-based anatomic reconstructions, as described by LaPrade.[4-6]

The goal of this Technical Note is to present a modification of this anatomic reconstruction technique of Dr. LaPrade.[4-6] A single semitendinosus graft with adjustable loop cortical suspension devices is used to reproduce the 3 primary stabilizers of the knee PLC.

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Surgical Technique (With Video Illustration)

Knee Examination Under Anesthesia

Once the anesthesia is confirmed and the patient relaxed, examination of the posterolateral corner is performed[7] with the following tests:

- Lachman test.
- External rotation recurvatum test (combined anterior cruciate ligament [ACL] + PLC injury).
- Posterior drawer test in internal, neutral, and external rotation.
- Varus stress test at 0 and 30° of flexion.
- Dial test at 30 and 90° of flexion.

Special care should be taken when looking at the "dial test'' to confirm that the proximal tibia subluxates posterolaterally but not anteromedially.

Graft Harvest and Preparation.

The ipsilateral semitendinosus tendon (ST) is the graft of choice for this modification of LaPrade's technique

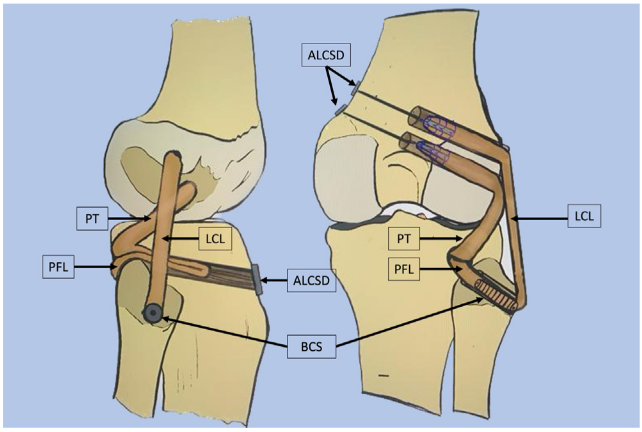

Fig 1. Schematic representation of the surgical technique. A single semitendinosus graft passes through the 4 tunnels. (ALCSD, adjustable-loop cortical suspensory device; BCS, biocomposite screw; LCL, lateral collateral ligament graft; PFL, popliteofibular ligament graft; PT, popliteus tendon graft.)

(Fig 1). When this tendon is not available (because of previous surgeries or multiligament injuries), the contralateral ST or both gracilis tendons (ipsi- and contralateral) can be harvested instead.

The goal is to obtain a graft with a minimum length of 24 cm. For this reason, it is crucial to release the ST from all its attachments before the use of the stripper.

Once the tendon has been released from its proximal muscular attachment, the ST is released from the tibia, with effort taken to reach the periosteum, to make the graft the longest possible. Insufficient graft length would make performing this technique impossible.

At the back table, the graft is cleaned and prepared. Both tails of the ST are whipstitched using a #2 FiberLoop (Arthrex, Naples, FL). When the distal tip of the tendon is reached, a TightRope RT (Arthrex) is added and the tendon is whipstitched again backwards (from distal to proximal) to block the suture

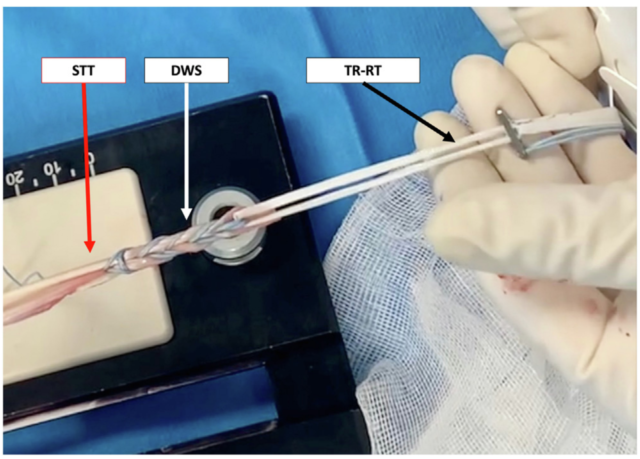

Fig 2. Graft preparation: A TightRope RT Device (TR-RT) is attached to both tails of the semitendinosus tendon graft (STT) with a double whip-stitch suture (DWS).

(Video 1 and Fig 2). Care must be taken to avoid interfering with the suture in the TightRope mechanism. At the end of the suture, it should be checked that the implant loop slides smoothly under the whipstitch.

At this point, it is crucial to elongate both loops of each TightRope until the length of the loop is longer than the width of the distal femur (from the lateral epicondyle [LE] to medial cortex). If the TightRope loops are not elongated, the button will not be able to cross the full width of the femur and therefore will not flip in the medial cortex. The graft is pretensioned and covered by a gauze soaked in vancomycin solution.

Surgical Approach

Performing an open surgical dissection of the lateral structures before any arthroscopic procedure is recommended to prevent fluid extravasation into the soft tissues, which can distort tissues and anatomical references. The surgical approach is that previously published by Robert LaPrade.[4-6]

The patient is placed in supine position with a lateral thigh post and one footrest. A tourniquet is placed on the upper thigh and may be inflated during the procedure as required. The appropriate landmarks are as follows: the LE, Gerdy's tubercle, and fibular head (FH) are palpated and marked. After this, a hockey-stick incision is made from 2 to 3 cm proximal to the lateral epicondyle and then extended distally between Gerdy's tubercle and FH, slightly closer to FH.[4-6] A flap of subcutaneous tissue is then dissected from the iliotibial band (ITB) down to the FH.[4-6]

Fibular Tunnel Drilling

The first fascial incision is made to expose the common peroneal nerve (CPN) (Fig 3). The nerve is located posteromedial to the long head of the biceps femoris and is dissected up to 6 cm proximally and 5 to 7 mm distally, incising the peroneus longus fascia.

The complete neurolysis just distal to the anterior fibula is carried out and the nerve is inspected and protected posterior and laterally. The use of a surgical silicon loop is recommended. The CPN must be perfectly identified and controlled throughout the surgery to avoid causing any trauma. Iatrogenic neural injury would be a devastating complication. Once the CPN is safely identified, the biceps' bursa is incised at the level of FH and a posterior flap is dissected including the proximal portion of the peroneus longus muscle.

When the posterior part of the FH is exposed, a curved retractor is used to protect the neurovascular structures and the specific guide with a fibular marking hook (Arthrex) is applied.

A 2.4-mm guide-pin is passed through FH, in an anterolateral to posteromedial direction, from the lateral collateral ligament (LCL) attachment site to the attachment site of the posterior division of the

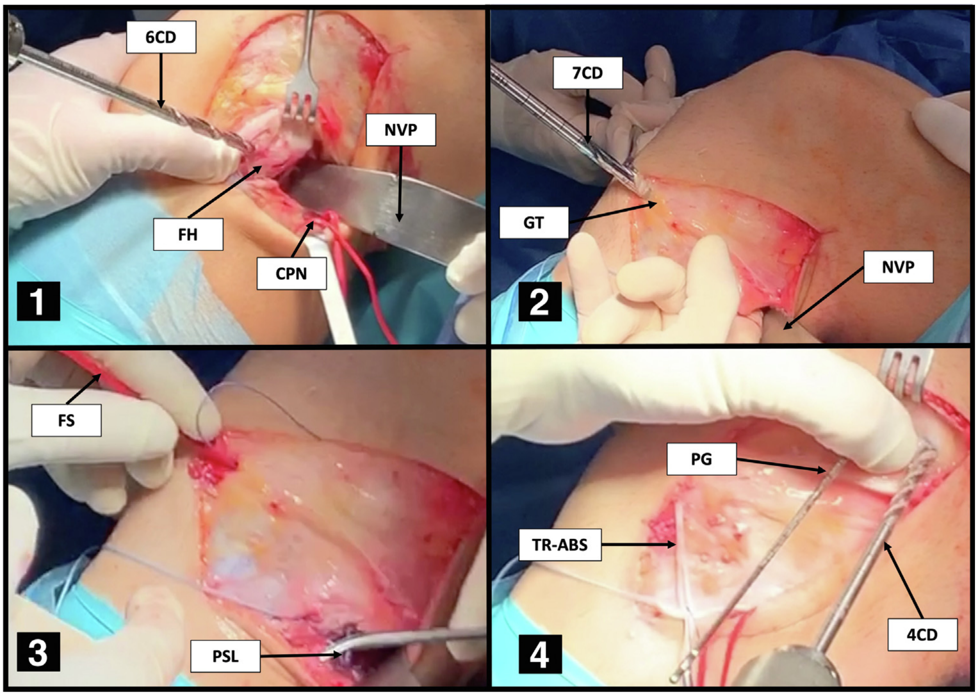

Fig 3. Drilling of the 4 tunnels on the lateral side of a left knee at 90° of flexion: (1) fibular tunnel drilling: A 6-mm cannulated drill (6CD) is used to perform the tunnel in the fibular head (FH). The neurovascular protector (NVP) must be perfectly in place and the common peroneal nerve (CPN) controlled. (2) The tibial tunnel entry point is located slightly anterior to Gerdy's tubercle (GT). A 7-mm cannulated drill (7CD) is used, and the presence of the NVP is mandatory. (3) A FiberStick (FS) is introduced in the tibial tunnel. (4) This suture is used to pass a TightRope ABS (TR-ABS) through the tibial tunnel, leaving the loop of the device behind the tibia. Parallel 2.4-mm guide pins (PG) are used to drill completely drill femoral tunnels with a 4/4.5-mm cannulated drill (4CD). The 6-mms sockets are overdrilled afterwards.

popliteofibular ligament (PFL) on the posteromedial aspect of the fibular styloid process. To decrease the risk of a FH fracture, it is crucial to avoid aiming the guide pin too proximally.

A 6-mm cannulated reamer is used to create the tunnel for graft passage. A passing suture is then passed through the tunnel. At this point, intra- articular procedures are performed if needed.

Tibial Tunnel Drilling

When the intra- articular steps are finished (except the passage of the ACL graft), the procedure is restarted (Fig 3). Blunt dissection is carried out posterior to the FH in the interval between the lateral gastrocnemius and soleus muscle, creating a window just anterior to the lateral head of the gastrocnemius to access to the posterolateral aspect of the tibial plateau.

The flat spot on the anterior tibia, just distal and medial to Gerdy's tubercle, is identified, and a 2.4-mm guidewire is drilled through the proximal tibia, from anterior to posterior, aiming toward the musculotendinous junction of popliteus muscle.

A specific drill guide with a tibial marking hook (Arthrex) is used to protect the neuro-vascular structures. The exit point is 1 cm proximal and 1 cm medial approximately to the fibular tunnel. This is undoubtedly the most complicated step in the technique. On the one hand, there is no visual control of the exit point of the guide pin and the control is exclusively

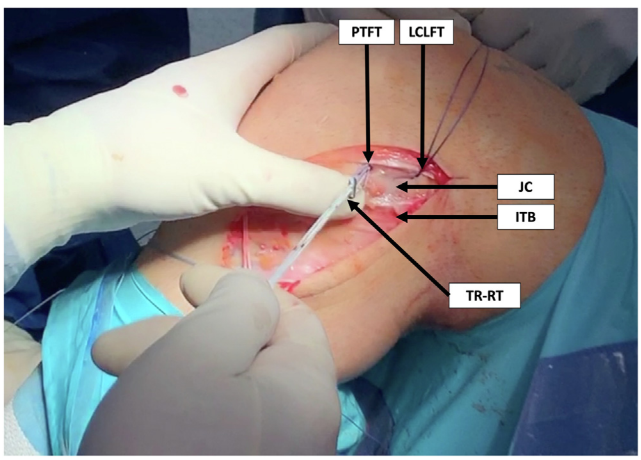

Fig 4. Graft insertion in the popliteus tendon femoral tunnel (PTFT) from the lateral side of a left knee at 90° of flexion. The assistant pulls from the medial side to introduce the TightRope RT device (TR-RT) in the tunnel. The lateral collateral ligament femoral tunnel (LCLFT) is located proximal and slightly posterior. The popliteus tendon graft will be passed underneath the joint capsule (JC) while the lateral collateral ligament graft will run over the JC and underneath the iliotibial band (ITB).

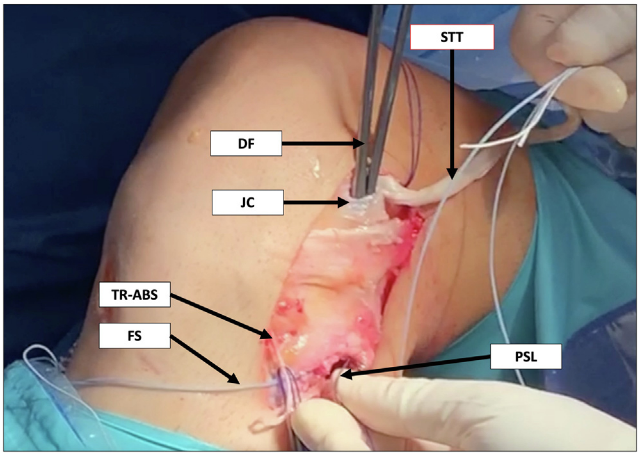

Fig 5. Preparation of a passing suture for the popliteus tendon graft (lateral side of a left knee at 90° of flexion). With the help of dissector forceps (DF), a passing suture loop (PSL) is driven underneath the joint capsule (JC) to pass the semitendinosus tendon (STT). A TightRope ABS (TR-ABS) and a FiberStick are prepared in tibial and fibular tunnels for further steps.

tactile; on the other hand, a retractor must be carefully positioned to avoid damaging the popliteal artery. If the exit position of the guide pin is not exact, it is mandatory to repeat this step

The tunnel is then overdrilled to allow easy passage of the doubled loop of ST graft. A loop of suture is then passed from anterior through the tunnel and is retrieved at the posterior tibia. With the help of this passing suture, an ABS-TightRope with no button (Arthrex) is then placed in the tibial tunnel with its loop in the posterior aspect of the tibia (Video 1).

Femoral Tunnels Drilling

The second fascial incision is made through the ITB at the mid-point and centered over the lateral condyle

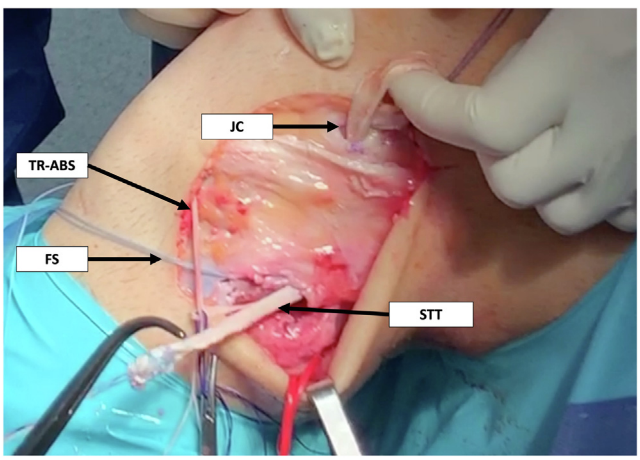

Fig 6. The semitendinosus tendon (STT) is driven through the joint capsule (JC) on the lateral side of a left knee at 90° of flexion. The TightRope ABS (TR-ABS) and a FiberStick remain in tibial and fibular tunnels for further steps.

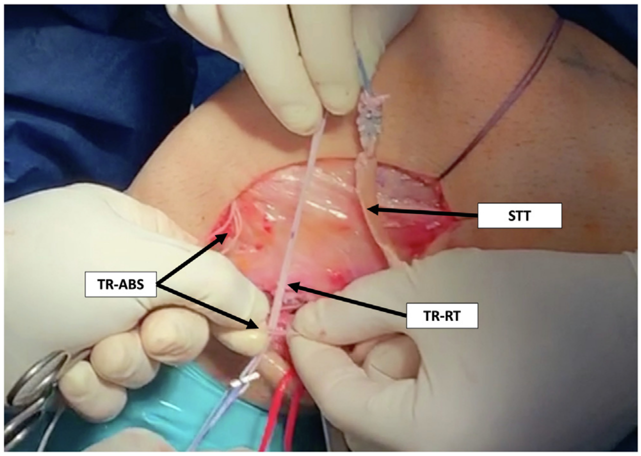

Fig 7. The TightRope RT (TR-RT) and the semitendinosus tendon (STT) are passed through the loop of the TightRope ABS (TR-ABS) that was left at the posterior aspect of the tibia, tails of the TR-ABS remain at the anterior gate of the tunnel (view from the lateral side of a left knee at 90° of flexion).

(Fig 3). Identification of the femoral footprint of the popliteus tendon (PT) is carried out. A 2.4-mm guidepin is drilled through the PT footprint at 35° angulation anterior and 30° proximal to avoid tunnel convergence with possible concurrent ACL reconstruction (ACLR).

The LCL femoral attachment is localized 1.4 mm and 3.1 mm proximal and posterior, respectively, to the LE. Another guidewire is drilled parallel to the PT guidewire, exiting on the medial cortex. The distance between the 2 guide pins should be close to 18.5 mm, which is the normal distance between the centers of the LCL and PT attachment sites. The parallel pin guide (Arthrex) is used to maintain distance and parallelism

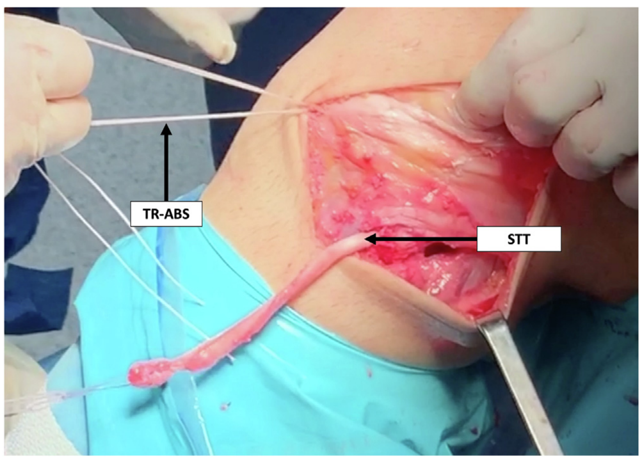

Fig 8. Insertion of a loop of semitendinosus tendon (STT) into the tibial tunnel. By pulling from the TightRope ABS (TR-ABS), the surgeon gets an adequate length (2 cm) of looped graft inside the tibial tunnel. It is important to make sure that the TR-ABS loop doesn't close accidentally during this maneuver (view from the lateral side of a left knee at 90° of flexion).

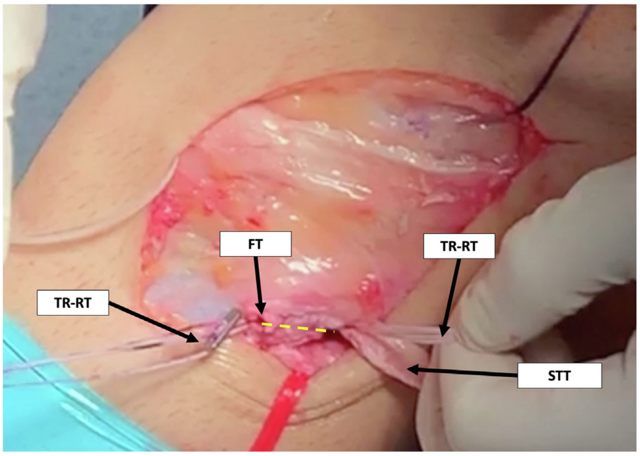

Fig 9. Passing of the graft through the fibular tunnel (FT) on the lateral side of a left knee at 90° of flexion. With the help of a passing suture loop, the TightRope RT (TR-RT) and the semitendinosus tendon (STT) are passed through the FT from posterior to anterior (the direction of the tunnel is represented by a dotted yellow line).

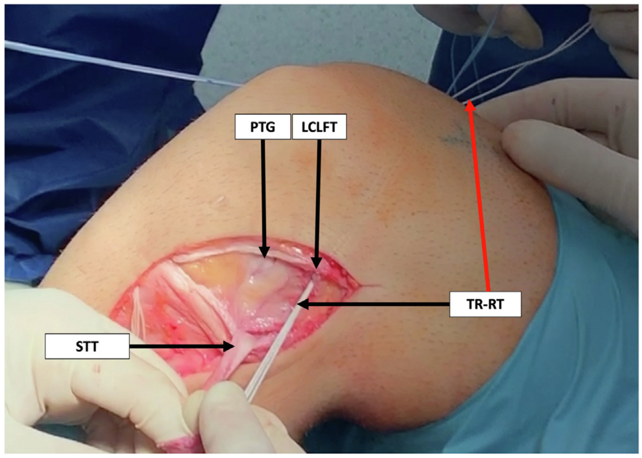

Fig 11. Insertion of the graft in the lateral collateral ligament femoral tunnel (LCLFT) from the lateral side of a left knee at 90° of flexion. An assistant passes the TightRope RT (TR-RT) through the proximal femoral tunnel (LCLFT). Manipulating the TR-RT will allow one to get 20 mm of the semitendinosus tendon (STT) inside this socket. The popliteus tendon graft (PTG) will be located distal (18.5 mm) and slightly anterior.

of both guide pins. Both tunnels are then overdrilled to achieve 2 femoral closed-socket tunnels of 25 mm in depth (Video 1).

To avoid tunnel convergence in the case of a concurrent ACLR, it is recommended to drill the femoral ACL socket first and to place the arthroscope inside. A "tunnelscopy" is then performed during the drilling of the PT and LCL femoral tunnels; if any of the wires or reamers invades the ACLR femoral tunnel, slight changes in guidewire direction should be made. Two passing sutures are placed in the femoral tunnels for future graft passage.

Graft Passage Through All the Tunnels

First, the graft is introduced in the PT socket (Video 1). With the help of the previously placed passing suture, one of the TightRope RTs attached to the graft is driven into the socket and fixed, by shortening the adjustable loop, and the graft is partially introduced in the socket (Fig 4). Using dissectors or/and passing sutures, the graft is passed down through the joint to the posterior aspect of the lateral tibial plateau (Figs 5 and 6). The loop of ABS-TightRope that was left at the posterior aspect of the tibial plateau is identified and recovered. The graft is

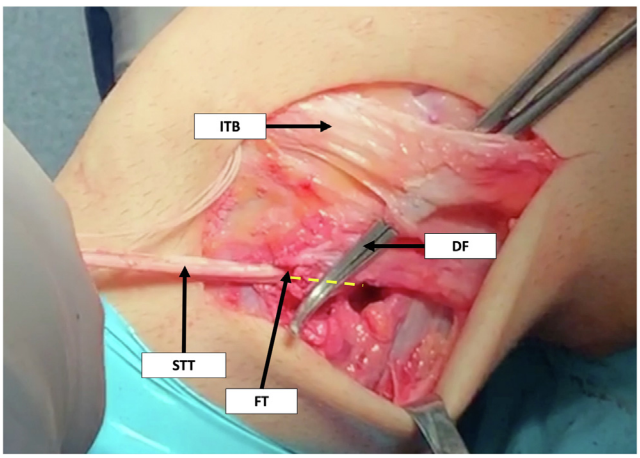

Fig 10. Passing of the graft underneath the iliotibial band (ITB) on the lateral side of a left knee at 90° of flexion. Once the semitendinosus tendon (STT) is completely retrieved from the fibular tunnel (FT; yellow dotted line), the TightRope RT and the STT are passed underneath the ITB with the help of a dissector forceps (DF).

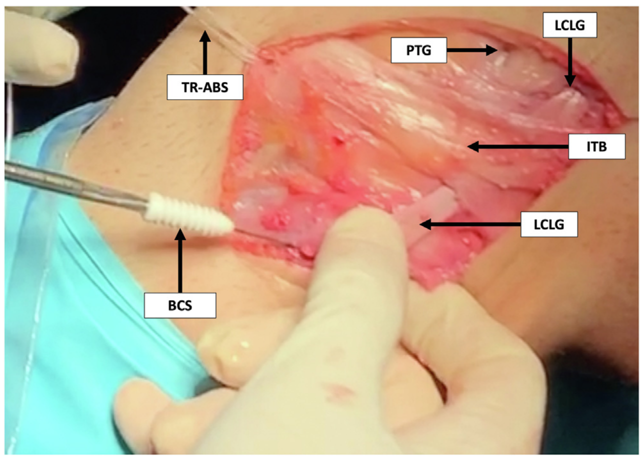

Fig 12. Blocking of the graft in the fibular tunnel. A 6-mm biocomposite screw (BCS) is driven into the fibular tunnel. The lateral collateral ligament graft (LCLG) and the popliteus tendon graft (PTG) will be tensioned afterwards. The LCLG runs underneath the iliotibial band (ITB). The TightRope ABS (TR-ABS) is tensioned as the final step (view from the lateral side of a left knee at 90° of flexion).

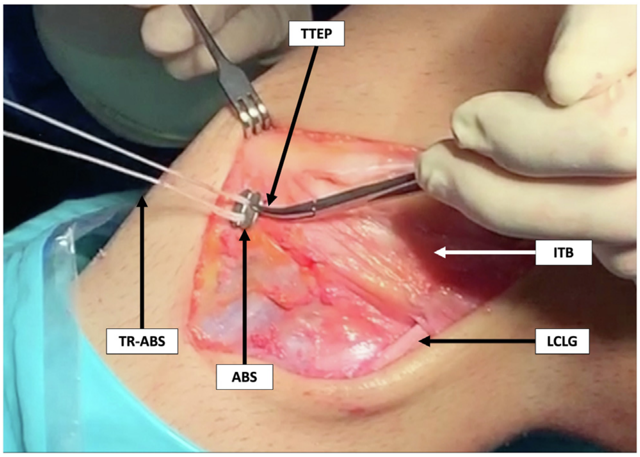

Fig 13. Final tension of the graft on the lateral side of a left knee at 90° of flexion. The surgeon alternatively pulls from the TightRope ABS Device (TR-ABS) tails with an attachable button system (ABS) placed on the tibial tunnel entry point (TTEP). The lateral collateral ligament graft (LCLG) runs underneath the iliotibial band (ITB).

then passed through this loop and partially introduced in the tunnel (Figs 7 and 8). The free end of the graft (and its TightRope RT) is passed from posterior to anterior through the fibular tunnel (Fig 9). Finally, the graft mimics the LCL trajectory below the ITB (Fig 10) and by means of a passing suture and the TightRope RT is introduced in the femoral LCL socket (Fig 11).

Independent Tensioning of the Grafts

Once the graft is placed in all the sockets and tunnels, it is crucial to have even lengths in both femoral sockets and the appropriate amount of graft looped in the tibial tunnel (Video 1). The goal is 20 mm of looped graft to allow progressive tensioning of the TightRope devices. Insufficient graft loop in the tibial tunnel could result in a suboptimal amount on tendon in the tunnel after tensioning the popliteal femoral TightRope ABS. With an excess of graft in the tibial tunnel, the final tensioning on the ABS-TightRope could be at risk because the loop of the implant does not close completely. (There is limit in the shortening of the loop.)

At this point, the graft should be placed along the whole course of its final position but with no tension at all. The graft is fixed in the fibular head with a 6 × 20-mm interference screw. From this point, there are 2 independent systems: the LCL graft and the PT-PFL graft (Fig 12).

Final fixation with progressive and independent tensioning is then achieved. The LCL graft is tensioned with the knee at 20° of flexion, neutral tibial rotation and with a valgus force applied. The correspondent TightRope RT allows progressive shortening of the loop until the desired tension is reached. With the knee at 70° of flexion and neutral rotation, the PT-PFL is tensioned. The corresponding TightRope devices of femur and tibia are tensioned progressively (Fig 13).

The stability and range of motion of the knee must be assessed. Retensioning of the grafts is possible if the stability is considered suboptimal. Before closure, the wound is irrigated with copious amounts of sterile fluid and the integrity of CPN is verified for the last time.

Rehabilitation

The rehabilitation program is highly dependent on concomitant injuries and must be personalized. With concomitant PCL injury, a specific dynamic brace is prescribed. Partial weight-bearing is allowed depending on the presence of meniscal or chondral injuries.

Discussion

The original description of this technique by LaPrade et al.[4] requires 2 allografts. LaPrade et al.[5] illustrated the same technique with 2 autografts, the ST and gracilis

Table 1. Technical Pearls and Pitfalls of Anatomic Posterolateral Corner Reconstruction Using Single Semitendinosus Autograft and Adjustable Loop Cortical Suspensory Devices (ALCSD)

Surgical Pearls	Pitfalls
Careful harvesting of the semitendinosus tendon to achieve the longest possible graft.	Insufficient length of the graft will make impossible to perform this technique.
Graft preparation by expert surgeon. Elongation of the loops of both TightRopes is recommended.	Trapping the loop of the TightRope with the FiberLoop while attaching the device will lock the system.
Complete drill of femoral tunnels to 4 or 4.5 mm to allow the passing and flipping of the TightRope buttons. Overdrill socket to desired diameter (6 mm).	CPN can be damaged if an optimal dissection is not performed.
Start graft passing sequence by the popliteal femoral tunnel.	The popliteal artery can be damaged when performing the tibial tunnel if guide and retractors are not carefully positioned.
Assure enough tendon loop in the tibial tunnel.	Any mistake in the graft-passing sequence through the tunnels will jeopardize the outcome of the procedure.
Slow and progressive tensioning of every TightRope.	Graft fixation in internal or external rotation will lead to suboptimal outcome.

CPN, common peroneal nerve

Table 2. Advantages and Disadvantages of Anatomic Posterolateral Corner Reconstruction Using Single Semitendinosus autograft and Adjustable Loop Cortical Suspensory Devices (ALCSD)

Advantages	Disadvantages
Anatomic technique which reproduces the 3 primary stabilizers of the PLC.	The whole procedure is based in obtaining a semitendinosus graft of the adequate length.
No need for allograft tissue.	Technically demanding procedure when compared with fibular-based techniques.
No risk of disease transmission due to allograft tissue.	
Reduced cost due to use autograft tissue.	
Because of the suspensory devices, progressive tensioning can be achieved.	
Can be applied to fibular-based techniques.	

PLC, posterolateral corner.

tendons. Wood et al.[8] have recently published another anatomic PLC technique using an isolated ST autograft.

The new technique that we describe has several advantages (Table 1), the main one being the use of a single ST and the progressive graft tension achieved with adjustable-loop cortical suspensory device. In addition, it can be helpful when access to allograft is limited or in the setting of multiligament injuries. The same principles can be applied to fibular-based techniques. We have not found any difficulties achieving optimal autograft length, but we are aware that this can be one of the main difficulties (Table 2).

Recently, several new techniques and modifications for the reconstruction of the PLC have been reported,[5,8-11] but none of them have the advantages that our technique provides. The benefits of adjustable-loop cortical suspensory device are widely known, with the possibility of progressive tensioning and retightening if needed. Moreover, LCL and the PT-PFL grafts can be tensioned independently.

The main risks associated with the procedure are those associated to any tibia and fibular based PLC reconstruction.[4-6,12-15] There is not enough clinical evidence to support the superiority of these techniques over the fibular-based ones,[14] but some biomechanical studies have reported better rotational stability.[4,15]

In conclusion, the use of a single autograft and the adjustable-loop cortical suspension device is a reliable technique that provides multiple benefits without adding special difficulties to previously known anatomic techniques.

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