Technical Note

Posterolateral Corner Reconstruction: Modification of the LaPrade Technique Using Autologous Hamstring Tendon Grafts: "The Popliteofibular Loop"

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Abstract: Posterolateral corner (PLC) injury is a significant cause of knee instability. In recent years, a better understanding of the anatomy and biomechanics of the PLC structures has led to significant advancements in the surgical treatment of this injury. Anatomical reconstruction techniques, particularly the LaPrade technique, have shown promising results. However, in some settings, the reliance on allografts limits the feasibility of this technique, prompting surgeons to seek reproducible alternatives that use autologous grafts, eliminating the need for tissue banks. The purpose of this Technical Note is to describe a modification of the LaPrade technique for PLC reconstruction using autologous hamstring tendon grafts. The surgical technique is described to ensure reproducibility, with particular emphasis on the proposed modifications: the use of autologous grafts (gracilis and semitendinosus tendons); the configuration in which they are used to increase the thickness of the reconstructed structures; and the exclusive fixation with widely available interference screws.

Despite being uncommon, posterolateral corner (PLC) injury is a significant cause of knee instability. Accounting for approximately 16% of all joint injuries, PLC injury often is accompanied by other ligamentous injuries, with isolated ligamentous injury accounting for only 28% of cases.[1]

In recent years, improved understanding of the anatomy and biomechanics of the PLC, combined with the fact that most of these injuries are intrasubstantial, has driven the development of different surgical reconstruction techniques,[2-5] which are currently preferred over surgical repair for acute and chronic injuries.[1,6]

Among the described techniques for PLC reconstruction, those referred to as "anatomical" techniques, aiming to reproduce the 3 main structures of the PLC, ie, the lateral collateral ligament (LCL), the popliteus tendon (PT), and the popliteofibular ligament (PFL), generally yield the best results in restoring joint biomechanics.[1] LaPrade et al.[7] described an anatomical technique for PLC reconstruction, now considered a classic, which uses an allograft Achilles tendon with bone block for ligamentous reconstruction of the 3 key structures of the PLC. Although the LaPrade technique has shown favorable outcomes,[8] its use becomes impractical in locations without access to tissue banks.

With this in mind, modifications of the technique using autologous grafts have been described.[1,9,10] However, these techniques have some limitations, including a smaller graft diameter, as hamstring tendons are generally thinner than allografts, and they cannot be used in double bundles due to the need for increased length.[1] Moreover, these techniques present greater technical difficulty and require specific fixation materials.[9,10]

Therefore, considering that PLC injury is typically associated with other ligamentous injuries that also require

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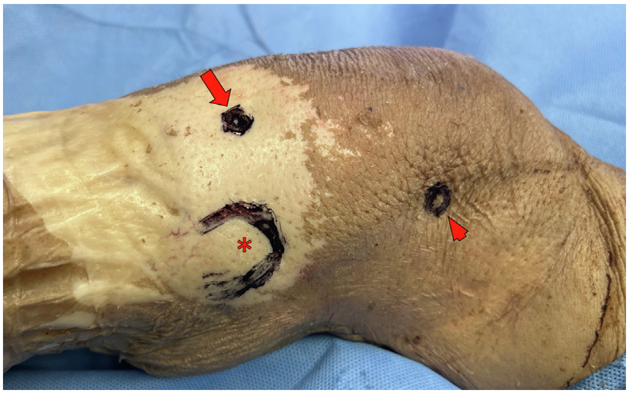

Fig 1. Anterolateral view of a left knee in 30° of flexion, supine position (cadaver specimen), showing the 3 anatomical landmarks for guidance of the skin incision for PLC reconstruction. Asterisk: fibular head; red arrow: Gerdy tubercle; red arrowhead: lateral epicondyle. (PLC, posterolateral corner.)

reconstruction, we propose a modification of the LaPrade technique[7] using autologous hamstring tendon grafts, which provides adequate diameter of the reconstructed structures and fixation solely with interference screws.

Surgical Technique (With Video Illustration)

Positioning

The patient is positioned supine on a conventional surgical table, preferably with a cushion under the lumbar region and ipsilateral buttock, so that the operated lower limb is slightly internally rotated when fully extended. The use of a cushion allows the knee to remain stable on the surgical table when flexed at 90°, facilitating the approach to the entire lateral region of the knee, especially the posterolateral portion of the tibia. Usually, an inflatable tourniquet is positioned at the proximal portion of the thigh.

Graft Harvesting

Graft harvesting is performed through a 30-mm longitudinal incision made in the anteromedial region of the ipsilateral leg, at the midpoint between the posterior margin of the tibia and the anterior tuberosity. The longitudinal opening of the pes anserinus sheath is performed, and the tendons of the semitendinosus and gracilis muscles are identified. After detachment and preparation of the distal end of the tendons with VICRYL or ETHIBOND (Ethicon, Somerville, NJ) sutures (using the "baseball stitch" technique), the expansions to the medial gastrocnemius are released, and the grafts are then removed with the aid of a closed tenotome. Subsequently, the grafts are prepared by removing any remaining muscle tissue and suturing the proximal end, in the same manner as previously described.

Surgical Approach

With the knee flexed at 90°, an arched incision is made, with the parameters being the lateral femoral epicondyle, Gerdy tubercle, and the head of the fibula (Fig 1 and Video 1).

Dissection

Initially, subfascial dissection is performed, creating a clear plane between the iliotibial tract and the superficial fascia/ subcutaneous tissue, which facilitates closure and minimizes damage to the skin's vascularization. Next, the identification and protection of the common peroneal nerve are crucial. It can be found deep and inferior to the biceps femoris tendon (Fig 2). After careful neurolysis, from approximately 6 cm proximal to the fibula and to the peroneus longus fascial sheath distally, the nerve is isolated with a Penrose drain (Video 1).

Following this, the 3 fascial windows are created: the most posterior one, adjacent to the fibular neck, anterior to the fibular nerve and posterior to the biceps femoris tendon; the intermediate one, located anterior to the biceps femoris tendon and proximal to the head

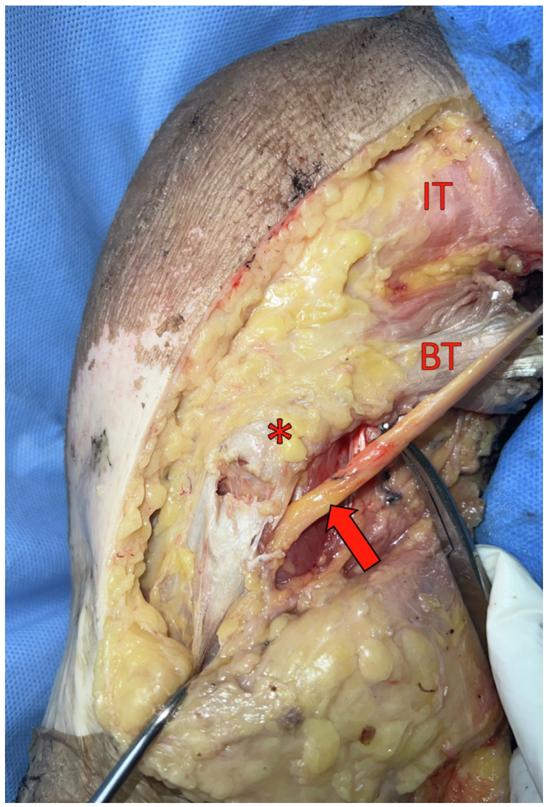

Fig 2. Lateral view of a left knee in 90° of flexion (cadaver specimen), after superficial dissection and neurolysis of the common peroneal nerve (arrow). Asterisk: fibular head. (BT, biceps tendon; IT, iliotibial band.)

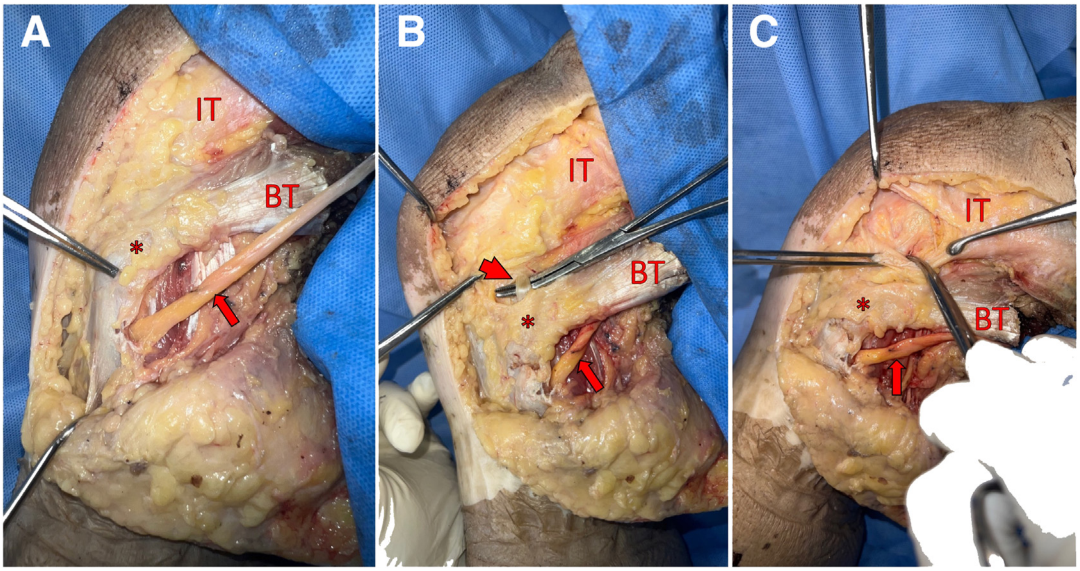

Fig 3. Lateral view of a left knee in 90° of flexion (cadaver specimen), after superficial dissection, showing the 3 fascial windows: (A) the posterior one, at the level of the fibular neck; (B) the intermediate one, where the LCL can be identified; (C) the anterior one, through the iliotibial band. Red arrow: common peroneal nerve; red arrowhead: LCL. Asterisk: fibular head. (BT, biceps tendon; IT, iliotibial band; LCL, lateral collateral ligament.)

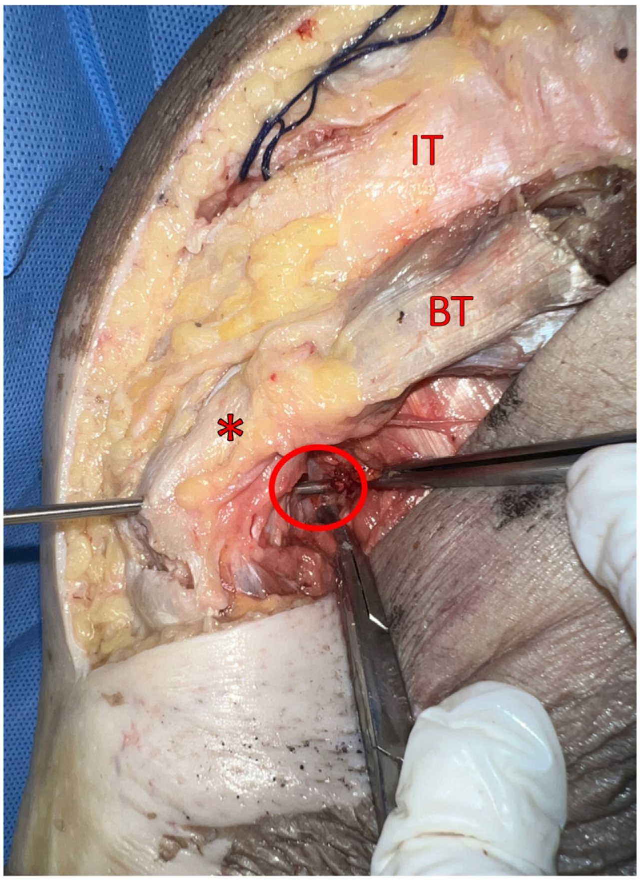

Fig 4. Posterolateral view of a left knee in 90° of flexion (cadaver specimen), showing the correct placement of the guidewire for creation of the fibular tunnel. The red circle shows the exit point of the guidewire, close to the proximal tibiofibular joint. Error in placement of the guidewire can lead to fracture of the fibula and failure of the reconstruction. Asterisk: fibular head. (BT, biceps tendon; IT, iliotibial band.)

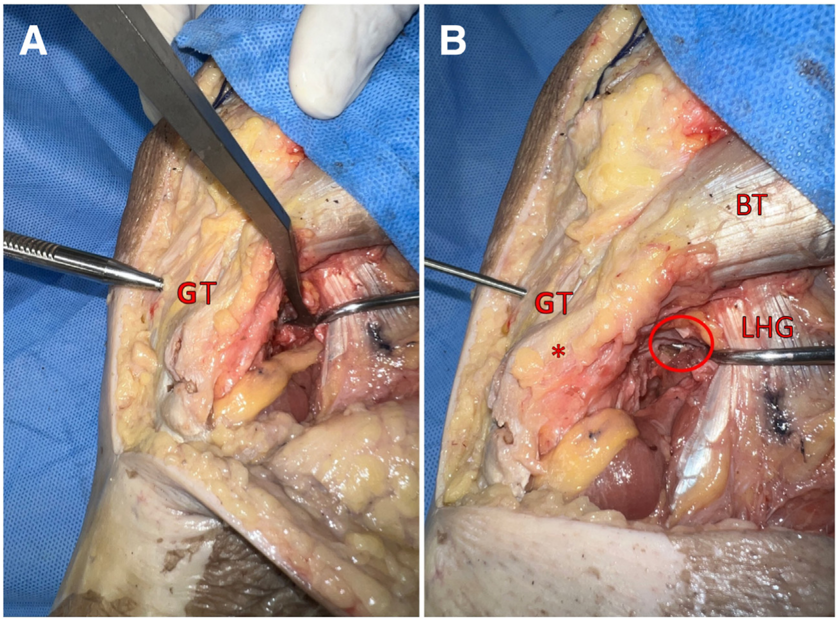

Fig 5. Posterolateral view of a left knee in 90° of flexion (cadaver specimen), showing the correct placement of the guidewire for creation of the tibial tunnel. (A) position of the guide for passing of the guidewire, medial to the Gerdy tubercle (GT); (B) the red circle shows the exit point of the guidewire at the posterior aspect of the tibia, slightly medial and proximal to the proximal tibiofibular joint. Caution must be taken here to avoid damaging of the posterior neurovascular structures. Asterisk: fibular head. (BT, biceps tendon; GT, Gerdy tubercle; IT, iliotibial band; LHG, lateral head of the gastrocnemius.)

of the fibula, where the remaining of the native LCL is usually found; and the most anterior one, made through a longitudinal incision of approximately 6 cm on the iliotibial band, at the level of the lateral epicondyle and the PT groove (Fig 3 A-C).

Creation of Bone Tunnels

After identifying the anatomical landmarks, the bone tunnels can be prepared. These can be created in any order, and the parameters are the same as described by LaPrade et al.[7,11] As each bone tunnel is drilled, a

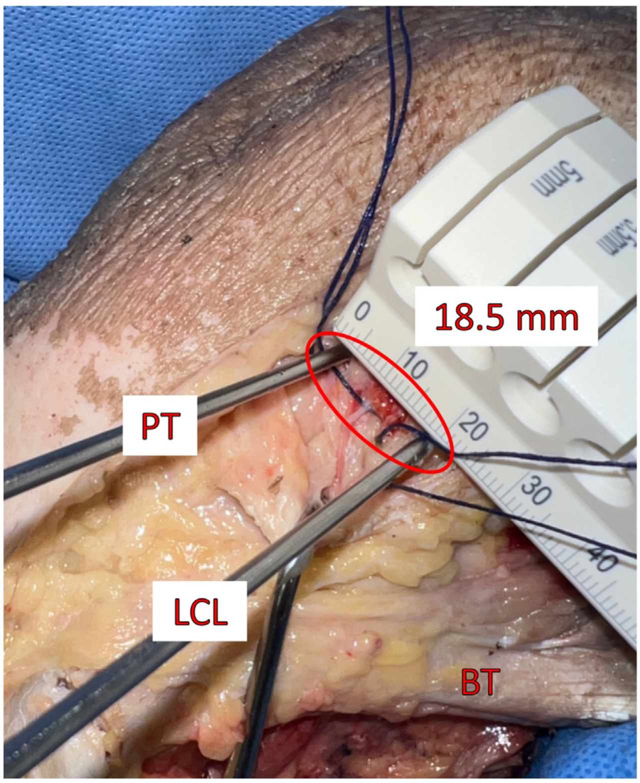

Fig 6. Superolateral view of a left knee in 90° of flexion (cadaver specimen), showing the adequate position of the guidewires for creation of the femoral tunnels, and the distance between then, around 18.5 mm. The guidewires are passed through the anterior fascial window. (BT, biceps tendon; PT, guidewire for creation of the popliteus femoral tunnel; LCL, guidewire for creation of the LCL femoral tunnel.)

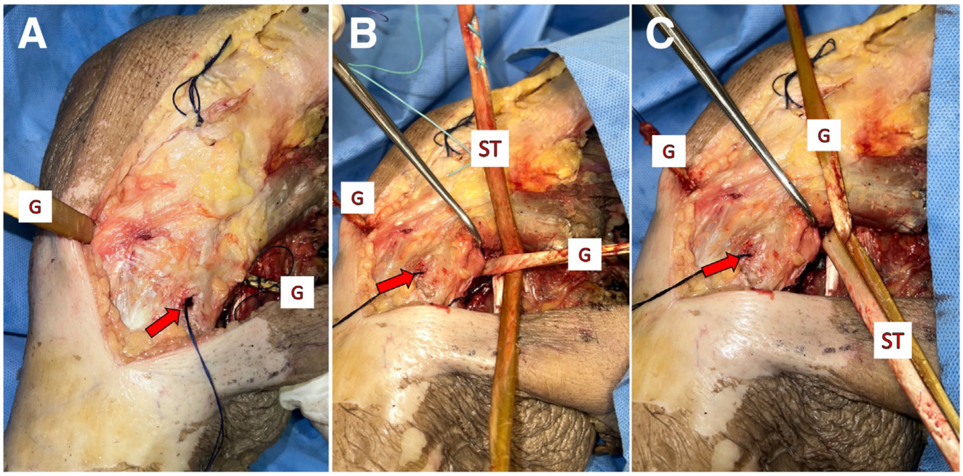

Fig 7. Anterolateral (A) and posterolateral (B and C) views of a left knee in 90° of flexion (cadaver specimen), showing passage and winding of the autografts. (A) passage of the gracilis graft through the tibial tunnel, from anterior to posterior. (B and C) Winding of the semitendinosus graft around the gracilis graft, close to the posterior exit of the tibial tunnel. Red arrow: anterolateral exit of the fibular tunnel. (G, gracilis graft; ST, semitendinosus graft.)

suture loop should be left in place, to aid in the passage of the grafts later on (Video 1).

The fibular tunnel is created at the transition between the head and neck of the fibula, immediately proximal to the "champagne glass drop-off," approximately 25 to 30 mm distal to the tip of the fibular styloid and 7 to 10 mm posterior to the anterior margin of the fibular head.[11] Through the inferior fascial window, the guidewire is passed obliquely, from distal—lateral—anterior (at the LCL fibular insertion) to proximal-medial-posterior, using an appropriate guide (Arthrex), so that the posterior exit of the tunnel is adjacent to the proximal tibiofibular joint, at the PFL fibular insertion. Alternatively, the guidewire passage can be aided "off-the-shelf" by a tibial guide for ACL reconstruction (Arthrex) or even done freehand (Fig 4 and Video 1). After the guidewire is passed, the tunnel is created with a drill bit of a diameter corresponding to the size of the doubled semitendinosus tendon.

The tibial tunnel is created at the superolateral portion of the tibia, in an anteroposterior fashion. With the help of an appropriate guide (Arthrex) positioned through the inferior fascial window, the guidewire is passed from anterior to posterior in the lateral metaphyseal region of the tibia (Video 1), with its entry immediately distal and medial to Gerdy tubercle (at the "tibial flat spot")[1,12] and the exit adjacent to the proximal tibiofibular joint, 1 cm proximal and 1 cm medial to the fibular tunnel, at the tibial popliteal sulcus, which can be palpated through blunt dissection posteriorly and medially to the fibular

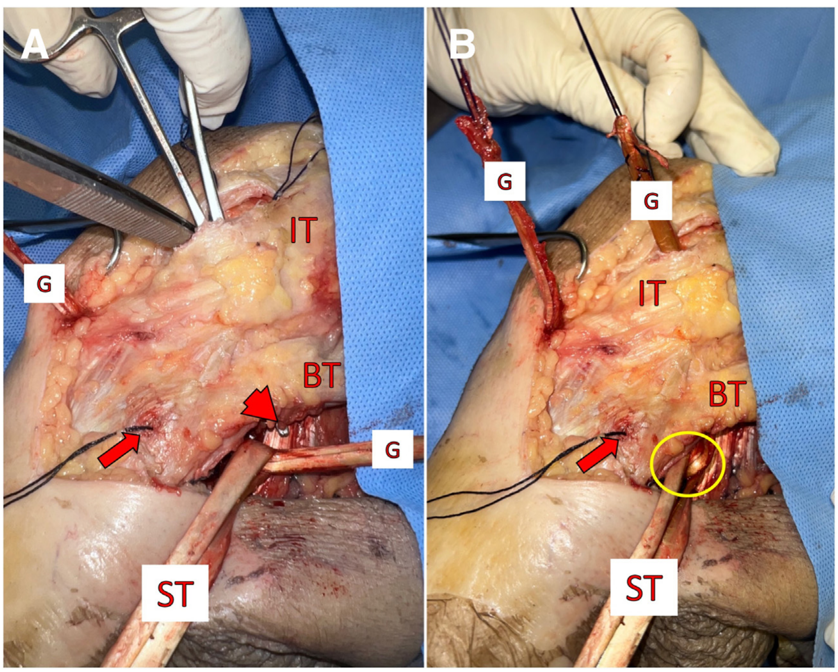

Fig 8. (A and B) Lateral view of a left knee in 90° of flexion (cadaver specimen), showing passage of the gracilis graft underneath the lateral structures of the knee, for reconstruction of the popliteus tendon, with the aid of a hemostat. The yellow circle shows the winding of the semitendinosus around the gracilis. Red arrow: anterolateral exit of the fibular tunnel; red arrowhead: tip of the hemostat underneath the lateral structures. (BT, biceps tendon; G, gracilis graft [both arms]; IT, iliotibial band; ST, semitendinosus graft.)

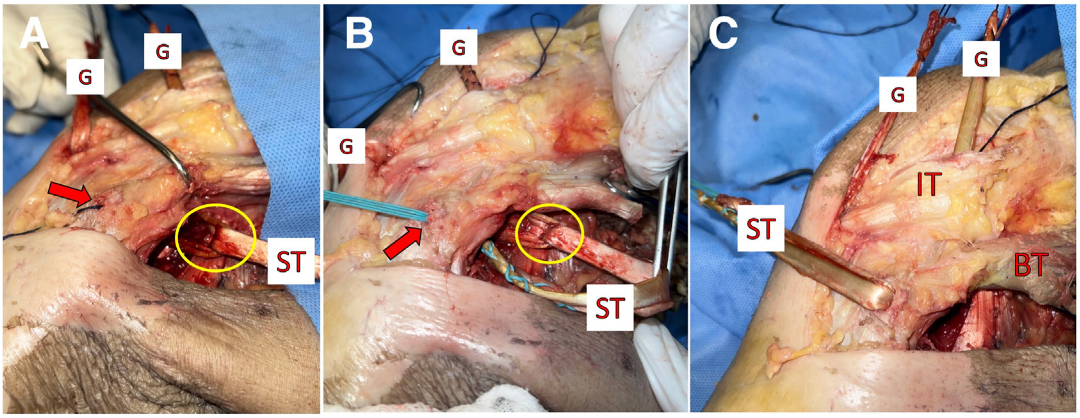

Fig 9. (A-C) Posterolateral view of a left knee in 90° of flexion (cadaver specimen) depicting the passage of the double semitendinosus graft through the fibular tunnel. In "A" and "B," the yellow circle is showing the "popliteofibular loop." Red arrow: anterolateral exit of the fibular tunnel. (BT, biceps tendon G, gracilis graft [both arms]; IT, iliotibial band; ST, semitendinosus graft.)

head, in the interval between the lateral gastrocnemius and soleus muscles[1] (Fig 5 A and B). Protection of the posterior neurovascular structures must be observed here, which can be done with a large retractor positioned posterior to the tibia and fibular head, or even with the surgeon's finger, as long as the tip of the guidewire can be palpated (Video 1). The tibial tunnel is drilled on a diameter corresponding to an unfolded gracilis graft, usually the thinnest drill bit available.

The femoral tunnels are created through an incision at the iliotibial band, as described previously. The tunnel for the LCL is positioned 3.1 mm posterior and

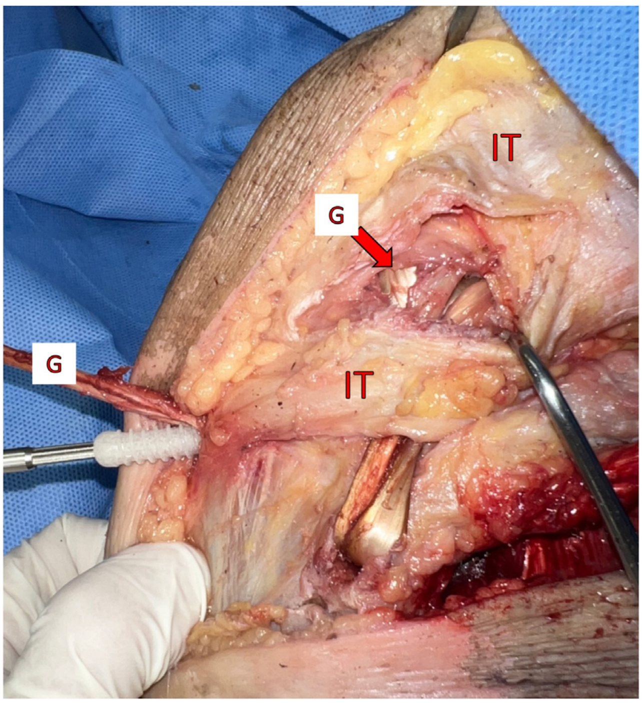

Fig 10. Lateral view of a left knee in 60° of flexion (cadaver specimen). After fixation of the gracilis graft in the popliteus femoral tunnel with an interference screw (first screw—not shown), fixation of the gracilis graft is done in the tibial tunnel, under tension, keeping the knee at 60° of flexion and neutral rotation, with an interference screw (second screw) passed from anterior to posterior, as depicted. The order of fixation is crucial for adequate tension of the reconstructed structures. Red arrow: gracilis graft inside the popliteus femoral tunnel (already fixed). (G, gracilis graft [both arms]; IT, iliotibial band.)

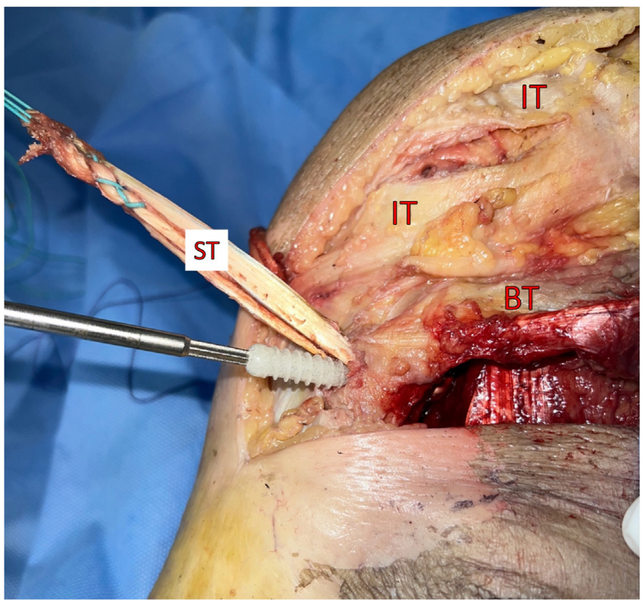

Fig 11. Lateral view of a left knee in 60° of flexion (cadaver specimen). After tight fixation of the gracilis graft is accomplished, fixation of the double semitendinosus graft in the fibular tunnel is done with an interference screw (third screw), under tension, keeping the knee at 60° of flexion and neutral rotation, as shown. (BT, biceps tendon; IT, iliotibial band; ST, semitendinosus graft [folded].)

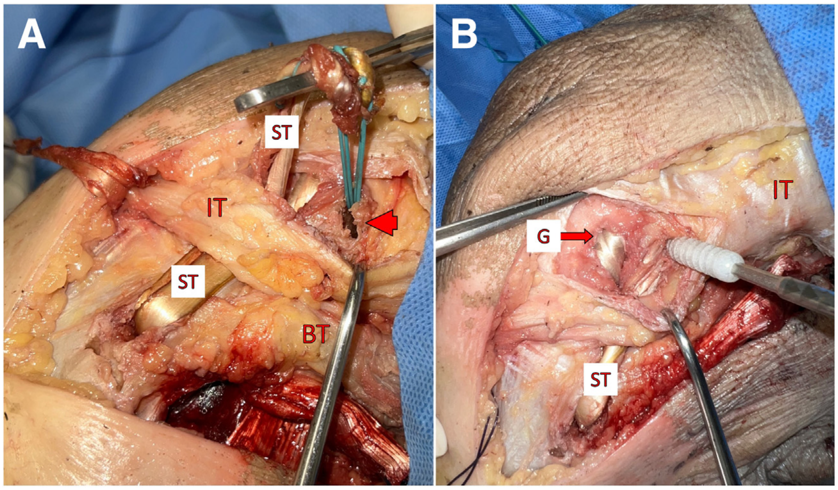

Fig 12. Posterolateral (A) and lateral (B) views of a left knee in 30° of flexion (cadaver specimen). (A) Passage of the double semitendinosus graft underneath the iliotibial band and then through the LCL femoral tunnel (red arrowhead); (B) the last step of the procedure is shown: fixation of the double semitendinosus graft in the LCL femoral tunnel with an interference screw (fourth and last screw), under tension, keeping the knee at 30°of flexion and neutral rotation, thus reconstructing the LCL. Red arrow: gracilis graft (G) inside the popliteus femoral tunnel. (BT, biceps tendon; IT, iliotibial band; LCL, lateral collateral ligament; ST, semitendinosus graft [folded].)

1.4 mm proximal to the lateral epicondyle.[11] If identification of the femoral insertion of the LCL is difficult at this point, the midportion of the remaining native ligament can be identified and tagged through the intermediate fascial window, created approximately 1 cm proximal to the fibular head, and the femoral insertion of the ligament can then be observed by slight traction (Fig 3B). This remnant of the ligament can usually be found even in complete grade III LCL injuries.[1] After identification of the LCL femoral footprint, a guidewire is passed using an appropriate reconstruction guide (Arthrex), or even freehand, at an angle of approximately 35° anterior and slight proximal, to avoid tunnel convergence with an eventual ACL reconstruction.[1] The tunnel for the popliteus tendon, in contrast, is created in the anterior portion of the tendon sulcus, approximately at its anterior fifth,[11] and it can be identified through the same incision at the iliotibial band. A guidewire is passed at this point, parallel to the LCL guidewire (Video 1). After checking the distance between both guidewires, on average 18.5 mm (Fig 6), the femoral tunnels can then be drilled: the LCL tunnel of a diameter corresponding to the doubled semitendinosus graft, and the PT tunnel of a diameter corresponding to an unfolded gracilis graft (usually the thinnest drill bit available).

Graft Passage, Placement, and Fixation

The next step is the passage and fixation of the grafts. Differently from the creation of the bone tunnels, passage and fixation of the grafts must follow a specific order (Video 1).

The gracilis tendon is used for reconstruction of the popliteus tendon: the graft is passed without any folds ("single") through the tibial tunnel, from anterior to posterior. Then, the semitendinosus tendon is passed around the previously passed gracilis tendon (in a "loop" around it) so that this winding of one graft over

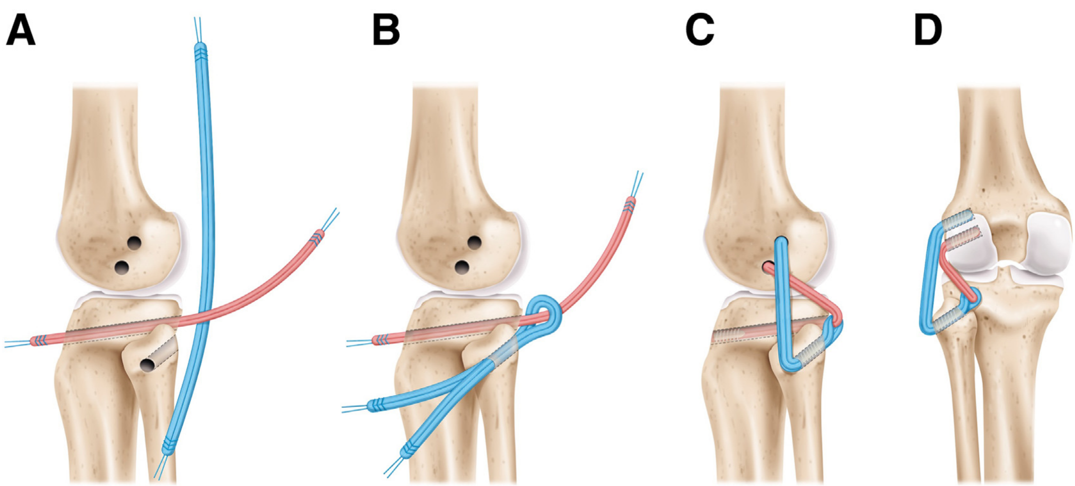

Fig 13. Schematic drawing of lateral (A, B, and C) and posterior (D) views of a left knee, showing the grafts passage (A and B) and their final disposition when the reconstruction is complete (C and D). In red: gracilis graft; in blue: semitendinosus graft.

Table 1. Pearls and Pitfalls of the Described Technique for PLC Reconstruction

Pearls	Pitfalls
Detailed physical examination of all possible knee instabilities is extremely important for adequate surgical programming, since isolated PLC injury is uncommon. Stress radiographs are also mandatory and can help to elucidate cases in which the physical examination is not evident.	The accurate instability diagnosis dictates the adequate reconstruction technique, ie, isolated LCL or PT reconstruction can be indicated, which can make the procedure considerably faster and easier.
Chronic tears—in our practice, the majority—must be carefully evaluated regarding the alignment of the lower limb. Corrective osteotomy should be performed in cases of varus malalignment, in a staged manner or at the same time as the ligament reconstruction surgery.	Failure to recognize lower-limb malalignment, usually through limb-alignment radiographs, increases the risk of failure for PLC and eventual cruciate ligament reconstructions.
Identification and wide neurolysis of the CPN should always be the first surgical step after superficial dissection.	CPN damage can happen by excessive manipulation and/or traction, and by postoperative swelling—a wide neurolysis can help prevent this.
The adequate position for tunnel placement can be found through careful dissection, palpation and by using the various measured parameters as described by LaPrade et al., ie, by measuring the distance between both guide pins on the femur, of 18.5 mm.	Misplacement of the guidewires will lead to misplacement of the tunnels, which will cause unacceptable residual laxity after the reconstruction—this is especially dangerous in the fibula, where a misplaced tunnel can cause fracture of the cortical bone and, consequently, failure of the whole reconstruction.
Adequate preparation of the graft ends and proper clearing of bone tunnels entrances will make grafts passage much easier.	The surgeon must not advance the guidewire or the drill bit too far posterior when creating the fibula and tibia tunnels, to avoid lesion of the posterior neurovascular structures. This can be done using a rigid protector or even the surgeon's finger, provided the advancement of the wire or drill bit is done cautiously.
Suture loops should be left inside each bone tunnel just after their perforation, to facilitate graft passage later on.	In cases of concomitant ACL reconstruction, femoral tunnel convergence can be an issue. Directing the LCL and PT guidewires anterior and slightly proximal can avoid this.
The bone tunnels can be created in any order, as preferred by the surgeon.	The order of grafts passage and fixation, as described in the text, should be strictly observed, otherwise the adequate tensioning of the reconstructed structures will not be possible.
When in doubt or facing positioning difficulties, using fluoroscopy can help the surgeon with adequate guidewire positioning before creating the bone tunnels. This can be especially useful for the tibial tunnel.	Adequate position of the reconstructed LCL and PT—with the PT passing deeper than the LCL under the lateral structures—must be observed to avoid biomechanical issues and failure of the technique.

ACL, anterior cruciate ligament; CPN, common peroneal nerve; LCL, lateral collateral ligament; PLC, posterolateral corner; PT, popliteus tendon.

the other is adjacent to the posterior exit of the tibial tunnel and the proximal tibiofibular joint (Fig 7 A-C).

The gracilis tendon is then directed to the femoral tunnel, ensuring that it lies deep to the lateral structures (Fig 8 A and B). After that, with the semitendinosus graft now folded ("doubled"), it is passed through the fibular tunnel, from posterior to anterior (Fig 9 A-C).

After passage through the femoral tunnel corresponding to the PT, fixation of the gracilis graft with interference screws can be performed: first in the femoral tunnel and then in the tibial tunnel, under manual tension. Care must be taken at this point to maintain the knee at 60° of flexion and neutral rotation, reproducing the PT (Fig 10).

Subsequently, again under manual tension and with the knee in the same position, the double bundle of the semitendinosus graft is fixed with an interference screw in the fibular tunnel, reproducing the PFL (Fig 11).

Finally, after passing the doubled semitendinosus graft under the iliotibial band, ensuring that it is adjacent to the remaining native LCL, it is passed and fixed with an interference screw in the corresponding femoral tunnel, under manual tension and with the knee at 30° of flexion, neutral rotation, and slight valgus stress, reproducing the LCL (Fig 12 A and B). After confirming the stability of the reconstruction, the surgical wound is closed in layers, paying attention to the position and protection of the common peroneal nerve. Table 1 summarizes pearls and pitfalls of the described surgical technique.

Discussion

Considering that PLC injury often is accompanied by other knee ligament injuries, the need for multiple autografts can present a serious problem for 2 main reasons: prolonged surgical time (due to the need for graft harvesting) and a lack of suitable grafts, either in terms of quantity or length. Grafts such as the patellar or quad tendon, commonly used in knee ligament reconstructions, for example, may not have adequate length for PLC reconstruction.

Many orthopaedic services do not have access to tissue banks, making autografts the only option. The proposed technique was designed to optimize PLC reconstruction

Table 2. Advantages and Disadvantages of the Described Technique for Posterolateral Corner Reconstruction, as Compared to the Classical LaPrade Procedure

Advantages	Disadvantages
No need of an allograft tissue bank—autografts are virtually always available	Longer surgical time, considering the need for harvesting the hamstring tendons
Fixation only with interference screws, which are wide available and easy to apply	Higher risk of complications, related to longer surgical time and harvesting of autografts
Thicker reconstructed structures (LCL and PFL) using only one set of hamstring tendons	Uneven width of the reconstructed structures, as the PT is reconstructed with a single and unfolded hamstring tendon
Cheaper surgical procedure	

LCL, lateral collateral ligament; PFL, popliteofibular ligament; PT, popliteus tendon.

when performed with autografts and offers the following advantages (Table 2): the use of only one set of hamstring tendons, which are widely used in knee surgery; obtaining grafts with a larger diameter compared to the "classic" LaPrade technique using the same grafts, as the loop allows for the use of a thicker, double graft for LPF and LCL reconstruction (Fig 13); allowing the use of shorter grafts, since the semitendinosus is used folded and therefore does not need to be very long; and finally, the simplicity of graft fixation using only interference screws, a widely available method.

Although the present technique provides a better diameter for the reconstructed LCL and the PFL, the same does not happen with the reconstructed PT, which remains thin in relation to the other 2 components of the PLC. This can prove to be a disadvantage, especially in cases that present with significant posterolateral rotational instability, such as those with combined grade III posterior cruciate ligament. Furthermore, this technique has not yet been biomechanically tested, and cannot be, at this time, considered as effective as the classic LaPrade technique, which uses thick allografts. However, no study to date has demonstrated biomechanical or clinical inferiority when using autografts for PLC reconstruction.[13,14]

We believe that the modification of the LaPrade technique presented here is reproducible, inexpensive, and easily implemented, since it does not depend on allograft availability and requires simple materials for adequate fixation. However, future biomechanical and clinical studies are needed to demonstrate its real effectiveness.

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