Technical Note

Onlay Technique for Posterior Cruciate Ligament Reconstruction: The Paccola's Technique

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Abstract: The primary function of the posterior cruciate ligament (PCL) is to restrict the posterior translation of the tibia, and its secondary function is to limit the tibial external rotation, mainly at 90° and 120° of knee flexion. The prevalence of PCL rupture ranges between 3% and 37% of patients with knee ligament tears. This ligament injury often is associated with other ligament injuries. Surgical treatment is recommended for acute PCL injuries associated with knee dislocations or when stress radiographs show a tibial posteriorization greater than or equal to 12 mm. The techniques classically described for the surgical treatment are inlay and transtibial, which can be performed in a single- or double-bundle fashion. Biomechanical studies suggest that the double-bundle technique is superior to the single femoral bundle, suggesting less postoperative laxity. However, such superiority has not yet been proven in clinical studies. This paper will describe the step-by-step technique for PCL surgical reconstruction. The tibial fixation of the PCL graft is performed by using a screw and spiked-washer, and the femoral fixation can be done with a single- or double-bundle technique. We will explain the surgical steps in detail, with tips to perform them simply and safely.

The posterior cruciate ligament (PCL) is an intra-articular and extra-synovial structure located in the knee joint center. It consists of 2 main components or bundles, the anterolateral and posteromedial. Its primary function is to restrict the posterior translation of the tibia, and its secondary function is to limit the external rotation, mainly at 90° and 120° of knee flexion.[1]

Injuries to this ligament are considered rare in medical literature, ranging from 2% to 3% of all knee joint injuries and 3% to 37% of knee ligament injuries.[2,3] We can classify the posterior cruciate tears into 3 types: grade I indicates incomplete tears (<8 mm of posterior translation in the radiographic examination with kneeling stress); grade II indicates isolated tears (8-12 mm of posterior translation in the radiographic examination with kneeling stress); and grade III indicates associated lesions (>12 mm of posterior translation in the radiographic examination with kneeling stress).[4,5]

We know that PCL ligament injuries often are associated with other ligament injuries. The LaPrade group published that the incidence of isolated PCL ruptures was 18% in a previous article.[6] Becker et al.[7] showed that PCL tears are associated with injuries of the anterior cruciate ligament (ACL) and posterolateral corner in 43%, ACL and medial collateral ligament injuries in 17%, posterolateral corner injuries in 7%, and ACL injuries in 5% of the evaluated cases.

Conservative treatment may be the choice in isolated injuries, and knee braces are frequently used to avoid posteriorization of the tibia. This nonsurgical treatment

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The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received September 3, 2022; accepted December 14, 2022.

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2212-6287/221192

https://doi.org/10.1016/j.eats.2022.12.013

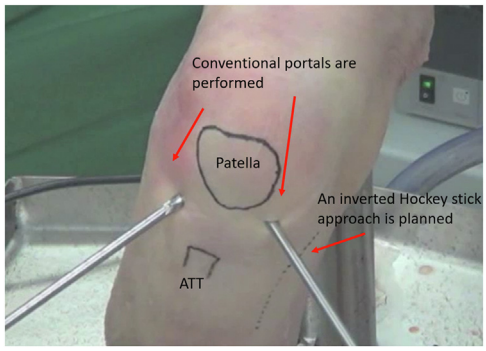

Fig 1. Conventional portals are made, and a 7-cm length inverted hockey stick approach is planned. (ATT, anterior tibial tubercle.)

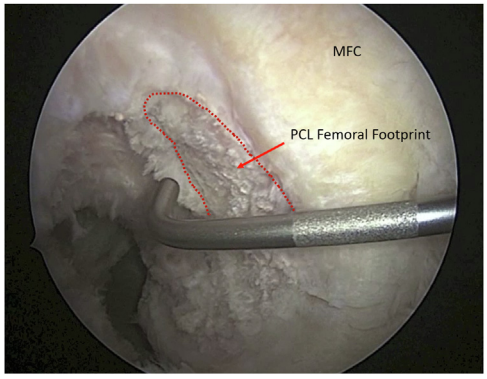

Fig 2. PCL footprint bound by the red line. (MFC, medial femoral condyle; PCL, posterior cruciate ligament.)

has a greater chance of success in grade I or II PCL tears.[8,9] Jacobi et al.[10] published a study showing that the posterior drawer decreased from 7.1 to 2.3 mm when patients used a dynamic brace for 4 months.

Therefore, a surgical approach is recommended for PCL injuries in acute cases when associated with knee dislocations or when stress radiographs show a tibial posterior translation greater than or equal to 12 mm. Associated injuries such as meniscal tears, for example, also may indicate acute surgical treatment of the PCL associated with meniscal repair. A systematic review published in 2022 showed that the surgical treatment of isolated PCL lesions is an option to be considered, as the surgical treatment decreases residual lassitude and the incidence of osteoarthritis.[11] In chronic cases, ligament reconstruction is indicated when the patient complains of functional limitations correlated with patellofemoral symptoms, such as difficulty in descending ramps and stairs and also with gait deceleration. PCL reconstruction also can be indicated if the patient presents with a stress radiograph with more than 8 mm of posteriorization and has no contraindications for surgical treatment.[12]

The techniques classically described for the surgical treatment are inlay and transtibial, which can be performed in a single- or double-bundle technique, either on the femur or on both origin and insertion sites (femur and tibia).[13-15]

Biomechanical studies suggest that the double bundle is superior to the single femoral bundle, suggesting less postoperative laxity.[16-18] However, such superiority has not been proven in clinical studies.[19,20]

Salim et al.[21] described a new surgical onlay PCL reconstruction technique called Paccola's technique. A screw–washer assembly performs the tibial fixation of the PCL, and femoral fixation can be achieved with 1 or 2 tunnels. A detailed stepwise description of Paccola's technique will be reported, along with tips to perform it safely and straightforwardly.

Technical Note (With Video Illustration)

The patient is placed in the supine position. Spinal anesthesia and peripheral blocks are performed. The pneumatic cuff is positioned in the upper thigh, and it is inflated during the arthroscopic procedure as required. Asepsis and antisepsis are performed, and the pneumatic cuff is inflated.

We start the surgical procedure by creating the anterolateral and anteromedial portals in a conventional manner (Fig 1), performing a joint inspection, and treating possible associated injuries. We then identify the

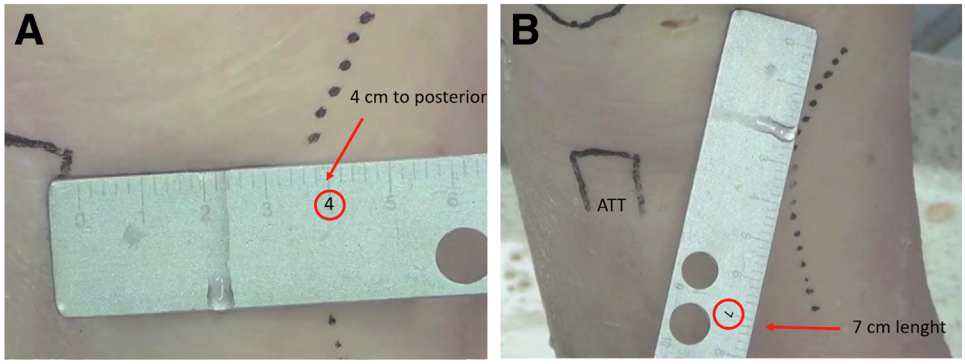

Fig 3. An inverted hockey stick approach is performed (A) 4 cm to posterior in the medial side of the knee; (B) 7 cm in length. (ATT, anterior tibial tubercle.)

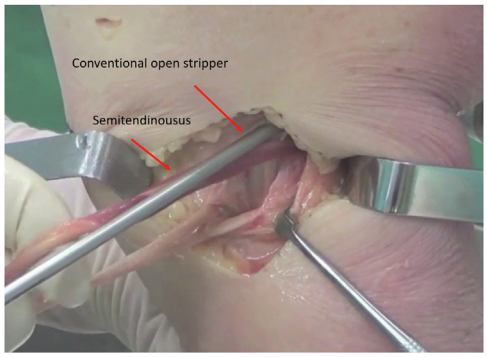

Fig 4. The semitendinosus and gracilis tendons are harvested in the conventional manner.

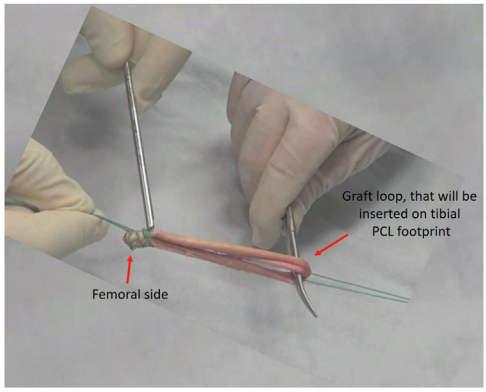

Fig 5. Quadruple grafts are prepared for use. The loop is fixed on the tibia, and the graft's extremities are fixed on the femoral tunnel. (PCL, posterior cruciate ligament.)

PCL tear and debride the PCL femoral footprint (Fig 2). We perform a slightly curvilinear surgical approach (inverted hockey stick) about 4 cm medial to the anterior tibial tuberosity and about 7 cm long (Fig 3 A and B). We then identify and harvest the semitendinosus and gracilis tendons and prepare them with nonabsorbable ETHIBOND sutures (Ethicon, Somerville, NJ) at each end of both tendons (Figs 4 and 5).

With the hip flexed, abducted, and externally rotated, we then make a longitudinal incision in the posterior juxtacortical location of the tibia over the popliteal muscle, and we retract it posteriorly (Fig 6 A and B). We palpate the posterior proximal surface of the tibia, identifying the tibial PCL footprint (Fig 7).

Through the previously performed anterolateral portal, and with the knee at 90°, we position the guidewire in the anatomical position of the PCL, aiming to its anterolateral bundle, with proximal and anterior inclination, introducing this wire until it pierces the medial cortex and exits the distal one-third of the thigh (Fig 8A). We drill the entire length of the femoral tunnel with the same diameter of the already prepared 4-strand hamstrings graft (Fig 8 B and C). Where the drill touches the vastus medialis muscle, a small incision of approximately 1 to 2 cm is made on the skin, and the muscle is bluntly dissected.

We pass an ETHIBOND suture through the newly prepared femoral tunnel with the ends of the suture in the articular region of the femoral tunnel and a loop out through the skin, passing through the small access made in the vastus medialis muscle topography.

Using a Mixter forceps introduced through the surgical approach to the proximal medial tibia (Fig 9), we reach the knee joint by entering the joint capsule with the Mixter forceps at the level of the tibial footprint, pulling the 2 ends of the ETHIBOND suture (Ethicon), to the extra-articular region of the surgical incision on the tibia (Fig 10 A-C). Alternatively, we can perforate the posterior capsule in an antegrade fashion, inserting the Mixter forceps through the anteromedial portal and then exteriorizing its extremities on the posterior tibial approach. Passing sutures can be retrieved in either direction to leave the final suture with the loop proximally, where it will bring the graft from the femur towards the knee joint and then reach the tibial insertion.

We prepare the 2 quadruple grafts with a suture thread, tensioning them in their central region, forming a loop. This loop will be fixed on the tibia, and the ends of grafts will be inserted into the femur (Fig 5).

Through the ends of the ETHIBOND suture (Ethicon) already located in the proximal tibial medial approach, we pull the sutures of the graft loop, passing it through

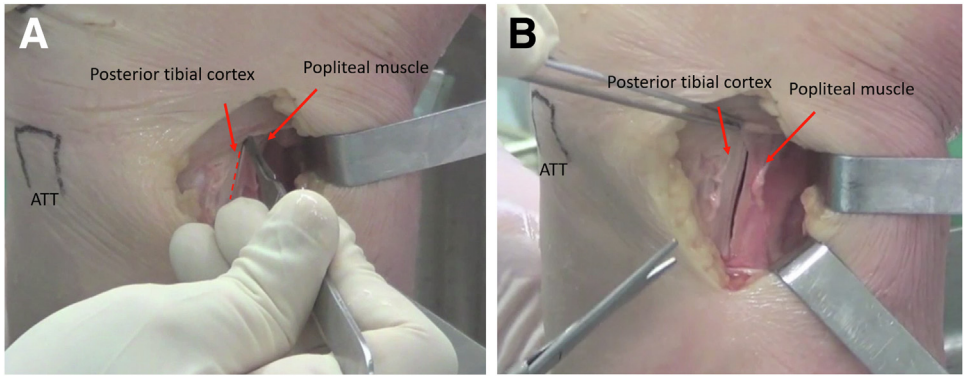

Fig 6. (A) Posterior incision on the juxta-posterior-cortex, between the posterior cortex and popliteal muscle. (B) Aiming to gain access to the proximal tibia's posterior face. (ATT, anterior tibial tubercle.)

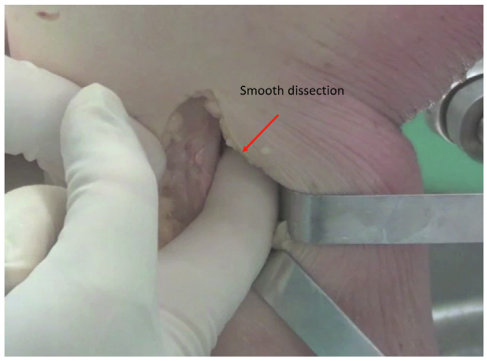

Fig 7. Dissection is performed carefully with the index finger of the juxta-posterior tibial cortex, palpating the femoral footprint.

the mini access in the vastus medialis muscle, then passing it through the femoral tunnel, intra-articular space, posterior joint capsule, and exiting the medial access of the tibia (Fig 11 A and B and Fig 12 A-C).

We palpate the footprint of the PCL and, through osteotomes, we created a bone channel in this location to facilitate the osseointegration of the graft loop. With a femoral drill guide passed through the graft loop, using a 3.2-mm drill bit, we drill in the proximal posterior tibial cortex, immediately distal to the PCL tibial footprint (Fig 13A), measure the screw length, and select a partially threaded cancellous screw 5 mm longer than the length measured. We add 5 mm to the measured length because we need to consider the spiked washer and the graft thickness.

We fix the tibia first, placing a spiked washer on the screw and passing the screw–washer assembly through the graft loop (Fig 13 B and C). The graft is tensioned by manual traction on the femoral side, and the graft is fixed on the femur using regular interference screws. In patients with obesity or those with a large muscular volume of the sural triceps, it may be necessary to perform a mini posteromedial accessory incision in the proximal topography of the medial gastrocnemius muscle (Fig 14A). Through this incision, we make drill in the tibial, as mentioned previously, and insert the cancellous screw with the spiked washer, fixing the graft loop (Fig 14 B and C). This accessory incision facilitates both the tibial drilling and the graft fixation by the spiked-washer and screw construct. However, great care must be taken when preparing this posterior percutaneous incision. It should be well located over the medial head of the gastrocnemius and avoid going along the midline or with the drill toward to the midline

After the washer has fixed the graft loop on the tibia, the knee is positioned at 70° of flexion, an anterior drawer is performed, and we fix the graft in the femoral tunnel with a metallic interference screw 1 mm greater than the diameter of the tunnel (Video 1). This screw is inserted through the anterolateral portal (Fig 15 A-C). Stability tests are performed, the surgery is complete and the final radiographs are performed (Fig 16 A and B).

If the surgeon chooses to perform the surgery with a femoral double bundle, the anterolateral bundle must be tensioned and fixed first at 90°. At this moment, an anterior drawer must be performed, visualizing the ACL in a normopositioned way. Then, the posteromedial bundle must be fixed in a complete extension.[12]

Discussion

PCL reconstruction surgery is challenging for orthopaedic surgeons. Since it is not a frequent injury, with low prevalence compared with the ACL reconstruction surgery, most surgeons are not familiar with its surgical technique.[22]

In addition, even in specialized centers, PCL reconstruction outcomes are not excellent and are inferior to ACL reconstruction. It is common for the patient to persist with some degree of posterior tibial translation even after a well-performed surgery. Sometimes it may be justified by the other commonly associated ligament

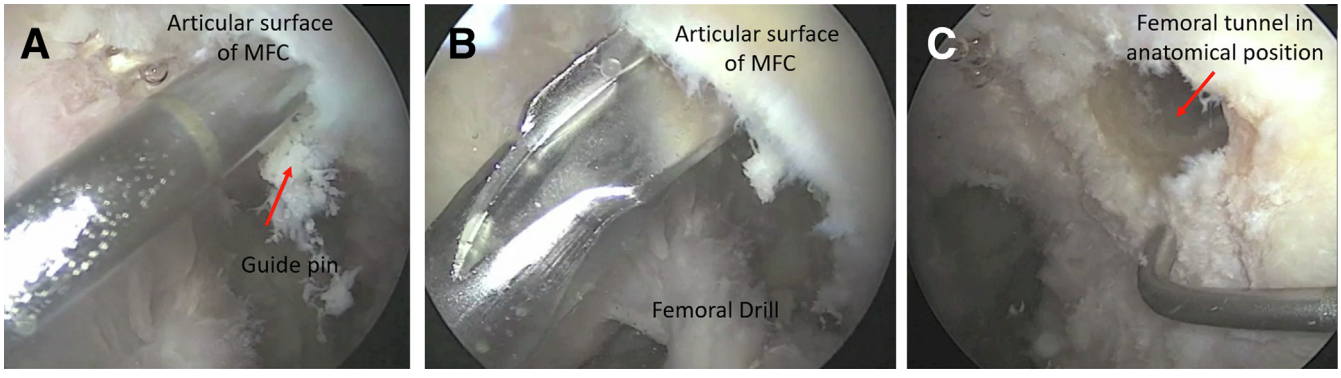

Fig 8. (A) The guide pin is inserted in the anatomic location of the anterolateral bundle of the posterior cruciate ligament femoral insertion. (B) A femoral drill is used to create the femoral tunnel. (C) Anatomic femoral tunnel is ready. (MFC, medial femoral condyle.)

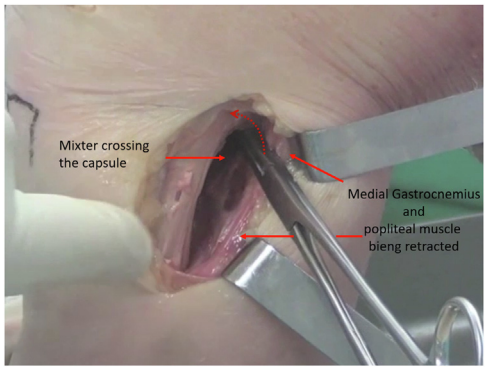

Fig 9. Mixter clamp crossing the capsule to pull the 2 extremities of the ETHIBOND located inside the joint.

injuries.[22] Several factors can influence the results after this surgery, such as the chosen technique (transtibial arthroscopic or open inlay), the graft used (quadriceps, patellar, and hamstring tendon autografts or allografts), and the type of fixation used.[23]

In a biomechanical study comparing 5 different PCL reconstruction settings—single-bundle all-inside arthroscopic inlay, single-bundle all-inside suspensory fixation, single-bundle arthroscopic-assisted open onlay, double-bundle arthroscopic-assisted open inlay, and double-bundle all-inside suspensory fixation—no one technique performed with a very similar biomechanical behavior closest to the native PCL. However, the authors found that double-bundle reconstruction had the best biomechanical results.[24]

A recent systematic review selected 13 studies to evaluate the clinical results of double-band and single-band PCL reconstruction. After analyzing the articles, the authors concluded that there was no clinically relevant difference when comparing the 2 techniques.[25]

The transtibial arthroscopic technique requires the surgeon to work in an unusual area at the level of the posterior tibial cortex, using a 70° optic lens that also deviates from its usual viewing parameter. The PCL footprint arthroscopic preparation in the tibia is usually a tense step for the surgeon during the procedure because of the proximity of the neurovascular structures.[23,26]

Another transtibial technique complicator is that the graft bends as it leaves the tibia and enters the joint toward the femoral tunnel, the so-called killer angle, which increases the chance of failure by shearing the graft at the tunnel exit.[23,27]

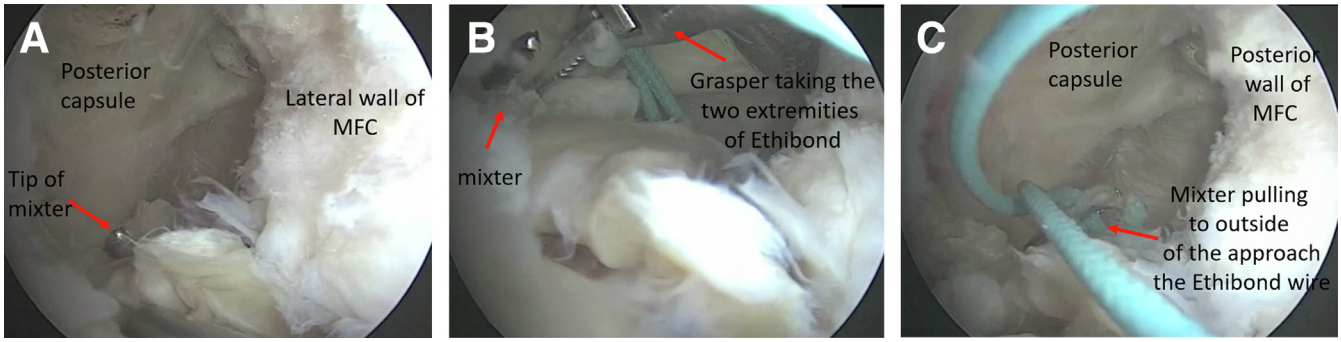

Fig 10. (A) Tip of the Mixter clamp is visualized on the posterior capsule. (B) Shown is the grasper clamp taking the 2 extremities of the ETHIBOND to the Mixter clamp. (C) Shown is the Mixter clamp pulling the 2 extremities of the ETHIBOND to the outside of the approach. (MFC, medial femoral condyle.)

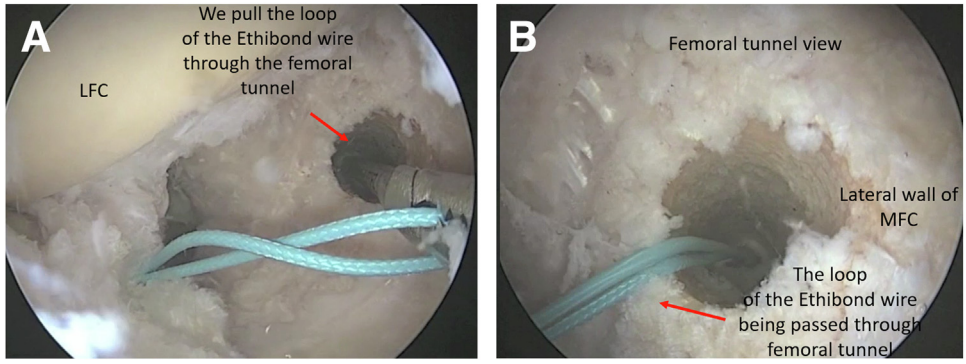

Fig 11. (A) We pull the loop of the ETHIBOND wire through the femoral tunnel. (B) Femoral tunnel view of the ETHIBOND loop wire passing through it. (LFC, lateral femoral condyle; MFC, medial femoral condyle.)

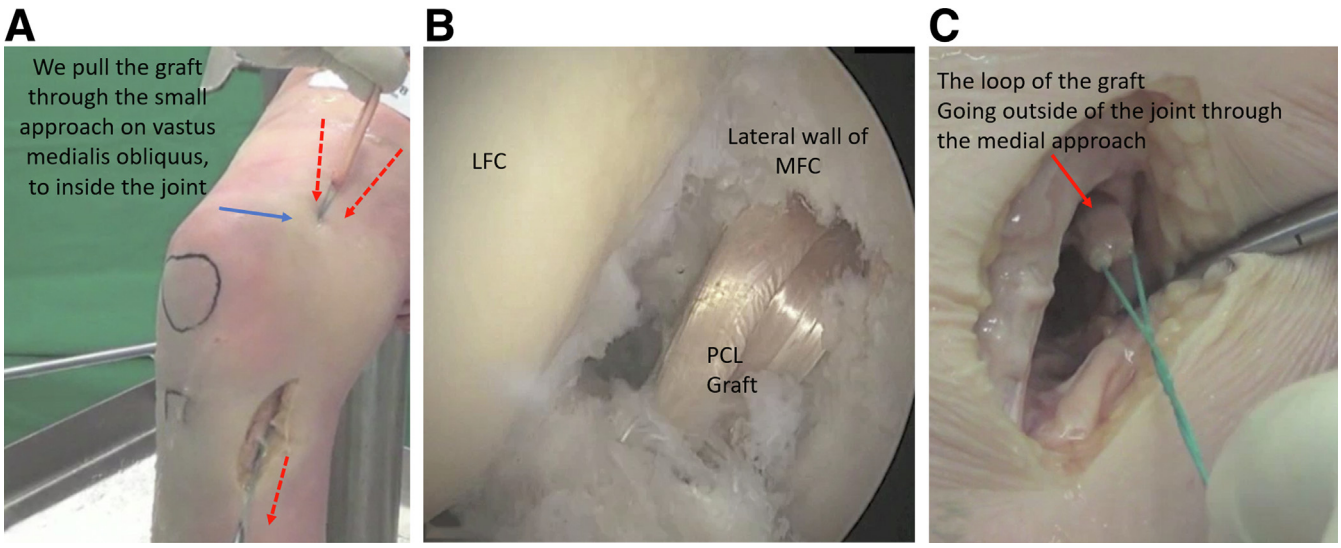

Fig 12. (A) We traction the ETHIBOND pulling the graft inside the joint, with the loop emerging through the medial access. (B) Arthroscopic view of the graft passing through the femoral tunnel. (C) The graft loop exits the joint through the medial access. (LFC, lateral femoral condyle; MFC, medial femoral condyle; PCL, posterior cruciate ligament.)

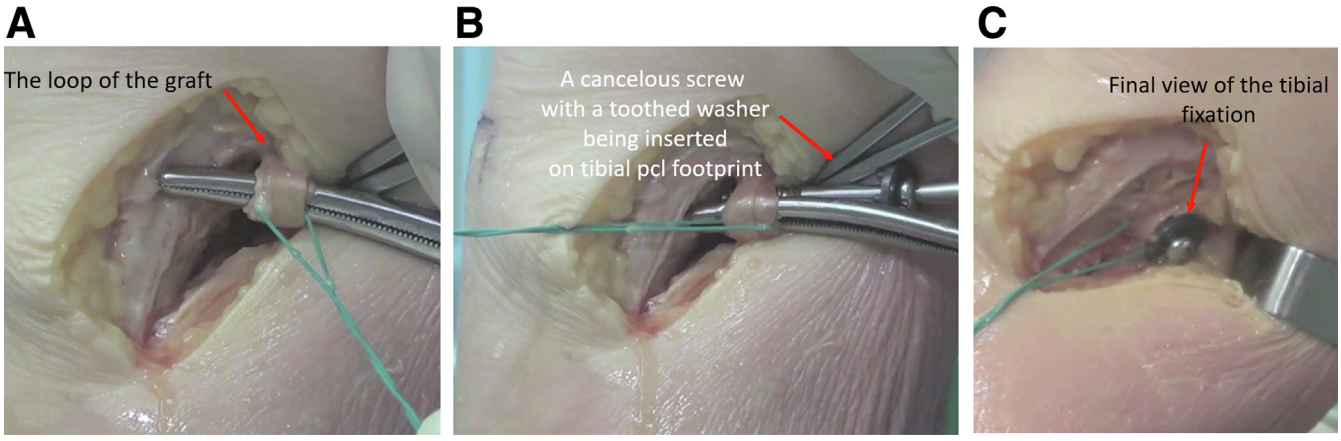

Fig 13. (A) With the graft loop outside the joint, we drill a tunnel on the PCL tibial footprint (posterior cruciate ligament). (B) We then measure and insert a 4.5-mm cancellous screw with a toothed washer. Simultaneously, we insert the screw and exerted slight traction on the extremities of the graft wires. (C) Final view of the tibial fixation. (PCL, posterior cruciate ligament.)

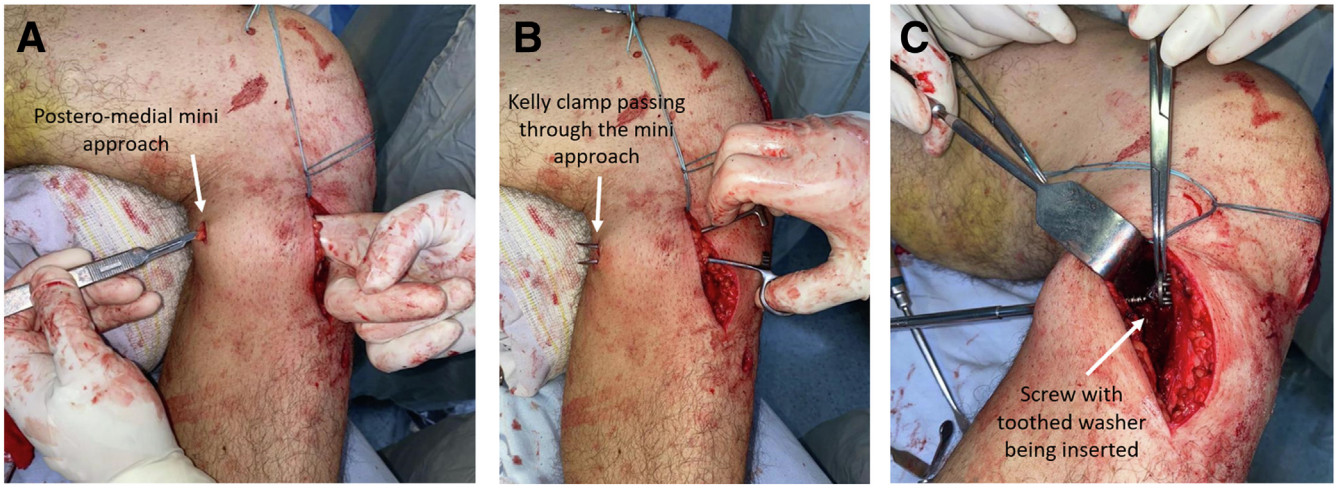

Fig 14. (A) In patients with obesity or those with hypertrophied sural triceps, we perform a posteromedial mini-incision in the proximal topography of the medial gastrocnemius. (**B**) We use a Kelly clamp to guide the passage of the drill (already with the drill guide) to perform the tibial tunnel. (**C**) We insert the cancellous screw with the toothed washer, fixing the graft loop through the mini surgical approach.

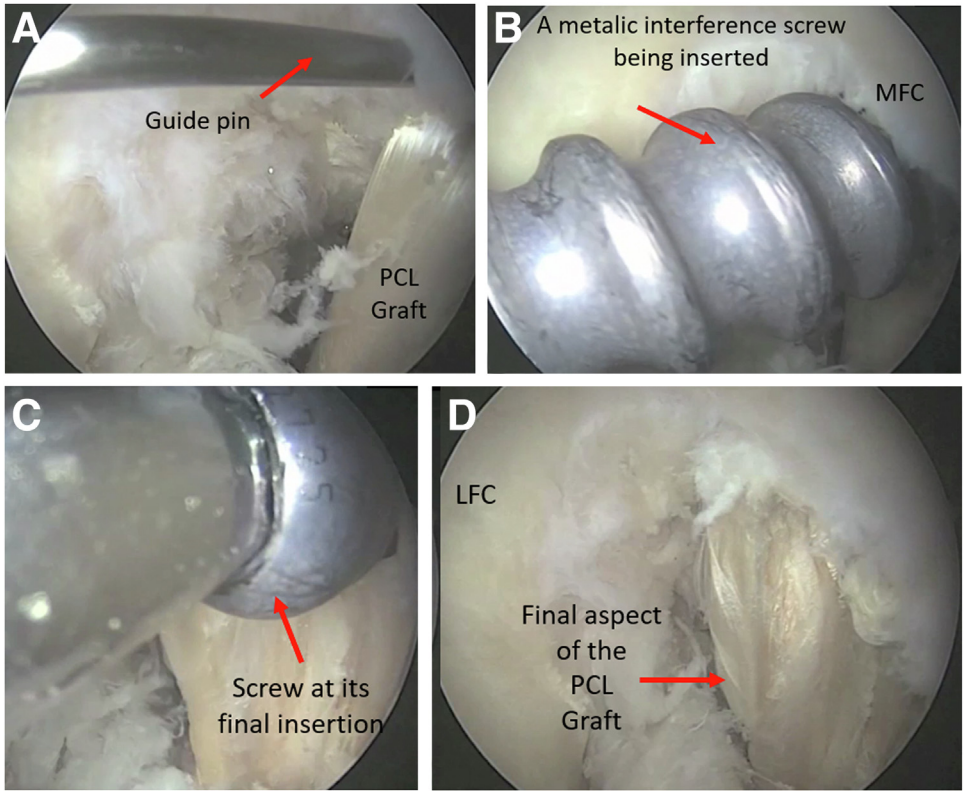

Fig 15. (A) We create an anterior drawer, tensioning the graft, pulling it from the femoral approach, and inserting a guide pin. (B) After the guide pin is correctly positioned, a metallic interference screw through the anterolateral portal is inserted. (C) Femoral screw in its final insertion. (D) Final aspect of the PCL graft. (LFC, lateral femoral condyle; MFC, medial femoral condyle; PCL, posterior cruciate ligament.)

The inlay technique is an alternative to minimize the difficulties and risks of the transtibial arthroscopic procedure. Through a posterior incision with the patient in the prone position, the neurovascular structures are protected by direct vision and retracted with the medial gastrocnemius muscle.[23,28]

Another advantage of the inlay technique is that there is no killer angle, as the graft is fixed to the tibia directly on the footprint. However, it requires a tendon–bone graft, such as the autogenous quadriceps or allogeneic Achilles, where the bone plug is attached to a keel created at the level of the tibial footprint.[23,28]

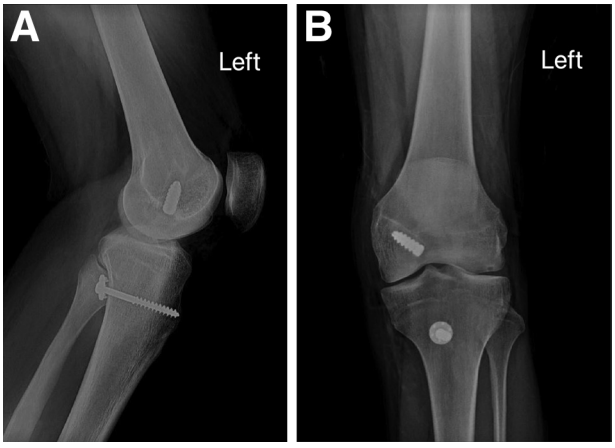

Fig 16. (A and B) Lateral- and anteroposterior-view radiographs with the postoperative treatment with the Paccola's technique, noting the tibial cancellous screw's positioning more distal than PCL footprint. (PCL, posterior cruciate ligament.)

In the technique described by our group, we combine the advantages of reconstructing the PCL by direct palpation of the tibial footprint, through a safe posteromedial approach, without a killer angle and with hamstrings grafts, which are quick and straightforward to remove without requiring additional incisions.

The use of semitendinosus and gracilis grafts for PCL reconstruction has excellent results. It has the advantages of using autografts, not damaging the extensor mechanism, having low morbidity of the donor area, an easy passage of the graft through the femoral bone tunnel, and complete tunnel filling, favoring osteointegration.[22]

The fixation of the flexor tendon grafts using the transtibial technique is subject to failure because the cancellous tibial bone near the posterior cortex may provide little pullout resistance and frequently requires a backup fixation in the tibial cortex.[27,28] In the onlay technique, fixing the tendons directly to the tibia minimizes the risk of fixation failure, and additional secondary fixation is unnecessary. The advantages and disadvantages of the onlay technique are summarized in Table 1.

Albuquerque Ii et al.[29] evaluated the biomechanical characteristics of the tibial fixation screw of the onlay technique. The authors compared 2 groups, 1 group in

Table 1. Advantages, Disadvantages, Risks, and Tips to Performing the Onlay Technique for Posterior Cruciate Ligament Reconstruction

Advantages	Disadvantages	Risks	Tips
Easy to remove the graft, which does not require an additional incision.	The diameter of the quadruple flexor graft, which averages 8-9 mm, cannot fill the femoral footprint of approximately 11- 12 mm.	Retract neurovascular structures with caution, avoiding iatrogenic injuries.	Pretension the graft before fixing it.
Low morbidity in the donor area.		Perform fixation with a partial-thread, 6.5 cancellous screws of the appropriate length.	During fixation, keep the graft tight under the washer, which must be toothed, preventing it from slipping when compressed by the screw.
Dispensing the tissue bank.			Fix the femur with the maximum anteriorization with the anterior drawer maneuver, with the knee at 70° of flexion in the single-bundle technique.[27,30]
Do not attack the extensor mechanism.			In the double-bundle technique, fix each bundle in different degrees of flexion. The anteromedial bundle at 90° and the posterolateral in extension, both with maximum anteriorization of the tibia.[30]
It does not require tibial tunnel drilling, thus avoiding the killer angle.			We recommend not using lateral support, because it can interfere with an essential step of the procedure, in which, we perform the posteromedial approach and insert the screw with the washer on the PCL tibial footprint
Low cost of fixation with the cancellous screw and toothed washer compared with metallic or absorbable interference screws.		Placing the tibial insertion of the PCL distal to its footprint increases the chance of the graft not having a full length in the femoral tunnel	Placing the tibial insertion of the PCL distal to its footprint, we increase the graft capacity to resist the posterior drawer
It allows for a double or single bundle on the femur.			
It does not require changing the decubitus for posterior access to the tibia, used in the inlay technique.			
Easy passage of the graft through the femoral tunnel.			
Optimal graft osteointegration in the femoral tunnel.			

PCL, posterior cruciate ligament.

which the cancellous screw was unicortical and another group with a bicortical screw. The authors observed better biomechanical behavior in the group where the cancellous screw crossed the 2 cortices. Thus, we emphasize making sure the screw used is a 6.5 mm partially threaded cancellous screw that approaches the opposite cortex of the tibia, maximizing the fixation and allowing for compression, avoiding the posterior migration of the screw and failure of the fixation or loosening of the graft. It is essential to emphasize the importance of using the spiked washer to fix the graft, as it allows the graft loop to remain adhered and fixed to the previously created bone bed, enhancing the osseointegration of the graft. The pitfalls related to the onlay technique are summarized in Table 1.

Recently, D'Ambrosi et al.[30] performed a systematic review. In this study, the authors evaluated whether preserving the PCL remnant would improve the clinical and radiologic results in the postoperative period of PCL reconstructions. The result was that the preservation of the remnant presents good clinical and radiologic outcomes in an average follow-up of 24 months. However, this study emphasizes that the preservation of the remnant is technically more laborious and must be performed by experienced surgeons.[30] It is important to mention that the Paccola's technique allows the surgeon to preserve the remnant if desired, which is an interesting feature of the technique described in this study.

Our group published a case series with 21 patients with an average follow-up of 4.4 years. With the aid of the KT2000 arthrometry, we observed that the average difference between the operated knee and the contralateral side was only 3 mm (0-10 mm). In total, 85% of these patients were included with a posterior grade I drawer at the time of the postoperative reassessment. The means of the subjective Lysholm and International Knee Documentation Committee scores were 85 and 66.6, respectively. An isokinetic evaluation also was performed, with extension and flexion strengths of 86% and 79.8%, respectively, compared with the contralateral side.[27]

Thus, we presented a step-by-step simple, safe, and low-cost reconstruction technique for the PCL with good outcomes in published articles, which may allow this surgery to be performed with reproducible results.

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