



# Anterior Cruciate Ligament Reconstruction Using Bone-Patella Tendon-Bone Autograft With Press-Fit Femoral Fixation: The Original Chambat Technique

Yoann Levy, M.D., Lampros Gousopoulos, M.D.,  
Graeme P. Hopper, M.D., F.R.C.S., (Tr.&Orth.), Charles Grob, M.D.,  
Thais Dutra Vieira, M.D., Jean-Marie Fayard, M.D., Mathieu Thaunat, M.D.,  
Pierre Chambat, M.D., and Bertrand Sonnery-Cottet, M.D.

**Abstract:** Patellar tendon grafts have long been considered the gold standard for anterior cruciate ligament reconstruction (ACLR). This Technical Note describes ACLR using bone-patella tendon-bone (BPTB) autograft with press-fit femoral fixation using an outside-in drilling technique.

## Introduction

Anterior cruciate ligament reconstruction (ACLR) has evolved over recent decades.<sup>1</sup> Historically, bone-patella tendon-bone (BPTB) autograft was considered the gold standard for ACLR, as it allowed bone-to-bone tunnel healing, providing excellent biomechanical strength.<sup>2</sup> However, BPTB autografts are frequently associated with donor site morbidity, including anterior knee pain, pain when kneeling, and extensor mechanism complications, such as patella fractures and patellar tendon ruptures.<sup>3</sup> This has led to hamstring autografts gaining increasing popularity.<sup>4</sup>

Additionally, debate still exists regarding the different femoral tunnel drilling techniques. Femoral guides have

been developed that enable the femoral tunnel to be drilled from outside to inside under arthroscopic control. This aims to reproduce the anterior portion of the ACL, namely, the anteromedial bundle. This establishes a favorable nonisometry, relaxed in flexion and tight in extension, which addresses the parameters in which the ACL-deficient knee produces greatest instability.<sup>1,5</sup>

## Surgical Technique

This technical note describes an arthroscopic reconstruction of the ACL using BPTB autograft with outside-in drilling and press-fit femoral fixation (Video 1). Pearls and pitfalls plus advantages and disadvantages are described in Tables 1 and 2.

## Patient Positioning and Landmarks

The patient is placed in the supine position on the operating table with a lateral support at the level of a padded tourniquet and a foot roll positioned to stabilize the leg at 90° of knee flexion. The injured leg is prepared and draped using the surgeons preferred method, and then appropriate landmarks are palpated and marked (Fig 1).

## Graft Harvest

Traditionally, a single incision extending from the inferior pole of the patella to the tibial tuberosity is performed. However, this technique has evolved, and we now use two incisions to reduce the risk of damage to the infrapatellar branch of the saphenous nerve. The first incision extends proximally from the distal pole of the patella, as the key step is harvesting the patella bone

From the Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Groupe Ramsay-Générale de Santé, Hôpital Privé Jean Mermoz, Lyon, France.

The authors report the following potential conflicts of interest or sources of funding: B.S.-C. reports personal fees from Arthrex, outside the submitted work. G.H. reports a fellowship grant from Arthrex. J.-M.F. reports consulting fees from Arthrex and Newclip Technics, outside the submitted work. M.T. reports being a paid consultant for Arthrex. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received March 3, 2022; revised manuscript received June 8, 2022; accepted July 8, 2022.

Address correspondence to Thais Dutra Vieira, M.D., Centre Orthopedique Santy, 24 Avenue Paul Santy, 69008, Lyon, France. E-mail: [thaisdutravieira@hotmail.com](mailto:thaisdutravieira@hotmail.com)

© 2022 Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/22299

<https://doi.org/10.1016/j.eats.2022.07.001>

**Table 1.** Pearls and Pitfalls

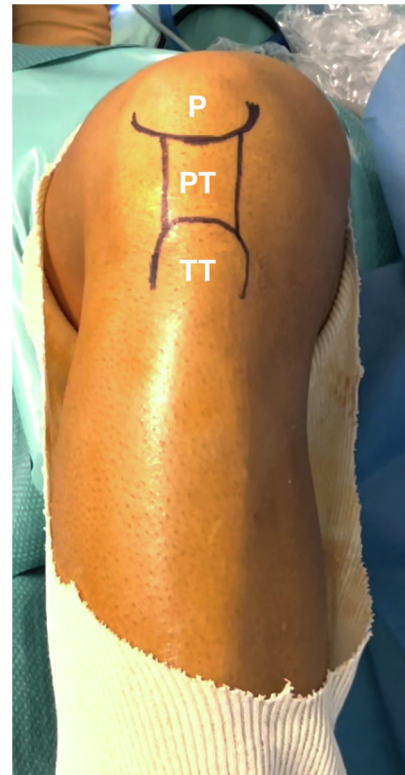
Pearls	Pitfalls
<ul style="list-style-type: none"> <li>• Drill holes should be made around the bone blocks to prevent fractures when the bone blocks are removed.</li> <li>• Mark the junction between the tendon and each bone block with a sterile marker pen to ensure the bone blocks are positioned correctly following graft passage.</li> <li>• Initially use a 6-mm reamer when creating the femoral and tibial tunnels to enable adjustments if required.</li> <li>• Reamings can be collected during reaming of the tibial tunnel to add to the harvest sites at the end of the procedure.</li> <li>• When passing the graft, position the clamp proximally on the bone block to be able to turn around the condyle.</li> </ul>	<ul style="list-style-type: none"> <li>• Occasionally, graft passage is difficult due to the size of the bone block, particularly at the intra-articular entrance of the femoral tunnel. A probe can be used to assist the graft passage.</li> <li>• Ensure the tibial bone block is inserted in the femoral tunnel with the cortex face posteriorly to avoid difficult graft passage.</li> </ul>

block. The second incision is located more medially at the level of the tibial tuberosity. This incision has several advantages, including being able to drill the tibial tunnel through the same incision, incorporating previous hamstring harvesting incisions in revision cases and similarly being able to use the incision if future revision surgery is required using hamstring autograft (Fig 2).

The paratenon is identified and divided longitudinally. The middle third of the patellar tendon is then

**Table 2.** Advantages and Disadvantages

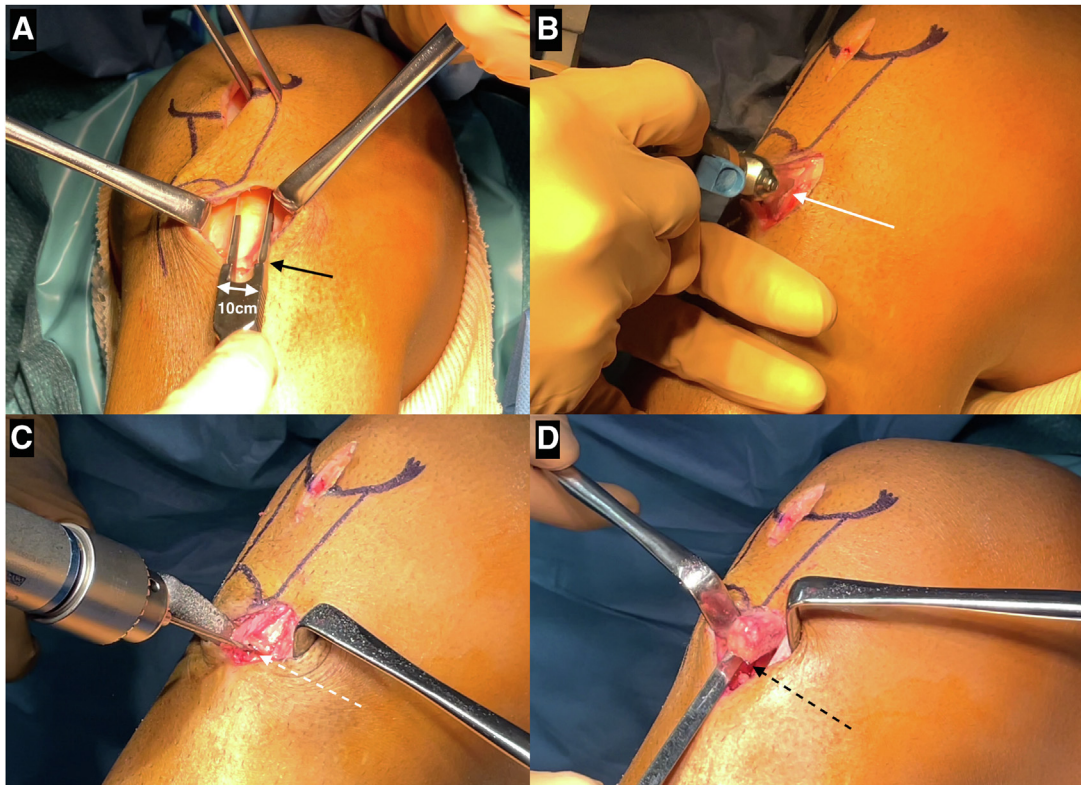
Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Press-fit femoral fixation means there is no need for an interference screw at the femoral tunnel.</li> <li>• Minimally invasive graft harvesting avoids damage to the infrapatellar branch of the saphenous nerve.</li> <li>• The two-incision technique enables drilling of the tibial tunnel through the same incision, incorporating previous hamstring harvesting incisions in revision cases and similarly being able to use the incision if future revision surgery is required using hamstring autograft.</li> <li>• Double fixation on the tibial side means the screw can be removed in cases of acute infection.</li> </ul>	<ul style="list-style-type: none"> <li>• Risk of patella fracture during graft harvest</li> <li>• Anterior knee pain</li> </ul>



**Fig 1.** Patient positioning and landmarks. Right knee, frontal view. Positioned at 90° of knee flexion. Appropriate landmarks are palpated and marked. P, patella; PT, patellar tendon; TT, tibial tuberosity.



**Fig 2.** Incisions for graft harvest. Right knee, frontal view. The first incision extends proximally from the distal pole of the patella. The second incision is located more medially at the level of the tibial tubercle. P, patella; PT, patellar tendon; TT, tibial tuberosity.



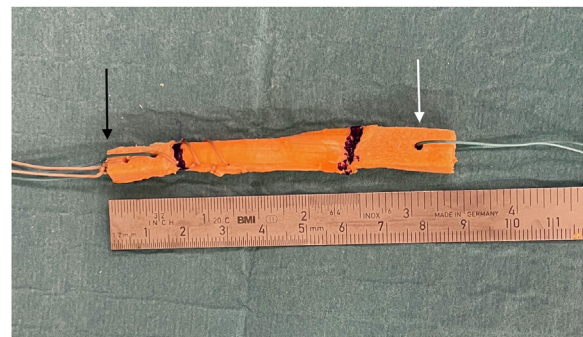
**Fig 3.** Graft harvest. (A) Right knee, frontal view. The middle third of the patellar tendon is incised longitudinally using a double-bladed scalpel (black arrow) with a width of 10 mm. (B) Right knee, medial view. The bone blocks are harvested using an oscillating saw (white arrow). (C) Right knee, medial view. Drill holes (white dotted arrow) are made around the blocks to prevent fractures when they are removed. (D) Right knee, medial view. The blocks are removed with a chisel (black dotted arrow).

incised longitudinally using a double-bladed scalpel with a width of 10 mm. The bone blocks are harvested using an oscillating saw. Two 2-mm drill holes are placed on the patella bone block for a figure-of-8 traction suture, and a further drill hole is made 5 mm from the end of the tibial bone block. Drill holes are then made around the bone blocks to prevent fractures when they are removed with a chisel. First, the tibial bone block is removed, and then it is delivered to the proximal incision after releasing adhesions from the patellar tendon; then finally, the patella bone block is removed (Fig 3).

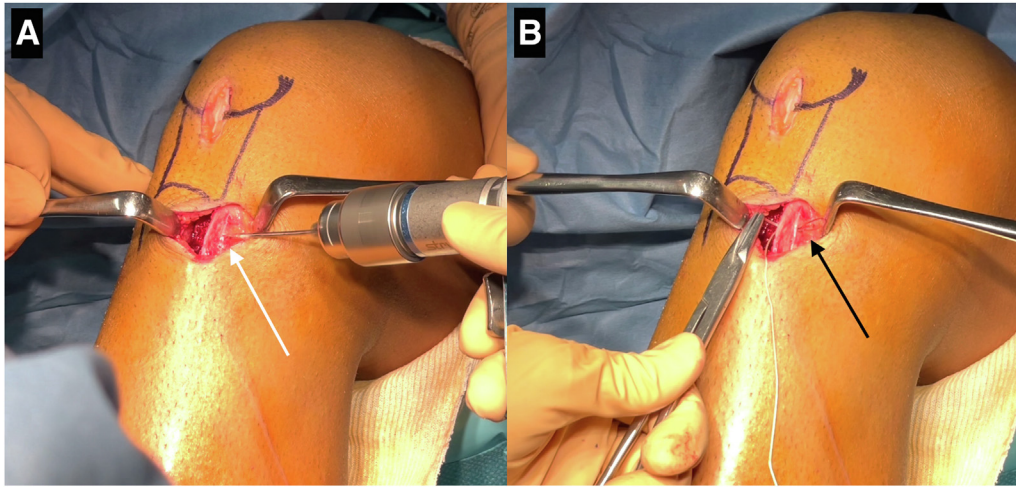
#### Graft Preparation and Diagnostic Arthroscopy

The tibial bone block is cut in a trapezoidal fashion, and the patella bone block is cut in a triangular fashion. The intention is to create a  $11 \times 20$  mm bone block from the tibial tuberosity and a  $9 \times 15$  mm bone block from the patella. A number-3 suture (Mersilene, Ethicon) is passed through the 2-mm drill hole in the tibial bone block. The patella bone block is prepared with a number-3 suture (Mersilene, Ethicon) and a number-2 suture (Polysorb, Covidien) in a figure-of-eight shape then a knot is positioned at the extremity. This configuration allows this bone block to be pulled during

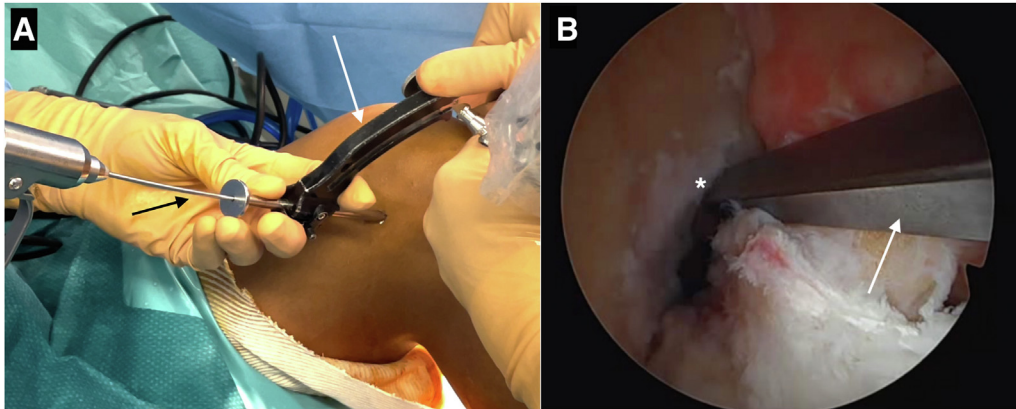
graft passage. The junctions between the tendon and bone are then marked with a sterile marker pen. Any excess bone from the graft preparation is kept for adding to the harvest sites at the end of the procedure (Fig 4).



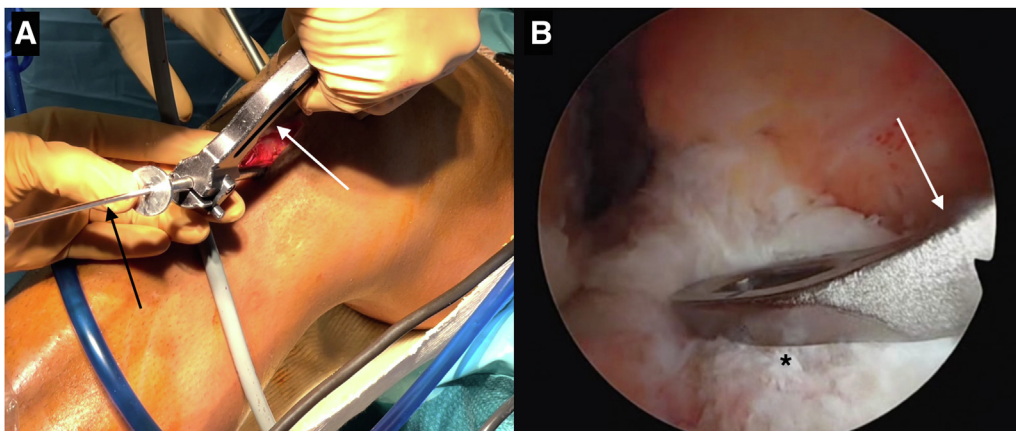
**Fig 4.** Graft preparation. A  $11 \times 20$  mm bone block from the tibial tuberosity and a  $9 \times 15$  mm bone block from the patella is created. A single suture is positioned through the drill hole in the tibial block (white arrow) and the patella block is prepared with 2 separate sutures in a figure-of-eight (black arrow) to allow the block to be pulled during graft passage.



**Fig 5.** Preparation for secondary fixation. Right knee, medial view. (A) 2-mm drill holes (white arrow) are made at the harvest site on the tibia. (B) Sutures are looped through the drill holes (black arrow) to be used to facilitate secondary fixation later in the procedure.



**Fig 6.** Femoral tunnel. (A) Right knee, lateral view. The bullet of the femoral outside-in ACL guide (white arrow) is positioned and a guidewire (black arrow) is inserted (B) Right knee, arthroscopic view. The guide (white arrow) is positioned at the femoral origin (\*) of the ACL.



**Fig 7.** Tibial tunnel. (A) Right knee, medial view. The tibial ACL guide (white arrow) is positioned and a guidewire (black arrow) is inserted. (B) Right knee, arthroscopic view. The guide (white arrow) is positioned over the ACL footprint (\*).



**Fig 8.** Graft passage. Right knee, lateral view. (A) A passing suture (white dotted arrow) is delivered from the tibial tunnel then through the femoral tunnel and the sutures from the patella bone block (\*) are then inserted into the loop (white arrow) created by the passing suture. (B) Using a clamp (black arrow), the surgeon guides the patella bone block (\*) through the femoral tunnel then the traction sutures are pulled (white dotted arrow) to allow passage of the graft. (C) While the surgical assistant performs gentle traction distally (white dotted arrow), the surgeon lightly hammers the bone block (black dotted arrow) using an impactor until press fit fixation is achieved.

Two 2-mm drill holes are then made at the harvest site on the tibia, and number-1 sutures (Polysorb, Covidien) are looped through, to be used to facilitate secondary fixation later in the procedure. In addition, the patellar tendon defects are closed to help prevent leakage of fluid during the arthroscopy (Fig 5).

High anterolateral and anteromedial portals are established. A diagnostic arthroscopy is performed and any meniscal or chondral lesions are addressed before the ACLR.

### Femoral Tunnel

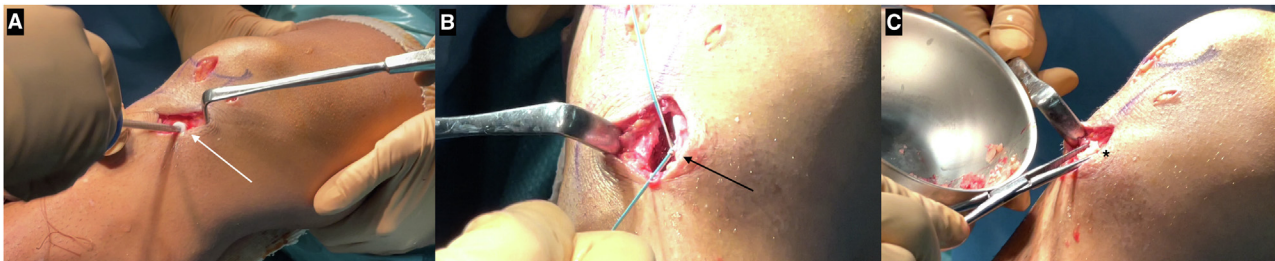
The femoral outside-in ACL guide (Arthrex) is positioned at the femoral origin of the ACL via the anteromedial portal. A lateral skin incision of around 2 cm is made for the guide to be positioned after it is set at an angle of 90°. A guidewire is inserted, and the correct position is confirmed arthroscopically. The femoral tunnel is established using outside-in drilling, starting with a 6-mm cannulated reamer. Initially, using a 6-mm reamer allows the position of the femoral tunnel to be rechecked and adjustments can be made in the direction of the subsequent 10-mm reamer, if necessary. The lateral aperture of the tunnel is then reamed to 11 mm for press-fit fixation (Fig 6).

### Tibial Tunnel

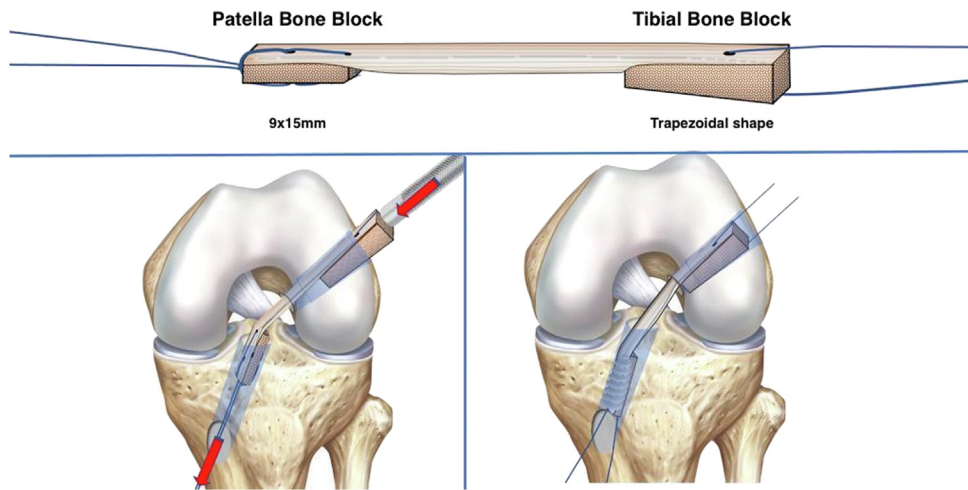
The tibial ACL guide (Arthrex) is set at 55° and then introduced through the anteromedial portal. It is positioned over the ACL footprint, and a guidewire is inserted. The tibial tunnel is established, starting with a 6-mm reamer and then upsizing to a 9-mm reamer once the position is confirmed. A shaver is then introduced into the tibial tunnel to debride the aperture of the tunnel. Reamings are collected to add to the harvest sites at the end of the procedure (Fig 7).

### Graft Passage and Fixation

A number-2 passing suture (Polysorb, Covidien) is delivered from the tibial tunnel then through the femoral tunnel for antegrade passage of the graft. The sutures from the patella bone block are then inserted into the loop created by the passing suture. Using a clamp, the surgeon guides the patella bone block through the femoral tunnel and then the traction sutures are pulled to allow passage of the graft. A probe is sometimes required to assist the graft passage, particularly at the intra-articular entrance of the femoral tunnel. The tibial bone block is inserted in the femoral tunnel with the cortex face posteriorly. While the surgical assistant performs gentle traction distally, the



**Fig 9.** Graft fixation. Right knee, medial view. (A) The knee is placed in 30° of flexion, and tibial fixation is achieved using an interference screw (white arrow) (B) Double fixation of the graft is performed on the tibial side using the transosseous sutures positioned on the tibial tuberosity (black arrow) (C) Bone graft (\*) is inserted into the graft harvest sites.



**Fig 10.** The original technique. Illustration demonstrating the graft preparation, graft passage, and final construct following fixation.

surgeon lightly hammers the bone block using an impactor until press fit fixation is achieved. The previously marked junction is seen arthroscopically arriving at the intra-articular entrance of the femoral tunnel. Moreover, the marked junction is important on the tibial side to ensure that the whole bone block is in the tunnel and that there is no risk of impingement (Fig 8).

Maximal manual tension is then applied to the sutures of the patella bone block, and the knee is cycled through full flexion and extension several times in order to assure the full passage of the graft. The knee is then placed in 30° of flexion, and tibial fixation is achieved using an interference screw (Biocomposite, Arthrex). Double fixation of the graft is then performed on the tibial side using the transosseous sutures positioned on the tibial tuberosity earlier in the procedure. Finally, bone graft is inserted into the graft harvest sites, and the wounds are closed (Fig 9).

### Postoperative Rehabilitation

Postoperative rehabilitation begins with brace-free, full weight bearing and progressive range of motion exercises, with restriction of range of motion to 0-90° for 6 weeks in patients undergoing meniscal repair. Early rehabilitation focuses on maintaining full extension and quadriceps activation exercises. Return to sports is allowed at 4 months for nonpivoting sport, 6 months for pivoting noncontact sport, and 8 to 9 months for pivoting contact sports.

### Discussion

This original ACLR technique using press-fit femoral fixation of the BPTB graft through an outside-in drilling technique was first described by Pierre Chambat in 1989. This technique has been associated with numerous studies and has evolved over the years.<sup>6-8</sup> The rationale of this technique is based on two

important technical aspects, press-fit fixation and outside-in drilling (Fig 10).

Primary stability of the bone plug of the BPTB graft into the femoral tunnel is achieved through press-fit fixation leading to bone-to-bone healing. Therefore, additional screw fixation of the graft on the femoral side is not required. Indeed, Gobbi et al.<sup>9</sup> has outlined the problems of interference screw fixation, such as screw misplacement, potential impingement, and abrasion. In addition, MRI interpretation postoperatively, especially when rerupture is suspected, can be difficult when metallic screws have been used. Revision ACLR is also made easier by the fact that no hardware requires removal. Additionally, recent studies have demonstrated that the implant-free press-fit fixation provides adequate primary stability with ultimate load to failure that is at least equal to the published results for interference screws.<sup>10,11</sup> Furthermore, Biazzo et al.<sup>12</sup> found better clinical results and better knee stability using press-fit femoral fixation in comparison to screw fixation in a 20-year follow-up study.

Outside-in drilling is a safe technique and leads to anatomic positioning of the ACL femoral tunnel at the center of the native ACL footprint. Moreover, outside-in drilling facilitates posterior wall preservation and adequate tunnel length, which is important for the stable fixation of the graft into the tunnel, whichever graft is used.<sup>7,13</sup> This technique is also essential during revision ACLR (RACLR) as a result of its unconstrained nature, allowing the creation of RACLR tunnels that are divergent to the previous tunnels. Consequently, adequate graft fixation and positioning can be achieved regardless of the preoperative presence of tunnel widening or malposition.<sup>14</sup>

In summary, this original technique describes anterior cruciate ligament reconstruction using bone-patella tendon-bone autograft with press-fit femoral fixation using an outside-in drilling technique.

## References

1. Chambat P, Guier C, Sonnery-Cottet B, Fayard JM, Thaumat M. The evolution of ACL reconstruction over the last fifty years. *Int Orthop* 2013;37:181-186.
2. Delay BS, Smolinski RJ, Wind WM, Bowman DS. Current practices and opinions in ACL reconstruction and rehabilitation: results of a survey of the American Orthopaedic Society for Sports Medicine. *Am J Knee Surg* 2001;14:85-91.
3. Webster KE, Feller JA, Hartnett N, Leigh WB, Richmond AK. Comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction: A 15-year follow-up of a randomized controlled trial. *Am J Sports Med* 2016;44:83-90.
4. Mascarenhas R, Tranovich MJ, Kropf EJ, Fu FH, Harner CD. Bone-patellar tendon-bone autograft versus hamstring autograft anterior cruciate ligament reconstruction in the young athlete: a retrospective matched analysis with 2-10 year follow-up. *Knee Surg Sports Traumatol Arthrosc* 2012;20:1520-1527.
5. Chambat P, Verdot F. Reconstruction du ligament croisé antérieur avec un tunnel fémoral de dehors en dedans. In: *Arthroscopie*. 2e ed. Elsevier, 2006;139-142.
6. Garofalo R, Mouhsine E, Chambat P, Siegrist O. Anatomic anterior cruciate ligament reconstruction: the two-incision technique. *Knee Surg Sports Traumatol Arthrosc* 2006;14:510-516.
7. Gill TJ, Steadman JR. Anterior cruciate ligament reconstruction the two-incision technique. *Orthop Clin North Am* 2002;33:727-735, vii.
8. Gaudot F, Leymarie JB, Drain O, Boisrenoult P, Charrois O, Beaufils P. Double-incision mini-invasive technique for BTB harvesting: its superiority in reducing anterior knee pain following ACL reconstruction. *Orthop Traumatol Surg Res* 2009;95:28-35.
9. Gobbi A, Diara A, Mahajan S, Zanazzo M, Tuy B. Patellar tendon anterior cruciate ligament reconstruction with conical press-fit femoral fixation: 5-year results in athletes population. *Knee Surg Sports Traumatol Arthrosc* 2002;10:73-79.
10. Pavlik A, Hidas P, Czigány T, Berkes I. Biomechanical evaluation of press-fit femoral fixation technique in ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2004;12:528-533.
11. Arnold MP, Burger LD, Wirz D, Goepfert B, Hirschmann MT. The biomechanical strength of a hardware-free femoral press-fit method for ACL bone-tendon-bone graft fixation. *Knee Surg Sports Traumatol Arthrosc* 2017;25:1234-1240.
12. Biazzo A, Manzotti A, Motavalli K, Confalonieri N. Femoral press-fit fixation versus interference screw fixation in anterior cruciate ligament reconstruction with bone-patellar tendon-bone autograft: 20-year follow-up. *J Clin Orthop Trauma* 2018;9:116-120.
13. Robin BN, Jani SS, Marvil SC, Reid JB, Schillhammer CK, Lubowitz JH. Advantages and disadvantages of transtibial, anteromedial portal, and outside-in femoral tunnel drilling in single-bundle anterior cruciate ligament reconstruction: A systematic review. *Arthroscopy* 2015;31:1412-1417.
14. Pioger C, Saithna A, Rayes J, et al. Influence of preoperative tunnel widening on the outcomes of a single stage-only approach to every revision anterior cruciate ligament reconstruction: An analysis of 409 consecutive patients from the SANTI Study Group. *Am J Sports Med* 2021;49:1431-1440.