Technical Note

Adjustable Button Devices for All-Arthroscopic Posterior Cruciate Ligament Reconstruction Using the Hamstrings Tendons and the "Forgotten" Transseptal Approach

Paul Brossard, M.D., Achilleas Boutsiadis, M.D., Ph.D., Jean-Claude Panisset, M.D., Frédéric Mauris, M.D., and Johannes Barth, M.D.

Abstract: Posterior cruciate ligament (PCL) ruptures account for nearly 20% of all ligamentous knee injuries. These may be either isolated or in the setting of a more complex knee trauma. Isolated tears with moderate posterior laxity (grades I or II) are commonly treated conservatively; nevertheless, symptomatic grade III injuries frequently require surgical intervention. PCL reconstruction remains a challenging surgery for multiple reasons like the neurovascular structures' proximity, the difficult passage of the graft with the "killer turn" angle, or the risk of poor graft fixation. We describe an all-inside operative technique using hamstrings tendon autografts with tibial and femoral adjustable buttons cortical fixation and the visualization of the posterior transseptal portal.

Posterior cruciate ligament (PCL) tears represent 20% of all ligamentous knee injuries and are concomitantly presented with more complex knee trauma.[1] Due to their rareness, the individual experience of each surgeon is often limited and the restoration of the joint kinematics remains a challenge.[1] In daily clinical practice, when a transtibial reconstruction is preferred, several technical issues should be considered, such as the appropriate tibial guide placement, the neurovascular bundle's proximity, the "killer turn" angle, the poor visualization of the posterior compartment, and important difficulties in the graft passage.[2,3] Furthermore, in arthroscopic PCL operations, the length of the graft used and its fixation on the lower density cancellous bone of the area should always be considered.[1]

In 2000 Ahn and Ha described the transseptal (TS) portal with the combination of posteromedial (PM) and posterolateral (PL) portals, providing a safe and reliable approach for posterior knee compartment exploration.[4] Additionally, the newest adjustable cortical fixation devices facilitated various ligamentous reconstructions using hamstring tendon autografts with promising results.[5]

The purpose of this report is to present a reproducible and reliable technique for single-bundle PCL reconstruction by creating a posterior TS portal and using hamstring tendon autografts, secured by 2 adjustable button devices.

Surgical Technique

Patient Positioning

Under spinal anesthesia the patient is positioned supine and a thigh tourniquet is placed mainly for security reasons (the procedure could be performed without inflating it). Using a distal foot stop and a lateral support, the knee is retained in 90° of flexion (Fig 1A), allowing varus or valgus stress maneuvers and full passive range of motion without any difficulty. Furthermore, the fluoroscopy is always placed preoperatively as a second control during tibial guide pin placement.

Graft Preparation

The hamstring tendon grafts are harvested using an open tendon stripper and detached from the tibia with a small periosteal sleeve, obtaining their maximum length. The GraftTech table (SBM SAS, Lourdes,

From the Department of Orthopaedic Surgery, Centre Osteoarticulaire des Cèdres, Grenoble, France.

The authors report the following potential conflicts of interest or sources of funding: J.B. receives support from Arthrex, SBM, and Tornier; J.C.P. receives support from SBM; F.F. receives support from Arthrex.

Received November 19, 2016; accepted March 7, 2017.

Address correspondence to Johannes Barth, M.D., Parc Sud Galaxie, 5 Rue Des Tropiques, 38130 Echirolles, Grenoble, France. E-mail: jrhbarth@yahoo.fr

© 2017 by the Arthroscopy Association of North America

2212-6287/161157/$36.00

http://dx.doi.org/10.1016/j.eats.2017.03.010

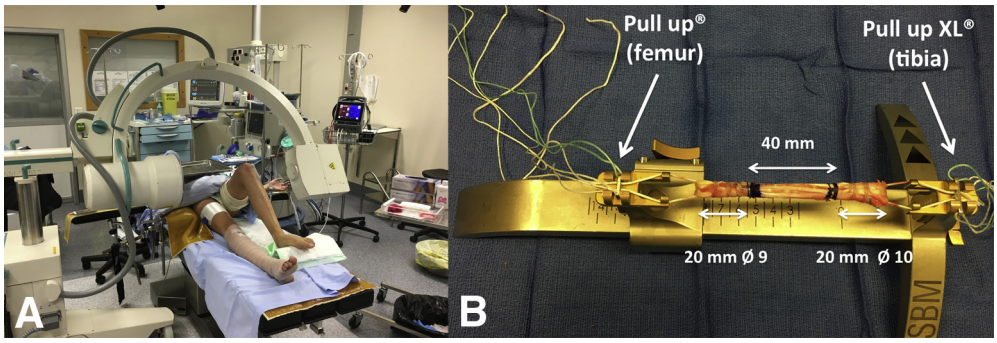

Fig 1. (A) Patient preparation and setup in the operating theater. The left knee is retained in 90° of flexion, and the fluoroscope is always placed preoperatively as a second control during tibial guide pin placement. (B) The prepared 4-strand hamstring graft. The accomplished length is 80 mm, and its midsubstance diameter is 10 mm. The normal-sized Pullup is attached at the femoral side, and the extralarge Pullup at the tibial side.

France) is used for the preparation of the graft. Two adjustable loop button devices, one extralarge (tibial side; Pullup XL, SBM SAS, Lourdes, France) and one normal sized (femoral side; Pullup, SBM SAS), are attached at each side of the GraftTech table. The PCL graft length is calculated as follows: the natural intra-articular distance of the PCL is 30-38 mm; the minimum desired length for the graft incorporation is 20 mm in each tunnel, tibial and femoral, respectively.[1] Therefore, the minimum accomplished graft length has to be 80 mm. According to the aforementioned measurements, both hamstring tendons are looped 3-4 times (depending on their length) through the Pullup XL and the Pullup normal and secured provisionally with a clamp. Finally, by using a no. 2 ultrahigh molecular-weight polyethylene fiber (PowerTex, SBM SAS), each side of the 3- to 4-strand graft is secured with 2 figure-of-8 stitches and the previously mentioned lengths are marked on the prepared tendons (Fig 1B).

Arthroscopy

Using a 30° arthroscope and through standard anterolateral (AL) and anteromedial (AM) portals, initial arthroscopic examination of the knee joint is performed and the PCL rupture is confirmed. In order to improve visualization but also to respect the biology, the minimums of the PCL remnants are initially excised using a 4.2-mm shaver from the AM portal. Therefore, the arthroscope can be more easily introduced into the PM compartment.

Thereafter, as described by Ahn and Ha,[4] by the AL portal and through the intercondylar notch, the 30° arthroscope is passed between the medial femoral condyle and the PCL remnants and placed in the PM compartment. A spinal needle is inserted under direct arthroscopic visual control, and a PM portal is established with a no. 11 blade 5-10 mm above the tibial surface, just posteriorly to the medial femoral condyle. Next the arthroscope is moved to the AM portal and positioned in the PL compartment through the intercondylar notch passing laterally the ACL fibers (between the ACL and the lateral femoral condyle). By again using the outside-in technique, a spinal needle is inserted under direct arthroscopic visual control 5-10 mm above the tibial surface, just posteriorly to the lateral femoral condyle. The PL portal is realized using a no. 11 surgical blade. No arthroscopic cannulas are necessary to be placed in the PM or PL portals. During the creation of the PM and PL portals, the knee should be placed in 90° of flexion and the transillumination of the arthroscope can be used in order not to damage the crossing vessels and nerves. In this position the mean distance between the PM portal and the 2 branches of saphenous nerve is approximately 17 mm and 20 mm, and between the PL portal and the common peroneal nerve, 25 mm.[6]

The arthroscope is placed to the PM portal viewing the PCL remnants, its footprint, the posterior septum, and the capsule. By using the blunt switching stick through the PL portal, the posterior septum, just behind the PCL remnants, is slowly pushed medially, and gradually a small aperture is created (TS portal; Fig 2 A and B). This aperture can be widened with the radiofrequency or the shaver without using any suction. All the instruments used to establish the TS portal are blunt and introduced through the PL portal with taking care not to damage the posterior capsule and consequently the vulnerable neurovascular structures, which are at a mean distance of 18 mm in 90° of knee flexion.[6] Therefore, all the soft tissue of the posterior tibial plateau can be safely cleaned and the PCL insertion identified and preserved (Fig 2C).

Tunnel Preparation

Tibial Tunnel Preparation. By using sequentially both the PM and PL as viewing portals and under 90° of knee flexion, the PCL tibial guide (Arthrex, Naples, FL,

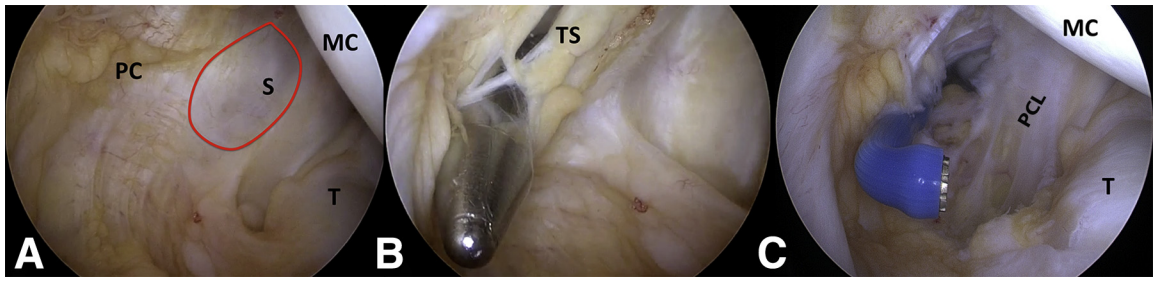

Fig 2. The patient is placed supine, and his left knee is in 90° of flexion. (A) Posteromedial (PM) portal view showing the posterior septum (S) and the safety zone for the aperture opening (red zone). (B) Aperture of the posterior septum (transseptal [TS] portal) with the switching stick from the posterolateral portal (PM portal view). (C) Posterior compartment cleaned with the radiofrequency electrode. PM portal view showing also the preserved posterior cruciate ligament (PCL) remnants, the medial condyle (MC), and the medial tibial plateau (T). (PC, posterior capsule.)

U.S.A.), set at 65°, is placed through the AM portal at the anatomic position of the tibial PCL insertion (Fig 3A), in the middle of its remnants. The appropriate drill sleeve is placed anteriorly at the level of the hamstring tendon harvesting incision.

With the 30° arthroscope in PM portal, a 2.4-mm guide pin is drilled into the tibia with care not to damage the vulnerable posterior neurovascular structures (Fig 3A, inset a.1). This crucial step is performed under direct arthroscopic visualization, however, a parallel fluoroscopic control is still used to confirm the guide placement in the sagittal plane (Fig 3B). Next a protection curette is inserted from the PL portal and placed over the 2.4-mm guide pin, and a cannulated reamer that matches the graft diameter is used for the final tibial tunnel preparation. Soft-tissue remnants at the posterior exit of the tibial tunnel are removed by using the shaver or the radiofrequency probe through the PL portal. Therefore, the final graft passage through the tibial tunnel is facilitated.

By keeping the arthroscope in the PM portal and the switching stick in the PL portal, a looped no. 3 nonabsorbable suture (Mersuture, Ethicon SAS, Johnson & Johnson, Cedex, France) is inserted into the tibial tunnel using a suture passer with an eyelet. With an arthroscopic grasper, this suture is retrieved from the AM portal through the intercondylar notch. During this step, it is important to pass the aforementioned suture behind the switching stick. In this manner, the switching stick can serve as a pulley during final graft passage, avoiding the difficulties of the killer turn angle (Fig 3C).

Femoral Tunnel Preparation. The arthroscope is transferred from the PM to the AM portal. By using the radiofrequency probe, the femoral footprint is partially cleaned and the borders of the cartilage are identified.

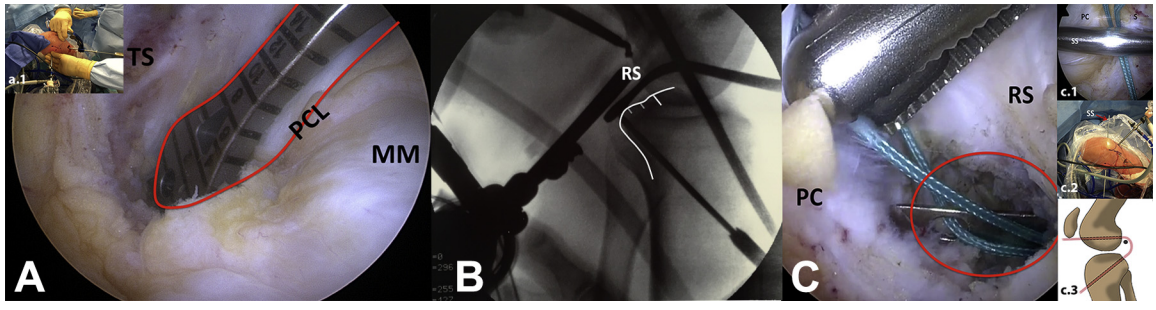

Fig 3. The patient is placed supine, and his left knee is in 90° of flexion. (A) Posteromedial (PM) portal view showing the posterior cruciate ligament (PCL) drill guide placement through the anteromedial (AM) portal at the center of the preserved PCL footprint (red zone). (Inset a.1) The arthroscope is positioned in the PM portal. A 2.4-mm guide pin is drilled through the PCL guide. (B) Sagittal plane fluoroscopy control of the left knee. As shown, the 2.4-mm pin is placed at the posterior third of the retrospinal area (RS). (C) A looped no. 3 Mersuture is inserted into the tibial tunnel and retrieved through the AM portal (PM portal view showing also the posterior capsule [PC] and the retrospinal area [RS]). (Inset c.1) The arthroscope is placed through the AL portal to the PM compartment of the left knee showing the switching stick (SS) passed anteriorly the shuttling no. 3 Mersuture. (Inset c.2) The SS is passed through the PL and PM portals in order to serve later as a pulley during graft passage and avoid the difficulties of the killer turn. (Inset c.3) Art drawing showing lateral view of the knee. The black dot represents the position of the switching stick anterior to the tibial shuttling suture (red). Therefore, it can serve as a pulley during graft passage. (MM, medial meniscus; PC, posterior capsule; S, septum; TS, transseptal portal.)

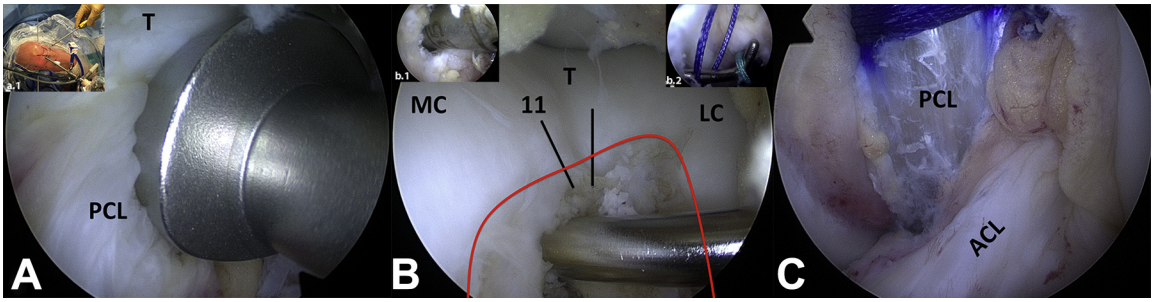

Fig 4. The patient is placed supine, and his left knee is in 90° of flexion. (A) The femoral posterior cruciate ligament (PCL) guide is placed through the anterolateral (AL) portal at the center of the ligament insertion. The arthroscope is placed in the anteromedial (AM) portal. (Inset a.1) Extra-articular image showing the femoral PCL guide placement through the AL portal. The arthroscope remains in the AM portal. (B) The 2.4-mm guide pin is drilled between 10:30 and 11 o'clock for the left knee (1 and 1:30 o'clock for a right knee). (Inset b.1) Final femoral socket of 25 mm depth is prepared (AM portal view). (Inset b.2) In order to avoid any further anterior soft-tissue conflict, the tibial suture loop (green) is passed through the femoral loop (blue suture). AL portal view showing the intercondylar notch. (C) Final image from the AL portal showing the PCL reconstructed and the anterior cruciate ligament tensioned. (ACL, anterior cruciate ligament; LC, lateral condyle; MC, medial condyle; PCL, posterior cruciate femoral footprint; T, femoral trochlea.)

With the knee in 90° of flexion and through the AL portal, the femoral PCL guide (Arthrex) is positioned at the center of the ligament insertion next to the condyle's articular surface (Fig 4A). A 2.4-mm guide-passing pin is drilled, until it penetrates the medial femoral cortex and exits the skin (Fig 4 A and B). A 4.5-mm cannulated drill is used to create the first full-length passing channel, and sequentially another cannulated drill, which matches the graft diameter, is selected for the final femoral socket preparation. The depth of the socket is calculated according to the length of the prepared graft, avoiding also breakage of the medial femoral cortex (usually 25-30 mm; Fig 4B, inset b.1). The free ends of a no. 2 Vicryl (Ethicon, Johnson & Johnson, U.S.A.) suture loop (different color from the tibial one) are advanced out the AM thigh using the guide-passing pin.

Thereafter, the arthroscope is transferred to the AL portal and the femoral (blue Vicryl) and tibial (green Mersuture) shuttling sutures are retrieved from the AM portal. In order to avoid any further entrapment with the anterior soft tissues (mainly fat pad), the tibial loop (green Mersuture) is retrieved and passed through the femoral loop (blue Vicryl) under arthroscopic control inside the notch and before any graft passage (Fig 4B, inset b.2).

Graft Passage and Fixation

Graft Passage Through the Tibial Tunnel. The difficult part of the procedure is to pass gradually the graft through both the tibial and femoral tunnels, which do not go in the same direction, and excessive friction may lead to entrapment or even rupture of the graft. For this reason, we divided the procedure into 2 steps: Initially, the sutures of the normal Pullup (femoral side of the graft) are shuttled through the tibial tunnel and retrieved through the AM portal by the no. 3 nonabsorbable (green) Mersuture. The killer turn angle at the posterior exit of the tibial tunnel is certainly the most perilous step, because of the severity of the reflexing angle and the difficulty of controlling the graft progression in the posterior hidden and narrow compartment, especially when using anterior viewing portals. Therefore, the arthroscope can be placed in the PM portal, and while the assistant pulls the sutures of the Pullup through the AM portal, the surgeon uses the switching stick from the PL portal as a pulley (Fig 3C, inset c.3), aiding the progressive graft passage until the tibial side mark appears posteriorly (a 2-cm length is left in the tibial tunnel).

Graft Passage Through the Femoral Tunnel—Final Fixation. Second, as mentioned before, the loop of the no. 3 nonabsorbable Mersuture (tibial tunnel) is passed through the loop of the no. 2 Vicryl (femoral tunnel). Consequently, the traction sutures of the normal-sized Pullup are already passed through the no. 2 Vicryl suture and directly shuttled through the femoral tunnel. The femoral Pullup is flipped over the medial femoral cortex, and by pulling its adjustable loop sutures the graft is secured into the prepared socket. The graft is cycled through the full range of motion, and final PCL tensioning is performed by pulling the sutures and securing the adjustable loop of the XL button at the tibial side. During final fixation, the knee is retained in 70° of flexion, and an anterior drawer is applied (Fig 4C, Table 1, Video 1).

Discussion

Arthroscopic PCL reconstruction is a rarer and more technically demanding technique than any ACL operation. The limited visualization of the posterior compartment with the standard AM and AL portals and

Table 1. Surgical Steps, Tips, and Pearls and Pitfalls of the Technique Described

Surgical Steps	Tips and Pearls	Pitfalls
1. Graft harvesting and preparation	With an open-type tendon stripper and a small periosteal sleeve, obtain the maximum length of both hamstrings tendons.	Avoid using a closed-type stripper.
	The whole graft length (according to published data) is approximately calculated as follows: 2-cm tibial tunnel + 3- to 4-cm PCL intra-articular part + 2-cm femoral tunnel = 7-8 cm	Clean all tendon-muscle attachments before final harvesting.
	By using both hamstrings, a 3-4 stranded graft of 10-11 mm diameter is usually accomplished.	Create an 8-cm graft length in order to avoid incorporation problems.
2. Transseptal portal	Through the AL portal, advance the arthroscope PM and create the PM portal.	It is difficult to perform the PM and PL portals in overweight or muscular patients.
	Through the AM portal, advance the arthroscope PL and create the PL portal.	Use the transillumination of the arthroscope in order not to damage the crossing vessels and nerves during portal creation.
	With the arthroscope in the PM portal and the switching stick in the PL portal, create gradually an aperture of the posterior septum.	
	Avoid using the shaver aspiration posteriorly and be cautious also with the radiofrequency probe.	
3. Initial tibial guide placement and tunnel preparation	Use both PM and PL as viewing portals and place through the AM portal the PCL tibial drill guide in the center of the PCL insertion.	Despite the safety of the transseptal portal, it is possible to damage the vulnerable neurovascular bundles during the tibial tunnel creation.
	The maximum of the remnants can be preserved.	Damage to the anterior cruciate ligament during shaving from the anterior portals or during PCL tibial drill guide passage.
	The PM and PL portals can always be used for careful dissection of the posterior compartment.	
	After direct visual and fluoroscopic control of the 2.4-mm guide pin position, create the appropriate full-length tibial tunnel.	
	Pass a shuttling suture from the tibial tunnel and retrieve it from the AM portal.	
	The switching stick from the PL portal should stay in front of the tibial shuttling suture in order to serve as a pulley during the final graft passage.	
4. Femoral tunnel	Use the AM as viewing portal.	Iatrogenic cartilage lesions of the lateral femoral condyle during femoral tunnel creation from the AL portal.
	Through the AL portal place, the femoral PCL drill guide at the center of its femoral insertion (between 10:30 and 11 o'clock for a left knee and between 1:00 and 1:30 for a right knee).	Breakage of the medial femoral cortex with the final drill made. In this case an extralarge button could be used for the femur also.
	Insert the 2.4-mm passing guide pin, create a full-length 4.5-mm tunnel, and finally create a 20-30 mm depth socket with a drill that matches graft diameter.	
	Pass a different color shuttling suture through the femoral tunnel.	
	Pass the tibial shuttling suture through the femoral shuttling suture.	
5. Graft passage	Shuttle the graft from the AL portal through the tibial tunnel starting from the side of normal Pullup until it appears into the intercondylar notch.	The surgeon should beware not to flip the button inside the femoral socket and not to entrap the vastus medialis muscle between the button and the femoral cortex.
	Use posteriorly the switching stick as pulley to aid graft passage and avoid the killer turn phenomenon.	PCL graft damage or rupture due to the killer turn. Always use the switching stick as a pulley.
	Shuttle directly the normal Pullup and the graft through the femoral tunnel. Flip the button onto the cortex and secure its adjustable loop pulling the graft into the femoral socket.	Conflict mainly with the fat pad during final graft passage. Be sure that the shuttling suture of the tibia is passed through the femur's shuttling suture.
	Tension the graft by securing the extralarge Pullup at the tibial side.	

AL, anterolateral; AM, anteromedial; PCL, posterior cruciate ligament; PL, posterolateral; PM, posteromedial.

Table 2. Advantages, Risks, and Limitations of the Posterior Cruciate Ligament Reconstruction Using the Transseptal Portal and the 2 Adjustable Loop Button Devices

Advantages	With adjustable loop button devices, a satisfactory size of PCL graft can be accomplished and the hamstring tendon length restrictions can be avoided.
	The TS portal increases the safety and offers continuous direct visual control of the posterior compartment.
	Through the TS portal, a switching stick is placed that can be used as a pulley during final graft passage and avoid the killer turn phenomenon problems.
	Minimally invasive, reproducible with a cosmetic scar.
	Possibility to preserve PCL remnants (if present).
	In combined ACL and PCL ruptures, the BPTB or quadriceps could be used for ACL and the hamstrings for the PCL reconstruction. Allografts or more difficult tibial inlay techniques could be avoided.
	Accurate tibial tunnel position in axial (mediolateral plane).
Risks	Neurovascular structures damage during portals creation (posteromedial, posterolateral, TS).
	Less but existing risk of vascular injury during tibial tunnel creation.
Limitations	The diameter of prepared 3- to 4-strand graft for the PCL should be 10-11 mm at least.
	In cases where the lateral structures are also involved, another type of autograft, hamstrings from the other side, or allografts could be considered.

ACL, anterior cruciate ligament; BPTB, bone–patellar tendon–bone; PCL, posterior cruciate ligament; TS, transseptal.

the proximity of the neurovascular structures can lead to limb-threatening complications when performing a transtibial reconstruction. However, the creation of the reliable and reproducible PM, PL, and TS portals in 90° of knee flexion provides direct approach of the posterior structures, thus increasing the safety and protecting the neurovascular structures.[2,4,6,7] Additionally, creation of the portals offers an accurate tibial tunnel placement under direct visual control and inside the native tibial PCL insertion. Most studies have focused mainly on the superior malpositioning of the tibial tunnel and the importance of the intraoperative fluoroscopy control.[1,2] By the TS portal the surgeon can accomplish an ideal placement not only in the sagittal but also in the axial- and mediolateral plane[8] (Table 2).

The most common reported technical difficulty during the transtibial PCL reconstruction is the killer turn angle phenomenon as the graft emerges from the tibial tunnel and courses toward the femur.[1] Again, through the TS portal, a 4-mm switching stick could play the role of a pulley and facilitate the safe and gradual graft passage, avoiding its disastrous rupture. Additionally, the combination of a sharp bony surface (after excessive tibial footprint cleaning) and a killer turn angle could lead to graft attenuation and residual knee laxity.[1,9] By this technique, the maximal preservation of the PCL remnant tissue offers a smooth tibial aperture and could decrease the negative effect of the killer turn.

Recently, many investigators have suggested that PCL remnant preservation could offer better synovial coverage, increased blood circulation, and mechanoreceptor preservation, enhancing the healing process and the restoration of knee kinematics.[1,7] However, the main concern is again the poor posterior visualization and the difficulties in the graft passage.[7] Using the TS portal, the maximal remnant fibers could be preserved, while, with the aid of the switching stick, the "free of conflicts" graft passage is assured.

Finally, knowing that the intra-articular part of the PCL may reach up to 38 mm and its cross-sectional area is about 11 mm,[1] one main concern is the graft's length and width. For the aforementioned reasons, many investigators have preferred the application of allografts.[1,7] However, newer studies have shown that the use of suspensory devices in PCL reconstruction has advantages in the length of the graft used and provides stable fixation.[10] Therefore, by using 2 adjustable loop button devices and after the length calculation as presented above, a 3 or 4-strand graft with satisfactory diameter can be achieved and stabilized outside the lower density cancellous bone of the posterocentral area of the tibia.[11]

Although this study is only a technical note presentation, it should be noted that it has several limitations. No long-term results are available, and a possible comparison with other single- or double-bundle techniques is necessary. In conclusion, the described technique is reliable and reproducible, maximally increases the visualization and security in the posterior compartment, offers improved biological environment with remnant preserving, and avoids graft length problems.

Acknowledgment

The senior author acknowledges Joon Ho Wang, M.D., and Jin Goo Kim, M.D., from Seoul, Korea, and Jian Li, M.D., from Chendu, China, who took the time to explain to him the transseptal portal during the APKASS ESSKA traveling fellowship. The authors also thank Mrs. Christina Eleftheriadou, graphic designer, for the design of the professional-quality drawings.

References

1. Voos JE, Mauro CS, Wente T, Warren RF, Wickiewicz TL. Posterior cruciate ligament anatomy, biomechanics, and outcomes. *Am J Sports Med* 2012;40:222-231.
2. Zawodny SR, Miller MD. Complications of posterior cruciate ligament surgery. *Sports Med Arthrosc Rev* 2010;18:269-274.

3. Pace JL, Wahl CJ. Arthroscopy of the posterior knee compartments: neurovascular anatomic relationships during arthroscopic transverse capsulotomy. *Arthroscopy* 2010;26:637-642.
4. Ahn JH, Ha CW. Posterior trans-septal portal for arthroscopic surgery of the knee joint. *Arthroscopy* 2000;16:774-779.
5. Colombet P, Graveleau N, Jambou S. Incorporation of hamstring grafts within the tibial tunnel after anterior cruciate ligament reconstruction: magnetic resonance imaging of suspensory fixation versus interference screws. *Am J Sports Med* 2016;44:2838-2845.
6. Makridis KG, Wajsfisz A, Agrawal N, Basdekis G, Djian P. Neurovascular anatomic relationships to arthroscopic posterior and transseptal portals in different knee positions. *Am J Sports Med* 2013;41:1559-1564.
7. Ahn JH, Lee SH. Anatomic graft passage in remnant-preserving posterior cruciate ligament reconstruction. *Arthrosc Tech* 2014;3:e579-e582.
8. Lee YS, Ko TS, Ahn JH, et al. Comparison of tibial tunnel techniques in posterior cruciate ligament reconstruction: C-arm versus anatomic fovea landmark. *Arthroscopy* 2016;32:487-492.
9. Weimann A, Wolfert A, Zantop T, Eggers A-K, Raschke M, Petersen W. Reducing the "killer turn" in posterior cruciate ligament reconstruction by fixation level and smoothing the tibial aperture. *Arthroscopy* 2007;23:1104-1111.
10. Lee YS, Wang JH, Bae JH, et al. Biomechanical evaluation of cross-pin versus interference screw tibial fixation using a soft-tissue graft during transtibial posterior cruciate ligament reconstruction. *Arthroscopy* 2009;25:989-995.
11. Lee YS, Nam SW, Hwang CH, Lee BK. Computed tomography based evaluation of the bone mineral density around the fixation area during knee ligament reconstructions: clinical relevance in the choice of fixation method. *Knee* 2012;19:793-796.