Double-Bundle, All-Inside Posterior Cruciate Ligament Reconstruction: A Technique Using 2 Separate Autologous Grafts

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Abstract: In a double-bundle posterior cruciate ligament reconstruction, several surgical techniques are available. Compared with other techniques, the advantages of the all-inside technique and cortical suspension devices with variable loop length are that shorter grafts can be used, tendons can be quadrupled, and a double-bundle posterior cruciate ligament reconstruction can be performed with autologous grafts. Furthermore, the all-inside technique provides independent outside-in socket reaming and is soft tissue, cortex, and bone sparing because no full diameter tunnels but sockets are created with a small diameter guide pin, which can transform into a retrograde drill. Sockets could however lead to bottoming out of the grafts at the femoral side and subsequent residual laxity. This can be avoided by using 2 separate grafts that are fixed in 2 femoral sockets before they are independently fixed and tensioned in 1 tibial socket in their corresponding flexion angle. In this technical note, we present a double-bundle, all-inside posterior cruciate ligament reconstruction using 2 separate autologous grafts.

The posterior cruciate ligament (PCL) is an important stabilizer of the knee. Its codominantly acting larger anterolateral bundle (ALB) and smaller posteromedial bundle (PMB) function as a primary restraint to posterior translation in all flexion angles as well as a restraint to internal and external rotation.[1]

Currently, several surgical options such as the all-inside technique as well as cortical suspension devices with variable loop length are available. The advantages over fixed length cortical suspension devices include the possibility of fixing the graft in a femoral as well as a tibial socket, of completely filling a socket with graft substance, and of correctly tensioning a graft even after graft fixation.[2]

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In this technical note, we present a surgical technique of an all-inside double-bundle (DB) PCL reconstruction (PCLR), using 2 separate autologous semitendinosis and gracilis grafts that are fixed in 2 femoral sockets after which they are fixed and tensioned in 1 tibial socket independently in their corresponding flexion angles.

Surgical Technique

Graft Harvest

The ipsilateral semitendinosis and gracilis or the ipsi- and contralateral semitendinosis tendons are harvested with a mini-incision technique at the posterior side of the knee (Fig 1; Video 1).[3]

Graft Preparation

The minimum required graft length is the estimated intra-articular length of the PCL + 15 mm for the femoral socket and 20 mm for the tibial socket.[4] Both separate grafts are tripled or quadrupled and prepared according to the GraftLink principle.[5] A TightRope (variable loop length cortical suspension device; Arthrex, Naples, FL) Reverse Tension or Attachable Button System (ABS) is linked to the femoral side, and a TightRope ABS is linked to the tibial side of each graft (Fig 2). The shortening strands of both TightRopes of

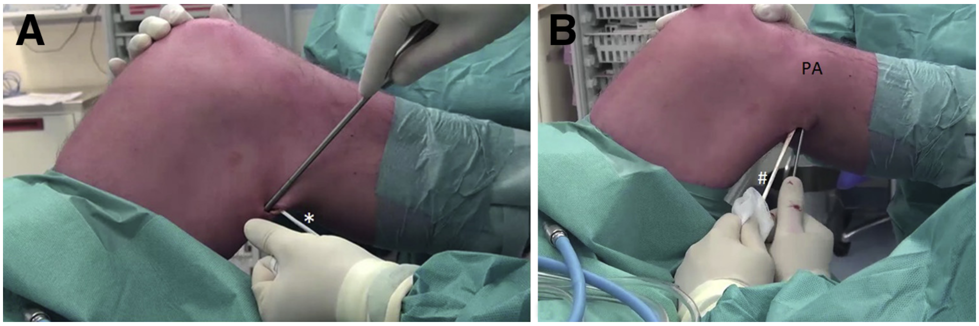

Fig 1. Graft harvest. medial view of the left knee, with the patient in supine position. The ipsilateral semitendinosis and gracilis or the ipsi- and contralateral semitendinosis tendons are harvested with a mini-incision technique at the posterior side of the knee. (A) The tendon is held with a tape (*) and the open stripper is aimed proximal, stripping the tendon from the muscle. (B) The proximal free end of the tendon (#) is held with a gauze and the closed stripper is aimed distal, stripping the tendon off the pes anserinus (PA).

the ALB graft are marked to differentiate them from the unmarked TightRopes of the PMB graft during tensioning (Fig 3).

Graft Sizing

The femoral diameter is measured individually for the ALB graft and the PMB graft. The tibial sides of the ALB graft and the PMB graft are fixed in the same socket, so their combined diameter is measured. Because the grafts can be compressed, first, the tibial side of the ALB graft is passed into the sizing block, after which the tibial side of the PMB graft is passed into the same hole to ensure a tight fit of the grafts (Fig 4). Also, the diameters of the tibial and femoral sockets are drilled 1 mm smaller than measured.

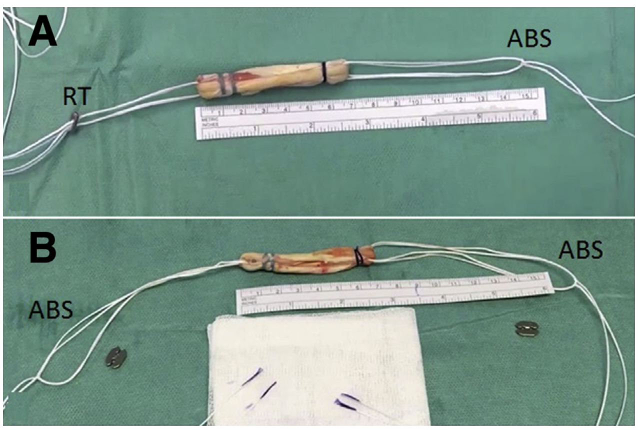

Fig 2. Graft preparation. Both separate grafts are quadrupled and prepared according to the GraftLink principle. (A) A TightRope (variable loop length cortical suspension device; Arthrex) Reverse Tension (RT) is linked to the femoral side, and a TightRope Attachable Button System (ABS) is linked to the tibial side of each graft. (B) Alternatively, a TightRope ABS is linked to both sides of both grafts. The minimum required graft length is the estimated intra-articular length of the posterior cruciate ligament + 15 mm for the femoral and 20 mm for the tibial socket.

Arthroscopy

Routine knee arthroscopy is performed with a 30° arthroscope and anteromedial, anterolateral, and posteromedial portal placement (Fig 5). A cannula is placed in the posteromedial portal. The femoral and tibial attachments of the ALB and PMB of the PCL are identified, cleared from PCL remnants, and their centers are marked.

Tibial Socket Preparation

A dedicated tibial PCL guide (Arthrex) is placed in the center of the tibial PCL attachment and the tibial bone bridge is measured. The minimum length of the tibial socket is as follows: total graft length − estimated intra-articular length of the graft − 15 mm femoral socket length + 15 mm for correction of calculation error and tensioning. Also, the residual tibial bone bridge after drilling the tibial socket should be at least 10 mm. Using a small diameter guide pin, which can transform into a retrograde drill (FlipCutter; Arthrex), the tibial socket is reamed to its calculated length under the arthroscopic and fluoroscopic view to evaluate drill guide placement and drill advancement to the posterior tibial cortex (Fig 6).[6] Two suture shuttles are passed through the tibial tunnel. One exits the joint through the anteromedial portal and the other through the posteromedial portal (Fig 7).

Femoral Socket Preparation

A dedicated femoral PCL guide (Arthrex) is placed in the center of the femoral ALB attachment. Using a FlipCutter, a femoral socket with a length of 15 mm is reamed. One suture shuttle is passed through the femoral tunnel. The same procedure is repeated for the PMB socket (Fig 8). Both suture shuttles exit the joint through the anteromedial portal (Fig 9).

Graft Advancement and Femoral Fixation

Starting with the ALB graft, the *marked* TightRope ABS is loaded with a passing suture and shuttled

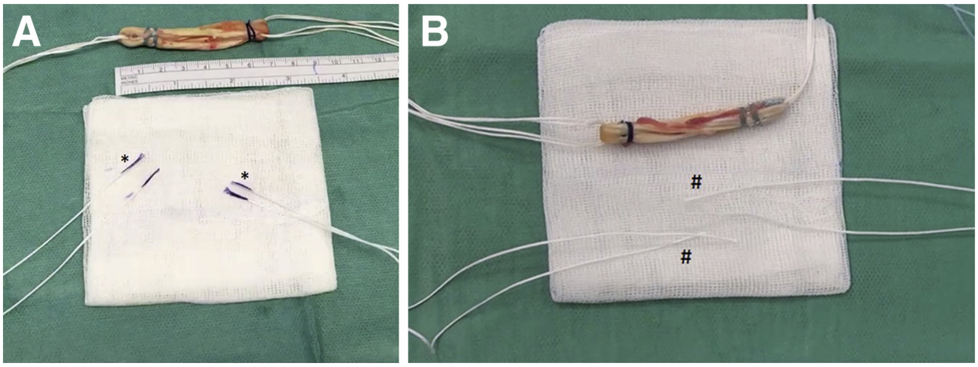

Fig 3. Graft preparation. (A) The shortening strands of both TightRopes of the anterolateral bundle graft are marked (*) to differentiate them from the unmarked TightRopes of the posteromedial bundle (PMB) graft during tensioning. (B) The unmarked TightRopes (#) of the PMB graft.

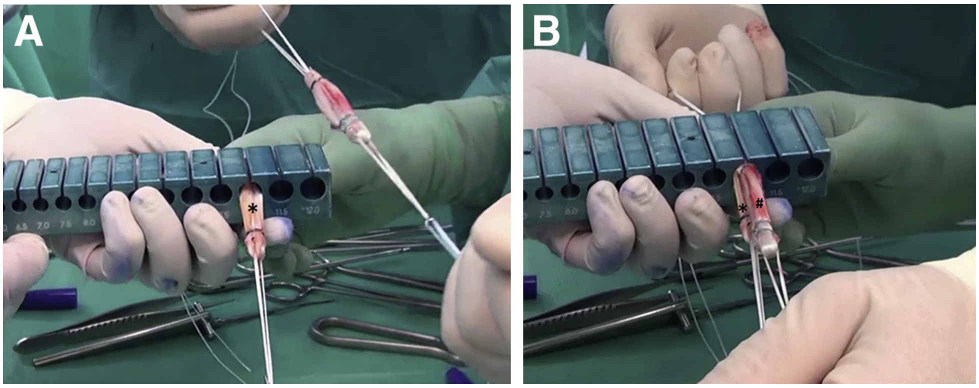

Fig 4. Graft sizing. The tibial sides of the anterolateral bundle (ALB) graft and the posteromedial bundle (PMB) graft are fixed in the same socket, so their combined diameter is measured. (A) First, to replicate the graft advancement procedure, the tibial side of the ALB graft (*) is passed into the sizing block. (B) Next, the tibial side of the PMB graft (#) is passed into the same hole to ensure a tight fit of the grafts.

through the tibial tunnel with the tibial suture shuttle that exits the joint from the anteromedial portal. The tibial suture shuttle that exits the joint from the posteromedial portal is left untouched. The TightRope ABS is pulled through and out of the tibial tunnel and the graft is advanced into the tibial socket by pulling the loop (and not the shortening strands!) of the TightRope. Next, the previously *marked* femoral-sided-TightRope (ABS or Reverse Tension) is shuttled through the femoral ALB tunnel with the corresponding suture shuttle, and the cortical suspensory button of the TightRope is flipped and placed against the cortex of the medial femoral condyle. The femoral-sided-TightRope is shortened until the graft is bottomed out in the femoral ALB socket. The same procedure is repeated for the PMB graft with its *unmarked* TightRopes (Fig 10). The remaining tibial suture shuttle is relocated from the posteromedial portal to the anteromedial portal passing the ALB graft on the medial side, so the PMB graft is advanced in the tibial socket medial and posterior to the ALB graft to replicate the anatomic tibial orientation of the bundles (Fig 11).

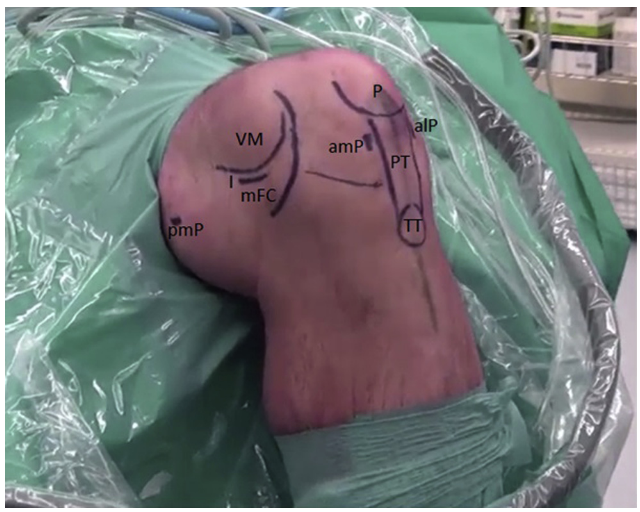

Fig 5. Arthroscopy. Anteromedial view of the left knee. Routine knee arthroscopy is performed with anteromedial (amP), anterolateral (alP), and posteromedial (pmP) portal placement. Also marked tuberosity (TT), patellar tendon (PT), patella (P), medial femoral condyle (mFC), vastus medialis (VM), and the location of the skin incision for both femoral sockets (I).

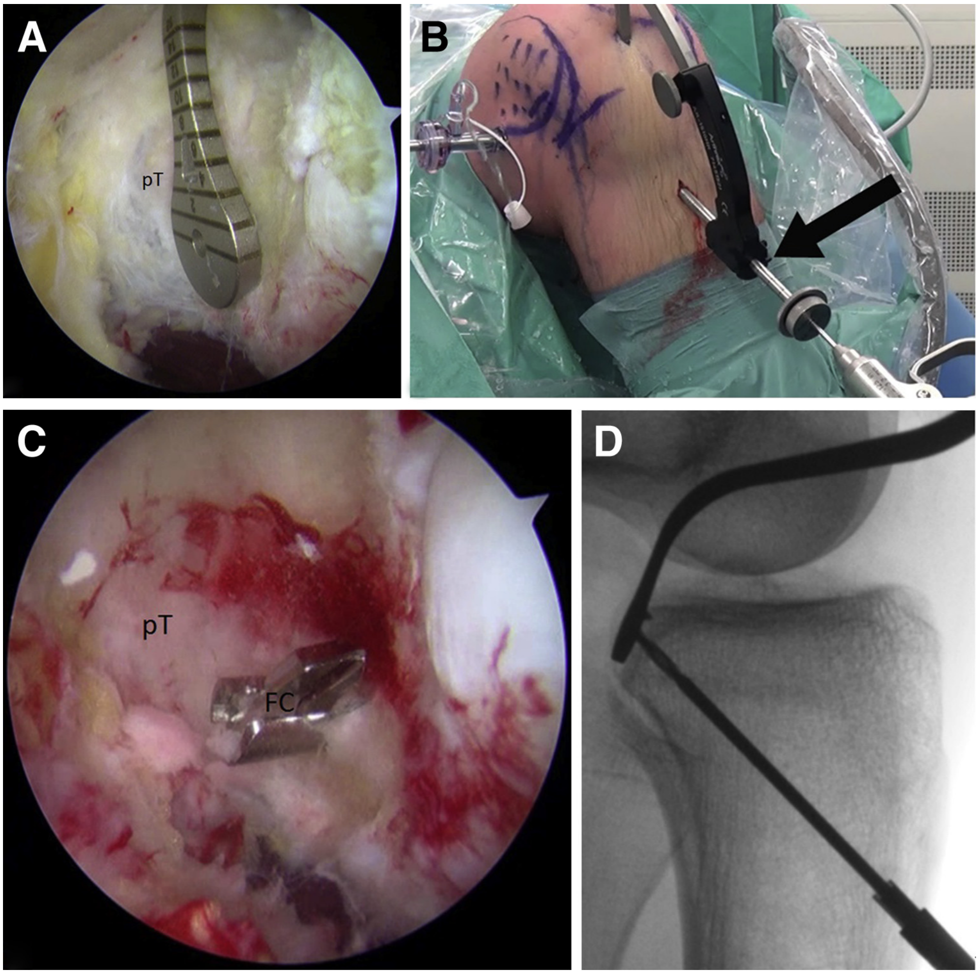

Fig 6. Tibial socket preparation. (A) Arthroscopic view of the posterior side of the proximal tibia (pT) of the left knee with the 30° arthroscope in the posteromedial portal. A dedicated tibial posterior cruciate ligament (PCL) guide is placed in the center of the tibial PCL attachment. (B) The tibial bone bridge is measured with the calibrated sleeve of the tibial guiding device (arrow). The minimum length of the tibial socket is as follows: total graft length − estimated intra-articular length of the graft − 15-mm femoral socket length + 15 mm for correction of calculation error and tensioning. The residual tibial bone bridge after drilling the tibial socket should be at least 10 mm. (C) Arthroscopic view of the left knee with the 30° arthroscope in the posteromedial portal. Using a FlipCutter (FC), the tibial socket is reamed to its calculated length under the arthroscopic and fluoroscopic view to evaluate drill guide placement and drill advancement to the pT. (D) Direct lateral fluoroscopic view of the left proximal tibia to evaluate drill guide placement and drill advancement to the posterior tibial cortex.

Graft Tensioning and Tibial Fixation

With both tibial TightRopes adjusted to the same length, their strands are passed in the slots of a precontoured cortical suspensory button (Dog Bone; Arthrex). The button is held in the end of both loops during simultaneous shortening of both tibial TightRopes, until the button is loosely approximated against the tibial cortex (Fig 12). While applying an anterior drawer force, both tibial TightRopes are shortened individually in their corresponding flexion angles so the grafts are advanced in the tibial tunnel until the desired graft tension is obtained. The *marked* TightRope (ALB graft) is tensioned in 90° to 105° of flexion, and the *unmarked* TightRope ABS (PMB graft) is tensioned in 0° of flexion[1,7] (Fig 13). Correct tension is verified under the arthroscopic view (Fig 14).

Postoperative Care

A standard PCL rehabilitation protocol is used,[8] which includes a PCL Jack brace full time for a period of 12 weeks and during activities for a period of at least 24 weeks, a non−weight bearing period with crutches of 6 weeks, and avoidance of isolated hamstring exercises for the period of 4 months. Return to sports is expected no sooner than 9 to 12 months postoperatively.

Discussion

In most PCLR, full femoral (inlay technique) or femoral/tibial (transtibial technique) tunnels are

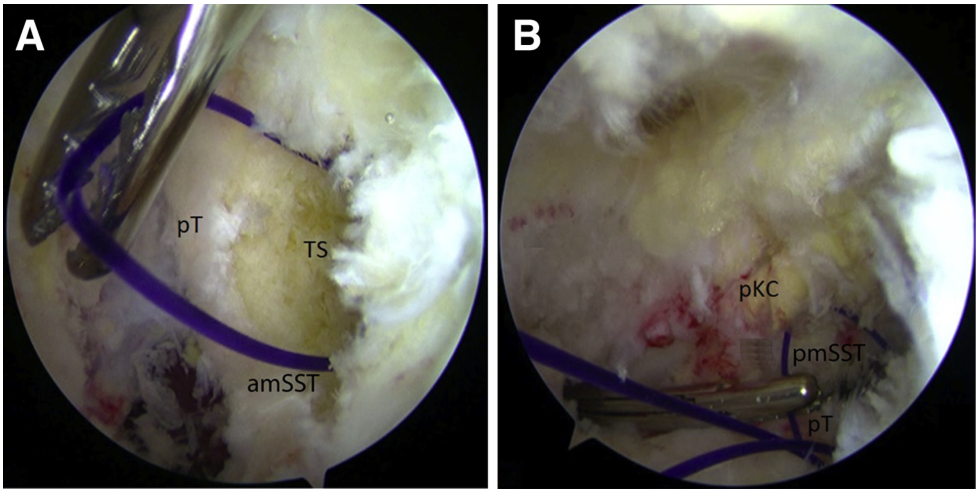

Fig 7. Tibial suture shuttle placement. Two suture shuttles are passed through the tibial tunnel. (A) Arthroscopic view of the tibial socket (TS) at the posterior side of the proximal tibia (pT) of the left knee, with the 30° arthroscope in the posteromedial portal and the arthroscopic grasper in the anteromedial portal. The first suture shuttle is grasped and exits the joint through the anteromedial portal (amSST). (B) Arthroscopic view of the posterior side of the pT and posterior knee capsule (pKC) of the left knee, with the 30° arthroscope in the anterolateral portal and the arthroscopic grasper in the posteromedial portal. The second suture shuttle is grasped and exits the joint through the posteromedial portal (pmSST).

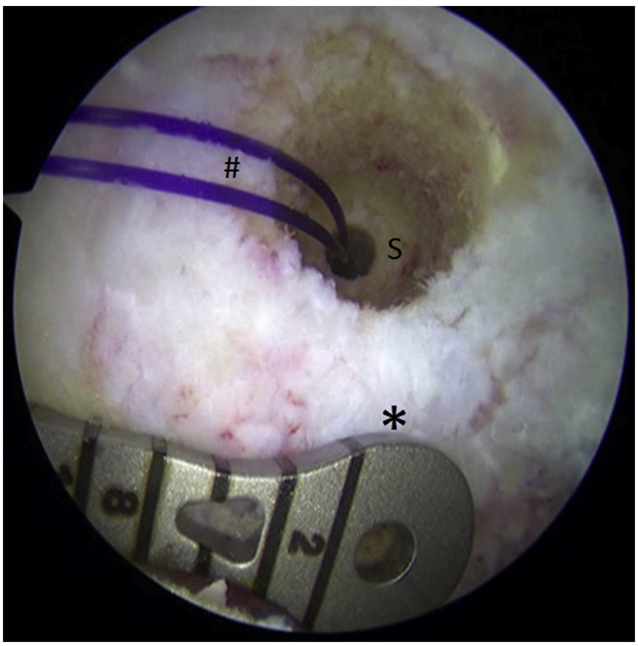

Fig 8. Femoral socket preparation. The arthroscopic view of the left knee with the 30° arthroscope in the anterolateral portal, viewing the lateral side of the medial femoral condyle. Using a FlipCutter, a socket (S) with a length of 15 mm was reamed at the femoral attachment of the anterolateral bundle of the posterior cruciate ligament (PCL) and a suture shuttle was placed (#). A dedicated femoral PCL guide (*) is placed in the center of the femoral attachment of the posteromedial bundle. One suture shuttle is passed through each femoral tunnel.

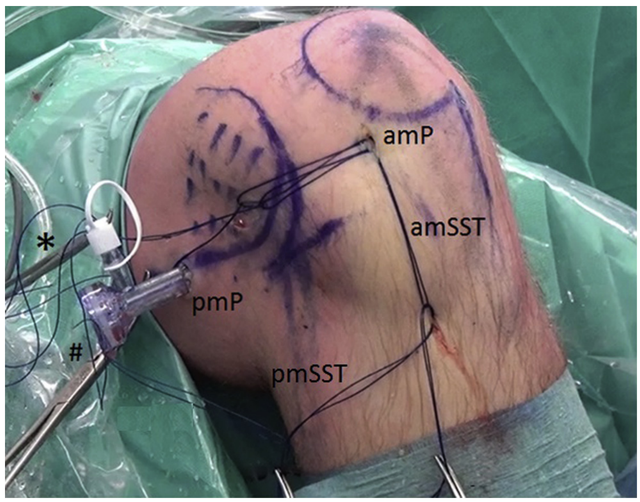

Fig 9. Suture shuttle overview. Anteromedial view of the left knee with an overview of the suture shuttles. One suture shuttle was passed through each femoral tunnel and both suture shuttles exit the joint through the anteromedial portal (amP). The suture shuttle in the femoral anterolateral bundle tunnel (alSSF) is marked with a larger clamp (#) compared with the suture shuttle in the femoral posteromedial bundle tunnel (pmSSF), which is marked with a smaller clamp (*) to keep them apart. Two suture shuttles were passed through the tibial tunnel; one (pmSST) exits the joint through the posteromedial portal (pmP) and one (amSST) through the amP.

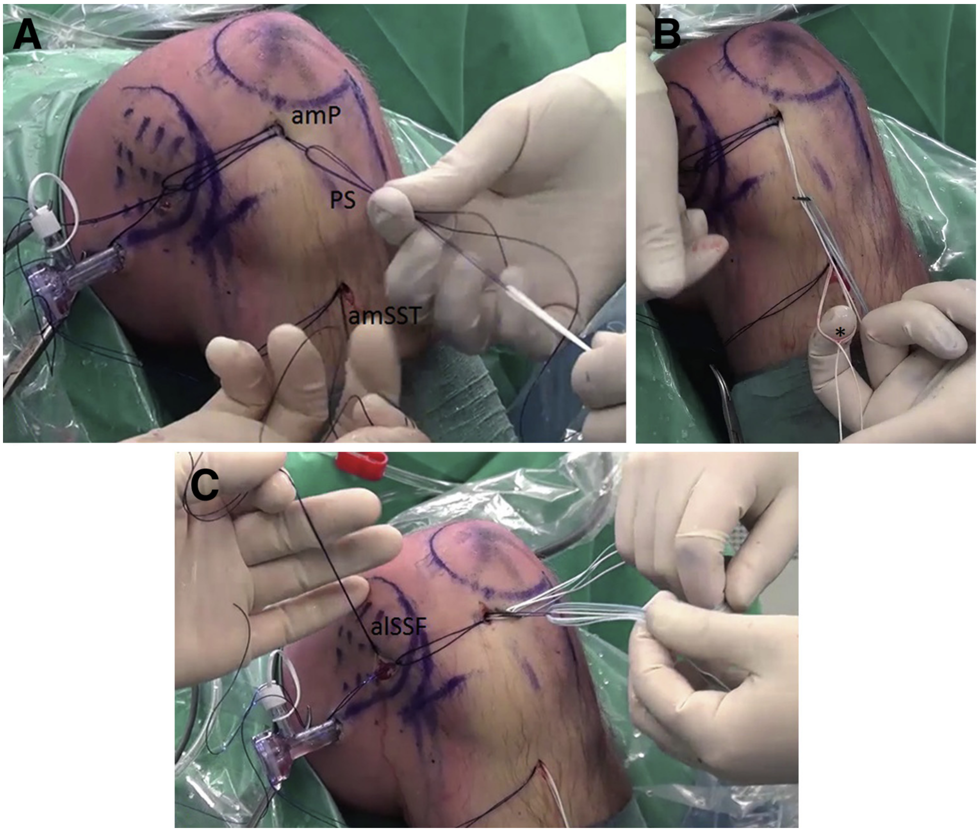

Fig 10. Graft advancement and femoral fixation. Anteromedial view of the left knee. (A) Starting with the anterolateral bundle (ALB) graft, the marked TightRope Attachable Button System (ABS) is loaded with a passing suture (PS), and shuttled through the tibial tunnel with the tibial suture shuttle (amSST) that exits the joint from the anteromedial portal (amP). (B) The TightRope ABS is pulled through and out of the tibial tunnel and the graft is advanced into the tibial socket by pulling the loop (and not the shortening strands!) of the TightRope (*). (C) Next, the previously marked femoral-sided TightRope (ABS or Reverse Tension) is shuttled through the femoral ALB tunnel with the corresponding suture shuttle in the ALB tunnel (alSSF) and the cortical suspensory button of the TightRope is flipped and placed against the cortex of the medial femoral condyle. The femoral-sided TightRope is shortened until the graft is bottomed out in the femoral ALB socket. The same procedure is repeated for the posteromedial bundle graft with its unmarked TightRopes.

reamed; in addition, a posterior arthrotomy of the knee is sometimes performed (inlay technique). Because the femoral insertion of the ALB and PMB of the PCL is broad and the tibial insertion is more compact, in DB PCLR, 1 tibial tunnel and 2 femoral tunnels are reamed to replicate the native PCL[9] and the graft is usually Y-shaped. The ALB and PMB are combined and fixed in the tibial tunnel first, after which the ALB and the PMB are tensioned and fixed in their corresponding femoral tunnels and flexion angles independently. Full femoral tunnels do not limit graft tensioning before fixation.

When using an all-inside technique, no full tunnels yet individual sockets are created. The advantages of the all-inside technique are that shorter grafts can be used and tendons can be quadrupled. Consequently, a DB PCLR can be performed with 2 autologous grafts arthroscopically. A DB PCLR is favored over a single-bundle PCLR in clinical and biomechanical studies,[7,9-13] and autografts are associated with less residual laxity compared with allografts.[14] Furthermore, the all-inside technique provides independent outside-in socket reaming and is soft tissue, cortex, and bone sparing because no full diameter tunnels but sockets are reamed with a small diameter guide pin, which can transform into a retrograde drill (FlipCutter, Arthrex).[2]

Although the all-inside technique has many advantages, sockets instead of full tunnels could lead to bottoming out of the graft.[15] In contrast to the femoral side, where the sockets have short length because of the short bone bridge of the medial femoral condyle, the bone bridge between the tibial attachment of the PCL and the anteromedial cortex of the tibia is long, and therefore a long tibial socket can be achieved. This leaves sufficient room for tensioning of the graft in the tibial socket, with a much lower chance of the graft bottoming out in the tibial socket compared with tensioning of the graft in the femoral sockets. This will avoid the occurrence of residual laxity after the

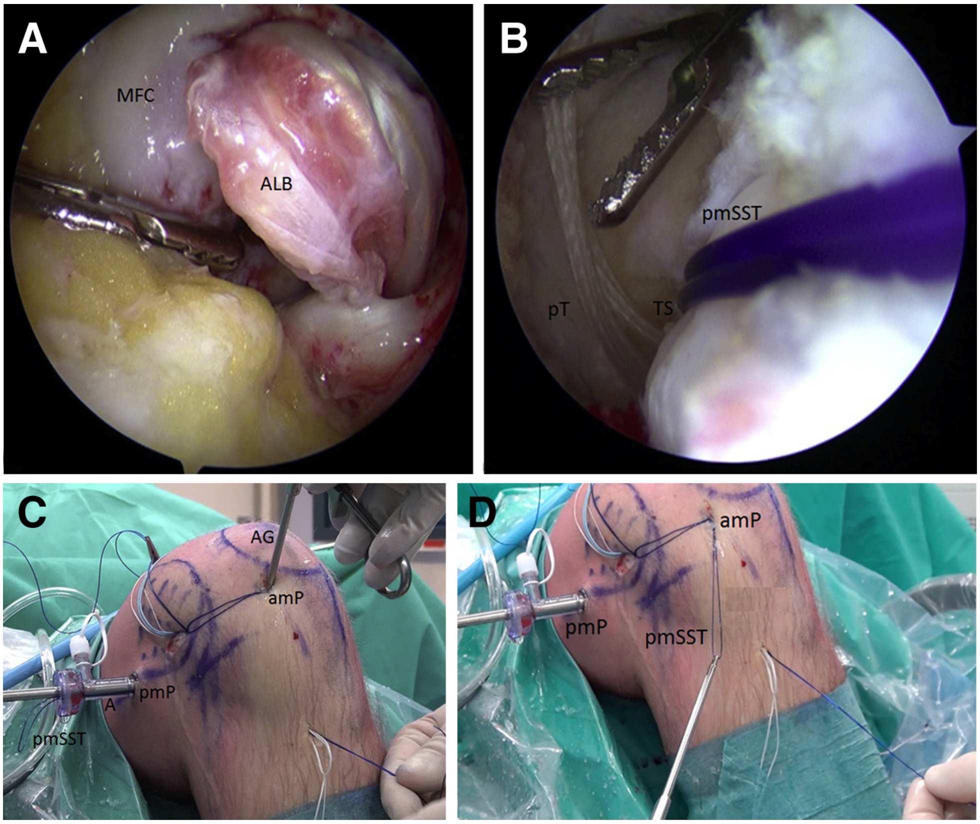

Fig 11. Relocation of the tibial suture shuttle from the posteromedial to the anteromedial portal. (A) Arthroscopic view of the left knee with the 30° arthroscope in the anterolateral portal, viewing the lateral side of the medial femoral condyle (MFC). The arthroscopic grasper is passed to the posterior side of the knee medially to the anterolateral bundle (ALB) graft. (B) Arthroscopic view of the tibial socket (TS) at the posterior side of the proximal tibia (pT) of the left knee, with the 30° arthroscope in the posteromedial portal and the arthroscopic grasper in the anteromedial portal. The remaining tibial suture shuttle that exits the joint from the posteromedial portal (pmSST) is grasped with the arthroscopic grasper. (C) Anteromedial view of the left knee in (B), with the 30° arthroscope (A) and the remaining tibial suture shuttle (pmSST) in the posteromedial portal (pmP) and the arthroscopic grasper (AG) in the anteromedial portal (amP). (D) The remaining tibial suture shuttle (pmSST) is relocated from the pmP to the amP passing the ALB graft on the medial side (so the posteromedial bundle graft is advanced in the tibial socket medial and posterior to the ALB graft to replicate the anatomic tibial orientation of the bundles).

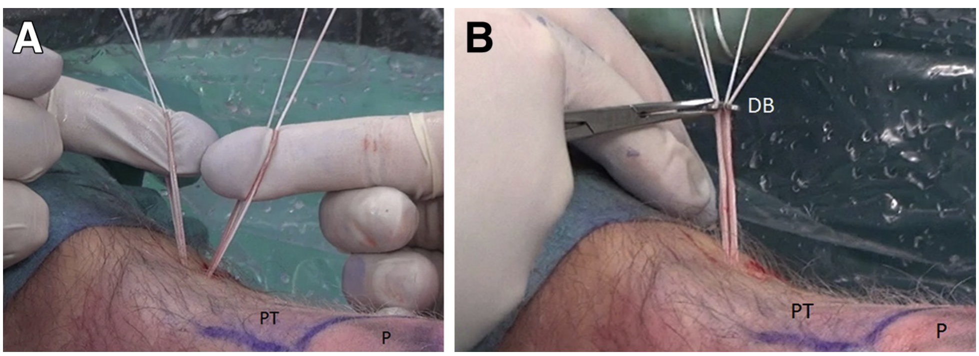

Fig 12. Tibial button placement. Anterolateral view left knee. (A) Both tibial TightRopes are adjusted to the same length. (B) The strands of both tibial TightRopes are passed in the slots of a precontoured cortical suspensory button (Dog Bone [DB]; Arthrex). The button is held at the end of both loops during simultaneous shortening of both tibial TightRopes until the button is loosely approximated against the tibial cortex. Also marked patella (P) and patellar tendon (PT).

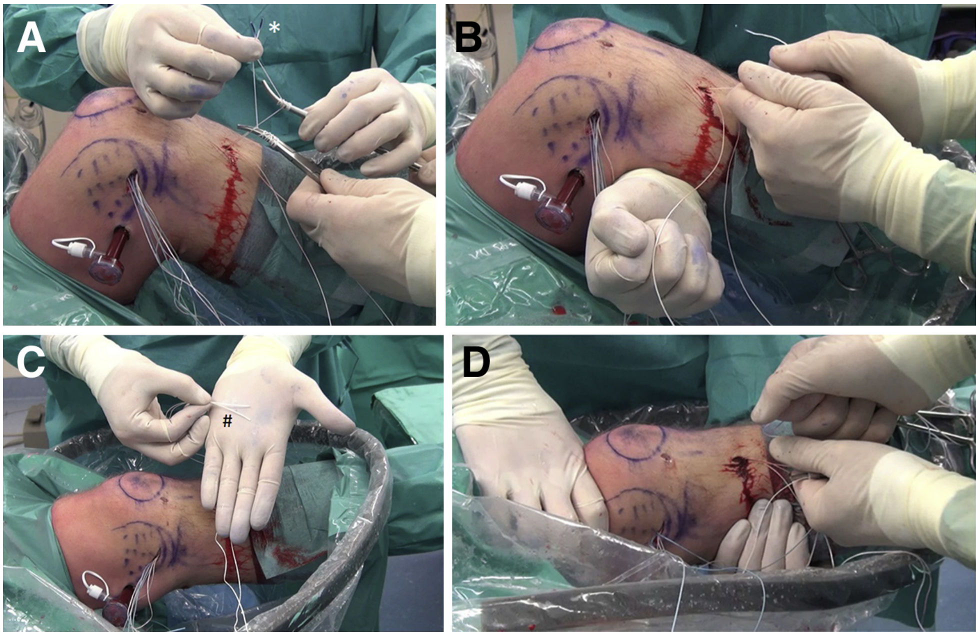

Fig 13. Graft tensioning and tibial fixation. Medial view of the left knee. Both tibial TightRopes are shortened individually in their corresponding flexion angles so the grafts are advanced in the tibial tunnel until the desired graft tension is obtained. (A) The marked TightRope of the anterolateral bundle (ALB) graft (*) is tensioned in 90° to 105° of flexion. (B) Tensioning of the ALB graft is performed while applying an anterior drawer force. (C) The unmarked TightRope Attachable Button System of the posteromedial bundle (PMB) graft (#) is tensioned in 0° of flexion. (D) Tensioning of the PMB graft is performed while applying an anterior drawer force.

reconstruction. Also, when fixing the grafts on the femoral side first, the short femoral sockets are fully filled with graft substance. However, graft tensioning in a single tibial socket after graft fixation in the femoral sockets does dictate the use of 2 separate grafts, because individual tensioning of the ALB and the PMB at different flexion angles is not possible on the tibial side when a Y-shaped graft is used. In addition, both grafts are fixed inside 1 tibial socket and to only 1 cortical suspension button, and can be independently tensioned in their corresponding flexion angle after fixation of the graft in their femoral sockets (Table 1).

All-inside PCLR techniques were described earlier,[16-19] but reported single-bundle procedures[16-18] or the use of allografts.[18] Furthermore, the 2 papers reporting a DB all-inside PCLR fail to address the independent

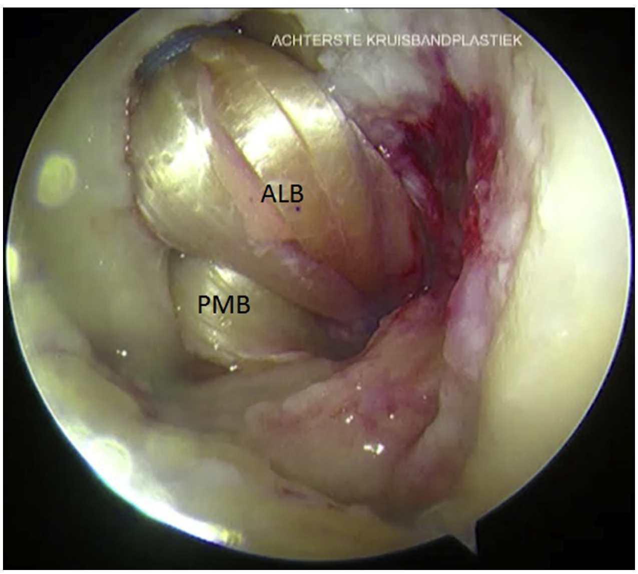

Fig 14. Arthroscopic verification of correct graft tension. Arthroscopic view of the knee, with the arthroscope in the anterolateral portal viewing the lateral side of the medial femoral condyle and the anterolateral (ALB) and posteromedial (PMB) posterior cruciate ligament grafts. Graft tension can be verified with a probe.

Table 1. Pitfalls and Pearls

Pearls	Pitfalls
Mark both TightRopes of the anterolateral bundle graft; leave TightRopes of posteromedial bundle graft unmarked	Correct calculation of the graft and tunnel length
Pull TightRope Attachable Button System loop, and not the shortening strands	Leaving sufficient tibial bone bridge while having enough tibial socket length
Electric leg holder	Insufficient graft length (30 cm)
Posteromedial portal for direct visualization of tibial attachment, drill guide, and FlipCutter	Suture-shuttle management
	Tension correct graft in corresponding flexion angle

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Autologous graft	All-ligamentous grafts do not address the killer angle
Less invasive, all-inside technique	
Safe, low risk of neurovascular complications	
Individual graft tensioning in the corresponding flexion angle	
No risk of graft bottoming out in sockets	

tensioning of the grafts in their corresponding flexion angles,[19] or tensioning is performed in the femoral socket,[16] which might lead to bottoming out of the graft and residual laxity as we previously described.

In summary, we describe an anatomic all-inside DB PCLR technique using 2 separate, individually tensioned autologous grafts, which is a simple to use, less invasive, and safe technique for PCLR (Table 2).

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