Operative Orthopädie und Traumatologie

Operative Techniken

Oper Orthop Traumatol 2021 · 33:445–455
https://doi.org/10.1007/s00064-021-00708-9
Received: 25 April 2020
Revised: 15 September 2020
Accepted: 26 November 2020
Published online: 3 June 2021

Christian Konrads · Stefan Döbele · Atesch Ateschrang · Valeska Hofmann · Sufian S. Ahmad
Department of Trauma and Reconstructive Surgery, BG Klinik, University of Tübingen, Tübingen, Germany

Posterior cruciate ligament reconstruction using a septum-preserving technique

Introductory remarks

Posterior cruciate ligament (PCL) reconstruction has always been a technically more demanding procedure compared to ACL reconstruction. With the improved understanding of the peripheral knee stabilizers, knee reconstruction is becoming more complex and demands consideration of the four corners of the knee. Therefore, PCL reconstruction frequently represents only a portion of the procedure that should be performed in a simple and efficient technique in a reasonable time [1].

Severe posterior instability >10 mm due to an insufficient PCL deteriorates knee biomechanics and can lead to posttraumatic arthritis not only in the femorotibal compartments but also in the femoropatellar compartment because patellofemoral joint reaction forces are elevated in a PCL-deficient knee due to the posterior sag of the tibia.

The anterolateral bundle of the PCL is considered to be more important than the thinner posteromedial bundle. Among other passive stabilizers the posteromedial bundle of the PCL becomes taut in knee extension, but the most important function of the PCL is stabilizing the tibia against posterior translation in flexion. Single bundle reconstruction of the anterolateral PCL bundle is accepted as a standard procedure. It can be performed faster than a double bundle PCL reconstruction and this time factor is relevant as these patients often have multiligament injuries.

For PCL reconstruction, opening the septum is not necessary. The trans-septum technique is more traumatic, time-consuming, and endangers the neurovascular structures. The septum sparing technique is presented with focus on certain important landmarks like the champagne-glass drop-off and the shiny white fibers.

Surgical principle and objective

The technique described here is based on a septum-sparing approach for single-bundle anterolateral reconstruction of the PCL that is technically reproducible. The surgical steps to simplify the technical aspects of the procedure are illustrated.

Advantages

The advantage of the reconstruction technique presented here can be seen in the reproducibility and simplicity of the technique, alongside sufficient surgical exposure. A posterolateral portal is not needed, operation time is reduced, and the neurovascular structures are securely spared.

Disadvantages

The method is optimized for a single-bundle reconstruction. Therefore, it is mostly suitable when combined with reconstruction of the posterolateral or posteromedial corner. This allows for restoration of rotational stability. The technique is less suitable for the fixation of bony avulsions.

Indications

- A complete grade III symptomatic tear of the PCL (Harner classification). It might be associated with discomfort (deceleration, stairs) or subsequent gonalgia arising from the medial compartment or patellofemoral joint [2, 3].
- Injury of the peripheral joint stabilizers alongside the PCL including the posterolateral corner or a complete medial knee injury.
- Posterior translation of the proximal tibia >10 mm (Harner grade III) compared to the contralateral side in posterior stress x-rays.
- In the acute setting: complete intraligamentous PCL tear with dislocated ligament stumps and grade III instability (Harner classification).

Contraindications

- Bony avulsions of the PCL suitable for refixation
- Soft tissue compromise
- Infection
- Advanced osteoarthritic disease
- Dysfunctional joint

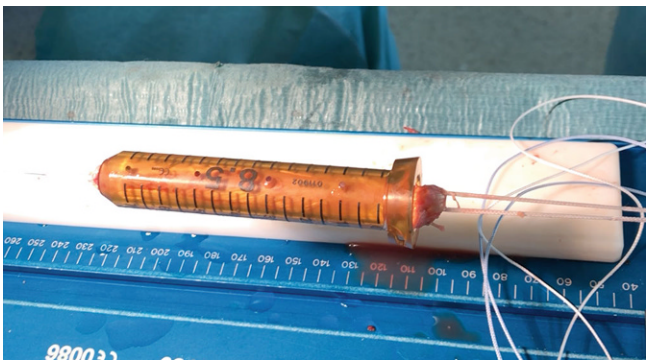

Fig. 1 ◀ Graft tube set. For downsizing the graft via compression

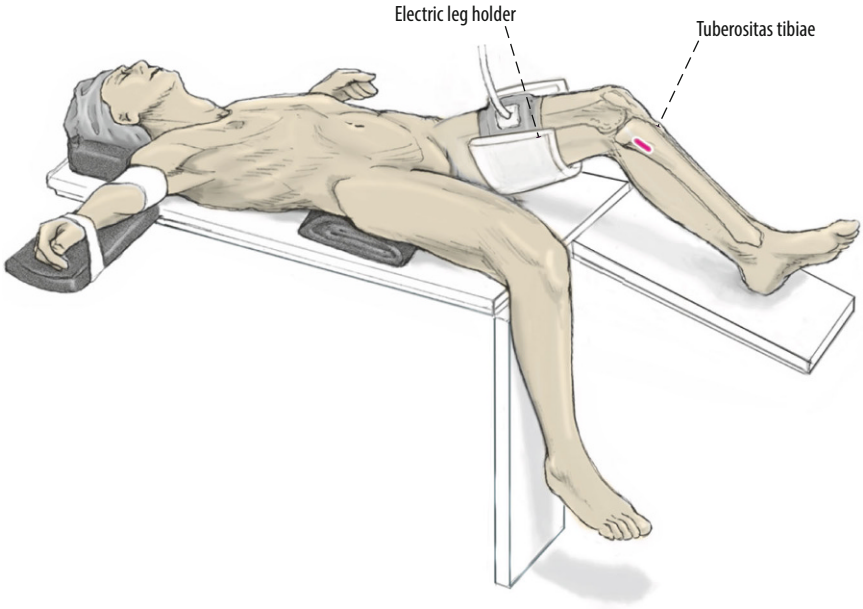

Fig. 2 ▲ Positioning of the patient in the operating room

- Chronic fixated posterior sag: before PCL reconstruction, a reduction by an orthosis for 8 weeks is needed!

Patient information

- General surgical complications associated with thrombosis and infection, sensation issues around the wound sites.
- Injury of the neurovascular structures (popliteal artery) that are at risk when reaming the tibial tunnel.
- Graft re-rupture
- Donor site morbidity in the case of autogenous graft utility
- Necessity of a postoperative rehabilitation program

Preoperative workup

- Patient history must take into account patient symptoms and physical demand.
- It is important to perform a detailed examination of the knee joint that should include testing the integrity of the PCL by clinically grading posterior translation.
- Determine the presence of a lateral or medial injury.
- Evaluate the posterolateral and posteromedial corners. A PCL injury is a combined injury until proven otherwise.
- Magnetic resonance imaging (MRI) is necessary in the overall workup and is particularly valuable in the acute setting due to its high sensitivity [4].
- Stress radiographs present an important tool to determine and objectify the location of lesions, especially in the case of multiple ligamentous laxity. Stress radiography help greatly in determining the corner requiring reconstruction in addition to the PCL. A variety of protocols and gapping thresholds have been published throughout the years [5]. Therefore, regardless of the technique used to perform stress radiography, the method should be standardized and repetitively applied [5]. It is recommended to perform stress radiographs for preoperative planning in all nonacute cases.
- We perform anterior and posterior, lateral and medial stress radiographs of both knees. Regarding the PCL, a posterior translation of the proximal tibia >10 mm is an indication for reconstruction.
- For PCL reconstruction, we use the ipsilateral hamstrings. In multiligament injuries, we use allografts (tibialis anterior tendon).

Instruments and implants

Instruments required for the procedure include a blade, a tendon stripper, a 30° scope, an arthroscopy set with trocar, shaver, probe and arthroscopic grasper. A PCL reconstruction set including beath pins, cannulated reamers and aiming devices (many suppliers available). A graft tube set for downsizing of the graft (Arthrex, Naples, FL, USA; ◘ **Fig. 1**) is optional. A femoral suspension device for femoral fixation as well as bioabsorbable interference screws and a tibial button are necessary.

Anesthesia and positioning

- General or spine anesthesia
- Supine position
- Use of a nonsterile tourniquet
- Positioning the leg in a leg holder (◘ **Fig. 2**)
- Positioning the contralateral leg in a flexed position to allow freedom of movement around the knee during surgery (◘ **Fig. 2**).

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C. Konrads · S. Döbele · A. Ateschrang · V. Hofmann · S. S. Ahmad

Posterior cruciate ligament reconstruction using a septum-preserving technique

Abstract

Objective. Description of a reproducible surgical technique for single-bundle anterolateral reconstruction of the posterior cruciate ligament (PCL) based on a septum-sparing approach. This technique is less traumatic than the trans-septum approach. The article illustrates surgical steps to simplify the technical aspects of the procedure.
Indications. A complete grade III symptomatic tear of the PCL associated with instability and often discomfort (deceleration, stairs) or subsequent gonalgia arising from the medial compartment or patellofemoral joint. Injury of the peripheral joint stabilizers alongside the PCL including the posterolateral corner or a complete medial knee injury. The procedure is indicated in chronic cases, but also in acute cases of posterior instability > 10 mm, if it is an intraligamentous tear with dislocated PCL stumps.
Contraindications. Bony avulsions of the PCL suitable for refixation, soft tissue compromise, infection, advanced osteoarthritic disease.
Surgical technique. After diagnostic arthroscopy of the knee, the ipsilateral semitendinosus and gracilis tendons are harvested and prepared as a 6-strand graft for PCL reconstruction. One high anterolateral viewing portal, one low anterolateral portal, one anteromedial portal, and a posteromedial portal are used for single-bundle reconstruction via one femoral and one tibial bone tunnel and hybrid graft fixation.
Postoperative management. Weight bearing is restricted to 20 kg for 6 weeks. PCL brace with tibial support for a period of 12 weeks. Flexion is limited to 30° in the first 2 postoperative weeks, then 60° for 2 weeks, and 90° for 2 further weeks. Passive flexion in prone position is performed. Active focused muscle strengthening exercise is begun after 6 weeks postoperatively and participation in competitive sports is not recommended before full muscle strength and coordination is re-established, at the earliest 9–12 months postoperatively.
Results. Two isolated and 19 combined PCL injuries were treated. Mean patient age was 27.4 years, and the minimal follow-up was 12 months. On average, we found good clinical outcome with slight degree of posterior laxity (4.1 mm) after PCL reconstruction in comparison with the contralateral knee. No patient showed signs of effusion at follow-up. Range of motion was fully restored in 19 of 21 patients. One patient suffered failure due to persistent posterior instability and persistence of symptoms.

Keywords

Knee · Instability · Posterior cruciate ligament · Posterior sag · Minimally invasive surgical procedures

Ersatzplastik des hinteren Kreuzbands in septumerhaltender Technik

Zusammenfassung

Operationsziel. Beschreibung einer reproduzierbaren Operationstechnik zur einsträngigen anterolateralen Rekonstruktion des hinteren Kreuzbandes (HBK) auf der Grundlage eines septumerhaltenden Zugangs. Diese Technik ist weniger traumatisch als der transseptale Zugang. Der Beitrag veranschaulicht die Operationsschritte zur Vereinfachung der technischen Aspekte des Verfahrens.
Indikationen. Eine vollständige, drittgradige und symptomatische HBK-Ruptur, verbunden mit einem Instabilitätsgefühl und häufigen Beschwerden (Dezeleration, Treppensteigen) oder anschließender, vom medialen Kompartiment oder Patellofemoralgelenk ausgehender Gonalgie. Verletzung der peripheren Gelenkstabilisatoren neben dem HKB einschließlich der posterolateralen Zone oder eine komplette mediale Knieverletzung. Der Eingriff ist indiziert bei chronischen Fällen, aber auch bei akuter posteriorer Instabilität > 10 mm, wenn es sich um eine intraligamentäre Ruptur mit dislozierten PCL-Stümpfen handelt.
Kontraindikationen. Knöcherne HKB-Ausrisse, die sich refixieren lassen, ausgeprägter Weichteilschaden, Infektion, fortgeschrittene Gonarthrose.
Operationstechnik. Nach diagnostischer Arthroskopie des Kniegelenks Entnahme der ipsilateralen Semitendinosus- und Gracilissehne als 6-fach-Graft zur HKB-Rekonstruktion. Anlage eines hohen anterolateralen Arthroskopieportals sowie weiterer Arbeitsportale: tief anterolateral, anteromedial und posteromedial. Über die Anlage eines femoralen und eines tibialen Bohrkanals erfolgt die einsträngige Ersatzplastik des HKB mit Hybridfixation des Grafts.
Weiterbehandlung. Teilbelastung 20 kg für 6 Wochen. HKB-Orthese mit tibialer Unterstützung 12 Wochen postoperativ. Flexionslimitierung auf 30° für die ersten 2 Wochen, dann 60° für 2 Wochen, dann 90° für weitere 2 Wochen. Passive Flexion in Bauchlage wird durchgeführt. Training der aktiv-dynamischen Kniegelenkstabilisatoren startet ab der 7. postoperativen Woche. Empfohlen wird, Freizeit- und Wettkampfsport erst wiederaufzunehmen, wenn Kraft und Koordination vollständig wiederhergestellt sind, frühestens 9–12 Monate postoperativ.
Ergebnisse. Zwei isolierte und 19 kombinierte HKB-Verletzungen wurden behandelt. Das durchschnittliche Patientenalter betrug 27,4 Jahre und das minimale Follow-up 12 Monate. Nach HKB-Ersatzplastik fanden wir durchschnittlich gute klinische Ergebnisse mit geringer hinterer Kniegelenklaxizität (4,1 mm) im Vergleich zur gesunden Gegenseite. Bei der Nachuntersuchung zeigte klinisch kein Patient einen Gelenkerguss. Die Beweglichkeit des operierten Kniegelenks war in 19 von 21 Fällen vollständig wieder hergestellt. Ein Patient erlitt ein Graftversagen, was sich anhand einer fortgesetzten posterioren Instabilität und anhaltenden Symptomen bemerkbar machte.

Schlüsselwörter

Knie · Instabilität · Hinteres Kreuzband · Hintere Schublade · Minimal-invasive chirurgische Interventionen

Surgical technique

(◘ Figs. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17)

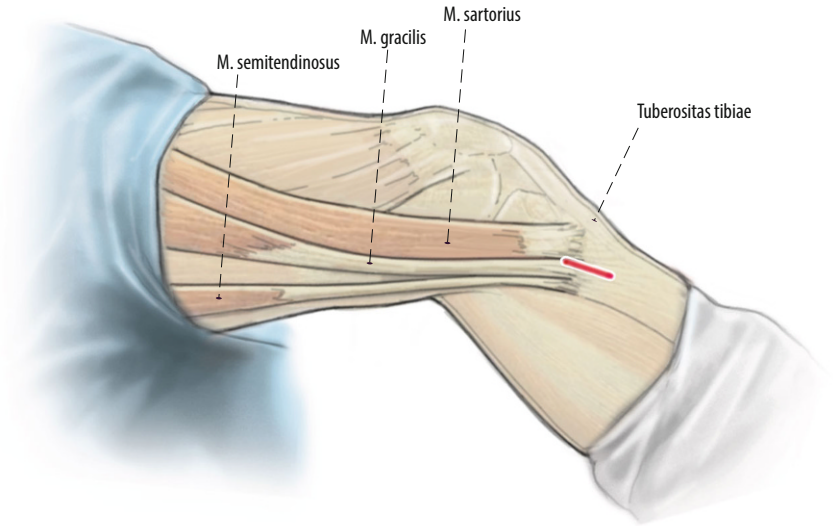


Fig. 3 ▲ For the process of tendon harvesting, a longitudinal incision is made halfway between the tibial tuberosity and the medial border of the tibia [6]. The point in the mid-way should present the proximal border of the incision that should be extended distally to achieve a total incision length of 2–3 cm. In a nutshell, the localization of the longitudinal skin incision is 2 cm medial and distal of the tibial tubercle. The subcutaneous tissue has to be dissected and a vein is frequently encountered and should be coagulated. It is essential to dissect onto the sartorius fascia. This can easily be performed by pulling on the tissue using forceps and dividing the retracted mobile tissue, after which replacement of the two Langenbeck retractors is performed. The process may be repeated one or two times until the non-mobile white vascularized sartorius fascia is definitively identified. Once the sartorius fascia is identified, a blunt instrument (forceps) can be used to roll over the hamstrings to identify the midpoint between the semitendinosus and gracilis tendons. Once this is done, the sartorius fascia is incised between the gracilis and semitendinosus tendons in the direction of these tendons. The gracilis tendon is the most prominent one, lying directly proximal to the distal semitendinosus tendon. The wide sartorius covers both other tendons of the pes. Once the sartorius fascia is incised, the hamstring tendons are easily identified. An Overholt clamp is used to sling the semitendinosus or gracilis tendon. The tendon is separated subperiosteally from the bone using a subperiosteal elevator. By pulling on the tendon, the vinculi and tendon attachments come into view and should be dissected gradually until a rubbery feeling of the tendon is achieved. Both tendons are harvested using a tendon stripper. Both, semitendinosus and gracilis tendons are used for preparation of a PCL graft to achieve sufficient length of 9–11 cm and width of > 8.5 mm. The muscle is stripped off the tendon and the tendons are aligned alongside each other. The thick end of one tendon should be adjacent to the thin end of the other tendon. Absorbable Vicryl suture 2 is used to arm both ends in baseball stitch technique. One end of the 2-stranded tendon is looped through the adjustable loop of the femoral button and clamped mid-way. The tendon is then armed using baseball stitches in this zone

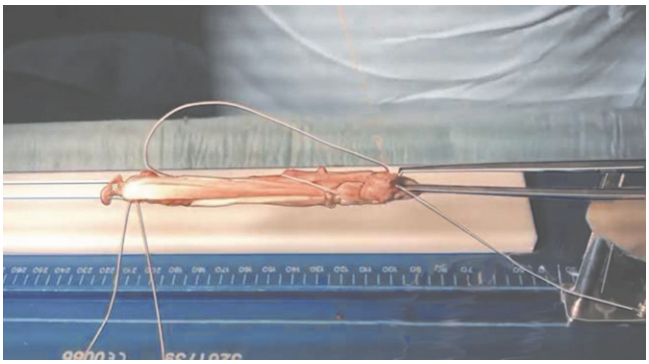


Fig. 4 ▲ The remaining portion of the tendon is now looped through the tibial loop and pulled back towards the femoral adjustable loop, where it is fixed with baseball stitches to achieve a 6-stranded graft

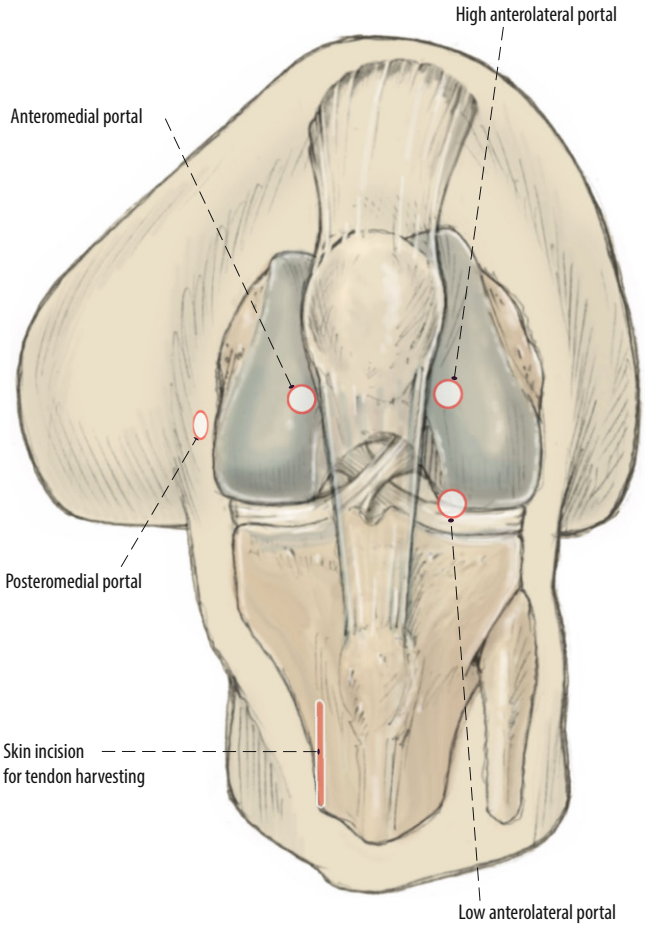
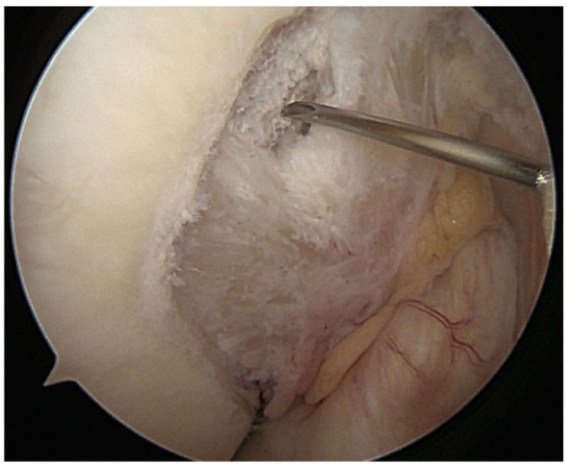
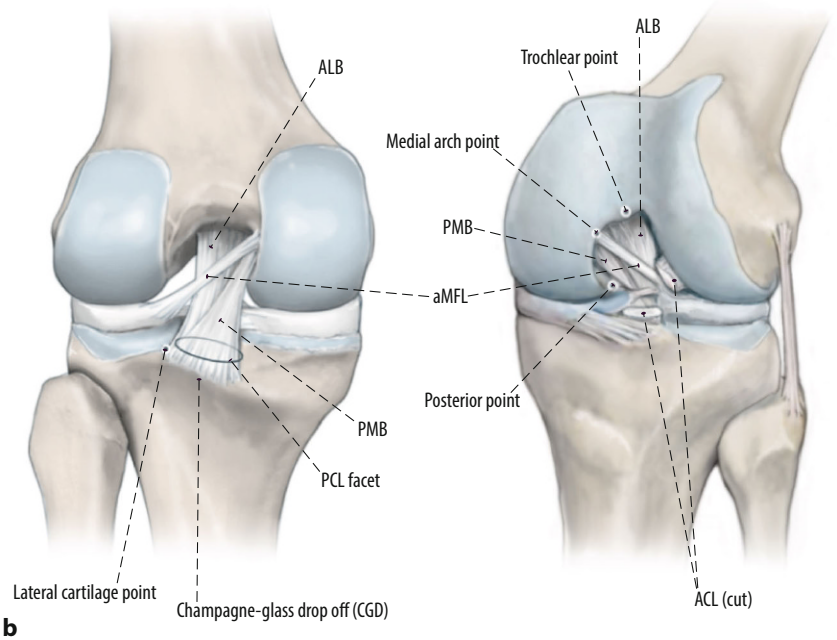


Fig. 5 ▲ Two primary portals are initially required to start the procedure. The first high anterolateral portal (1) should be made in close vicinity to the patella tendon. The anteromedial portal (2) should also be made close to the patella tendon in outside-in technique



a



b

Fig. 6 ▲ Upon placement of the anterolateral viewing portal and the anteromedial working portal and completion of the diagnostic round, the femoral footprint region of the posterior cruciate ligament (PCL) is visualized and debrided in the region of the anterolateral bundle (**a**). This is the area centered between the trochlea point and the medial arc point [7]. *ALB* anterolateral bundle, *aMFL* anterior meniscofemoral ligament, *PMB* posteromedial bundle, *pMFL* posterior meniscofemoral ligament, *ACL* anterior cruciate ligament

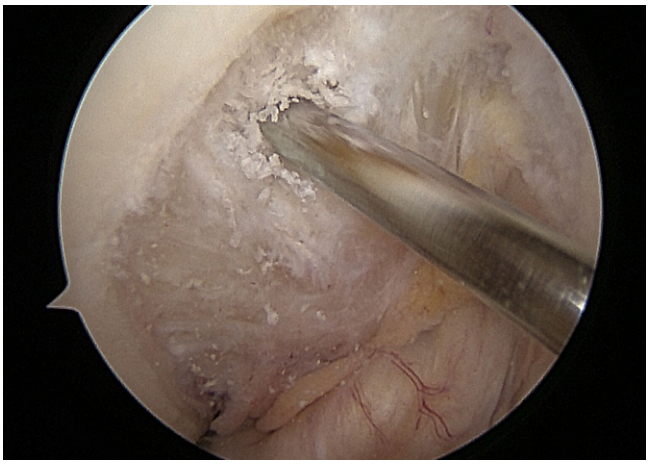


Fig. 7 ▲ Additionally, a deep anterolateral portal is placed for a better drilling angle. A beath pin is then placed through that portal

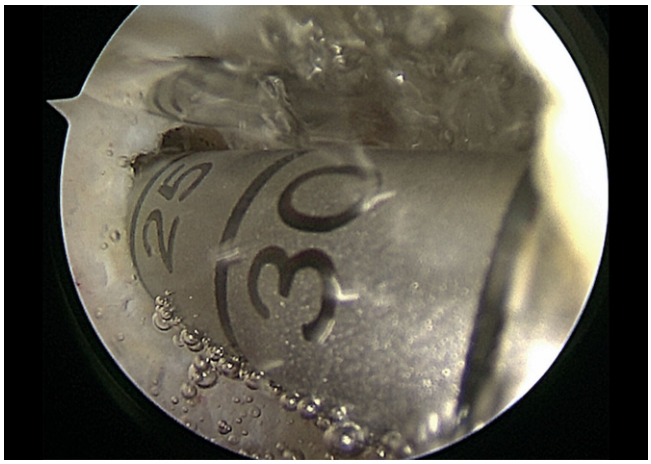


Fig. 8 ▲ A 25 mm femoral tunnel is then drilled over the beath pin and a suture loop is inserted and pulled through the femur using the beath bin

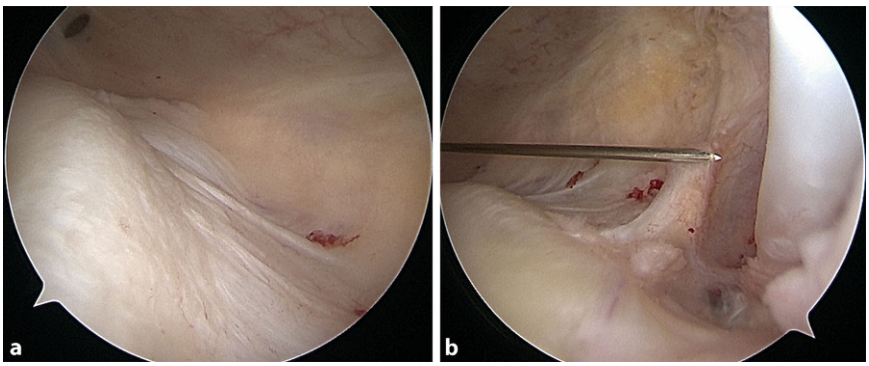


Fig. 9 ▲ It is now important to gain access into the posteromedial gutter (**a**). This may require release of some of the posteromedial posterior cruciate ligament (PCL) fibers to allow access of the scope. The scope can be advanced posterior below the PCL (between medial femoral condyle and PCL) or between PCL and anterior cruciate ligament (ACL) by opening the synovial membrane. A 20 gauge needle should be inserted posteromedially in a proximal and anterior position, just over the capsular fold to allow for a good position to reach the tibial footprint region of the PCL (**b**)

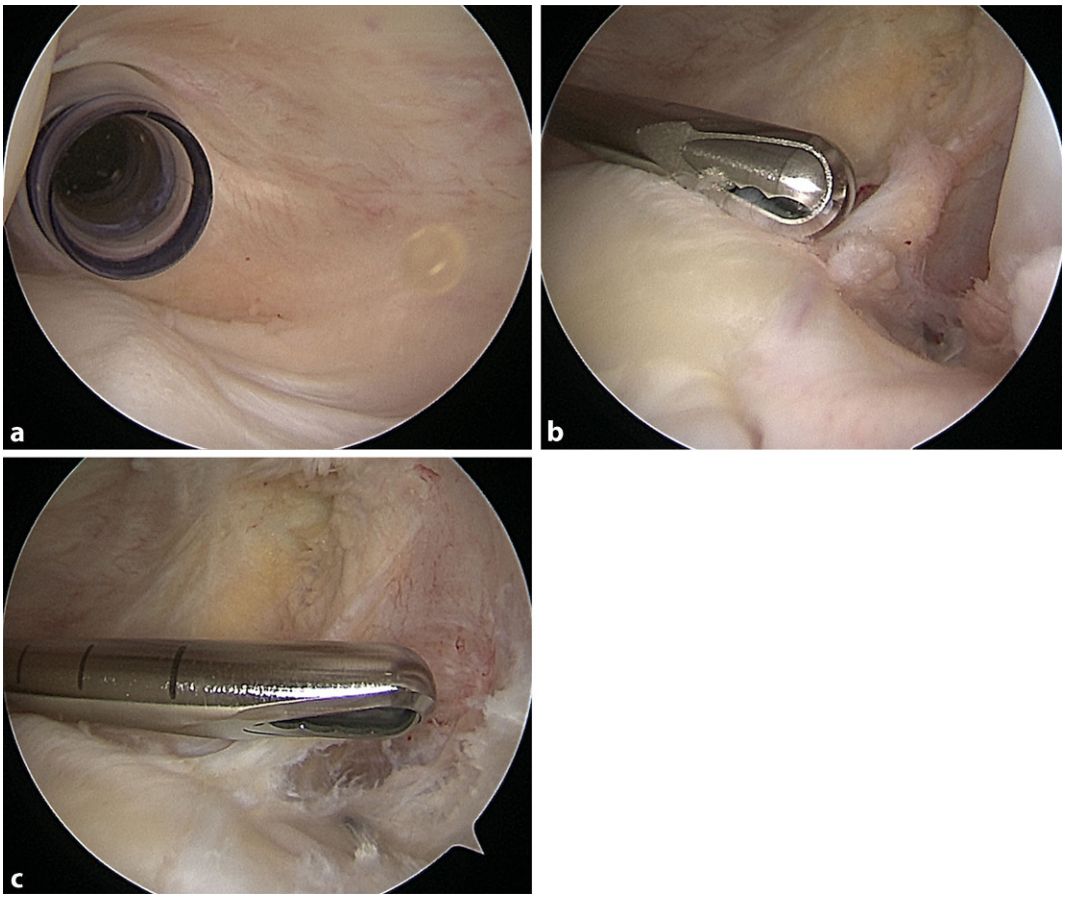


Fig. 10 ◀ An arthroscopy cannula is then placed (**a**) and a shaver is inserted (**b**). The posterior cruciate ligament (PCL) synovium should be debrided in close vicinity to the tibial plateau to allow for exposure of the shiny white fibers of the posterior root of the medial meniscus that present the lighthouse of the anatomic region of interest (**c**)

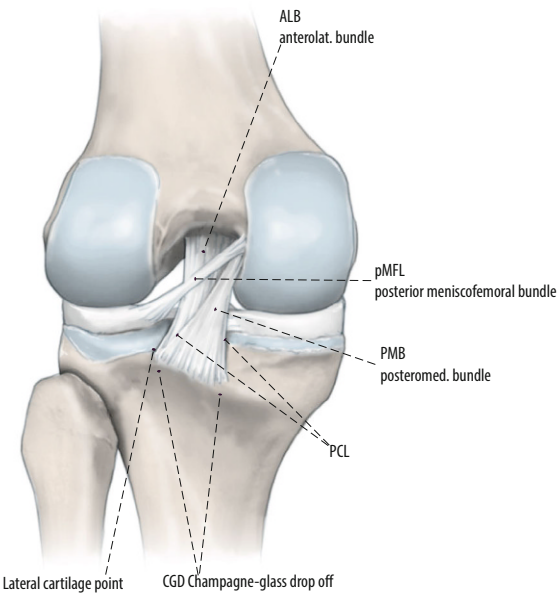


Fig. 11 ▲ The interval between the posterior meniscal attachment and the posterior cruciate ligament (PCL) should be developed towards the so-called champagne glass drop-off (CGD) region. This process may require peeling off the PCL fibers a little bit, developing good sight to the tibial footprint of the PCL without debriding the footprint or the posteromedial fibers of the PCL. *ALB* anterolateral bundle, *PMB* posteromedial bundle, *pMFL* posterior meniscofemoral ligament

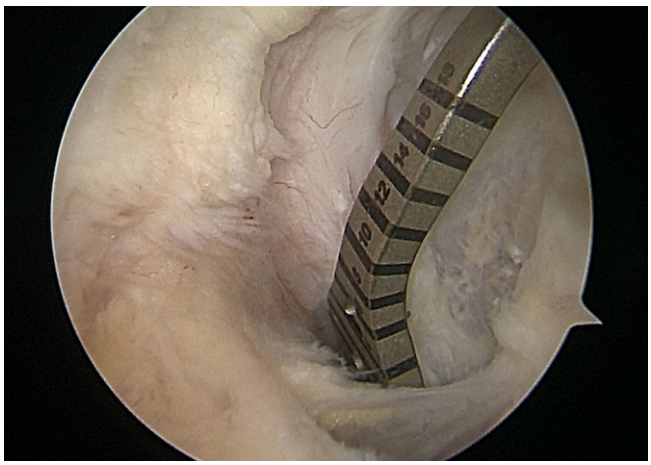


Fig. 12 ▲ A tibial guide is placed through the anteromedial portal between the cruciate ligaments in the correct position with the tip 15 mm distal to the medial meniscus and between both posterior meniscal horns directly above the champagne glass drop-off (CGD). This allows for a wire position 7 mm distal and lateral to the shiny white fibers in the center of the tibial footprint of the posterior cruciate ligament (PCL)

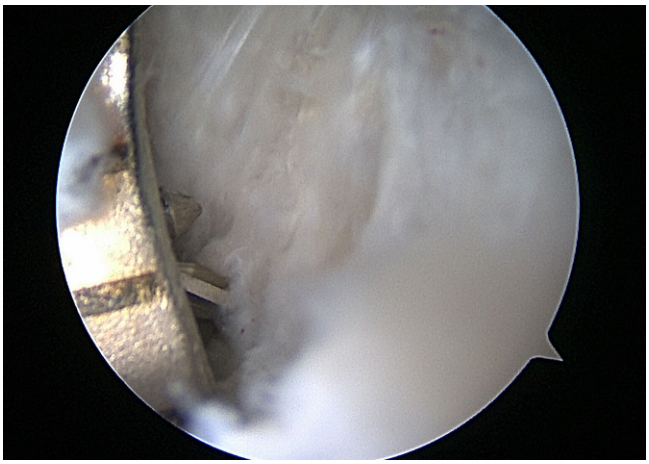


Fig. 13 ▲ The starting position for the tibial tunnel should be rather centered and only slightly medial to the tibial tuberosity. This would allow for a sufficient drilling angle and bony purchase. It is legitimate to drill 0.5 mm larger than the graft width to simplify bringing in the graft. Protection of the neurovascular structures is performed with a curette through the posteromedial portal. The tunnel should be debrided and smoothened using an arthroscopic shaver

Fig. 14 ▲ A suture loop is brought through the tibial tunnel and with the loop distal, the proximal end of the suture is pulled through the anteromedial portal. Visualization is performed through the anterolateral portal

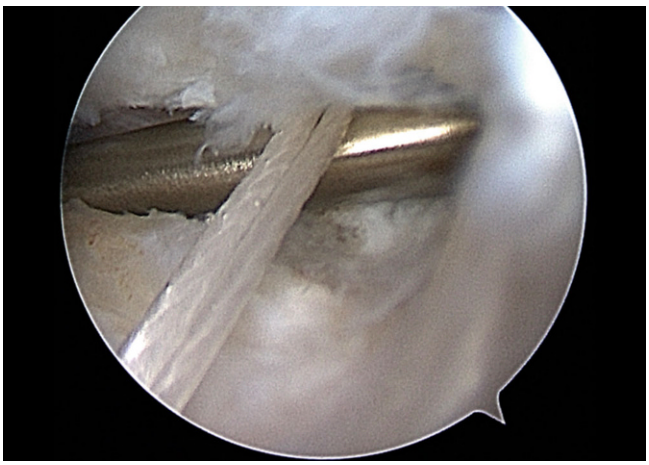


Fig. 15 ▲ The graft is pulled through the tibial tunnel. A rod may be used as a fulcrum through the posteromedial portal to reduce the effect of the killer curve. Beforehand, the killer turn can be smoothened by a special instrument not to risk graft failure at this sharp bony hypomochleon. The graft is finally pulled towards the anteromedial portal

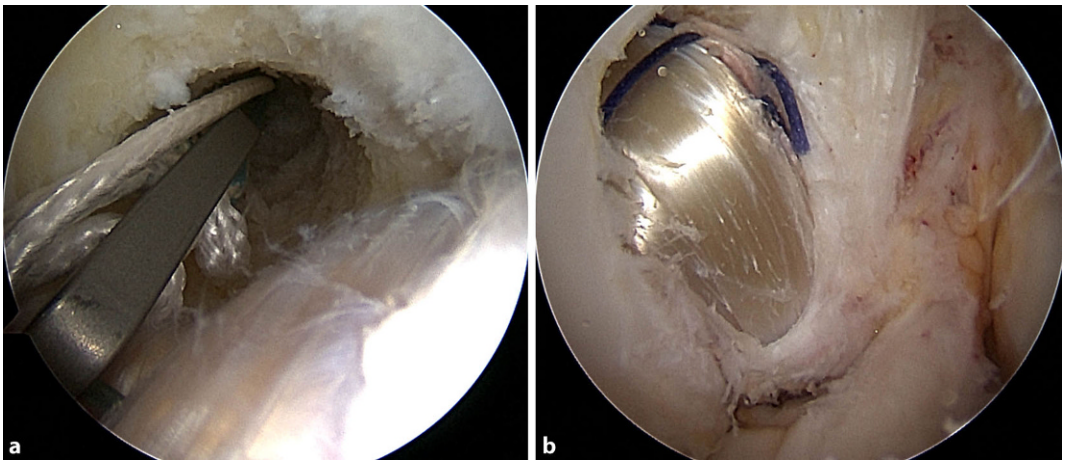


Fig. 16 ▲ The femoral button is then shuttled using the femoral suture loop through the femoral tunnel and flipped under vision through the anterolateral portal (**a**). The graft is then pulled in the femoral tunnel (**b**) using the adjustable femoral loop (TightRope). The graft is tensioned in 90° of flexion and fixed using enough force to reduce the femorotibial step-off correctly. An interference screw equivalent to the tunnel size is used for additional hybrid fixation of the femoral and tibial tunnels. For the tibial tunnel, this process could be controlled by visualization through the posteromedial portal to avoid excessive posterior protrusion of the interference screw through the tibia. An additional tibial button to reinforce tibial fixation is also applied, the wounds are closed, and the leg is put in a static posterior cruciate ligament (PCL) orthosis with tibial support. This orthosis can be used at night during further phases of rehabilitation

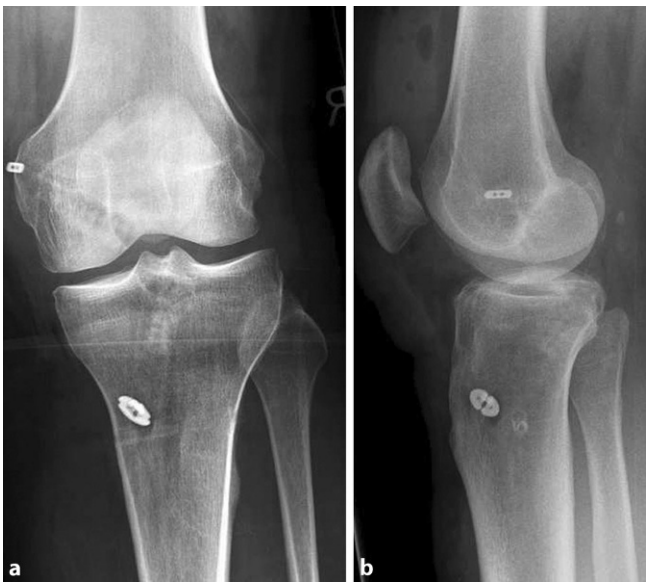


Fig. 17 ◄ Postoperative X-ray control is optional: right knee after posterior cruciate ligament (PCL) reconstruction. Anteroposterior (**a**) and lateral (**b**) views

Special surgical considerations

In the case of a concomitant injury to the medial or lateral side of the knee requiring simultaneous reconstruction, it would be advisable to start the placement of the peripheral tunnels prior to beginning arthroscopy. This would simplify soft tissue dissection and identification of the peroneal nerve. However, it is important to tension the grafts of the central compartment (PCL) first, prior to tensioning the periphery in order to avoid rotational over-constraint [8].

In multiligament injuries, we do not hesitate to use allograft (tibialis anterior tendon). We do not use intraoperative fluoroscopy, but this is always an option to control certain steps of the procedure, especially to control femorotibial reduction.

Postoperative rehabilitation

Patients are all provided with a functional PCL brace for a period of 12 weeks. This brace ideally provides an anterior force that increases with flexion in order to protect the graft during the phase of integration. Flexion is limited to 30° in the first 2 postoperative weeks, then 60° for 2 weeks, and 90° for 2 further weeks. Passive flexion in prone position is performed. Weight bearing is restricted to 20 kg for 6 weeks. Active focused muscle strengthening exercise is begun 6 weeks postoperatively and participation in competitive sports is not recommended before full muscle strength and coordination is re-established, at the earliest 9 to 12 months postoperatively.

Errors, hazards and complications

It is important to appreciate the posterior neurovascular bundle during the procedure. The most dangerous complication in PCL surgery is iatrogenic injury of the popliteal artery. Avoiding a posterior tibial blowout by ensuring correct placement of the tibial tunnel is important to reduce the risk of injury to the neurovascular bundle. The guidewire must be held in place during reaming to avoid protru-

sion into the neurovascular bundle. This could be achieved using a spoon, curette, or clamp.

It is essential to avoid injury to the posterior meniscal root. This is most likely to occur with a tibial tunnel that is too proximal. It is therefore important to identify the shiny white fibers of the posterior root of the medial meniscus and to drill the guidewire at a distance that is sufficiently inferior. The tip of the guidewire should therefore be 7 mm distal and lateral to the shiny white fibers [7].

Results

Between January 2017 and December 2018, 21 patients were treated using this technique. All patients presented at 6 and 12 months for postoperative follow-up. The objective International Knee Documentation Committee Score (IKDC-Score) was measured alongside stress radiographs. Failures were noted.

The mean age of the patients was 27.4. Concomitant ligament injuries were found in 19 patients and included the posterolateral corner, ACL, collateral ligaments.

The surgical time was 72 min in isolated PCL reconstruction and 138 min with combined reconstruction of the posterolateral corner (LaPrade technique) and 127 min with combined reconstruction of the posteromedial corner.

Stress X-rays at last follow-up demonstrated a mean side-to-side posterior translation of 4.1 ± 3.0 mm.

No patient showed signs of effusion at follow-up. Range of motion was fully restored in 19 patients.

One patient suffered failure due to persistent posterior instability and persistence of symptoms.

Overall, the results seemed reproducible with a rather short learning curve. It is known that posterior tibial translation might increase postoperatively over time. This is true especially during the first 12 months postoperatively. A recent study demonstrated no further increasing posterior knee joint laxity in the second year after PCL reconstruction [9]. Finally, we like to emphasize the fact that combined PCL and posterolateral corner injuries are very common and in these highly unstable cases addressing the posterolateral corner injury in addition to PCL reconstruction is important to avoid PCL graft failure [3].

Corresponding address

PD Dr. med. Christian Konrads
Department of Trauma and Reconstructive Surgery, BG Klinik, University of Tübingen
Schnarrenbergstr. 95, 72076 Tübingen, Germany
christian.konrads@gmail.com

Declarations

Conflict of interest. C. Konrads, S. Döbele, A. Ateschrang, V. Hofmann and S.S. Ahmad declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case.

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