Technical Note

Anatomic Posterolateral Corner Reconstruction With Autografts

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Abstract: Anatomic posterolateral corner reconstruction reproduces 3 main structures: the lateral collateral ligament, the popliteofibular ligament, and the popliteus tendon. The LaPrade technique reproduces all 3 main stabilizers. However, it requires a long graft, limiting its indication to clinical settings in which allograft tissue is available. We propose a surgical procedure that is a modification of the LaPrade technique using the same tunnel placement, hamstring autografts, and biceps augmentation when necessary. It relies on artificial graft lengthening provided by the loop of the suspensory fixation device fixed at the anterior tibial cortex. The final reconstruction reproduces the popliteus tendon with the bulkiest end of the semitendinosus; the popliteofibular ligament with a strand of the semitendinosus and a strand of the gracilis; and the lateral collateral ligament with a strand of the semitendinosus and a strand of the gracilis, which can also be augmented with a biceps strip.

The posterolateral corner (PLC) of the knee is the primary restraint to varus stability and external rotation, also acting as a secondary restraint to posterior translation. The 3 main structures of this complex are the lateral collateral ligament (LCL), popliteofibular ligament (PFL), and popliteus tendon (PT). Its injury is frequently associated with other ligament lesions, especially the cruciates. More than half of the patients present with a combined PLC—posterior cruciate ligament injury. PLC deficiency may lead to residual instability, chronic pain, and surgical failure of cruciate reconstruction by biomechanical overloading when not treated properly.[1-5]

Because of the low healing potential of these injuries, surgery is usually indicated. PLC reconstruction is normally advocated for grade 2 or 3 PLC lesions, considering its superior outcomes compared with conservative treatment.[1-7] The reported PLC reconstruction procedure achieves mean postoperative International Knee Documentation Committee scores ranging from 62.6 to 86.0 and a 10% failure rate based on objective stability assessment.[4]

Development of autograft-based anatomic PLC reconstruction techniques may aid surgeons in accurately addressing such severe injuries, without the need for allograft tissue. We describe a modification of the

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Table 1. Pearls and Pitfalls

Pearls
Distal dissection of the fibular nerve helps to attain better exposure of the fibular head to make sure enough bone is present for tunnel drilling, facilitates its retraction during surgery, and prevents irritation to the nerve due to postoperative swelling. Two main nerve entrapments can be addressed and decompressed in the following order, as necessary: the peroneal muscle fascia over the common peroneal nerve and the intermuscular septum between the anterior and lateral compartments of the leg over the deep peroneal nerve.
A blunt clamp should be used to dissect the nerve and expose the overlying soft tissues; an assistant should cut these using a scalpel blade while the underlying blunt instrument protects the nerve.
The muscle interval window is located posterior to the biceps and anterior to the lateral gastrocnemius; however, to better visualize the posterolateral tibial surface, blunt dissection and periosteal elevation of the popliteus muscle can be very helpful.
Use of a spoon or speculum helps to expose the posterolateral tibial surface for tunnel drilling and protects the neurovascular structures.
Use of a PCL or ACL guide helps to achieve accurate tibial tunnel placement with guide pin exit visualization, inserted from anterior to posterior.
The semitendinosus tendon must be mounted asymmetrically onto the EndoButton CL to have 1 strand 4 to 5 cm longer than the other strand; otherwise, it will not have the necessary length for femoral tunnel fixation.
The bulkiest end of the semitendinosus should be used to reproduce the PT because the LCL will be reproduced by 1 strand of the semitendinosus and 1 strand of the gracilis, as well as the biceps if necessary.
Both the longest semitendinosus strand and the gracilis should be passed together from posterior to anterior at the fibular tunnel.
The surgeon should leave the femoral screw guide pins at the tunnels before graft passage because this avoids problems related to tunnel identification due to soft-tissue cover.
Isometry testing is performed before femoral tunnel drilling at the identified anatomic landmarks to ensure optimal graft length behavior during range of motion.
All grafts must be routed deep to the ITB, whereas the posterior strands must also be routed deep to the biceps.
The biceps graft should be routed deep to the ITB independently from the semitendinosus and gracilis strands that will reproduce the LCL, because they are not emerging from the same point and common routing can cause them to be stuck at the ITB.
Biceps preparation with tubularization and/or Chinese finger-trap sutures may help graft passage into tunnels.
Grafts reproducing the PT and PFL must be routed deep to the grafts reproducing the LCL.
Pitfalls
Dissection of the fibular nerve with sharp instruments may cause an iatrogenic lesion.
Improper muscle interval window preparation may hamper accurate tibial posterior tunnel exiting.
Inadequate posterolateral tibial exposure enhances the chances of neurovascular injuries and incorrect tibial tunnel placement.
Inadequate asymmetrical strands of the semitendinosus mounted onto the EndoButton CL needing adjustment after graft tunnel passage can damage the tissue.
Non-perpendicular anterior tibial cortex EndoButton CL apposition leads to unstable fixation; the surgeon should make sure to adjust the device position.
Staged graft passage at the fibular tunnel is not recommended because it can damage the grafts.
The ITB can hamper the LCL and PT femoral attachments if the longitudinal splitting incision is made posterior to them.
An inadequate bridge between the PT and LCL femoral insertion tunnels may cause tunnel aperture communication. The surgeon should respect the reported 18.5-mm anatomic distance between them.
Unsatisfactory isometry because of incorrect tunnel placement can elongate the grafts and cause range-of-motion limitation.
Femoral tunnel drilling perpendicular to the coronal and sagittal axes can cause reaming into the intercondylar notch and cause tunnel collision with other ligament reconstructions, mainly ACL reconstruction. The PT femoral insertion tunnel should be drilled with 20° proximal and 20° anterior angulation, whereas the LCL femoral insertion tunnel should be drilled with 0°-20° proximal and 20° anterior angulation.
Each graft strand should be individually tensioned from the medial side during interference screw femoral insertion to avoid looseness. It is recommended to identify each one and pull them individually to apply proper tension to each graft during interference screw insertion.
Proud interference screws at the femur can cause soft-tissue irritation and/or screw migration or breakage due to ITB anteroposterior movement during range of motion.
Excessive internal rotation during graft fixation can lead to gait with internal rotation. Just a slight internal rotation of 5° should be applied in relation to the foot-neutral position (normally externally rotated 10°-15°) instead 5° of absolute internal rotation.

ACL, anterior cruciate ligament; ITB, iliotibial band; LCL, lateral collateral ligament; PCL, posterior cruciate ligament; PFL, popliteofibular ligament; PT, popliteus tendon.

LaPrade anatomic PLC reconstruction technique for treating PLC injuries based on hamstring autografts and biceps augmentation when necessary (Table 1).[2] It has been performed at our institutions since 2013.

Physical Examination and Imaging Findings

The most important clinical tests to diagnose posterolateral knee injuries are the varus stress, posterolateral drawer, and dial tests. However, a thorough examination is mandatory including the reverse pivot-shift test, external rotation recurvatum test, analysis of any varus thrust during gait, and fibular nerve neurologic assessment. All tests should be performed bilaterally to allow comparison with the uninjured knee.[1,5-9]

A standing long-leg anteroposterior radiograph can be used to recognize varus malalignment requiring osteotomy. Varus stress radiographs obtained at 20° of knee flexion can objectively identify an isolated complete LCL lesion presenting a side-to-side difference of 2.7 to 4.0 mm, whereas a difference of greater than 4 mm represents an associated grade 3 PLC injury, which can be very helpful, especially in the multiligament-injured knee. Magnetic resonance imaging can help in diagnosing acute lesions and concurrent injuries, as well as determining the location of the damaged structures.[8,9]

Surgical Technique

Patient Positioning

The patient is positioned supine on the operating table, and an examination under anesthesia is performed to confirm the diagnosis. A tourniquet is placed on the upper thigh of the operative leg, which is then prepared and draped in a standard fashion.

Surgical Approach

A 1.5-cm medial incision is made 2 cm medial to the tibial anterior tubercle and around 4 fingerbreadths distal to the joint line. Semitendinosus and gracilis grafts are harvested and prepared with No. 2 Ultrabraid (Smith & Nephew, Andover, MA) Krackow stitches at each end and pre-tensioned to 20 lb for 20 minutes.

A curvilinear incision is made on the lateral side of the knee along the iliotibial band and distally extended between the fibular head and Gerdy tubercle with the knee held at 90° of flexion. The subcutaneous tissue is then dissected. The biceps femoris is exposed. The fibular nerve is identified and isolated. The space anterior to the lateral gastrocnemius and posterior to the biceps is dissected.

All the tunnels are placed at the same location described by LaPrade et al.[2] for anatomic PLC reconstruction. A transtibial tunnel is made from anterior to posterior, protecting the neurovascular structures. A posterior cruciate ligament femoral guide or anterior cruciate ligament tibial guide from the Acufex Director set (Smith & Nephew) can be used in an off-label manner. The anterior tibial tunnel entry point is 0.5 cm distal and 0.5 cm medial to the Gerdy tubercle. The posterior tibial tunnel entry point is placed at the tibial PT sulcus, 1 cm distal to the articular surface. Initially, a guide pin is introduced at these locations, and a 7- to 8-mm drill is used to perforate the desired tunnel guided by the pin.

The transfibular tunnel is first created with a guide pin and subsequently drilled to 7 mm. It is oriented from anterior, lateral, and distal to posterior, medial, and proximal, aiming at reproducing the origin of the LCL at the fibular head.

The tibial tunnel is measured, and an EndoButton CL (Smith & Nephew) of the appropriate size to keep 2 cm of the graft inside the tunnel is chosen. The semitendinosus tendon is mounted asymmetrically onto the EndoButton CL to have 1 strand 4 to 5 cm longer than the other strand. The bulkiest end of the semitendinosus is set to be the shortest strand. The graft is passed from anterior to posterior at the 7-mm tibial tunnel and is secured anteriorly by suspensory fixation. An Xtendobutton (Smith & Nephew) or a regular washer can be added to the fixation at the anterior tibial cortex. Alternatively, a retrograde drill can be used to drill a 2-cm posterior tibial tunnel; in addition, an adjustable-loop suspensory fixation device can be applied to the anterior cortex fixation of the semitendinosus graft.

The longest semitendinosus strand and the gracilis are passed along the fibular tunnel from posterior to anterior. The gracilis tendon will have 1 anterior strand and 1 posterior strand around the fibular head. A 7-mm interference screw is introduced into the fibular tunnel while the grafts are tensioned with 10 lb. The longest semitendinosus strand passed through the fibula will be directed toward the LCL femoral insertion along with the anterior gracilis strand. The shortest semitendinosus strand exiting at the posterior part of the tibial tunnel will be directed toward the PT femoral insertion along with the posterior gracilis strand.

The longest semitendinosus strand and the anterior gracilis strand will reproduce the LCL. The shortest and bulkiest semitendinosus strand will reproduce the PT. The tibia-fibula connecting part of the longest semitendinosus strand and the posterior gracilis strand will reproduce the PFL.

At the femur, the LCL and PT insertions are identified. Isometry of the grafts is tested using the guide pins at the identified sites. If suboptimal, with more than 5 mm of graft excursion during flexion-extension, the guide pin is relocated to an optimal isometric point. Two tunnels are made, using a guide pin and an 8-mm drill. If biceps augmentation is planned, a 10-mm reamer should be used at the LCL femoral insertion tunnel instead. Both tunnels are placed through 20° of anterior angulation at the axial plane and 20° of proximal angulation at the coronal plane. A bone bridge measuring approximately 5 to 10 mm will separate both tunnels. These femoral tunnels are reamed through the medial femoral cortex to facilitate graft passage.

The grafts are routed through the third layer of the lateral side of the knee, deep to the iliotibial tract, lateral retinaculum, and biceps. The shortest and bulkiest semitendinosus strand emerging directly from the tibia and the posterior strand of the gracilis are inserted into the PT femoral insertion tunnel and secured with an 8-mm interference screw with the knee flexed 60° and in 5° of internal rotation in relation to the foot-neutral position with 10 lb of tension. The longest semitendinosus strand emerging from the fibula and the anterior gracilis strand will be inserted into the LCL femoral insertion tunnel and secured with an 8-mm interference screw with the knee flexed 30°, neutral rotation of the leg, valgus force, and 10 lb of tension (Fig 1, Video 1).

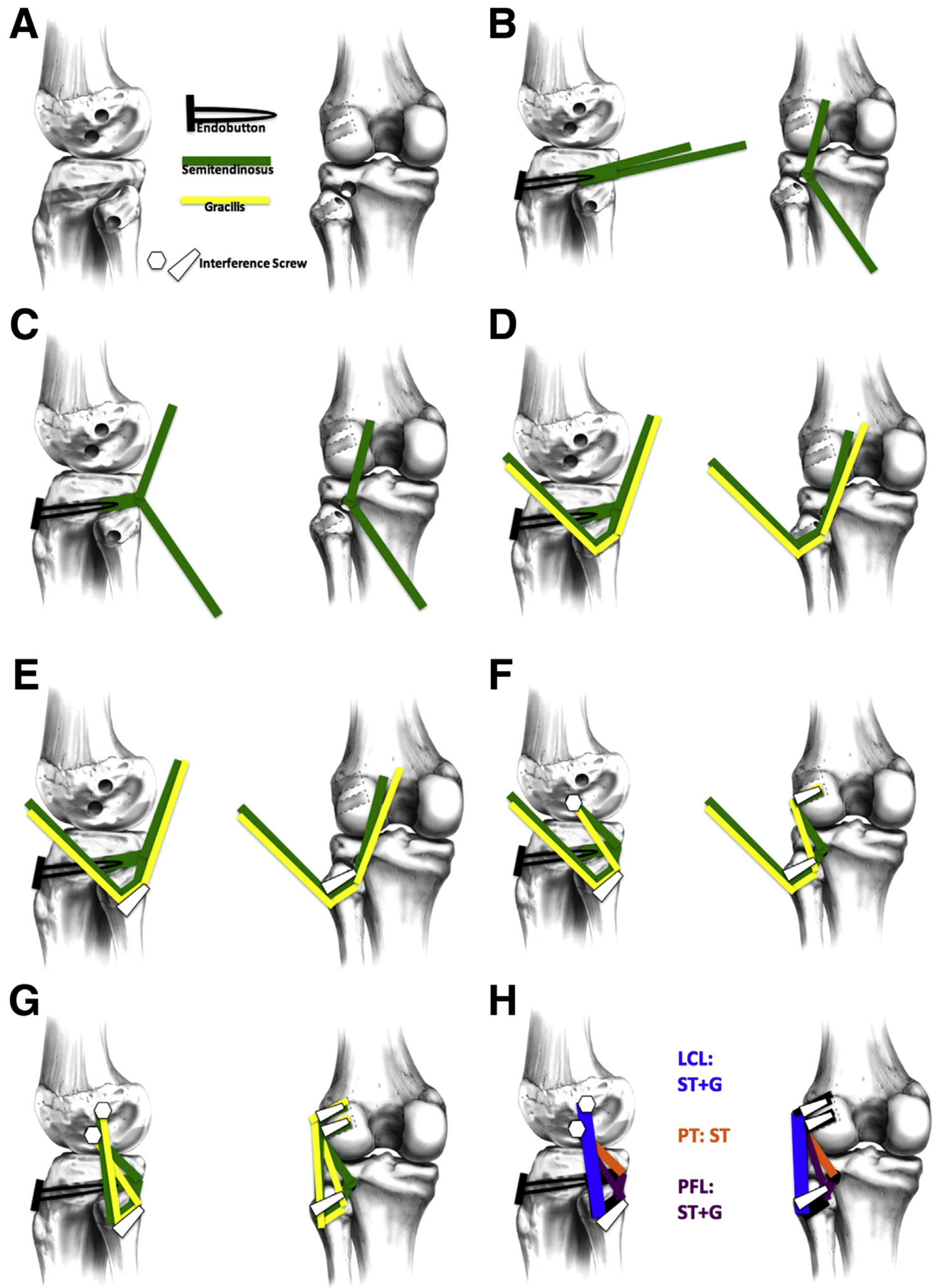

Fig 1. Posterolateral corner reconstruction with autologous hamstring adapted with permission from LaPrade et al.[2]: step-by-step approach. (A) The same tunnels from the LaPrade anatomic posterolateral corner reconstruction are made at the tibia, fibula, and femur.[2] (B) The semitendinosus graft is asymmetrically mounted onto an EndoButton CL and passed from anterior to posterior into the tibial tunnel: The shortest strand will be the bulkiest one, whereas the longest strand will be 4 to 5 cm longer. (C) The semitendinosus strands are separated at the posterior aspect of the knee. (D) The longest semitendinosus strand and the gracilis are passed along the fibular tunnel from posterior to anterior. (E) The grafts are tensioned, and a 7-mm interference screw is introduced into the fibular tunnel. (F) The shortest and bulkiest semitendinosus strand emerging directly from the tibia and the posterior strand of the gracilis are inserted into the popliteus tendon femoral insertion tunnel and secured with an interference screw with the knee flexed 60° and in 5° of internal rotation in relation to the foot-neutral position with 10 lb of tension. (G) The longest semitendinosus strand emerging from the fibula and the anterior gracilis strand are inserted into the lateral collateral ligament femoral insertion tunnel and secured with an interference screw with the knee flexed 30°, neutral rotation, valgus force, and 10 lb of tension. (H) The final reconstruction reproduces the popliteus tendon (PT) with the bulkiest end of the semitendinosus (ST), the popliteofibular ligament (PFL) with a strand of the semitendinosus and a strand of the gracilis (ST+G), and the lateral collateral ligament (LCL) with a strand of the semitendinosus and a strand of the gracilis (ST+G).

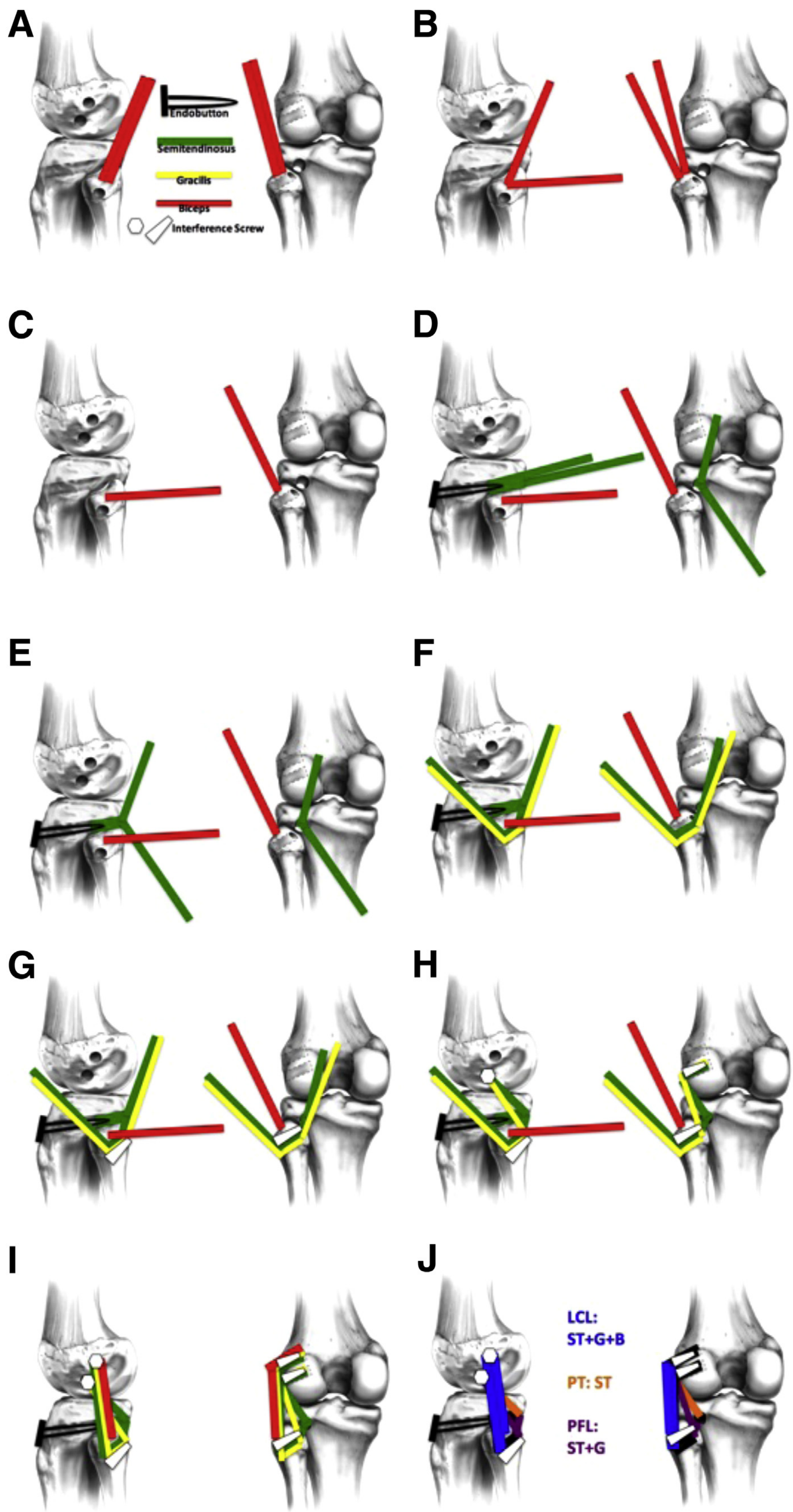

Fig 2. Posterolateral corner reconstruction with autologous hamstring and biceps augmentation adapted with permission from LaPrade et al.[2]: step-by-step approach. (A) The same tunnels from the LaPrade anatomic posterolateral corner reconstruction are made at the tibia, fibula, and femur.[2] (B) A strip from the posterior half of the biceps tendon, 1 to 1.5 cm wide by 5 to 7 cm long, is prepared, splitting the biceps tendon and proximally detaching it. (C) The biceps' fibular head insertion is preserved. (D) The semitendinosus graft is asymmetrically mounted onto an EndoButton CL and passed from anterior to posterior into the tibial tunnel: The shortest strand will be the bulkiest one, whereas the longest strand will be 4 to 5 cm longer. (E) The strands of the semitendinosus are separated at the posterior aspect of the knee. (F) The longest semitendinosus strand and the gracilis are passed along the fibular tunnel from posterior to anterior. (G) The grafts are tensioned, and a 7-mm interference screw is introduced into the fibular tunnel. (H) The shortest and bulkiest semitendinosus strand emerging directly from the tibia and the posterior strand of the gracilis are inserted into the popliteus tendon femoral insertion tunnel and secured with an interference screw with the knee flexed 60° and in 5° of internal rotation in relation to the foot-neutral position with 10 lb of tension. (I) The biceps tendon strip combined with the longest semitendinosus strand emerging from the fibula, as well as the anterior gracilis strand, is inserted into the lateral collateral ligament femoral insertion tunnel and secured with an interference screw with the knee flexed 30°, neutral rotation, valgus force, and 10 lb of tension. (J) The final reconstruction reproduces the popliteus tendon (PT) with the bulkiest end of the semitendinosus (ST); the popliteofibular ligament (PFL) with a strand of the semitendinosus and a strand of the gracilis (ST+G); and the lateral collateral ligament (LCL) with a strand of the semitendinosus, a strand of the gracilis, and the biceps strip (ST+G+B).

Biceps Augmentation

By use of this technique, biceps augmentation of the LCL can also be indicated in a few cases: quadruple graft composed by the folded semitendinosus and folded gracilis smaller than 8 mm in diameter, grade 3 varus instability, and short grafts compromising femoral fixation of the semitendinosus at the LCL femoral insertion. A strip from the posterior half of the biceps tendon 1 to 1.5 cm wide by 5 to 7 cm long is prepared splitting the biceps tendon and proximally detaching it. Its fibular head insertion is preserved. The biceps tendon strip is transferred and fixed at the LCL insertion site at the femur in combination with the longest semitendinosus strand and the anterior gracilis strand reproducing the LCL. It can be sutured together with the corresponding hamstring if the strands are too short (Fig 2).

Rehabilitation

Patients use a knee immobilizer and mobilize in a non—weight-bearing manner for 6 weeks. Passive range of motion is initiated on the first day postoperatively, and patients gradually progress to full range of motion as tolerated. A goal of at least 90° of knee flexion is desired by 4 weeks postoperatively. At 6 weeks, patients are permitted to begin spinning on a stationary bike and wean off crutches, progressing to full weight bearing around 8 weeks. Further rehabilitation follows the LaPrade protocol for posterolateral corner reconstruction.[2] Running is typically allowed around 6 months. Return to sports is not allowed before 6 months. It is based on the type of sport and at least 80% strength recovery on isokinetic evaluation compared with the uninjured knee.[8,9]

Discussion

Several PLC reconstruction techniques have been described. Nonanatomic fibula-based techniques can rely on autografts; however, anatomic techniques or techniques involving the tibia and fibula normally require allografts to have enough graft length. Our technique provides anatomic PLC reconstruction using autologous grafts because the loop of the suspensory fixation device artificially lengthens the semitendinosus graft.[1-7]

Full recovery is difficult to achieve when addressing these complex lesions by PLC reconstruction. The results vary among the related studies, presenting mean postoperative Lysholm scores ranging from 65.5 to 91.8 and mean postoperative International Knee Documentation Committee scores ranging from 62.6 to 86.0.[4]

Many studies have shown similar results when comparing anatomic and nonanatomic PLC reconstruction techniques; however, some presented superior results favoring the anatomic reconstruction, mainly

Table 2. Advantages and Disadvantages

Advantages
The technique results in anatomic PLC reconstruction with autologous grafts using the loop of the suspensory fixation device to artificially lengthen the semitendinosus graft.
Autograft has better availability and a lower cost than allograft because a tissue bank is not required.
Autograft has the potential for better ligamentization and a lower failure rate than allograft.
Anatomic reconstruction of the PLC reproduces its 3 main structures: LCL, PFL, and PT. The LCL is reconstructed with a strand of the semitendinosus and a strand of the gracilis, as well as biceps augmentation when necessary. The PFL is reconstructed with a strand of the semitendinosus connecting the tibia to the fibula and a strand of the gracilis anatomically reproducing this ligament connection between the fibula and the PT. The PT is reconstructed with the bulkiest semitendinosus strand.
Anatomic PLC reconstruction potentially has a biomechanical advantage over nonanatomic techniques. This advantage indicates the use of the proposed technique or other anatomic reconstruction instead of nonanatomic reconstruction for the following PLC cases: substantial knee hyperextension, substantial external rotation—recurvatum, proximal tibiofibular instability, and concomitant posterior cruciate ligament injury.
Biceps augmentation can be used to improve overall stability, being recommended for grade 3 varus instability and quadruple hamstring graft <8 mm in diameter.
Biceps augmentation can be used in the rare cases in which a short semitendinosus graft would compromise femoral fixation. The posterior half of the split biceps free end is sutured in combination with the hamstring strands reproducing the LCL and inserted into the femoral tunnel.
The interference screw at the fibular tunnel diminishes the working area of each graft section representing 1 of the 3 main structures of the PLC and allows independent tensioning of the grafts for each intended purpose because the LCL and PFL-PT are under greater tension at different knee flexion angles.
Disadvantages
Donor-site morbidity of autograft
Hamstring autograft length and diameter variability
Grafts without bone plug relying on just soft-tissue incorporation
Long lateral incision
Technically more demanding and time-consuming than nonanatomic reconstruction, with biceps augmentation increasing time and complexity of surgery
Risk of neurovascular injury during tibial tunnel creation
Increased chance of femoral ACL tunnel collision compared with single femoral insertion techniques
Need for 3 interference screws and 1 suspensory fixation device

ACL, anterior cruciate ligament; LCL, lateral collateral ligament; PFL, popliteofibular ligament; PLC, posterolateral corner; PT, popliteus tendon.

because of the external rotation and posterior translation but also because of the varus analysis.[3,5] Regarding this biomechanical superiority and rationale, we believe some conditions favor and are indications for anatomic reconstruction over nonanatomic reconstruction, such as substantial knee hyperextension, substantial external rotation–recurvatum, proximal tibiofibular instability, and concomitant posterior cruciate ligament injury. This technique is an autograft option for such PLC lesion cases because its anatomic nature poses a biomechanical advantage over the nonanatomic techniques.[1,3,5-7]

Anatomic and tibia-fibula–based PLC reconstruction relies on allografts because of minimum graft length. Hamstring from the contralateral knee can be harvested in addition to hamstring from the injured side to attain an acceptable graft length pattern to perform an anatomic PLC reconstruction similar to the LaPrade technique[2] using 2 semitendinosus grafts to replace the split Achilles tendon. However, this autologous graft source would be compromised, and it can be especially hazardous for PLC lesions because they are frequently associated with other ligament injuries. Although allograft does not have the donor-site morbidity associated with autograft, it has important disadvantages, including its low availability and high cost, as well as its potential for a higher failure rate compared with autograft, inferior ligamentization process, and disease transmission risk—although this risk is very low (Table 2). Because tissue banks are not a widespread resource, the proposed technique intends to overcome this problem, posing an option over allograft-related PLC reconstruction techniques. Despite these logistic and biological advantages, we still consider the LaPrade anatomic PLC reconstruction using Achilles tendon allograft the gold-standard surgical treatment for PLC injuries because of its biomechanical validation and well-documented subjective and objective outcomes.[1,2,8-12]

In our technique the loop of the suspensory fixation device helps acquire at least 1 to 2 cm of graft inside each femoral tunnel, which is important for in vivo graft incorporation. Without this loop, the semitendinosus may have insufficient length to reach the femoral tunnels if secured to the anterior tibial cortex by other fixation devices. Normally, at least a 24- to 26-cm-long semitendinosus is necessary for the proposed technique. When dealing with shorter grafts, surgeons could use just 1 cm of tendon to be secured inside the posterior part of the tibial tunnel and adjust fibular tunnel obliquity, decreasing its length but still requiring at least 21 to 23 cm of semitendinosus tendon. Considering the average length of the semitendinosus of 24.9 ± 3.7 cm, the role of the EndoButton CL in increasing the graft's length becomes evident.[13]

This procedure relies on an interference-screw fibular tunnel fixation, diminishing the working area of each graft section representing 1 of the 3 main structures of the PLC (LCL, PFL, and PT). Moreover, it allows independent tensioning of the grafts for each intended purpose as the LCL and PFL-PT are under greater tension at different knee flexion angles. This is a biomechanical advantage over techniques that apply the same tension and flexion angle to reproduce different structures.[1-7]

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