

The Posterolateral Corner of the Knee

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8.1 Introduction

Previously referred to as the “dark side of the knee,” the posterolateral corner (PLC) of the knee has a reputation for being enigmatic. Relatively recent studies have elucidated the complex anatomy and biomechanical significance of the PLC. The primary static stabilizers of the PLC are the fibular (lateral) collateral ligament (FCL or LCL), popliteus tendon (PLT), and popliteofibular ligament (PFL) [1, 2]. These are collectively recognized as structures that should be examined for concomitant pathology in the case of anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) tears [1–5]. In fact, only 13–28% of these injuries occur in an isolated fashion (that is, without other concomitant ligamentous pathology) [1–4]. The incidence of PLC injuries, as reported by LaPrade et al., is 9% of all knee ligament injuries, 16% of acute knee ligament injuries, and 9% of knee injuries concomitant with a hemarthrosis [6]. Detection and proper repair of injuries to the PLC are critical for preventing recurrent lateral-sided instability and graft failure [7].

Descriptions of the PLC commonly subdivide structures of the region into primary and secondary stabilizers. This is based on the biomechanical role each structure plays within the PLC in preventing varus gapping, hyperextension, and external rotation of the tibia. The FCL is the predominant structure stabilizing the knee to varus stress, whereas the PLT and PFL primarily contribute to preventing posterolateral rotation of the tibia on the femur [1, 8]. These stabilizers work together with secondary stabilizers of the PLC to fully perform the biomechanical functions of an intact PLC. The secondary stabilizers of the PLC function in both static and dynamic stabilization and include lateral capsular thickening of the mid-third lateral capsular ligament, coronary ligament, lateral gastrocnemius tendon, fabellofibular ligament, biceps femoris long and short heads, and iliotibial band [1].

The three primary static stabilizers of the PLC have a somewhat trigonal planar orientation to one another, with the FCL forming the base of the triangle and running parallel to the tibiofemoral joint and crossing superiorly over the PLT. The apex of the triangle points posteriorly and is formed by the intersection of the PFL and the PLT as it courses obliquely (inferomedially), deep to the FCL and toward the posteromedial tibia [9]. Owing to its oblique, intraarticular course, the PLT is the only primary PLC stabilizer that is directly visible on arthroscopy [10].

Studies elucidating the quantitative anatomy of the PLC have been foundational to the development of anatomically correct techniques for repairing and reconstructing injuries to the substructures of this region. Proximally, the FCL inserts onto a small osseous depression posterosuperior (3.1 mm posterior and 1.4 mm superior) to the lateral femoral epicondyle [10]. The footprint of its distal insertion covers 38% of the fibular head's width, occupying a bony sulcus 8.2 mm posterior to the anterior margin of the fibular head [10]. The anterior-most portion of the PLT belongs to its proximal (femoral) insertion, 18.5 mm anterior to the proximal insertion site of the FCL [10]. The PFL is divided into a larger posterior division and a smaller anterior division, both of which cradle the popliteus musculotendinous junction proximally and take an anteroinferior course distally toward a posteromedial insertion on the fibular head [1, 10].

As stated previously, injuries to the PLC are often concomitant with injuries to other ligaments of the knee. In fact, the force necessary to compromise the integrity of the PLC is less than that required for tearing the ACL and PCL [11]. Biomechanical studies have also demonstrated the significance of the intact PLC to the biomechanics of the knee joint. PLC deficiency causes a significant increase in strain on ACL and PCL grafts, which is a phenomenon that has been reported to lead to higher graft failure rates and poorer outcomes [5, 9]. These two points underscore the significance of the failure to properly diagnose and treat injuries to the PLC. The purpose of this chapter is to cor-

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relate findings on magnetic resonance imaging (MRI) with arthroscopic findings in order to improve diagnosis, planning, and treatment of injuries to the PLC and its substructures.

8.2 Case 1: ACL Tear, Grade III FCL Tear, Complete Avulsion of Biceps Femoris Off the Fibular Head and Styloid, and Partial PLT Tear

8.2.1 History/Exam

A 25-year-old male presented to clinic for initial evaluation of his left knee. A month prior to the visit, he was playing flag football when he suffered a hyperextension injury and had immediate pain and instability within the left knee. He was unable to bear weight and had to be carried off the field. The patient is from another country. This was his first injury to his left knee, and he had a symptomatic history of Osgood-Schlatter disease. He endorsed swelling and both anteroposterior and mediolateral instability since the injury. He denied any paresthesias into the toes.

On physical examination, there was a small effusion present in the left knee. Range of motion was 8 cm of heel height to 125° of flexion as compared to 4 cm of heel height to 135° of flexion on the right. The patient had good quadriceps control without coactivation or atrophy. He had no retro-patellar crepitus. The patient had a positive Lachman and pivot shift was deferred secondary to guarding. Posterior drawer test was negative and valgus stress at 0° and 20° was stable. Grade III varus gapping was present at 20° knee flexion; however there was no significant increase in his left dial test compared to the right. Neurovascular exam was normal except for very mild extensor hallucis longus weakness on the left.

8.2.2 Imaging

Weight-bearing anteroposterior (AP), Rosenberg, long leg alignment, sunrise, and left knee long lateral radiographs were obtained in the clinic and reviewed. The patient was in mild varus weight-bearing alignment bilaterally. His posterior tibial slope was 8°. He had well-preserved medial and lateral patellofemoral joint spaces without degenerative changes. A chronic ossicle at the base of the patellar tendon was identified which is indicative of prior Osgood-Schlatter disease.

Varus stress radiographs were obtained and reviewed in clinic to reveal 5 mm side-to-side difference with the left being greater than the right. This difference is indicative of a high-grade lateral sided injury.

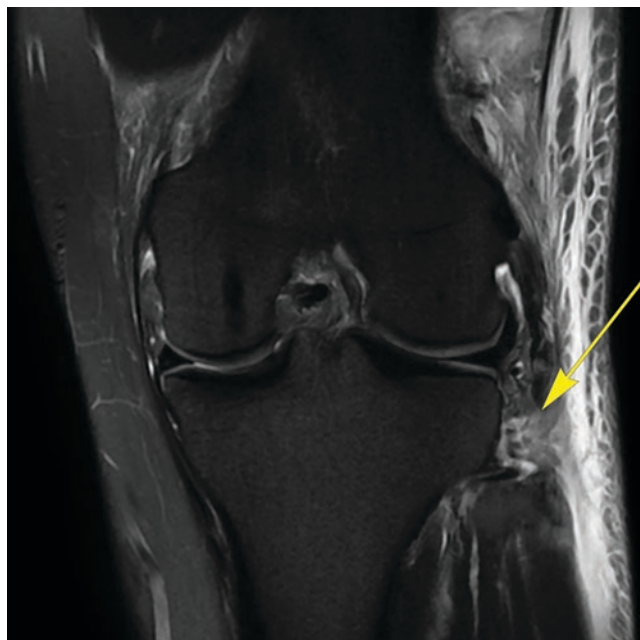


Fig. 8.1 A PD FS COR MRI exhibiting the presence of an avulsed FCL tear with some proximal retraction (yellow arrow)

MRI obtained at an outside facility 5 days after the injury was reviewed in the clinic. There was a complete ACL tear as well as a complete FCL tear avulsed from the fibula with some proximal retraction (Fig. 8.1). The biceps femoris was also avulsed off the fibular head (Fig. 8.2). The popliteus appeared to be intact without any significant edema around the muscle belly and without any obvious tearing from the femoral origin (Fig. 8.3). Posteromedial structures were intact. A relatively long patellar tendon was noted with a chronic ossicle within the base of the patellar tendon from prior Osgood-Schlatter disease. Medial and lateral meniscal bodies appeared to be intact as well as medial and lateral compartment articular cartilage. Patellofemoral cartilage was also well preserved. His lateral meniscus root appeared to possibly be damaged (Fig. 8.4). There was significant swelling of the common peroneal nerve around the fibular head.

After discussing all treatment options, the patient elected to proceed with surgical treatment. The surgical plan included ACL reconstruction with BTB autograft with FCL reconstruction with hamstring autograft. Additionally, the surgical plan included biceps femoris repair and peroneal nerve neurolysis. His lateral meniscus root would also be assessed intraoperatively.

8.2.3 Arthroscopy

The patient was induced under general anesthesia. A high well-padded left thigh tourniquet was placed. Evaluation of



Fig. 8.2 A PD FS SAG MRI exhibiting the biceps femoris with an avulsion tear (yellow arrow). Significant swelling and stretching of the common peroneal nerve can be seen as well (white arrow)

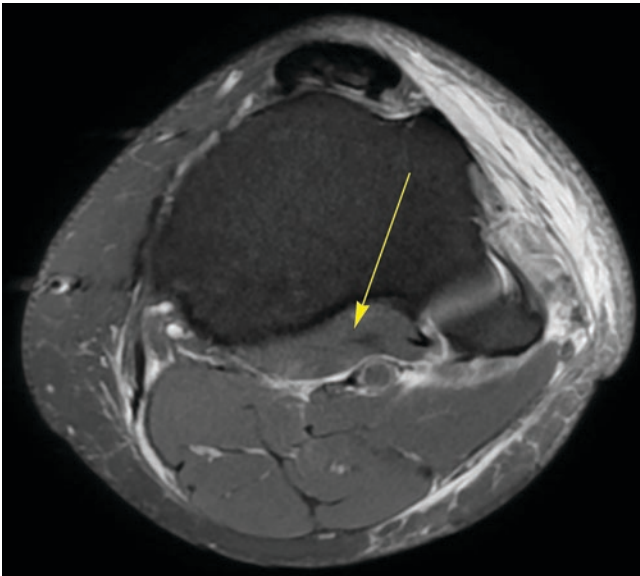


Fig. 8.3 A PD FS AX MRI exhibiting the popliteus without any edema around the muscle belly (yellow arrow)

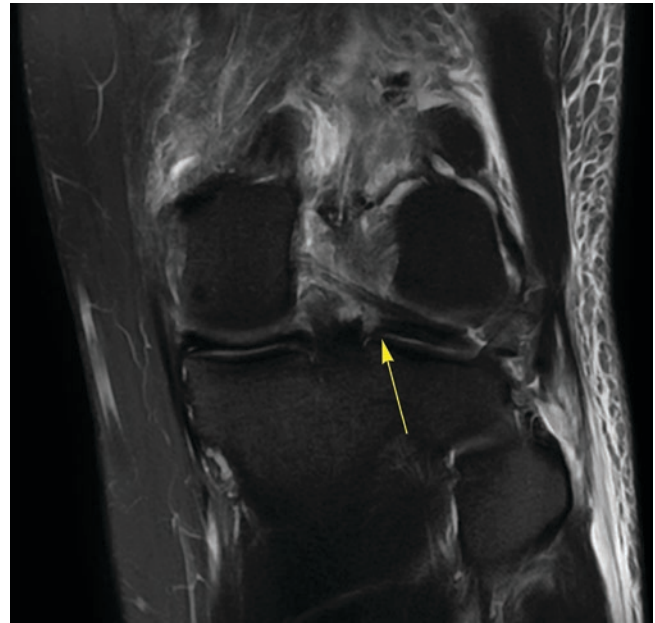


Fig. 8.4 A PD FS COR MRI exhibiting a possible tear of the posterior root of the lateral meniscus (yellow arrow)

the injured knee under anesthesia revealed significant genu recurvatum with 9 cm of heel height to full flexion at 135°. His Lachman and pivot shifts were both 3+. He had significant varus gapping; however due to the extent of nerve injury on MRI, the varus stress exam was limited. Dial test and posterolateral drawer test appeared to be symmetric to his right knee. The exam under anesthesia was consistent with complete ACL and FCL tears with biceps femoris tear and partially damaged popliteus complex which was consistent with the diagnosis made on clinical exam and diagnostic imaging.

The posterolateral corner was approached first by making a standard lateral hockey-stick incision. Significant scarring and adhesions were present. Slow and meticulous dissection down to the superficial layer of the iliotibial (IT) band was performed due to the extent of scar tissue that was present. The short head of the biceps was identified. Dissection was performed more distally. With the nerve being significantly irritated, slow and meticulous common peroneal nerve neurolysis was performed. A 2.5 cm area of intrasubstance injury and significant edema was noted in the common peroneal nerve, which was consistent with what was seen on the MRI scan. The scar tissue surrounding this area was removed with extreme care. The biceps femoris was confirmed to be completely avulsed off the fibular head. A proximal release of the biceps was performed to ensure that it could be later reduced with the knee in full extension. A tag stitch was placed through the biceps. Dissection was performed along the lateral aspect of the fibular head to identify the normal attachment site of the FCL. The fibular head reconstruction tunnel was reamed, and a passing stitch was placed.

Next, the IT band was split and the thickened femoral attachment of the FCL was identified. A guide pin was then placed anteromedially across the thigh. An incision is made through the lateral capsule, and the popliteus tendon is identified. A large flap of the popliteus tendon was present, but there was still a significant portion that was not torn. After verification of the functional integrity of the popliteus tendon, a repair of the partial tear of the tendon was performed with a suture anchor. The FCL femoral reconstruction tunnel was then reamed to a depth of 25 mm, followed by a 7 mm tap and placement of a passing stitch. The channel for the FCL graft was cleared out, ensuring that it would be passed through the biceps bursa and the torn portion of the biceps tendon. An incision was then made along the medial aspect of the patella, down to the medial aspect of the tibial tubercle. The patellar tendon autograft with a 10 × 20 mm bone plug from the patella and a 10 × 25 mm bone plug off the tibial tubercle was harvested. Extreme care was taken to dissect around the chronic ossicle that was present in the distal patellar tendon. The graft was prepared to be used for the ACL reconstruction, and the ossicle was removed from the graft at this point.

Next the arthroscopic portion of the procedure was initiated by making the medial and lateral arthroscopic portals. The patellar articular cartilage and trochlear groove articular cartilage were normal.

The medial compartment was then inspected, and an undersurface ramp tear of the medial meniscus was found (Fig. 8.5). This ramp tear was in the hidden zone, but upon pulling of the undersurface, the tear could be seen extending

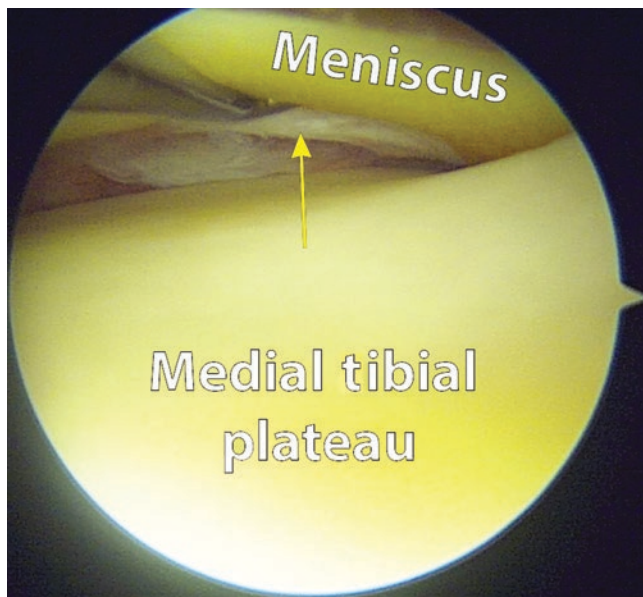


Fig. 8.5 Arthroscopic image exhibiting the presence of a ramp tear in the hidden zone of the extending to the superior surface of the medial meniscus (yellow arrow)

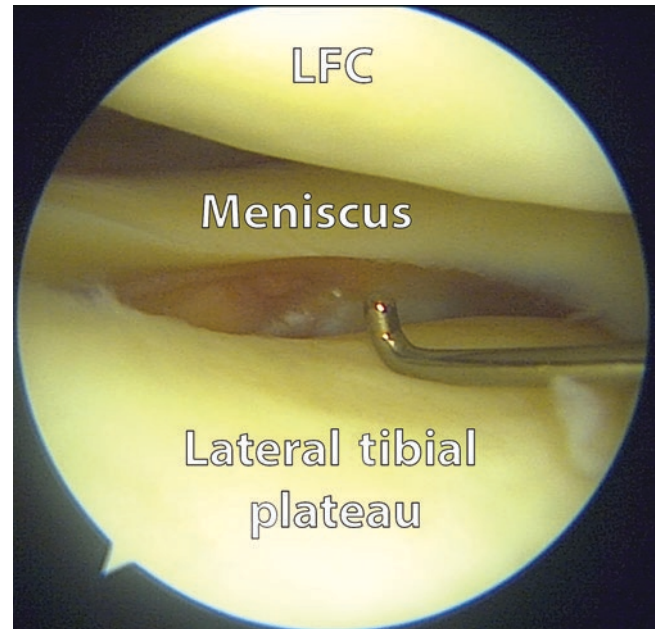


Fig. 8.6 Arthroscopic image illustrating an intact lateral meniscus and wide-open drive-through sign of the lateral compartment

into the superior surface. This was approximately 2 cm in size on the undersurface of the meniscotibial portion of the posterior capsule. His PCL was normal, and his ACL was completely torn. His lateral compartment had a wide-open drive-through sign (Fig. 8.6), and the popliteus tendon repair was confirmed to be taut. His lateral meniscus was entirely intact including the root attachments.

The ACL reconstruction was performed next. The ACL attachments on the femur were debrided. An accessory medial portal was made, and a bur hole was made halfway between the attachment of the anteromedial and posterolateral bundles of the ACL. The knee was then maximally flexed, and the femoral tunnel was reamed to 25 mm, followed by placement of a passing stitch. Arthroscopic visualization confirmed that a 1.5 mm backwall of solid bone and tissue was present.

The medial meniscus inside-out ramp repair was then performed. The surgeon entered the interval anterior to the medial head of the gastrocnemius and above the semimembranosus. Repair was performed by placing four vertical mattress sutures into the ramp tear (Fig 8.7a, b).

The tibial ACL reconstruction tunnel was then reamed with a 10 mm acorn reamer. The passing stitch for the ACL graft was then pulled down the tibial tunnel and pulled into place. It was then fixed into the femur with a 7 × 20 mm titanium screw. The FCL graft was then passed through the FCL reconstruction tunnel and held in place with a 7 × 20 mm bioabsorbable screw. The FCL graft was then passed through the previously created channel and through the biceps femoris avulsion portion. The FCL graft was then passed through

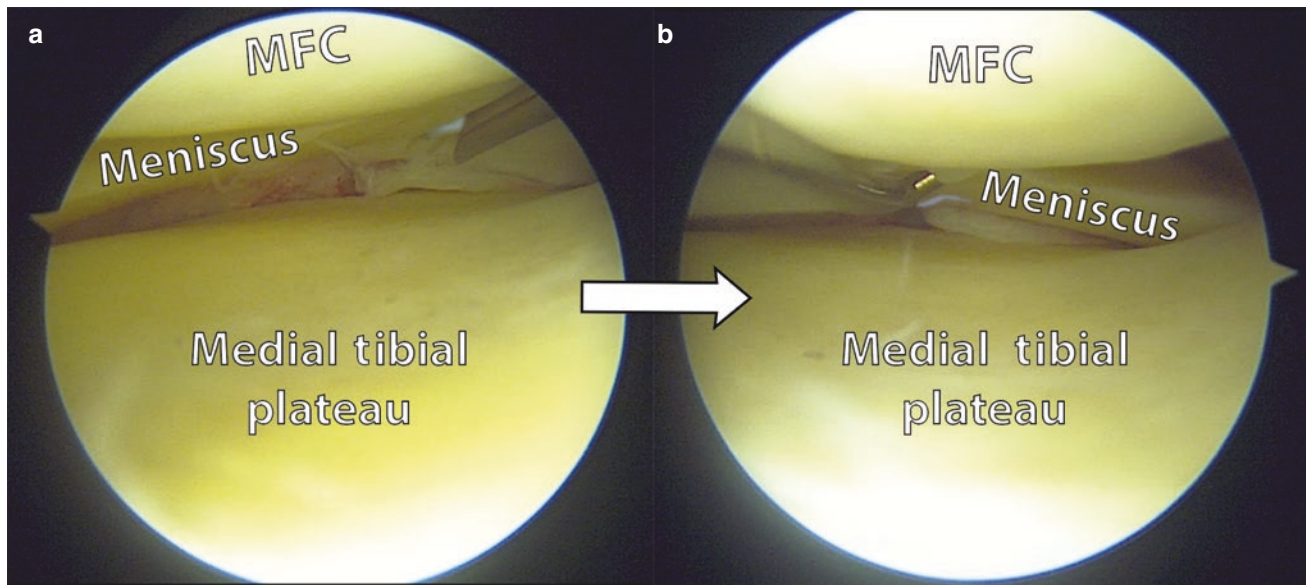


Fig. 8.7 (a, b) Arthroscopic images illustrating medial meniscus ramp tear during and after repair with four vertical mattress sutures. MFC, medial femoral condyle

the fibular head and styloid, with the knee had been cycled through flexion and extension to eliminate any slack. The FCL graft was then fixed with a 7×20 mm bioabsorbable screw with the knee flexed at 20° and a valgus reduction force being applied to the knee. This eliminated varus gapping.

Two anchors were placed into the lateral aspect of the fibular head and styloid, followed by placement of the sutures into the torn biceps tendon substance while taking extreme care to protect the common peroneal nerve. The sutures were then tied to the fibular head with the knee in full extension. This eliminated the hyperextension that was previously present. Due to his elongated patellar tendon, there was still some graft tunnel mismatch. To address the mismatch, a trough was created using an arthroscopic bur, and two small Richards staples were placed to hold the graft with the knee in full extension and traction on the graft. Lachman's test was now normal, and the ACL graft was arthroscopically confirmed to be taut. The procedure was completed by letting the tourniquet down and closing the incisions in the deep tissue and superficial skin.

8.2.4 Discussion

Posterolateral corner injuries are complex injuries that often occur with concomitant injury to additional structures of the knee. By utilizing a combination of the patient's history, physical exam, diagnostic imaging, and arthroscopy, it is possible to identify and treat all concurrent injuries that the patient presents with. With this case, utilizing the correlation

between imaging on varus stress radiographs, MRI, and arthroscopic findings allowed for proper surgical treatment of this complex injury pattern.

Respective to the PLC, diagnostic MRI showed a partial tear to the popliteus tendon and a complete tear of the FCL. More specifically, the MRI also revealed an avulsion tear of the FCL off the fibular head with proximal retraction. A popliteus tear can appear as a linear increase in signal intensity and can be located from the musculotendinous junction to the popliteal sulcus on the lateral femoral condyle. Varus stress radiograph also showed a side-to-side difference of 5 mm, which is suggestive of injury to the FCL and the PLC [12]. The MRI also exhibited an avulsion tear of the biceps femoris off the fibular head. The findings on diagnostic imaging pertaining to the FCL and popliteus tendon were confirmed on arthroscopy. The lateral meniscus root appeared to possibly be torn on diagnostic imaging; however, the entire lateral meniscus was intact and stable when viewed arthroscopically. The medial meniscus had a ramp tear in the hidden zone that extended to the superior surface, and this was repaired during the procedure. Repair of meniscus tears is preferred to preserve the biomechanical properties of the meniscus. Partial or total meniscectomies are unfavorable due to the increased risk of osteoarthritis that is associated with these procedures [13–17]. The injury patterns to the common peroneal nerve observed intraoperatively were consistent with findings on diagnostic MRI.

In many cases requiring repair or reconstruction of the PLC, a hybrid approach combining arthroscopic and open procedures is necessary to effectively address all injuries. PLC repairs and reconstructions often occur in combination

with repairs and/or reconstructions of other structures in the knee, as was the case in this patient. It is critical to confirm MRI findings through both open and arthroscopic examinations. In this patient, a few of the repairs and reconstructions, such as the partial popliteus tear, the biceps femoris tear, and the FCL reconstruction, were performed through an open incision due to the anatomy of these structures. Arthroscopy was utilized for reconstructing the ACL and repairing the medial meniscus ramp tear. A “drive-through” sign was also observed within the lateral compartment using arthroscopy. Drive-through sign is typically an indication of PLC injury [18], which was present in this patient who experienced a partial tear of the popliteus tendon. It is imperative that the popliteus be repaired or reconstructed following injury due to the risk of recurrent instability if left untreated [8]. Arthroscopy is often utilized to assess for the extent of articular cartilage damage or meniscal tears in the setting of complex knee injuries involving the PLC.

8.3 Case 2: Grade III PCL Tear, Grade III Complete Posterolateral Corner Injury, Mild Entrapment of the Common Peroneal Nerve, and Medial Meniscus Cyst

8.3.1 History/Exam

An 18-year-old male presented to the clinic with bilateral knee pain. The patient endorses that his right knee pain began 5 months prior when he was wrestling and had his leg forced into hyperextension and varus. He was reportedly diagnosed with injuries to the right knee PLC and PCL. He was treated with physical therapy and a static PCL brace and continued to wrestle. At the clinic visit, the patient endorsed persistent pain, instability, and mild mechanical symptoms.

He reports that his left knee was injured 1 month ago while wrestling when his knee was forced into flexion, varus, and external rotation. He finished the tournament at this time but was diagnosed with an isolated FCL tear. He reports mechanical symptoms and instability. Symptoms improved with rest and worsened with activity. He had not yet attempted treatment of his left knee and was here for initial evaluation of the left knee.

Examination of the right knee showed no effusion. The right knee was non-tender to palpation throughout. ROM is 5 cm heel height to 140° of flexion. The knee was stable to Lachman’s test and valgus stress. A grade 3 posterior drawer was present, along with a positive dial test. The PTFJ was stable and neurovascular exam was normal.

Examination of the left knee showed no effusion. The left knee was non-tender to palpation throughout. ROM was 5 cm heel height to 140° of flexion. There was moderate gap-

ping with varus stress testing at 30°. The left knee is stable to Lachman’s, dial test, and posterior drawer. The PTFJ was stable and neurovascular exam was normal.

8.3.2 Imaging

Bilateral AP complete lower extremity long-standing view, bilateral AP weight-bearing knee view, bilateral Rosenberg view, bilateral sunrise view, and bilateral lateral view radiographs were obtained and reviewed at this clinic visit. The patient was in slight varus weight-bearing alignment bilaterally. There was no evidence of acute fracture or soft tissue abnormalities. PCL stress radiographs showed a 3.1 mm increased posterior tibial translation on the right compared to the left, but the patient noted he was guarding to protect his right knee. Varus stress radiographs showed a 1.8 mm increased gapping on the right compared to the left. However, the patient did not have a normal knee to compare to, making varus stress radiographs somewhat inconclusive.

Review of previously obtained MRI of the right knee showed evidence of injuries to the PCL and posterolateral corner. Prior MRI confirmed complete posterolateral injury, represented by tears of the FCL, PLT, and PFL (Figs. 8.8, 8.9, and 8.10). A previously obtained left knee MRI showed evidence of complete tear of the FCL avulsed off the femur. After discussing treatment options with the patient, he

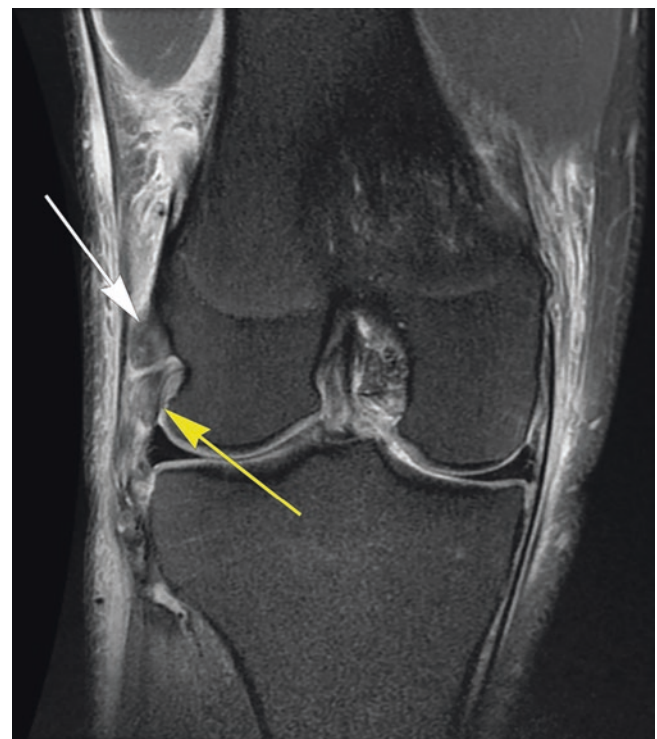


Fig. 8.8 A PD FS COR MRI illustrating the PLT (yellow arrow) presence of a complete midsubstance tear of the FCL (white arrow)

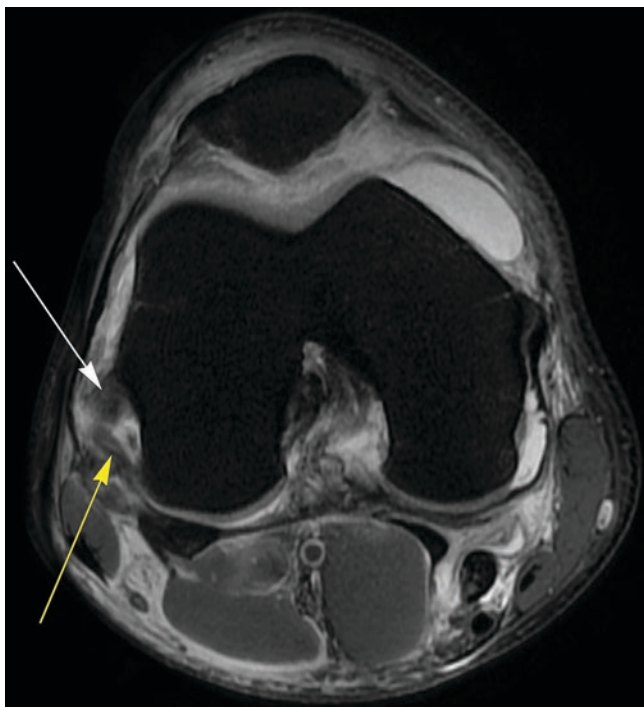


Fig. 8.9 A PD FS AX MRI illustrating the proximal portion of the torn FCL (white arrow) and the presence of a complete tear of the PLT (yellow arrow)



Fig. 8.10 A PD FS COR MRI illustrating the presence of a tear in the PFL (yellow arrow)

decided to move forward with surgical treatment. Given the complex and bilateral nature of the patient's injuries, the surgical plan involved treating the left knee first given that it still fell within an acute window for treatment. The left knee treatment would consist of a left knee scope, FCL

reconstruction with hamstring autograft, common peroneal nerve neurolysis, and possible medial meniscus repair. Approximately 3 months after the initial surgery, the patient would then proceed with surgical treatment of his right knee. The right knee treatment would involve a right knee scope, double-bundle PCL reconstruction with allograft, complete PLC reconstruction with allograft, and excision of a medial joint line cyst. The following section will cover the right knee procedure that addressed the grade III PLC tear.

8.3.3 Arthroscopy

The patient was induced under general anesthesia. He had a well-padded high right thigh tourniquet place. Exam under anesthesia was significant for range of motion of the right knee showing 5 cm of heel height to 140° of flexion. His Lachman's and valgus stress tests were normal both at 0° and 30° of knee flexion. His pivot shift was normal. His posterior drawer was 3+ and his posterolateral drawer was 3+ as well. His varus gapping at 30° of knee flexion was 3+, and in full extension it was 2+. Evaluation of the contralateral knee revealed 2 cm of heel height to 130° of knee flexion with no varus gapping. This was consistent with complete severe PCL and posterolateral corner injury on his right knee and a well healing FCL reconstruction on his left knee. Together, his exam under anesthesia was consistent with diagnosis made on clinical exam and diagnostic imaging.

The posterolateral corner approach was performed first so that the common peroneal nerve could be identified prior to fluid extravasation. A standard hockey stick incision was made, and dissection was performed down to the superficial layer of the IT band and over both heads of the biceps. Dissection was then slowly performed down to the common peroneal nerve. On palpation of the nerve, the foot went into dorsiflexion, which was representative of the severe scarring and irritation that was present. A meticulous 6 cm common peroneal nerve neurolysis was performed, including the peroneus longus fascia, to minimize the risk of footdrop postoperatively. The surgeon then entered the biceps bursa and identified the remnant of the FCL and its attachment site on the lateral aspect of the fibular head. A fibular head guide was used to drill a guide pin across the fibular head, which was then reamed with a 7 mm reamer while protecting the neurovascular structures. This was followed by placement of a passing stitch.

Dissection was performed anteriorly to identify the flat spot that is located distal and medial to Gerdy's tubercle. The surgeon then proceeded to dissect posteriorly and elevate under the remnant popliteus musculature to identify the musculotendinous junction. A pin was drilled from anterior to posterior using a tibial collateral instrument guide. The pin was confirmed to be in the desired location and was over-

reamed using a 9 mm acorn reamer while protecting the neurovascular structures. This was also followed by placement of a passing stitch.

The IT band was split over the femoral attachment site of the posterolateral corner structures. The FCL was not in continuity, and at this point the femoral attachment could not be identified. Further dissection was performed down to the lateral capsule to find the popliteus sulcus. His popliteus tendon had torn off the top of the sulcus, so the sulcus was identified and a Beath pin was drilled anteromedially across his thigh using the collateral instrument guide. The surgeon then measured 18 mm posterior to this and dissected down the femur to find the remnant of the FCL. A guide pin was drilled at this location. The distance between the two guide pins was measured to ensure anatomic positioning, and both were over-reamed with a 9 mm acorn reamer to a depth of 25 mm. This was followed by placement of passing sutures. The anterolateral bundle of the PCL was prepared from an Achilles tendon allograft with an 11 × 20 mm bone plug and distal tubularized graft. The posteromedial bundle of the PCL was prepared from a tibialis anterior allograft, which was whipstitched on each end with #2 nonabsorbable sutures.

The arthroscopy was now started by creating medial and lateral portals. The articular cartilage of the patellofemoral joint and medial compartment was normal. The medial meniscus and the ramp attachment area were normal without evidence of tears extending to the cyst that was known to be bothering him in the posteromedial knee. His lateral compartment was examined, and a wide-open drive-through sign was present. His lateral meniscus including the root attachment was normal. The ACL had a slack sign, which was reduced when pulling the tibia anteriorly. His PCL had healed, but it was very loose, which was consistent with his physical exam.

The PCL reconstruction was now performed. The femoral attachments of the PCL bundles were identified using the trochlea point and the medial arch point as anatomic guidelines. Guide pins placed at the anatomic attachment sites were then over-reamed with an 11 mm reamer for the anterolateral bundle and a 7 mm reamer for the posteromedial bundle to a depth of 25 mm while maintaining a 2 mm bone bridge between the tunnels. The shiny white fibers from the posterior horn of the medial meniscus were identified. An incision was then made medial to the tibial tubercle, and the surgeon dissected down 3–4 cm for the PCL reconstruction tunnel and fixation. A guide pin was placed using the shiny white fibers as a landmark while maintaining 1–2 mm of backwall, which was confirmed on fluoroscopic imaging. The PCL tibial tunnel was reamed using a 12 mm acorn reamer to a depth of about 70%, and the rest was reamed by hand. This was followed by a large Gore smoother which was used to smooth the aperture. The posteromedial bundle for the PCL was passed through the femoral tunnel and held

in place with a 7 × 20 mm bioabsorbable screw. The bone plug for the anterolateral bundle was then passed into its femoral tunnel and held in place with a 7 × 20 mm titanium screw. The PCL grafts were then passed through the tibia and pulled taut to eliminate the ACL slack sign. The two bone plugs for the posterolateral corner reconstruction were passed into their femoral tunnels and held in place with 7 × 20 mm titanium screws. The popliteal tendon was then passed down the popliteal hiatus, and the FCL was passed under the IT band and through the fibular head tunnel from lateral to medial.

An incision was made posteromedially over the joint where the large cyst was visible and palpable. Dissection was performed until the large cyst was appreciated. The cyst was excised, and complete decompression and excision of the cyst were confirmed. The PCL grafts were affixed on the tibia, with the anterolateral bundle affixed first at 90° of flexion with the knee held reduced and traction being placed on the graft. The posteromedial bundle was affixed in full extension. Both were affixed with 6.5 mm cancellous screws and washers. The FCL graft was fixed into its fibular head tunnel with the knee flexed 20° with a valgus reduction force and traction on the graft. This eliminated varus gapping. The popliteofibular ligament and popliteus tendon graft were passed from posterior to anterior and cycled through flexion and extension several times to remove any slack in the grafts. The grafts were fixed on the tibia with the knee flexed to 60° and the foot in neutral rotation with a 9 × 20 mm bioabsorbable screw. The surgeon then arthroscopically confirmed that the knee was well reduced, the PCL grafts were taut, and the patient's posterior drawer, posterolateral drawer, and varus stress gapping were all eliminated. The procedure was completed by letting down the tourniquet and closing the incisions in the deep tissue and superficial skin.

8.3.4 Discussion

The diagnostic MRI was particularly useful for this patient since varus stress radiographs were somewhat inconsistent due to the lack of a normal contralateral knee. In patients with a normal contralateral knee, a side-to-side difference of at least 2.7 mm is indicative of an isolated FCL injury, while greater than 4.0 mm is indicative of a combined FCL and PLC injury [12]. The MRI in this patient exhibited a complete tear of FCL, PLT, and PFL, also known as a grade III PLC injury. A tear of the FCL, PFL, or PLT appears as a linear increase in signal intensity on T2 MRI. This signal increase can be due to the presence of edema around the tear or discontinuity of the tissue resulting from a tear.

This patient also exhibited a lateral compartment drive-through sign, which is often associated with PLC injury. The lateral compartment drive-through sign is viewed during

arthroscopy and is defined as increased gapping in the lateral compartment [18]. Although the drive-through sign is associated with lateral compartment instability, damage to the FCL and PFL must be confirmed through an open lateral incision. Due to the positioning of these ligaments, they must also be reconstructed through open lateral incisions. Arthroscopy is also useful for assessing pathology in the menisci and articular cartilage that may lead to negative outcomes if left unaddressed. In this patient, both menisci were normal and stable except for a medial meniscus cyst that was excised through a posteromedial incision.

8.4 Case 3: PLC Reconstruction Revision, ACL Tear, Chronic PCL Tear, Biceps Femoris Avulsion with Concurrent Displaced Fibular Head Fracture, Stable Impaction Fracture of the MFC, and Severe Entrapment of the Common Peroneal Nerve

8.4.1 History/Exam

A 20-year-old patient presented to the clinic for an initial evaluation of his right knee. He was in a motor vehicle accident 2 months prior to presentation, in which he suffered a right knee dislocation. He also suffered a right wrist fracture, left hand lacerations, bowel injury, and a nondisplaced right distal fibula fracture. He underwent closed reduction the day of the injury followed by nonanatomic sling-type posterolateral corner reconstruction 11 days later. He was discharged to rehabilitation for 2 weeks and then discharged back home. He has not been doing formal physical therapy since that time. He has been in a locked hinged knee brace and has done very minimal range of motion rehabilitation. He did not have any issues with this knee prior to the injury and would like to return to an active lifestyle.

On physical examination, a well-healed lateral incision about 15 cm in length is appreciated on the right knee. There appeared to be a suture granuloma in the middle aspect of the incision overlying the lateral tibial plateau. There was no surrounding erythema or drainage. The patient had significant quadriceps atrophy with coactivation, but he was able to perform straight leg raise. His range of motion was extremely limited with a 0–30° range of motion arc as compared to 3 cm of heel height to 140° of flexion on the left. A formal posterior drawer test was not performed due to significant stiffness, but he did have a significant posterior tibial sag. Lachman test is positive but limited by associated guarding. He was stable to valgus stress exam at 30° of flexion. There was grade two gapping on varus stress exam at 30° of flexion. Neurovascular exam is normal.

8.4.2 Imaging

Bilateral standing AP view, bilateral long standing AP view, bilateral sunrise view, PCL stress view, and right leg lateral view radiographs were obtained and reviewed in the clinic. Due to the patient being partial weight-bearing on the affected leg, weight-bearing alignment could not be assessed on the right. However, he was neutral to mild varus alignment on the left. On the right, there was a displaced fibular head fracture and evidence of a prior medial femoral condyle impaction fracture. There was also evidence of disuse osteopenia.

MRI from the date of the accident was reviewed in the clinic. The MRI was significant for complete rupture of the ACL, PCL, and all of the posterolateral corner structures including the lateral capsule (Fig. 8.11). The IT band and peroneal nerve appeared to be intact and in continuity. There was significant bony edema with an associated impaction fracture of the medial femoral condyle and a displaced fibular head fracture. The lateral meniscus was extruded with a significant meniscocapsular disruption present. The medial collateral ligament (MCL) appeared to be intact, and there was a potential ramp lesion of the medial meniscus.



Fig. 8.11 A PD FS COR MRI exhibiting complete tears of the FCL (yellow arrow) and PFL (white arrow)

Patellofemoral articular cartilage was preserved, and there was no evidence of patellar dislocation. A large lipohemarthrosis was also present.

After discussing all treatment options, the patient decided to proceed with surgical treatment. Prior to surgery, he was advised to improve his range of motion through PT or manipulation under anesthesia. Once ROM improved, the surgical plan would include a complete posterolateral corner reconstruction revision with allograft as well as an ACL reconstruction with bone tendon-bone autograft and a double-bundle PCL reconstruction with allografts.

8.4.3 Arthroscopy

The patient was induced under general anesthesia without complications. He had a well-padded high right thigh tourniquet placed. Range of motion of the right knee was from 0° to 135°. His posterior drawer was 3+ and his Lachman was 2 to 3+. His valgus stress testing was normal. Varus stress testing was 3+ both in full extension and at 30° of knee flexion. His posterolateral drawer test and dial test were also 3+, respectively. This was compared to a left knee range of motion 3 cm of heel height to 140° of flexion and stability to all planes for his tibiofemoral joint. His exam under anesthesia was consistent with a failed posterolateral corner reconstruction with PCL and ACL tears. These findings were consistent with the clinical exam and diagnostic imaging.

The PCL grafts were prepared early in the case due to the anticipated length of the surgery. The PCL grafts consisted of an Achilles tendon graft with an 11 × 20 mm bone plug and a distal tubularized graft for the anterolateral bundle. A tibialis anterior graft from a young donor was used for the posteromedial bundle and whipstitched on each end with #2 nonabsorbable sutures. The posterolateral corner reconstruction grafts were prepared from a split Achilles tendon graft. The popliteus tendon graft consisted of a 9 × 20 mm bone plug and a distal tubularized graft. The FCL and popliteo-fibular ligament grafts were similar in size to the popliteus tendon graft with two passing sutures in each bone graft and distal tubularized grafts with #2 nonabsorbable sutures.

The PLC reconstruction revision approach was performed first due to the anticipation of severe scarring being present around the common peroneal nerve. His previous incision was used, which was significantly scarred. Dissection was performed down to the superficial IT band. An Adson point hemostat and #15 blade were used to be able to get down to the fibular head. Complete scarring and matting of the tissues were present around the biceps and the common peroneal nerve. Dissection proximal to and under the biceps was necessary to find the peroneal nerve. A slow and meticulous peroneal nerve neurolysis was performed. At the region of the fibular head, the nerve was flattened and nearly indistin-

guishable from scar tissue, so the neurolysis was stopped at this point. A curved elevator was used to elevate the soleus off the posteromedial aspect of the fibular head. A guide pin was drilled across the fibular head using a fibular head guide, and then this was over-reamed with a 7 mm reamer. This was followed by placement of a passing stitch. Dissection is performed anteriorly, and the flat spot distal and medial to Gerdy's tubercle is identified. The popliteus musculotendinous junction was then identified using an elevator. A guide pin was then drilled anterior to posterior and confirmed to be 1 cm medial and 1 cm proximal to the exit of the fibular head tunnel posteromedially. This guide pin was then over-reamed with a 9 mm acorn reamer while protecting the neurovascular structures posteriorly. This was followed by placement of passing stitches.

The IT band was split, and the surgeon entered the lateral capsule. The area where the popliteus normally attaches was identified. A guide pin was then drilled through the center of the attachment site which exited anteromedially on the femur. The surgeon went 18 mm posterior to this and dissected down to find some remnants and sutures. A second guide pin was drilled similarly parallel to the popliteus tendon guide pin. The distance between these two pins was verified to be 18 mm, and they were verified to be in anatomic position. Both guide pins were over-reamed with 9 mm acorn reamers to a depth of 25 mm, and then passing stitches were placed. The channel for passage of the grafts was then cleared out for later passage of the grafts. The biceps femoris was then dissected out, and a tag suture was placed so that a repair could be performed later in the case.

An incision was made along the medial aspect of the patella down to the medial aspect of the tibial tubercle for harvesting of the patellar tendon autograft. An autograft with a 10 × 20 mm bone plug off the patella and a 10 × 25 mm bone plug off the tibial tubercle was harvested.

The arthroscopic portion of the procedure was then started by making medial and lateral arthroscopic portals. The suprapatellar pouch had mild scar tissue reformation. The medial femoral condyle impaction fracture had some recurrent chondromalacia, so a chondroplasty was performed here with a shaver. The medial compartment had no evidence of any tearing, and his ramp and root attachment areas were normal. His lateral compartment has a wide-open drive-through sign (Fig. 8.12). The lateral meniscus including the root attachment was still intact.

The PCL attachment site on the femur was prepared next. The anteromedial and posteromedial bundle attachment sites were outlined using anatomic landmarks. An 11 mm closed socket tunnel was reamed for the anterolateral bundle, and a 7 mm closed socket tunnel was reamed for the posteromedial bundle. Next, the lateral intercondylar ridge was identified, and a bur hole was placed between the anteromedial bundle and the posterolateral bundle of the ACL. The knee was then

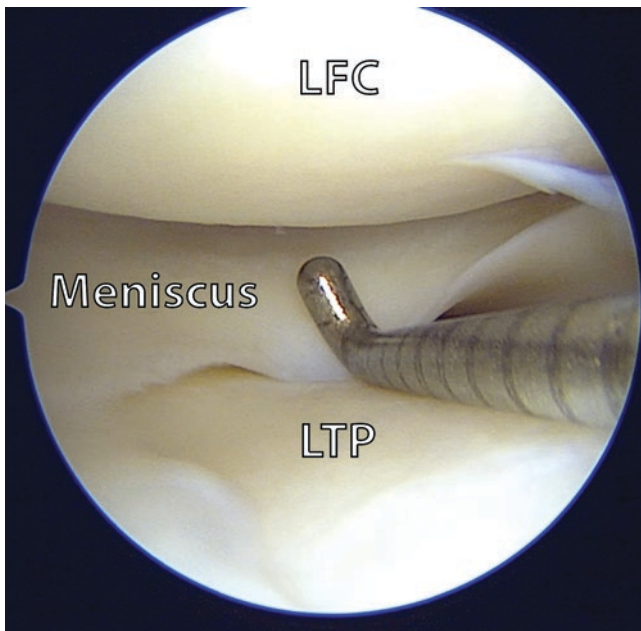


Fig. 8.12 An arthroscopic image of the lateral compartment illustrating a wide-open drive-through sign

maximally flexed, and an over-the-top guide was used to drill a beath pin anterolaterally out of his thigh. This was then over-reamed with a 10 mm low profile reamer to a depth of 25 mm while maintaining a 1.5–2 mm back wall. This was followed by placement of a passing stitch.

The PCL tibial attachment site was debrided through a posteromedial arthroscopic portal. There was significant scarring present, and the tibial bundle ridge was visualized after extensive use of a shaver and coagulator. The guide pin for the PCL tibial tunnel was drilled into the tibia. Correct positioning of the pin was confirmed with fluoroscopic imaging. The tibial ACL attachment was outlined just medial to the anterior horn of the lateral meniscus. A guide pin was drilled directly into the center of the tibial ACL attachment, with extreme care being taken to avoid the PCL tunnel. The PCL tunnel was then reamed with a 12 mm acorn reamer, with 80% of the depth being reamed by power and the remaining 20% being reamed by hand with a large curet protecting from over-penetration. A large Gore smoother was passed through the tibial tunnel to smooth off the aperture. The ACL tunnel was then reamed, and the apertures were cleaned. The posteromedial bundle of the PCL was pulled in place and fixed in the femur with a 7 × 20 mm bioabsorbable screw. Then the bone plug for the anterolateral bundle of the PCL was pulled in place and fixed in the femur with a 7 × 20 mm titanium screw. The sutures in the ends of both grafts in the anterolateral portal were inserted into the large Gore smoother and pulled down through the tibia. Arthroscopic confirmation showed no bunching of the grafts. The passing stitch for the ACL graft was pulled down the

tibial tunnel into place and fixed to the femur with a 7 × 20 mm titanium screw.

The FCL graft and popliteus bone plugs were then passed into their respective femoral tunnels and held in place with 7 × 20 mm titanium screws. The popliteus graft was then passed down the previously created channel along the popliteus hiatus, and the FCL graft was passed under its normal course, which was complicated by the extent of scarring resulting from the previous surgery. The FCL graft was then passed through the fibular head tunnel. The PCL graft was fixed on the tibia with 6.5 mm cancellous screws and washers with the anterolateral bundle fixed first at 90° of knee flexion and the surgeon holding the knee reduced in neutral rotation. The posteromedial bundle was fixed in full extension with the knee in neutral rotation. The ACL graft was now fixed in the tibial tunnel with the knee in full extension and the lateral compartment reduced using a 9 × 20 mm titanium screw. The FCL graft was fixed with a 7 × 20 mm bioabsorbable screw, while the knee was flexed to 20° and a slight valgus reduction force was applied. Varus gapping was eliminated at this point. The popliteofibular ligament grafts and popliteus tendon grafts were then passed from posterior to anterior and held in the tibia with a 9 × 20 mm bioabsorbable screw with the knee flexed to 60° and the foot in neutral rotation. During all portions of the PLC repair, extreme care was taken to protect the common peroneal nerve. Following repair of the PLC, it was noted that the patient's posterior drawer, posterolateral drawer, Lachman test, varus stress testing, and dial test were completely normal. The biceps femoris was then repaired by fixing an anchor into the fibular head and then placing the sutures into the biceps. The biceps femoris was then tied to the fibular head with the knee in full extension, which resulted in restoration of the tension of the biceps tendon. The ACL was intraarticularly confirmed to be taut without impingement. The procedure was completed by letting down the tourniquet and closing the incisions in the deep tissue and superficial skin.

8.4.4 Discussion

Nonanatomic reconstructions of the posterolateral corner can stretch out over time, especially in the context of a concurrent chronic PCL tear and poor rehabilitation compliance. On diagnostic imaging following the initial injury, there was evidence of a grade III posterolateral corner tear, in addition to an avulsion tear of the biceps femoris and a medial femoral condyle impaction fracture. The patient presented with significant posterior tibial translation, limited range of motion, and stiffness secondary to the nature of his previous repair and rehabilitation. Anatomic reconstruction of the PLC is preferred over nonanatomic reconstruction because it provides biomechanical advantages, namely, improved

external rotatory stability and reduction of posterior tibial translation and improved patient outcomes [1, 8, 19–22]. Concurrent PCL injury is also reported to be an indication for anatomic reconstruction of the PLC [23].

In this case, MRI missed the chondromalacia that was present on the medial femoral condyle secondary to the impaction fracture that occurred during the initial injury. On MRI, the lateral meniscus was extruded; however on arthroscopy there was no meniscal pathology, and the entire lateral meniscus was stable. There was a drive-through sign during arthroscopic examination of the lateral compartment, which is indicative of PLC injury. The initial MRI showed a possible tear of the medial meniscus ramp lesion; however, arthroscopic examination showed no evidence of tearing.

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