Introduction

Posterolateral corner (PLC) injuries of the knee are a rare but often debilitating injury. If left untreated, PLC injuries can lead to persistent instability, pain, articular degeneration, and failure of surgically treated cruciate ligament reconstructions. Often resulting from a high energy hyperextension varus impact to the anteromedial knee, cruciate ligament injuries, fractures, and neurovascular compromise are commonly associated with this injury. Early recognition and appropriate treatment relies on an understanding of the anatomy, a thorough knee examination, careful surgical technique, and a protected rehabilitation protocol.

Due to the rarity of isolated PLC injuries, much of the literature on identification, treatment, and outcome is obtained from studies involving multiligament knee injuries. Acknowledging that the multi-ligament literature may not be directly applicable to the patient with an isolated PLC injury, the vast majority of patients with this condition will present in the setting of a knee dislocation.

Anatomy

There are over 28 described structures that comprise the PLC of the knee. Recent biomechanical studies have simplified the description to 3 main anatomic structures: the popliteus tendon, popliteofibular ligament (PFL), and fibular collateral ligament (FCL). These 3 have been identified as the most important structures for posterolateral knee stability. The FCL is the primary restraint to varus stress, most notably during the first 30° of flexion. The popliteus tendon and PFL are important structures for resisting external rotation torque. Repair or reconstruction of the PLC typically attempts to recreate the stability provided by these 3 structures. The FCL originates in a slight depression slightly proximal and posterior to the lateral epicondyle of the femur. Distally the FCL inserts on the anterolateral portion of the fibular head. The popliteus tendon attaches on average 18.5 mm anterior and distal to the FCL within the popliteus sulcus of the lateral femur. The sulcus can easily be seen and palpated during operative exploration. Distally the tendon gives rise to 3 popliteomeniscal fascicles which attach to the lateral meniscus. The popliteofibular ligament originates at the musculotendinous junction of the popliteus providing anterior and posterior divisions which course laterally to insert on the posteromedial fibular styloid and FCL.

There is an important correlation that exists between the integrity of the cruciates and PLC in providing stability to the knee. The posterior cruciate ligament (PCL) primarily resists posterior translation of the tibia on the femur. In addition, the posterior cruciate acts as a secondary restraint when varus and external rotation forces are applied to the knee. The PLC, on the other hand, provides a primary restraint to varus stress and external rotation forces to the knee. An important secondary role of the PLC is to provide restraint to posterior translation of the tibia on the femur. Understanding this correlation between the PCL and PLC will improve the clinical diagnostic accuracy of complex ligament injuries to the knee.

Diagnosis

Gait and Alignment

Patients with chronic injuries to the PLC may demonstrate a varus thrust during foot strike of the gait cycle. While this can also be seen in medial compartment knee arthritis, recognition of this gait pattern in the setting of combined varus malalignment and anterior cruciate ligament (ACL) deficiency is important for identifying a PLC injury.

Recognition of preexisting limb malalignment on physical exam impacts treatment strategy regarding ligament injuries about the knee. Varus malalignment and varus thrust gait are specific indications for a valgus-producing proximal tibial osteotomy prior to ligament reconstruction surgery, especially when the ACL and/or PCL are involved.

Varus Stress

The varus stress test is performed at both full extension and 30° of knee flexion. A positive test at full extension indicates a PLC injury with damage not only to the FCL and other varus stabilizing structures, but also indicates damage to the cruciate ligaments of the knee. Varus stress at 30° of flexion relaxes the cruciates and other posterolateral structures, allowing isolated assessment of the FCL. This test is typically graded in relation to joint line opening, with Grade I demonstrating 0 to 5 mm of joint line opening, Grade II having 5 to 10 mm, and Grade III demonstrating over 1 cm of joint line opening as compared to the normal contralateral side. Evaluation of the opposite, sound knee, illustrates the patient’s normal cruciate and collateral laxity. If the contralateral knee is abnormal, evaluation is more difficult in the injured knee.
Dial Test
The dial test is an important maneuver to assess the integrity of the PLC. The test is performed supine or prone, the thigh is stabilized by the examiner, and the foot is externally rotated. Attention is directed to the degree of external rotation of the foot as measured by the thigh-foot-angle of the injured knee compared to the unaffected knee. The exam is considered abnormal if side-to-side comparison demonstrates more than 10° to 15° of external rotation at either 30° or 90° of flexion. An increase in external rotation at 30° of flexion indicates injury to the PLC, whereas increased external rotation at both 30° and 90° indicates injury to both the PLC and the PCL.20,21

Posterior Drawer
The posterior drawer test is used to assess the integrity of the PCL. Performed by applying a posterior force to the proximal tibia with the knee in 90° of flexion, the translation is assessed by noting the difference between the anterior tibial plateau and femoral condyles before and after the applied load. A posterior drawer test with less than 10 mm of translation suggests an isolated posterior cruciate injury. Posterior tibial translation greater than 10 mm during the posterior drawer test, however, raises the suspicion of a combined posterior cruciate and PLC injury.11,21

Posterolateral Drawer
The posterolateral drawer test is a functional exam that helps determine the integrity of the PLC. This is performed by flexing the knee to 90°, and with the foot in external rotation a posterior force is applied to the proximal tibia. The amount of translation is noted by assessing the degree of prominence of the anteromedial tibial plateau as compared to the femoral condyles. If the degree of translation that occurs with the posterolateral drawer is less than that which occurs with the posterior drawer test, the PLC is likely intact, and the posterior cruciate ligament is likely affected. If the degree of translation is equivalent in both posterolateral drawer and posterior drawer tests, the PLC and posterior cruciate both are likely disrupted.19,22

External Rotation Recurvatum
The external rotation (ER) recurvatum test is performed by lifting the leg into full extension by the great toe. The degree of ER recurvatum which occurs is compared to the contralateral knee. A positive test suggests a multiligament knee injury involving both cruciate ligaments and posterolateral corner.3,22 This exam will usually be negative if a PLC injured knee retains a functioning anterior cruciate.

Reverse Pivot Shift
The reverse pivot shift test is performed by extending the knee from 45° to 60° of flexion while applying external rotation to the foot and a valgus stress to the knee. Damage to the PLC may result in a palpable shift or reduction of the subluxed knee as the knee is extended. This occurs as the effect of the iliotibial band (ITB) changes from a flexor to extensor force on the knee, which occurs between 25° to 30° of flexion. Although associated with a large number of false positives, this is a functional test that contributes to assessment of the integrity of the PLC.23,24

Neurovascular Exam
A postero lateral corner injury may result in numbness or tingling in the peroneal nerve distribution with or without weakness with ankle dorsiflexion and great toe extension. These are signs suggestive of a common peroneal nerve injury. Identification and documentation of such findings is important as they are said to occur in as many as 15% of PLC injuries.18 In cases in which the creation of a fibular head tunnel, reattachment of the biceps femoris tendon, or exploration of the PFL, FCL, or popliteus is needed, exploration and protection of the common peroneal nerve is warranted. Knowledge of peroneal nerve function preoperatively is critical in determining if surgical exploration affected nerve function postoperatively.

A dedicated vascular exam is also essential in the setting of a multi-ligament knee injury. The popliteal artery is at risk of injury, being tethered both proximally and distally as it courses through the popliteal fossa. Vascular injury has been documented in 7% to 40% of knee dislocations, with severity ranging from intimal wall injury to complete transection.25 Clinical examination of distal pulses and perfusion, ankle brachial index (ABI), as well as computed tomography (CT) angiography are useful to assess vascular integrity of the injured limb.26 An ABI less than 0.9 indicates injury to the vascular tree, and warrants additional vascular imaging, usually in the form of a CT angiogram.27 If vascular compromise is suspected, an emergent vascular surgery consult is indicated. A patient with normal initial vascular exam following a multi-ligament knee injury should be followed closely with serial clinical examinations due to the limb-threatening consequences of a vascular injury.

Imaging Examination
Standard imaging includes weight bearing radiographic evaluation and magnetic resonance imaging (MRI). The arcuate sign, which is an avulsion fracture of the fibular head by the PFL, can be identified with standard radiographs and is pathognomonic for a PLC injury.
Treatment Options

A Segond fracture, which is an avulsion fracture off the anterolateral proximal tibia from the middle third of the lateral capsule, can be identified with standard radiographic evaluation as well. Although nonspecific for a PLC injury, a Segond fracture may indicate a higher energy injury to the knee with concerns for cruciate disruption. A Segond fracture off the anterolateral proximal tibia from the middle third of the lateral capsule, can be identified with standard radiographic evaluation as well. Although nonspecific for a PLC injury, a Segond fracture may indicate a higher energy injury to the knee with concerns for cruciate disruption. Varus malalignment can contribute to a PLC injury. Delay leads to tissue retraction and scar formation, issues which complicate identification and compromise quality of ligamentous structures. If tissue compromise is significant, reconstruction of the involved structure is unable to hold suture, or mid-substance rupture of the stabilizing structure has occurred, reconstruction, as opposed to repair, is recommended. Likewise, tissue retraction and shortening will compromise primary repair, and in this setting reconstruction of the involved PLC structure is recommended.37-39

The differences between early and delayed surgery in multiligament knee injuries were studied in a recent systematic review by Levy et al. The group that underwent early treatment received surgery on average 2 weeks post injury. The delayed surgery group underwent operative intervention on average 51 weeks post injury. Those who underwent early surgical treatment had higher Lysholm scores, as well as a higher percentage of good/excellent IKDC scores than those treated late. Collected knee outcome surveys available for review showed higher sports activity scores in the “early” group, however, failed to demonstrate a statistical difference in activities of daily living (ADL) scores. Tegner scores, mean postoperative ROM, and flexion loss were similar between those undergoing early versus delayed treatment.38,3,41-43

Surgical Timing

The literature is controversial in regards to the definition of early versus late treatment of PLC injuries. Although concurrent injuries often preclude the ability to perform early surgery, most authors agree that early intervention is aimed at tissue repair, and as such should be carried out no later than 3 weeks post injury. Delay leads to tissue retraction and scar formation, issues which complicate identification and compromise quality of ligamentous structures. If tissue compromise is such that the involved structure is unable to hold suture, or mid-substance rupture of the stabilizing structure has occurred, reconstruction, as opposed to repair, is recommended. Likewise, tissue retraction and shortening will compromise primary repair, and in this setting reconstruction of the involved PLC structure is recommended.37-39

Scores in patients undergoing operative treatment, with poorer results seen with nonoperative management. Patients were more likely to return to work and sports activities following surgical intervention. However, mean range of motion (ROM) and ultimate flexion loss were not significantly different between the 2 groups.34,35

Nonoperative Treatment

Nonoperative treatment, consisting of bracing, strengthening, and activity modification, may be appropriate for a select group of patients with isolated PLC injuries. A few studies have shown similar results in patients treated operatively or nonoperatively with Grade I and II injuries to the PLC.31,32 Other studies have shown that Grade III PLC injuries, and combined PLC/cruciate ligament injuries respond unfavorably to conservative measures. Surgical intervention is encouraged in these situations for optimal outcome.31,33

Three specific studies have examined operative versus nonoperative management of multiligament knee injuries.34-36 These studies have shown higher Lysholm and Tegner functional scores as well as a higher percentage of good/excellent results when evaluating International Knee Documentation Committee (IKDC) scores in patients undergoing operative treatment, with poorer results seen with nonoperative management. Patients were more likely to return to work and sports activities following surgical intervention. However, mean range of motion (ROM) and ultimate flexion loss were not significantly different between the 2 groups.34,35

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The development of arthrofibrosis in the postoperative patient with a multiligament knee injury is a concern, particularly for those undergoing early intervention. Multiple authors have cautioned against such early treatment due to a higher risk of this complication.44-49 The senior authors of this paper caution against early bicruciate or multiligament reconstruction in the presence of a preoperative flexion contracture due to the higher risk of arthrofibrosis. To address this issue, preoperative rehabilitation is currently employed in our institution early after injury to decrease joint effusions and to establish ROM prior to reconstruction. Levy, however, failed to show any significant difference in final...
mean ROM and flexion loss between the early and late surgically treated groups.40

Reconstruction Techniques
Multiple techniques for addressing PLC reconstruction have been described. In 1996 Larson described passing a semitendinosus graft in a figure-of-8 manner through the proximal fibula and fixing the graft to the lateral femoral condyle between the attachment sites of the FCL and popliteus tendon.50 Arciero, in 2005, introduced an anatomic reconstruction of the insertion sites of the popliteus tendon and FCL on the femur utilizing a dual–femoral socket technique.51 LaParade outlines another anatomic technique for reconstruction in which the FCL, PFL, and popliteus tendon are reconstructed with allograft tissue through bone tunnels placed at their respective sites of origin and insertion.52 Additionally, a 4 stranded hamstring autograft reconstruction has recently been described for reconstruction of the FCL and remaining PLC structures.53 Although no consensus exists at present regarding recommended technique, the trend is towards anatomic PLC reconstruction. The anatomic reconstruction, as described by LaParade, is preferred by one of the senior authors (RCS).

Repair vs Reconstruction
Several studies have examined outcome differences between reconstruction versus primary repair of the PLC in concert with a multiligament knee reconstruction. Stannard et al showed a failure rate of 37% with isolated PLC repair versus a failure rate of 9% with reconstruction.33 Levy et al showed similar findings, with a failure rate of 40% for repair and 6% for reconstruction of the PLC in the setting of a multiligament knee injury.37 There were, however, no significant difference between patients undergoing a reconstruction following failed repair compared to those knees which were initially reconstructed.37 Understanding the inter-relationship of cruciates and PLC prior to surgery is important. Reconstruction of a cruciate without addressing the PLC in a multiligament injured knee will eventually fail. Likewise, reconstruction of the PLC without addressing a cruciate injury will eventually fail. Due to concerns for excessive graft load on the reconstruction, most authors recommend reconstruction of all damaged ligaments in a single setting compared to staged surgery.35,28,29,54

High Tibial Osteotomy
Limb malalignment, particularly varus, greatly impacts reconstructive surgery in a patient with a chronic PLC knee injury, so attention to limb alignment is critical.55 Chronic repetitive loads placed across a ligament reconstruction in the setting of limb malalignment will most likely produce an unsatisfactory result through graft attrition and eventual failure. High tibial osteotomy (HTO) is a procedure that redirects the mechanical weight-bearing axis and alters the loads distributed across the knee. Typically reserved for medial compartment osteoarthritis and painful varus malalignment, HTO can also be used to address coronal and sagittal malalignment associated with chronic ligament insufficiency to provide a more favorable mechanical environment for ligament reconstruction. Following HTO, ligament reconstruction is typically delayed 6 months to allow healing of the osteotomy. The stability afforded by the osteotomy is occasionally sufficient to provide the patient a functional knee without need for subsequent surgery. If instability persists following HTO, reconstruction of all injured ligaments may then be undertaken.55

Treatment Summary
The literature suggests improved functional and clinical outcomes with early compared with delayed surgery, and favors reconstruction of the cruciates as well as the PLC for multiligament injuries of the knee. Management of all torn structures at one setting is considered the most reliable approach to successful surgery. HTO is recommended prior to ligament reconstruction in the unstable knee with malalignment.

Operative Approach
For surgical exposure, a straight, curvilinear, or hockey–stick incision is carried out over the lateral aspect of the knee.56–58 The best approach in our experience is a curvilinear incision from the lateral epicondyle proximally, and in line distally between Gerdy’s tubercle and the fibular head. Palpation of the knee flexed to 90° helps in identification of the 3 windows used for this approach. “Window I,” posterior to the biceps femoris tendon, is where one finds the peroneal nerve. Most authors recommend visualization of the nerve with neurolysis, followed by visualized protection throughout the procedure. “Window II,” between the biceps femoris and ITB, is the internervous plane used historically for an inside out lateral meniscus repair. Identification and repair versus reconstruction of the fibular-based components of the PLC, as well as the popliteus tendon off the posterolateral tibia, can be done through “Windows I and II”. Anterior, to this is “Window III”, where the ITB is split from the lateral epicondyle of the femur to Gerdy’s tubercle. This allows identification of the origin of the FCL and popliteus tendon from the lateral femur. LaParade19 suggests placing a stay suture
in the FCL, if intact, in Window II. Pulling on this suture permits palpation of the FCL origin on the lateral epicondyle of the femur and identification of the starting point for exposure to “Window III”. Utilization of the “Windows” concept provides a safe and effective stepwise approach to the posterolateral knee.

Rehabilitation

Multiple postoperative rehabilitation protocols have been proposed in the literature for both isolated and combined injuries to the PLC. Although no gold standard has been established, some general recommendations can be extrapolated from previous studies. Non-weight-bearing on the operative extremity is typically recommended for the first 4-6 weeks postoperatively. During this time immediate ROM exercises can be initiated with avoidance of knee hyperextension. Goals of 90° of knee flexion by 2 weeks, and full ROM by 14 to 16 weeks postop, are set for the patient. Progressive strengthening is encouraged with the exception of active hamstring exercises. These are generally avoided for the first 4 months following surgery. Return to sporting activity is generally withheld until 9 to 12 months from surgery.

Conclusion

Injuries to the PLC can be devastating, and often are associated with multiligament injuries to the knee. Prompt diagnosis and appropriate treatment are essential for restoration of stability. Simultaneous surgical treatment of all injured structures is typically recommended. Anatomic techniques are generally preferred, with attention placed on reconstruction of the FCL, PFL, and popliteus tendon. Postoperative rehabilitation focuses on return of strength and ROM. Further research is needed to provide optimal surgical and rehabilitation protocols for this high energy injury.

References


