Role of Anatomical Reconstruction in Injuries of Posterolateral Corner of the Knee

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Abstract:

Posterolateral corner (PLC) of the knee has been shown to play a significant biomechanical and anatomical role in knee stability. Although uncommon pathology, Injuries to the posterolateral corner of the knee are a challenging problem to manage and lead to significant symptomatic instability. Anatomic reconstruction attempts to recreate the fibular collateral ligament, popliteofibular ligament, and popliteus based on their native attachment sites. This has been shown to both biomechanically improve varus and rotatory laxity of the knee.

Keywords: Anatomical, Reconstruction, Posterolateral Corner of the Knee.

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Introduction:

Management of lateral side injuries is different to medial side tears. Medial side injuries are more common than lateral, and the majority can have good outcomes with conservative treatment. This finding does not apply for the PLC injury, due to an inherent anatomic instability of the lateral tibiofemoral compartment. This compartment with a convex lateral tibia plateau articulating with a convex lateral femoral condyle is designed to have more mobility. Consequently, this intrinsic instability does not lead to a spontaneous healing of PLC structures. The studies conclude that PLC reconstruction, in addition to being useful for longterm ACL graft stability, is also necessary to restore normal knee kinematic with a good overall stability (1).

Although definitive guidelines for management of all PLC injuries cannot be derived from the available literature, it would be reasonable to suggest from the available evidence that grade I and II isolated PLC injuries do not usually require surgical treatment, whilst grade II with a combined injury and grade III will be best managed surgically (2).

Conversely, nonoperative management for PLC grade III has been shown to result in poor functional outcomes, persistent instability and subsequent development of osteoarthritis.

Nonoperative management consists of a hinged knee brace to protect against varus stress and an early mobilization protocol, including gentle and progressive mobilization to avoid stiffness, quadriceps stimulation and gait training. Partial weight bearing is commenced immediately and progressively increased, according to the patient tolerance. Protection with crutches in the first 4 weeks will avoid any falls that may cause varus stress, and the use of a valgising unloader brace may have additional benefits in protecting the injured lateral structures if available **(3).**

Repair versus Reconstruction Techniques:

Historically, both repair and reconstruction have been used for treating PLC tears. PLC repairs have been reported to have a higher reoperation rate when compared with reconstructive techniques. As a result, reconstruction is recommended for grade III injuries **(4).**

Regarding the timing of surgery, acute treatment(<3 weeks after the injury) is reported to have better outcomes than treatment in subacute (3–12 weeks) or chronic phases (>3 months) **(5).**

Acute PLC injuries may be treated by direct repair, augmentation or reconstruction. Primary repairs of bony avulsions of FCL and PLT, without mid substance injury, can be done only during the acute phase. After this endpoint, the fibrosis associated with tissue healing makes anatomic reduction and reattachment of injured structures difficult to achieve. Therefore, injuries older than 3 weeks are difficult to achieve primary repair and will usually require a reconstruction **(6).**

Stannard and Levy et al. reported 37–40% failure rate with repair compared to 6–9% with reconstruction **(7).**

However, there can be difficulties in making definitive recommendations from these studies due to the heterogeneous nature of patient groups, but as a general guideline, reconstruction, or augmentation with a reconstruction, is usually required when a satisfactory repair cannot be achieved. This is mostly in the case of mid substance injuries, which in the acute setting are best dealt with by primary repair augmented by a reconstruction. Bony avulsions which can be reduced and secured will usually do well without reconstruction, and indeed in these cases, the usual reconstruction is not technically possible due to the fibular head avulsion. In the surgical management of acute injuries, the position of the common peroneal nerve is usually altered by the surrounding avulsion injury. Therefore, careful exploration and identification of this nerve and a neurolysis are recommended, to allow careful retraction of the nerve to avoid injury. This should be the first step of the surgical procedure prior to commencing the repair and reconstruction components **(3).**

For chronic PLC injuries, reconstruction is always recommended, regardless of the location of the injury **(6).**

Good outcomes were achieved with both repair and reconstruction of PLC injuries treated concurrently with ACL reconstruction at 6-year follow-up. Patients treated with reconstruction had lower activity levels 6-years after surgery **(8).**

Reconstruction of the posterolateral structures is suitable for chronic instability rather than acute cases. There are various methods of reconstruction, which can be divided into anatomic reconstruction and non-anatomic reconstruction **(2).**

Surgical Repair

Regarding acute management of PLC injuries, bony avulsions should be fixed. This is most commonly an avulsion of the fibular head but may also involve avulsions from the lateral tibial plateau. As with any internal fracture fixation, the size of the fragment will determine which fixation device, and which size, is most appropriate. For larger fragments, screws with soft tissue washers can be used, whereas smaller, more comminute fragments may require suture anchors, with the sutures passed through the bony fragments and attached soft tissues (fig., 1). Suture imbrication is possible when the PLT musculotendinous tendon region is injured. Sutures are passed through the remaining tendon and anchors in the posterior part of the tibia. The PFL can be repaired in the same way. Moreover, it is necessary to diagnose and treat all of the additional lateral side injuries. Initial surgical dissection should identify the zone of injury and all structures within that zone that are injured and need to be repaired. Capsular structures, such as the coronary ligament, the proximal tibiofibular ligaments, the mid-third lateral capsular ligament and the ITB, all need to be repaired, usually by anchoring into their bone attachments (fig.,2). For mid substance injuries, a good quality isolated repair is not usually able to be achieved and hence usually requires augmentation with a reconstruction to reduce the risk of recurrent laxity **(3).**

Some authors recommend a repair with an augmentation using synthetic ligament, whereas most commonly the augmentation reconstruction would use a soft tissue graft **(9).**

Apart from these specific injuries in the acute phase, the preference would generally be towards reconstruction for PLC injuries. Regarding associated ACL injuries, with the exception of bony avulsions, the recommendation would clearly be for reconstruction **(3).**

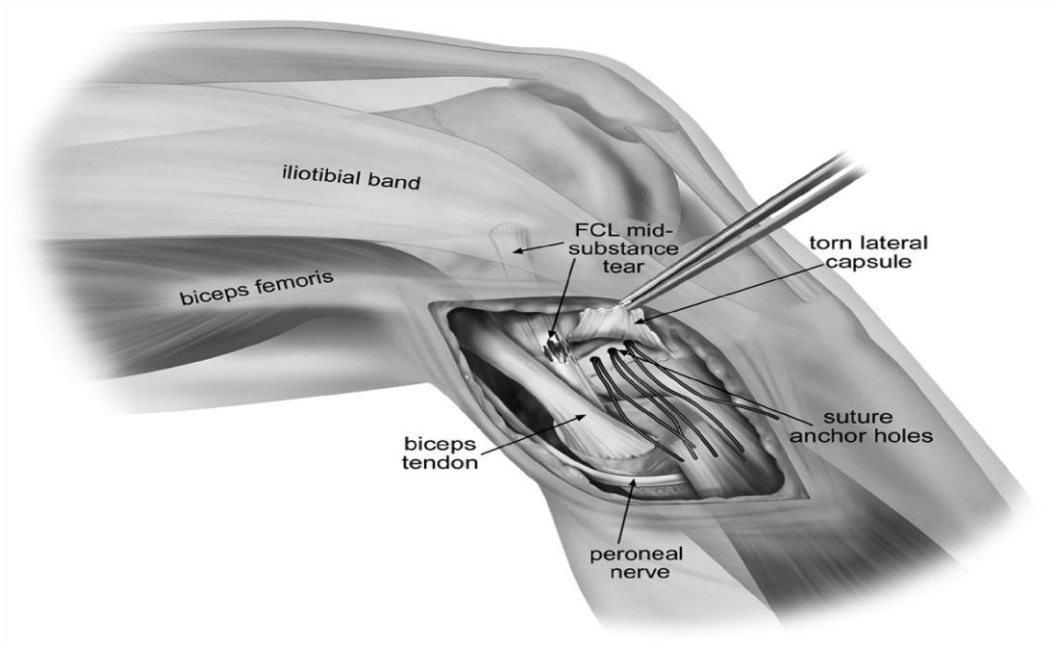

Figure 1: Illustration of lateral capsule repair with suture anchors is shown (9).

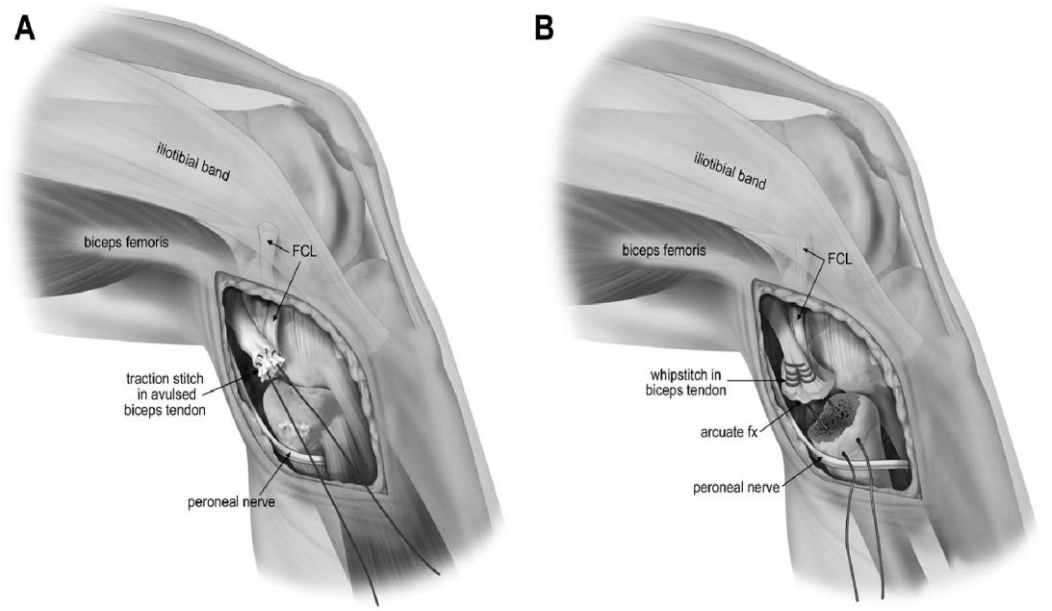

Figure 2: (A) Illustration depicting a whipstitch placed into the distal end of the avulsed biceps femoris tendon before suture anchor repair. (B) Arcuate fracture repair is illustrated using fibular bone tunnels with a whipstitch in the distal aspect of the biceps femoris tendon (9).

High tibial osteotomy

Alignment of the lower limb is of course an important prognostic factor to consider Malalignment of more than 3° of varus, associated with a varus thrust when walking, can lead to increased stress on the graft and increase the failure rate. This should therefore not be ignored as

it will most likely lead to failure of the reconstruction. For these cases, a HTO, either as an initial procedure alone or combined with reconstruction, is recommended **(3).**

If there is more than 3° of varus deviation or the hip knee axis passes within 30% of the medial side of the tibial plateau, high tibial osteotomy can be considered. In cases of complex knee instability, the 3-dimensional osseous alignment of the knee should be considered (eg, mechanical weight bearing line and tibial slope). In cases of failed ACL reconstruction, the tibial slope should be considered, and slope-reducing osteotomies are often helpful in the patient revised multiple times. In cases of chronic PCL and/or PLC instability, osseous correction of the varus alignment may reduce the failure rate and is often the first step in treatment. Changes in the mechanical axis should be considered in all cases of instability accompanied by early unicompartmental osteoarthritis **(10).**

Chronic PLC injury

A chronic injury of the posterolateral structure is one that has persisted for more than 3 weeks following injury. The torn structure becomes fibrotic scar tissue after 3 weeks and direct repair can be difficult owing to tissue adhesion. Moreover, joint stiffness may occur after surgery. Therefore, reconstruction is recommended in chronic injuries **(2).**

Historically, posterolateral advancement of the "arcuate tissue complex" (the fibular collateral ligament [FCL], popliteus tendon, and all structures attached to the fibular head) was a common treatment for chronic grade III PLC injuries. Recent advancements in biomechanical research have elucidated the key structures of the PLC that provide varus and external rotational stability **(11).**

Currently, there is no consensus on the preferred reconstruction technique for treating patients with chronic PLC injuries **(11).**

Chronic PLC injuries were reconstructed in all studies, and while techniques varied, the surgical management of chronic PLC injuries had a 90% success rate and a 10% failure rate **(11).**

Reconstruction

(1)Non-anatomic reconstruction: Non-anatomic reconstruction is to obtain posterolateral stability by applying tension on the uninjured posterolateral structures. Arcuate complex or bone block advancement, extracapsular ITB sling, augmentation technique, and bicep tenodesis are recommended for non-anatomic reconstruction. In 2003, Kim al. reported altered biceps tenodesis as a single reconstruction method for posterolateral structures. The average postoperative Lysholm score was 93.6 in the study **(2).**

(2)Anatomic reconstruction: Anatomical and biomechanical research of posterolateral structures has been conducted recently and precise anatomic reconstruction of the injured LCL,

popliteus tendon and PFL is recommended with use of the fibular based technique and tibiofibular based technique. In 2005, Larsen et al. reported fibular sling. It is a fibular based technique that can make the popliteal complex and LCL balanced appropriately (fig., 3). This method is commonly used because it is quite a simple procedure that provides good results. Camarda et al. reported that the fibular based technique offered excellent results in chronic posterolateral instability patients. Ho et al. conducted a cadaver study comparing the results between the non-anatomic reconstruction group and the anatomic reconstruction group using the fibular based technique. The anatomic reconstruction group obtained better results. Niki et al. reported excellent clinical results of a modified Larson's procedure (fig., 4) and emphasized the recovery of tension in the PFL and LCL. For the recovery, the article underlined the importance of fixation in the fibular tunnel. In 2014, Kuzma et al. reported anatomic reconstruction of the PFL and LCL using the fibular based technique and the Achilles tendon as an allograft. With this method, the reconstructed ligament can be repaired with the existing popliteus tendon. In addition, this technique does not require a transtibial tunnel. LaPrade and Wentorf introduced the tibiofibular based technique to reconstruct all of the LCLs, popliteal tendon, and PFL, which are the important structures of the PLC. Yoon et al. reported a tibiofibular based technique using the Achilles tendon as an allograft. The varus and external rotation were reduced significantly in the anatomic reconstruction group compared to the non-anatomic reconstruction group. The tibiofibular based technique seems to be advantageous since it allows for anatomic reconstruction of the three important structures (fig., 5). However, this method is somewhat difficult to perform and may excessively limit the posterolateral motion. Yoon et al. reported that there was no significant difference between the group that had all three structures reconstructed and the group where the popliteus tendon was not reconstructed. There have been few long-term researches on the PLC reconstruction; however, the short-term studies showed good results. Many cadaveric studies have compared the fibular based technique with the tibiofibular based technique. However, the results have shown little conformity. Kim et al. compared the operation methods that reconstruct only two structures among three structures in a cadaveric model. The results showed no significant difference among the methods and none was effective for restoring normal function of the knee joint. McCarthy et al. compared reconstruction of all three components with reconstruction of only the popliteal tendon and LCL. The results were better after reconstruction of all three components. Thus, they recommended reconstruction of all of the three structures. Miyatake et al. conducted a comparison study between the two strand reconstruction and the four strand reconstruction the four strand reconstruction provided better biomechanical results (2).

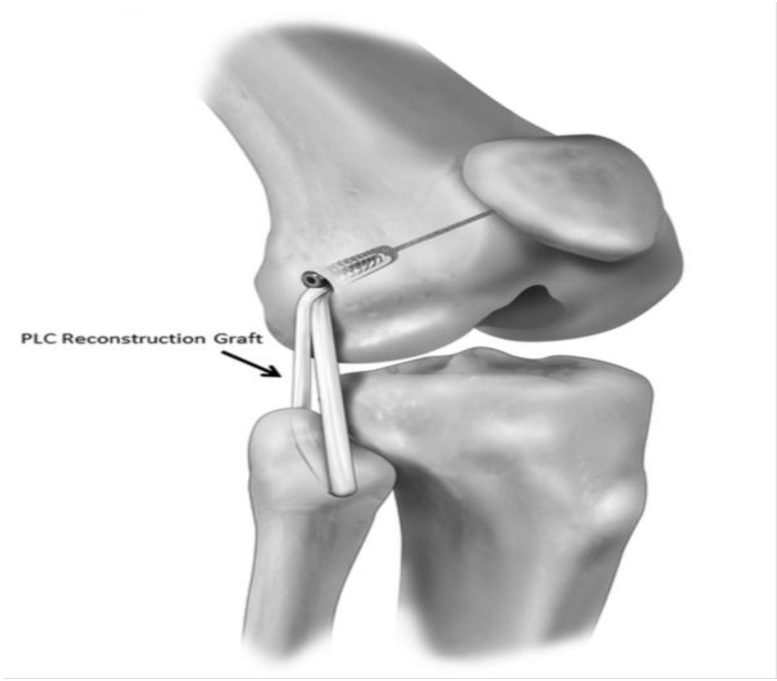

Figure 3: Fibular sling technique with a single femoral fixation point for the posterolateral corner (PLC) (11).

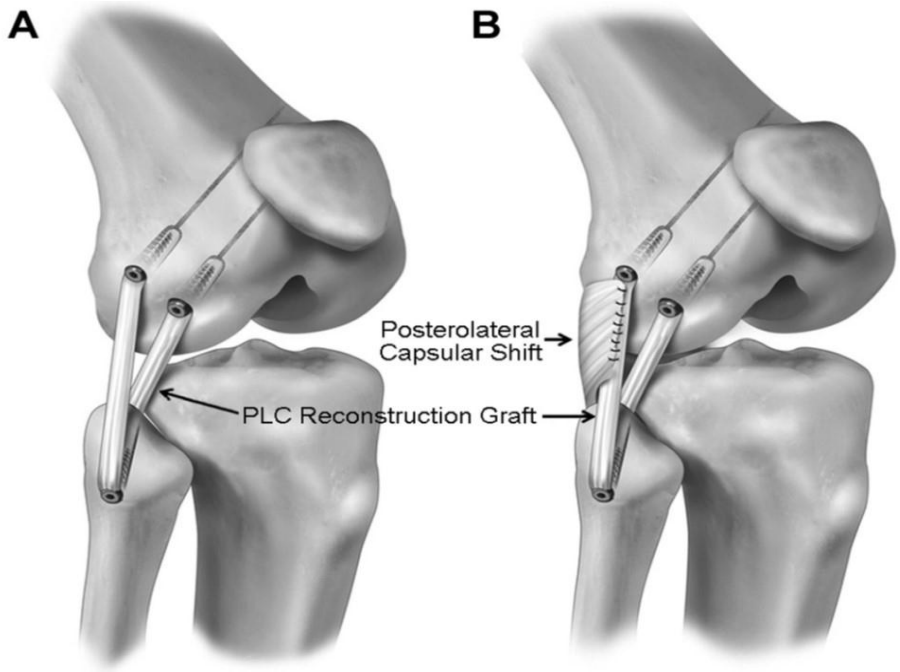

Figure 4: (A) Fibular sling technique with 2 femoral insertion points for the posterolateral corner (PLC) reconstruction graft intended to re-create the fibular collateral ligament and popliteofibular ligament function is shown as originally described2 and (B) modified with a posterolateral capsule shift (11).

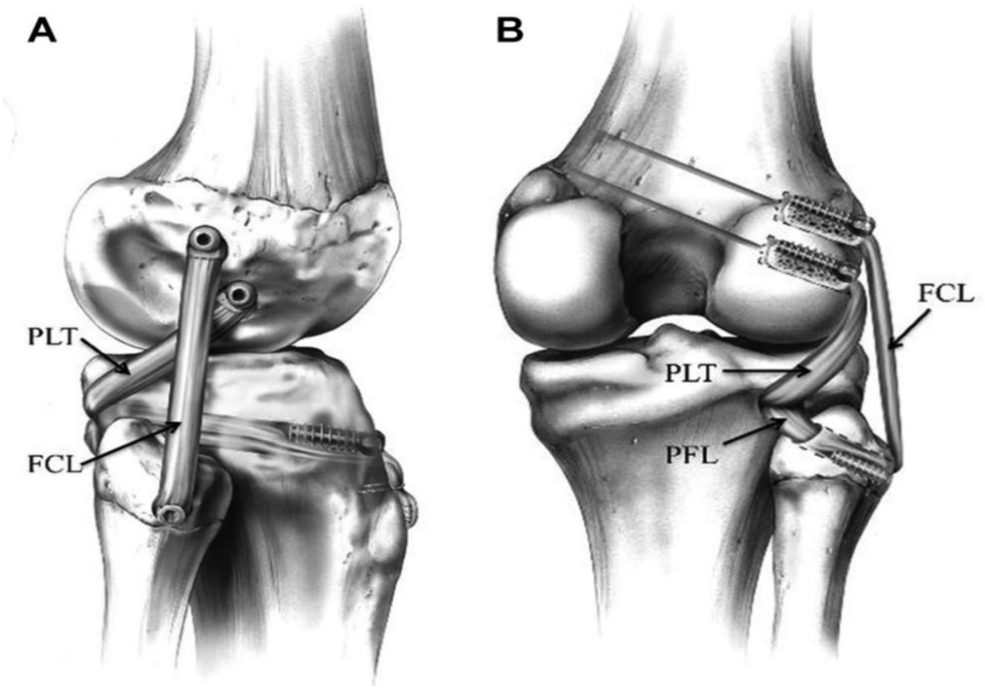

Figure 5: Illustrations of anatomic-based posterolateral corner reconstruction from the (A) lateral view and (B) posterior view are shown, addressing the fibular collateral ligament (FCL), popliteus tendon (PLT), and popliteofibular ligament (PFL) (11).

Postoperative Rehabilitation

The purpose of postoperative rehabilitation is to protect the reconstructed or repaired ligament structures. Strengthening of the quadriceps muscle and protection of the patellofemoral joint are emphasized in early rehabilitation. This gradually leads to muscle strengthening, functional exercises, and daily activities so that the patient may eventually participate in sports activities. Many studies follow the guidelines of Robert F. LaPrade for posterolateral reconstruction involving the popliteus tendon, PFL, and LCL. However, guidelines may be modified depending on other associated knee ligament injuries. After PLC reconstruction, the patient should stay immobilized and non-weight bearing for 6 weeks. During the immobilization period, the patient may wear an immobilizer brace with the knee extended except for range of motion exercises. Rehabilitation begins immediately after surgery and initial rehabilitation focuses on restoring tibiofemoral and patellofemoral range of motion. For the first 2 weeks, passive range of motion exercises are performed from 0° to 90°, which then progresses to full range of motion as tolerated. At 6 weeks, patients are permitted to begin spinning on a stationary bike and wean off crutches. After full weight bearing, the exercise is focused on developing muscular endurance. An exercise such as closed chain strengthening is permitted. Then, the exercise focuses on progressive muscular strength development. Isolated hamstring strengthening is limited to avoid stress on reconstruction until a minimum of 4 postoperative months. Running or agility training may begin once appropriate strength and power are restored. At approximately 6 months after

surgery, return to sports activities is allowed after checking the muscle strength, stability of the joint, and range of motion **(2).**

After PLC reconstruction, patients use a knee immobilizer and mobilize non-weight bearing for 6 weeks. Formal rehabilitation begins immediately postoperatively and focuses on restoration of tibiofemoral and patellofemoral range of motion, edema, and pain management as well as restoration of quadriceps function. Passive range of motion is initiated on the first day postoperatively and is gradually progressed to full range of motion as tolerated. A goal of at least 90 of knee flexion is desired by 2 weeks postoperatively. At 6 weeks, patients are permitted to begin spinning on a stationary bike and wean off crutches. Once they are fully weight bearing, patients begin closed chain strengthening exercises with training parameters focused on first developing a muscular endurance base before progressing to muscular strength and power development. Isolated open chain hamstring strengthening is limited to avoid stressing the reconstruction until a minimum of 4 months postoperatively. Situations in which the tibia is subject to posterior sag or external rotation should also be avoided for a period of 4 months. Running exercises, along with speed and agility workouts, may begin once appropriate strength and power characteristics have been developed, typically around 6 months after surgery. Return to sports or activity is allowed when normal strength, stability, and knee range of motion comparable to the contralateral side have been achieved usually between 6 and 9 months and based on associated cruciate ligament or other structure surgery **(4).**

Complications

1. Persistent Instability: Instability may continue after repair or reconstruction surgery. Technical errors may result in persistent instability if the major anatomic structures are not restored PFL should be restored with either reconstruction or repair Also, instability may differ according to the treatment of choice. Failure rates of repairs were higher than those of reconstructions in the studies. To prevent persistent instability after surgery, it is vital to choose an appropriate surgical treatment according to the indications. Varus malalignment of the knee can be another factor in persistent laxity. A staged approach may be necessary in chronic PLC injuries or failure of previous reconstruction **(2).**

2. Neurovascular Problems: Common peroneal nerve injury may be accompanied by PLC injuries owing to its close proximity. When the knee is subjected to varus and hyperextension forces associated with a PLC injury, the common peroneal nerve is vulnerable. Therefore, special caution is necessary during surgery. Deep vein thrombosis (DVT) may occur after any lower extremity surgery. Therefore, DVT may also occur after PLC reconstruction or repair. In high risk patients, there should be a prophylactic administration of low molecular weight heparin if necessary. Early mobilization and rehabilitation is also effective for preventing DVT **(2).**

3. Infection after Surgery: Superficial or deep infection has always been a potential problem in all knee surgeries. In open knee reconstruction, the incidence of wound infection is thought to range from 0.3% to 12.5%. Prophylactic antibiotics, meticulous soft tissue handling, and careful planning of skin incision may help reduce wound problems. Posterolateral reconstruction is preferred to direct repair in surgical treatment of PLC injuries. Reconstruction of posterolateral structures is required in the chronic stage, and anatomic reconstruction is more recommended than non-anatomic reconstruction. There are two types of techniques for anatomic reconstruction: fibular-based technique and tibiofibular-based technique. Currently, fibular-based reconstruction is preferred to the tibiofibular-based technique. This may be because the comparable biomechanical performance and technical ease of the fibula based reconstruction coupled with preservation of the remaining tissue provide advantages that tip the balance in favor of this approach.

Clinical Outcomes

Despite numerous clinical tests for assessing the integrity of the PLC, many of these injuries are missed initially, and present late as a chronic problem. Recent trends in the literature suggest that the best clinical outcomes are obtained through the early identification and timely management of PLC injuries. It is imperative to perform a detailed history and thorough physical examination, with the supplemental use of appropriate investigations, to achieve an accurate diagnosis and to formulate a management plan **(12).**

Treatment outcomes of PLC injuries can vary according to the severity of injury, associated ligament pathologies, and the treatment of choice. Outcomes of Acute Repair Outcomes of repair of acute PLC injuries are better when performed earlier in the acute stage. Shelbourne et al. conducted a comparison study between the two strand reconstruction and the four strand reconstruction the four strand reconstruction provided better biomechanical results. During the immobilization period, the patient may wear an immobilizer brace with the knee extended except for range of motion exercises. Rehabilitation begins immediately reported that repair of the PLC by 4 weeks post injury resulted in significantly better outcome than repair performed between 4 to 6 weeks post injury. The better outcomes of early repair may be associated with management of the problems presented by tissue retraction, adhesion, and scarring of the peroneal nerve that may occur in the first few weeks after injury. If the surgery is performed within the first 2 weeks of injury, the anatomy is much easier to identify and anatomic repair can often be achieved with ease **(2).**

Outcomes of Reconstruction Acute reconstruction is thought to be an effective treatment option for PLC injuries with irreparable soft tissue. **Ibrahim et al. (13)** reported the outcomes of 20 patients who underwent acute bi cruciate reconstruction and PLC reconstruction using the contralateral hamstring as an auto graft. The study showed improved outcome scores after acute reconstruction: the mean Lysholm score was 90 points at the 44-month followup. **Levy et al. (7)**

found a higher failure rate in the repair group than reported cases of multiligament knee injury patients who underwent repair, followed by delayed reconstruction of the cruciate ligaments. The failure rate was much lower in them than in the repair only group. In recent studies, reconstruction is described to have better outcomes. However, outcomes may differ according to the choice of different reconstruction methods the surgeons make. A handful of studies reported improved patient outcomes using an anatomic technique. **Stannard et al. (14)** reported outcomes of 15 patients who underwent anatomic reconstruction: the mean Lysholm knee score was 92. LaPrade et al. demonstrated an anatomic PLC reconstruction technique in 2004 and reported outcomes of a cohort group afterwards: the patients showed significant improvement in IKDC objective scores after surgery **(15).**

References:

[1] **LaPrade RF, Resig S, Wentorf F, Lewis JL.** The effects of grade III posterolateral knee complex injuries on anterior cruciate ligament graft force. A biomechanical analysis. Am J Sports Med 1999;27(4):469–75.

[2] **Shon OJ, Park JW, Kim BJ.** Current Concepts of Posterolateral Corner Injuries of the Knee. Knee Surg Relat Res 2017;29(4):256–68.

[3] **Margheritini F, Espregueira-Mendes J, Gobbi A, editors.** Complex Knee Ligament Injuries: From Diagnosis to Management. 2019;105–21.

[4] **Serra Cruz R, Mitchell JJ, Dean CS, Chahla J, Moatshe G, LaPrade RF.** Anatomic Posterolateral Corner Reconstruction. Arthrosc Tech 2016;5(3):e563–72.

[5] **Geeslin AG, LaPrade RF.** Outcomes of treatment of acute grade-III isolated and combined posterolateral knee injuries: a prospective case series and surgical technique. J Bone Joint Surg Am 2011;93(18):1672–83.

[6] **Levy BA, Stuart MJ.** Treatment of PCL, ACL, and lateral-side knee injuries: acute and chronic. J Knee Surg 2012;25(4):295–305.

[7] **Levy BA, Dajani KA, Morgan JA, Shah JP, Dahm DL, Stuart MJ.** Repair versus reconstruction of the fibular collateral ligament and posterolateral corner in the multiligament-injured knee. Am J Sports Med 2010;38(4):804–9.

[8] **Westermann RW, Spindler KP, Huston LJ, Wolf BR.** Posterolateral Corner Repair versus Reconstruction: 6-year Outcomes from a Prospective Multicenter Cohort. Orthopaedic Journal of Sports Medicine 2017;5(7_suppl6):2325967117S00268.

[9] **Geeslin AG, Moulton SG, LaPrade RF.** A Systematic Review of the Outcomes of Posterolateral Corner Knee Injuries, Part 1: Surgical Treatment of Acute Injuries. Am J Sports Med 2016;44(5):1336–42.

[10] **Tischer T, Paul J, Pape D, Hirschmann MT, Imhoff AB, Hinterwimmer S, et al.** The

[11] Impact of Osseous Malalignment and Realignment Procedures in Knee Ligament Surgery: A Systematic Review of the Clinical Evidence. Orthopaedic Journal of Sports Medicine 2017;5(3):2325967117697287.

[12] **Moulton SG, Geeslin AG, LaPrade RF.** A Systematic Review of the Outcomes of Posterolateral Corner Knee Injuries, Part 2: Surgical Treatment of Chronic Injuries. Am J Sports Med 2016;44(6):1616–23.

[13] **Martin RK, Berdusco R, MacDonald PB.** Physical Examination and Imaging Studies in Posterolateral Corner Injuries. J Knee Surg 2015;28(6):435–40.

[14] **Ibrahim SAR, Ghafar S, Salah M, Abo Alnas M, Al Misfer A, Farouk H, et al.** Surgical Management of Traumatic Knee Dislocation With Posterolateral Corner Injury. Arthroscopy: The Journal of Arthroscopic & Related Surgery 2013;29(4):733–41.

[15] **Stannard JP, Brown SL, Robinson JT, McGwin G, Volgas DA.** Reconstruction of the Posterolateral Corner of the Knee. Arthroscopy: The Journal of Arthroscopic & Related Surgery 2005;21(9):1051–9.

[16] **LaPrade RF, Wentorf FA, Crum JA.** Assessment of healing of grade III posterolateral corner injuries: an in vivo model. J Orthop Res 2004;22(5):970–5.