POSTEROLATERAL CORNER RECONSTRUCTION

WHEN AND HOW?

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Injury of the posterolateral corner (PLC) is relatively rare and most commonly associated with high-energy trauma (athletic trauma, motor vehicle accidents and falls). The most common mechanisms leading to PLC injuries include a posterolateral force to the anteromedial tibia, knee hyperextension and/or severe tibial external rotation while the knee is partially flexed.

PLC injuries are often associated with other ligament lesions. In acute PLC injuries, the incidence of multiple ligament injuries has been reported to range from 59% to 65%[1,2]. With chronic PLC injuries, the incidence, particularly the anterior cruciate ligament (ACL) and the posterior cruciate ligament, increases to 80%[3].

Unrecognised injuries to this part of the knee are a cause of failure of cruciate ligament reconstruction[4]. LaPrade showed in a cadaveric study that sectioning of the PLC induced a significant increases in forces on ACL reconstruction grafts for both varus loads and combined varus-internal rotation loads at 0° and 30° of knee flexion[5], and a significant increase in forces on posterior cruciate ligament grafts for both varus loads and for coupled posterolateral rotation loads at all knee flexion angles[6].

Laxity due to an injured PLC leads to medial compartment knee arthritis and can cause chronic pain[7].

The consequences of a missed acute PLC injury can be significant to the patient because of the poor outcomes and the more extensive surgery required for chronic reconstruction rather than acute repair[8-10].

The aim of this article is to describe the anatomy and biomechanics, clinical and imaging evaluation, surgical techniques and outcomes of posterolateral corner injuries.

ANATOMY

The posterolateral corner of the knee is anatomically complex. LaPrade et al[11-14] found 28 separate structural components. There are static structures (fibular collateral ligament, popliteofibular ligament, posterolateral joint capsule, coronary ligament of the lateral meniscus, oblique popliteal ligament, fabellofibular ligament) and there are dynamic structures (popliteus complex, iliotibial band, biceps femoris, lateral gastrocnemius)

The structures of the PLC are responsible for posterolateral stabilisation of the knee. They resist varus angulation, posterior translation and external rotation.
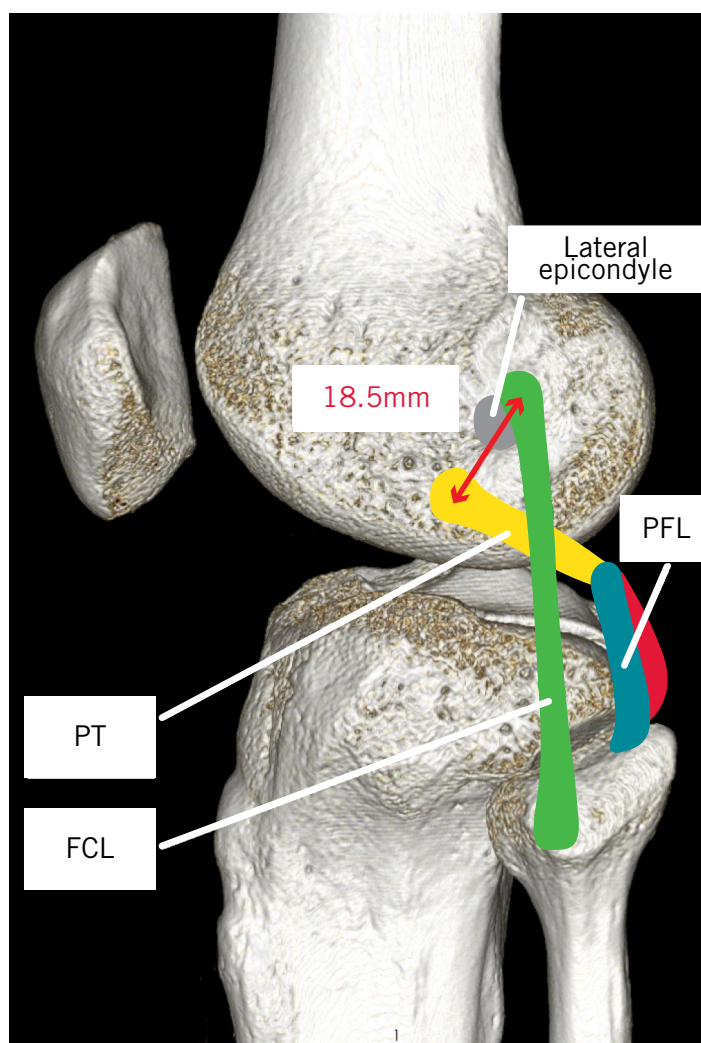
Figure 1: Schematic illustration of the posterolateral corner (lateral view, left knee): fibular collateral ligament (FCL), popliteus tendon (PT) and the popliteofibular ligament (PFL).

The three most important stabilising structures are the fibular collateral ligament, the popliteus tendon and the popliteofibular ligament (Figure 1):

Fibular collateral ligament (FCL)

This ligament is the primary static stabiliser to varus opening at the knee from 0° to 30°. LaPrade et al[12] found that its femoral attachment is not onto the lateral epicondyle, but rather to a small depression 1.4 mm proximal and 3.1 mm posterior to the lateral epicondyle. It measures approximately 7 cm in length. Distally, the main attachment is to the lateral basal aspect of the fibular head as the conjoined tendon, which it forms with the biceps femoris tendon 1 cm proximal to the insertion. The FCL is most readily identified and accessed through a horizontal incision into the biceps bursa. The FCL is easily identified on MRI as a low-signal-intensity structure in all standard imaging planes.

Popliteus tendon (PT)

The PT is an important primary stabiliser against knee external rotation[15]. The main tendinous attachment of the PT is to the femur at the anterior aspect of the popliteus sulcus, just posterior to the articular surface of the lateral femoral condyle. The average distance between the centres of the femoral attachment sites of the FCL and the PT is 18.5 mm[12]. It has been shown that reconstruction techniques that used a single femoral-based graft for the FCL and PT would result in non-anatomic locations for both structures and be at a high risk of graft failure or over-constraining of the knee.

Popliteofibular ligament (PFL)

The PFL is an important stabiliser of external rotation of the knee. It extends from the musculotendinous junction of the popliteus and attaches to the posteromedial aspect of the fibular styloid. Visualisation of the PFL is improved on MRI by use of coronal

oblique images obtained in the plane of the popliteus tendon[16].

EVALUATION
Clinical evaluation[17]

In the acute phase there may be pain and swelling over the posterolateral corner. Motor weakness in the foot is present when the common peroneal nerve is injured (prevalence 12 to 29%[1]). In the chronic phase, a feeling of discomfort may persist and patients may complain about instability of the knee in hyperextension, noticeable when climbing or descending stairs.

There are several special tests for PLC injuries that should be used to help confirm the diagnosis:

Dial test

In prone or supine position, the knees are flexed 30° and external rotation stress is placed on the foot with the foot dorsiflexed and the thigh-foot angle is measured. Increased external rotation of 15° or more is abnormal and indicative of a potential injury to the PLC or, more specifically, the popliteus complex. A positive test at both 30° and 90° indicates both a posterior cruciate ligament and PLC injury.

Varus stress test

If varus laxity is present in full extension, there is an FCL tear and likely a cruciate injury. If it is present at 30°, it indicates an FCL injury.

Posterolateral drawer test

The knee is flexed to 80° to 90° with the hip flexed 45° and the foot externally rotated 15°. A posterolateral drawer force is applied with the tibia in different degrees of rotation. If the test is positive in neutral and internal rotation, an injury to the posterior cruciate ligament is suspected. If the test is positive in external rotation a PLC injury is suspected.

External rotation recurvatum test

In a supine position, the great toe of each foot is grasped and used to elevate the foot

off the examining table. The injured knee is evaluated for increased hyperextension and varus compared with the non-injured knee, which is indicative of PLC injury.

Reverse pivot shift

The test begins with the knee in flexion. As the knee is slowly extended, valgus and axial loads are placed on the knee. As the knee extends to 30° of flexion, a sudden reduction of the tibia onto the femur by the iliotibial band indicates a positive test.

Imaging

Standard radiographs

These can show osseous injuries that accompany PLC injuries:

- Arcuate fracture of the fibula is an avulsion fracture of the proximal fibula at the PLC attachment (Figure 2). Lee et al[18] found that small bone fragments (1 to 8 mm) were the result of avulsion of the arcuate ligament, PFL and fabellofibular ligament, while larger (15 to 25 mm) fragments were the result of FCL and biceps tendon avulsion.
- Fractures of the anteromedial tibial plateau can be associated with lesions of both the PLC and the posterior cruciate ligament[19].
- Segond fracture and avulsion of Gerdy's tubercule can be associated with PLC injuries.

Varus stress radiographs

Previously, evaluation of lateral compartment gapping was solely subjective. LaPrade[20] showed in a radiographic study that increased varus opening of 2.7 mm was indicative of a complete tear of the FCL, while increased varus opening of 4 mm or more was indicative of a grade III posterolateral knee injury. The LaPrade radiological classification for posterior cruciate ligament injuries can be used (Table 1).

Magnetic resonance imaging

Improved MRI techniques are necessary to increase diagnostic accuracy. The majority of the important posterolateral structures attach to the fibular head and styloid, it is essential to include this region on MRI scans. LaPrade[16] developed a posterolateral knee MRI technique using a high field MRI scanner with 2 mm slices that included the entire fibular head and styloid, and coronal

Figure 2: Arcuate fracture (3D CT-scan, left knee, antero-lateral view).

Grade	Anatomical lesion	Varus opening
	TABLE 1: VARUS STRESS RADIOGRAPHS	
I	FCL	2.7 mm
II	FCL, PT	3.5 mm
III	FCL, PT, PFL	4 mm

Table 1: Grading scale for PLC injuries of the knee (LaPrade[20]).

oblique imaging technique, angled along the course of the popliteus tendon – which provides the best view of these structures.

In acute injuries, the presence of fluid in the region tends to facilitate diagnostics. The majority of PT lesions are extra-articular, located at the myotendinous junction, but avulsion of the femoral insertion of PT and FCL are not unusual (peel-off lesions). Injuries of the posterior capsule structures, including the arcuate ligament and fabellofibular ligament, may not be directly seen, but should be suspected in the presence of surrounding soft tissue oedema and haemorrhage. Acute grade III PLC injuries are often accompanied by bone bruises located in the medial compartment, most commonly the anteromedial femoral condyle.

SURGICAL TECHNIQUES

Injury of the PLC should be precisely defined and treatment should be tailored for each lesion. All grade III lesions should be treated surgically. We have recently shown that grade II lesions associated with meniscal hypermobility also respond well to surgical repair.

Approach

The authors are still using a longitudinal 'hockey stick' incision along the lateral aspect of the knee. The length of the incision depends on the procedure; one should favour good exposure to allow for precise identification of the anatomy. In all extensive reconstructions, the common peroneal nerve should be either exposed or at least precisely located. Various techniques

have been described to reconstruct the PLC, nonetheless we have always preferred anatomy-based reconstructions.

Subtle PLC injury

Subtle injury associated with meniscal hypermobility is treated by a repair-reinsertion of the meniscus at the anterior aspect of the hiatus popliteus in a way that recreates the connection of the meniscus to the posterolateral structures. If necessary, a plasty to re-tension the PLC can be performed as initially described by Werner Müller (Figure 3).

Isolated rotational laxity

This should be addressed via reconstruction of the popliteofibular ligament using an anatomy-based technique with either an autologous semitendinosus tendon or an allograft. A precise tunnel is drilled into the fibular head, a second tunnel is drilled into the insertion of the popliteus tendon on the femur. The graft is secured into the fibular head and the femur (Figure 4). The graft is sutured to the popliteus tendon below the joint line.

Severe grade III injury

The lateral collateral ligament and popliteofibular ligament must be reconstructed. In the case of popliteus tendon rupture, a popliteal bypass should be performed or, if feasible, a suture of the popliteus musculotendinous junction. We aim for an anatomy-based reconstruction using one sling on the fibula and two slings on the femur (Figure 4), rather than a modified Larson technique. Although, according to Apsingi et al[21] the biomechanical effect is similar for both techniques. When using soft tissue autografts or allografts, a 6 to 7 mm tunnel should be drilled into the fibular head and the femur as described above, one more tunnel is drilled into the insertion of the femoral collateral ligament. One additional anterior-to-posterior tunnel can be drilled at the posterior and lateral aspect of the tibia to perform the bypass (Figure 5). However, reconstruction of the popliteus has been shown to make no difference in the final outcome[22]. The graft is passed from the fibula and tibia to the femur, tensioned at 20° for the lateral collateral ligament and at 80° of knee flexion with the foot internally rotated for the popliteofibular ligament/bypass. The graft can be fixed by interference screws
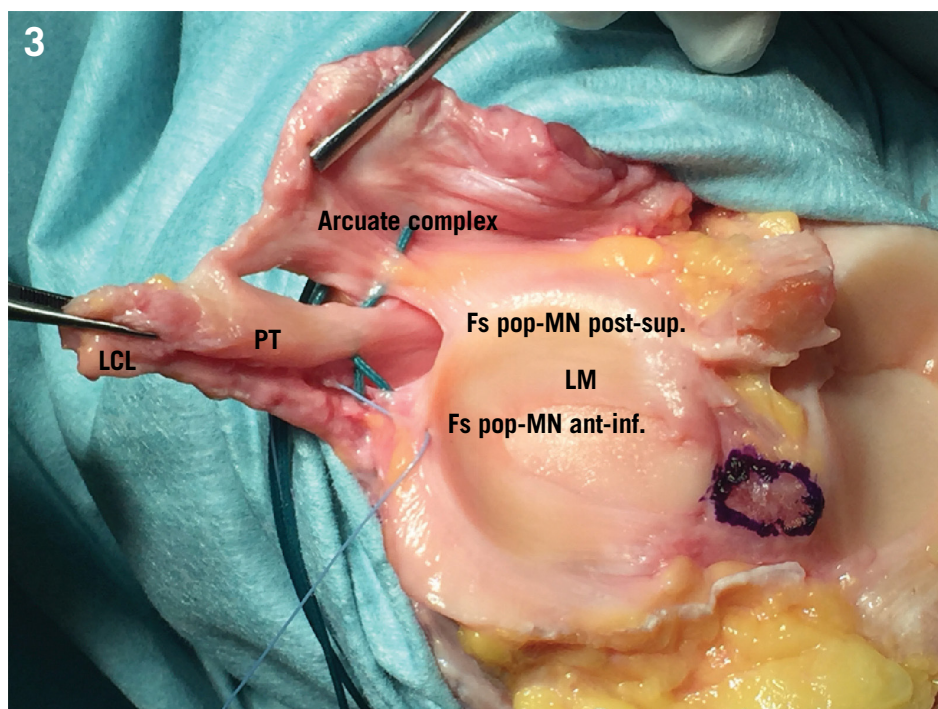

Figure 3: Repair of the subtle PLC injury consists of (1) the reinsertion of the lateral meniscus to the capsule-ligamentous complex, (2) to a tensioning plasty of the arcuate complex on the LCL and antero-lateral structures, including the popliteo-fibular ligament as described by Werner Müller.
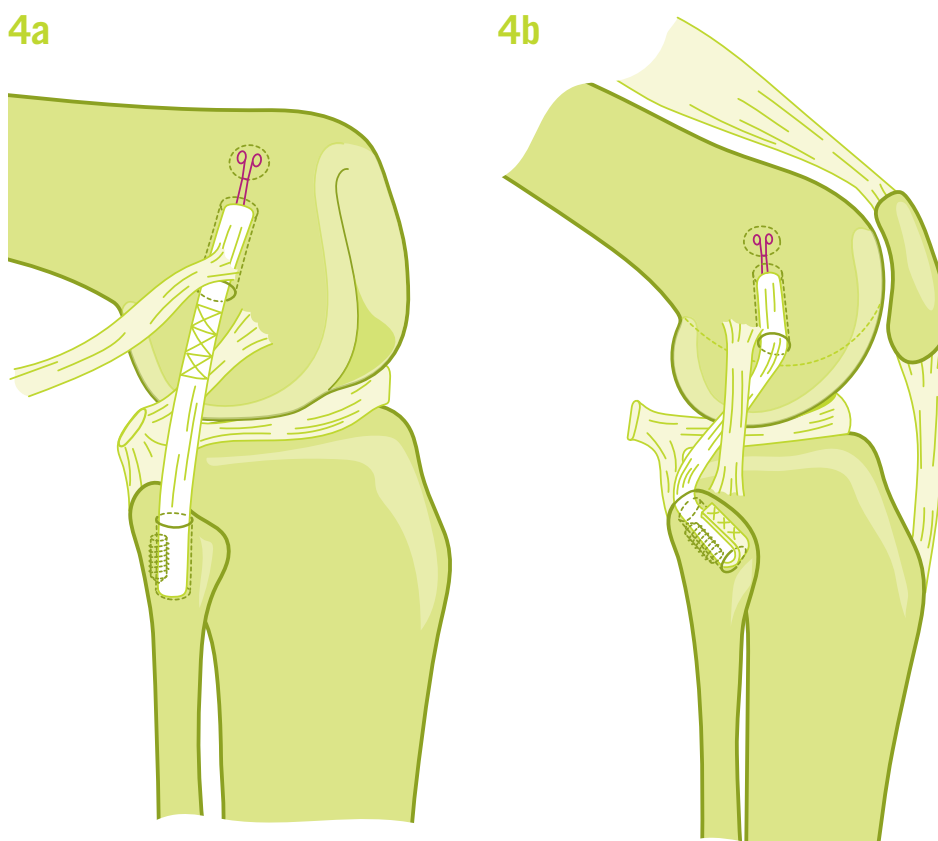

Figure 4: (a) Reconstruction of the lateral collateral ligament; (b) Reconstruction of the popliteo-femoral ligament. If the two reconstructions are combined, the graft is sutured on the fibular head at the original LCL insertion.

and/or suspensory systems. Finally, the arcuate complex is sutured back to the graft and the anatomy is restored.

When to suture-repair and when to reconstruct?

With the exception of subtle PLC injuries, only an osseous avulsion of the fibular head (arcuate fracture) warrants suturing and fixation back onto the head using osteo-sutures or screw/washers. In our experience, as well as that of others, all other lesions should be treated by reconstruction. In their review, Geeslin et al[23] reported a 38% failure rate with acute repair of the PLC and staged treatment of the cruciate ligaments.

Patients older than 40

For older patients with varus alignment greater than 5 degrees, especially those with chronic PLC injury, high tibial osteotomy can be indicated. If a posterior cruciate ligament injury is associated with the PLC lesion, a tri-planar high tibial osteotomy can be performed, which often negates the need for surgery on the PLC[24,25].

Postoperative rehabilitation

The postoperative regimen should take into account all associated lesions. Regarding the PLC, the patient can walk from the first postoperative day – in toe touch for the first 10 days and then in partial weight-bearing (20 kg) up to 6 weeks. The authorised range of motion is 90-0-0 for 6 weeks. Muscle strengthening begins from the first day in isometric patterns and in extension for the hamstring. Co-contraction by mini-squatting is performed from the sixth week. No isolated contraction of the hamstring is authorised before the fourth month. Muscle reconditioning and proprioceptive training are generally started from the third month. Return to play (RTP) is determined according to the global injury and associated lesions and is mostly based on the recovery of neuromuscular performance. RTP can be considered from the fifth month or later, according to the severity of lesions.

POSTOPERATIVE RESULTS AFTER ISOLATED OR COMBINED POSTEROLATERAL CORNER RECONSTRUCTION

Postoperative results after PLC reconstruction are biased by limited numbers of patients, short- and mid-
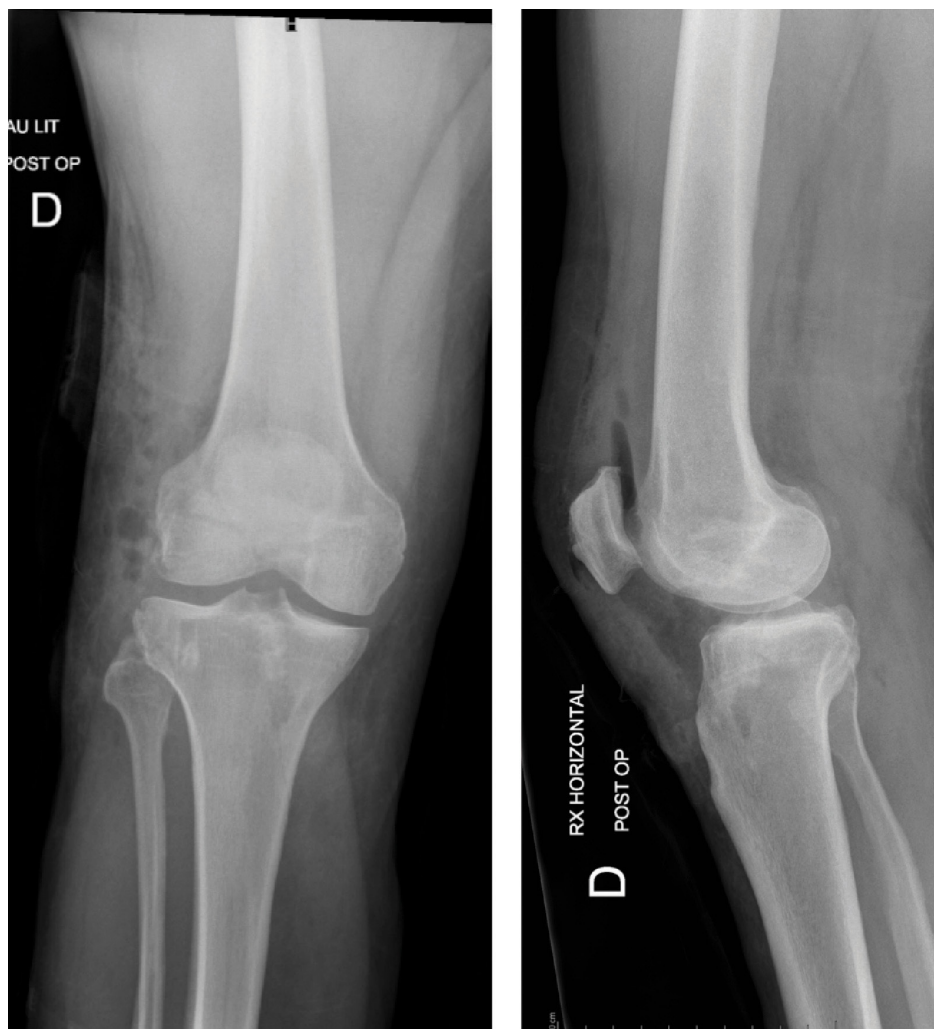

Figure 5: Postoperative radiographs after a reconstruction of the PFL and a popliteal bypass associated with ACL reconstruction using a quadriceps tendon.

term follow-up studies (2 to 4 years) and level 3 or 4 evidence studies using different reconstruction techniques (one or two femoral tunnels and fibular sling reconstruction, popliteal bypass or 'anatomic' PLC reconstruction with PT and PFL)[23,26]. Furthermore, most of the reported outcome studies include acute and chronic cases, with and without cruciate ligament injuries.

In the acute setting PLC injuries used to be repaired, however, functional results were poor, with high failure rates reported for intra-substance and femoral avulsion injuries – up to 40% of cases[27,28]. Fibular head avulsions – as seen on conventional radiographs or MRI as an arcuate sign – are the only exception, and can be repaired with satisfactory functionality and stability[29]. However, femoral avulsions of the ligamentous complex and/or the popliteal tendon, and intra-substance tears show

better results with PLC reconstruction using an auto- or allograft[30-32].

Early diagnosis of PLC instability in concomitant anterior or posterior cruciate ligament injuries is crucial to prevent increased stress and therefore early failure of cruciate ligament reconstruction[4,5]. One-stage PLC and cruciate ligament reconstruction was found to be associated with lower a failure rate (9% vs 38%) than delayed PLC reconstruction in a systematic review by Geeslin et al[23], highlighting the importance of the initial diagnosis.

Isolated FCL[33] or PLC injuries[31] can be reconstructed anatomically with near normal postoperative stability and high functional outcome. However, isolated PLC instability is rare (12 to 30%) and mostly associated with posterior cruciate ligament (50%), ACL (20 to 23%) or bicruciate ligament (6%) injury[26,34,35]. Associated grade I to II posterior knee instability (with 3 to 7 mm

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side-to-side difference, which when isolated are usually treated conservatively) should not be treated with PLC reconstruction alone, according to a retrospective study by Kim et al[36]. Isolated PLC reconstruction was significantly associated with lower postoperative results in terms of functional outcome (Lysholm and International Knee Documentation Committee – IKDC – subjective and objective score) and posterior stability than simultaneous posterior cruciate ligament reconstruction.

In combined grade III posterior and posterolateral instabilities, a combined posterior cruciate/PLC reconstruction is necessary to decrease stress on the posterior cruciate ligament graft, since the PT and PFL play an essential role as secondary posterior stabilisers[37]. Combined PLC/posterior cruciate ligament reconstructions show satisfactory results in terms of stability, however with lower functional results than in combined PLC/ACL reconstructions[26]. No biomechanical or clinical advantage was found when double bundle posterior cruciate ligament reconstruction was combined with PLC reconstruction[21].

In combined PLC and ACL reconstruction for moderate to severe PLC injuries, sports participation and functional results (Lysholm and IKDC) are generally satisfactory, with a reported Tegner score of up to 5 according to the included population. Isolated ACL reconstruction for ACL tears without PLC instability shows no superior IKDC scores than combined ACL and PLC reconstruction,

however a lower level of subsequent sports participation is reported in patients also requiring PLC reconstruction[38].

Taking into account all these factors, overall success rates reach up to 90%[35], with postoperative Lysholm scores between 80 and 90 points[23] and better results in isolated PLC than combined cruciate ligament injuries, whereas combined ACL reconstructions show better and more predictable results than combined posterior cruciate reconstructions[26,39,40]. Persisting varus laxity may be found in up to 15% of cases, whereas posterolateral stability is more frequently over-corrected than under-corrected (32% vs 10%)[26]. So far, for isolated or combined PLC injuries, one or two femoral tunnel fibular sling reconstruction have shown similar results in term of postoperative stability, functional outcome or patients satisfaction compared to anatomical PLC reconstruction including PT and PFL reconstruction[23,26,41-46]. This contradicts biomechanical studies highlighting the importance of the PT and PFL[47,48].

Cases of chronic PLC instability tend to be more complex and secondary changes with limb malalignement might occur. Proximal tibial osteotomy should be considered in varus malalignment of 5° or more to protect PLC reconstruction[29,49]. Outcome studies for this procedure in the literature are scarce. There are no guidelines as to whether limb alignment should also be considered in acute PLC injury.

CONCLUSION

PLC injuries are rare, but severe knee injuries and can be deleterious if not detected and treated along with concomitant injuries. A high degree of suspicion is essential when considering the mechanism of trauma and clinical presentation. Clinical examination and imaging should permit a good definition of lesions. A good knowledge of the anatomy is essential and all torn structures should be reconstructed. So far, no surgical technique for PLC reconstruction has proven to be superior and direct repair is indicated only for subtle injury or fibular head avulsion injuries. Proper surgical treatment results in good outcomes although it may be a long and demanding surgery.

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