

PCL INJURY DIAGNOSIS AND TREATMENT OPTIONS

– Written by Philippe Landreau, Qatar

INTRODUCTION

Posterior cruciate ligament (PCL) injuries are less common in sport than anterior cruciate ligament (ACL) ruptures. Therefore, clinical studies and the experience of most surgeons are more limited than for ACL injuries. In the last decade new anatomical, biomechanical and clinical studies have provided some novel insight concerning this ligament and renewed interest on this topic.

Sports-related PCL ruptures are frequently associated with other pathologies, most commonly involving the posterolateral corner. It is critical to accurately diagnose PCL ruptures and their associated injuries because this will affect treatment and prognosis.

Injuries of the PCL can be classified according to severity, timing (acute vs chronic) and associated injuries (isolated

vs combined). The treatment options (conservative or surgical) are still a topic of debate.

ANATOMY

A thorough knowledge of the anatomy of the PCL is crucial for the surgeon considering performing a PCL reconstruction. The PCL is a large ligament extending from the lateral surface of the medial femoral condyle to the posterior aspect of the tibia (Figures 1 and 2). Anatomically, it is closely related to other structures such as the joint capsule, the ACL, the menisci, the ligaments of Humphrey and Wrisberg and the posterior neurovascular structures. It consists of longitudinal collagen fibres narrower in their middle portion, extending largely at its femoral insertion and on a smaller surface area on the tibia. The PCL averages between 35 to 38 mm in length and its width is 11 to 13 mm.

The ligament consists of two distinct but inseparable bundles with distinct footprints at both the femoral and tibial side. These are the anterolateral (AL) and the posteromedial (PM) bundles. The anterolateral bundle is twice as large as the posteromedial. It is the primary stabiliser of the knee when a posterior drawer test is applied.

Tibial insertion

The tibial insertion of the PCL is located 1.5 cm below the posterior joint line, in a trapezoidal fovea localised between the two tibial plateaus and slightly lateral (Figure 3). The AL bundle is inserted on the superolateral portion and the PM bundle on the inferomedial portion of fossa. The more posterior and distal fibres are close to the posterior capsule (1 to 2 mm only). It is important to mention that the anterior wall of the popliteal artery is located at a distance

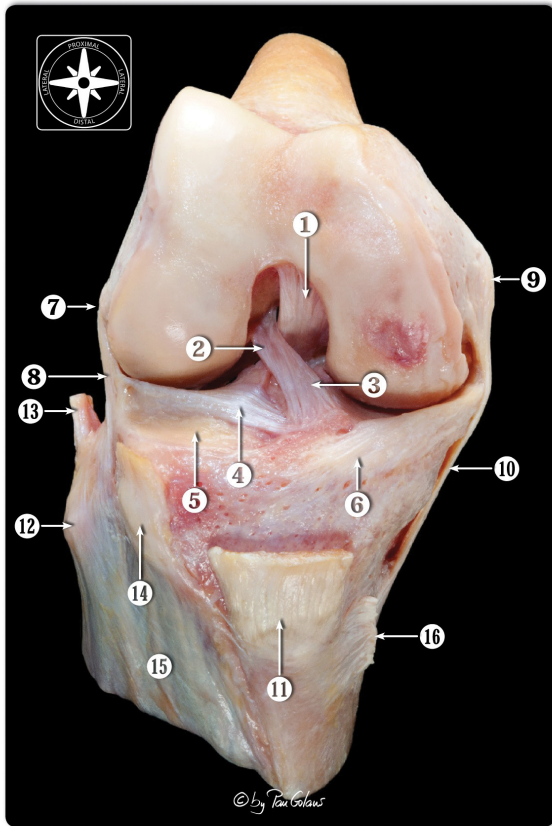


Figure 1: Anterior view of the osteoarticular dissection of the right knee joint. Knee in 90° of flexion. 1=Femoral insertion of the posterior cruciate ligament, 2=anterior cruciate ligament (posterolateral), 3=anterior cruciate ligament (anteromedial bundle), 4=anterior horn of the lateral meniscus, 5=coronary ligament (meniscotibial capsule), 6=anterior horn of the medial meniscus, 7=lateral epicondyle, 8=lateral collateral ligament, 9=medial epicondyle, 10=medial collateral ligament, 11=patellar tendon (cut), 12=head of the fibula, 13=biceps femoris tendon (cut), 14=iliotibial tract insertion in the anterior tubercle or Gerdy's tubercle (cut), 15=anterior compartment muscles of the leg, 16=pes anserinus (cut). (Figure copyright © Pau Golanó).

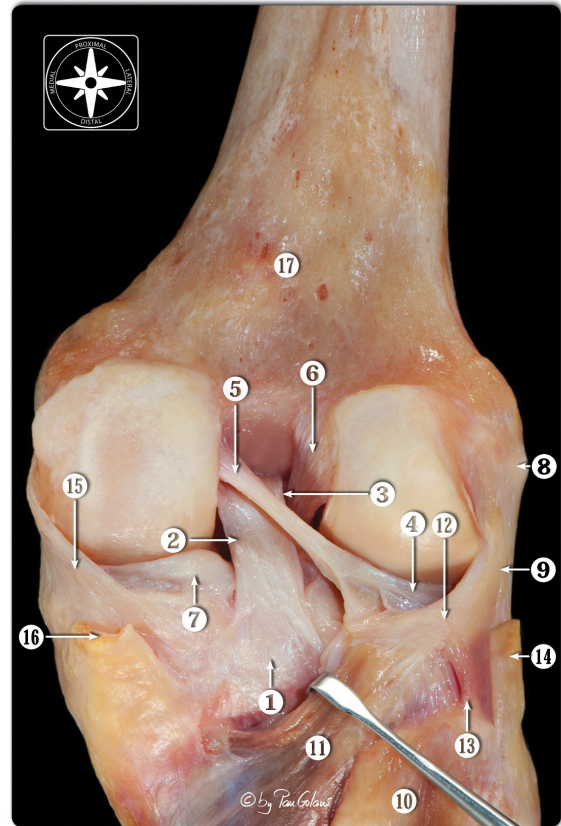
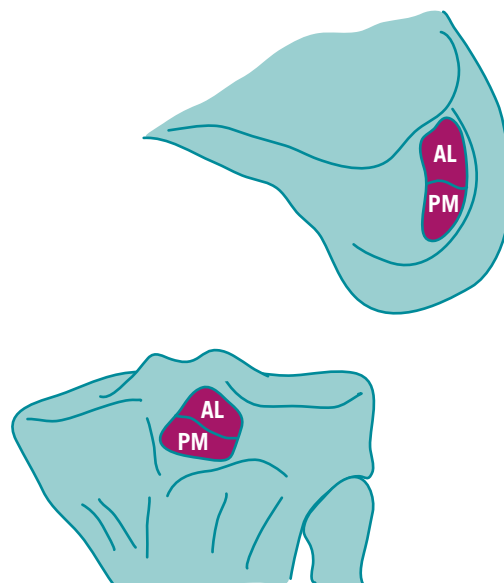


Figure 2: Osteoarticular dissection showing the posterior structures of the right knee joint after removing the joint capsule. 1=tibial insertion of the PCL, 2=posteromedial bundle of the PCL, 3=anterolateral bundle of the PCL, 4=lateral meniscus, 5=posterior meniscofemoral ligament or the ligament of Wrisberg, 6=femoral insertion of the anterior cruciate ligament, 7=medial meniscus, 8=lateral epicondyle, 9=lateral collateral ligament, 10=soleus fibular insertion muscle, 11=popliteus muscle, 12=popliteus tendon, 13=popliteo meniscal ligament (arcuate ligament), 14=biceps femoris tendon (cut), 15=medial collateral ligament, 16=semimembranosus tendon (cut), 17=popliteal surface. PCL=posterior cruciate ligament. (Figure copyright © Pau Golanó).

Figure 3: Anatomic position of the anterolateral and posteromedial bundles of the posterior cruciate ligament.



**The AL bundle:
is the stronger
bundle of the PCL
and controls the
posterior tibial
displacement in
flexion**

ranging from 7 to 10 mm from the posterior edge of the PCL.

Femoral insertion

The femoral insertion of the PCL on the medial femoral condyle has a semi-circular appearance (Figure 3). Its distal portion follows the cartilage of the medial condyle at a distance of 1 to 2 mm. This insertion is spread in the coronal plane from the 4 to 12 o'clock for the right knee and from the 8 to 12 o'clock for the left knee. The surface of the insertion for the AL and PM bundles is distinct. During arthroscopy, the AL bundle is the more easily located bundle (Figure 4).

The meniscomfemoral ligaments

The PCL is sandwiched by the two meniscomfemoral (MFL) ligaments. They are two distinct structures that connect the lateral meniscus to the medial inter-condylar surface (Figure 2). The ligament of Humphrey passes in front of the PCL and the ligament of Wrisberg is behind it. Recent anatomical dissections identified at least one MFL in 94 to 100% of cases. It can represent up to 25% of the size of the PCL. They are secondary restraints of posterior tibial translation. Their presence probably explains the potential of the PCL to heal, when compared with the ACL, by acting as a splint to keep a torn PCL in position while it heals. If the MFL are not injured, they should be protected during PCL reconstructive surgery.

BIOMECHANICS

The primary function of the PCL is to control posterior tibial displacement. Its secondary function is to assist with posterolateral stability and varus-valgus stress.

The tensile strength of the PCL ranges from 739 to 1627 N, depending on the knee angle. The AL bundle has a 43 mm² cross-sectional area and a mean strength of 1620 N, in comparison with 10 mm² and 258 N respectively for the PL bundle. Therefore, the AL bundle is clearly the stronger bundle of the PCL. A single bundle reconstruction must reconstruct this bundle. Note that the mean strength of the MFL averages 300 N (close to that of the PL bundle).

The tension of the two PCL bundles varies depending on the degree of knee flexion. In extension, the AL bundle is slack

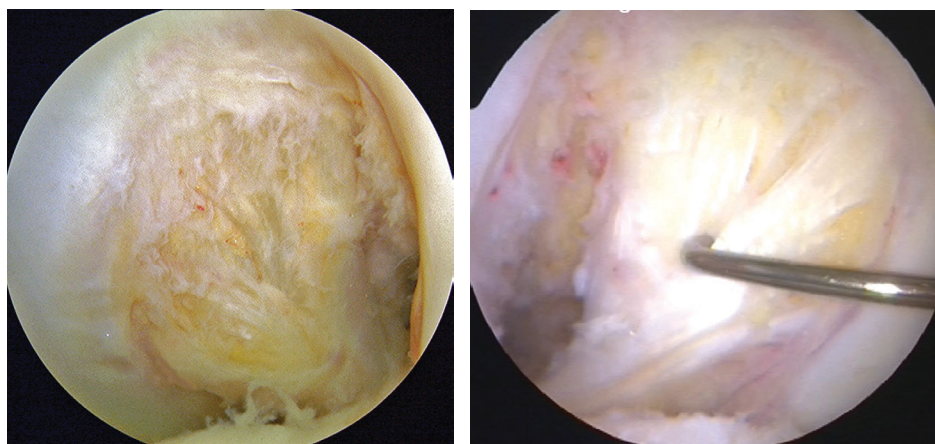


Figure 4: Arthroscopic view of the posterior cruciate ligament.

(appearing curved on the MRI) while PL bundle is taut. With the knee in flexion, the AL bundle is taut. This knowledge indicates to the surgeon that the AL bundle graft must be fixed in a flexed position during PCL reconstruction.

The posterolateral structures (PLS), which consist of the lateral collateral ligament, popliteofibular ligament and popliteus tendon, have an important synergistic relationship with the PCL to control posterior translation and external rotation. Biomechanical studies have shown that only the combined section of both PCL and PLS results in important laxity compared with an isolated section of either structure alone. This means that severe posterior laxity on clinical examination should raise suspicions of a combined PLS lesion.

EPIDEMIOLOGY AND MECHANISMS OF SPORTS-RELATED PCL INJURY

The reported incidence of PCL ruptures in the literature ranges between 1 and 44% of all acute knee ligament injuries. The variability is probably due to differences in the patient populations studied, as PCL injury rates are likely to vary when comparing trauma patients to an athletic population. In the general population, Miyasaka and Daniel reported the incidence to be 3%. The incidence in trauma or sporting activity is much higher. Fanelli and Edison reported the incidence to be 37% of all cases with acute haemarthrosis. In a large series, Schulz et al reported that of 494 complete PCL injuries, 45% of the injuries were related to traffic accidents and 40% to a sports injury. These types of injuries are also reported in other

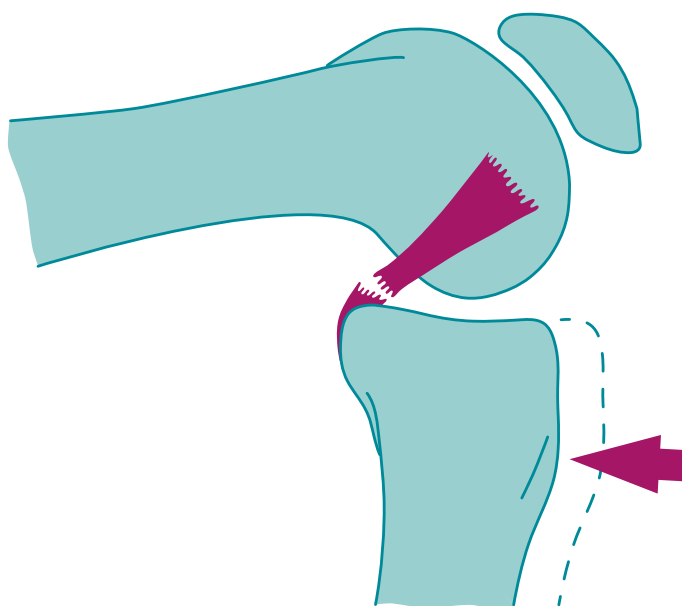


Figure 5: Dashboard mechanism injury.

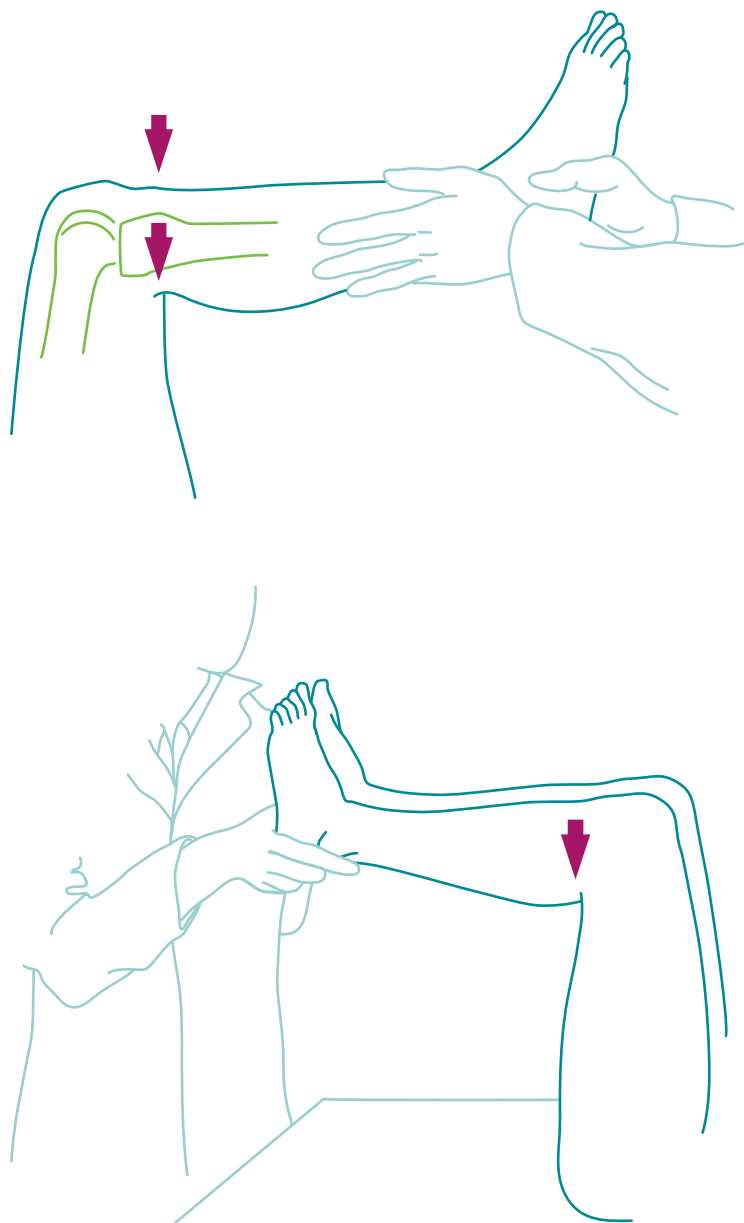


Figure 6: Posterior sag test.

publications. In the same series, motorcycle accidents were responsible for 28% of PCL ruptures, in comparison with 14% in car accidents. Football (soccer) represented 25% of the injuries and it is notable that 18% of all soccer-related PCL injuries involved the goalkeeper. Other sports such as rugby, American football and skiing are frequently associated with PCL injury (incidence range from 1 to 4%). Males are more frequently involved than females, probably due to the type of injuries and sports performed.

When comparing acute and chronic ruptures, the literature reports that sport injuries represented 70% of acute PCL injuries in contrast to chronic ruptures, where motor vehicle accidents caused 60%

of injuries. Patients injured in high-energy motor vehicle accidents suffer a higher incidence of additional life-threatening injuries and therefore ligamentous knee injuries can be easily overlooked. A combined injury (PCL and PLS) is frequent, particularly in traffic accidents, but can also occur in 50% of athletic injuries.

Two main mechanisms can cause a PCL rupture. The most common is the 'dashboard injury' (40%). Since the PCL is the primary restraint to posterior translation of the tibia relative to the femur, the PCL is the first ligament to be injured in these dashboard injuries. In this setting, the knee is in a flexed position and a posteriorly directed force is applied to the proximal tibia

as the joint strikes the dashboard (Figure 5). With the knee in external rotation, the traumatic forces are directed toward the posterolateral and lateral structures of the joint. In football or rugby, falls on the flexed knee with the foot in plantarflexion is the second most common mechanism of injury (25%). In this setting, the site of the impact is the tibial tubercle and the proximal tibia is driven posteriorly relative to the femur. If the foot is in dorsiflexion, the force is transmitted more through the patella and distal femur, protecting the PCL from injury. Hyperextension is typically reported to be a cause of PCL rupture and may result in disruption of the posterior capsule (12% in Schulz series) but a forced valgus or varus movement can result in a PCL rupture as well.

CLINICAL EXAMINATION

PCL ruptures as well as combined PCL and posterolateral structure lesions are frequently misdiagnosed. In many cases, the PCL rupture is missed despite typical injury mechanisms and symptoms. It is crucial to distinguish between PCL lesions that are isolated and those combined with other ligament injuries. A systematic clinical knee examination following trauma should always include PCL tests. It is essential to conduct posterolateral laxity as the prognosis and treatment will differ vastly if this is present.

1. *Don't miss PCL laxity!*
2. *Don't miss combined posterolateral laxity!*

Begin the knee evaluation by obtaining a detailed history of the injury and attempting to delineate the mechanism. In contrast to ACL ruptures, the patient rarely reports hearing or feeling a 'pop' and does not relate a sense of instability if the PCL rupture is isolated. Patients with combined injuries e.g. PCL and PLS, complain of pain, swelling and instability. The physical examination begins by exposing both lower extremities and observing the patient's gait pattern if he/she is able to walk. A varus thrust in

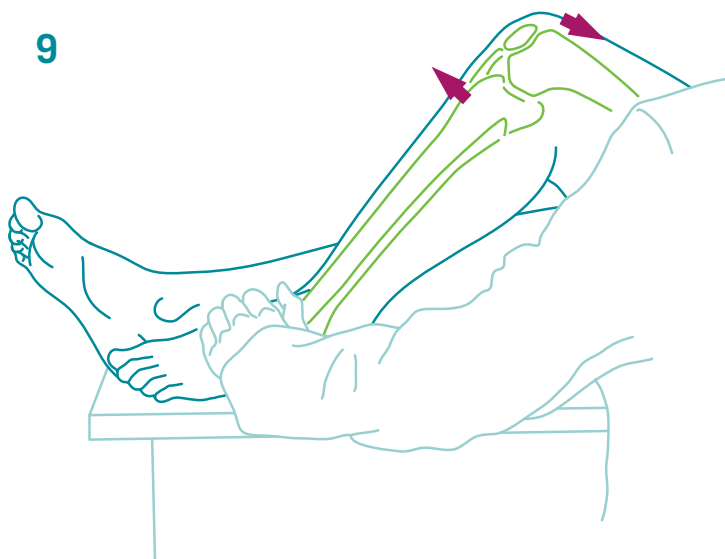
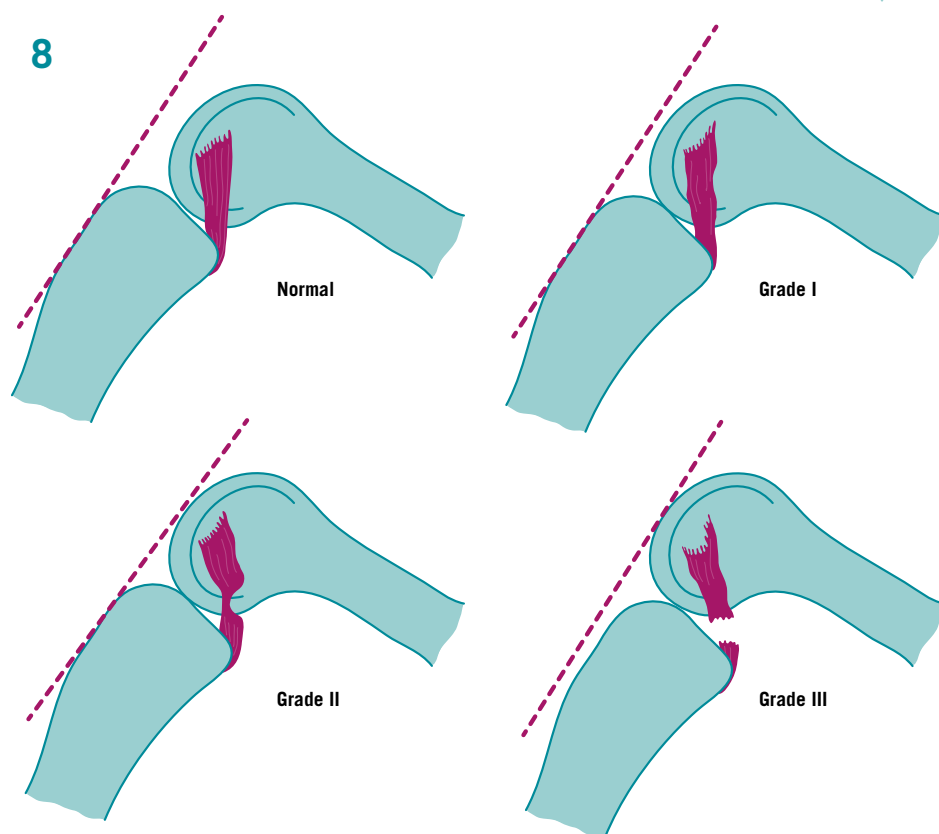


Figure 7: Posterior drawer test.

Figure 8: The three grades of posterior subluxation.

Figure 9: Quadriceps active test.



combination with a hyperextended knee gait may indicate a chronic combined PCL and posterolateral corner injury.

Posterior sag test

In the posterior sag test, the knees are flexed to 90° and the feet placed on the table (Figure 6). A PCL injury can be suspected when observing and palpating the anterior joint line. Normally, the anterior border of the medial tibial plateau sits about 1 cm anterior to the medial femoral condyle. The normal step is easily palpable and

compared with the contralateral side. In a PCL-deficient knee, gravity causes the tibia to rest in a posteriorly subluxed position compared with the intact knee. This test can be performed with the hip and the knee flexed to 90°, the examiner supporting the weight of the limb by the foot (Godfrey's Test).

Posterior drawer test

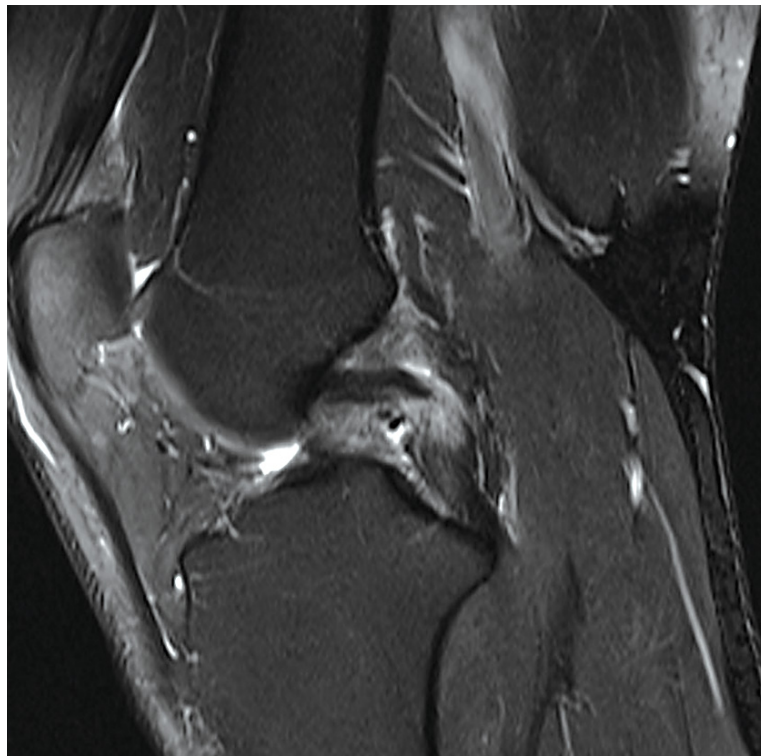
The posterior drawer test is the most accurate clinical test for assessment of PCL rupture. It is performed with the knee at

90° with the patient in supine position (Figure 7). The normal starting position is with the anterior border of the lateral tibial plateau 1 cm anterior to the lateral femoral condyle. Without a proper starting position, the examiner may elicit a false-negative posterior drawer and a false-positive anterior drawer test leading to an incorrect diagnosis. Isolated PCL injuries are usually classified by the degree of posterior subluxation of the tibial plateau relative to the femoral condyle (Figure 8). With a grade I injury, the tibial plateau remains anterior to the condyle, maintaining an anterior step-off. A grade II injury is likely when the anterior border of the tibia sits flush with the femoral condyle (5 to 10 mm translation). Grades I and II are usually partial tears. When the anterior border of the tibial plateau rests posterior to the femoral condyle (more than 10 mm of translation), a complete tear (grade III) is present and associated posterolateral structure damage should also be suspected.

The Quadriceps Active Test

In this test, the knee is placed at 60° of flexion and the examiner holds pressure on the foot (Figure 9). The patient is asked to contract the quadriceps isometrically. In the case of a complete rupture of the PCL, the quadriceps contraction achieves a dynamic reduction of the posterior displacement of the tibia.

Figure 10: MRI showing a partial tear of the posterior cruciate ligament.



Other tests

The reverse pivot shift test, the external rotation of the tibia test, the Lachman test and collateral ligament examination are essential and will complete the full assessment of the joint.

IMAGING

The standard knee series must include bilateral standing anteroposterior and lateral views in flexion weight-bearing ('Schuss views'). Look for subtle posterior tibial subluxation and avulsion fractures. Bony tibial avulsions, when recognised acutely, may be repaired primarily. In addition, long-leg cassette views allow an assessment of the lower limb alignment, particularly in chronic cases.

Stress radiographs (Telos), when available, can help the diagnosis and contribute to classifying the grade of the lesion.

MRI is the imaging study of choice for PCL ruptures. Not only will it detect acute ruptures, it will determine the precise location of the lesion and assess the menisci and other supporting ligaments of the knee and articular surfaces (Figure 10).

NATURAL HISTORY OF PCL RUPTURE AND CONSERVATIVE TREATMENT

The treatment of the PCL-injured knee is a controversial issue. Treatment should be based on the natural history of the PCL deficient knee because this provides the baseline against which any interventions can be compared. Unfortunately, there are very few true natural history studies on the PCL injured knee; most published studies are retrospective and include a mixture of patients and injuries. The retrospective studies generally report both acute and chronic injuries with various follow-up times, variable assessment criteria, small patient groups and even different PCL injury.

In a series of 45 patients, Dejour (1988) described the natural history of the isolated PCL injury as occurring in three phases:

1. Functional adaptation lasting 3 to 18 months, with return to sport.
2. Functional tolerance continuing for 15 to 20 years.
3. Osteoarthritic deterioration (medial tibiofemoral or generalised) that does not become disabling until 25 years have passed.

In a prospective study of the outcome of conservative treatment, Shelbourne reported the outcomes of 271 athletes with acute, isolated, nonoperatively treated PCL injuries. 76% were able to return to sport or activity at a similar level. Several series have described the intrinsic healing potential of the PCL, return to competitive sport, lack of symptomatic instability and good outcomes at mid-term follow-up.

Conservative treatment, based on a physiotherapy protocol, gives good results if the PCL rupture occurs as an isolated injury, with return to sport which can, in some cases, be in less than 2 months.

However, recent biomechanical studies have identified alterations in contact area and loads after PCL injury, particularly with flexion beyond 70°. These effects occur in the medial and patellofemoral compartments and some clinical series suggest progressive disability and degenerative joint disease

with chronic PCL deficiency. So the main problem after a PCL rupture seems to be more the degenerative lesions than the stability.

SURGICAL TREATMENT

A combined acute lesion of the posterolateral structure must be diagnosed as the repair must be done within the first 3 weeks after the injury. The surgical management of displaced avulsion fractures will usually result in a favourable outcome. Suture or screw fixations are an appropriate method with a posterior surgical approach for cases where there is a large bony fragment. Some surgeons argue for the repair of some ligament avulsions without any bone avulsions, but in the majority of cases, a PCL reconstruction is carried out.

PCL TESTS:

- 1 *Posterior drawer test*
- 2 *Posterior sag test*
- 3 *Quadriceps active test*

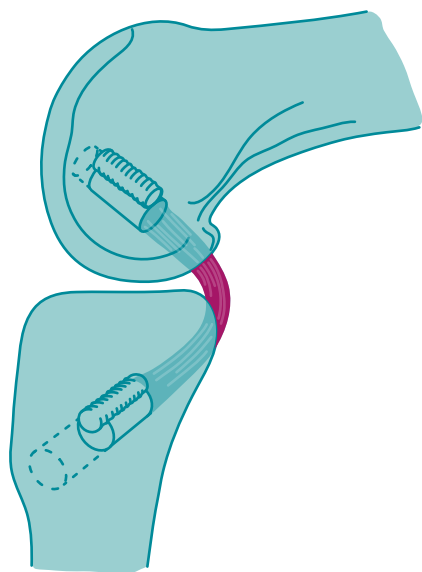


Figure 11: Single bundle transtibial reconstruction.

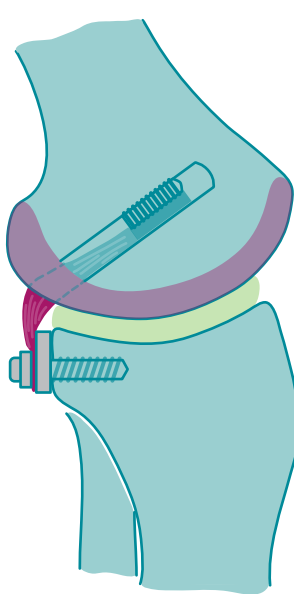


Figure 12: Inlay technique.

The general principles of the ligament reconstruction are based on the anatomical placement of the tunnels, the use of a strong and large graft, graft tunnels avoiding sharp angulations, knowledge of the proximity of the popliteal vessels, tension and fixation of the anterolateral bundle between 70 and 90° of flexion, solid fixation of the transplant, as well as a suitable rehabilitation programme.

During PCL reconstruction, an autograft (patellar tendon, quadriceps tendon or hamstrings) can be used. However, an allograft, if available, is a suitable alternative. The Achilles tendon is often the allograft of choice. Several methods exist for reconstruction of the PCL.

The single bundle transtibial technique

The transtibial technique was the first developed technique. Initially using an open procedure, now performed arthroscopically. It remains a technique of reference. Using an arthroscopic posteromedial approach and a specific tibial guide, a tibial tunnel is formed. The femoral tunnel is then made using an out-in or an in-out technique (Figure 11). The optimal tunnel positioning should take into consideration that the aim of the surgery is to recreate the anteromedial bundle of the native PCL. One of the key concerns with the transtibial technique is the so-called 'killer turn'. This describes the sharp angulation of the graft at the posterior end of the tibial tunnel which can generate progressive damage and failure of the graft. The inlay

technique was proposed in response to this concern.

The inlay technique

Once the arthroscopic procedure has been achieved, including drilling of the femoral tunnel, the patient is repositioned for an open posterior approach. After protection of the neurovascular structures, the posterior tibial plateau is exposed and prepared for placement of the bone block (Figure 12). The graft is inlayed flush and fixed with screws. Then, the proximal part of the graft is passed through the femoral tunnel for a standard fixation. So far this modified technique does not show any superior clinical results when compared with the transtibial technique.

The double bundle reconstruction

In order to better reconstruct the anatomy of the native PCL, the double bundle reconstruction was developed. The majority of the supporters of this surgical procedure perform two femoral tunnels. The tibial technique can be either single or double. Therefore, this technique can be carried out combining an inlay technique. Despite some cadaveric and biomechanical studies, no clinical difference has been found between single and double bundle reconstructions as of today.

Postoperative complications

Residual laxity is a common complication after PCL reconstruction, whatever the

The main problem is not the stability but the long-term degenerative changes

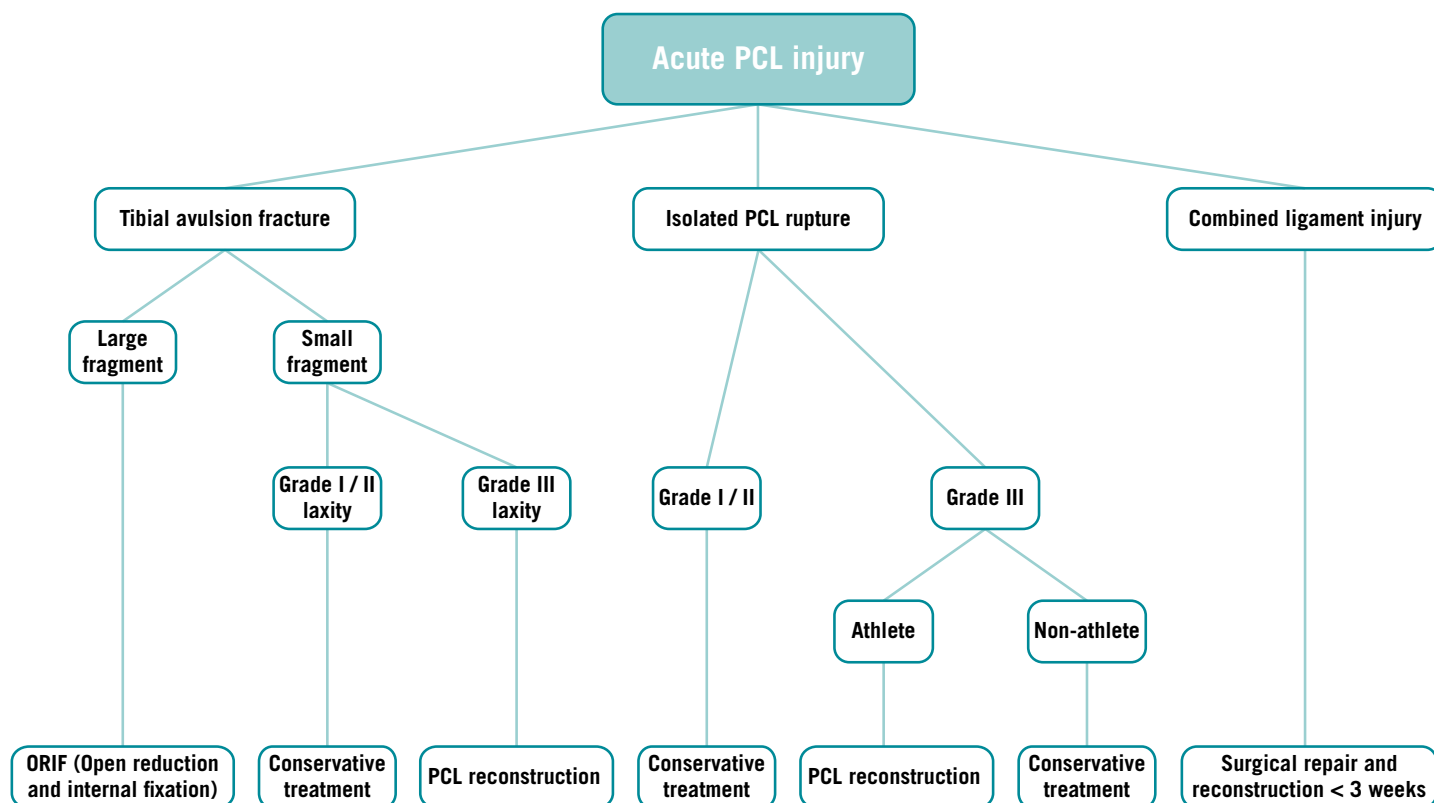


Figure 13: Treatment algorithm in acute PCL injury.

technique. The most serious risk of surgery is a neurovascular complication, given the close proximity of the popliteal artery to the PCL. Other postoperative complications include fractures, medial femoral condyle necrosis and arthrofibrosis.

Rehabilitation

Physiotherapy is crucial after PCL reconstruction. In contrast to ACL reconstruction, gravity tends to stretch the PCL graft. Therefore, some specific techniques of physiotherapy (prone position) and a slower pace, compared to the accelerated rehabilitation of ACL injury, has been supported to allow complete healing of the PCL graft. Return to sport is rarely achieved before 8 months.

Clinical outcomes after surgical reconstruction

The early results of surgical treatments reported in the literature were somewhat biased in that there was a mixture of acute, chronic, isolated and combined injuries. There are very few long-term results published. The conclusions of the 2004 symposium organised during the French Society of Arthroscopy Congress on isolated PCL ruptures were that PCL surgery can

improve knee function and sport activity significantly, but that the graft cannot fully control posterior laxity, with the average gain being 6 mm. Hammoud et al reported a systematic review of the evidence in 2010. Twenty-one papers in the literature reported the results after surgical treatment of isolated PCL injury. The percentage of return to same sport level activity ranges from 50 to 82% in comparison with the 19 to 68% range in case of combined ligament injuries treated surgically (10 studies in the literature).

CONCLUSION

The majority of isolated PCL ruptures can be treated conservatively with good results and return to sport in a few weeks. In the athletic population, the grade I and II injuries are usually treated conservatively with success and we recommend performing a PCL reconstruction in the case of grade III injuries. The combined injuries, particularly PCL and PLS lesions, must be treated surgically within the first 3 weeks following the injury as the treatment of the chronic posterolateral laxity is challenging.

Based on experience and the current literature, a treatment algorithm for acute PCL injury is proposed (Figure 13).

CONSERVATIVE TREATMENT

- 1 4 weeks extension immobilisation
- 2 Quadriceps therapy
- 3 Close kinetic chain exercises
- 4 Progressive return to activity

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