Rupture of Posterior Cruciate Ligament: Diagnosis and Treatment Principles

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Introduction

Posterior cruciate ligament (PCL) injuries often go undiagnosed because a popping sound is not as distinctive as in anterior cruciate ligament (ACL) injuries and swelling is not severe in sports injuries. However, early diagnosis and treatment is critical to prevent serious complications that can result from combined vascular injuries. Compared to the ACL, the PCL has a high potential for spontaneous healing, thus requires different treatment approaches. For proper treatment, the surgeon should be fully aware of the collateral ligament injuries that affect posterior stability, lower limb alignment, and the relationship between the posterior tibial slope and ligament instability.

In this review, we describe and discuss the diagnosis and treatment methods of PCL injuries based on our experience and a review of the literature.

Diagnosis and Treatment

1. Diagnosis

1) History of illness and mechanism of injury

The most common mechanisms of PCL injuries include pretilial trauma, hyperflexion, and hyperextension of the knee. Fowler and Messieh reported that, isolated PCL injuries were common in athletes and hyperflexion was the most frequent mechanism of injury. In most of the PCL injuries caused by hyperflexion, the posteromedial bundle remains intact and only the anterolateral bundle is ruptured. However PCL tears mostly occur in combination with other injuries. Fowler and Messieh reported that, isolated PCL injuries were common in athletes and hyperflexion was the most frequent mechanism of injury.

2) Physical examination

A careful vascular examination of the lower extremities is essential because a PCL injury can be accompanied by a popliteal artery injury. If the pulses are weak or the ankle-brachial index
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is ≤0.8, an intimal tear should be suspected and arteriography should be performed. If blood flow disruption below the knee is obvious, arteriography should be omitted to prevent delay in treatment\(^\text{10}\).

Acute PCL injuries present with joint swelling and about 10° to 20° of restriction in further flexion due to pain. Chronic PCL injuries may present with limited activity such as having difficulty in climbing slopes due to lethargy and pain in the anterior and medial areas of the knee rather than instability. The posterior drawer test is the most accurate test for PCL injuries. At 90° of knee flexion, posterior sagging of the tibia is observed on the affected side. If the tibia is pulled forward or the quadriceps is contracted with the knee flexed to 90° (quadriceps active test), anteroposterior instability of the knee is noted\(^\text{10}\). However, these tests can be unreliable for detecting acute PCL injuries with severe swelling\(^\text{11}\). In contrast, the sensitivity of the posterior drawer test increases for the detection of chronic PCL injuries because of the absence of swelling and pain in further flexion\(^\text{12}\).

A presence of ≥10 mm posterior translation requires tests for posterolateral ligament complex (PLC) injuries. The presence of tenderness and an arcuate fracture in fibula head suggest acute a PLC injury, but a diagnosis of chronic PLC injury should be based on various test results. In the dial test, the thigh-foot angle is measured with an external rotation force applied to the knees flexed to 30° and 90°. If the angle on the affected side is ≥10°-15° greater than the contralateral side at 30° of flexion only, at 90° of flexion only, and at both 30° and 90° of flexion, the diagnosis is an isolated PLC injury, an isolated PCL injury, and a combination of PCL and PLC injury, respectively. Posterior translation is greater in combined injuries of the PCL and PLC than in an isolated injury\(^\text{8,10,12}\).

Considering that the dial test can be misleading in cases of minor injuries\(^\text{13}\), it is recommended to reduce the tibia with an anterior force during the test. To better assess posterior subluxation of the tibia, the examiner should palpate with 4 fingers posterolateral translation of the posterolateral condyle of the tibia with respect to the posterolateral condyle of the femur with an assistant holding the knees flexed to 90°\(^\text{14}\).

The posterolateral drawer test, external rotation recurvatum test, and reverse pivot shift test can also be used to assess injuries to the posterolateral structures. However, a positive external rotation recurvatum test is more indicative of an ACL injury than a PCL injury\(^\text{15}\) and the reverse pivot shift test should be used with care because the test may yield positive results in about 30% of normal knees\(^\text{12}\).

Combined PLC injuries have much influence on the prognosis of PCL injury treatments. This is why the exact assessment of PLC injuries is important. However, it may be impossible to detect PLC injuries with a single test. Therefore, it is recommended to palpate the articular surface during various tests with suspicion.

Fig. 1. (A) Varus aligned lower limb. (B) Varus thrust during gait.
of PLC injuries and determine the diagnosis based on the test results. Besides, the overall lower limb alignment should be assessed for varus malalignment and gait for instability such as varus thrust (Fig. 1)\(^\text{10,16}\).

3) Imaging

Radiography is a valuable tool in diagnosing PCL injuries. The presence of a fracture can be determined on the anteroposterior, lateral, and Merchant views of the knee. The lower limb alignment, especially the presence of varus malalignment, can be evaluated on the standing radiographs. The presence and degree of instability can be assessed on stress radiographs. Especially, PCL injuries can be best visualized on posterior stress radiographs (Fig. 2)\(^\text{10,17,18}\). A presence of ≥10 mm posterior translation on posterior stress radiographs may suggest posterolateral ligament injuries combined with PCL injuries\(^\text{19}\).

External rotation valgus stress radiogram is useful in assessing PLC injuries\(^\text{20}\) and ultrasound can be used to evaluate the degree of instability\(^\text{21}\).

Magnetic resonance imaging (MRI) has 96 to 100% accuracy for the detection of acute PCL injuries and can determine the location and severity of an injury and other damages to the cartilage and ligaments. Bone bruise patterns on MRI can be helpful in identifying the mechanism of injury. In acute PCL injuries, bone bruises are often located anterior to the tibia (Fig. 3). In chronic PCL injuries (Fig. 4), MRI scans may appear to be normal if the ligament healed spontaneously\(^\text{10}\). The popliteofibular ligament, an important structure in posterolateral instability of the knee, may not be clearly visualized on MRI\(^\text{22}\).

4) Instrumented examination

The KT-1000 can be used to assess anteroposterior instability, but may be less accurate than Telos stress radiography\(^\text{12}\).

5) Arthroscopy

PCL lesions can be visualized with arthroscopy in acute cases. They may appear to be healed in chronic cases, but arthroscopy will reveal ACL pseudolaxity where the ACL appears lax due to posterior translation of the proximal tibia but the laxity resolves when an anterior force is applied to the tibia. Care should be taken not to misinterpret this pseudolaxity as an indication of...
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ACL injuries. An abnormal contact can also be observed between the medial femoral condyle and the medial meniscus anterior horn due to the posterior translation of the proximal tibia. PLC ruptures can be visualized with arthroscopy or evidenced by hemorrhage in some cases. However, it is more common to identify a “lateral gutter drive through sign” that can be observed by inserting the arthroscope into the posterolateral aspect of the knee or tension of the popliteus tendon.

2. Treatment Principles

Conservative treatment is indicated for PCL injuries with 5 to 10 mm posterior instability (grade I and II) and surgical treatment is recommended for PCL injuries with ≥10 mm posterior instability (grade III) or with combined collateral ligament injuries or avulsion fractures. However, the natural history, healing potential, and the influence of remnant, alignment, and posterolateral ligaments should be taken into consideration in determining treatment plans.

1) Natural history

Surgical treatment of less than moderate isolated PCL injuries (grade I and II) still remains controversial. Short-term results of nonoperative treatment have been reported successful in many studies. However, there are studies showing unfavorable long-term results including degeneration of the tibiofemoral cartilage in the medial compartment and increased tibiofemoral pressure and meniscal strain, which eventually led to arthritis. In the study of Dejour et al., osteoarthritis occurred eventually in the patients in whom the isolated rupture of the PCL was functionally well tolerated for 3 to 18 months. According to Clancy et al., degenerative arthritis was observed in 80% of the patients after nonoperative treatment. Likewise, nonoperative treatment of grade I and II isolated PCL injuries have been associated with functional limitation and early degenerative arthritis in many studies. Therefore, surgical treatment of grade II PCL injuries can be considered as an option if a hot spot is shown on bone scan of highly active patients or the surgeon is competent.

2) Healing potential

Acute PCL tears, especially those within substance, can be treated with conservative measures because of the ligament’s high healing potential. However, when PCL injuries are combined with PLC injuries, the PCL should be treated with reconstruction and the PLC with repair or reconstruction because the PLC tears do not heal with conservative treatment, which eventually leads to instability and cartilage degeneration.

3) Remnant

Remnants are observed in most PCL injuries because the ligament has a high chance of spontaneous healing. It has been known that preservation of the remnant fibers during operative treatment of PCL injuries plays a pivotal role in obtaining successful outcomes. If remnant fibers are observed, retensioning of the remnant PCL fiber, stent procedure, single-bundle or double-bundle PCL reconstruction with PCL remnant preservation, albeit technically challenging, can be performed depending on the quality of the PCL remnants. If no remnant is present, albeit controversial, double-bundle PCL reconstruction may be an appropriate procedure.

4) Alignment

Left untreated, varus malalignment may increase the risk of treatment failure after PLC and PCL reconstruction. Therefore, if varus malalignment is present, an osteotomy should be carried out even in acute cases of PCL combined with PLC injuries. Improvements can be made with varus malalignment correction.

Fig. 4. (A) In acute posterior cruciate ligament (PCL) injuries, T1-weighted sagittal view, ligament has been torn with the frayed ends being clearly visualized. (B) In chronic PCL injuries, T1-weighted sagittal view, MRI scans may appear normal when grade I and II injuries are present.
alone and then subsequent reconstruction procedures may become unnecessary. An increase in tibial slope results in an anterior shift of the resting position of the tibia relative to the femur and anterior tibial translation under an axial load. A varus osteotomy may improve posterolateral instability and make PLC reconstruction unnecessary.

5) Collateral ligaments

Medial collateral ligament injuries are rare but may have an influence on the PCL. Therefore, reconstruction is required if a ≥12 mm increase in the medial gap is observed at 30° of knee flexion. Posterolateral ligament injuries should be aggressively treated because left untreated, it results in severe posterior translation that has been associated with most of the PCL reconstruction failure cases. The classification of posterolateral structure injuries has yet to be established. According to Fanelli et al., type A injury was defined as increased external rotation only due to popliteus tendon and popliteofibular ligament injuries, type B as ≤10 mm varus instability and increased external rotation, and type C as ≥10 mm varus instability and increased external rotation. They suggested that type A and B injuries can be conservatively treated and type C injuries should be surgically treated. Kannus also recommended operative treatment for grade III injuries. The most common surgical reconstruction procedures include primary repair, posterolateral complex advancement, biceps femoris tendon tenodesis, and anatomic posterolateral corner reconstruction.

6) Rehabilitation

In contrast to ACL rehabilitation, PCL rehabilitation should be carried out at a slow pace. Depending on the patient's condition and the surgeon's intraoperative judgment, appropriate joint exercises that allow early joint motion within a safe range should be determined. Although some differences exist among studies in terms of the appropriate timing and method, the rule of thumb is as follows. Postoperatively, there is a tendency to posterior translation in flexion of the knee, especially in active flexion. In addition, the tendon graft becomes weak by the 6th postoperative week and requires protection. Therefore, during the 2nd and 3rd postoperative week, the knee should be immobilized in an extended position with a padded posterior splint or a long leg brace. Quadriceps femoris muscle strengthening exercise and straight leg raising exercise are started immediately after surgery for synergy effect. To prevent joint adhesion, joint exercises should be performed in anteroposterior and mediolateral directions. Passive flexion exercise is performed with the tibia pulled forward until 90° of flexion is achieved by the 4th to 6th postoperative week. For isolated PCL injuries, weight-bearing can be helpful in maintaining muscle strength even before the 6th postoperative week without the risk of posterior translation because the tibial slope increases the tendency to anterior tibial translation. However, for combined PCL injuries, partial-weight bearing is allowed soon after surgery and progressed to full weight-bearing at the 6th to 12th postoperative week. In addition, passive range of motion should be gradually increased to 140° of flexion avoiding active contraction of the hamstrings. From the 12th postoperative week when collagen fibers become organized, flexion exercise is permitted, light jogging is allowed 3 to 6 months after surgery, and sports activities are allowed 6 months after surgery.

Conclusions

An early and accurate diagnosis of a PCL rupture should be based on the history of illness, vascular examination to exclude vascular damages, and physical examination for the assessment of PCL and collateral ligament injuries and radiographic examination. Once a diagnosis is established, appropriate treatment plans should be determined according to the time of injury, rupture pattern, presence of remnant, combined collateral ligament injuries, alignment, and tibial slope.

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