
Nonoperative Treatment and Natural History of Posterior Cruciate Ligament Injuries

K. Donald Shelbourne

Introduction

Posterior cruciate ligament (PCL) injuries are uncommon and only a few of these injuries may be seen each year in a general orthopedist's practice. PCL injuries can occur with athletic activity and activities in daily life but are more commonly seen with trauma, where the PCL can be torn along with other ligamentous structures. Although one can detect a PCL injury, if trained properly, the injury can be missed unless the physician suspects it based on the patient history. Even when the diagnosis is made, it can be difficult to develop a treatment protocol for patients with PCL injuries because of the varying degrees of the injury and the lack of consensus among orthopedic surgeons as to the best treatment approach.

Orthopedic surgeons are trained to focus on surgical solutions to musculoskeletal injuries, always striving to restore perfect anatomy. Through the years, PCL reconstruction surgery has been developed and improvements in techniques have been made. But it is still unclear as to whether surgical treatment will provide better results than nonoperative management.

The nonoperative treatment approach to PCL injuries found in this chapter is in contrast to most opinions. This approach is based on more than 30 years of an orthopedic practice that has been devoted to knee injuries only. The practice began in 1982 at a time when PCL reconstructions were infrequently done, mostly because the PCL injury was not recognized and, when it was, the surgical procedures available could not reliably restore the native anatomy or stability. In 1983, a true natural history study of PCL injuries was begun at my institution. Only a few natural history studies have been conducted of PCL injuries, as most reports of nonoperative treatment include patients who sought treatment for chronic PCL instability [1–4].

This chapter reviews the findings of natural history studies of PCL injuries and other studies from investigators seeking to find answers to the treatment of PCL injuries. The mechanism of injury, patient history, and clinical diagnosis will be outlined. The nonoperative treatment with both isolated PCL injuries and PCL injury in combination with other ligamentous instability will be described. Finally, results of nonoperative treatment will be compared and contrasted with current outcomes of PCL reconstruction.

Mechanism of Injury

Understanding the common mechanisms of PCL injuries is essential to clinically suspect and diagnose PCL tears. PCL injuries can occur in isolation or with other ligamentous injuries, and they can occur from low- or high-velocity impact or force. High-velocity PCL injuries can occur from trauma such as automobile accidents, where the front of the tibia comes in contact with the dashboard and is forced backwards. This same mechanism of impact on the front of the tibia occurs in athletics and everyday life when a person falls with the foot in plantar flexion. A blow to the proximal tibia is probably the most common mechanism of injury for isolated PCL injuries.

Hyperflexion of the knee is another method of isolated PCL injury, with the PCL usually tearing near its tibial attachment or at midsubstance [5, 6]. With hyperflexion, the anterolateral portion is damaged but the posteromedial portion remains intact [7, 8]. Another mechanism for an isolated PCL injury is an external rotation force on a weightbearing leg with the knee in near full extension (Fig. 7.1) [9].

PCL injuries are more commonly found in conjunction with other ligamentous injuries. Shelbourne et al. identified a combined PCL-medial collateral injury (MCL) in patients who had sustained a valgus external rotation force to a flexed knee with a planted but nonweightbearing foot (Fig. 7.2) [10]. This injury typically occurs when the foot gets stuck on a surface or in a hole, the weight is on the other leg, there is

K. D. Shelbourne (✉)
Shelbourne Knee Center, 1815 N. Capitol Ave.,
Indianapolis, IN 46202, USA
e-mail: tgray@fixknee.com

Fig 7.1 The *right foot* is fixed but becomes unloaded as the athlete shifts his weight and forward momentum to his *left leg*. The *right knee* is minimally flexed and sustains a relative external rotation twist while the *body* and the *right femur* are anteriorly translating and internally rotating

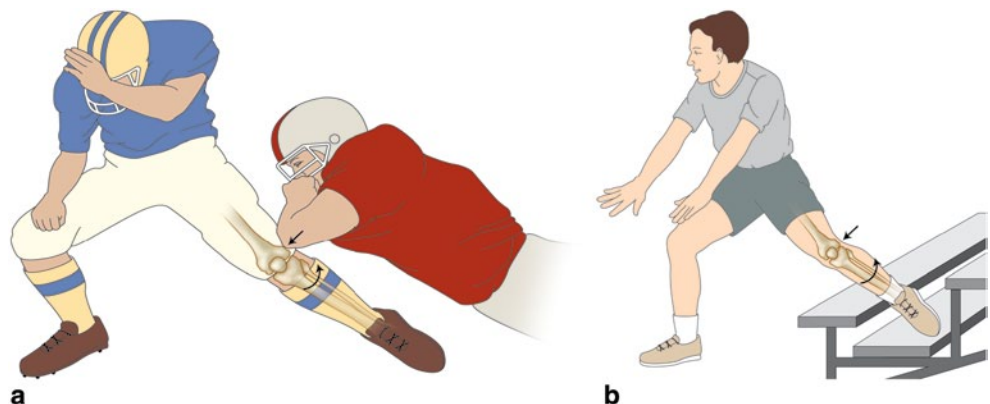


valgus stress on the knee, and the tibia is externally rotated. The injured MCL is easily recognized but the PCL can be slight and often missed on physical examination.

PCL injuries in conjunction with a dislocated knee, either medial or lateral, can have varying degrees of injury and subsequent laxity and have implications for treatment. When the injury occurs as a result of major trauma, as in the case with automobile accidents, the more serious injuries to the rest of the body take precedence in emergency care. The injury to the PCL may not be recognized or addressed until the patient later has symptoms affecting function. Given that the PCL injury is frequently overlooked, the incidence of the injury with major trauma may never be known.

Therefore, an understanding of the mechanisms of injury for PCL injuries, whether isolated or combined with other knee structures, will raise suspicion for the injury and proper examination techniques will lead to an accurate diagnosis and appropriate management.

Fig. 7.2 Combined PCL–MCL injuries can occur when the *foot* is planted or fixed, but not weight bearing, and the *leg* is either struck on the lateral side (**a**) or the *foot* being stuck causes a valgus stress with external rotation of the tibia (**b**). PCL posterior cruciate ligament, MCL medial collateral injury



Clinical Diagnosis/Physical Examination

As previous stated, being suspect of PCL injury by understanding the mechanisms of injury is very important for diagnosing a PCL injury. With an isolated injury to the PCL, the patient usually feels the injury was significant but perhaps not debilitating. The patient can usually bear weight but may walk with a slightly flexed knee, avoiding terminal extension and external rotation. In contrast to anterior cruciate ligament (ACL) tears, the patient usually denies hearing or feeling a “pop” and the presence of an effusion may be minimal. Most isolated PCL injuries seen acutely after the injury are accompanied by posterior knee pain, a mild hemarthrosis and difficulty squatting. The patient will often report that “something is not right” in the injured knee, but cannot elaborate on what feels wrong.

If the knee injury includes a PCL injury with other ligaments injured, the swelling is usually much greater. Patients with PCL/MCL injuries have the symptoms of an isolated MCL injury, with pain and tenderness on the medial side of the knee and a feeling of medial instability in the knee. The patient may have localized swelling along the ligament. If the PCL injury is part of a knee dislocation with ACL and either medial or lateral collateral ligament (LCL) injuries, the patient will have a significant hemarthrosis. If there has been a significant capsular injury, swelling may dissect into the subcutaneous tissues resulting in the development of edema and ecchymosis in the leg below the knee. The main concern with multiple ligament dislocations is the possibility of neurovascular injury. Careful assessment must be made of the vascular and neurologic status of the limb, and consultation with a vascular surgeon may be required. Patients with ACL, PCL, and lateral-side knee injuries have an almost 30% incidence of peroneal nerve injury [11].

If not seen acutely after a PCL injury, many of the patient’s symptoms will resolve and activities can be resumed without the patient knowing of the injury. Patients usually will not seek treatment unless they develop chronic knee symptoms, with pain being the most common complaint [1, 12]. Instability is usually a secondary complaint in about 20–45% of patients with chronic PCL-deficient knees [1, 12].

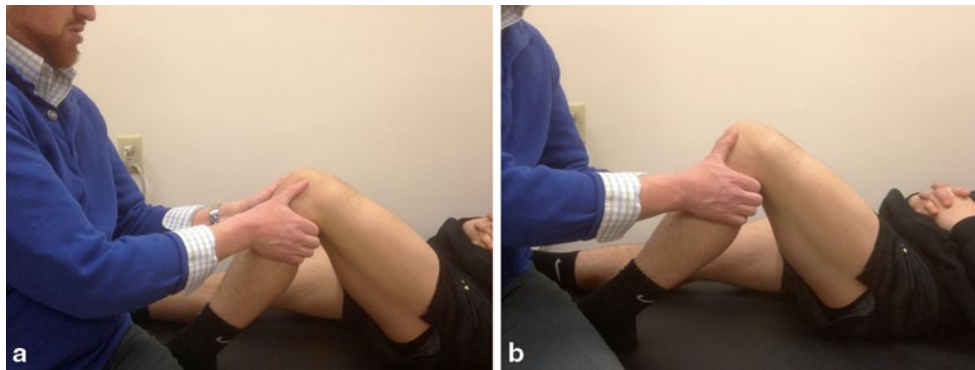


Fig. 7.3 Posterior drawer test: The patient is supine and has the *hip* and *knee* flexed to about 90°. The examiner sits at the edge of the patient's *foot* so the *foot* cannot slide on the exam table. This allows the patient to relax his/her *leg* completely. The examiner places his/her *hands* so that the *thumbs* can feel for the normal prominence of the tibia in relation to

the femoral condyles (a). The *index fingers* can be used to feel for relaxation of the hamstring muscles. The examiner pushes directly posterior on the tibia and feels for translation of the tibia and the loss of normal prominence of the tibia. When the tibia is completely flush with the femoral condyles upon posterior force, the patient has 2+ posterior laxity (b)

Table 7.1 Grade of posterior cruciate ligament laxity as evaluated with posterior drawer examination

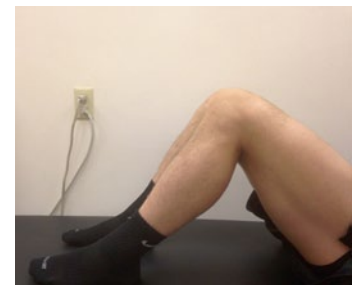
Grade	Difference on posterior drawer (mm)	Anatomical landmarks
1	3–5	Tibial plateau prominence remains anterior to femoral condyles
1.5	6–8	Tibial plateau prominence not quite flush with the femoral condyles
2	9–10	Tibial plateau and femoral condyles lie flush
2.5	11–13	Anterior tibial plateau is slightly posterior to the femoral condyles
3	>13	Anterior tibial plateau is grossly posterior to the femoral condyles

Physical Examination

Physical examination serves to confirm the diagnosis suspected from the patient's history. Physical examination of the acutely injured knee can be difficult due to pain, swelling, muscle spasm, limited range of motion (ROM), and patient apprehension. The normal, uninjured knee should be examined first so that a normal baseline for the patient can be determined by the examiner for all parameters, including knee stability. An examination of the normal knee allows the patient to know what to expect when the clinician examines the injured knee and may instill some confidence in the patient, allowing them to relax somewhat, thus making the examination a little easier.

The best physical examination test for diagnosing PCL injuries has been found to be the posterior drawer test, which was found to be 96% accurate, 90% sensitive and 99% specific with an interobserver agreement for the grade of injury of 81% [13]. The posterior drawer examination is performed with the knee bent at 90° of flexion. The examiner places his leg over the patient's toes so the patient can relax the leg and the foot is stabilized on the examination table. The examiner places both hands on the front of the tibia with the thumbs over the femoral condyles. Force is applied and directed posteriorly to evaluate posterior excursion (Fig. 7.3). Posterior laxity is graded as described in Table 7.1, with grade 2 laxity indicating that the tibia is flush with the femoral con-

Fig. 7.4 Posterior sag: The *knee* in the foreground shows posterior sag of the tibia compared with the normal *knee* that can be seen with PCL injury. PCL posterior cruciate ligament



dyles. Translation greater than 13 mm is classified as a grade 3 injury, which usually indicates that other knee ligamentous injuries are present.

The accuracy of the posterior drawer exam comes with experience. If the posterior drawer exam becomes a part of the regular routine of a thorough knee examination for any patient with a knee injury, the clinician gains experience for feeling differences in PCL laxity and the feel of an endpoint of stability. If the patient's knee cannot be bent to 90° due to significant injury or swelling, one can reexamine the patient a few days later to give time for the initial pain and swelling to subside.

With both knees bent to 90° for the posterior drawer exam, the clinician can also observe for posterior sag of the tibia in the involved knee compared with the normal knee (Fig. 7.4). With an intact PCL, the anteromedial proximal tibia will be about 1 cm anterior to the distal femoral con-

dyles. When the PCL is injured with laxity, the proximal tibia will sag to varying amounts related to different degrees of PCL injury. The traditional way for looking for posterior sag is with both the hips and knees flexed to 90°. The clinician can observe the knees from the patient's side, and this method has the added advantage of gravity for producing sag of the tibia. However, this method may cause more pain for a patient with an acute PCL injury and may not be possible. Other tests to assess clinical integrity of the PCL include the reverse Lachman test, the dynamic posterior shift test [14], and the quadriceps active drawer test [15].

When a multiple ligament injury is suspected, further ligamentous testing should be performed. The medial and LCL can be examined by applying valgus and varus stresses respectively at 30° of knee flexion. Repeating these tests at 0° of flexion will also assess the capsular and cruciate components to valgus and varus stability. Repeating the posterior drawer test with the tibia placed in internal rotation will assess the medial structures. If the posterior drawer decreases with internal tibial rotation, the medial structures are most likely intact. In combined ligament injuries (PCL/MCL or PCL/ACL/MCL), the usual tightening observed when the posterior drawer is performed with the patient's tibia in internal rotation is lost.

Diagnostic Imaging

Plain Radiographs

A routine series of radiographs include a 45° flexed weight-bearing posteroanterior [16], lateral, and Merchant's view [17] radiographs, and these images should be obtained for all patients with acute knee injuries. The radiographs, however, are not diagnostic for a PCL injury. Occasionally, an avulsion fracture of the tibial PCL insertion may be seen, but these are fairly uncommon [18]. A modified axial view has been described that allows for measuring of the amount of posterior tibial translation, which is compared to the uninjured side [19].

Magnetic Resonance Imaging

In the acute setting, magnetic resonance imaging (MRI) of the PCL-injured knee has been reported to be 99–100% sensitive and specific [20, 21]. We do not recommend routine MRI examinations for patients with PCL tears because the severity of damage to the PCL as seen on the MRI does not correlate with function or laxity. In my opinion, MRI diagnosis of PCL injuries with knee dislocations has led to unnecessary surgical treatment of the PCL. This overtreatment stems from a lack of knowledge that the PCL can heal [22, 23], even when a “complete tear” is diagnosed from the MRI scan [22].

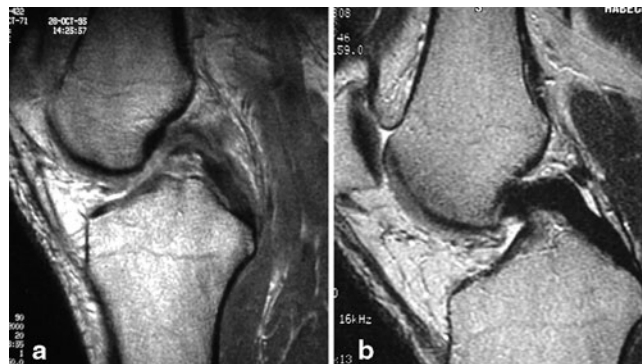


Fig. 7.5 The MRI scan (a) of an acute PCL injury determined to be a complete PCL tear. A follow-up scan (b) at 8 months after injury shows the PCL to be in continuity. PCL posterior cruciate ligament, MRI magnetic resonance imaging

Tewes et al. [23] obtained follow-up MRI scans at an average of 20 months after injury for 13 patients with high-grade PCL tears. The results showed that the PCLs of 10 of 13 patients (77%) had regained continuity, although with an abnormal appearance. Clinical or functional status did not correlate with the degree of posterior laxity.

In a similar study, Shelbourne et al. [22] obtained MRI scans acutely after injury and then again at a mean of 3.2 years after injury on 27 patients with isolated acute PCL tears and 17 patients with acute PCL injuries in combination with other ligamentous injuries. The investigators assessed the healing potential of partial and complete tears as graded on the MRI scans. The results showed that all partial and most complete (19 of 22) PCL tears regained continuity on MRI scans and that location, severity, and associated ligament injury were not factors. The healed PCL did demonstrate abnormal morphology in 25 of the 37 continuous PCLs at follow-up.

Ahn et al. [24] evaluated PCL laxity in 49 patients who were treated with casting and bracing after acute PCL injury to determine if there would be a change in laxity with treatment. The grade of laxity at initial evaluation was grade 1 in 13 patients and grade 2 in 25 patients. At a mean of 24 months after injury, the grades of PCL instability improved grade 0 in 3 patients, grade 1 in 21 patients, and grade 2 in 14 patients.

The time to obtain PCL healing after acute injury is as yet unknown. However, Shelbourne et al. [25] described the development of a firm endpoint and painless posterior drawer at follow-up examination of acute PCL injured knees at about 2 weeks after injury.

Given the findings of these studies showing a “normal” PCL in the chronic setting, MRI evaluation of the PCL for patients who suffer chronic instability may not be helpful (Fig. 7.5). Therefore, treatment decisions should not be based on MRIs, but on clinical examination.

Fig. 7.6 MRI scanning in PCL lax knees often shows the posterior medial meniscus (white arrow) to be behind the femur and out of contact with the femoral condyle. PCL posterior cruciate ligament, MRI magnetic resonance imaging



With PCL laxity, the MRI scan will often show the posterior medial meniscus to be behind the femur and out of contact with the femoral condyle. If this is seen on a scan with the PCL in continuity, it may serve as an adjunctive sign of a previous PCL tear that has healed with PCL laxity (Fig. 7.6).

Natural History Studies

Most published studies of PCL injuries treated nonoperatively were conducted retrospectively and included patients who sought treatment because of chronic PCL laxity and painful symptoms or include patients with multiple knee ligament injuries [1–4]. These studies do not give a true picture of the natural history of isolated PCL injuries and may represent a worse outcome than what would be found from evaluating a population of patients prospectively after acute isolated PCL injury.

Only a few PCL studies report long-term subjective or objective results for isolated, PCL injuries in patients followed prospectively after an acute injury [25–27].

Patel et al. [26] evaluated 57 patients (58 knees) who were seen acutely for isolated PCL injuries and were treated nonoperatively with rehabilitation to restore the knee ROM and strength. Patients were evaluated again at a mean of 6.9 years after the injury and they were not being seen because they were having troubling symptoms. No correlation was found between subjective scores and length of follow-up or between subjective scores and grade of PCL laxity. The mean Lysholm score was 85.2 ± 10 points. Radiograph showed medial compartment degenerative changes in ten knees (seven mild grade 1; three knees moderate grade 2) and four knees had mild grade 1 patellofemoral changes.

In a subjective follow-up study of 215 patients at a mean of 7.8 years after acute, isolated PCL injury, a similar lack of correlation was found between subjective scores and grade of PCL laxity [27]. The subjective results were lower than scores of normative data of patients with no history of injury to the knee, but the scores did not decrease significantly with time.

Shelbourne et al. [25] reported the natural history of 133 patients after acute, isolated PCL injury. Sixty-eight of the patients returned for objective follow-up at a mean of 5.4

years after the injury and the other 65 returned subjective surveys. There was no statistically significant difference in subjective survey scores between patients who returned for both objective and subjective follow-up and patients who were able to return surveys only. No change in laxity was found from initial exam to final follow-up, and patients with greater laxity did not have worse subjective or objective scores. No correlation was found between radiographic joint space narrowing and grade of laxity. Ten of 67 patients (1 patient refused radiographs) had evidence of arthrosis in the injured knee alone, and 15 patients had arthrosis in both the injured and noninjured knees. Regardless of PCL laxity, one half of the patients returned to the same sport at the same level, one third of the patients returned to the same sport at a lower level, and one sixth of patients were not able to return to the same sport.

In a longer-term follow-up study of the same population, Shelbourne et al. [28] obtained objective and subjective follow-up for 44 of the original 68 patients who were evaluated objectively in the original study [25]. These evaluations were performed at a mean of 14.3 years after injury (range, 10–21 years) and subjective follow-up was obtained from all 68 patients at a mean of 17.6 years after injury. PCL laxity did not increase with time.

The mean knee ROM for the PCL injured knee was from 4° of hyperextension to 138° of flexion compared with 4° of hyperextension and 137° of flexion in the noninjured knee. Eight patients (18%) had trace effusion in one or both knees and one patient had a mild effusion in both knees. There was no difference in mean quadriceps muscle strength based on PCL laxity and the mean for all patients was 97.2% of the noninjured knee.

The overall grade of radiographs were rated as normal in 26 patients (59%), nearly normal in 13 patients (30%), abnormal in 4 patients (9%), and severely abnormal in 1 patient (2%). The grade of osteoarthritis (OA) on radiographs was not different in any knee compartment based on PCL laxity grade. Five patients (11%) had medial joint space narrowing greater than 2 mm. When comparing radiographic ratings of the same patients in the original follow-up study [25], seven patients (16%) had increased degenerative changes in at least one compartment of the knee; five of the seven patients had grade 2 PCL laxity. However, the same five patients had similar degenerative changes in the noninjured knee as well.

Mean International Knee Documentation Committee (IKDC) and modified Cincinnati Knee Rating System (CKRS) subjective scores at a mean of 17 years after injury were 73.4 ± 21.7 and 81.3 ± 17.4 points, respectively; there was no difference in subjective scores between PCL laxity grades. There was no difference in subjective scores between patients who completed a minimum 10-year objective follow-up and patients who completed surveys only. Forty patients had completed at least four CKRS

surveys through time, and an evaluation of consistency of scores revealed that the scores were consistent for less than half of the patients. Nine patients had consistently improving scores through time, 5 patients had consistently declining scores through time, and 12 (30%) were inconsistent.

An activity-level survey revealed that 20 patients (45%) were still participating in jumping/pivoting sports at a mean of 17 years after their injury. Seventeen patients were still participating in recreational sports such as tennis and golf. Only seven patients (16%) reported that they were limited to activities of daily living.

The incidence of meniscus tears associated with isolated PCL injury has been reported to be between 5 and 28%, with common tears being in the lateral meniscus [7, 25, 29–31]. Although meniscus tears are not that common with PCL injuries, the medial meniscus does not function normally because the meniscus is posterior to the femur with posterior laxity. I believe this is what may cause osteoarthritic changes in the medial compartment to occur in some patients with PCL laxity.

Patellofemoral arthritis is thought to be common with PCL injuries, but the data from true natural history studies do not confirm this thought. The incidence of patellofemoral arthrosis has been reported to be between 7 and 16% with follow-up between 6 and 14 years [12, 25, 26, 32]. Anterior knee pain can be seen in patients with PCL laxity, but the pain may be caused from the posterior translation of the tibia on the femur and anterior impingement of the meniscus with knee extension versus arthrosis of the patellofemoral joint as has been proposed.

Nonoperative Rehabilitation

Isolated PCL Injury

The patient's symptoms and physical examination may vary greatly depending on the severity of the PCL injury. With mild injuries, the patient may have only minimal swelling and ill-defined symptoms. Other patients may have had an injury that stopped them from the activity or sport in which they were participating. Regardless of the degree of injury or symptoms, the goals of rehabilitation are the same: Minimize effusion, restore knee extension and flexion, and then restore any loss of strength or function to return the patient to his or her activities.

Cold/compression with elevation is used to reduce the effusion. Exercises to restore normal knee extension, such as towel stretch and heel prop exercises, are performed. Full flexion can be obtained with the use of heel slide exercises. Strengthening exercises include single-leg extension, leg press, and squats. The use of a stationary bicycle or stair-climbing machine can be used to increase endurance. The

patient then progresses through functional activities before returning to sports.

PCL with Multiple Ligament Knee Injuries

Different treatment approaches are recommended depending on the degree and the combination of each injured structure. The initial treatment approach is based on recognizing that the PCL and MCL can heal without surgery, and the ACL and lateral structures generally do not. Thus, most ligament injuries do not require acute surgery and, in most cases, immediate surgery is not desirable because of the increased incidence of arthrofibrosis and long-term loss of knee ROM.

An understanding of the healing response of individual structures provides an explanation for potential postoperative stiffness associated with acute surgery. The long-term goal of treatment is for the patient to obtain a functionally stable knee with full ROM. In observing a young, athletically active population, I have found that patients who have a stable but stiff knee have disability and would much rather prefer a knee that has full ROM that would allow a functional activity level. Once an accurate diagnosis has been made and associated injuries have been evaluated, the treatment plan for the knee is formalized.

Combined ACL, PCL, MCL Injury, or PCL/MCL Injury

Our goal with an ACL, PCL, and MCL injury is to allow the PCL and MCL to heal and then address ACL instability as needed for the individual patient. The patient's leg is initially placed in a cylinder cast with 20° of flexion and encouraged to weight-bear. The goal is to prevent valgus stress, allow healing of the MCL and PCL. We recommend using a cast instead of a splint or brace because a cast provides more rigid weightbearing support, allows for more comfortable weightbearing, and mandates compliance. In addition, because residual medial laxity in combination with cruciate ligament injuries can be problematic, a cast is preferred to assure healing of the MCL with minimal laxity. The cast is changed weekly so that ligament healing can be evaluated and because a decrease in swelling typically makes the cast loose. Gentle valgus stress testing is performed to check for an endpoint. Once stability is achieved in the MCL with a stable endpoint and the patient is pain free and can comfortably bear weight, the cast is discontinued. Typically, a firm endpoint can be felt upon physical examination at about 2 weeks after injury for a proximal MCL injury and at 4–5 weeks after injury with a distal MCL injury.

Once MCL healing is confirmed clinically, knee rehabilitation for ROM and strength can begin. Once full ROM has

been established, knee stability can be reevaluated. Casting usually allows the PCL to heal with a good endpoint on posterior drawer examination. This treatment approach usually results in no medial laxity, acceptable posterior laxity, and ACL deficiency. Depending on the patient's activity level and athletic goals, an ACL reconstruction may be warranted. In some patients, this approach also allows for healing of the ACL, which may provide enough stability to allow patients to do well functionally without having the ACL reconstructed.

Combined ACL, PCL, and Lateral-Side Knee Injury

A lateral-side knee dislocation requires semi-urgent attention. Our philosophy is to balance obtaining ROM and decreased swelling with the ability to repair the lateral structures. While medial structures tear interstitially and can heal, lateral-side structures almost always tear distally to the knee joint and retract proximally above the joint. Consequently, injured lateral-side structures will not heal properly without surgical repair. I recommend semi-acute surgery for lateral-side repair, allow the PCL to heal, and perform ACL reconstruction according to the patient's need.

The initial goals and program for rehabilitation are again to decrease swelling and restore normal ROM without causing further injury to the lateral compartment. Because of lateral instability, the patient most likely will need to have a splint and use crutches for ambulation for protection.

The patient is typically prescribed an antiembolism stocking, a cold/compression device, and a continuous passive motion (CPM) machine. The patient also attends several preoperative physical therapy sessions with the goal of decreasing swelling, improving leg control, and achieving satisfactory ROM. Our goal is to have knee extension equal to that of the opposite knee and about 130° of knee flexion before surgery.

Repair of the lateral complex in less than 2 weeks from injury usually is reliable in reestablishing lateral stability; results of surgical repair more than 3 weeks from injury are less predictable. If the initial injury is unrecognized, patients can have significant disability. An ACL reconstruction may be needed but I still recommend that the PCL be left to heal.

Treatment Outcomes: Nonoperative Versus PCL Reconstruction

It could probably be said that there is a consensus for treating isolated PCL injuries that are grade 2 or less in laxity, with grade 2 laxity being defined as the femoral condyles being flush with the tibia on posterior drawer exam. Most would agree that patients with grade 2 or less PCL laxity should be

treated nonoperatively with rehabilitation for the acute injury so the patient can return to his or her daily and sporting activities [31]. It is when PCL laxity is greater than grade 2 or when the PCL is torn in combination with other ligamentous injuries that surgery is commonly recommended, although I believe PCL reconstruction is recommended unnecessarily in many cases.

Given that the PCL can heal, even when other ligaments are damaged, my recommendation would be to allow the PCL to heal and treat other ligamentous injuries as is needed for the individual patient. With an acute knee dislocation, the PCL injury can appear as "complete" on the MRI, and physicians may rely on the diagnosis from the MRI because physical examination of PCL laxity can be difficult to detect with acute knee dislocations. PCL reconstruction is more commonly performed in combination with ACL reconstruction in patients who suffer with knee dislocations. I believe, however, that the PCL can be left to heal, and ACL laxity and other medial or lateral ligamentous laxity can be addressed nonoperatively or surgically as indicated for the patient.

The only knee ligamentous injury that requires semi-acute surgery is a lateral-side knee dislocation, which occurs only rarely. Most knee dislocations are medial-side injuries, and these injuries are known to cause extreme stiffness, especially when surgery is performed acutely after the injury. There are many advantages in waiting for the knee swelling to resolve, restoring normal ROM, and waiting to reevaluate ligamentous laxity and function before determining whether any surgery is needed for the patient.

One of the main complications with PCL reconstruction for knee dislocations is knee ROM problems after surgery, with the rate of ROM deficits being reported to be from 7 to 30% [33–39]. Knee ROM loss has been found to be related to the presence of OA after ACL reconstruction [40, 41] and we would expect that ROM deficits after PCL reconstruction would also be related to development of OA.

The purpose of PCL reconstruction would be to restore normal laxity, with the hope of preventing the development of osteoarthritic changes in the joint. It is unclear, however, whether PCL reconstruction can restore normal PCL stability. In studies that reported both initial laxity and laxity after PCL reconstruction, the rate of achieving grade 0 or normal PCL stability ranged from 0 to 90%, with most reporting less than 50% success [33–38, 42–44]. Several investigators concluded that PCL reconstruction can improve PCL stability but may not be able to normalize it [43–47].

Long-term follow-up of more than 10 years after nonoperative management or PCL reconstruction that also include radiographic evaluation for OA is limited to only a few studies. The long-term outcome of nonoperative treatment shows an incidence of OA to range from 17 to 53% as compared with a range of 36–59% with PCL reconstruction. At a mean of 7 years after PCL injury, Patel et al. [26] found that 10

of 58 knees (17%) had evidence of OA. Parolie et al. [12] found arthritis in 36% of their patients at a mean of 8.4 years after PCL injury. Boynton and Tietjens [32] reported articular degeneration in the medial tibiofemoral compartment in 53% of their patients at a mean time of 13.2 years after PCL injury. Finally, at a mean of 14 years after injury, Shelbourne et al. [28] found evidence of some OA in 41% of patients overall, but moderate to severe OA was found in only 11% of patients.

These results of nonoperative treatment compare favorably with long-term outcome of PCL reconstruction for isolated PCL injuries. With a mean of 9 years after PCL reconstruction, Hermans et al. [45] found medial joint line narrowing in 59% of their patients and the IKDC ratings of radiographs were normal for 9 of 22 patients (41%), nearly normal for 10 (45%), and abnormal for 3 (9%). Jackson et al. [34] found evidence of OA in 8 of 22 patients at 10 years after PCL reconstruction; 4 patients had osteophytes but normal joint space width, and 4 (18%) had moderate degenerative changes. If PCL reconstruction is being done to prevent OA in the future, it appears that, thus far, this goal has not been met.

Long-term subjective evaluations of patients after nonoperative treatment and PCL reconstruction are strikingly similar. At a mean of 17 years after nonoperative treatment, Shelbourne et al. [28] found that patients had a mean IKDC score of 73 points, which compares to IKDC scores of 75 and 87 found by studies of operative treatment that had much less follow-up times of 9–10 years [45].

Given that objective and subjective results found in the long-term after nonoperative treatment of isolated PCL injuries is so similar to treatment with PCL reconstruction, I question recommendations for surgical approach to these injuries, especially when considering the expense and potential morbidity PCL reconstruction can cause.

Summary

The trend for treatment of PCL injuries is toward performing more PCL reconstructions. However, the natural history of PCL shows that the injured PCLs can heal without treatment, even in the presence of other ligamentous injuries. Ten-year follow-up shows that PCL laxity does not change with time from injury and patients with lesser PCL laxity do not have better subjective survey scores or less radiographic evidence of OA than patients with greater PCL laxity. Radiographic evaluation showed the prevalence rate of OA being abnormal or severely abnormal was 11% at a mean of 14 years after injury. The mean IKDC subjective survey score was 73 points at a mean of 17 years after injury. Both objective and subjective results of nonoperative treatment of PCL injuries compare favorably with long-term outcome of PCL reconstruction.

References

1. Dandy DJ, Pusey RJ. Long term results of unrepaired tears of the posterior cruciate ligament. *J Bone Joint Surg Br.* 1982;64:92–4.
2. Dejour H, Walch G, Peyrot J, et al. The natural history of rupture of the posterior cruciate ligament. *French J Ortho Surg.* 1988;2:112–20.
3. Keller PM, Shelbourne KD, McCarroll JD, et al. Nonoperatively treated isolated posterior cruciate ligament injuries. *Am J Sports Med.* 1993;21:132–6.
4. Torg JS, Barton TM, Pavlov H, et al. Natural history of posterior cruciate ligament—deficient knee. *Clin Orthop Relat Res.* 1989;246:208–16.
5. Kennedy JC, Hawkins RJ, Willis RB, et al. Tension studies of human knee ligaments. Yield point, ultimate failure and disruption of the cruciate and tibial collateral ligaments. *J Bone Joint Surg Am.* 1976;58:350–5.
6. Trickey EL. Rupture of the posterior cruciate ligament of the knee. *J Bone Joint Surg Br.* 1968;50:334–41.
7. Fowler PJ, Messieh SS. Isolated posterior cruciate ligament injuries in athletes. *Am J Sports Med.* 1987;15:553–7.
8. Harner CD, Xerogeanes JW, Livesay GA, et al. The human posterior cruciate ligament complex: an interdisciplinary study. Ligament morphology and biomechanical evaluation. *Am J Sports Med.* 1995;23:736–45.
9. Shelbourne KD, Rubinstein RA Jr. Isolated posterior cruciate ligament rupture: an unusual mechanism of injury. A report of 3 cases. *Am J Knee Surg.* 1993;6:84–6.
10. Shelbourne KD, Mesko JW, McCarroll JR, Rettig AC. Combined medial collateral ligament—posterior cruciate rupture. Mechanism of injury. *Am J Knee Surg.* 1990;3:41–4.
11. DeLee JC, Riley MB, Rockwood CA. Acute straight lateral instability of the knee. *Am J Sports Med.* 1983;11:404–11.
12. Parolie JM, Bergfield JA. Long term results of non operative treatment of isolated posterior cruciate ligament injury in the athlete. *Am J Sports Med.* 1986;14:35–8.
13. Rubinstein RA Jr, Shelbourne KD, McCarroll JR, VanMeter CD, Rettig AC. The accuracy of clinical examination in the setting of posterior cruciate ligament injury. *Am J Sports Med.* 1994;22:550–7.
14. Shelbourne KD, Benedict F, McCarroll JR, et al. Dynamic posterior shift test. An adjuvant in evaluation of posterior tibial subluxation. *Am J Sports Med.* 1989;17:275–7.
15. Daniel DM, Stone ML, Barnett P, Sachs R. Use of the quadriceps active test to diagnose posterior cruciate ligament disruption and measure posterior laxity of the knee. *J Bone Joint Surg Am.* 1988;70:386–91.
16. Rosenberg TD, Paulos LE, Parker RD, et al. The forty-five-degree posteroanterior flexion weight-bearing radiograph of the knee. *J Bone Joint Surg Am.* 1988;70:1479–83.
17. Merchant AC, Mercer RL, Jacobsen RH, et al. Roentgenographic analysis of patellofemoral congruence. *J Bone Joint Surg Am.* 1974;56:1391–6.
18. Strand T, Molster AO, Engesaeter LB, et al. Primary repairs in posterior cruciate ligament injuries. *Acta Ortho Scand.* 1984;55:545–7.
19. Paddu G, Gianni E, Chambat PD, De Paulis F. The axial view in evaluating tibial translation in cases of insufficiency of the posterior cruciate ligament. *Arthroscopy.* 2000;2:217–20.
20. Fischer SP, Fox JM, Del Pizzo W, et al. Accuracy of diagnoses from magnetic resonance imaging of the knee. A multicenter analysis of 1014 patients. *J Bone Joint Surg Am.* 1991;73:2–10.
21. Polly DW Jr, Callaghan JJ, Sikes RA, et al. The accuracy of selective magnetic resonance imaging compared with the findings of arthroscopy of the knee. *J Bone Joint Surg Am.* 1988;70A:192–8.

22. Shelbourne KD, Jennings RW, Vahey TN. Magnetic resonance imaging of posterior cruciate ligament injuries: assessment of healing. *Am J Knee Surg.* 1999;12:209–3.
23. Tewes DP, Fritts HM, Fields RD, et al. Chronically injured posterior cruciate ligament. Magnetic resonance imaging. *Clin Orth Relat Res.* 1997;335:224–32.
24. Ahn JH, Lee SH, Choi SH, Wang JH, Jang SW. Evaluation of clinical and magnetic resonance imaging results after treatment with casting and bracing for the acutely injured posterior cruciate ligament. *Arthroscopy.* 2011;27:1679–87.
25. Shelbourne KD, Davis TJ, Patel DV. The natural history of acute isolated non-operatively treated posterior cruciate ligament injuries. A prospective study. *Am J Sports Med.* 1999;27:276–83.
26. Patel DV, Allen AA, Warren RF, Wickiewicz TG, Simonian PT. The nonoperative treatment of acute, isolated (partial or complete) posterior cruciate ligament-deficient knees: an intermediate-term follow-up study. *HSS J.* 2007;3:137–46.
27. Shelbourne KD, Muthukaruppan Y. Subjective results of nonoperatively treated, acute, isolated posterior cruciate ligament injuries. *Arthroscopy.* 2005;21:457–61.
28. Shelbourne KD, Clark M, Gray T. Minimum 10-year follow-up of patients after an acute, isolated posterior cruciate ligament injury treated nonoperatively. *Am J Sports Med.* 2013;41:1526–33.
29. Geissler WB, Whipple TL. Intra-articular abnormalities in association with posterior cruciate ligament injuries. *Am J Sports Med.* 1993;21:846–9.
30. Hamada M, Shino K, Mitsuoka T, et al. Chondral injury associated with acute isolated posterior cruciate ligament injury. *Arthroscopy.* 2000;16:59–63.
31. Wind WM, Bergfeld JA, Parker RD. Evaluation and treatment of posterior cruciate ligament injuries. Revisited. *Am J Sports Med.* 2004;32:1765–75.
32. Boynton MD, Tietjens BR. Long term follow-up of the untreated isolated posterior cruciate ligament deficient knee. *Am J Sports Med.* 1996;24:306–10.
33. Chan YS, Yang SC, Chung CH, Chen AC, Yuan LJ, Hsu KY, Wang CJ. Arthroscopic reconstruction of the posterior cruciate ligament with use of a quadruple hamstring tendon graft with 3- to 5-year follow-up. *Arthroscopy.* 2006;22:762–70.
34. Jackson WFM, van der Tempel WM, Salmon LJ, Williams HA, Pinczewski LA. Endoscopically-assisted single-bundle posterior cruciate ligament reconstruction: results at minimum ten-year follow-up. *J Bone Joint Surg Br.* 2008;90:1328–33.
35. Jenner JT, van der Hart CP, Willems WJ. Mid-term results of arthroscopic reconstruction in chronic posterior cruciate ligament instability. *Knee Surg Sports Traumatol Arthrosc.* 2006;14:848–53.
36. Shon OJ, Lee DC, Park CH, Kim WH, Jung KA. A comparison of arthroscopically assisted single and double bundle tibial inlay reconstruction for isolated posterior cruciate ligament injury. *Clin Orthop Surg.* 2010;2:76–84.
37. Wu CH, Chen ACY, Yuan LJ, Chang CH, Chan YS, Hsu KY, Wang CJ, Chen WJ. Arthroscopic reconstruction of the posterior cruciate ligament by using a quadriceps tendon autograft: a minimum 5-year follow-up. *Arthroscopy.* 2007;23:420–7.
38. Zhao J, Huangfu X. Arthroscopic single-bundle posterior cruciate ligament reconstruction: retrospective review of 4- versus 7-strand hamstring tendon graft. *Knee.* 2007;14:301–5.
39. Zhao J, Xiaoqiao H, He Y, Yang X, Liu C, Lu Z. Sandwich-style posterior cruciate ligament reconstruction. *Arthroscopy.* 2008;24:650–9.
40. Shelbourne KD, Gray T. Minimum 10-year results after anterior cruciate ligament reconstruction: how the loss of normal knee motion compounds other factors related to the development of osteoarthritis after surgery. *Am J Sports Med.* 2009;37:471–80.
41. Shelbourne, KD, Urch SE, Gray T, Freeman H. Loss of normal knee motion after anterior cruciate ligament reconstruction is associated with radiographic arthritic changes after surgery. *Am J Sports Med.* 2012;40:108–13.
42. Chen B, Gao S. Double-Bundle posterior cruciate ligament reconstruction using a non-hardware suspension fixation technique and 8 strands of autogenous hamstring tendons. *Arthroscopy.* 2009;25:777–82.
43. Garofalo R, Jolles BM, Moretti B, Siegrist O. Double-bundle transtibial posterior cruciate ligament reconstruction with a tendon-patellar bone-semitendinosus tendon autograft: clinical results with a minimum of 2 years' follow-up. *Arthroscopy.* 2006;12:1331–8.
44. Wajsfisz A, Christel P, Djian P. Does reconstruction of isolated chronic posterior cruciate ligament injuries restore normal knee function? *Orthop Traumatol Surg Res.* 2010;96:388–93.
45. Hermans S, Corten K, Bellemans J. Long-term results of isolated anterolateral bundle reconstructions of the posterior cruciate ligament: A 6- to 12- year follow-up study. *Am J Sports Med.* 2009;37:1499–507.
46. Lien, OA, Aas EJ, Johansen S, Ludvigsen TC, Figved W, Engbretsen L. Clinical outcome after reconstruction for isolated posterior cruciate ligament injury. *Knee.* 2010;18:1568–72.
47. MacGillivray JD, Stein BE, Park M, Allen AA, Wickiewicz TL, Warren RF. Comparison of tibial inlay versus transtibial techniques for isolated posterior cruciate ligament reconstruction: minimum 2-year follow-up. *Arthroscopy.* 2006;22:320–8.