Posterior Cruciate Ligament Injuries of the Knee Joint

Andreas T. Janousek, Deryk G. Jones, Mark Clatworthy, Laurence D. Higgins and Freddie H. Fu

Center for Sports Medicine and Rehabilitation, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA

Contents

Abstract ................................................................................................................................................. 429
1. Anatomy and Biomechanics ................................................................................................................. 430
2. Natural History ..................................................................................................................................... 430
3. Incidence ............................................................................................................................................. 430
4. Classification ....................................................................................................................................... 432
5. Mechanism of Injury ........................................................................................................................... 432
  5.1 Hyperflexion .................................................................................................................................... 433
  5.2 Pretibial Trauma ............................................................................................................................ 433
  5.3 Hyperextension ................................................................................................................................ 433
6. Clinical Evaluation ............................................................................................................................... 434
  6.1 History ............................................................................................................................................ 434
  6.2 Physical Findings ........................................................................................................................... 434
  6.3 Ancillary Tests .................................................................................................................................. 435
7. Decision Making ................................................................................................................................... 436
8. Nonoperative Treatment ....................................................................................................................... 436
9. Operative Treatment ............................................................................................................................ 437
10. Postoperative Rehabilitation ................................................................................................................ 439
11. Conclusion ......................................................................................................................................... 439

Abstract

Posterior cruciate ligament (PCL) injuries have a reported incidence of between 3 and 37%, depending on the clinical setting. The most common mechanism of injury in motor vehicle accidents is a dashboard injury or direct force to the proximal anterior tibia. Sports related injuries result from hyperflexion of the knee with the foot typically plantarflexed. The latter mechanism is the most common cause of isolated PCL injuries, while in the trauma population as many as 95% of patients with knee injuries have combined ligamentous damage. Improved knowledge at an anatomical, biomechanical and clinical level has provided the orthopaedist with a more defined treatment algorithm. Isolated, partial PCL injuries (grades I and II) can best be treated nonoperatively while complete injuries (grade III) may require operative treatment based on clinical symptoms. All combined ligamentous injuries usually respond best with surgical management.
Over the past 2 decades the treatment of knee ligament injuries has focused on injuries to the anterior cruciate ligament (ACL). The reason for this disparity is probably multifactorial. Certainly techniques for treating ACL injuries are more refined than our current methods for treating posterior cruciate ligament (PCL) injuries. There is a considerable level of disagreement amongst experts concerning all aspects of PCL treatment. As a result, the most appropriate method of managing these patients remains controversial.

1. Anatomy and Biomechanics

Anatomical studies have demonstrated that the PCL averages between 32 and 38mm in length from origin to insertion, and the cross-sectional area narrows distally. Each component is named by its femoral insertion first, followed by the tibial insertion. The PCL femoral insertion is half-moon shaped and the PCL tibial insertion is nonplanar and rectangular in shape. The anterolateral bundle has twice the cross-sectional area and 150% of the structural properties of the posteromedial bundle. The former bundle becomes taut in flexion, while the latter bundle is taut in extension but loosens in flexion. Recent biomechanical testing revealed that the meniscofemoral ligaments possessed an elastic modulus twice as large as the posteromedial bundle. The exact implication of this finding is unclear, but signifies that these ligaments may play a more important secondary role than has been previously recognised.

The PCL is the primary restraint to posterior tibial translation and the secondary restraint to external rotation. These functional roles are most pronounced at 90° flexion as sectioning studies have demonstrated minimal posterior translation with an isolated PCL lesion with the knee in full extension. Additional studies have demonstrated significant interactions between the posterolateral corner and the PCL. Kinematic differences increased significantly with combined PCL/posterolateral corner (PLC) lesions compared with isolated lesions. Standard knee scoring systems, Posterior translation at 90° flexion increased from ± 0 (isolated PLC) or 2+ (isolated PCL) to 3+ with a combined lesion. Similarly, external rotation and varus increased from I+ with either isolated lesion to 2+ with combined injuries. These findings verify the significance of recognising the associated involvement of the posterolateral structures in PCL injuries.

Another significant sectioning study revealed that the absence of the PCL and the posterolateral complex produced noticeable increases in the articular contact pressures in the patellofemoral and medial compartments with increasing flexion angles. These findings are consistent with the late degenerative changes in these 2 compartments observed with late follow-up in this patient population.

Cadaveric studies assessing the influence of quadriceps, hamstring and gastrocnemius muscle forces on cruciate ligament load demonstrated increased in situ PCL forces at flexion angles greater than 30°. These studies clearly direct the orthopaedist to maintain the knee in full extension and avoid excessive hamstring and gastrocnemius contraction following anatomical reconstructions.

2. Natural History

The natural history of an isolated posterior cruciate deficient knee has yet to be clearly defined. Insight can be gained from the literature. However, most papers are retrospective and combine isolated PCL injuries with combined ligamentous injuries and do not stratify their findings by the degree of instability.

The largest series is from Shelbourne et al. He evaluated 133 patients prospectively with isolated, acute PCL deficient knees. The majority of patients had sporting injuries with grade I to II laxity, No patient had grade III laxity. The mean follow-up was 5.4 years (2.3 to 11.4 years). He reported that patients with grade II knees had the same results as those with less laxity, and there was a low incidence
of osteoarthritis that did not increase with greater laxity. The results of nonoperative treatment were the same as current operative treatment.

Other series have reported good function. Parolise and Bergfeld\textsuperscript{[19]} reviewed 25 patients treated non-operatively with an isolated PCL injury, with a mean follow-up of 6.2 years (range 2.2 to 16 years), 80% of the patients were satisfied with their knees and 84% had returned to their previous sport (68% at the same level of performance). The amount of knee instability as determined by the KT-1000 was not related to the patient's return to sport nor to knee satisfaction. They concluded that the majority of athletes with isolated PCL injuries who maintain strength in musculature return to sports without functional disability. Fowler and Messieh\textsuperscript{[20]} demonstrated good function in the short term with an isolated grade II midsubstance rupture.

Series which had longer follow-ups reported deterioration of function with time. The paper with the longest follow-up was that of Dejour et al.\textsuperscript{[21]} Of 36 patients treated conservatively, 21 showed isolated posterior laxity, 8 posterolateral laxity and 7 posteromedial laxity. The follow-up was between 5 and 44 years, with a mean of 15 years. With an isolated rupture the patients showed remarkable functional tolerance, enabling them to return to sport, even at the highest level, after a mean period of adaptation of 12 months. However, these investigators found that 89% had pain and that pain worsened with time, as did instability. The disturbance of knee kinematics lead to osteoarthritis after an average of 25 years. Significant degenerative changes were seen in 17% while lesser changes were seen in 69%. This was either medial tibiofemoral or generalised depending on the morphological features of the patient, 62% had changes in the patellofemoral joint. In a report on 38 patients with an isolated PCL injury with a mean follow-up of 13.4 years (5 to 38 years), Boynton and Tietjens\textsuperscript{[22]} showed that as time from injury increased, progressive articular degeneration was seen on radiographs. However, their study suggested that the prognosis for this injury varied and they were unable to identify any factors which determined outcome, Keller et al.\textsuperscript{[23]} during a mean of 6 years after injury. They found that 90% of patients had pain with activity, 65% were limited in their activity level and 43% had problems with walking. Function decreased and radiographic changes increased with time. Joint deterioration was seen in 88% of patients more than 4 years after injury.

Geissler and Whipple\textsuperscript{[24]} have arthroscopically compared the incidence of meniscal tears and chondral pathology in the acute and chronic PCL deficient knee. Chondral defects were present in 12% of patients with acute injuries, These occurred
both on the lateral femoral condyle and patella, Meniscal tears were present in 27% of patients (6 lateral and 3 medial), and in the chronic knee chondral defects were found in 49% of patients. Medial femoral condyle lesions were the most common, Meniscal tears were present in 36% of patients (7 lateral and 17 medial). From these results, the investigators ascertained that the mechanism of injury resulting in an isolated injury of the PCL is most likely to affect the lateral compartment and the articular cartilage of the patella. The incidence of articular defects and the incidence of meniscal tears increased in patients with chronic PCL injuries, predominantly in the medial compartment. Clancy et al. \cite{23} also showed significant deterioration of the articular cartilage with time from injury. The incidence of grade III and IV changes after isolated PCL injuries were 14% up to 2 years, 75% up to 4 years and 82% between 4 and 20 years.

In summary, it appears that the patient with an isolated grade II or less PCL injury does well functionally in the short term. Some patients go on to develop degenerative changes in the medial and patellofemoral compartment with time, Increased pain, instability and deterioration in function ensue.

3. Incidence

There is considerable variability in the reported incidence of PCL injuries in the literature. This disparity clearly results from differences in the population of individuals examined. Miyasaka and Daniel \cite{26} reported an incidence of 3% in the general population, while Fanelli and Edson \cite{27} reported an incidence of 38% in patients with an acute knee haemarthrosis in an emergency room setting.

Both the mechanism of injury and the degree of knee involvement also appear to be dependent on the population examined. Two separate studies demonstrated an association between athletic injuries and 'isolated' PCL injuries, \cite{27,28} The most frequent mechanism of injury in this population was a hyperflexion injury. By contrast, in an emergency room setting where 56.5% of injuries were traumatic-related and 32.9% were athletic-related, Fanelli and Edson \cite{27} reported that 96.5% of the PCL injuries occurred in combination with other ligamentous damage. Although it was difficult to delineate the exact mechanism of injury in all cases, the majority of PCL tears occurred in motor vehicle and motorcycle accidents, They concluded that trauma patients have a higher incidence of PCL injuries than athletes.

4. Classification

A great deal of the confusion in the literature concerning the appropriate treatment of PCL injuries stems from the inaccurate classification of patients in follow-up studies, PCL injuries are classified according to:
• the structures damaged: isolated vs combined (table I)
• the degree of instability (table I)
• the mechanism of injury (see section 5).

5. Mechanism of Injury

Three mechanisms have been proposed for rupture of the PCL (fig. 4).
5.1 Hyperflexion

The most common injury in sport is a hyperflexion injury, in which the patient falls onto a flexed knee. The traumatic forces are directed proximally up the tibia, and the tibia subluxes posteriorly, of the PCL tightens. With sudden hyperflexion, the tension of the PCL increases beyond its elastic limits and plastic deformation or rupture occurs. The PCL impinges between the posterior tibial plateau and roof of the femoral notch, and the PCL is guillotined. There is nearly always an isolated intrasynovial intrasubstance tear and often the posteromedial bundle remains intact. There is rarely greater than grade II laxity. These lesions heal to some extent and with time the laxity may decrease one grade.

5.2 Pretibial Trauma

The most common traumatic mechanism is the dashboard injury. The knee is in a flexed position and a posteriorly directed force is applied to the pretibial area. An intrasubstance tear at the level of the tibial plateau or a tibial avulsion occurs. Significant trauma will result in damage to the meniscofemoral ligaments. If the force is anteromedial and a rotational component is present the posterolateral corner can be torn. Pretibial trauma with the knee near extension initially tightens the posteromedial bundle. Thus, the PCL may sleeve off its origin. These patients often have greater instability than the hyperflexion group.

5.3 Hyperextension

Hyperextension can result in tearing of the PCL and posterior capsule, and can progress to dislocation and neurovascular compromise. The PCL injury is frequently a proximal disruption at the femoral attachment.

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Laxity (mm)</th>
<th>Tibial plateau</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>PCL stretched</td>
<td>&lt; 5</td>
<td>5 to 10 mm anterior to femoral condyle</td>
</tr>
<tr>
<td>II</td>
<td>PCL torn, MF ligaments intact</td>
<td>5 to 9</td>
<td>0 to 5 mm anterior to femoral condyle</td>
</tr>
<tr>
<td>III</td>
<td>PCL torn, MF ligaments torn</td>
<td>&gt; 10</td>
<td>Flush with femoral condyle</td>
</tr>
<tr>
<td>IVA</td>
<td>PCL and LCL, posterolateral injury</td>
<td>&gt; 12</td>
<td>&gt; 2 mm posterior to femoral condyle</td>
</tr>
<tr>
<td>IVB</td>
<td>PCL and MCL, posteromedial injury</td>
<td>&gt; 12</td>
<td>&gt; 2 mm posterior to femoral condyle</td>
</tr>
<tr>
<td>IVC</td>
<td>PCL and ACL</td>
<td>&gt; 15</td>
<td>&gt; 5 mm posterior to femoral condyle</td>
</tr>
</tbody>
</table>

a Grades I to III are isolated injuries, grade IV is a combined injury.

ACL = anterior cruciate ligament; LCL = lateral collateral ligament; MCL = medial collateral ligament; MF = meniscofemoral.
6. Clinical Evaluation

6.1 History

A thorough history is imperative. It is important to differentiate the mechanism of injury, as the degree of laxity and treatment is often dependent on this information. The chief complaint and level of activity should be determined. In the acutely injured, isolated PCL the patient will complain of mild swelling, pain and inability to bear weight. The most common complaint in patients with chronic injury is pain. This is most prevalent with long distance walking and descending stairs. The pain is felt predominantly in the retropatellar area and medial compartment. Other subjective complaints include difficulty ambulating with the knee extended in mid stance, and apprehension while descending stairs because of a sense of unsteadiness or sliding of the joint. Athletes may report a decreased ability to rapidly change direction. However, the significant giving way or buckling that is commonplace with an ACL deficient knee is rarely seen with an isolated PCL rupture. Thus, instability is commonplace in the combined injury.

6.2 Physical Findings

A routine physical examination for a posterior cruciate deficient knee must include inspection over the anterior tibia for abrasions, ecchymosis or lacerations, gait assessment, range of motion and a neurovascular examination. The most accurate test for determining a posterior cruciate rupture is the posterior drawer test at 90° (fig. 5). In the acute knee it is often uncomfortable for the patient to achieve this degree of flexion, Staubli and Jakob described significant posterior translation at 10 to 15° of flexion. It is important to assess the position of the tibial plateau in relation to the anterior aspect of the femoral condyle prior to performing a posterior drawer test so a false positive or false negative result is not obtained. The degree of laxity is obtained by comparing the posterior translation to the contralateral normal knee. The posterior tibial sag and Lachman examinations can be helpful on occasion (fig. 5). Other clinically useful indicators of PCL insufficiency are the reverse pivot shift test (fig. 5) and the quadriceps active test (fig. 6).

It is extremely important to examine the other ligamentous structures of the knee. The ACL is assessed in the standard fashion with the Lachman, pivot shift and anterior drawer tests. In the combined cruciate injury it is important to delineate the position of the tibia in relation to the femur when determining anterior and posterior translation. The normal anteromedial step off of 10mm must be predetermined prior to testing translation.

Specific tests must be performed to evaluate the posterolateral corner. The lateral collateral ligament must be tested in 0 and 30°. Instability in full extension is indicative of a posterolateral capsule injury. Posterior translation must be documented at 30 and 90°. Slightly increased posterior translation at 30° but not 90° indicates a posterolateral injury, Increased translation at both positions indicates a combined injury. The tibial external rotation test...
critical for the physician to examine the foot pulses and perform a thorough neurological examination, especially of the peroneal nerve. If a diminished pulse is detected an immediate arteriogram should be obtained.

6.3 Ancillary Tests

Following any acute knee injury we routinely take radiographs to rule out an avulsion fracture of the PCL at its tibial insertion and fibular head fractures, which are indicative of a PLC injury. Our chronic PCL radiographic series consists of a 45° posteroanterior flexion weightbearing, lateral and Merchant’s view to determine whether degenerative changes are present, particularly in the medial and patellofemoral compartments. For chronic injuries we often perform a technetium bone scan to evaluate early degenerative changes. In patients with pain and increased radionucleotide uptake we perform a reconstruction with the hope of stabilising the knee and abating progressive degenerative changes. We are currently evaluating this treatment rationale, Magnetic resonance imaging (MRI) has been shown to be highly accurate in the diagnosis of a complete PCL tear. We have also found it

(fig. 1) is a good test for diagnosing a PLC injury. This is best performed prone, and the thigh foot angle is measured at 30 and 90° of knee flexion. The difference compared with the contralateral side is determined, with a 10° difference deemed pathological. An isolated PLC injury increases external rotation at all angles of flexion, but this is maximal at 30°. Increased external rotation at 30 and 90° indicates combined instability.

The medial structures are assessed by testing valgus opening in 0 and 30° of knee flexion. The degree of opening at 30° will determine the integrity of the medial collateral ligament. If the knee opens up in terminal extension, the posteromedial capsule has been damaged.

The remainder of the knee must be thoroughly assessed for meniscal, chondral and patellofemoral pathology. When a combined injury occurs it is

6.3 Ancillary Tests

Following any acute knee injury we routinely take radiographs to rule out an avulsion fracture of the PCL at its tibial insertion and fibular head fractures, which are indicative of a PLC injury. Our chronic PCL radiographic series consists of a 45° posteroanterior flexion weightbearing, lateral and Merchant’s view to determine whether degenerative changes are present, particularly in the medial and patellofemoral compartments. For chronic injuries we often perform a technetium bone scan to evaluate early degenerative changes. In patients with pain and increased radionucleotide uptake we perform a reconstruction with the hope of stabilising the knee and abating progressive degenerative changes. We are currently evaluating this treatment rationale, Magnetic resonance imaging (MRI) has been shown to be highly accurate in the diagnosis of a complete PCL tear. We have also found it

(fig. 1) is a good test for diagnosing a PLC injury. This is best performed prone, and the thigh foot angle is measured at 30 and 90° of knee flexion. The difference compared with the contralateral side is determined, with a 10° difference deemed pathological. An isolated PLC injury increases external rotation at all angles of flexion, but this is maximal at 30°. Increased external rotation at 30 and 90° indicates combined instability.

The medial structures are assessed by testing valgus opening in 0 and 30° of knee flexion. The degree of opening at 30° will determine the integrity of the medial collateral ligament. If the knee opens up in terminal extension, the posteromedial capsule has been damaged.

The remainder of the knee must be thoroughly assessed for meniscal, chondral and patellofemoral pathology. When a combined injury occurs it is
Fig. 7. Tibial rotation test: (top) patient in prone position and (bottom) degree of external rotation (for posterior-lateral rotatory instability) and internal rotation (for posterior-medial rotatory instability) from neutral position is compared with the uninvolved side (from Fu et al., [5] with permission).

useful in determining the site of the tear (fig. 8). Furthermore, it is a very useful adjunct to identify associated collateral ligament, meniscal and chondral injuries. However, we agree with Rubinstein et al., [39] who demonstrated that a good history and physical examination is very accurate in diagnosing a PCL injury, and therefore MRI is not required routinely. Similarly, arthrometric testing [45] and stress radiographs, [46] although very precise, are not ordinarily required.

7. Decision Making

The treatment of an injury to the posterior cruciate is dependent on the site of the injury and the degree of laxity. The indications for early operative intervention are a bony avulsion of the tibial insertion and a ‘peel off’ injury from the femoral origin. The bony avulsion is best treated early via a posteromedial approach, although good results have been reported up to 7 weeks after injury, [49] The ‘peel off’ injury is common with a hyperextension injury and pretibial trauma with the leg in relative extension. Patients with this mechanism of injury should be arthroscoped or MRI should be performed to determine the geographical site of the PCL injury. If there is a ‘peel off’ disruption present it can be repaired arthroscopically or through a mini open approach.

Patients with grade I and II intrasubstance tears are best treated nonoperatively. The treatment of isolated grade III injuries is controversial. We believe that these patients are at increased risk of developing progressive knee laxity due to the non-physiological loads on the posterolateral structures and posterior capsule. This is likely to increase the joint contact forces on the articular cartilage above acceptable loads, leading to medial and patellofemoral degenerative changes. This is the most probable explanation for increasing degenerative changes and laxity with deterioration in knee function with time; [21,23-25] early surgery can prevent the development of osteoarthrosis after a PCL tear, Clancy et al. [25] also reported that the acute reconstruction demonstrates better results than those reconstructed chronically, Thus, at our institution an isolated grade III PCL injury in a young active patient is a relative indication for surgery. Patients with combined injuries should undergo early surgery where possible. Our algorithm for acute and chronic injuries is demonstrated in figure 9.

8. Nonoperative Treatment

Nonoperative treatment is very effective in treating the patient with an isolated grade I or II tear, [19,20,23] as the integrity of the secondary restraints and a high incidence of intact posteromedial fibres result in this injury being relatively benign. Treatment in this group consists of protected weight bearing, early range of motion and aggressive physi-
ical therapy emphasising quadriceps rehabilitation and proprioceptive training. Patients are allowed to return to sport once they have regained a full range of motion and 90% of quadriceps and hamstring strength compared with the contralateral limb. It usually takes 4 to 6 weeks to achieve these milestones.

The postinjury course of a patient with a grade III isolated PCL injury is not so predictable, In this injury we recommend immobilisation of the knee in full extension for 2 to 4 weeks, This ensures that the joint is reduced, minimising posterior tibial sag and decreasing the forces on the torn PCL or potentially damaged posterolateral structures. Finally, the posterior translation of the tibia enacted by the hamstrings is decreased.

During this period of immobilisation quadriceps sets, straight leg raising and partial weight bearing with crutches is instituted. Active assisted range of motion and progressive weightbearing is begun after brace removal, Quadriceps muscle strengthening exercises are emphasised, as they have been shown to counteract posterior tibial subluxation. The patient then progresses to functional exercises such as biking, stair climbing, leg presses and knee extension exercises. With grade III injury it is usually at least 3 months until the patient is able to return to sport, Those patients that do not do well may require a delayed stabilisation.

Chronic grade I and II injuries generally do well with physical therapy, We have found that PCL braces are unhelpful in this setting, Infrequently, patients with grade II injuries develop recurrent pain and swelling. When this occurs we order a bone scan to assess the status of the joint, If it is positive, we recommend a reduction of activities until the pain and swelling subside, We do not recommend surgical intervention in these patients as our current operative procedure is unable to consistently improve this degree of instability.

9. Operative Treatment

Once again, symptomatic grade III and combined ligament injuries are the most frequent indications for surgical intervention. As a result, the surgeon should be comfortable with repair of the PCL and any associated ligamentous or capsular damage. These cases should be performed in a
Fig. 9. Treatment algorithm for acute (top) and chronic (bottom) posterior cruciate ligament (PCL) injuries. ACL = anterior cruciate ligament; LCL = lateral collateral ligament; MCL = medial collateral ligament; PLC = posterolateral corner; PMC = posteromedial corner.

Semielective setting with an experienced operative team. In addition, due to the proximity of the posterior neurovascular structures to the operative area, a well-trained vascular surgeon should be immediately available if necessary. As previously alluded to in the basic science section of this article, there are many variables to consider during preoperative planning for this type of surgery. The timing of surgery is critical. At our institution, the operative reconstruction of an acute, multiple ligament injury should be within 10 days to 2 weeks of the event. This avoids capsular scarring, atrophy of collateral ligaments and capsular structures, and the development of a fixed posterior tibial subluxation. These issues do not apply to the isolated PCL injury, as these cases are usually chronic in nature, having failed conservative treatment.

At our institution, we utilise an arthroscopic-assisted technique for reconstruction of the PCL. In addition to the standard anterolateral and anteromedial arthroscopic portals, a posteromedial portal is created for visualisation and posterior instrumentation. Traditionally 2 skin incisions are utilised for this technique. The 2 incisions can be combined into a single medial hockey stick incision if a concomitant medial collateral ligament injury is present. A separate lateral incision is made if there is a concomitant injury to the posterolateral and lateral structures of the knee.
Allograft tissue is preferable to autologous tissue in these cases to minimise any additional trauma to the knee from the surgical procedure. We tend to use achilles tendon rather than bone-patellar tendon-bone as our graft source. The latter tissue more closely recreates the shape and size of the native ligament with the collagen fibres filling the tunnels more adequately. Furthermore, the soft tissue end of the graft eases passage of the graft from proximal to distal through the bone tunnels. Proximal bony fixation is achieved with an interference screw in the femoral tunnel taking advantage of the calcaneal bone plug. Distally, excellent tibial fixation with a bicortical screw and soft-tissue washer can be achieved.

For reasons discussed previously in the basic science section of this article, tunnel placement is performed in an attempt to recreate the important anterolateral component of the PCL. Recently, other institutions have performed double-bundle techniques in an attempt to recreate the physiometric anterior fibres and the isometric posterior fibres. Currently, we have had good success stabilising the knee with a single-bundle technique. The latter technique, although theoretically appealing, is more technically difficult and time-consuming and has not demonstrated a clear clinical advantage to date.

Proximal fixation of the graft is performed first, and attention is then turned to any concomitant ligamentous injuries. In our experience, these associated lesions are variable in terms of their level of involvement of the knee. Each case has unique characteristics and as a result operative treatment of these injuries should be individualised. The goal is restoration of the normal anatomical relationships of the collateral ligaments and the posterolateral structures. If a fibular head fracture has occurred, anatomic reduction of the proximal fragment should restore any associated structures (popliteofibular ligament, lateral collateral ligament, etc.) to their anatomical positions. Following a restoration of the tissues to their normal relationships the PCL graft is fixed distally, thus avoiding excessive stress on the reconstruction during the procedure.

10. Postoperative Rehabilitation

The patient is maintained partially weightbearing with a hinge knee brace locked in extension for 2 to 4 weeks. This position assures that the knee will maintain a reduced position avoiding the effects of gravity and the posterior hamstring forces as previously discussed in the basic science section. As a result, no excessive stress is placed on the PCL reconstruction or the other ligamentous repairs. Isometric quadriceps and ankle pump exercises are allowed on the first postoperative day. Approximately 20% of cases require a manipulation under anaesthesia approximately 2 months following the initial procedure to increase terminal flexion. The average loss of flexion is 10°, which is then fully regained following the manipulation. There has been no loss of extension in these patients in our experience.

At 4 weeks, passive, protected range of motion is performed with a therapist providing an anterior drawer to the proximal tibia. Active-assisted range of motion is not initiated until 8 weeks following surgery, avoiding the posterior forces of the hamstrings. After 8 weeks, increased range of motion is initiated as well as closed chain rehabilitation and dynamic quadriceps strengthening exercises. Return to activity following PCL reconstruction is anticipated 12 months following surgery, and requires sport-specific functional training.

11. Conclusion

Posterior cruciate injuries may be caused by a variety of different mechanisms. The primary settings are trauma and sports. It is imperative to differentiate the isolated from the combined injury. This can usually be carried out by a skilled clinician. If the diagnosis is uncertain MRI, stress radiography or examination under anaesthesia may be beneficial. It is critical to rule out neurovascular injuries in patients with combined injuries.

Most patients with isolated grade I or II injury do well with conservative treatment. The mainstay of rehabilitation is quadriceps strengthening with avoidance of active hamstring exercises. The treat-
ment of the acute grade III isolated PCL injury is controversial. For the more sedentary patient we recommend immobilisation in extension for up to 4 weeks, while in a young active patient reconstruction may be indicated. Symptomatic chronic PCL injury patients often have predominantly medial and patellofemoral compartment degenerative changes. They may benefit from a stabilisation or osteotomy.

Significant advances in our knowledge of the anatomy and biomechanics of the PCL and PLC have increased our understanding of the relationship between these structures. As a result, our surgical treatment of combined injuries attempts to restore this anatomical relationship. Our current technique for the PCL attempts to reconstruct the anterolateral bundle of the PCL. Although the role of a double-bundle technique is under investigation, the greater anatomical relationship, Our current technique between these structures. As a result, our surgical anatomy and biomechanics of the PCL and PLC changes. They may benefit from a stabilisation or osteotomy.

References


Correspondence and reprints: Dr Freddie H. Fu, UPMC Health System, UPMC Presbyterian, University of Pittsburgh, Pittsburgh, PA 15261, USA.
E-mail: ffu@voi.upmc.edu