The Posterior Cruciate Ligament is the largest ligament in the knee. Injury to this is less common than to the Anterior Cruciate Ligament, but it is still relatively common: most high level football teams having one or two players who have had an injury to it. Despite the size of the ligament, injury to it does not usually warrant surgery. Its loss does not generally produce instability and, for most, near normal function can be obtained with a conservative approach to treatment. Despite this however, there is a small group who will go on to develop rapidly progressive osteo-arthritis of the knee which may need more active management in its own right. Reconstruction is rarely necessary for isolated injuries but it is frequently performed when there is a multi-ligament injury to the knee which requires surgery.

The Posterior Cruciate Ligament

The PCL is the largest ligament in the knee. Like the anterior cruciate ligament, it is in the inter-condylar notch area in the middle of the knee. These ligaments cross over each other so that from the side they looked like an ‘x’, hence they are called cruciate (cross shaped) ligaments.

The anterior cruciate ligament not only prevents the tibia from coming forwards on the femur, it also holds the femur and tibia together in rotation. In contradistinction, whilst the poster cruciate ligament prevents the tibia from moving backwards on the femur, it has nothing to do with rotational control of the knee joint. For this reason, injury to the PCL tends not to cause instability.

The function of the PCL

This PCL pushes the tibia forwards on the femur and hence, is responsible for maintaining congruency of the joint. By virtue of its position at the back of the joint, it also acts like a pivot point about which the rest of the knee moves. When the PCL is damaged, the tibia slides backwards on the femur and, in a complete tear, it moves about 12 mm in that direction. When this happens, the joint surfaces that normally match each other, are now not paired up quite as well. This means that the area of contact of the femur on the tibia is reduced, particularly on the medial side (inside aspect) of the knee. When there is a complete tear, it is thought that the pressure on the medial side of the knee doubles. For this reason, osteoarthritis (wearing out) of the medial compartment of the knee, can develop.

The other thing that happens when the PCL is ruptured, is that the patello-femoral joint comes under more stress. As the tibia moves backwards (posteriorly), the quadriceps-patella-patella tendon unit has to go around a bigger angle. This in turn puts the patella under more pressure and can lead to both patello-femoral pain and, in the longer term, wear (osteoarthritis) of that part of the joint.

How is it damaged?

The commonest cause of injury to the PCL is by a direct blow to the front of the tibia. If hit hard had enough, the tibia will be pushed backwards to the extent that the PCL will rupture. This rupture can be partial or complete, or in more substantial cases, can be associated with injuries to other ligaments. Usually it is associated with a fall onto, or a direct blow to, the tibial tubercle or upper tibia, rather than a blow to the patella. If there is a fall onto the knee with the ball of the foot still on the ground, it tends to be the patella that hits the ground first: hence the problem will be one of an injury to the patellofemoral joint. On the other hand, if the fall occurs such that the dorsum (top) of the foot is still on the ground, the fall tends to be directly onto the upper tibia. In this situation therefore, the PCL is at risk.
A less common method of tearing this ligament is during a hyperflexion injury to the knee whereby the knee is flexed up past the buttock. Hyperextension injuries, where the knee is overstraightened, can damage the ligament as well, but usually, in this circumstance, the ACL is damaged at the same time.

Interestingly, despite the size of this ligament, and therefore despite the amount of force required to rupture this ligament, a surprising number of people sustain this injury and feel like they have had just a minor sprain of the knee. It is for this reason, that when the American football league started to examine all its players, it found that every team had one or two players who had sustained an un-diagnosed PCL injury. Whilst we are more sensitive to this injury then we were, and whilst we are better at diagnosing this injury than we were, we still see people who have had this injury and have never sought medical attention for it. We are now also more aware of how common this is in our elite teams, and indeed, almost every ruck man in the AFL will sustain, or will have sustained, this injury.

What Is the Natural History?

Despite the number of these injuries that occur, and despite how long we have been able to diagnose this injury, the natural history of this condition is still not well understood. The largest long term follow up series has less than 200 patients in it, but follow up has been on-going for nearly 20 years now. What is known is that the majority do well but that, by 15 years, most have started to get trouble with their knee. Usually, this is a combination of medial compartment osteoarthritis and patello-femoral osteoarthritis. Early on, this can be treated by some sort of realignment, be that a tibial osteotomy (see our information sheet on arthritis) to unload the medial side of the knee, or by patello-femoral surgery (see our information sheets on patellofemoral pain and patellofemoral mal-alignment) to improve the mechanics of the patella.

There is a small group, albeit that in some series this is as high as 20%, who go on to develop rapid, or moderately rapid onset, medial compartment osteoarthritis. We know that the pressures in the medial compartment of the knee are significantly raised after PCL injury, and this is thought to be a strong contributing factor to premature wear of that part of the knee. Despite this, early on, wear is not the norm: and indeed, most people do not show any signs of wear until 10 to 15 years post injury. It is thought therefore, that other factors may be involved in this more rapid process, of which the most significant is a varus (bow-leg) deformity, which further adds weight to the medial compartment of the knee. In this scenario, tibial osteotomy to correct the varus deformity, thereby unloading the medial side of the knee, is the treatment of choice.

What Is the Treatment?

A PCL rupture is not as painful as an ACL rupture, and there is not as much swelling within the knee. Part of the reason for this is that the PCL is behind the knee, and therefore technically outside the knee; unlike the ACL which is inside the joint. This means that, the bleeding that arises from the tear does not fill the joint up with blood, thereby making it tense and painful. Despite this, the injury is usually bad enough to require some treatment, usually some physiotherapy directed at reducing swelling, improving quadriceps function, and maintaining strength.
Initially following the injury, the knee and the ligament will be swollen, and the swelling acts like a splint preventing the tibia from moving backwards on the femur. Hence, in the first instance, it is easy to miss the diagnosis clinically: and the extent of the injury may not be known until the swelling subsides, perhaps some 2 to 3 months.

As the tibia slides backwards, the patella comes under more stress, and it is frequent that, as the knee itself settles down, patellofemoral pain becomes noticed. This is treated by quadriceps strengthening, including VMO exercises, usually with physiotherapy supervision. In most cases, the knee will then become relatively asymptomatic by the three-month mark.

It is important that, in the rehabilitation phase, quadriceps exercises predominate. Any strengthening of the hamstring tendons will pull the tibia backwards, thereby aggravating the tear. On the other hand, quadriceps exercises pull the tibia forwards, thus opposing the tendency for the tibia to slide backwards.

Most people are back to full sport by three months, and usually, there is no limitation on what they can do. In order to maintain function however, it is important to maintain quadriceps strength. Where these muscles are strong, good function can be achieved even when the tear is complete. When tested, athletes with a complete PCL rupture, who are back at sport, show some loss of acceleration but no loss of running speed or pivoting ability.

**Do I need a splint?**

The PCL is loose when the knee is in full extension (fully straight), and tight after 20° of knee flexion (bend). If the knee is splinted straight for the first few weeks after injury, then there is no tension on this ligament and, because it is outside the joint and not within it, there is a good chance of repair (unlike the ACL). In people who have a complete tear, and whose tibia sags backwards early on (and in those who need a splint for another concomitant ligament injury - such as an MCL tear), a straight splint may be indicated for a period of up to 6 weeks. After that, the knee can be gradually mobilised and, usually by the time that 90° of knee flexion has been obtained, the function of the PCL can be assessed. Whilst this rarely leads to completely normal PCL function, it mostly leads to adequate function not requiring surgery.

**Will I get instability?**

Unlike the ACL, PCL insufficiency does not give rise to rotatory instability: hence, it rarely leads to recurrent giving way of the knee. What it can lead to however, is a feeling of instability or unsteadiness that is most noticed going down slopes or down stairs. This is straight line instability and is quite different to the rotatory instability caused by an ACL rupture. It happens because, in the process of going down a step with the affected leg, the hamstring tendon braces the knee, pulling the tibia posteriorly on the femur. As the weight is then taken on that leg, the quadriceps contract to stop the knee collapsing. In the process, the quadriceps then pulls the tibia forwards on the femur, which then moves the tibia from a posteriorly subluxed position into a more normal position. That movement (the tibia sliding backwards and then forwards again, under the weighted leg), which then reverses as the leg is unloaded to go down the next step, can lead to a feeling of instability in the knee requiring caution. Fortunately, this is not a common problem, despite how loose some knees seem to be.
Management of Patellofemoral Pain

Patello-femoral pain is the single biggest remaining problem after the swelling of the acute injury has settled down. It is due to an overload of the patello-femoral joint, secondary to posterior subluxation of the tibia. In the first instance it is treated by a therapy regime aimed at improving patellofemoral function: and in most cases the knee can be rendered relatively asymptomatic by three months post injury.

Management of Medial Compartment OA

Medial compartment osteoarthritis (wearing out of the medial or inside part of the knee) occurs due to the increased contact pressures that are created on that side of the joint by PCL deficiency. When this is first noticed, it is important to check the overall alignment of the leg with a view to correcting that alignment (tibial osteotomy) if necessary. This procedure significantly unloads that side of the knee, moving weight onto the other side. If this is done, the evidence would suggest that, there is about a 90% likelihood that the medial pain will be lost, and a similar likelihood that the knee will function well for another 10 to 15 years, without coming to replacement.

In some cases, the patellofemoral pain is persistent, in which case it may need surgery: either on the patello-femoral joint itself, or to reconstruct the PCL, thereby making the patello-femoral mechanics more normal. If this can be achieved, it is highly likely that the patello-femoral pain will resolve. A decision to proceed with either form of surgery however, is unlikely to be made within six months of injury, and certainly not until a full quadriceps rehabilitation programme has been tried.

In a few cases, the patellofemoral pain resolves within the first three months, only to recur 6 to 12 months down the line. If therapy doesn’t reverse this fairly quickly, it is likely that PCL reconstruction will be required to try and more normalise the mechanics of the knee, the aim being to decrease the force across the patello-femoral joint. Providing that this joint has not started to wear out, there is a very good chance that this will work.

In the medium term, particularly if PCL function is reasonable, assessment of patella tracking, with a view to patella realignment, may also be an option.

In the long term, if there is substantial wear of the patellofemoral joint, and particularly if there is substantial wear of the medial compartment, then the treatment of choice may be knee replacement. When this is done, it is possible to prosthetically substitute for the PCL, hence leading to more normal mechanics of the knee. Clearly however, this is an option of last resort.
PCL reconstruction is also indicated where there has been failure to adequately control patello-femoral pain, and where there is a significant posterior sag of the tibia which can be corrected. It is important that it is correctable, something that changes with the chronicity of the injury. Similarly, where there has been a multi-ligament injury of the knee, and the PCL has not been reconstructed, it is more likely that, with the passage of time, the tibia will become fixed in its posteriorly subluxed position, thereby making it un-correctable: and therefore un-reconstructable.

Finally, PCL reconstruction is also indicated where there is some instability which, as discussed, is most noted going down slopes and down stairs.

How Is Reconstruction Done?

Like a ACL reconstruction, the PCL is reconstructed using tendon or tendons from elsewhere. There are a variety of different techniques used to reconstruct this ligament, which would suggest that none of these are perfect. This ligament is quite a bit harder to reconstruct then the ACL, it needs more protection in the post-operative period, and it takes longer to fully recover.

The upper end of the normal PCL is quite broad and, in order to try and reduplicate this, a double bundled hamstring reconstruction, passing the two bundles through separate tunnels in the femur, is perhaps the best that we have. Whilst single bundle hamstring reconstructions are more straightforward, they do not provide as anatomic a reconstruction as the double bundle construct and, in particular, they don’t seem to keep the tibia in its normal position throughout the flexion range. Usually, they work quite well at 90° of flexion, but they are not so functional at 20 to 30° of flexion. This means that there is some laxity in that range which sometimes manifests itself as instability going down slopes and stairs.

Patella tendon has also been used, but it tends to be a few millimeters too short for the job when used through tunnels. This means that it is not ideal for use in endoscopic reconstruction of this ligament. Despite this however, it can be used as a graft when the tibial end is applied using open surgery, in what is known as an ‘onlay’ graft. This procedure, was developed in order to overcome the problem of the large curve that a hamstring tendon has to go through to get out of the back of the knee and down into the tibial tunnel. The hope of this procedure was that it would enable quicker and safer rehabilitation post surgery. To some extent those goals have been achieved, but this technique has not become as widely adopted as the hamstring ones.
Fortunately though, this is not a functional deficit and it does not prevent sporting activity.

Unlike ACL reconstruction, the outcome is a little more variable. This is because the surgery is more difficult, and because nobody does a very high number of these: thus even the most experienced sports surgeons do not perform anything like the same number of PCL reconstructions as they do ACL reconstructions. Nevertheless, in the last 25 years that we have been performing this procedure, the results have significantly improved and, with appropriate post-operative management, it is now something that we can recommend when necessary.

Although we are now reasonably good at reconstructing this ligament, the long-term results of acute reconstruction for isolated PCL rupture, are similar to the long-term results of a conservative programme. Hence, in the setting of an isolated PCL rupture, there is probably little indication for immediate reconstruction. As discussed above however, there are indications for surgery and, in those situations, good results can be expected.

Use of the LARS Ligament

The Ligament Augmentation Reconstruction System (LARS) is the latest in a series of artificial ligaments and ligament augmentation devices that have been brought to the market. It is made of polyethylene terephthalate, a plastic similar to that used in the manufacture of drink bottles. It has gained some popularity for ACL reconstruction in Australia, albeit that that popularity is now waning because of the high number of failures and complications. Similarly, whilst excellent results have been published on the use of autografts for reconstruction of this ligament, little has been published to support the use of this or any of the other artificial ligaments. Accordingly, use of this device as an augment to a conventional reconstruction, or as a replacement for it, continues to be regarded as experimental.

In the PCL, where the results of auto graft reconstruction have not been as good as for ACL reconstruction, it may be that some form of augmentation will improve the results. Although unproven, early indications are that we can protect our hamstring reconstructions in the short to medium term by using a LARS strip as an augment. Because these are strong, they can be put alongside the major hamstring bundle, where they can hold the tibia forwards until the tendons heal into the tunnel in the tibia. In the few of these that have been done, we have been able to get the knee moving a little more quickly and, certainly at the one-year mark, the stability that we have achieved is good and may even be better than with hamstring tendons alone. This however is not a long-term follow-up, and we know that these artificial constructs will all rupture with time. For this reason, whilst there may be good theoretical reasons for continuing to augment PCL reconstructions, we do not have long-term studies to suggest that this should be standard management.

Complications of Reconstruction

As one might expect, given the complexity of PCL reconstruction, there are a number of complications that are peculiar to it. For the most part however, most are similar to those related to ACL reconstruction (see our ACL information sheet).

Swelling of the calf in the immediate post operative period is common. This is because the tibial tunnel exits into the back of the knee, deep to the upper calf, outside the knee joint itself. In order to visualise this area, and to drill the tibial tunnel, the back of the capsule of the knee joint needs to be partly removed, thereby opening the knee joint to the calf and leg.

Arthroscopy is done by pumping fluid under pressure into the joint, thus distending the joint, allowing things to be seen. Although not high, this pressure will exceed tissue pressure: and hence, given time, fluid will gradually be forced out into the calf and leg tissues. To help reduce this problem, the lower calf is bandaged tightly. The upper calf above the bandage however, will still swell, and hence, the speed and experience of the surgeon to complete the procedure in a reasonable time frame becomes important.

The swelling in the calf is usually not harmful, and usually subsides quickly after the tourniquet is released. Nevertheless, the less swelling the better and; it is important to keep an eye on this, particularly when a complex, multi-ligament reconstructive procedure is being performed.

Bruising in the immediate post-operative period is the commonest problem. Obviously everybody has some bruising, but occasionally, it is such that the knee becomes swollen and sore, and the normal mild discolouration that extends to the foot becomes very obvious. This gives discomfort, particularly when standing up, and may last 2 weeks. To a degree this can be avoided by not walking around too much when first allowed home from hospital.

Obviously there is quite a bit of variation in this, and some people do bruise more easily than others. Rarely however, the degree of bruising seems to be excessive, in which case, studies looking for disorders of coagulation may be indicated.

D.V.T.'s (deep venous thromboses) also occur but are uncommon (less than 5%). These represent clots in the deep veins of the leg, usually the calf. They may occur at the time of surgery, or sometime over the next few weeks. Most commonly however, it is in the first 10 days. If noticeable, it is usually as an ache in the calf at the back of the leg. If this is occurring, then a doppler (ultrasound) scan can be used to detect it, and appropriate treatment organised.

Usually, some mild thinning of the blood will be organised for every ACL reconstruction, most commonly being aspirin 100mg per day for 2 weeks. When a patient is at higher than normal risk for this complication (e.g. a significantly positive thrombophilia factor like Factor V Leiden) then this prophylactic thinning of the blood can be upgraded to low dose clexane injections, extended over a longer period of time, or both. These measures, particularly the latter upgrades, increase bleeding and bruising however, and thus will be instituted based on a risk benefit assessment.

The at risk period for getting a DVT is generally regarded as being the first two months, albeit that the majority occur within the first 10 days. For those who travel in that period of time however, consideration of further anticoagulation should be given and, depending on distances travelled, prophylaxis may be indicated even out to the three month mark. This can be done using clexane (or similar) injections, and usually by self injection. A newer alternative however is to use oral anticoagulants, which may not be on the PBS listing yet, but are not overly expensive. Different tablets are taken as per their recommended dose regime. For rivaroxaban, 10mg taken 1-2 hours before travelling, and repeated at 18 hours
if still travelling, will provide good prophylaxis, especially if combined with flight socks or flight stockings. Such travel would include plane flights, long-distance car journeys and long train journeys.

**P.E. (Pulmonary Embolism)** is perhaps the most serious complication of all surgery and anaesthesia, and indeed, can be fatal. The problem of having clots in a vein (DVT) is always that they may spread to the lungs. This, fortunately, is a rare event, occurring perhaps just once in every 100 cases. It generally presents as chest pain which is worse with deep breathing. It may also lead to intermittent shortness of breath and a general feeling of unwellness. Unfortunately, whilst we can reduce the incidence of DVT’s by the use of low-dose peri-operative anticoagulation, the same cannot be said for pulmonary embolism. Standard peri-operative anticoagulation does not seem to change the incidence of pulmonary embolism, almost as if it is a separate disease entity (and therefore not directly related to a DVT). For those at high risk of P.E. therefore, more substantial anticoagulation is required which may involve full, and prolonged, anticoagulation with warfarin or similar agents.

**Deep infection** is uncommon, occurring in less than 1% (exact figure unknown). If detected early, it is treatable, hopefully such that recovery can follow without loss or failure of the graft. Nevertheless, the graft is threatened by this problem and the situation requires prompt treatment, including arthroscopic washout of the knee and antibiotics. In order to decrease the risk of infection, peri-operative antibiotics are always given. Also, the graft is harvested in a manner which, where possible, avoids excessive contact with the skin and, usually, it is soaked in vancomycin (an antibiotic that has very high potency for skin organisms, is absorbed well into the graft tissue, and does not alter the biomechanical properties of the graft).

**Loss of full extension** of the knee is not very common, perhaps because the knee is splinted in the straight position initially, and for a period of time. Either way, it is not of the same order as the same problem in ACL reconstruction, and rarely requires separate treatment.

**Loss of full flexion** of the knee is relatively common and is described separately in the above notes. Generally this is not a functional problem and, only rarely, does it require intervention. When significant however, it is usually due to scarring up of the inside of the joint, something that can be dealt with by arthroscopically removing the scar to re-create a normal knee cavity.

**Arthrofibrosis** is the condition referred to above, where the knee fills with scar in the post operative period. It is more common where the extent of the surgery has been greater, the surgery has been performed in the first 8 weeks, and where prolonged splintage has been necessary. Nevertheless, it remains relatively uncommon as a significant entity and is usually treatable by arthroscopic removal of the scar. This would normally be done only if the knee range of motion did not return in the first several months, and it is not something that would be considered early on. For this surgery to be successful, the knee has to be quite settled, notably being past the inflammatory stage, during which it can be stirred up.

**Graft loosening and failure** may also occur, and it is more common with PCL reconstruction than it is with ACL reconstruction, as discussed above. Vigilance with the use of a splint in the post operative period is essential to decrease the incidence of this. Similarly, physiotherapy, when indicated (6 - 12 weeks post surgery) needs to be with someone experienced with these sort of reconstructions.

**Graft re-rupture** can and does occur. No graft is as strong as a normal ligament and re-injury is possible.

**Ache from the tibial fixation screw** is not all that uncommon early on but, fortunately, is rarely bad enough for long enough to require treatment. Also, many of the screws that are used for hamstring reconstructions are biodegradable and, ultimately, over 2 - 3 years, will dissolve. Prior to that happening however, the screw occasionally comes loose, in which case it can be easily removed.

Once the eight-week mark is reached, the screw is no longer necessary anyway, the ends of the graft having healed adequately to bone by then. This means therefore, that it can be removed any time after that with minimal consequence. Thus, after that period of time, if the screw is prominent enough to suggest that it might interfere with kneeling, it can be safely removed.

**A screw ganglion** is a fluid lump that develops around the screw, often some years after reconstruction. It presents as a lump near the scar that can be quite hard but is not red or inflamed. It is thought to represent fluid leakage from the knee joint which has made its way, either down past the screw, or through the central cannulation of the screw, creating a build up under the skin. Whilst not harmful, it can be a little bit sore, and certainly can be clearly visible. If it becomes persistent or very tight, then removal of the screw is indicated. For most people, the hole left by the screw then fills with scar, thus sealing the hole and preventing recurrence of the lump. Rarely, the hole does not adequately fill up with scar and seal off the leak from the knee. In this instance, bone grafting of the hole may be required.

**Damaging the popliteal artery** is a special problem of PCL reconstruction. It is only millimeters away from the back of the tibia.

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**Guide wire for the drill**

**Popliteal Artery**

Deep in the calf and just behind the tibia

**Drilling the tibial tunnel**

The popliteal artery is only 2 - 3 mm away of the tibial tunnel and the drill, or the guide wire for the drill, can damage it. Extra care and experience is required...
for this step and it must be done under direct vision with the arthroscope. Despite this care, some damage can still occasionally occur: hence, pulses need to be monitored post operatively.

The commonest injury is not one of complete rupture of the artery, but rather one of minor damage to the wall. This may not be noticed at the time because, unless the wall is penetrated, the artery does not bleed. If the wall is damaged however, it may start to balloon out under pressure when the tourniquet is released. This balloon, or false aneurysm, can then slowly increase in size, sometimes unnoticed, sometimes presenting with a lump in the back of the knee. Rarely does it rupture.

Suspicion of this problem needs to be investigated with a doppler ultrasound, following which appropriate treatment by a vascular surgeon may be necessary.

**Summary**

The PCL is a large ligament in the back of the knee that acts to keep the tibia forwards on the femur. It also acts as the central pivot point for the knee. It is injured by direct blows to the upper tibia or by forced hyperflexion of the knee (bent right up). When torn in isolation, the treatment of choice is a conservative rehabilitation program, with the emphasis on quadriceps strengthening.

When the above fails, when there is persistent or recurrent patello-femoral pain, when there is instability on stairs or slopes, or when there has been a multi-ligament injury to the knee, PCL reconstruction is indicated. This is a more complex procedure than ACL reconstruction, though similar in principle. More so than in ACL reconstruction, the graft needs a good deal of protection in the early phases, a splint is required, and motion takes quite a long time to recover. Nevertheless, with modern techniques and good care, a good result can be expected. Return to sport is usually possible if the rest of the knee is in good shape and if good stability can be achieved. This will usually take 9 - 12 months.