Ligamentous injuries in the knee are often sustained during contact sports and are one of the commonest reasons for a professional athlete's career to be halted. There are four ligaments in the knee which may be injured. These are the anterior and posterior cruciate ligaments (ACL and PCL) and the medial and lateral collateral ligaments (MCL and LCL).

**Anatomy**

It is important to understand the anatomy of the knee ligaments before looking at how they are injured, assessed and treated.

**Collateral Ligaments**

The picture above shows the knee from the front. The collateral ligaments lie on the medial and lateral aspect of the joint and act as stabilisers to valgus and varus stress respectively. They are tight in extension and loose in flexion making injury most common when the knee is extended.

The medial collateral ligament is actually divided into two layers, superficial and deep. The deep medial collateral is part of the joint capsule. It attaches proximally to the medial femoral epicondyle and distally to the medial condyle of the tibia, around 5cm below the joint line (more distal than you think).

The lateral collateral ligament is separate from the capsule and is more flexible making it less susceptible to injury. Its proximal attachment is to the lateral epicondyle of the femur and distally to the fibula head.

**Cruciate Ligaments**

The cruciate ligaments provide both rotational and anteroposterior stability to the knee joint. They are very strong and a significant mechanism of injury is usually needed to cause complete rupture. The anterior cruciate ligament (ACL) prevents forward displacement of the tibia on the femur and is at its most taut when the knee is in hyperextension.

It inserts on the tibia in its fossa just anterolateral to the tibial spine. It then takes a posterolateral course to the femur inserting on the posteromedial corner of the lateral femoral condyle (see second image below). The tibial insertion is larger and therefore stronger than the femoral insertion making the latter the more common site of rupture.

The posterior cruciate ligament (PCL) prevents posterior displacement of the tibia and is at its most taut in flexion.

It attaches on the femur in the intercondylar notch and passes inferiorly and posteriorly to attach on the back of the central portion of the tibial plateau.
Etiology

Ligamentous injuries in the knee occur when a force greater than the tensile strength of the ligament occurs. This is common with sporting injuries and trauma such as road traffic accidents. It is particularly common in athletes where a sudden force is transmitted through the knee joint with the foot planted. Depending on the position of the limb and the angle or rotation of the force, different patterns of injury emerge.

The knee is the joint most commonly affected in sporting injuries with ligament injuries making up around 40% of the total injury burden. The ACL is the most commonly affected ligament accounting for nearly 50% of injuries with the MCL being the second most injured.

The x-ray below shows an anterior dislocation of the tibia on the femur which was sustained by a patient during a game of rugby. The ACL is responsible for preventing forwards translation of the tibia and so must be disrupted in this patient. One or both of the collateral ligaments may be ruptured but the PCL could still be intact.

Isolated ligament injuries are often diagnosed, but in practice remember it is common for multiple ligaments to be involved. The four ligaments work in concert to stabilise the knee and when a force is great enough to completely disrupt one ligament, partial or complete injury to at least one other ligament often occurs.

Four classical mechanisms of ligamentous injury have been described by Palmer:

- **Abduction, flexion and internal rotation** (of the femur on the tibia): This is the commonest mechanism of injury, usually sustained during contact sports. This causes injury to the MCL initially and if the force is significant the ACL may also be involved.
- **Adduction, flexion and external rotation** (of the femur on the tibia): This is much less common than the first mechanism but can be more significant. Initially the LCL is disrupted. In cases of more extreme force structures such as the popliteus tendon, fascia lata (iliotibial band), lateral gastrocnemius tendon, popliteofibular ligament and the biceps femoris, which together constitute the posterolateral corner may be injured. There may also be injury to the common peroneal nerve and the cruciate ligaments.
- **Hyperextension**: In hyperextension injuries the ACL is the first structure to rupture as seen on the previous x-ray. As the degree of extension increases the posterior capsule and PCL may also be injured.
- **Anteroposterior displacement**: Injuries with this mechanism cause rupture of either or both the ACL and PCL.

Epidemiology

Most patients who sustain ligament injuries are young patients injured whilst playing sports. Patients of any age who are involved in significant trauma may also be affected.

There is no racial predilection to injury and overall men sustain more ligament injuries than women. However, in high risk sporting subgroups such as football, women will sustain injuries more frequently than their male counterparts.

History and Examination

In the patient history the mechanism is key to deciding how likely a ligamentous injury is and which structures could have been injured. Enquire about the position of the knee and the direction of any force applied, whether linear or torsional (twisting).

One key thing to note is whether the patient noticed an effusion developing immediately or gradually after injury. Swelling in the first hour indicates a large haemarthrosis indicative of complete ACL or PCL rupture, whereas swelling over the subsequent 24 hours is more common in traumatic synovitis without significant injury.

Patients may describe an audible pop at time of injury, especially with cruciate ligament disruption. The ability to weight bear after injury and whether the knee felt stable on weight bearing is important.

In the acute phase initial examination may be difficult but should always be attempted. Pain and muscle spasm may mask the full extent of the patient's injuries. In the outpatient setting however, the examination should be easier as the acute pain from the trauma should have settled to a degree, giving a fuller picture. A good history and examination in experienced hands can be up to 90% sensitive for ACL rupture.

Examination of the ligaments involves applying a force against the main stabilisation mechanism of the structure being tested. When examining an intact ligament a firm ‘end point’ should be felt. Ligaments which have been injured will demonstrate a ‘soft end point’ where the ligament itself does not stop the force, but the surrounding soft tissue structures do.

Clinical instability is divided into three grades which correlate to the severity of the injury:

- **Grade I**: Joint opening or translation under 5mm from normal.
- **Grade II**: Joint opening or translation 5-10mm from normal.
- **Grade III**: Joint opening or translation over 10mm from normal.
To test the ACL, Lachman’s test is the most sensitive and specific. With the patient supine the knee is placed into 15 degrees of flexion. The distal femur is stabilised with one hand while the other attempts to lift the proximal femur forwards.

The anterior drawer test is significantly less sensitive and specific but can be used to add weight to the suspected diagnosis and is more commonly positive in chronic degenerative tears. It is performed with the affected knee in 90 degrees of flexion. The examiners thumbs should lie over the joint line as the tibia is pulled forward so anterior translation can be felt.

Before it is performed the unaffected knee should be placed in the same degree of flexion and compared from the side, to ensure that a posterior sag consistent with PCL injury is not present.

Testing of the PCL is best performed by again initially checking for a posterior sag with both knees in 90 degrees of flexion and the feet planted flat on the examination couch. If this does not reveal a deficit then a posterior drawer test should be performed. With the knees in the same position apply posterior pressure to the proximal tibia looking for translation on the distal femur.

The standard test for stability of the collateral ligaments is the abduction and adduction test where valgus and varus stress tests the MCL and LCL respectively. With the patient supine and the knee and hip in roughly 20 degrees of flexion apply stress to the MCL and then the LCL feeling for quality of the endpoint and the distance of travel.

Imaging

X-ray
In the acute setting where injury is suspected, AP, lateral and skyline x-rays should be performed as an initial investigation to exclude a fracture and to exclude arthritis in the older patient. Where a significant injury has occurred, a lipohaemarthrosis may be seen on the lateral x-ray as shown below.

A lipohaemarthrosis indicates the presence of fat floating on blood and is usually associated with a bony injury such as a tibial plateau fracture or bony PCL avulsion.
MRI
The mainstay of imaging is MRI which is both sensitive and specific and will pick up around 90% of ligament injuries. The diagram below shows two sagittal MRI images. The image on the left shows an intact ACL and on the right a ruptured ACL. Note the oedema (white on the T2 scan) and loss of continuity of the fibres.

The next image shows an intact PCL side by side with a ruptured PCL. The avulsion in this case is from the femoral insertion with the torn fibres having bunched up below.

In the next example there has been a PCL avulsion from the tibial insertion where a sliver of bone has been avulsed with the ligament. This is a bony avulsion rather than a rupture of the ligament itself.

The grading and appearance of lateral collateral ligament injuries is much the same as for medial collateral injuries. The following MRI shows an intact LCL which nicely shows its anatomical origin and insertion.

The following image shows the grading of injuries to the MCL as seen on MRI. A normal MCL is shown first for comparison.

**Grade 1:** high signal (white) is seen superficial to the ligament indicating a minor sprain.
**Grade 2:** high signal both superficial and within the ligament or a partial ligament disruption indicating severe sprain or partial tear.
**Grade 3:** complete disruption of the ligament. Note the distal avulsion and the bunching up of the fibres.
Arthroscopy

Though not technically an imaging technique in the traditional sense, a diagnostic arthroscopy may be performed where imaging has not given a clear diagnosis. This is mainly performed in cases of ACL injury where imaging may show an intact tendon but the patient clinically and symptomatically still seems to have ACL dysfunction. It has the added benefit of being dynamic; that is, the ligament can be probed for its tension and watched as the knee is moved. The image below shows a normal ligament at arthroscopic assessment.

Non Surgical Management

Non operative management for cruciate ligament injury is an option, especially in older patients or those with lower functional demands. It may be especially appropriate for patients who live a sedentary lifestyle. Non-operative management is almost always the option of choice for collateral ligament trauma, unless they form part of an unstable multi-ligament injury. Most patients will return to pre-injury activity levels.

Some studies have found that with non operative management in patients with an ACL rupture, as many as 80% are happy with the outcome, despite almost all having clinically significant laxity and up to a third sustaining significant re-injury.

The key factor in a non-operative treatment plan is a prolonged physiotherapy course and patient education about the activity level they can reasonably hope to return to.

Surgical Management

Anterior Cruciate Ligament

Surgical intervention is the treatment of choice for many active or younger patients who have a desire to reach their pre-injury level of function. The most common procedure performed is an arthroscopic tendon graft repair. The donor site is usually either hamstring (semitendinosus and gracilis) or patella tendon. The two have various advantages with hamstring graft typically being stronger (around 2 times the tensile strength of the ACL compared to patella tendon which is 1.3 times stronger) but patella tendon graft integrating quicker as it is an osseotendinous graft.

Timing of reconstruction is a controversial issue with many surgeons preferring to perform the surgery in the first few weeks after injury. However, it can be performed as a late procedure when conservative management has failed.

Occasionally the ACL becomes dysfunctional, not because it has suffered a tear of the tendon substance but has in fact avulsed its bony attachment. In these cases repair is advocated as the tendon itself is still intact. This can be effected with transosseous sutures or screw fixation depending on the size of the bone fragment.

Posterior Cruciate Ligament

Injury to the PCL is much less common than the ACL and so less is known about optimal management. It is common for a PCL injury to be associated with other ligamentous injury or damage to the posterolateral corner. Isolated injury is occasionally seen, usually as a consequence of a ‘dashboard injury’ in road traffic accidents where the anterior tibia is displaced posteriorly with the knee in flexion (when the PCL is at its most taut).

The main indication for surgical repair of the PCL is in cases of bony avulsion. This should be operated on early and the method of choice is usually screw fixation followed by bracing in extension with gradually increasing degrees of flexion.

Some patients who have undergone conservative management may complain of persisting aching at the back of the knee. In these cases, provided they clinically exhibit significant laxity, reconstruction can be performed, either as an open or arthroscopic procedure.

Collateral Ligaments

In the small number of cases where acute surgical management is needed, it should ideally be performed within two weeks of injury. This is usually a direct repair, but in cases of a mid-substance rupture augmentation with a tendon graft may be needed. Patients who present late with instability are unable to undergo direct repair as the healing potential of the ligament has passed. In these cases reconstruction with a tendon graft is the only option.