MINI SYMPOSIUM: SOFT TISSUE KNEE PROBLEMS

(i) The crucial ligaments

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Summary
Anterior cruciate ligament (ACL) damage is a high-risk sports injury which, if not treated surgically, leads to significant medium- to long-term disability and degenerative change. ACL reconstruction should be carried out using autogenous tendon grafting a month to 6 weeks after injury. With appropriate rehabilitation, return to sports can occur at around 6 months. Posterior cruciate ligament (PCL) injury is much less common and occurs by attenuation rather than midsubstance rupture and thus conservative treatment is an option. Surgery is not an option for isolated PCL injury, but is as part of chronic complex injury reconstruction.

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The anterior cruciate ligament

Anterior cruciate injury is common and has been shown to have an incidence of about 30 per 100,000 population per year.1 It can have a devastating effect on an individual’s sporting aspirations or daily life, and for a professional sportsman or woman is usually career threatening. In addition, we now live in an age when patients have high expectations and many wish to return to normal, recreational sporting activities following this injury, irrespective of age or occupation.

History and diagnosis

The vast majority of these injuries occur during sport. High-risk sports include soccer, rugby and skiing, which account for over 90% of the injuries in the author’s practice. Typically, there is a non-contact twisting injury or a valgus/external rotation strain. The individual often feels or hears a pop or snap, and is unable to carry on playing. Swelling usually occurs within 4 h. A study in the UK in 1995 showed that this was followed by a visit to casualty, a normal X-ray and a discharge with an elasticsupport bandage in 87% of cases.2 This study was repeated recently and things have not improved! The swelling generally takes 2–3 weeks to settle and thereafter the patients have few problems during straight line activities but find that a sudden change of direction causes their knee to give way.

When they present to an orthopaedic clinic the signs of a positive Lachman and a pivot shift are always present, but can occasionally be difficult to elicit (especially in the acute setting). Clinical diagnosis in the hands of an experienced knee clinician is 99% sensitive and specific.3 A plain X-ray is important to identify anterior cruciate ligament (ACL) avulsion (which completely alters management); MRI is rarely indicated and rarely alters decision making.4 It is important to identify associated injuries, particularly of the posterolateral or posteromedial corners, as failure to recognise these and address them at the time of surgery, compromises the results and usually leads to early failure. Never mistake a posterior cruciate ligament injury for an anterior cruciate injury, as can occur if reliance is placed on an anterior draw test, failing to recognise that there is a posterior sag to start with (Fig. 1).
Many believe that patients can manage well without an anterior cruciate. This may be true in the short term but by as little as 5 years post-injury 75% of patients have stopped playing sport and the majority have had a significant further injury.\textsuperscript{5,6} Noyes et al.\textsuperscript{7} found that 31% had disability for walking alone and there is evidence that by 8 years post-injury 70% of patients have radiographic osteoarthritis.

What is unknown is whether ACL reconstruction can slow down or prevent the degenerative process. Some recent evidence\textsuperscript{8} does seem to show that there is no acceleration of osteoarthritis following reconstruction despite continuing participation in sport, provided that the menisci and articular cartilage are intact at the time of surgery (Fig. 2).

**Biomechanics**

The knee is a complex joint with six degrees of freedom. For its stability it relies on the arrangement and interaction of ligaments, muscles and capsule. The ACL is the primary restraint to anterior translation of the tibia on femur. It also has a secondary role as a restraint to varus and valgus torques and internal and external rotation\textsuperscript{9,10}. Its primary function however is in controlling rotation of the knee. ACL deficient patients do no complain of their tibias sliding forward but of giving way of the knee when trying to change direction.

The ligament is made up of fibres arranged in such a way that some part of the ligament is taught throughout the full range of movement. It can be roughly divided into an anteromedial bundle, taught in flexion, and a posterolateral bundle, taught in extension.\textsuperscript{11}

The ACL inserts on the tibia approximately in the centre, between the tibial spines, an ideal location to ensure normal physiological rotation during flexion and extension of the joint. When the ACL is ruptured, this normal control is absent and when a valgus torque is applied to the knee the centre of the axis of rotation shifts to the medial structures and an abnormal rotation occurs (Fig. 3)\textsuperscript{12}. This is the basis of the pivot shift test. It is interesting that this test was so-called because the problem occurred when the patient was pivoting,\textsuperscript{13} but unknowingly the authors correctly described what happens biomechanically—the pivot shifts!

Whilst the pivot shift occurs in all ACL deficient knees, the degree to which it occurs varies from one individual to another. Matsumoto found that in some knees little happens until a sudden shift occurs and in others, the abnormal

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**Natural history**

Many believe that patients can manage well without an anterior cruciate. This may be true in the short term but by as little as 5 years post-injury 75% of patients have stopped playing sport and the majority have had a significant further
rotation occurs smoothly and gradually. This may be why some individuals are better able to cope with insufficiency and is probably related to the anatomy of the lateral compartment and the relative convexities of the lateral tibial plateau and lateral femoral condyle.

**Treatment options**

Indications for reconstruction remain a matter of debate. Reconstruction (when performed satisfactorily) now has a low morbidity and a high degree of success—consequently the indications for surgical intervention have shifted. An active lifestyle and a refusal to change sporting activities to accommodate knee injury (particularly in a professional who's livelihood depends on knee function), or recurrent giving-way episodes, are indications for reconstruction. Associated injuries, particularly reparable meniscal tears (which do not heal well in the presence of ACL deficiency), may prompt early reconstruction. Patients with low demand lifestyles and who have rare giving-way episodes may cope quite well with rehabilitation aimed at improving muscle strength and proprioception.

ACL injury in skeletally immature adolescents presents particular problems. If an ACL avulsion has occurred the energy of the injury is dissipated through the fracture line and the ligament usually remains intact. Early anatomical fixation produces good results. Adolescents who suffer a mid-substance rupture, however, are an entirely different group. It has been shown that they are at high risk and if left untreated suffer significant morbidity in terms of reinjury, articular cartilage damage and meniscal tears. This has to be balanced against the potential for growth plate injury when drilling tunnels for an intra-articular ACL reconstruction. This risk, however, seems to be small compared to the risk of significant further injury if treated conservatively. Hamstring reconstruction fixed above and below the growth plate can allow return to competitive sport and seems to grow with the patient (Figs. 4a and b), though quite how this occurs is unknown.

Partial ACL tears do occur and generally have a good prognosis if there is no clinical laxity at the time of presentation, irrespective of the amount of tearing seen during arthroscopy. If ACL injury occurs associated with a valgus strain, the pattern is often that of an avulsion from the femoral attachment. There is an anatomical synovial fold that runs from the ACL to the lateral wall of the notch and if this is not disrupted it holds the torn ACL in a roughly anatomical position, allowing healing to a slightly antero-inferior attachment site (Figs. 5a and b). This results in a set of consistent clinical signs: a larger Lachman than the normal limb but with a hard end stop, a large anterior draw with no end stop and a pivot glide or 1+ pivot.

**Surgical technique and outcome**

ACL reconstruction is not a difficult operation to do, but it is a very easy operation to get wrong. Biomechanical studies have shown that a misplacement of only 2 mm anteriorly from the ideal femoral tunnel position results in a restriction in range of movement. The most common reason (80%) for failure of an ACL reconstruction is technical error (Fig. 6).
Unlike many orthopaedic procedures, a badly done ACL reconstruction does not work from day one and this cannot be corrected by prolonged physiotherapy!

The vogue for reconstruction with synthetic materials has largely passed. Some of the initial reports were quite promising but this has not been sustained with time. Some quite serious biological reactions have occurred (Fig. 7) and artificial ligaments are often very difficult to revise when they fail.

The principal grafts that are now used are the middle third patellar tendon (bone–patellar tendon–bone–BPTB) and four strand hamstring (doubled gracilis and semitendinosus tendons). They have stood the test of time and have a high success rate. The picture that seems to be emerging from the literature is that they can both provide satisfactory results and there is little to choose between them, other than that there is a higher incidence of kneeling pain following BPTB grafts.\textsuperscript{20–22} Successful reconstruction has even been shown to improve symptomatology in knees with significant degenerative change.\textsuperscript{23,24}

\textbf{Figure 5} (a) The normal synovial fold can be seen running from a normal ACL to the lateral wall of the notch. (b) An antero-inferior reattachment of the ACL showing laxity at 90° of flexion.

\textbf{Figure 6} Grossly anterior femoral tunnel and anterior placement of the tibial tunnel in a referred patient who’s knee “has never been right” from day one after reconstruction.

\textbf{Figure 7} Gross osteolysis in a femoral condyle following goretex ligament reconstruction.
The timing of intervention is important. The long-term outcome really depends on the state of the joint at the time of surgery and studies have shown that more than 6 months post-injury the likelihood of meniscal injury or articular cartilage damage increases with time.\textsuperscript{25–27} Immediate intervention can also be problematic, with a very high incidence of arthrofibrosis occurring if surgery is performed before the initial swelling has settled and a full range of motion has been regained.\textsuperscript{28,29} Generally, this will take somewhere between 4 and 6 weeks.

There is an enormous literature on different types of graft fixation, their loads to failure, their ability to biodegrade, etc., but there is no hard evidence that any particular fixation method produces superior clinical results. Indeed two of the weakest forms of fixation—interference screws for hamstring grafts and sutures tied over a button for BPTB grafts—have been shown to produce clinical results at 2 and 5 years that are as good as any other study that has been published.\textsuperscript{30,31}

The essentials for technical success are to place the graft so that it is isometric during flexion and extension and does not impinge in full extension (in most individuals this means a degree of hyperextension). In a right knee the femoral tunnel is placed at 10.30/11 O’clock with the whole tunnel in the posterior third of Blumenstedt’s line (seen on a lateral X-ray). The tibial tunnel is centred 2/3–3/4 along a line from the anterior horn of the lateral meniscus to the medial tibial spine. More detail can be obtained from the British Orthopaedic Association web site—good practice guidelines.

Rehabilitation

Changes in rehabilitation have revolutionised the outcome and morbidity from ACL reconstruction. A patient 15–20 years ago may have been in plaster for 6 weeks followed by a cast brace for 6 weeks and it took nearly a year of rehabilitation to get back to anything like normal. You had to be a pretty good athlete to survive the surgery! It was when Don Shelbourne critically reviewed his patients and realised that the patients who ignored the protocols and just ‘did their own thing’ did better than the patients who followed the instructions to protect weight bearing, restrict range of motion, etc., that the concept of accelerated rehabilitation was born. Follow up has shown no deleterious effects of regaining full extension in the first couple of weeks and then progressing to activities such as jogging by 6–12 weeks post op and returning to sport by around 6 months.\textsuperscript{30,32}

The future

The last 10 years have seen no dramatic changes in the treatment of ACL injury but rather a steady refinement of technique and better recognition and management of associated injuries. The race is on to develop synthetic collagen ligaments that can be seeded with the patients’ own fibroblasts and implanted 4–8 weeks post-injury, further reducing the morbidity, accelerating the maturation of the graft and allowing earlier return to normal activity. We will still need to place them correctly and the cost implications need to be seen, but this is currently the Holy Grail of knee reconstruction surgeons!

The posterior cruciate ligament

Isolated posterior cruciate ligament (PCL) injury is much less common than ACL injury. In Myasakas’ study\textsuperscript{1} it accounted for less than 5% of ligament injuries. The true incidence is probably unknown for reasons that will be outlined below, and our management of this sometimes difficult problem lags significantly behind that of the ACL.

History and diagnosis

Isolated PCL injury occurs usually with a fall onto a flexed knee or, more rarely, with a direct blow to the anterior aspect of the proximal tibia. It is most often a low violence injury—higher violence injuries such as road traffic accidents frequently produce combined injuries of the PCL and other structures. It is common in the sport of rugby league where tackling is done by two players, one round the legs and one round the shoulders, resulting in a fall onto flexed knees with an additional 120 kg across the shoulders. In the rugby league squads that the author looks after, approximately 30% of the players have a ruptured PCL in one knee, some in both!

Typically there is pain in the popliteal fossa on injury, but the individual may be able to carry on playing. The injury is often dismissed as ”minor” by the player. There is generally some swelling, but this may be a small amount. By a couple of weeks things are beginning to settle, but as the player tries to resume running, they are comfortable at a moderate pace but get pain or discomfort in the popliteal fossa when trying to sprint. This settles over a few weeks.

If seen acutely there is a posterior sag (Fig. 8), increasing pain in the popliteal fossa on flexing the knee and a change in tibial step off (felt anteromedially at 90° of flexion, the anterior edge of the medial tibial condyle is usually anterior to the medial femoral condyle—compare to the normal knee).

Figure 8 Large posterior sag in a knee with a PCL-posterolateral corner injury.
It is important to exclude associated injuries, as these have a major bearing on management. Pick the patient’s legs up by the toes—varus-recurvatum indicates damage to the posterolateral structures. A posterior draw of over 1 cm should also alert the examiner to the possibility of combined ligament injury. With the patient prone, an increased dial test at 30° and 90° of flexion may indicate associated posterolateral corner damage (it is important not to confuse anteromedial rotatory subluxation with posterolateral rotatory subluxation—you need to repeat the dial at 90° with the patient supine and carefully look at the tibial condyles to see if the medial tibial condyle is rotating forward or the lateral tibial condyle is going backwards).

X-rays may show a PCL avulsion (although this is rare) but usually confirm posterior displacement of the tibia relative to the femur. MRI may be useful in acute, combined injuries but is generally unhelpful in isolated PCL injuries. In chronic injuries it is even less helpful, only picking up the diagnosis in 57% of cases.33

Natural history

Patients who have sustained an isolated PCL injury usually return to sport and normal activities without too many problems, especially if quadriceps strength is built up.34–36 The fact that 30% of professional rugby league players, playing at an elite level, have a ruptured PCL, indicates that in the short term there is little functional disability. Following recovery from the initial injury, patients undergo a period of functional adaptation and then a long period of functional tolerance which may be 15–25 years before symptoms start to deteriorate and arthritic change becomes symptomatic.37

Biomechanics

The PCL may be twice the size of the ACL but it is not twice as strong.38 Like the ACL it has 2 major functional bundles but arranged the other way round—a posteromedial bundle taught in extension and an anterolateral bundle in flexion. The PCL provides the primary restraint to posterior translation of the tibia on the femur but, unlike the ACL, does not have a significant role in controlling rotation.

Experimental studies have shown that tension increases in the ligament in flexion and is reduced in extension.39,40 Very importantly, even in PCL deficiency the knee reduces anatomically in extension as long as the collateral ligaments are intact.41

Treatment options

Unlike the ACL, which normally ruptures mid-substance, the PCL tends to attenuate, explaining the difficulty in identifying the injury on MRI in chronic cases. This also allows the possibility of conservative treatment in acute cases. We know the knee reduces in extension if the collateral ligaments remain intact (see above) and therefore bracing in extension for 4 weeks allows the possibility of the injured PCL to scar and shorten, reducing the residual laxity. Following this, the patient can be rehabilitated, concentrating on quadriceps strength, and generally can be returned to sport somewhere between 8 and 12 weeks post-injury.

Surgery is rarely indicated in the acute situation except for PCL avulsions and combined injuries. There is some debate about reconstruction in grade 3 injuries, but the exact role for surgical intervention in isolated injuries remains to be defined.

Surgical treatment and outcome

Techniques have undergone a gradual evolution over the last 10–15 years and so the long-term results from reconstruction are unknown. Certainly PCL reconstruction as part of a complex reconstruction in chronic complex injuries can provide satisfactory results in this group of patients, who usually have fairly low expectations. In 14 years of practice as a knee reconstruction surgeon the author has yet to perform a reconstruction for an isolated PCL injury.

Using the ACL, where closed kinetic chain exercises put very little strain on the graft, it is difficult to minimise the tension on the PCL graft as soon as the knee is flexed. It is difficult to find a study that claims to have restored posterior laxity to normal after PCL reconstruction.

The current discussion revolves around whether it is better to perform a one- or two-bundle reconstruction. Two bundle reconstruction offers the potential advantage of providing a more anatomical reconstruction but clinical studies have so far failed to show any significant improvement over a single bundle (effectively reconstructing the anterolateral bundle) technique.

Technically, PCL reconstruction is more difficult to perform than ACL reconstruction, with the acute angle as the graft exits the back of the tibia and turns forward to the femoral tunnel, potentially causing difficulties in graft

Figure 9 Image intensifier picture during drilling of the tibial tunnel in a complex reconstruction. The popliteal artery lies about 1 cm from the drill tip—it is important not to advance it too far!
passage. The exit position for the tibial tunnel also puts the posterior vessels at risk and it is advisable to carry out this part of the operation under image intensifier control (Fig. 9).

BPTB grafts are difficult to fix and difficult to pass, although can be used with a tibial onlay technique—this does however mean turning the patient during the operation to use a posterior approach to allow access for fixation of the graft to the PCL fossa. Hamstring grafts are much easier to pass and allow the possibility for a double bundle passage. The exit position for the tibial tunnel also puts the possibility for a double bundle technique but there are concerns about whether they are strong enough in many patients. Fresh frozen allografts (especially tendo-Achilles) are useful in PCL reconstruction, being easy to pass from femur to tibia and are of sufficient size and strength to reproduce normal PCL characteristics.

The future

The biomechanics of the PCL have been worked out, but much remains to be improved and consolidated with regard to reconstruction techniques and rehabilitation. It will probably be another 10 years before a lot of today’s practice will have been evaluated and validated. As with the ACL the possibilities of biological grafts and manipulation of the healing process offer the potential of reducing morbidity and improving outcome.

References


