An approach to the ruptured anterior cruciate ligament

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Isolated anterior cruciate ligament (ACL) injuries account for up to half of all ligamentous injuries to the knee and have been reported to occur in an estimated 1 in 3000 people in the general population.[1] However, as 95% of ACL injuries occur in individuals between the ages of 16 and 45,[2] the recalculated incidence in this age group is 1 in 1750 people.[3] For these otherwise healthy young individuals this injury can have devastating consequences, both in the short term by limiting safe activity levels, and in the long term because the resultant instability predisposes the joint to meniscal and chondral damage, and early osteoarthritis.[4]

ACL reconstruction is indicated if the injured individual wishes to remain active in cutting or pivoting sports. In Australia, the number of knee ligament reconstructions performed within the private health system has almost doubled over the last 10 years (Figure 1), with most being reconstruction of the ACL.

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Mechanism of ACL injury

Up to 70% of all ACL injuries occur in a noncontact environment through a pivot or cutting motion. Studies have shown that the most dangerous playing situations are those that require the foot to be planted and the body to change direction with a valgus-external rotation force being generated through the slightly flexed knee.

Contact injuries with severe valgus or varus trauma commonly result in complex ligament injuries, requiring urgent specialist consultation for appropriate treatment. Accurate history of the mechanism of injury can help establish the extent of the injury and the need for early intervention and treatment (Table 1).

The 'at risk' athlete

The rate of ACL injuries in women has been documented at two to eight times the rate of ACL injuries in men.[5] The number of women participating in sports is also increasing and ACL rupture, therefore, represents a significant and growing problem for female athletes.

The factors contributing to ACL injury are both intrinsic and extrinsic. Intrinsic factors include anatomical variations and neuromuscular and physiological variables. Extrinsic factors include: those that increase the friction between the shoe–surface interface (such as dry grounds and cleats); muscular strength; and jumping and landing techniques, which can be modified by training.

Examination

During the acute phase following an ACL injury, the patient will have a large knee effusion and difficulty weight bearing. Patients commonly present with a loss of extension and this is frequently misdiagnosed as a displaced bucket handle tear of

continued

Table 1. Diagnosis of ACL injury

Acute history
- Noncontact injury (side step, land from a jump)
- Contact mechanism (tackle with valgus force)
- Audible 'pop' or 'crack'
- Knee gave way
- Immediate pain, poorly localised
- Difficulty weight bearing
- Knee effusion

Chronic history
- Instability and/or swelling during activities involving a change of direction

Examination
- Large effusion (if acute)
- Decreased range of motion for two to three weeks post injury
- Posterolateral tenderness
- Tenderness at the proximal attachment of medial collateral ligament
- Positive Lachman's test (increased translation, soft end point)
- Positive pivot shift test (may be falsely negative if knee range of motion is limited)

Investigations
- X-ray: usually no bony injury but assess for Segund fracture or avulsion of tibial spine
- MRI: will show an ACL rupture, translational bone bruising (in 80% of patients) posterolateral tibial plateau, lateral femoral condyle and meniscal injury (in 60 to 70% patients)

the medial meniscus. This loss of extension is more likely to be related to knee haemarthrosis, a medial ligament sprain or the ACL stump. On palpation there is frequently tenderness on the posterolateral joint line and proximal attachment of the medial collateral ligament.

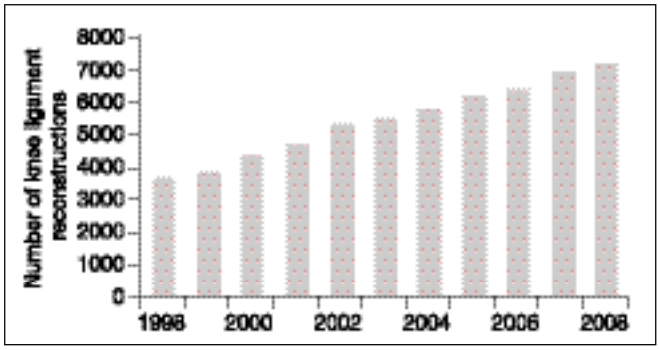

Figure 1. Number of knee ligament reconstructions performed per year in the Australian private health system from 1998 to 2008 (data from the Health Insurance Commission of Australia).

Ligamentous testing should always be compared with the uninjured knee because large variation in laxity is seen. Lachman's test should be performed at 30 degrees of knee flexion. With the femur stabilised there is increased anterior displacement of the tibia relative to the femur and a soft end point. The pivot shift test is performed by applying a valgus and internal rotary force to the tibia as the knee moves from extension to flexion. At approximately 15 degrees of flexion the tibia relocates and this is described as the 'shift'. However, if range of motion is limited or the patient is guarding the knee, the pivot shift may be unable to be elicited. The collateral ligaments should be closely examined as significant medial ligament injury may require bracing in the acute phase.

X-rays are indicated in the acute setting. Although these x-rays are usually normal, it is important to exclude an avulsion injury of the tibial attachment of the ACL (Figure 2). MRI scans are not an essential investigation but may be useful in clinically equivocal cases and in assessing associated ligamentous, meniscal and chondral injuries (Figures 3 and 4).

Management

During the acute phase following an ACL injury appropriate management includes specialist referral of the patient to confirm the diagnosis and assess concurrent injury that may require treatment. Physiotherapy should ideally be commenced early with the aim of restoring a pain-free, mobile joint and normal gait. The use of arthroscopy to make the diagnosis following an acute injury should not be considered.

In patients who are chronically ACL deficient, instability may develop after reinjury that results in further intra-articular pathology, involving a medial meniscal tear. Prior to the reinjury, ACL deficiency may not have been associated with instability.

Surgical reconstruction

Surgical reconstruction usually takes place in the subacute phase (two to 12 weeks post injury) once patients have regained a pain-free joint with an almost full range of motion and a normal gait pattern. Reconstruction should be recommended in patients who are:
- very young
- expecting to return to heavy work
- expecting to return to sporting or recreational activities that involve jumping, landing, pivoting or side-stepping
- experiencing instability in their day-to-day activities.

Arthroscopic ACL reconstruction using four-strand hamstring tendon autograft is regarded by many surgeons as the gold standard for reconstructing the ruptured ACL (Figure 5).[6] In most cases, the ACL reconstruction can be performed as day surgery. Braces are rarely used postoperatively and immediate weight bearing is encouraged.

Figure 2. Anteroposterior x-ray demonstrating an avulsion of the tibial spine at the attachment of the anterior cruciate ligament.

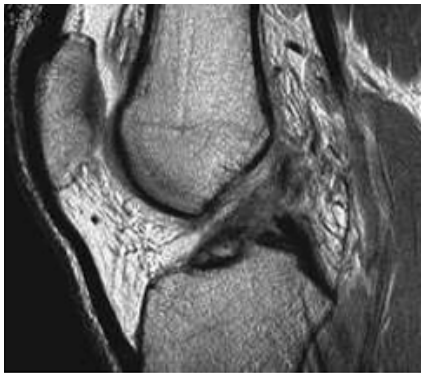

Figure 3. MRI scan documenting midsubstance rupture of the anterior cruciate ligament.

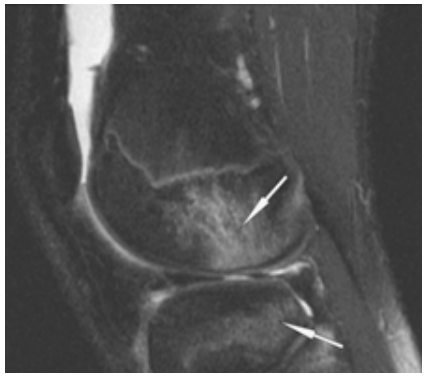

Figure 4. MRI scan documenting translational bone bruising associated with anterior cruciate ligament rupture.

Fixation of the graft can be apical (interference screws) or suspensory (endobutton, staples), and placement of the graft should be anatomical.

Long-term studies of the knee with injured ACL have shown that a significant reduction in the incidence of further injury and necessity for meniscal or chondral surgery is achieved with ACL reconstruction.[7] The most popular alternative graft tissue is the mid-third patellar tendon. Studies have shown a significantly increased graft-site morbidity and anterior knee pain with the use of this graft, and long-term studies have shown a higher incidence of radiological osteoarthritis compared with knees reconstructed using hamstring tendons.[8] Overall, the clinical outcomes are generally similar.

Accelerated rehabilitation programs

The introduction of accelerated rehabilitation programs over the last 15 years has greatly improved the speed of postoperative recovery of an ACL injury. A supervised program is encouraged and this involves closed chain quadriceps exercises started immediately after surgery, stationery cycling commenced after a few days, achievement of normal gait 10 to 14 days postsurgery and straight-line jogging commenced six weeks postsurgery.

Prevent injury and Enhance Performance program

Recent studies have documented that the incidence of ACL injury can be reduced by up to 70% with the implementation of a specific warm-up program.[9] The Prevent injury and Enhance Performance (PEP) program has been shown to decrease both first-time ACL injuries and further ACL injuries after reconstruction. Athletes can reduce their risk of ACL injuries by performing training drills that require balance, power and agility. All patients after ACL reconstruction are encouraged to familiarise themselves and their trainers with this program to prevent further injury.

Return to sport

After ACL reconstruction it is commonly recommended that return to unrestricted activities is delayed for at least six months. However, the risk of ACL graft rupture is elevated for the first 12 months after surgery.[10,11] Basic science studies examining the 'ligamentisation' process of the reconstructed ACL suggest that the maturation process of the ACL graft continues for at least one year after reconstruction and may extend well beyond that time.

There is also clinical evidence suggesting that the neuromuscular performance of the knee is also impaired for at least 12 months from surgery. These findings suggest that patients should be advised that the risk of reinjury is elevated for the first 12 months (or 24 months in the under 21-year-old athlete) after reconstruction and therefore return to activity

Figure 5. Postsurgery anterior cruciate ligament reconstruction with interference screw fixation.

Figure 6. A successful return to skiing following anterior cruciate ligament reconstruction in a boy when he was 9 years old. This patient returned to unrestricted activity two years after surgery.

Figure 7. Anterior cruciate ligament reconstruction using transphyseal tunnels and extraphyseal fixation (femoral endobutton and tibial staple).

Figure 8. One year after anterior cruciate ligament reconstruction using transphyseal tunnels and extraphyseal fixation (femoral interference screw and tibial staple). Note that screw and staple have moved away from the growing growth plates that are still open.

should be considered with caution before this time. We are hopeful that the introduction of the PEP program will have a positive impact on the safe time to return to sport.

Special issues in young patients

Traditionally, ACL injuries were regarded as uncommon but they are now occurring with increasing frequency in children and adolescents.[12,13] Those who report a noncontact or contact knee injury that results in the knee giving way with pain, swelling and an inability to play-on should be presumed to have an ACL injury until proven otherwise.

The treatment of the skeletally immature patient with a ruptured ACL has been controversial. Nonreconstructive treatment or 'waiting until the child has stopped growing' typically results in recurrent instability with a greater risk of injury to meniscal and articular cartilage, and consequent implications in terms of the development of degenerative joint disease. This risk is greater than the risk to the open growth plates using an appropriate surgical reconstruction technique.

In the hands of a suitably experienced knee surgeon, the outcome of operative management of a young patient with an ACL injury results in less instability and higher activity and return to sport levels compared with a conservative approach or nonoperative management until skeletal maturity is reached (Figure 6).[14,15] Operative management also results in lower rates of reinjury and meniscal tears in these children.

Surgical considerations in young patients

When contemplating ACL reconstruction in skeletally immature patients, consideration needs to be given to the open growth plates around the knee. Traditionally, transphyseal drilling techniques have caused some concern due to the risk of growth arrest; however, with the use of extraphyseal fixation and soft-tissue graft, these risks have been shown to be small when compared with the risk of continuing intra-articular pathology with nonoperative treatment of these children and adolescents. Appropriate anatomical reconstruction with close-to-vertical drilling across open growth plates, extraphyseal fixation using endobutton, screws, posts or staples, and radiological and clinical follow-up until skeletal maturity is the preferred treatment of choice in young patients (Figures 7 and 8).

Soft-tissue grafts are the preferred choice of graft in the knee reconstruction of skeletally immature patients. Traditionally, this has involved the use of hamstring tendons of patients. There are a number of issues that have led to the

Table 2. Key points for patients with ACL injuries

- Diagnose (pop, collapse, effusion/haemarthrosis)
- Undergo early mobilisation/ prehabilitation
- Consider reconstruction
- Stabilise the patient's knee using the appropriate technique
- Undergo rehabilitation
- Institute Prevent injury and Enhance Performance program

search for alternate graft material and the introduction, as an experimental technique, of living-related donor hamstring tendon allografts. These issues include higher reinjury or rerupture rate in younger patients, the subsequent need for further graft material at a later stage, the size of graft material available in skeletally immature patients, and the morbidity associated with the harvest of graft material. An allograft can be harvested from a parent under general anaesthetic using sterile techniques in the operating theatre at the same time or just prior to the child/adolescent undergoing the ACL reconstruction. The allograft is then transferred to the recipient by the surgeon immediately after the harvest at the time of the reconstruction.

The use of living-related allograft hamstring tendon is an ongoing area of research in skeletally immature ACL reconstruction. This is currently being performed by our group in a subspecialised practice with appropriate ethics approval. Early results are promising, with patients experiencing less morbidity and donors experiencing minimal morbidity and time off work. Patients should be followed radiologically and clinically until they are skeletally mature.

Conclusion

The diagnosis of a ruptured ACL in a knee that has experienced a noncontact mechanism of injury involving a land from a jump, a side-stepping manoeuvre or a contact mechanism on a fixed foot with a valgus-rotational force can be confirmed with appropriate clinical examination and imaging modalities. Institution of appropriate acute management modalities should involve early mobilisation and the understanding that the most common cause of a 'locked' knee after a ruptured ACL is not a displaced bucket-handle tear of the medial meniscus.

Once the joint has recovered from the initial injury or insult and has regained a reasonable amount of motion, the appropriate treatment regimen should be instituted. Surgical reconstruction should be considered in patients demonstrating clinical laxity, in those expecting to return to risky activities, or in the skeletally immature. The role of diagnostic arthroscopy to make the diagnosis should not be considered.

Following reconstruction, or the decision to manage the injury nonoperatively, an appropriate rehabilitation program, a return to sport program, and a continuing PEP program should be instituted based on the patient's age, educated expectations and activity level (Table 2). MT

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COMPETING INTERESTS: None.