Surgical treatment of anterior cruciate ligament injury in adults

Anterior cruciate ligament injury is among the most common soft tissue injuries of the knee joint and reconstruction of the anterior cruciate ligament is the gold standard treatment for young active symptomatic patients. This review summarizes the surgical treatment of anterior cruciate ligament injury.

The main benefit of anterior cruciate ligament reconstruction is providing joint stability that reduces potential recurrent joint subluxations, which can result in new meniscal and/or chondral damage (Rayan et al, 2015). Athletes and young active symptomatic patients will have superior outcomes with surgical reconstruction than if they were treated non-operatively. This review discusses the various aspects of the surgical reconstruction of the anterior cruciate ligament.

Surgical treatment of anterior cruciate ligament ruptures

Primary repair of ruptured anterior cruciate ligaments showed unsatisfactory results at more than 30 years follow-up relating to activity levels and various outcome scores measured (Taylor et al, 2009). This may be related to the poor blood supply to the ligament or inhibitory factors in the synovial fluid (Kaar et al, 2011). The first attempt at anterior cruciate ligament reconstruction was performed by Hey Groves in 1915 using fascia lata (Lopez-Vidriero and Hugh Johnson, 2009). Since then, anterior cruciate ligament reconstruction has provided successful and predictable outcomes, becoming the gold standard for surgical treatment of anterior cruciate ligament ruptures (Carey et al, 2009).

Timing of anterior cruciate ligament reconstruction (acute *vs* delayed)

There is a common belief that early anterior cruciate ligament reconstruction within the first 3 weeks of injury is associated with inferior results compared to delayed reconstruction (within 8–12 weeks) because of the increased risk of arthrofibrosis and the reduced range of movement (Harner et al, 1992; Wasilewski et al, 1993; Meighan et al, 2003). However, current best evidence available from three randomized controlled trials (Meighan et al, 2003; Bottoni et al, 2008; Frobell et al, 2010) shows no difference in achieved range of movement and outcome scores at more than 1 year follow-up. Inferior results in relation to function and quadriceps power in the early group were reported in only one of the above randomized controlled trials at 12 weeks postoperatively and this was not maintained at later follow-up (Meighan et al, 2003). Other reports, however, showed a correlation between the delay in anterior cruciate ligament reconstruction and developing new meniscal and chondral lesions (Tayton et al, 2009; Chhadia et al, 2011; Demirag et al, 2011).

Surgical approach (open *vs* arthroscopic)

Anterior cruciate ligament reconstruction can be performed open, arthroscopically assisted or entirely using an arthroscopic approach. With the advancement of arthroscopic surgery over the last two decades, arthroscopic anterior cruciate ligament reconstruction has become the standard procedure (*Figure 1*) – open anterior cruciate ligament reconstruction is now rarely performed (Hui et al, 2011; Li et al, 2011).

Types of anterior cruciate ligament grafts

The ideal graft is the one that heals rapidly, provides a stable knee and has minimum associated morbidity (Maletis et al, 2007). There are three broad types of grafts often used for anterior cruciate ligament reconstruction: autografts, allografts and synthetic grafts (Li et al, 2011). Autografts commonly used include the hamstrings, bone–patellar tendon–bone and less frequently the quadriceps (Hospodar and Miller, 2009). For many years the bone–patellar tendon–bone graft was considered as the graft of choice for anterior cruciate ligament reconstruction as it provided rapid bone to bone healing and more kinematic stability than other types of grafts available at the time (Maletis et al, 2007; Sun et al, 2011). However, bone–patellar tendon–bone grafting has its own problems of donor site morbidity, risk of patella fracture, postoperative

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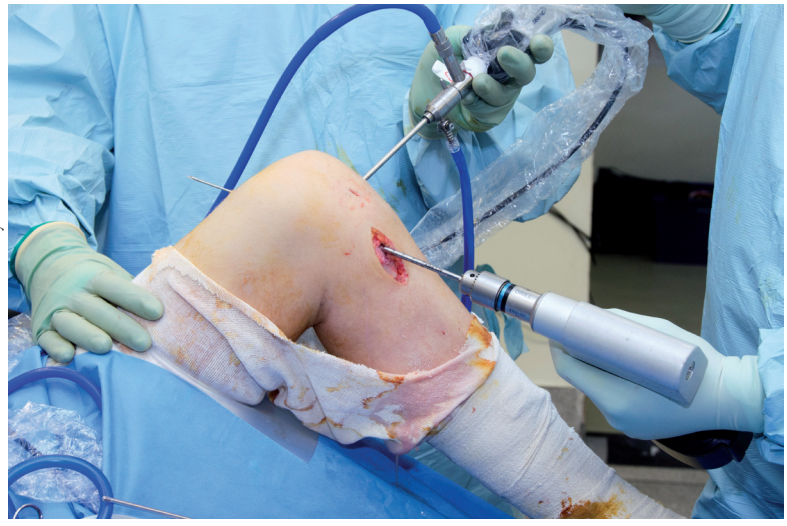
Figure 1. Arthroscopic anterior cruciate ligament reconstruction. A donor ligament is being grafted onto the torn anterior cruciate ligament to restore full function of the knee.



patellofemoral (anterior knee) pain and loss of extensor mechanism strength (Laxdal et al, 2007; Marrale et al, 2007).

More recently, owing to the advances in arthroscopic surgery and modern fixation devices, as well as the introduction of four strand anterior cruciate ligament reconstruction techniques, there has been a shift towards increased use of the hamstring tendons (Beard et al, 2001). Advantages of using the hamstring tendons include lower complication rates than bone–patellar tendon–bone grafts and improved outcomes in relation to anterior knee pain, kneeling pain and loss of extensor strength (Prodromos et al, 2005; Biau et al, 2006). Potential disadvantages include an increased risk of tunnel widening and knee laxity, weakness in deep flexion, possibility of saphenous nerve injury during following tendon harvesting, and the long period needed for graft to bone integration (Marrale et al, 2007). Other possible autogenous grafts include the contralateral patellar tendon (De Carlo et al, 1999), but this is less common in primary ligament reconstruction.

Allografts used for anterior cruciate ligament reconstruction include the patellar, peroneus, hamstring, achilles and tibialis tendons. Allografts have the advantages of reduced operative time and postoperative pain, earlier postoperative recovery, no donor site morbidity and applicability in revision or multiple ligament reconstruction (Krych et al, 2008; Hospodar and Miller, 2009). However, potential disadvantages associated with allografts include delayed incorporation, possible late failure, infection transmission, host immunological response and the increased cost (Krych et al, 2008; Hospodar and Miller, 2009). There is also conflicting evidence in the literature about whether allografts provide comparable stability and success rates to autografts (Krych et al, 2008; Carey et al, 2009; Foster et al, 2010).

Synthetic grafts made of materials such as carbon fibres, polypropylene, dacron or polyester can either be used as a graft or an augment during anterior cruciate ligament reconstruction (Legnani et al, 2010). These are rarely used nowadays because of the high complication and failure rates (Hospodar and Miller, 2009; Legnani et al, 2010). The ligament advancement reinforcement system is a non-absorbable synthetic ligament made of terephthalic polyethylene polyester fibres. It has been increasingly used with a reported good outcome (Parchi et al, 2013; Ye et al, 2013).

Biology of graft healing

After anterior cruciate ligament reconstruction, the implanted graft undergoes two biological processes:

1. Graft healing within the bone tunnel which includes inflammatory and proliferative phases
2. Ligamentization of the intra-articular part of the graft (Orrego et al, 2008; Vogrin et al, 2010).

The duration and extent of these biological reactions vary depending on the type of graft used. Graft healing takes 6 weeks for bone incorporation in a bone–patellar tendon–bone graft and 12 weeks for hamstring graft incorporation (Hapa and Barber, 2009).

Graft tensioning

Tensioning of anterior cruciate ligament grafts before graft fixation contributes to a successful surgical outcome when using a hamstring–polyester graft (Arneja et al, 2009). However, evidence from a systematic review of five randomized controlled trials did not show enough evidence to support its benefit with other types of auto- or allografts (Arneja et al, 2009).

Single or double bundle

Use of a single bundle anterior cruciate ligament graft reduces the anteroposterior instability (Schreiber et al, 2010), but is less effective in restoring rotational stability. Therefore, the concept of using double bundle anterior cruciate ligament grafts has evolved as it theoretically restores the anteromedial and posterolateral bundles of the native anterior cruciate ligament (Schreiber et al, 2010). During single bundle anterior cruciate ligament reconstruction, the femoral tunnel is drilled in a 10–11 o'clock position for a right knee and a 1–2 o'clock position for a left knee while the knee is flexed at 90–135° (Rayan et al, 2015). A tibial tunnel is prepared with the guide set at 45° with 70° inclination from the sagittal plane (Gobbi, 2010) (*Figure 2*).

For double bundle anterior cruciate ligament reconstruction, a systematic review reported a variable location of the femoral anteromedial tunnel from 10.00/2.00 to 11.00/1.00 o'clock and the posterolateral tunnel between the 9.00/3.00 and 9.30/ 2.30 position (van Eck et al, 2010). Tibial tunnels for each bundle are prepared at an angle of 60° with the entry point separated by a distance of 1.5 cm (Gobbi, 2010).

Evidence from a systematic review showed that even though biomechanical results are encouraging, subjective

patient evaluation is similar for single and double reconstructions and overall available data are lacking to allow definitive conclusions on the use of double bundle anterior cruciate ligament reconstruction techniques for routine management of patients with an anterior cruciate ligament tear (Longo et al, 2012).

Anatomical anterior cruciate ligament reconstruction

The term 'anatomical' anterior cruciate ligament reconstruction refers to the technique whereby the femoral and tibial tunnels are placed in the centre of the native femoral and tibial insertion sites (van Eck et al, 2010). However, many authors have used the same term to refer to the use of double bundle hamstring grafts as it mimics the anatomical structure of the anterior cruciate ligament (van Eck et al, 2010). For both single and double bundle anterior cruciate ligament reconstructions, it has been suggested that using the anteromedial rather than the transtibial portal for femoral tunnel drilling results in more accurate positioning of the anterior cruciate ligament graft in the centre of the native footprint (Kopf et al, 2010; Bedi et al, 2011; Bowers et al, 2011; Schairer et al, 2011; Silva et al, 2012).

Graft fixation

Important factors determining the choice of fixation device include:

1. The material of graft used, i.e. physical properties of the graft, whether it is soft tissue (e.g. hamstring) or bone (e.g. bone–patellar tendon–bone)
2. The quality of bone at the fixation site (i.e. the tibial site has less bone density than the femoral site)
3. Characteristics of the fixation device (Hapa and Barber, 2009).

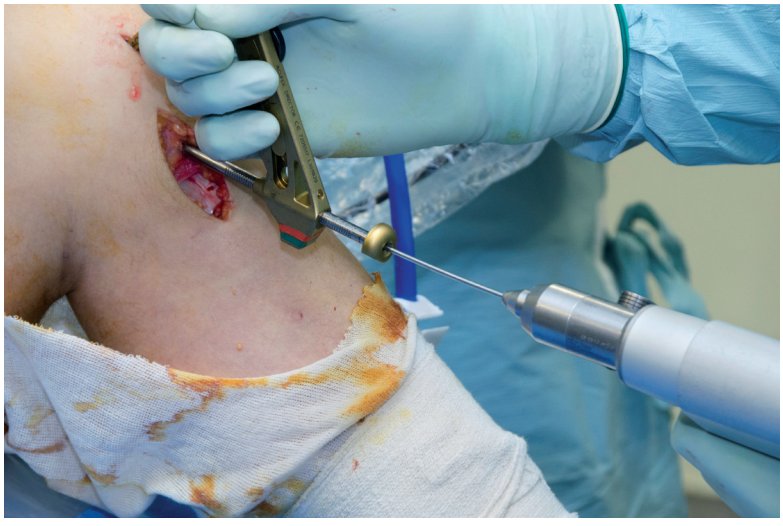
Bone plug fixation at the tibial site can be achieved using metallic or bioabsorbable interference screws, staples, sutures with a post, expansion bolts or fixation pins. Soft tissue graft fixation at the tibial site is more commonly achieved with interference screws. Biodegradable interference screws have become more popular over the last few years, as they are made of different poly-alpha-hydroxy acids so have the advantage of being magnetic resonance imaging compatible, less problematic if future revision surgery is required and produce less stress shielding. While metallic screws carry the risk of causing graft laceration, biodegradable screws have less mechanical strength and hence may provide less secure fixation than their metallic counterparts, they are more expensive and can lead to soft tissue reaction (Konan and Haddad, 2009a,b).

Fixation at the femoral site is commonly performed using an endoButton. Biodegradable and metal interference screws, cross pin fixation and other cortical suspension devices can also be used (Hapa and Barber, 2009).

Postoperative use of knee brace

Plaster casts were used in the past for knee immobilization after anterior cruciate ligament reconstruction (Andersson et al, 2009). This has been replaced widely by brace use instead with the potential benefits of improving knee extension, reducing pain and graft strain, although evidence from 12 randomized controlled trials does not demonstrate any advantage of using a brace after anterior cruciate ligament reconstruction (Wright and Fetzer, 2007).

Figure 2. Reconstruction of a patient's anterior cruciate ligament. Preparation of the tibial tunnel using a drill guide through the same incision that was used to harvest the hamstring tendons.



Complications of anterior cruciate ligament reconstruction

Anterior cruciate ligament reconstruction surgery is associated with a low risk of early postoperative complications. A study of 13 941 anterior cruciate ligament reconstructions reported deep venous thrombosis rate of 0.3%, pulmonary embolism rate of 0.18%, wound-related problems in 0.75% and requirement for a further procedure to wash out an infected knee joint in 0.25% of patients. There were no in-hospital deaths (Jameson et al, 2012). Femoral condyle fracture through the graft tunnel has also been reported (Konan and Haddad, 2010). The main long-term potential complication is graft failure, which varies according to graft type, surgical technique and the patient's activity.

Conclusions

The surgical management of anterior cruciate ligament rupture is useful for those who are symptomatic and for young adults with high physical demands (Haddad, 2014). The duration of time between injury and surgery may affect the outcome. However, further randomized controlled trials are required to provide a higher level of evidence. Autografts are suggested to provide better knee stability than allografts with a lower risk of infection transmission or immune reactions. Bone–patellar tendon–bone has been the most popular graft for many decades, but anatomical positioning of hamstring tendons with modern fixation devices provides an equivalent or superior outcome to

KEY POINTS

- Anterior cruciate ligament reconstruction provides superior outcomes for young active symptomatic patients than non-operative treatment.
- Early surgery within 3 weeks of injury can lead to arthrofibrosis while late reconstruction can result in new chondral and/or meniscal lesions.
- Using a hamstring tendon graft has lower complication rates than a bone–patellar tendon–bone graft.
- Using the anteromedial portal rather than the transtibial portal for femoral tunnel drilling results in more accurate positioning of the anterior cruciate ligament graft in the centre of the native footprint.
- There is not enough evidence to support the use of brace following anterior cruciate ligament reconstruction.

bone–patellar tendon–bone grafts with fewer postoperative complications. There is no evidence to support the use of double as opposed to single bundle anterior cruciate ligament techniques or bracing after anterior cruciate ligament reconstructions. **BJHM**

Conflict of interest: none.

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