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Personal and narrative review of the current management of the injured anterior cruciate ligament of the knee in the UK with reference to surgical treatment versus rehabilitation

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ABSTRACT

Rupture of the anterior cruciate ligament of the knee is a common injury occurring mostly in young athletic individuals taking part in pivoting, cutting and jumping sports. It is demonstrated by anterolateral rotatory instability on clinical testing. As yet there are no clear guidelines as to whom will benefit from surgical reconstruction as opposed to rehabilitation alone, apart from elite athletes (defined as varsity players or those participating in sport at national or international level). Also, some adolescent knees and those with combined injuries, usually meniscal tears, may benefit from surgery. Even after surgery there is an increased incidence of rerupture and the development of degenerative changes in the operated knee, particularly in the young athlete who has returned to a high level of sporting activity. Early diagnosis is essential to provide a focused care pathway and to avoid the consequences of chronic cruciate insufficiency. Currently, it seems that too many anterior cruciate ligament reconstructions may be undertaken where rehabilitation alone would have sufficed. Better preoperative clinical testing including improved arthrometric assessment, muscle and neurological testing and imaging including radiology and MRI may help refine the diagnosis, thus enabling a better decision on further management. There is also a requirement for better designed clinical studies reporting on the outcomes of treatment be it either surgical or conservative.

Key messages

What is already known

⇒ Rupture of the anterior cruciate ligament (ACL) is a common sporting injury.
⇒ Surgical reconstruction may benefit elite athletes with an ACL injury who are involved in level 1 sports.
⇒ Adolescents and those with certain combined knee injuries may also benefit from ACL reconstruction (ACLR).
⇒ The benefit of ACLR in older recreational sports participants is currently uncertain.
⇒ ACLR commonly involves a minimally invasive 'anatomical' arthroscopic technique and insertion of a variety of autologous grafts.
⇒ There is no clear evidence as to which autologous graft has the better outcome.

What are the new findings

⇒ Early diagnosis is essential for the successful management of the ruptured ACL, be it through either surgical or conservative methods.
⇒ Several myths have arisen over the years that are related to the management of injured ACLs. These include: indications for surgical treatment, surgical reproducibility, isometricity, ligamentisation of the graft and so-called anatomical placement.
⇒ The vast literature base is subject to a variety of biases and limitations which call for the introduction of better designed studies and more randomised controlled trials.
⇒ Targeted and more rigorous preoperative assessment than is currently usual is required.
⇒ The role of sports physiotherapists in the rehabilitation process should be given greater attention.

INTRODUCTION

Rupture of the anterior cruciate ligament (ACL) of the knee is a common injury in the sporting community. It can lead to anterolateral rotatory instability. This may manifest as episodes of giving way or functional instability during vigorous sporting activities that involve cutting, pivoting or jumping (level 1 sports such as hockey or football). Chronic instability is a problem that was commonly noted in the past in individuals with neglected knee injuries who may have experienced the knee giving way during activities of daily life. Between these two extremes are many individuals with injured ACLs who are little troubled by instability, although the knee may demonstrate laxity occasionally. These people have been termed copers while those who suffer chronic problems are non-copers or non-adapters. However, there are no clearly defined means of regularly distinguishing between the two categories

Non-copers have been identified as having deficits in muscular and neurological function and other specific anatomical features, such as an excessive posterior sloping tibial surface or a narrow intercondylar notch (notch stenosis). Gender is also a risk factor; reports indicate a two- to 10-fold increase in rates of ACL rupture in female athletes compared with males. 'At present, no single test or measurement can determine the functional status of a knee with ACL deficiency. Current passive instability tests are poor predictors of outcome following detailed rehabilitation'.[1 2]

Due to these difficulties, there is a large grey area in treating an individual with a ruptured ACL for whom the benefits of surgical reconstruction are unclear compared with a focused rehabilitation programme . This means that there are an unknown number of people who have undergone ACL reconstruction (ACLR) who may well have benefited from rehabilitation alone. This must produce a confounding effect in papers that report the results of ACLR in non-elite athletes. Hence, there is a requirement to assess this group in a more detailed manner before performing any operation.

SURGICAL TREATMENT AND MYTHS

There is a broad consensus that surgical reconstruction of a torn ACL in elite athletes of either sex who play in level 1 sports may facilitate a return to their chosen sport. Preteenage and adolescent knees do not seem to mend well after a torn ACL and therefore these young people, and patients with combined repairable meniscal and ACL tears, may benefit from ACLR.[3]

ACL injury in the Western world occurs largely due to sporting activity, usually in young individuals. Extrapolation of figures collected in other advanced Western nations indicate that its incidence in the UK must lead to approximately 200 fresh cases each year who present at district general hospitals with catchment areas of 300 000 patients. A USA study noted that peak incidence of the injury in males occurred between the ages of 19 and 25 years, and in females, between the ages of 14 and 18 years.[4] Clinicians still see chronic, cruciate-deficient knees, either because the lesion was previously missed in a casualty department setting or because that individual recovered after an injury in which the nature of the initial injury was not recognised and the individual has returned to sporting activities that involve cutting or pivoting. This series of events may lead to repeated episodes of instability and subsequent deterioration of knee joint function. It seems that, in the UK, there is a need for a specialised referral system, through which acute knee injuries that are seen in a casualty department are referred to a dedicated out-patient facility where an accurate diagnosis can be made, and a specialised care pathway implemented.[5]

Currently, the most commonly performed surgical procedures used to reconstruct a ruptured ACL employ a minimally invasive arthroscopic technique with so-called anatomical placement of an autologous implant. After ACLR, the following ideals should be fulfilled:

- Correction of rotatory and anteroposterior laxity.
- Return of a full range of motion and restoration of normal knee joint kinematics.
- Preservation of the long-term integrity of the articular surface of the joint.
- Return to preinjury levels of sporting activity.

A variety of autologous tissue substitutes are used. The most common of these is either bone patellar tendon bone (BPTB) or single-bundle or double-bundle hamstring tendon (gracilis and semitendinosus). None of these individual substitutes has yet been proven to provide a superior outcome to the others. However, more recent work has shown that a significantly higher incidence of revision surgery is required after using hamstring instead of BPTB grafts for primary ACLR, particularly in young athletes.[6]

In the UK, timing of surgery is sometimes dictated by fiscal rather than clinical considerations. This is a problem experienced in all publicly funded healthcare systems, where non-life-threatening conditions may not be prioritised. Whether the delay in performance of surgery is a disadvantage is uncertain for recreational sports participants who are diagnosed promptly. There is no clear evidence of whether operative treatment or rehabilitation alone has the better outcome in this group. Significant numbers of active people manage quite well without functioning ACLs. Elite athletes are likely to have privately funded healthcare and, therefore, the option of prompt operative management when this is indicated.

Function follows form, and it is axiomatic that restoring normal knee function after tearing an ACL demands surgery that provides accurate replication of the natural ligament if surgery is required.

Various myths relating to ACLR have arisen over the past few decades.[7 8] The first is that the five functions (see later) that are assigned to the ACL each play a pivotal role in the stability and functioning of the knee joint and, therefore, rupture of the ACL is an indication that reconstruction is necessary to avoid inevitable deterioration in knee joint function. This clearly is not the case. Even after ACLR, normal joint kinematics are not restored and, in the long term, degenerative changes may occur, especially in young, highly active patients. The challenge, therefore, is to detect those knees that are likely to benefit from surgery. Apart from elite athletes and other small, vulnerable groups, there is no consensus regarding who the owners of those knees might be, however, devising strategies to distinguish copers from non-copers could provide answers.

Another common myth that has been exploded is the concept of isometricity. This idea arose after the rolling and gliding movement of the femur on the tibial component of the knee joint was demonstrated in the two-dimensional sagittal plane during flexion and extension. The interaction between the ACL and posterior cruciate ligament (PCL) during knee movement was likened to that in a rigid, four-bar linkage system, in which the ACL and PCL acted as isometric structures. This led to the introduction of isotometers, designed to

aid isometric placement of an implant during surgery.[9] However, dynamic MRI studies clearly showed that the ACL and PCL wound around each other during knee movement, particularly during the 'screw home' phase of knee movement. This has been likened to the action of a 'Spanish windlass' that causes minimal shortening of the combined structures in terminal extension. Therefore, it was concluded that the ACL was not an isometric structure. Since then, there has been a shift from the concept of isometric placement towards what has been termed anatomical siting.[7 8]

It was also thought that, with time, following the implantation of an autograft, there was a process of ligamentisation that led to the conversion of the implant into a biological facsimile of the natural ligament. It is known that the graft undergoes an initial period of vascularisation accompanied by rapid weakening, followed by a period of cellular in-growth and maturation which is partly complete 6 months after the implantation. Proof of this process has been derived mainly from animal studies and human biopsy specimens (which of necessity must be relatively superficial). Studies that have reported on animal models also note that there is a significant difference between animal models and humans in the timescale for completion of the ligamentisation process, with a much longer time being required for human grafts. Most studies on the process of ligamentisation in human implants indicate that full restoration to either the biological or the mechanical properties of the natural ACL does not seem to be achieved.[10 11] Indeed, one significant study, which employed gadolinium-enhanced MRI after ACLR in military personnel, indicated that the graft remained avascular for up to 2 years after the operation.[12] Electron microscopy has confirmed that the ultrastructure of the implant after maturation is not the same as that of the natural ligament.[13 14]

It is also a myth that an ACL implant can be correctly placed anatomically. The term 'anatomical ligament placement' implies that the tunnels are sited somewhere within the anatomical origins of the ACL on the tibia and femur. For a single-bundle reconstruction, the recommended site is at the centre of the tibial and femoral origins. With the natural ligament the tibial origin is larger than the femoral origin and extends anteriorly. Therefore, particular care is required during fashioning of a tibial tunnel to avoid placement that is too far towards the anterior, as this may lead to implant impingement by the intercondylar notch when the knee is extended.[15–17] Also, it has been reported that tunnels, and therefore implants, that are placed in the centre of the anatomical origin of the femoral insertion of the ACL are more likely to fail than those placed off-centre.[18] Recent anatomical studies of the morphology of the ACL suggest that the ligament is a tape-like structure rather than the tapered cylinder that is described in classic texts. If true, these findings may require rethinking of the siting techniques employed in ACLR.[19] What is clear is that, after performance of ACLR with current anatomical placement techniques, normal knee joint kinematics are not restored. Point-to-point fixation of individual fibre bundles, which extend from their true anatomical origins on their tibial and femoral attachments and enable sequential tensioning throughout the ACL during flexion and extension, is not achieved. Indeed, given the highly complex nature of the anatomy of the natural ligament, it is improbable that current methods of ACLR, be they isometric or anatomical, can truly replicate its form and, therefore, its true function.

A further myth is that ACLR is always reproducible. Even in experienced hands Workshop studies and postoperative radiographs of tunnel positioning show wide variations in the placement of tunnels, particularly on the femoral side.[20–22]

CONSERVATIVE TREATMENT AND LITERATURE REVIEW

Clinicians agree that rehabilitation is necessary after ACL injury, preoperatively and postoperatively and for those patients who opt for conservative management. Precise details of the type of rehabilitation vary, but the general principles remain the same. In the coper category, in which rehabilitation may obviate the need for surgery, issues may arise with the required intensity of the rehabilitation and the patient's commitment to the programme. Failure to comply with such a programme should not be an indication that a surgical solution is necessary. The patient's expectations and psychosocial status require careful consideration. The sports physiotherapists role in managing cruciate-deficient knees should be given a greater priority than is currently the case.

The role of surgical versus conservative treatment in the management of injured ACLs was outlined several decades ago in the USA by the early pioneers of ACL injury management. Noyes *et al*[23] stated that 'the rule of thirds' came into play, such that, after an ACL rupture, 'a third of patients will require surgical reconstruction, a third will require rehabilitation that may avoid ACLR and a third will be asymptomatic not requiring surgery'. There is no question that each of these categories exists. The problem, however, is the assigning of the true percentage of patients to each category and knowing how to differentiate copers from non-copers.

Numerous articles in the orthopaedic literature report excellent to satisfactory outcomes after ACLR, but even the best series report that 10%–15% of results are poor. A recent report indicated that 86% of hamstring grafts implanted into adults during ACLR showed an overall 20-year survival rate. In adolescents, however, the 20-year survival rate was 61%, which was reduced to 22% in cases in which the posterior tibial slope was 12° or greater.[24] The paper signalled that a return to sport was a criterion for a successful result, yet it did not categorise the sports intensity level. Published studies also reveal increasing polarisation, both nationally and internationally, between those surgeons who are optimistic regarding the efficacy of ACLR in general, and those who, in more recent articles, have questioned this optimism in light of the results

of better-designed studies that have produced more rigorous data than those published in earlier years.[25] A recent umbrella review on the efficacy of commonly performed orthopaedic procedures has also questioned whether ACLR rather than rehabilitation has a better outcome.[26]

In the past, one of the drivers towards prompt surgical reconstruction after injury was the view that the ACL 'acts in synergy with all the other stabilising elements in the knee joint, including ligaments and menisci. Once the ACL is ruptured, this can lead to an uncoupling of its five modes of function (which are, in conjunction with other knee ligaments): (1) The ACL resists anterior tibial translation on the femur in flexion (assessed by the anterior drawer sign); (2) The ACL together with the PCL resists hyperextension; (3) The ACL provides a check to internal axial rotation, thereby affording rotary control of the knee; (4) The ACL acts as a secondary restraint resisting both valgus and varus forces throughout the range of knee joint flexion and (5) Tension in the ACL and PCL fine tunes the screw home mechanism of the joint as it approaches terminal extension. Repetitive cyclical loading of the cruciate deficient knee will result in the development of joint disorganisation and arthritis'. While this may be the outcome in some neglected cases, in others this may not occur, especially if the injury has been detected at an early stage and the patient is in the coper category. Prompt detection enables patients to undertake a period of rehabilitation and to modify their activities. While they may experience joint laxity, they will not necessarily experience instability, since the ACL is loaded to only about 20% of its maximum during daily life activities.[27] The challenge, therefore, is early detection. ACLR should be considered only if patients wish to return to high levels of sporting activity.

Over the past three to four decades, the number of measurements of outcomes related to ACL injury, reporting on all aspects of the management and basic sciences of the injured ACL has increased so much that the topic has become one of the most common reported in the orthopaedic literature. Despite this vast literature base, it is surprising that a consensus on the appropriate management of the cruciate-deficient knee has failed to emerge, except in cases of elite sportspeople.

A recent article that has discussed the evidence base in orthopaedic and sports medicine has stated that there is a need for 'large randomised multicentre trials that have a low risk of bias and that are powered for hard endpoints and a high level of evidence'.[8] The author argues that the evidence base for performance of orthopaedic procedures compares unfavourably with that of other specialities, as only 20% of procedures have been supported in at least one low bias randomised trial that found surgery was favoured over non-operative measures.[8]

Most reports on the medium-term results (5 years or more) of ACLR in terms of knee joint function confirm that moderate functional stability has been achieved, but often with the return of some degree of laxity, particularly rotatory laxity, which is often termed a tibial slip. A satisfactory range of motion and restoration of function is also reported. However, a report on rates of return to sports among people who had undergone ACLR indicated that only 50% of these people were able to achieve their preinjury levels. Reinjury rates of the ACL among people who had previously undergone ACLR were up to six times greater than rates of primary ACL rupture.[28] There is also a higher reinjury rate in female athletes who have previously ruptured their ACLs when compared with primary injury rates and a greater risk that a second injury will occur in the contralateral knee.[29 30] Generalised joint laxity, particularly when accompanied by hyperextension, has also been reported as a risk factor for reinjury.[31] ACLR does not restore normal proprioception to the knee, nor can it reproduce the multistranded structure of the natural ACL. There is no evidence either that normal knee kinematics are restored. Some medium-term and long-term studies report signs of joint degeneration in knees that have undergone ACLR, particularly if the individual has returned to a high level of sporting activity. Therefore, can long-term preservation of a healthy intra-articular environment be expected after ACLR? Indeed, are the criteria by which both patients and physicians regard their ACLR as a success, and which are mentioned above, being met?

Additional uncontrolled variables contribute to outcomes after ACL injuries, which include associated meniscal trauma and chondral lesions. As already mentioned individual proprioceptive adaptability and variable anatomical morphology, may also partly explain the conundrum of the copers vs non-copers. Bone bruising of the femoral condyles, often noted on MRI after a so-called isolated ACL injury, may contribute to the development of chondral lesions. This finding raises doubts about whether an ACL injury is ever an isolated event.

DISCUSSION AND BIAS DETECTION

The reaching of a consensus on the best treatment for individuals with a ruptured ACL is confounded by a large volume of sometimes contradictory studies that have been reported in the orthopaedic literature. For example, favourable results on ACLR in elite athletes that were reported in a systematic review and meta-analysis[32] were contradicted by further studies that showed poorer outcomes in this group.[33] Other studies may have suffered bias that arose from poor study design. Observer bias may account for up to 15% of favourable results because they are reported by the team involved. Therefore, these studies should be conducted by independent observers. Detection bias may arise when success is defined according to variable knee-scoring systems, however, there is now some agreement that post-operative results should be scored through use of standardised scoring systems such as the Lysholm or Tegner, devised by the International Knee Documentation Committee, or the more recently introduced Knee

Injury and Osteoarthritis Outcome score. Susceptibility bias occurs when there is a pooling of results for patients with fundamentally different prognoses, such as young athletic individuals versus occasional middle-aged skiers. Stratification based on their prognoses is required. Performance bias can arise when researchers pool results for cases in which different surgical techniques and rehabilitation programmes have been employed. Transfer bias occurs when unknown subsets of patients are lost to follow-up, which creates a false impression of either success or failure in those available for review. Finally, confirmation bias is enabled by the plethora of studies that are available that relate to the ACL; such a large number of studies allows the researcher in question to select papers that support preconceived notions.

There can also be a confusing disconnection in terms of results, between surgeon-based clinical tests and scores and patient-based assessments. For example, paradoxically a return of some degree of laxity is not necessarily matched by a decline in postoperative patient satisfaction. However, surgeons may not regard a return of any degree of laxity as a satisfactory outcome; one of the authors of this article took the view that there was a close correlation between the return of even a modest degree of laxity, often euphemistically called a 'glide', and a patient's ability to return to sports. Several researchers in their articles have emphasised the need to consider determinants of patient satisfaction and its correlation with the objective measurement of knee laxity.[34]

While there is a general call for evidence-based practice in all branches of medicine and surgery, its provision in the case of the injured ACL presents problems. This is partly due to the aforementioned factors and because dedicated clinics that can review postoperative progress over a long period are hampered by the poor recall of patients in what is a transient population, thus leading to transfer bias. Furthermore, in publicly funded healthcare systems with scarce resources, the cost implication of funding these clinics means that they are unlikely to be a priority. To build a strong evidence base, information from many centres should be collected over a long period along the lines of the Swedish ACLR review, provided that the possibility of performance bias is factored in. Setting-up of randomised controlled trials (RCTs) is difficult but would seem necessary to provide answers for the long-term management of injured ACLs.

SUMMARY

Current ACLR techniques do not result in truly anatomical reconstruction. Difficulties arise with bony tunnel fixation. The positioning of these tunnels and the nature of the various devices that are employed to fix grafts do not allow precise anatomical siting that mimics the individual bundle orientation and biomechanics of the natural ligament.[35–37] Current techniques that are used in ACLR may have reached an impasse, notwithstanding the ongoing debate on the relative merits of single-bundle versus double-bundle hamstring tendon reconstruction.[38 39] Recent work on the anatomy of the ACL has indicated that it is a tape-like structure; if this proves correct, current surgical techniques may require modification in order to take into account graft shape and its intra-articular fixation.[22]

After an injury of the knee that results in ACL rupture anterolateral rotatory instability must be demonstrated clinically in order to determine what treatment is necessary. However, the presence of the instability is not a clear indication that an ACLR is necessary. Maffulli and King stated in 2003 that there were no absolute indications for performance of ACLR surgery; this remains true today, although the relative indications outlined above suggest that performance of the operation could benefit young elite athletes.[40] A study undertaken at Lund University in Sweden indicated that as many as 60% of ACLRs were probably unnecessary.[41] An RCT that compared the results of operative with non-operative treatment indicated that 2 years after the injury, all the patients who had undergone an ACL rupture and had not received surgery had been treated successfully.[42] Those with injured ACLs who undergo ACLR must accept that there is no evidence that the operation will lead to restoration of normal kinematics or proprioception. The anatomy of the natural ligament is not replicated and, in the long run, there is the chance that the reconstructed joint will develop degenerative changes, especially in highly athletic, active, young people.

It has been emphasised in this article that recognition and diagnosis of rupture of the ACL at the earliest possible moment is essential. After that there is a need for a clear clinical pathway to distinguish copers from non-copers. If surgery is being considered, a rigorous and targeted preoperative assessment of the knee joint is required. Such assessment should include imaging (X-ray and MRI), measurement of arthrometric laxity, examination of neurological and muscular function and the general anatomy of the joint, and consideration of the injured person's gender. Paradoxically, the musculoskeletal features of the knee that are at risk in non-copers must surely increase the risk of further injury after ACLR. Therefore, is ACLR indicated for patients in the non-coper category?

Focused rehabilitation by sports physiotherapists must be clearly defined and applied to all patients with cruciate-deficient knees. ACLR should be reserved for a small number of individuals who have combined ACL and meniscal injuries or who play sports at a high level of activity and are likely to experience repeated episodes of instability if their knee is not reconstructed. All interested parties must also accept that ACLR alone does not protect against possible future development of traumatic, degenerative changes in the operated joint and that there is a significant risk of reinjury.

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