Anterior Cruciate Ligament Revision Surgery: Surgical Techniques

Author:

DAVID P JOHNSON
MB ChB FRCS FRCS(Orth). MD

Spire Glen Hospital, Redland Hill, Bristol BS6 6HW. UK
Appointments: 0117 970 6655
E-Mail: boc@orthopaedics.co.uk
Web site: www.orthopaedics.co.uk

Key words: Revision ACL surgery, rupture of ACL graft, revision ACL reconstruction, bone graft, ACL, anterior cruciate ligament, knee injury, ACL reconstruction, hamstring tendon graft, knee reconstruction, knee ligament, arthroscopy, Bone patellar tendon bone graft, graft fixation, kurosaka screws, ACL screws, interference fit screws

The number of primary Anterior Cruciate Ligament reconstruction is increasing exponentially. There is better recognition of the injury of Anterior Cruciate rupture in the clinical situation and increasing recognition of the long term consequences of instability, including stretching of the secondary restraints, articular damage, degeneration and restricted function. This has resulted in an exponential increase in the number of primary reconstruction procedures. Inevitably because of the increasing numbers and increasing numbers of surgeons undertaking this procedure, this leaves the increasing problem of increasing numbers of failed anterior cruciate ligament reconstructions and revision procedures.

There are some parts of the primary surgical technique, which if not undertaken corectly inevitably result in failure of the reconstruction. These principally include placing the anterior tibial tunnel too far anteriorly, an anterior femoral tunnel placement, loss of ligament fixation or capture of the knee due to over-constraint or incorrect tunnel positions. These problems are in addition to the various other complications general and specific associated with this surgical procedure.

The surgery of revision anterior cruciate ligament includes detailed pre-operative assessment and planning. An clinical assessment of the patient's symptoms, history and clinical signs is necessary. A review of the patient's lifestyle, activities, aspirations and restrictions in function must be analyzed to identify achievable goals, benefits and the risks of further surgical intervention. A review of the previous surgical history and

charaterisation of the precise procedures previously undertaken is vital. Further investigations include, radiology including weight-bearing and alignment leg views, an MRI Scan and a Radioisotope bone scan if necessary.

The surgical principals of revision ACL reconstruction can best be understood in simple steps; first the initial removal of the foreign material present in the knee, secondly reconstruction of the anterior cruciate ligament, and thirdly addressing the secondary restraint laxity. Any revision, however, is prone to failure unless additional attention is given to overall limb alignment and, in particular, detecting a varus thrust and the presence and extent of any arthritic changes.

Analysis of the metal work detected on the radiograph or from the details of the prior procedures will determine the type of metal work present, determination of the manufacturer, and identification of the appropriate introducer and screwdriver, which must be obtained for the revision procedure. An analysis of the position of the metal work is necessary in order to determine the ease of extraction of the fixation device. Estimation should be made as to the size position and nature of the resulting tunnel in order to determine whether it will accept a further ligament. Determination must be made as to whether the metal work was inserted arthroscopically or through an open incision. If inserted through an open technique arthroscopic removal may prove to be problematical. Analysis is necessary of any tunnel widening present on the radiograph or MRI, to determine if the insertion position and fixation of the ligament will be satisfactory. Tunnel widening is particularly applicable if hamstring tendon grafts have been previously used.

Removal of some Kurosawa Screws can be problematic. The Arthrex “Easy in, Easy out” self-tapping screwdrivers are of great assistance, but even these on occasions may in my experience fail or snap.

Removal of cortical fixation devices such as staples, togs and other metallic fixation may be very difficult to extract. This may not be possible through a minimal incision and removal may result in damage to the tunnel or cortex. These defects especially following staple removal may on occasions lead to a fracture.

The increasing use of Bio-Absorbable Fixation Screws makes the assessment and management of the failed primary procedure much easier. The MRI is not distorted by the substance of the screw and the accurate position of the screw and tunnel can be determined. As with many types of Poly-lactic Acid Screw re-absorption takes place within 3 – 5 years if at all. The screws, however, may be largely ignored during the revision procedure and further drill holes made through the bones with thorough irrigation to remove the resulting particulate, crystalline debris.

The next stage of consideration and pre-operative planning is the removal of any graft material. If this is an autogenus graft this may usually be ignores and left in situ or removed without further problem. However, removal of synthetic graft material may present more of a difficulty. The ABC Dacron augmentation device was initially fixed at both ends and subsequently only at one end. This was demonstrated not to confer any increased stability on the knee, however, the intra-articular Dacron does require excision during the revision procedure. My own preference is the remove the cortical staple device and then attempt to extract the usually ruptured and redundant augmentation device from the tibial or femoral tunnel. Once this is achieved then to thoroughly remove any intra-articular debris, particularly paying attention to the thin strands of Dacron which may not easily be removed by the articular shavers.

The Stryker Dacron ligament was a thick, stiff structure with central cores of Dacron and a loose outer coating mesh. Fibrous in-growth to the graft and substitution was claimed but histologically this only occurred into the loose peripheral mesh and the central cores were never incorporated, therefore, mechanical failure is an almost inevitable result. These can usually be removed from intra-articular tunnels although some difficulty can be made with a mechanical interlock on the loose fibrous covering. Particular attention must be made to remove all intra-articular and intra-tunnel material to avoid synovitis and facilitate incorporation of any revision grafts. As with all synthetic grafts tunnel widening in a fusiform pattern is often encountered. This is due to a tissue reaction to the material and surrounding infiltration and fibrosis. Tunnel widening in a cornet of funnel shape may also occur because of the lack of graft incorporation into the tunnel and the so called ‘windscreen wiper’ effect during knee flexion when the graft

may move or flap in the tunnel. This is analogous to the 'ice cream cone' or 'funnel' widening commonly found in hamstring reconstructions.

The Leeds-Keio ligament although more successful than some synthetics, was recently shown to be susceptible to a high and unacceptable rate of failure. Removal of the inter-tunnel portion of this graft is more difficult particularly if a bone block was used to fix the graft. In this instance the intra-articular and extra-cortical portion of the graft is excised with sharp dissection. It is my preference then to ignore the inter-tunnel incorporated portion of the graft and remove any displaced intra-articular fragments carefully after re-drilling of fresh intra-articular tunnels.

In my experience the removal of Carbon Fiber grafts has presented a major and significant problem. In particular in relation to the Jenkins-Carbon Fiber graft. The graft filaments are brittle, disrupt and form a dense, florid, carbon-fiber particulate synovitis. Removal of the graft results in more intra-articular debris and a synovectomy is commonly necessary. I have experience of several cases of chondrolysis occurring following use of this ligament. I know of two cases undertaken at other centers where this has disastrously resulted in early knee arthroplasty. The technique for the removal of this ligament should be excision of the intra-articular portion. It is my preference not to use articualr shavers as this tends to produce more particulate debris. However after removal of the ligament, the shaver is used with thorough irrigation for knee debridement and synovectomy. It is my preference to excise all the intra-tunnel and extra-articular portions of carbon-fiber through multiple small separate incision. This must be done as a separate stage to the revision procedure as particulate inflammation of the wounds is common which can take some time to settle.

Once all the particulate material and metalwork has been removed, consideration should then be given to a thorough synovectomy if necessary. As stated this should be routine in association with removal of carbon fiber grafts, and to a lesser degree where a Dacron or Goretex graft was used. Chondrolysis must be detected early and early graft removal, thorough irrigation and synovectomy undertaken.

At this stage when all extraneous material has been removed, attention can be given to repair and reconstruction of the knee. This must include consideration of the previous surgery and further management of the menisci, articular surfaces, leg alignment, collateral ligaments and secondary restraints. The bone tunnel position, widening and size should be addressed to determine whether these should be bone grafted as an initial procedure with a secondary revision ACL reconstruction. It is my experience that rarely can the original tunnels be used without compromise to the stability and functional outcome.

In terms of meniscal surgery, meniscal preservation must be undertaken if at all possible in order to delay the onset of degenerative changes. The meniscus is also important as a secondary restraint. This applies particularly to the posterior horn of the medial meniscus and thus repair is preferable. Although the new Bio-absorbable meniscal arrows and tacks are extremely user friendly, quick and simple to use. It is my experience that they are not without their own particular problems. Persistent tenderness over the repair site due to prominent arrows is common and in my experience the failure rate with these devices is significantly higher than with the traditional arthroscopic inside-out suture technique. In these revision cases where the menisci are somewhat degenerative, friable with a reduced healing potential, it would be my suggestion that the traditional arthroscopic intra-articular suturing techniques are preferable to the easier and simpler use of intra-articular arrows and darts.

The recent reporting of meniscal transplantation has in my opinion been much overstated to the detriment of the public and unrealistically raising the expectations of many patients. Meniscal transplants are not applicable in the unstable knee. Neither is it applicable in the degenerative knee. The early work by Warren and others demonstrated a very high failure rate when this technique is used in the degenerative knee. The indications for meniscal transplantation are; persistent pain following total menisectomy, the secondary benefit is the improvement in stability. It is not successful in the unstable knee nor is it capable of improving patient function and allowing the resumption of competitive sporting activities as has been widely publicised, promoted and advertised recently in some places.

Meniscal collagen scaffolds are still highly experimental at the present time and may be able to provide a scar tissue buffer, but have as yet been unable to show significant function, load distribution and protection against degenerative wear.

Articular surface damage is common in anterior cruciate ligament lax knees. Although a smoothing type chondroplasty can easily be undertaken simultaneously to the revision ACL procedure. However more significant defects may require further more invasive and significant management. The micro-fracture technique may be suitable for small, contained defects and may be an innocuous procedure. There is however very little peer review literature that shows this procedure to be effective. It is my experience that in certain weight bearing convex areas of the knee such as the femoral-tibial joints, and in particularly for bipolar lesions affecting the tibial and femur, that this procedure is ineffective. More significantly, Osteochondral Transplantation OATS may be required and undertaken. I have undertaken some 30 of these and to a great extent with some considerable success. None the less my latest patient sustained a deep infection and a initially had a compromised result. Chondrocyte transplantation has in the literature often been combined with a stabilising procedure, the technique would only be expected to be successful in a stable knee in the absence of excessive sheer forces and instability. It is interesting to note that within the multi-centre international study some 75% of patients had simultaneous significant surgery such as anterior cruciate ligament reconstruction. Although significant improvement was noted in these cases, as yet the improved results have not been shown to be due to the osteocyte transplantation rather than the stabilizing procedure.

We have already discussed the assessment of tunnel placement. This must be undertaken after removal of the previous graft and fixation devices. It is not uncommon that the site of the tunnel in the initial procedure is such that a completely separate femoral tunnel can be placed behind the original tunnel. This can only be successfully undertaken if an intact circumferential rim of the new tunnel can be obtained. If this can be achieved then the original tunnel need not be disturbed. It is not uncommon, however, that the original tunnel has widened, particularly following use of hamstring grafts with non-anatomical cortical fixation, or following removal of metalwork. In these cases anatomical fixation is vital in the revision situation, and consideration should be given to bone grafting of the tunnel opening as an initial procedure. When undertaking bone grafting to the tunnels a separate procedure is necessary with an interval of 6-8 weeks for incorporation before the index revision procedure. The bone of tunnel grafting may be obtained from a local site such as the distal femur or proximal tibia. When a more substantive graft or dowel is needed then a pelvic graft may be used. The core-reaming device by Arthrex may be useful to harvest a measured cylindrical core, which may be plugged into the defect. It is my experience that such bone graft insertion may be undertaken arthroscopically, allowing rapid rehabilitation of the patient, no loss of motion and subsequent anterior cruciate ligament revision at 6 – 8 weeks.

The revision procedure for anterior cruciate ligament reconstruction can often be undertaken arthroscopically. This requires the specialist arthroscopic anterior cruciate ligament equipment and trained personnel. The harvesting of the revision graft has already been described and maybe ipsi-lateral or contra-lateral patella tendon, hamstring tendon from the ipse-lateral or contra-lateral side or allograft materials. It is my preference that if the ipse-lateral hamstring tendon has been harvested then to use the ipse-lateral patello-tendon graft, whereas if the ipse-lateral patello-tendon has been utilized then the contra-lateral patella tendon graft is used. The increased strength and security associated with fixation of the patellar tendon graft in the revision situation is preferable. The success of the use of contra-lateral patellar tendon grafts has been reported by Bartlett amongst others. When using this technique the patients are warned that the contra-lateral harvesting site may be the more troublesome and painful in the first three months. However this has the advantage of allowing rapid pain-free mobilization of the revision knee and importantly the restitution of full extension at an early stage. Further it is my practice to use anterior cruciate ligament stabilizing braces in revision cases where indicated. Using the contra-lateral tendon allows the use of such a stabilizing brace for a two to three week period. This has the effect of protecting the graft during the early rehabilitation programme.

My rehabilitation programme for anterior cruciate ligament revision is otherwise as for the primary case. Early rapid mobilization is undertaken. This includes full extension post-operatively. Extension exercises from day one. Patients undertake an active range of motion and CPM post-operatively. This is not

restricted by a restricted range of motion brace. Patients are mobilized full weight bearing as tolerated and office work at two weeks, returning to static cycling and driving at four weeks, hydrotherapy at four weeks, gentle crawl swimming at six weeks, weight training at six weeks in a closed fashion and jogging at three months. As described for revision cases during the early introduction of any new activity an anterior cruciate ligament stabilizing brace is utilized.

During the surgical procedure the proposed tibial tunnel should be carefully assessed and it's position and length measured prior to drilling. the tunnel should be at least 30 mm in length. Angling the aiming device to 50 degrees rather than 45 degrees, is helpful at increasing the length of the tibial tunnel. The guide-wire should exit through the original anterior cruciate ligament stump. It is my preference that this should be through the anterior third of the stump, thus allowing a tendon graft to exit through a position in the center of the original anterior cruciate ligament stump. After placement of the guide-wire the notch clearance must be measured in full extension. The tibial hole is then drilled and once again the notch clearance is then checked. This should be fashioned such that the graft will be snug against the notch but not impinged by the notch in full extension. This avoids the increasingly common problem of the tibial tunnel placed to far posteriorly and an ineffective graft, or of graft impingement, fixed flexion and anterior knee pain.

Inserting and passing the graft may be aided by rotation of the bone block or hamstring tendons. The graft should be passed across the knee whilst the knee is flexed at 90 – 120 degrees. A pusher used to advance the patella tendon bone block may be helpful.

The femoral tunnel should be fashioned by using a guide measuring from the posterior cortex. The posterior aspect of the femoral tunnel should be within 1 mm of the posterior cortex but not such that the tunnel 'blows out' through the posterior aspect. Isometric measurement is not formally checked at this stage, however, any surgeon undertaking revision anterior ligament surgery should be perfectly familiar and should have experience of isometric measurement and understand the optimal centre of the proposed femoral tunnel. The position chosen must be centered in the superior lateral wall. Increasingly using the arthroscopic technique superior placement in the notch is a common fault. Using a patella tendon graft the cortex of the graft should be rotated posteriorly in the tunnel. This has the effect of placing the graft more posteriorly which proves to be more anatomically orientated and gives a better isometric result. The intra-articular anatomical fixation device should be placed superiorly or superiorly posterior if possible. This is facilitated by flexing the knee fully to 120 degrees during its insertion. For hamstring revision surgery adequate fixation may dictate that in addition to cortical non-anatomical fixation may require secondary supplementary anatomical fixation; thus two fixation devices may be necessary.

Fixation of the graft must be undertaken securely and should be anatomical. Metal Kurosawa screws are my preference due to the improved pullout strength, self-tapping ability over the Bio-absorbable Screws.

Prior to tibial fixation the graft should be adequately tensioned and moved repetitively through a full range of motion and the effect on the isometry of the inserted graft and the knee stability measured. The procedure must be considered unacceptable if the isometric displacement is greater than 2 mm or the stability inadequate. the isometricity may be altered to some degree by rotation of the grafts within the tunnels and the stability by re-tensioning the graft. It is conventional and has been shown by Hurtle amongst others that rotation of the inta-articular portion of the graft between 90 and 120 degrees improves its isometric replication and strength. Fixation of the tibial site should be undertaken using a 9 mm screw. The pull out fixation strength on the tibia is less than that on the femur and therefore the larger screw with improved strength should always be used. Better fixation can be achieved if this placed on the anterior cortical side of the tibial bone block of patellar tendon grafts. If this fixation proves insufficient then alternative or supplementary fixation with a post or stable may be necessary.

At the end of the procedure arthroscopic anterior cruciate ligament revision reconstruction should result in a graft with stable fixation, both in flexion and extension, allow a full range of movement, there should be a negative Lachman and Anterior Draw Test. Having undertaken the revision procedure arthroscopically, the scars should be minimal and the patient should be able to undertake the rapid rehabilitation program normally.

In association with chronic instability there are many reasons for medial knee degeneration and various mal-alignments. The varus mal-alignment is very destructive to anterior cruciate ligament reconstruction and is associated with an increased instance of failure. The varus may be of three types; primary, secondary or tertiary varus. A primary varus deformity may be due to a congenital, traumatic or degenerative medial condition. The degenerative medial condition is common with chronic anterior cruciate ligament laxity. Secondary mal-alignment can occur due to antero-lateral instability associated with anterior cruciate ligament rupture. The tertiary varus instability occurs in patients who have a lateral thrust on weight-bearing. The lateral thrust is resisted by the anterior cruciate ligament in association with the lateral and postero-lateral structures. It has also been reported that such a tertiary lateral thrust produces a high instance of failure in anterior cruciate reconstruction. Therefore, this must be addressed particularly in the revision situation and consideration given to undertaking a high tibial osteotomy.

There are two reports in the literature describing a high tibial Osteotomy in association with anterior cruciate ligament reconstruction. One which I reported in 1993 with Michael Mansfield, looked at simultaneous High Tibial Osteotomy and extra-articular Anterior Cruciate Ligament reconstruction. The results demonstrated that whilst the extra-articular reconstruction did not confer stability on the knee, the High Tibial Osteotomy relieved pain, decreased the subjective instability that patients complained of and allowed 50% of patients to return to active sporting activities despite significant degenerative changes. The conclusions of this study and larger study undertaking by Noyes et al, demonstrated that early High Tibial Osteotomy to correct primary, secondary or tertiary varus instability was an important factor. It was commonly experienced that once patients had undergone a High Tibial Osteotomy, they regained subjective knee stability and improved their function. This occurred to such a degree that anterior cruciate ligament reconstruction as a secondary procedure was not always necessary. It is, however, possible to combine a High Tibial Osteotomy with simultaneous intra-articular anterior cruciate ligament reconstruction in special circumstances.

Postero-lateral instability has been demonstrated to reduce the success of anterior cruciate ligament surgery. The postero-lateral structures are often stretched out as a secondary event in chronic instability. There are three main principals for the late reconstruction of the postero-lateral knee structures. The first and perhaps most commonly used is the advancement of the postero-lateral capsule or Arcuate complex, is perhaps the simplest and least invasive procedure. This can easily be undertaken simultaneously to anterior cruciate or posterior cruciate ligament reconstruction. Augmentation of the damaged postero-lateral structures may be undertaken, using autogenus or allogenic material to supplement the lateral collateral ligament and posterior-lateral capsule. Thirdly, a formal reconstruction of the lateral collateral ligament can be undertaken by a patellar tendon graft or biceps advancement to the lateral epicondyle of the femur. Popliteus advancement or recessing into its bed may be undertaken. The Popliteus has also been reconstructed using the Semitendonosis tendon. It should be noted that the High Tibial Osteotomy in a Varus knee has the effect of protecting the lateral and postero-lateral as such, possibly making the subjective instability less and protecting these structures. Therefore, I must stress the importance of the leg alignment in any patient with postero-lateral instability.

With all these considerations in mind as to what may be necessary during anterior cruciate ligament revision surgery it can clearly be seen that pre-operative planning is essential and careful consideration must be given as to whether this should be undertaken as a single or two stage procedure. Those problems which can easily be catered for within a single procedure include, meniscal repair, micro-fracture techniques, removal of arthroscopically placed Kurosawa Screws or Bio-absorbable fixation screws. The previous use of a bone/patella/bone graft without tunnel widening and a minor degree of postero-lateral rotary instability.

Those conditions present which require a two stage procedure, tunnel widening or the requirement for bone grafting, the previous use of carbon fibre, the necessity of a high tibial Osteotomy; the need for a medial collateral, lateral collateral ligament reconstruction or an osteo-chondral Transplantation will usually require a two stage procedure.

In such cases degenerative changes are commonly encountered. There are many causes of degenerative changes in such patients including; initial articular damage or subsequent damage due to

persistent instability, meniscectomy, capture and over restraint of the knee, and chondrolysis or recurrent laxity. It is reasonably expected that stabilization of the knee may reduce the progression of any degenerative change but is only one part of the overall management and specific measures to address the articular degeneration may be necessary.

One specific type of revision reconstruction has been undertaken on two occasions by myself. This involves a patient with an intact but lax patellar tendon anterior cruciate reconstruction. The patients, have sustained laxity of the intact graft due to a failure of fixation within the tibial tunnel and slippage. In one particular 17 year old patient this was probably sustained when he returned to casual soccer against advice, only six weeks following surgery. Using the Arthrex Core Reamer over a guide wire, the tibial bone block was mobilised with the attached ligament. This was re-tensioned gaining some 5 mm displacement, and re-fixed using a Kurosawa type Screw. This enabled rapid rehabilitation, early return to normal activities and sport. The KT 1000 assessment on this particular patient reduced from 7mm to 3 mm.

This particular case is presented from another center as an example of some of the very difficult problems one can face in revision ACL surgery. This 30 year old plumber with a wife and newborn child presented with a 13 year history of problems following a bilateral anterior cruciate ligament rupture and carbon-fiber reconstruction. Perusal of the medical records suggested that both ligaments failed at an early stage and the patient continued to suffer from instability, pain and swelling. Various biopsies were taken which demonstrated a particulate carbon synovitis but other than further arthroscopy nothing had been undertaken. The patient presented with right knee, pain, swelling and instability. On this particular knee the carbon fibre knot on the medial side of the knee measured some 7 cm by 4 cm and required removal of the intra-articular portion and the circumfrential circlage of carbon fibre. Bone grafting of the tunnels was undertaken. Subsequently a successful second stage revision patellar tendon graft reconstruction of the knee was undertaken.

Unfortunately this MRI scan was taken of his contra-lateral side which had also undergone carbon fibre reconstruction at the same time, had in a similar way failed at an early stage and resulted in chronic, pain swelling and instability. Severe chondrolysis occurred and this is the MRI Scan when he presented aged 30. The scan demonstrates complete absence of articular cartilage in the knee, subchondral oedema, cysts and a very significant global arthritis. Although the carbon fibre was removed from this knee it was considered that revision reconstruction would not beneficial. As was predicted due to progressive pain and disability he underwent a total knee replacement aged 32 years.

Therefore, with such significant surgery as commonly encountered in revision Anterior Cruciate Ligament Reconstruction, one must remember that no joint is so bad that it cannot be made worse with surgery. These procedures should probably be reserved for those surgeons with considerable experience and expertise in dealing with the varied and complex problems.

Please visit www.orthopaedics.co.uk for more information.

DAVID P JOHNSON
MB ChB FRCS FRCS(Orth). MD

Spire Glen Hospital, Redland Hill, Bristol BS6 6HW. UK
Appointments: 0117 970 6655
E-Mail: boc@orthopaedics.co.uk
Web site: www.orthopaedics.co.uk