British
Orthopaedic
Association

Best Practice for Management of Anterior Cruciate Ligament (ACL) Injuries

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BOA, BASK, BOSTAA Elective Care Standards:

Best Practice for Management of Anterior Cruciate Ligament (ACL) Injuries

British Association for Surgery of the Knee (BASK) and British Orthopaedic Sports Trauma and Arthroscopy Association (BOSTAA) have collaborated to commission a committee to produce best practice guidelines on the management of Anterior Cruciate Ligament (ACL) injuries. The Guideline Development Group (GDG) is made up as follows:

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DISCLAIMER

The recommendations in this guideline represent the view of the GDG, arrived at after careful consideration of the evidence available. It represents a consensus statement from The British Association for Surgery of the Knee and the British Orthopaedic Sports Trauma and Arthroscopy Association. It is hoped that this Guide will inform surgeons, hospitals and commissioners in making decisions about the care and management of patients. When exercising their judgement, professionals are expected to take this guideline fully into account, alongside the individual needs, preferences and values of their patients or service users. The application of the recommendations in this guideline is not mandatory and the guideline does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient, in consultation with the patient and/or their carer or guardian.

FOREWORD

We are delighted to support the dissemination of this document on best practice for management of anterior cruciate ligament injuries. These are extremely important injuries that affect more than 20,000 active individuals in the UK every year. Timely and appropriate management is critical to allow patients to regain their quality of life and activity and to try and help them to preserve function. The clinical guidance in this document spans the entire patient pathway and will act to improve care at all stages.

This document represents a collaboration between the British Association for Surgery to the Knee and the British Orthopaedic Sports Trauma and Arthroscopy Association with renowned experts summarising the current literature and current thinking and highlighting optimal management strategies. The work had been supported by the British Orthopaedic Association and is an important contribution to the growing body of best practice guidance developed with their help. We hope this will be one of several ongoing collaborations between the respective specialist societies and that it will benefit surgeons, allied practitioners and most importantly our patients.

Fares Haddad, President of BOSTAA

Andrew Price, President of BASK

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Summary of Audit Standards

1. Patients with haemarthrosis, following an acute knee injury, should be assessed by a clinician proficient in assessment of knee injuries. This should be in form of an Acute Knee injury clinic led either by a surgeon, a physiotherapist or a suitably trained doctor or allied professional.

a. This assessment should be done within 2 weeks of presentation, so as to identify injuries requiring urgent treatment.

b. Urgent access to imaging facilities should be available from this clinic. Magnetic resonance imaging (MRI), reported by a musculoskeletal radiologist, remains the imaging modality of choice to assess for ACL injury and associated internal derangement.

c. All coexisting injuries should be identified and documented, following imaging and repeat assessment, as required.

d. A management plan should be made in consultation with the patient after discussion of the treatment options, both non operative and operative.

2. The prime indication for ACL reconstruction is symptomatic instability. The decision for early surgical reconstruction vis a vis trial of non-operative treatment should be individual to each patient.

3. All patients being considered for surgery should be offered prehabilitation to recover knee movement and quadriceps strength.

4. Surgery, if considered, is usually performed when the knee is “quiet” with no swelling and a full range of movement, particularly extension, has been restored.

5. Patients with an unstable and repairable meniscal lesion in combination with ACL insufficiency should be ideally offered early combined meniscal repair and ACL reconstruction. Staged meniscal repair followed by later ACL reconstruction is acceptable in the case where the patient presents acutely with a locked knee associated with an ACL rupture and to allow the reconstruction to proceed when the knee has regained full extension or when suitable surgical expertise is available.

6. ACL injuries in patients who have not reached skeletal maturity and multiligament injuries should be managed by surgeons with an interest in the field.

7. **Consent**

a. Non-operative and operative options should be discussed. The benefits, limitations and likely outcome of each should be discussed and recorded. The general risks of surgical intervention together with the specific risks of reconstructive surgery should be discussed and documented. Risks of persistent instability and reinjury, including to the opposite knee should be discussed. Patients should be advised on timing of return to sports, which should be specific to the individual, but should rarely be less than 9 months after surgery due to higher risk of reinjury.

b. Graft selection should be discussed including autograft, allograft and synthetic ligaments. This should include the benefits, complications and risks of all and the preferred graft

recommendation.

c. The management of chondral and meniscal pathology should be discussed together with the implications on post-operative recovery.

d. Consent for inclusion into National Ligament Registry should be sought and patients should be registered in its database. Hospitals should facilitate the accurate recording of surgical procedures and patients' outcome by providing appropriate clerical and IT support.

8. **Surgery**

a. The procedure should be performed on a Day Case basis, for majority of patients. The surgery should be performed by or under supervision of a surgeon with special interest in soft tissue knee reconstruction.

b. Local anaesthetic infiltration, adductor canal block or femoral nerve block may be used for perioperative pain relief. When hamstring graft is used, harvest site should be infiltrated with local anaesthetic.

c. Pharmacological VTE prophylaxis is not indicated as a routine. However, all patients should be risk assessed upon admission to hospital. In high risk cases, chemical thromboprophylaxis may be used as per local guidelines. Mechanical prophylaxis like calf pumps should be used intraoperatively and in recovery following surgery, before the patient becomes mobile.

d. An examination under anaesthetic must be performed to take into account the degree of anteroposterior and rotational laxity as well as any other associated injuries and documented.

e. Graft choice should be decided based on individual patient characteristics and surgeon experience. Allografts are not recommended for primary reconstructions in younger patients (<35 yrs old). Synthetic ligaments are not currently recommended for routine primary reconstruction.

f. Tunnel position is a source of debate but any reconstruction should allow full range of movement of the knee joint with no impingement in the notch. There should be no excessive motion of graft on knee movement. Stability should be restored and pivot should be abolished following reconstruction. Graft fixation technique and implants should allow immediate knee mobilisation.

9. Following surgery, early quadriceps activation and full range motion should be encouraged with support from an appropriate physiotherapy programme.

10. Decision to return to sport should be criteria based taking into consideration physical factors relating to the knee; psychological factors including fear of reinjury and social factors; while being tailored to the specific sport. To assess readiness to return to play and the risk for reinjury, a range of tests, including strength tests, hop tests and measurement of movement quality, should be used.

1 INTRODUCTION

1.1 Anterior cruciate ligament (ACL) injury is a common injury usually affecting young and active individuals. It is the commonest knee injury requiring surgical intervention(1). Evidence on management of this injury is evolving. Though good outcome is achieved in majority of patients, still a large proportion of patients are unable to return to their preinjury state(2). The final outcome for patients is dictated not just by injury to the ACL but also by associated injuries to the knee joint. This is further influenced by a variety of psychosocial factors, including patient's aspirations and demands. Clinicians looking after these patients have an opportunity to shape the outcome by influencing the whole package of care; from the assessment at presentation, to treatment (both surgical and non-surgical) and rehabilitation, leading to the desired functional outcome for the patient.

1.2 This guide collates the current evidence on management of ACL injuries and summarises treatment options for the benefit of involved clinicians. These guidelines have been produced in collaboration between the BASK and BOSTAA. It may not be applicable to all patients and in all circumstances. The treating clinicians should consider the individual requirements of each patient, before formulating a management plan.

2. THE OUTPATIENT CONSULTATION

2.1 The orthopaedic outpatient consultation allows exchange of information between the patient and a clinician who has experience and expertise in both conservative & surgical management of patients with ACL injury to inform the shared decision-making process. There should be liaison between primary and secondary care in planning the local delivery of acute knee services, but it is considered best practice for all post-traumatic knee haemarthrosis to be assessed urgently by a clinician with special expertise in knee injury management(3–5).

2.2 Whether the ACL is deficient, what other comorbidity exists, and the extent to which that deficiency is responsible for current symptoms is determined by an assessment of the history and physical examination, usually supplemented by imaging.

2.3 It should take place face to face in a confidential environment, with access for relatives and allied health professionals with a minimum time of 15-20 minutes. Patients will often be months or even years after injury and frustrated by the delay in diagnosis. It may be the first time the diagnosis is made, but equally they may already have researched the diagnosis and made a decision on their preferred treatment. This decision may change following the consultation.

2.4 Past medical records from hospital and general practitioner including imaging (if any) should be available.

2.5 The history of the injury, subsequent and current symptoms should be documented, followed by a clinical examination and review of all imaging. Instrumented laxiometry may be helpful but is not considered to be universally necessary.

2.6 A management plan is made after discussion of both operative & non-operative options for both the ACL and coexisting knee pathologies, including the role of rehabilitation, whether pre or post-operative or as definitive treatment, bracing, modification of activities and surgical repair or reconstruction(6–13).

2.7 This is the start of the process of informed consent. The intended and likely benefits, along with serious or frequently occurring risks of harm or failure of treatment are discussed at a level suitable to the patient. This should include the likelihood of stability and a successful return to sporting activities being achieved in the short term, as well as the long term effect of instability on the knee, its menisci & articular surface(2,11,14–17). Patients should be aware of the lack of evidence for reconstruction reducing the risk osteoarthritis or improving long-term function in the absence of instability(15,18–21).

2.8 The arrangements for treatment, postoperative management & follow up are described with an estimate of duration, along with the role of the National Ligament Registry need to be discussed, but this may best be delegated to an allied health professional & supplemented with written and internet documents.

3. RADIOLOGY

3.1 Although all patients will probably have plain x-rays, Magnetic resonance Imaging (MRI) remains the imaging modality of choice to assess the knee for ACL injury and associated internal derangement.

3.2 Ideally the MRI should be reported by an experienced musculoskeletal radiologist who works with the referring clinical team.

3.3 MRI can now be 1.5T and 3.0T magnet strength, with lower strength magnets (<1.0T) less frequently used and unproven for accuracy. In the UK most clinical scanners are currently 1.5T with the incidence of 3.0T increasing.

3.4 Patients should lie supine with the knee minimally flexed encased in a specific multi-channel knee coil (typically at least 8 channel).

3.5 Typically, the MRI protocol can be comprehensive and still total less than 25 minutes allowing quick throughput. Longer scanning times with complex protocols often result in more patient discomfort and increased movement artefacts.

3.6 MRI Protocols should include(22–24);

3.6.1 Anatomical planes to include; sagittal oblique (angled 10 degrees so parallel to the ACL), coronal and transverse axial. Additional ACL specific coronal oblique sequences have been proposed but are rarely used in clinical practice and are not of proven diagnostic benefit. Specific orientations for the posterolateral corner have also been suggested but again rarely produce significant additional information to the standard planes and sequences. Newer faster 3D volume sequences (6-8 minutes) allow reformatting in any anatomical plane with good resolution particularly on 3.0T scanners.

3.6.2 Pulse sequences to include; PD weighted (+/- fat suppression), T2 weighted fat (+/- fat suppression) and T1 weighted (not fat suppressed) sequences to optimally assess all

structures including bone, articular cartilage, menisci and ligaments. Newer faster 3D volume sequences have been assessed and show promising results compared to traditional sequences for diagnostic accuracy in assessing menisci and ligaments particularly on 3.0T scanners but have not replaced established pulse sequences.

3.7 The origin, distal footprint and double bundle structure of the ACL is appreciated on MRI particularly on coronal and transverse axial sequences(22).

3.8 MRI has been shown to be very accurate for full thickness ACL tear (sensitivity >83-95% and specificity 95-100%). MRI findings can be classified as primary and secondary signs of ACL injury with primary signs the most specific(22–24).

3.8.1 Primary ACL injury signs include; ligament defect, diffuse abnormal signal, altered orientation or bowing (including collapse and pseudo mass) and non-visualisation.

3.8.2 Secondary signs include pivot shift pattern of osseous injuries, Segond fracture, anterior tibial translation (>5mm) and uncovering of the posterior horn of the lateral meniscus (>3.5mm).

3.9 MRI is accurate for assessing associated or combination injuries including bone bruising, Segond fracture, osteochondral lesions, menisci (tear or meniscocapsular injury), capsule, other ligament injuries and the posterolateral corner for oedema. Meniscal accuracy is the most studied and highly sensitive and specific for tears (>92%).

3.10 Bone marrow injury patterns can help determine the mechanism of injury, for example; pivot shift, hyperextension or varus rotation.

3.11 MRI accuracy is reduced in partial and chronic tears, as some primary signs described for complete tears are not present, such as orientation abnormality(22,23). Partial tear accuracy is reported at sensitivity >62-95% and specificity 19-97% but a lot of these studies are historic and used older equipment and sequences, hence the wide range reported. Recent studies on 3.0T scanners report sensitivity 77% and specificity 97%(25,26). Partial and chronic tears are best appreciated on coronal and transverse axial sequences(25,27).

3.12 Post reconstruction surgery - Caution is required within 18 months of surgery as the graft normally shows temporal signal change as it undergoes ligamentisation (synovial ingrowth and revascularisation); <3 months low T1w and T2w signal, 3-12 months increased T1w and T2w signal, then returning to low T1w and T2w signal by >18months(22,28). However the type of graft can also affect appearances with hamstring bundle reconstructions liable to have intervening fluid compared to patella grafts therefore resulting in a normal increase of T2w signal(28).

3.13 Post-surgical repair MRI assessment can evaluate for degenerative change, progressive osteochondral damage, graft failure, impingement lesions, tunnel abnormalities (cysts, expansion, lysis), extruded hardware, arthrofibrosis, donor site complications, acute graft tear or other acute internal derangement. Graft laxity while anatomically intact is very difficult to determine on imaging alone(23).

3.14 Artefact reducing sequences are now available to allow better assessment of tunnels and associated hardware on MRI. CT can be used when accurate tunnel sizes are required prior to revision.

3.15 MRI remains the imaging modality of choice to assess the knee for ACL injury and associated internal derangement. Accuracy is reduced in studies evaluating partial or chronic injuries but this often within a research setting. This can be minimised in clinical practice by correlation with the clinical history and examination findings from the referrer.

4. **THE INDICATIONS FOR THE OPERATION**

4.1 At this time, results of only two small randomised trials comparing early reconstruction to structured rehabilitation are available (29–31). While these studies suggest equal outcome between early reconstruction group, rehabilitation group and delayed reconstruction group; concerns remain over high cross over rates from non-operative arm to the surgical arm (9,29,31,32). There is also some concern about poorer long term outcome in the group undergoing delayed ACL reconstruction whilst reconstructed ACL appears to offer greater

objectively measured stability to the knee joint (13,29,32). ACL reconstruction also appears to have some protective effect on further meniscal injury, which may influence future osteoarthritis rates (11,33). Results from an ongoing UK based pragmatic randomized controlled trial are awaited (34).

4.2 Based on the currently available evidence, consensus group believes that decision for early surgical reconstruction vis a vis trial of non-operative treatment should be individual to the patient. This should be part of shared decision making with the patient, following discussion of their activity levels, aspirations and full assessment of the injury complex, including of associated injuries.

4.3. The aim of ACL reconstruction is to restore functional stability of the knee without compromising other joint functions, particularly range of movement(8). This is particularly important in the context of the knee with multiple ligament injury.

4.4 The prime indication for ACL reconstruction is symptomatic instability.

4.3 Each patient should be individually assessed taking into account, the type and frequency of physical activity and laxity at presentation, including a positive pivot shift test. Based on this assessment and following discussion with the patient, in certain circumstances primary reconstruction, before instability symptoms have been allowed to develop may be considered appropriate. This is usually once the initial inflammatory response to injury has settled, the knee is “quiet” with no swelling and a full range of movement, particularly extension, has been restored(8).

4.4 The presence of an unstable and repairable meniscal lesion in combination with ACL insufficiency is a strong indication for early combined ACL reconstruction and meniscal repair rather than partial meniscus excision. Staged meniscal repair followed by later ACL reconstruction is acceptable in the case where the patient presents with a locked knee associated with an ACL rupture, to allow the reconstruction to proceed when the knee has regained full extension(35).

4.5 There is no evidence as yet that reconstruction of the ACL reduces the incidence or progression of degenerative change in the knee, but early stabilization reduces the incidence

of subsequent meniscal pathology(11,33). Although no long term comparative studies are available, it is reasonable to conclude that this will have a protective effect(19).

4.6 Age and degenerative change are not in themselves contraindications to ACL reconstruction(36,37).

4.7 ACL injuries in patients who have not reached skeletal maturity pose particular problems, particularly in the very young, and should be managed by surgeons with an interest in the field.

5. MANAGEMENT OF ASSOCIATED PERIPHERAL AND OTHER INJURIES

5.1 Injuries associated with Anterior Cruciate Ligament rupture include: injury to other knee ligaments, medial and lateral meniscal tears, and articular cartilage injuries. In a cohort study of 1145 consecutive patients with traumatic knee haemarthrosis who underwent MRI within 8 days after the injury, 52% had ACL injury (38). However only in 12% of cases, the ACL injury happened in isolation. 39% of patients had associated MCL injury, 10% LCL injury, 3% PCL injury, 55% meniscal tear, 31% cortical depression and 1% osteochondral fracture(38). The most serious of these is a multi-ligament injury or dislocation, which can be a limb threatening injury. Increased failure rate of ACL reconstruction surgery may occur in patients with missed posterolateral corner (39) or MCL injury(40,41). Associated meniscal and chondral injuries increase risk of poorer outcome, with higher risk of development of osteoarthritis(42,43). Delay in managing a displaced meniscal tear reduces the chance of the tear being successfully repaired.

5.2 Concomitant injury should be excluded by careful examination of all ligamentous structures and additional imaging that should include MRI scan (44–46) and, in acute injury, x-ray. Identification of associated injuries may significantly alter the urgency of intervention required in the ACL injured knee.

5.3 **Dislocation/Multiple ligament injury:** These are defined as complete rupture of 2 or more of the main knee ligaments, usually ACL and PCL They are usually the result of high-energy

vehicular trauma but can occur in high impact sports and in low-velocity injuries in hypermobile or obese patients (47–50).

5.3.1 Emergency reduction of true dislocations is required.

5.3.2 Assessment and documentation of pre and post reduction vascular status is required as vascular injury occurs in up to 50% of dislocations or bicruciate injuries (51,52). There is a higher risk of vascular injuries not just in high velocity injuries, but also in ultralow velocity knee dislocations (53,54).

5.3.3 Vascular surgeons should be involved urgently if limb perfusion is compromised.

5.3.4 Facilities for urgent vascular radiology investigation are required, or rapid referral to an appropriate unit considered.

5.3.5 If distal pulses are asymmetrical or and ankle brachial pressure index (ABPI) <0.9 vascular investigation (angiogram, CT angiogram, MR angiogram) should be performed. If distal pulses are present and ABPI >0.9 the patient should be admitted, serially examined for 24 hours and vascular investigation should be considered prior to ligament reconstruction(55).

5.3.6 In low-velocity injury, a well-perfused foot may be observed clinically but this does not necessarily exclude an intimal tear and any variation in vascular observations or ABPI <0.9 should prompt further investigation(55).

5.3.7 Spanning external fixator treatment may be required as part of emergency management in the setting of vascular injury/repair or inability to hold the joint reduced by other means(56).

5.3.8 Early discussion of these cases and referral/transfer to an appropriately specialized knee surgeon is necessary to allow planning of further investigation or intervention.

5.4 Posteromedial Corner (PMC) Injury

5.4.1 Injury to the PMC - superficial MCL (sMCL), the deep MCL (dMCL) and the postero-oblique ligament (POL) – should be assessed by valgus stress testing at 0° and 20° - 30° knee flexion(57). Stability to valgus stress in full extension indicates no significant damage to the posteromedial capsule / POL(58,59).

5.4.2 PMC injuries may be graded as:

Grade 1: localized medial pain with no appreciable valgus laxity.

Grade II: pain along the sMCL ligament with valgus laxity at 20° - 30° knee flexion, but not in extension,

Grade III: complete tear involving all three functional structure (sMCL, dMCL and POL) with valgus laxity in extension.

5.4.3 Failure to appreciate the rotational instability resulting from a torn PMC may lead to failure of ACL reconstruction(40,41,60).

5.4.4 Combined ACL rupture and MCL injury may be treated initially with functional bracing(57,61).

5.4.5 The brace can usually be discontinued 8 to 12 weeks after injury(57,61).

5.4.6 Delayed, isolated ACL reconstruction in patients with chronic ACL rupture and Grade 2 MCL laxity has shown similar postoperative ACL stability and outcome to isolated ACL injuries(62).

5.4.7 Earlier intervention for medial injury may be warranted in specific indications: severe Grade 3 MCL injuries, intra-articular entrapment of the ruptured MCL, large bony avulsion, complete tibial avulsion, the presence of antero-medial rotatory instability and patients who have valgus knee alignment(58,63,64).

5.5 Posterolateral corner (PLC) injury

5.5.1 Posterolateral corner injury may be present in 9-10% of patients presenting with a knee haemarthrosis (38,65) and 10-15% of patients with chronic ACL deficiency(66).

5.5.2 Posterolateral laxity increases ACL graft failure(66–69).

5.5.3 Examination should include assessment of: limb alignment, gait, varus laxity at 0º and 30º flexion, and external rotation laxity at 30º and 90º ("Dial Test")(70).

5.5.4 Grade 1 and 2 sprains may respond well to non-operative treatment; although residual laxity may remain. Conservatively managed grade 3 injuries are associated with high levels of osteoarthritis(63).

5.5.5 Repair or reconstruction of the PLC should be considered in the setting of acute or chronic posterolateral instability(71). Some reports suggest higher revision rates with primary repair (72,73) while more recent report suggest equally good outcome of repair when compared with reconstruction (74). Repair, if considered, should be performed within 2-3 weeks of the original injury (70)

5.5.6 High Tibial Osteotomy should be considered for chronic combined grade 3 posterolateral knee injuries and varus alignment(65,70).

5.6 Posterior Cruciate Ligament (PCL) Injury

5.6.1 Combined ACL and PCL injury is uncommon but there should be a high index of suspicion that a dislocation has occurred and appropriate neurological and vascular assessment should be performed.

5.6.2 Superior results have been reported for surgical treatment of combined ACL / PCL injuries compared with conservative treatment(75–78). Evidence for superiority of a particular: surgical timing, technique or graft, is less clear.

5.7 Meniscal Injury

5.7.1 Meniscal injury is common after ACL tear, with reported incidence varying between 30 and 80%. Acutely, lateral meniscal injury is more common, but medial meniscal pathology increases after ACL injury. With time, tears become more complex, degenerative and less amenable to repair(79–84).

5.7.2 Repairing the meniscus at the same time as ACL reconstruction improves the success rate of the repair(85).

5.7.3 Significant lateral meniscal injury, particularly bucket handle and meniscal root tears are associated with a high grade pivot shift(86,87).

5.7.4 Medial meniscus posterior horn injury can predispose to premature ACL graft failure(88).

5.7.5 Repair of repairable meniscal tears (compared to menisectomy at the time of ACL reconstruction) may result in improved subjective knee pain and function(89), objective knee scores and reduce the progression of radiographic features of osteoarthritis(90–92).

5.7.6 Small, stable partial thickness fissures in the posterior horn of the lateral meniscus can usually be left untreated(93).

5.7.7 Patients presenting with ACL injury and a locked knee secondary to a bucket handle meniscus tear may develop fixed flexion deformity if untreated. The meniscus tear is more likely to be repairable if reduced early; the ACL may be reconstructed concomitantly or as a delayed procedure following the meniscus repair, when knee swelling has reduced and range of movement has been recovered. In a staged approach, the knee should be protected in a ROM brace. Concomitant repair of meniscal tears with ACL reconstruction improves meniscal healing (85).

5.8 Articular cartilage injury.

5.8.1 Articular cartilage injuries range from minor fissuring to full thickness chondral or osteochondral loss and fracture(38).More damage is seen in chronic cases(83).

5.8.2 More urgent intervention may be required to facilitate fixation of large osteochondral injuries or removal of loose bodies that are hampering pre-habilitation.

5.8.3 Treatment options for chondral defects depend on: chronicity, patient age, defect size and location. Surgeons undertaking ACL reconstruction should be familiar with these options. Treatment should be based on published outcome data for various techniques as well as guidance from the UK Cartilage Consensus statement(94).

6.THE JUVENILE ACL

6.1 Introduction

6.1.1 The incidence of juvenile ACL rupture is rising with juvenile patients now representing a small but significant portion of the work of many knee surgeons(95–97). One recent study reports 29 fold increase in the rates of paediatric and adolescent ACL reconstruction in UK over the last 20 years(98).

6.1.2 Injury prevention programs can reduce the incidence of ACL rupture in some groups and their use in schools should be encouraged(99–101).

6.1.3 Clinical and radiographic assessment can be difficult in juvenile patients with injuries in continuity disproportionately common.

6.1.4 Treatment presents a therapeutic dilemma. The consequences of the injury include progressive intra-articular pathology & instability and unfortunately there are risks associated with all types of treatment.

6.1.5 The current consensus is that in symptomatic patients the risks associated with conservative treatment exceed those associated with surgery(102).

6.1.6 Results following conservative or operative management in this group are less favourable compared to the adult population.

6.1.7 Due to the challenges posed by caring for this specific group of patients, BSCOS and BASK have initiated a national steering group to provide more specific evidence-based guidance on care of these patients. While this process is ongoing, the following recommendations serve as interim guidance, which will be carried forwards and expanded upon within the full joint BSCOS/BASK joint committee practice framework.

6.2 Conservative Treatment

6.2.1 Conservative treatment includes bracing, activity modification and structured rehabilitation and is very difficult to provide effectively. No studies directly compare conservative vs surgical treatment but meta-analysis reveals multiple trends favouring early surgery with patients treated surgically experiencing less instability and more able to return to previous levels of activity(103).

6.3 Surgical Treatment

6.3.1 Some injuries, including repairable meniscal tears, require early surgical treatment and in these cases, reconstruction should also be undertaken.

6.3.2 Symptomatic instability is the key indication for reconstruction and delay in treating symptomatic patients increases the risk of developing further meniscal & chondral pathology(104–106).

6.3.3 Surgical reconstruction is broadly of two types, either Transphyseal or Physeal Sparing. Although repair has been dismissed in the past some surgeons have also recently reported using augmented repair for proximal avulsions in young patients(107).

6.3.4 Transphyseal reconstructions have been reported on many hundreds of juvenile patients in all Tanner stages and with the largest case series reporting good or excellent results using hamstring tendon autograft. This technique is currently the most widely used in juvenile patients(108–114).

6.3.5 Physeal Sparing Extraphyseal reconstructions are variants of the MacIntosh & Micheli procedures. Relatively small numbers of these non-anatomic procedures have been reported(115–117).

6.3.6 Physeal Sparing All Epiphyseal reconstructions become increasingly difficult to perform in younger children with smaller physes. Surgeons regularly performing all inside reconstruction may be better equipped to use this technique(118–120).

6.3.7 Hybrid techniques combining Transphyseal tibial and Physeal Sparing All Epiphyseal femoral tunnels have also been reported(121).

6.3.8 The lack of consensus on surgical treatment has prompted the Paediatric Anterior Cruciate monitoring initiative (PAMI) recently announced by ESSKA(122,123).

6.4 Results of Surgical Treatment

6.4.1 Functional results following juvenile ACL reconstruction are generally good and in some large transphyseal series excellent. Juveniles report better functional outcomes than adults and are more likely to return to sport(111,114).

6.5 Iatrogenic Physeal injury

6.5.1 Direct physeal injury is caused by the drilling & reaming of bone tunnels and the associated heat generated. Larger tunnels are more damaging as are tunnels that are very oblique or very peripheral. Direct injury causes bone bridging with the presence of a soft tissue graft thought to be protective. Indirect injury includes physeal compression due to over tensioning, and vascular phenomena which can cause either growth arrest or overgrowth(124–126).

6.5.2 The greater the potential for growth the greater the consequences of growth arrest and the treatment of prepubescent patients in Tanner stage 1 & 2 gives the most cause for concern. Assessing the patient with their parents in clinic provides useful information and surgeons should consider making formal assessments of bone age and maturity when undertaking surgical treatment, including radiologic calculation of skeletal age.

6.6 Growth Disturbance

6.6.1 Growth disturbance does occur following reconstruction and historically its incidence may have been under reported(123,127).

6.6.2 Growth disturbance has been reported following Transphyseal and all of the available Physeal Sparing reconstruction techniques. Deformities include leg length inequality and angulation usually into valgus or recurvatum. Evolving deformity may not be apparent to the patient and may not be obvious clinically(128–131).

6.6.3 The incidence of growth disturbance is unknown but it is currently believed to be uncommon. The two largest Transphyseal series report no significant growth disturbance. Few studies accurately assess for growth disturbance. A meta-analysis found growth disturbance in only 19 of over 900 cases at risk with higher rates following Physeal Sparing than Transphyseal reconstruction. A case series using long standing radiographs reported a

4% incidence of coronal deformity exceeding 2 degrees (but none exceeding 5 degrees) at 2 yrs(108,109,111,112,114,132).

6.6.4 Surgeons performing ACL reconstruction in juveniles should undertake regular clinical review and should consider arranging regular radiographic review, including pre and postoperative long standing radiographs, until their patients have reached maturity(102,131).

6.6.5 The involvement of Paediatric Orthopeadic Surgical colleagues facilitates the monitoring for and treatment of growth disturbance.

6.7 Graft rupture and Contralateral ACL Rupture

6.7.1 Rates of graft rupture and contralateral ACL rupture are disproportionately high in juvenile patients with young age, return to sport and family history, the most important factors associated with an increased risk of re-injury. Around 1/5 juvenile patients will sustain an ACL graft rupture, and around 1/5 a contralateral ACL rupture within 5yrs of surgery. Altogether around 1/3 will eventually sustain a re-injury with most of the graft ruptures occurring within 2 years and most of the contralateral ACL ruptures between 3 & 5 years(112,133–138).

6.7.2 Although in Europe around 90% of juvenile ACL reconstructions are performed using hamstring tendon autograft some evidence suggesting that re-rupture rates in younger patients may be lower using patella tendon is emerging. Re-rupture rates using irradiated allograft in juveniles are high but one small case series using fresh allograft donated by parents has reported good results and low rates of graft rupture at 2 years(95,133,139–143).

6.8 Rehabilitation

6.8.1 Graft maturation continues for at least 12 months with neuromuscular performance impaired for up to 18 months and a conservative rehabilitation regime should generally be employed in juvenile patients. Although some authors recommend postoperative bracing it was not used in the largest Transphyseal series and there is no evidence supporting its routine use(144).

6.9 Conclusion

6.9.1 In symptomatic patients the benefits of surgical treatment outweigh the associated risk.

6.9.2 Assessments of bone age and maturity should be made when undertaking surgical treatment.

6.9.3 When performing ACL reconstruction in juveniles, surgeons should use the technique with which they are most familiar and perform the best reconstruction that they can whilst respecting the physis.

6.9.4 Surgical technique should be modified with longer less oblique tunnels of 7-8mm or less in diameter, very slow reaming avoiding heat, and care taken to avoid injury to the tibial tubercle apophysis and the femoral perichondrial ring. Bony debris should be cleared from tunnels, and if used bone blocks and screw threads should not be placed across the physes.

6.9.5 Functional outcomes are usually good following reconstruction.

6.9.6 The risk of significant growth disturbance remains relatively low.

6.9.7 The use of pre & postoperative long leg standing radiographs facilitates the detection of evolving deformity.

6.9.8 The involvement of Paediatric Orthopeadic Surgical colleagues facilitates the monitoring for and treatment of growth disturbance.

6.9.9 Re-injury rates are disproportionately high in juveniles and so patients and their families should be counselled accordingly.

6.9.10 For further guidance surgeons should refer to the BSCOS/BASK Steering committee report on the Child and Adolescent Knee.

7-PRE-OPERATIVE ASSESSMENT AND CONSENT

7.1 A systematic multidisciplinary pre-operative assessment is recommended as good practice. This assessment should include the presence of allergies, including latex, and co-morbidities e.g. diabetes mellitus, both for patient management and list planning. The risk for deep venous thrombosis should also be determined and prophylactic treatment based upon local and national treatment guidelines.

7.2 Patients should be swabbed for Methicillin Resistant Staph. Aureus and treated prior to the day of surgery (145).

7.3 The social support available for the patient should be ascertained to determine whether the procedure should be performed on a day case or in-patient basis.

7.4 The knee should be assessed to ensure full extension has returned, the knee is ideally free from an effusion and quadriceps activation and rehabilitation has been commenced prior to reconstruction(146–148)

7.5 Ideally the consent process should have started in the clinic, reaffirmed at the pre-operative assessment and continue on the day of surgery. Guidance on consent process has been given by the Royal College of Surgeons(149).

7.6 Operative and non-operative options should be discussed. The likely outcome of each including the benefits and limitations should be discussed and recorded(10,32,150). The general risks of surgical intervention together with the specific risks of reconstructive surgery should also be discussed and this conversation documented(151–157). Risks of persistent instability and reinjury, including to the opposite leg should be discussed(133,158,159). Patients should be advised on timing of return to sports, which should be specific to the individual (160–162), but should rarely be less than 9 months before surgery due to higher risk of reinjury (160).

7.7 Graft selection should be confirmed whether autograft, allograft or synthetic ligaments are to be used. This should include the benefits, complications and risks of the preferred graft. The frequency of complications together with their management and implications should be included in part of the consent process(151–153).

7.8 The management of chondral and meniscal pathology should also be discussed together with the implications on post-operative recovery. This allows the patient the opportunity to reflect on these discussions and ask further questions.

7.9 The National Ligament Registry (www.uknlr.co.uk) should be discussed with all patients including the benefits and importance of participation. Patients should be registered and consent obtained for inclusion of their data. Hospitals should facilitate the accurate recording of surgical procedures and patients' outcome by providing appropriate clerical and IT support.

7.10 Imaging should be reviewed as during the pre-assessment and if radiographs and scanned images were brought with the patient, they should be ensured that images are uploaded to the imaging system at the operative site. These can then be available to view in operating theatre during surgery.

8 THE ADMISSION TO HOSPITAL

8.1 The patient should be fully aware of the intended procedure prior to admission. The benefits, risks and potential complications of ACL reconstruction should be repeated. Emphasis should be given to the role of the pre and post-operative rehabilitation programme.

8.2 The surgical site should be marked in an area which is still visible after draping.

8.3 The patient must reconfirm consent to the operating surgeon or a suitably qualified deputy

8.4 The procedure can be performed on a Day Case basis, with appropriate domiciliary support.

9 HOSPITAL FACILITIES REQUIRED FOR THE OPERATION

9.1 Primary ACL reconstruction operations are best carried out in hospitals where knee ligament surgery is regularly performed and adequate numbers of trained nurses and the skills of Professions Allied to Medicine are available.

9.2 The potential for cross-infection should be reduced to a minimum. Patients should be admitted to and nursed on elective orthopaedic or day case wards that are staffed by a team experienced in the care of patients who have undergone ligament reconstructions.

9.3 The use of ultra-clean air theatres is still considered to be best practice for units performing any surgery with the implantation of foreign material or open joint surgery, though controversy exists on efficacy of laminar flow theatres(163–165) There is, however, no published evidence specifically in respect of ACL reconstruction to support this.

9.4 The operating theatre should be dedicated to clean elective orthopaedic surgery or joint

reconstruction. Shared facilities with other clean surgical disciplines is an acceptable practice, when using ultra clean air, but data supporting this practice are not available.

9.5 The surgeon must have trained assistance during the operation, and a trained scrub nurse fully familiar with the required complex instrumentation is mandatory. In the absence of junior staff, additional Nursing assistants or specifically trained Surgeon's assistants must be available.

9.6 Endoscopic ACL reconstruction is the gold standard. A fully functional arthroscopic stack camera system and fluid management system must be available. Power shaving system or radio-frequency ablation systems must also be available according to surgeons' preferences.

9.7 A full range of specialist implants and instruments suitable for both hamstrings and patellar tendon reconstructions must be available before the start of each case.

9.8 Specialist instruments and devices should be readily available to manage concomitant meniscal or chondral pathologies.

9.9 Image intensifier may be necessary for some cases such as paediatric physeal sparing ACL reconstructions.

9.10 Dynamic or static knee braces may be required in selected cases.

9.11 In units with several surgeons performing ACL reconstructions, it is desirable to form a consensus for a single instrument system and implants to be used. This is to enhance inventory and reduce cost. It will also help with theatre staff skill level and training.

9.12 Appropriate impenetrable clothing and drapes are essential.

10 **ANAESTHESIA**

10.1 ACL reconstruction will usually be carried out as an elective day case procedure under general anaesthesia, but spinal anaesthesia can be an alternative if deemed appropriate. Royal College of Anaesthetists have provided guidelines on standards of care for the provision of daycase

surgery (166). Recently, the Society for Ambulatory Anesthesia, in America have issued evidence based recommendations on perioperative pain management for ACL reconstruction(167).

10.2 Pre-assessment for anaesthesia- Specific arrangements and processes for pre-anaesthesia assessment will differ in detail between hospitals but the number of hospital visits for the patient should be minimised. Where possible, anaesthesia assessment should be synchronised with the orthopaedic clinic visit.

10.2.1 The majority of patients will be fit young adults requiring no specific pre-operative tests.

10.2.2 Pre-assessment aims to identify and delineate any medical co-morbidity (e.g. asthma, diabetes, hypertension, epilepsy) that may require optimisation, stabilisation or preparation prior to surgery.

10.2.3 Problems that may influence the selection of anaesthetic technique and choice of post-operative analgesia as well as suitability for day surgery are also best identified at the pre-assessment visit.

10.2.4 There may be a need to prioritise specific patients (such as diabetics) first on the operating list and planned overnight hospital admission may be necessary.

10.3 Anaesthesia- Consent for anaesthesia is usually obtained verbally and explanations of the risks of anaesthesia will be documented by the anaesthetist along with ASA (American Society of Anesthesiologists) grade.

10.3.1 Thrombo-embolic risk and requirement for prophylaxis will be evaluated for each patient in collaboration with surgical colleagues.

10.3.2 Fasting times prior to anaesthesia should follow local guidelines with clear fluids usually being permitted until 2 hours pre-op as a maximum(168). 250 mls of water should be encouraged prior to the start of the theatre list to avoid dehydration.

10.3.3 Local safety checklists and WHO guidelines should be followed

10.3.4 General anaesthesia for ACL reconstruction does not routinely require muscle relaxant or intubation. Inhalational or intravenous anaesthetic agents along with analgesics (opiates, NSAIDs & other adjuncts) and anti-emetics are deployed according to the anaesthetist's preference and patient's medical status.

10.3.5 Antibiotic prophylaxis will need to be administered prior to inflation of the tourniquet.

10.3.6 Multimodal analgesia inclusive of 2 or more non-opioid analgesics (e.g. Paracetamol

and NSAIDS or Cox-2 inhibitors) should be used for perioperative pain relief and to limit postoperative opioid use(167,169). Intraoperative opioid sparing drugs (e.g. Clonidine and $MgSO_4$) can aid in postoperative pain control and same day discharge.

10.3.7 Administering a preoperative single 600-mg dose of gabapentin may decrease both pain intensity and opioid consumption in patients undergoing arthroscopic ACL reconstruction(170).

10.3.8 A nerve block can be used to provide post-operative pain relief especially in patients unable to tolerate systemic analgesics(171). However, with local infiltration analgesia and multimodal analgesia, most patients can be managed without(167). Recommendations for patient explanation, consent and safety checks should be followed

10.3.9 Femoral Nerve block (FNB) provides good quality analgesia but concurrent motor weakness can delay full weight bearing and there are concerns about persistent quadriceps deficit (167,172,173). There is lack of evidence of benefit to femoral nerve block when used in the setting of local instillation analgesia(174).

10.3.10 Saphenous nerve block in adductor canal has been shown to be equally or more effective than femoral nerve block, without the risk of quadriceps weakness(175–179). Again, there is limited evidence of its benefit over local anaesthetic infiltration (180–182).

10.3.11 Local anaesthetic infiltration following ACL reconstruction has been shown to be equally effective in controlling postoperative pain and reducing opioid use, without any risks (167,174,180,182,183). However, for patients with risk factors such as tolerance to opioids or preoperative chronic pain, either adductor canal block or FNB for ACL reconstruction should still be strongly considered and is consistent with properly practiced evidence-based medicine(184).

10.3.12 There are some concerns about the intraarticular toxicity of local anaesthetics (185,186)which can be addressed by periarticular and pericapsular infiltration(187). When hamstring graft is used, harvest site should be infiltrated with local anaesthetic(188).

10.3.13 There is limited evidence to support the use of indwelling catheters(187)

10.4 Post-op recovery & discharge.

10.4.1 Standard practice for day case anaesthesia, recovery and analgesia including nurse led discharge should be followed(166). This includes opiate sparing analgesia to take home

(paracetamol and NSAID) to minimise post-operative nausea & vomiting (PONV).

10.4.2 Warnings about impaired co-ordination and balance for at least 24 hours post-op should be given (particularly regarding stairs and with crutches) and when stronger analgesics are prescribed.

10.4.3 Next day telephone follow-up by day unit staff can provide useful audit data and patient reassurance.

11 THE SURGEON

11.1 All patients should be admitted under the care of a consultant orthopaedic surgeon who has a specialist interest in the surgical management of the anterior cruciate deficient knee.

11.2 The surgeon may delegate all or part of the procedure to a trainee or another surgeon who is developing their skills in ACL reconstruction.

11.3 The supervising consultant may or may not be scrubbed at the operating table when teaching a surgeon in training. That decision should be made jointly between the trainer and trainee and would depend on the experience of the latter.

11.4 The lead surgeon undertaking ACL reconstruction should have received appropriate and adequate training and have sufficient experience to deal with the case including the development of unexpected intra-operative complications.

11.5 The issue of “minimum numbers” is a debatable and controversial topic. There is increasing evidence in other areas of surgery that better outcomes are achieved by high volume surgeons. Vice versa, poorer outcomes are associated with low volume surgeons. No absolute minimum numbers are recommended but it would be considered desirable for a surgeon to be performing ten or more ACL reconstructions per year.

11.6 The theoretical and practical skills of a surgeon performing primary ACL reconstructions must be maintained by relevant Continuing Professional Development (CPD). Such evidence should be presented annually at the surgeon’s appraisal.

11.7 It is expected that the surgeon will be registered with the National Ligament Registry (NLR)

and that every operation is centrally databased. Any clinician feedback data generated from the NLR must be included and discussed at the surgeon's annual appraisal.

11.8 The surgeon should preferably be a member of one of the relevant specialist societies (BASK British Association for Surgery of the Knee) or BOSTAA (British Orthopaedic Sports Trauma and Arthroscopy Association).

12 PROPHYLAXIS AGAINST VENOUS THROMBOEMBOLISM (VTE)

12.1 The risk of deep venous thrombosis following ACL surgery remains very low(155–157,189,190), therefore pharmacological VTE prophylaxis is not indicated as a routine. However, all patients should be risk assessed upon admission to hospital. In high-risk cases, and when the reconstruction is combined with posterior cruciate reconstruction, thromboprophylaxis should be considered.

12.2 Patients who had ACL reconstruction considered as being at increased risk of VTE when:

- 12.2.1 The surgical procedure takes more than 90 minutes
- 12.2.2 The patient or first-degree relative with a history of VTE
- 12.2.3 The patient uses hormone replacement therapy or estrogen-containing contraceptive therapy
- 12.2.4 They have varicose veins with phlebitis
- 12.2.5 The patient is obese (body mass index [BMI] over 30 kg/m2)
- 12.2.6 They have travelled recently on long haul flight.
- 12.2.7 They aged ≥35 years(155,189)

12.3 Patients can reduce the risk of VTE by starting the rehabilitation program early, staying hydrated and becoming more mobile. Mechanical prophylaxis like calf pumps should be used intraoperatively and in recovery following surgery, before patient becomes mobile.

13 SURGICAL PROCEDURE

13.1 An examination under anaesthetic must be performed to take into account the degree of anteroposterior and rotational laxity as well as any other associated injuries. The findings may influence the need to proceed to adjunctive procedures.

13.2 Tourniquets are frequently used but are neither mandatory nor contraindicated. The tourniquet may be inflated for part of the procedure, or for all of it.

13.3 The skin should be prepared with an appropriate alcohol based solution(191).

13.4 The surgical procedure of ACL reconstruction can take a variety of forms. Whether ACL reconstruction is undertaken arthroscopically (most common) or open (increasingly rare), arthroscopic examination of the joint to deal with any other associated intra-articular injuries is necessary. Most surgeons undertake the entire procedure arthroscopically, although incisions are needed for graft harvest, for femoral tunnel drilling or fixation in some techniques, and for extra-articular tenodesis when that is undertaken simultaneously.

13.5 The ACL is typically reconstructed using autogenous tissue but allograft or synthetic tissue may be used. The type of graft to be used should be discussed with the patient pre-operatively. The choice should be tailored to the individual and data entered into the National Ligament Registry. Surgeons should be familiar and proficient in the technique chosen.

13.6 The most common autografts being used include bone-patellar tendon-bone (BPTB), hamstring tendon (HT), and quadriceps tendon (QT). They all have been shown to have good outcome for majority of patients(151,192,193). Hamstring tendon might have a slightly higher re-tear rate when compared with BPTB (139,140,151) with main complication being of damage to the infrapatellar branches of the saphenous nerve(194). However, BPTB has a higher rate of anterior knee and kneeling pain(194) with suggestion of greater risk of osteoarthritis (195,196). Quadriceps graft have been shown to have less harvest site morbidity than BPTB graft with good functional outcome(193,197,198) but some studies suggest higher failure rates(199). Long term data from large studies on quadriceps tendon graft is awaited.

13.7 Allografts include hamstring grafts, Achilles grafts, patellar tendon grafts and other grafts

sourced from a number of other lower limb tendons. Surgeons should understand the source of the graft and the technique used for cleansing and storage(200,201). Patients should be aware of potential risks of infection and premature failure with some graft materials. Allograft is a viable option for revisions and primaries in patients greater than 35 years old as they avoid donor site morbidity; however, re-tear rate increases significantly in younger patients(202–204).

13.8 Graft choice should ultimately be decided upon based on surgeon comfort, experience and individual patient characteristics and should be one part of a larger conversation with each individual patient.(151)

13.9 Synthetic ligaments are not currently recommended for routine primary intra-articular reconstruction.

13.10 Wrapping of graft in Vancomycin soaked swab (5mg/ml), prior to implantation, has been shown to significantly reduce infection rates in ACL reconstruction surgery to approaching 0%(205–211). Experimental studies suggest the use of 5mg/ml Vancomycin soaked swab for 20 minutes decontaminates graft without affecting its biomechanical properties(212–214). No deleterious effects on surgery outcome or increased graft failure rates, have been reported in currently available literature(205,206). However, Vancomycin has not been compared against other antibiotics and wider issues about future drug resistance need to be considered(206,215)

13.11 Partial ACL injuries may also be augmented with allograft, autograft or synthetic tissue and there are procedures to 'repair' the ACL in selected cases for acute injuries(162,216–221). Repair techniques are currently experimental and should be undertaken as part of studies and within clear governance processes in the organisations where those procedures take place(222).

13.12 An ACL reconstruction requires tunnels in the femur and in the tibia. These tunnels can be drilled outside-in or inside-out. There are many theories regarding optimal tunnel placement(223–228). The anatomy of the knee needs to be clearly visualised in order to allow the surgeon access to their planned tunnel entry points. The use of shaver and electro-cautery systems is helpful.

13.13 The femoral tunnel is typically drilled through a transportal technique, although it may be drilled through a transtibial technique. The latter technique may constrain the position of the femoral tunnel(229,230).

13.14 The femoral tunnel is usually placed in an anatomical or near anatomical position. This is an area of great debate but is generally between 9:00 and 11:00 or 1:00 and 3:00(223–227). If the femoral tunnel is too posterior, it risks blowing out the posterior wall. If the femoral tunnel is too anterior, deep flexion is restricted and graft failure may ensue when motion is regained.

13.15 The tibial tunnel is typically placed in the middle third of the tibia within the ACL footprint. If the tunnel is too anterior, it leads to impingement and loss of extension. If the tunnel is too posterior, it impinges on the PCL(228).

13.16 Preservation of native tissue is encouraged wherever possible, although the data to support this is limited. Extra care should be taken when preserving the tibial stump as this may obscure tibial tunnel position and increase the risk of impingement(218).

13.17 During the procedure the surgeon should test that the graft position achieved does not result in loss of motion or in impingement.

13.18 Fixation can be undertaken in several ways. Suspensory fixation has gained popularity, but screw and cross-pin fixation is also possible on the femoral side. Fixation on the tibial side may be within the bone but can also be suspensory on the surface of the tibia. Once the graft has been fixed on one side, the knee should be cycled to ensure there is no impingement or excess graft motion, and it should then be fixed on the other side. Surgeons should be aware of the intricacies of fixation techniques that are used(231,232). Fixation technique used should allow for immediate knee movement

13.19 Both the graft harvest site and arthroscopic portals should be closed in an appropriate manner and compressive dressings applied.

13.20 **Lateral tenodesis.** Clinical evidence is currently emerging to support use of lateral extra-articular procedures, in certain indications, as an augmentation to the ACL reconstruction. Appropriate indications may include, patients younger than 25 years; patients with generalized

ligamentous laxity or genu recurvatum; patients with high grade pivot shift or in revision ACL reconstructions. Such reconstructions may have higher early morbidity but can reduce long term graft failure rates(233–239).

14 POSTOPERATIVE CARE AND FOLLOW UP

14.1 Analgesia-A locally agreed regime should be adopted in liaison with anaesthetic colleagues. This should include regular analgesia as well as adequate provision for breakthrough pain.

14.2 An Xray in the post-operative period is useful for confirming the position of the fixation devices and bone tunnels. Post-operative imaging is recommended for all patients where there is any clinical concern about symptoms or progress with rehabilitation.

14.3 **Bracing**-There is little evidence to support the routine use of brace following ACL reconstruction(240–248). Some data suggest that functional bracing may protect reconstructed graft during stressful activities(249). Occasionally surgeons may use a brace, at their discretion. Factors that may influence a consultant's decision to brace include:

- 14.3.1 Combined procedure such as Meniscal repair or Micro fracture.
- 14.3.2 Use of Femoral nerve block.
- 14.3.3 To facilitate day case discharge.
- 14.3.4 Preference towards slow early mobilisation.
- 14.3.5 In adolescents, where use of brace has been to shown to reduce the risk of graft retear(250).
- 14.3.6 To protect the graft on return to sport(246).

14.4 Weight bearing-All patients should be encouraged to fully weight bear as comfort allows, unless weight bearing is contraindicated by a concomitant procedure such as Micro fracture, high tibial osteotomy etc.

14.5 Wound care-Clear instructions should be given to the patient and all allied staff, as to the operating surgeons wishes in relation to timing of dressing changes, wound inspections, and removal of any stiches.

14.6 Follow up-The follow-up arrangements vary widely across the UK. At a minimum, patients

should be followed up and reviewed within the orthopaedic service at the following post-operative time points:

14.6.1 - Approximately 2 weeks. Wound review, surveillance for complications, facilitation/referral for rehab.

14.6.2 - Approximately 6-12 weeks. Assessment of early rehab goals, resolution of effusion, regaining range, early strength.

14.6.3 - Approximately 24-30 weeks. Assessment of late rehab goals, transition to sport.

14.6.4 Follow up may be conducted by the clinical team or trained allied healthcare professionals as part of a wider multi-disciplinary team. In the later stages the patient's 'Follow up' may be conducted within the rehab setting and under the care of experienced and specialist physiotherapists.

14.7 Commencement of Physio-Patients should be commenced upon an ACL specific rehabilitation programme following their post-operative follow up appointment. Please refer to the rehabilitation section of these guidelines.

15 NATIONAL LIGAMENT REGISTRY

15.1 Injury to the anterior cruciate ligament (ACL) is common but the incidence of ACL injury in the UK is unknown, the number of surgeons undertaking such surgery (and what volumes) is not clear and patient outcomes are only reported in single surgeon or small unit studies. If we apply the incidence of 1:80,000 (Swedish ACL registry report 2018)(251) to the UK population it would suggest that approximately 54,000 ACL injuries occur per annum in the UK. If 50% of these patients require surgery this would result in 27,000 primary ACL reconstructions each year, 3.5 times greater than the number of unicompartmental knee replacements recorded on the National Joint Registry(252)

15.2 The increased risk of degenerative joint disease following ACL rupture is well known but there is no clear understanding of the rate of repeat / revision surgery following ACL reconstruction, which could be as high as 20%. Arthroplasty publications suggest poorer outcomes with lower volume surgery, but it has yet to be determined whether similar trends occur with soft tissue knee surgery.

15.3 Our aim is to perform interventions which are the best and safest for our patients and the

recording of patient outcomes should be an essential component of patient care.

15.4 The National Ligament Registry (NLR) was established in 2013 to initially capture data on primary ACL reconstruction. It comprises an online data collection system which automatically contacts patients by email at certain time intervals and provides a secure link for them to securely enter the various PROMs. The selected outcome measures are the Knee injury and Osteoarthritis Outcome Score (KOOS), subjective International Knee Documentation Committee (IKDC), Euroqol (EQ5D) and the Tegner activity score. These scores allow comparison and communication with existing ACL registries as well as allowing potential 'generic health benefit' comparisons to other non-Orthopaedic procedures. The registry should provide patients with an element of 'quality assurance' which extends beyond patient functional outcome to surgical numbers, patient selection, rehabilitation, prostheses and surgical techniques.

15.5 The main roles of the NLR are to:

15.5.1 Encourage the development of better surgical practice for our patients.

15.5.2 Provide a framework for surgeons to collate and audit their results, satisfying the modern requirements of appraisal and revalidation.

15.5.3 Record all aspects of each specific injury and intervention, including primary ligament repair, differing graft options and fixation types, allowing equitable comparison.

15.6 The website (www.uknlr.co.uk) has been developed for both patients and professionals and in time we hope will be the 'go to place' following ACL injury. It contains patient and surgeon information videos and a mobile platform has been developed for use with tablets and smart phones. There is also a 'map' of NLR registered surgeons which will enable patients to see where surgeons who record their ACL reconstruction data on the NLR are based.

15.7 The NLR is independent of both Government and Private Medical Insurance company support and receives its' financial support from industry partners involved in various aspects of ACL reconstruction surgery.

15.8 Big collections of data are powerful provided that such data is interpreted, presented and incorporated in a responsible, professional way. The key to the success of the registry is the involvement of all stakeholders and it is important that patients, surgeons and industry are

involved, feel valued and benefit from the process.

15.9 Annual reports are published to coincide with the BASK annual meeting and are available to view or download as a PDF from the website.

15.10 Compliance remains a challenge to all registries and at the time of writing the NLR is not yet a 'mandated' Orthopaedic registry. However, the submission of data to all established registries is supported by the BOA and the NLR is also strongly supported by BASK. Discussions are ongoing about NLR involvement in the BOA registry framework, known as TORUS.

15.11 With the increasing requirements for surgical outcome data the NLR is a ready to use online data collection system which has the functionality to provide information at surgeon level (appraisal/revalidation), unit level and national level. It is overseen and coordinated by surgeons and will ultimately provide the information we require to continue treating patients with this type of intervention in the best way we can.

15.12 It is recommended that trusts would provide administrative support to help input patient data into National Ligament Register and all surgical reconstructions of the ACL would be documented in the ligament registry.

16 CONSERVATIVE MANAGEMENT, REHABILITATION AND RETURN TO SPORT OF ACL INJURY (RECONSTRUCTED) PATIENT

16.1 Pre-operative management

16.1.1 Knee function at time of surgery has been shown to be a significant factor in predicting outcome(253). Preoperative quadriceps weakness (greater than 20% difference between sides) has been shown to predict poor quadriceps strength & low self-reported function after surgery(146,254). It would be recommended that the patient engage in a lower limb, especially quadriceps strengthening programme prior to surgery.

16.1.2 A restriction of range of movement pre-operatively has been shown to significantly limit the progression of post-operative rehabilitation (146,147), if the patient does not have full range of movement pre-operative it may prove useful to undertake a course of physiotherapy to regain range of movement.

16.2 **Management of the immediate post-operative phase**

16.2.1 Persistent quadriceps lag on straight leg raise has been shown to indicate an inability to actively fully extend the knee. If this is not achieved by week 5 post-operation this would be considered a predisposing factor for significant quadriceps weakness at 6 months post operation. This activation failure of the quadriceps is likely to serve as a major barrier to rehabilitation limiting rehabilitation progress(255). Early activation of quadriceps can be achieved through exercise and/or neuromuscular electrical stimulation. Early joint motion is beneficial in order to avoid capsular contractions, reduce swelling and pain. Even small losses of knee extension (3-5 degrees) appear to adversely affect subjective and objective outcome markers later in the rehabilitation phase(248). Early quadriceps activation and full range motion should be encouraged and where necessary support with an appropriate physiotherapy programme.

16.2.2 Abnormal gait patterns have been associated with low patient satisfaction and decreased functional performance(256).These gait abnormalities also often become further exaggerated when the patient returns to running (257). It is important then to retrain the patients gait in the immediate post-operative period.

16.3 **Rehabilitation phase**

16.3.1 The retraining of postural and movement control requires the incorporation of both static balance exercises along with dynamic balance and movement tasks (247). The regaining symmetry in relation to limb alignment control during limb loading activities after ACLR may significantly reduce their potential for future ACL injury (258). Progressive strengthening programmes for key muscles (quadriceps, hamstrings & gluteal muscles) is required to prepare the patient for controlled load acceptance and subsequent return to sport (247). It is not uncommon to have significant deficits in rate of force development in patients post ACLR which may impact on the functional performance and affect the ability to perform sport specific speed and agility based tasks(259,260). There is a strong relationship between cross over hop performance and functional outcome(261) correlating significantly to IKDC subjective and KOOS questionnaire scores(262). Once the patient has sufficient strength and static-dynamic balance, they need to have rehabilitation exercises targeting both rate of force development and plyometric ability.

16.4 **ACLR and return to sport (RTS)**

16.4.1 There are now guidance available guiding assessment criteria to be used before allowing patient to return to unrestricted sports activities (161,263–266). RTS is a continuum comprising three elements: return to participation, return to sport and return to performance(266). Decision to return to sport should be criteria based, taking into consideration- physical factors relating to the knee; psychological factors including fear of reinjury and social factors; while being tailored to the specific sport. To assess readiness to return to play and the risk for reinjury, a battery of tests, including strength tests, hop tests and measurement of movement quality, should be used(161). These tests should include assessments of direction changes and reactive agility tests and the assessment of psychological readiness to RTS using an instrument such as the ACL-Return to Sport after Injury scale(267)

16.4.2 Gradual and sequential introduction of sport-specific training can be used as functional tests that include an element of protected reactive decision-making.(266)

16.4.3 Return to sport 9 months or later after surgery and with symmetrical quadriceps strength prior to return substantially reduces the reinjury rate(160,161)

16.5 **Conservative management of ACL injured patient:**

16.5.1 Here the goals would be to minimise any functional instability of the knee and mitigate against future degenerative changes within the knee. These two goals are not mutually exclusive. Improving strength, dynamic and static balance will improve knee stability and reduce the tendency towards co-contraction and increased shear and compressive forces which add increased stress onto the articular surfaces. The global management strategy is very similar to that for ACL reconstruction.

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