PCL Reconstruction in Multi-ligament Injured Knees: State of the art

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Abstract

Significant injury to the posterior cruciate ligament (PCL) is an uncommon injury in isolation, but frequently occurs in the context of the multi-ligament injury of the knee. A multi-ligament knee injury (MLKI) is commonly defined as rupture of at least two of the four major ligament complexes with resultant coronal and sagittal plane instability [1], [2]. This review discusses the optimal approach to treating the PCL in the context of these injuries. While there is an overall paucity of high-quality evidence, recommendations can be made regarding the necessity for surgical intervention, and that best results appear to be a result of early (less than six weeks) surgery performed as a single reconstruction of all structures in an anatomical manner, including the PCL. In terms of the PCL, a double-bundle anatomic reconstruction is biomechanically preferential, but of little proven clinical benefit and may not always be possible. There is insufficient evidence in the MKLI to discern outcomes between autograft and allograft. The use of synthetic grafts is controversial, and should be avoided until longer-term data is available. Novel strategies such as internal bracing show some promise, but similarly lack clinical data at this stage. Overall, good outcomes can be obtained following this complex and potentially devastating injury, but further research and co-operation across treatment centres is needed to gain sufficient power to draw solid conclusions about the best way to treat the ruptured PCL in the MLKI.

Introduction

The Posterior Cruciate Ligament (PCL)

The PCL is the largest and strongest ligament in the knee[3]. It is an intra-articular, extrasynovial structure with an ultimate strength of 2500-3000N and acts to minimise posterior tibial displacement by approximately 95%. The PCL is 32-38mm in length and 11-13mm in diameter, making it 30% larger than the ACL. The PCL is divided into two bundles, the antero-lateral and postero-medial that share load with each other during flexion and extension[4]. It is innervated by branches from the obturator and tibial nerves. Similar to the ACL, this innervation serves a proprioceptive function[5].

The primary function of the PCL is to resist posterior translation of the tibia on the femur at all angles of flexion. It also acts as a secondary stabiliser against excessive external rotation and varus or valgus angulation. It works to a great extent in synergy with the posterolateral corner (PLC) anatomy with significant load-sharing between these structures with different rotatory, coronal and sagittal loads [5]. The role of the PCL is summarised in Figure 1 emphasising the overlapping symbiotic relationship with the PLC.

PCL Rupture

Physical examination of acute injuries can be challenging due to pain and guarding [6], but the key point is the position of the tibia relative to the femur with the knee at 70^0 flexion– the medial tibiofemoral step-off. This is the basis of the most common classification of PCL injuries (Fig. 2). The quads active test is a reverse dynamic analogue to the posterior draw sign, and the dial test is used to differentiate between isolated and combined injuries of the PCL and PLC (Fig. 3).

Good quality magnetic resonance (MR) imaging is very useful with a near 100% accuracy for diagnosing PCL injuries[6]. It allows a full assessment of additional pathology since up to 95% of PCL injuries are accompanied by injures to other critical ligaments[6]. Careful correlation is needed between MRI and clinical findings for appropriate decision-making and surgical planning.

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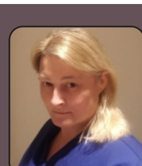

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Multi-ligament Knee Injury (MLKI)

The bony architecture of the knee offers little constraint, but this is well compensated for by strong ligamentous and tendinous support [7]. Multi-ligament injury to the knee is uncommon, occurring in 0.02-0.2% of all orthopaedic injuries[1, 8]. It is a complex and potentially devastating injury encompassing disruption of two or more of the four major stabilising ligament complexes– the anterior cruciate ligament (ACL), the posterior cruciate ligament, the posteromedial corner (PMC) and the posterolateral corner [1, 8–10]. These injuries are very heterogenous in their exact patterns, with frequent concomitant injuries to surrounding structures including menisci, articular cartilage, bone, other ligaments, and neurovascular structures. For the majority of these injuries the ACL and/or the PCL are torn[7, 11, 12]. Vascular and neurological injury have a high incidence in these circumstances, affecting up to 64% of MLKIs [1], and while they may present as a frank dislocation they frequently spontaneously reduce, necessitating a high level of clinical suspicion to avoid missed diagnosis.

Aetiology and Classification

MLKI can be divided into those with and without frank knee dislocation. Knee t

	PCL	LCL	Popliteus	PFL
Function	1° restraint to posterior translation of tibia 1° restraint to IR 2° restraint to ER	1° restraint to varus 2° restraint to tibial ER	1° restraint to ER Small role resisting IR, varus & anterior tibial translation	1° restraint to ER
Position of Function	All knee angles Maximal at 90°	All knee angles Maximal at 30°	30°=60°=90°	Greatest at 60°
Co-function	LCL, Popliteus, PFL, meniscii	PCL is 2° restraint Popliteus, PFL	PCL, ACL, PCL, PFL	PCL, ACL, LCL, Popliteus

Figure 1: Summary of the function of the PCL and PLC.

Classification	
Grade I (Partial)	1-5mm posterior tibial translation
	Tibia remains anterior to the femoral condyles
Grade II (complete isolated)	6-10mm posterior tibial translation
	Anterior tibia is flush to femoral condyles
Grade III (complete combined - MLKI)	>10mm posterior tibial translation
	Tibia posterior to femoral condyles - Often suggests bicruciate injury

Figure 2: Grading of the PCL injury.

dislocation may represent a higher level of injury severity, which is reflected in their generally poorer outcomes when compared to MLKI without dislocation[1]. It should be kept in mind that many MLKI may have had a spontaneous re-location of dislocation prior to presentation[7, 13].

MLKI can be divided in high, low and ultra-low energy injuries. High energy injuries include motor vehicle accidents and falls from height, low energy injuries occur in sports, and there is a distinct ultra-low energy group in the morbidly obese population sustaining trips and falls. High-energy dislocations are associated with poorer outcome scores[1, 14]. The ultra-low energy group also have relatively poor outcomes, partly due to a higher rate of neurovascular injury.

Classification

There are several classifications of MKLI from the aetiology of injury to the pattern of ligament disruption. The heterogeneous nature of the injury makes it difficult for any classification system to be both comprehensive, replicable and easy to use. Further, the lack of sufficient high-quality data limits the utility of any system based on outcomes. It is, however, worthwhile approaching these injuries from a few broad classifications in order to describe them consistently. The most commonly used systems (shown in Fig. 4) are the Kennedy classification that refers to the direction of dislocation, and the Schenk classification, which is based on patterns of ligament disruption. PCL disruption can be present in any of the Kennedy or Schenk subgroups, highlighting the limitations of classification in hese injuries.

Treatment

These injuries are difficult to study. They are uncommon injuries with high degree of heterogeneity making it difficult to obtain large numbers of identical injuries to compare. The patients are younger and more geographically mobile making follow-up challenging, and the treatment strategies employed tend to be as diverse as the injury patterns observed further diluting any standardisation of data. Therefore, many aspects of management and treatment of the MKLI remain controversial[13, 15]. Nonetheless, there is sufficient information to draw broad guidelines.

Surgical Intervention

Operative versus non-operative

In the context of isolated injuries, the general consensus is that the PCL rarely needs acute surgical intervention [4, 8, 16]. Several studies have shown no clinical difference between those having had an isolated PCL reconstruction and those managed without surgery [17] although those with symptomatic grade III injuries may be the exception [18]. It is clear though that rupture of the PCL can lead to functional and objective instability and altered kinematics[8, 19]. Longer term, with loads shifting to the medial and patellofemoral compartments [20] rupture is associated with the development of osteoarthritis, classically in the patellofemoral compartment. Studies have also shown that an unreconstructed PCL leaves the posterolateral structures more vulnerable to injury [21] and increases the forces borne by the ACL. Further, in the PCL-deficient knee the medial collateral ligament (MCL) becomes more important in controlling posterior translation. Sectioning of the MCL in this context increases posterior tibial translation by up to 350% [12]. This data highlights that while PCL disruption may be well tolerated clinically in the short- to medium-term, there are distinct biomechanical consequences to the injury.

PCL rupture in the MLKI is a different story. Trasolini et al. [12] points out that one must recognise that in MLKI the biomechanical disturbance to the knee is greater than the sum of the individual ligamentous injuries. The approach to the treatment of the PCL in this context highlights that thinking. The general consensus is that surgical management has superior outcomes to non-surgical management. There is very little data looking specifically at the PCL's contribution to outcomes in management of a MLKI with most studies looking at this injury as a whole.

Levy et al's systematic review in 2009 reported better outcomes with reconstruction [9]. Peskun and Whelan published a systematic review of 31 studies comparing operative against non-operative management, finding that surgical intervention showed superior results in patient reported outcome scores (Lysholm), range of movement, and return to work and sport [22]. The PCL forms an essential part of knee stability, which is amplified in the setting of the MLKI, thus making its treatment necessarily more aggressive than in the isolated setting.

Timing

The timing of surgery is frequently dictated by

Test	Outcome
Varus/Valgus Stress	Laxity at 0° = MCL/LCL and PCL Laxity at 30° only = Isolated MCL/LCL
Posterior Draw	Translation 10-12mm in neutral rotation = Isolated PCL
	Translation 6-8mm in internal rotation = Isolated PCL
	Translation >15mm in neutral rotation = MLKI
	Translation >15mm in internal rotation = MLKI
Quads Active	Anterior tibial reduction relative to femur when extending knee from 90° = PCL
Dial Test	ER >10° at 30° flexion = PLC
	ER >20° at 90° flexion = PLC and PCL
	Note: PCL injury alone does not increase ER

Figure 3: Table of tests for the diagnosis of PCL and accompanying ligament ruptures.

Direction of Dislocation	Comments
Anterior	Most common (30-50%) Due to hyperextension injury Highest rate of peroneal nerve injury
Posterior	Second most common (30-40%) Due to axial load to a flexed knee ('dashboard injury') Highest incidence of popliteal artery tear
Lateral	13% Due to varus force Usually involves tears of both cruciates
Medial	Rare (3%) Due to valgus force Usually causes disruption of PCL and PLC
Rotational	4% Posterolateral is the most common rotational dislocation Usually irreducible (femoral condyle buttonholes through capsule)

Figure 4 a: Kennedy classification of knee dislocation.

Type	Description
KD I	Multi-ligamentous with one cruciate remaining intact
KD II	Bicruciate rupture with collaterals intact (rare)
KD III	Bicruciate rupture and either posteromedial or posterolateral injury
KD IV	Bicruciate rupture and both posteromedial and posterolateral injury (panligamentous)
KD V	Dislocation with associated periarticular fracture
Sub-group C	with arterial injury
Sub-group N	with nerve injury

Figure 4 b: Schenk classification of knee dislocation

associated injuries. Life- or limb-threatening pathologies, such as vascular compromise, open fractures, significant soft tissue wounds, and threatened or emergent compartment syndromes can all influence the urgency of surgical intervention. Any intervention to address these associated injuries should be done with thought towards subsequent definitive management of the ligaments of the knee itself. In the interval before surgery it is key that the knee is anatomically reduced and temporarily stabilised. This should be done with the minimum intervention required to maintain a stable congruent reduction. Generally, a simple brace is sufficient, but where this is inadequate then an external fixator should be applied.

Early versus delayed surgery

Whilst there is no absolute consensus, early surgery is generally considered as falling within three weeks of injury, and surgery thereafter considered delayed. Chronic injuries tend to refer in the literature to those more than either 6 weeks or 3 months from the time of injury. It should be noted that there will always be selection bias in studies examining this differentiation due to associated injuries dictating both timing of surgery and severity of injury in many cases. In a systematic review, Levy et al. found little difference in clinical and functional outcomes when comparing early against delayed surgery[9, 23]. However, the authors summarise that acute surgery is preferred and the many differences between the acute and chronic cohorts may have a great effect on the reported outcomes. Harner et al. [24] reported significantly better results in terms of KOOS outcome scores and less post-operative laxity for those MLKI treated acutely. Comparing acute with delayed (rather than chronic) treatment LaPrade et al. [10] evaluated their cohort of MLKI patients undergoing a single-stage ACL/PCL reconstruction. They reported no significant difference in any of the outcome scores between patients treated in the acute (less than 6 weeks post-injury) or delayed (greater than 6 weeks) phases. Nevertheless, most recent systematic reviews are showing better outcomes in favour of early intervention [1].

If we are to consider an ideal time to perform surgery, it would be between 10-20 days post-injury [9, 25]. This gives sufficient time for any capsular breaches to heal thus facilitating easier arthroscopic surgery with minimised fluid extravasation, yet not enough for excessive scarring of any associated soft tissue avulsions and tears that can complicate dissection for possible repair. Further, it allows earlier stability limiting the effect of altered kinematics and risk of graft failure [26] combined with earlier rehabilitation, which may reduce post-operative knee stiffness.

What to fix

In the context of MLKI it is common for both cruciates to be affected [8, 12]. Reconstruction of all affected ligaments in one stage is advocated (if possible) in order to allow early rehabilitation and avoid joint stiffness [26]. Reconstruction of anterior and posterior cruciate ligaments in young active patients can optimise functional outcomes[7, 9, 27]. In a study by LaPrade et al. in MKLI sustained during sport, they advocated fixation of all ligaments in a single stage, finding significantly improved outcomes regardless of whether the injury was ACL- or PCL-based [10]. In this study the patient cohort was not as heterogeneous as most studies since it focussed on the MLKI sustained through sport. This made a young and highly motivated group, with a good early rehabilitation protocol, which may go some way to explaining such good outcomes. Further, all the surgeries were performed by a single, experienced high-volume surgeon in a tertiary referral centre, supporting the notion that this type of complex injury should ideally be performed by experienced surgeons with a specialist interest in knee ligament surgery[1, 19].

A high incidence of meniscal and chondral injuries has been reported in the MKLI, up to 76% in those experiencing a knee dislocation [28] and up to 55% in those without known dislocation [10]. These injuries should be diagnosed and treated at the same time as any reconstruction [26]. In general, failure to address all factors contributing to instability can result in early failures or persistent instability [12]. This makes sense when you recall the basic biomechanical data discussed earlier, showing that PCL and PLC acting in a synergistic load-sharing fashion.

Technique

Reconstruction versus repair

Most authors advocate reconstruction of the PCL over repair as most studies show considerably higher failure rate with repair alone[8, 25]. Plancher and Siliski [29]reviewed the long-term outcomes of 52 MLKIs, finding that all 4 post-operative re-ruptures were in the repairs rather than reconstructions. Levy et al. also reported that repair of PLC and PMC was suboptimal with a high overall failure rate of 39% [9]. Levy et al. [13] found that a review of the literature was lacking in terms of outcomes in MKLI and cruciate repair, making it difficult to draw firm conclusions. Mariani et al. [30] retrospectively compared the outcomes of surgical repair of both or each cruciate ligament finding that repairs compared less favourably to reconstruction in laxity and IKDC outcome scores. They concluded that that repair of the cruciates in the context of knee dislocation was not recommended in any combination.

Single or double bundle reconstruction

From the laboratory data there is good evidence that double-bundle reconstruction offers biomechanical advantages over single-bundle isolated PCL reconstruction[4, 12]. Harner et al. [24] evaluated the biomechanics of the PCL in 10 cadavers concluding the double-bundle reconstruction most closely resembles the native PCL. Whiddon [31] added weight to the evidence for double-bundle PCL reconstruction finding it most beneficial in terms of both translational and rotational stability when the PLC is also damaged. The clinical situation, however, is more complex than the laboratory. The complexity of PCL surgery in the context of the MLKI, and the need for multiple osseous tunnels in these cases is amplified if a double-bundle PCL reconstruction is performed. There is little clinical evidence that justifies this added complexity. Markolf et al. [32] showed that in the context of PLC reconstruction a single-bundle PCL reconstruction was no different in terms of outcomes compared with a double-bundle PCL reconstruction. In a systematic review of both biomechanical and clinical studies, Kohen and Sekiya [21] concluded that there was no definite advantage to the double-bundle reconstruction in either cadaver or clinical studies, although they do acknowledge the significant limitations with clinical trials including lack of randomisation and few published studies. One conflicting study is that by LaPrade et al. [10] who performed single-stage multiple ligament reconstructions using an anatomic double-bundle PCL reconstruction and showed significantly improved outcome scores in all aspects of recovery.

Tunnel position

The requirement for several bony tunnels during reconstruction poses a risk of convergence, increasing the possibility of graft failure [26]. This can be additionally complicated by bony fractures, particularly in the proximal tibia. Poorly placed tunnels that do not re-create anatomic features predispose patients to instability and inferior outcomes [19]. In a cadaveric study, Gelber et al. [33] prioritised the double-bundle PCL fixation and calculated the optimal tunnel position for repair of medial and posteromedial structures in order to avoid convergence with the cruciate tunnels. In this study however, the tunnel sizes for the PCL used were smaller (7mm) than would be generally recommended in clinical reconstruction, and the difficulties of combining reconstruction of the PCL with that of the other medial structures without tunnel convergence are highlighted. Thus, for the reasons discussed above, the PCL in the context of MLKI is frequently reconstructed using a single-bundle bone-conserving technique with tunnels placed as close as possible to anatomic replication of the native PCL, or with the tibial inlay technique [4, 32].

Graft choice

The choice of graft in the MLKI is determined by the pattern of injury, surgeon choice [34], and what is available both in terms of viable autograft and readily obtainable allograft. Ideally rigorous data would be used to make this decision, but it simply isn't available, and we can only make broad deductions from what data does exist.

Autograft versus allograft

Extrapolating from the single ligament ACL reconstruction literature, autograft should be considered the gold standard option. It has superior outcomes, a higher return to work and sports, and a lower re-rupture rate compared with allograft [34–36]. Information specific to the PCL, however, is sparse.

When it comes to the best autograft, there are few studies looking at this specifically. A recent study from BarbieriMestriner [37] compared double-bundle PCL reconstructions in patients with either isolated or multi-ligament injuries requiring PCL reconstruction. They used either quadriceps tendon and semitendinosus or a bilateral hamstring tendon autograft to reconstruct the PCL. Results from all outcome scores (Lysholm and IKDC) were comparable as was the objective measure of laxity from the KT-1000, suggesting neither option was superior.

There are technical issues that may make allograft a preferred option in the PCL reconstruction, particularly in the MLKI setting. The amount of graft required to make both sufficient length and diameter of reconstruction, the need for multiple grafts in an already traumatised knee, and the benefits of ease of harvest (none) with timely preparation, all make allograft an appealing option. In a systematic review and meta-analysis of 5 studies, Belk et al. [38] reported that those reconstructed with allograft showed a significant increase in knee laxity compared with the autograft group. The clinical outcomes as measured by Lysholm, PROMs and IKDC, however, showed no difference between the 2 groups. A recent review by Strauss et al. [8] comparing the use of allograft for the reconstruction of the PCL in the MLKI demonstrated equivalent clinical results between autografts and allografts. They conclude that when considering the need for reconstruction of other structures as well as the preservation of synergistic muscles (i.e. practicalities over the minimal evidence) use of allograft for the PCL reconstruction is recommended [9]. Many studies reporting their surgical techniques for the treatment of MLKI predominantly use allografts (e.g.[7, 10, 27, 39]) and consistently report good outcomes. Whilst there are acknowledged risks associated with allograft use including disease transmission, slow bony integration and availability [37, 40], its benefits and mostly equivocal clinical performance in published studies, has meant the use of allograft has become fairly standard for PCL reconstruction whenever it is available.

Synthetics

The clinical outcomes of PCL reconstruction has frequently highlighted the lack of complete restoration of normal stability. The technical challenges of reconstructing the PCL, the inability to fully reconstruct anatomy, the replacement of a ligament with the biologically different tendon, and the forces working on the graft during rehabilitation all contribute to a propensity for some increase in laxity during the healing and recovery process [12]. When compared with ACL surgery, PCL outcomes generally report greater residual post-operaive laxity. This acts as an argument for consideration of novel options in their reconstruction, including synthetic grafts or internal bracing. Evidence for the use of synthetic ligaments however, has been marred by poor early-mid outcomes in single ligament surgery [1, 41]. A recent publication from Chaing et al. [42] showed long-term follow-up in 33 patients who had an arthroscopic double-bundle PCL reconstruction using the LARS ligament. They reported no advantage in outcomes by using LARS, and while they reported 'acceptable clinical results' and suggest the LARS ligament showed good durability, their data included 2 complete ruptures and over 1/3 of their patients showed a partial rupture of the synthetic ligament on magnetic resonance imaging(MRI). Longer-term follow-up results are required, particularly given that the demographics of those sustaining this type of injury is generally younger and more active, so at this current time the use of synthetic ligaments cannot be recommended.

Internal brace

Recently, the concept of reinforcing a biological ligament reconstruction with a load-sharing 'internal brace' [12] has been put forward. The aims of these braces are to introduce a load-sharing implant to support the graft while healing and integration occurs, and to act as a potential back-up constraint to supra-physiological loads during high risk activity. Evidence taken from single ligament ACL reconstruction seems to suggest favourable characteristics, particularly in the case of small hamstring autografts [43], but further investigation is required. Currently clinical evidence of the efficacy of internal bracing PCL reconstructions remains sparse. A number of groups have reported their techniques, but thus far outcome studies are not yet reported.

Rehabilitation

Post-operative management and rehabilitation protocols play a crucial role in the efficacy of treatment and outcomes [8]. The aim of rehabilitation is to restore motion whilst protecting the vulnerable graft reconstructions, and to re-activate and strengthen the surrounding musculature as soon as possible. It typically requires 9-12 months of work prior to returning to full activities [26]. There is little published, high quality data rigorously comparing specific protocols, though there are several authors reporting their own specific approach. There is no consensus around weight bearing status, ROM goals, or bracing protocols, let alone tested approaches to activity based rehabilitation. However, it appears that early controlled and protected movement is the most effective in the recovery process.

Fanelli et al. [27] reports locking the knee in extension for 3 weeks non-weight-bearing, followed by progressive weight-bearing and closed chain exercises. The brace is removed at 10 weeks post-surgery. They report good long-term results with functionally stable knees. LaPrade et al. [10] were more aggressive, allowing range of motion (0-90 degrees) from day one within a protective brace. The patients remained non-weight-bearing for 6 weeks before transitioning to full weight-bearing by week 8. All patient having PCL-based surgery wear a dynamic PCL brace for 6 months. They report excellent ROM without compromise of stability using this protocol.

Braces are commonly used post PCL reconstruction, including in MLKI. These PCL-specific braces are used to protect the PCL graft from the effect of gravity (which applies a posterior force on the graft when the patient lies supine) and the actions of the hamstrings (creating a posterior pull on the tibia when activated) during the period of PCL graft healing and incorporation [44]. Li et al. [45] compared a standard knee brace with a tibial support (or static PCL-specific) brace after isolated PCL reconstruction, finding significantly improved IKDC and Lysholm scores after 2 years from surgery in the tibial support group. LaPrade et al. [46] showed the effect of a dynamic force brace. This type of brace increases its effect to counteract the posterior pull of the tibia the greater the flexion of the knee, allowing the patient to be more active while still providing effective protection of the graft. The clinical benefit of this type of brace is yet to be reported.

Outcomes

The outcomes of PCL reconstruction, both in isolation and in the context of MLKI, are generally good with a stable and functional knee being reported [2, 8, 10, 15, 19, 26, 27]. PCL reconstruction has repeatedly demonstrated improved subjective outcomes when compared with the injured knee prior to surgery [4]. However, when making the comparison with pre-injury status the results are generally less favorable with 86% of patients reporting some functional deficit [1]. The outcomes of isolated PCL reconstruction compared with ACL reconstruction are historically inferior [44]. There are very few studies comparing the outcomes of PCL-based reconstructions following a multi-ligament injury. La Prade et al. [10], however, compared the outcomes of ACL-based and PCL-based multi-ligament reconstructions and showed no difference in the outcomes between the two groups.

Several factors have been shown to correlate with poor outcomes following multi-ligament knee surgery including higher energy trauma, medial repairs, younger age (<30) and educational level [19, 26]. In addition, the technical factors of the complex anatomy to be reconstructed, the relative rarity of this injury (PCL reconstruction forms 2.6% of all ligament reconstructions according to the Danish Ligament Registry [8])and consequent lack of experience in performing the reconstruction in some centres [19] all contribute to reasons for lower success rates.

Residual laxity has been postulated as a prominent reason for poorer outcome scores. There are several contributing factors as to why the PCL reconstruction is frequently more lax than the native knee. Bony architecture must be considered, including varus malalignment and the posterior slope of the tibia. The most likely issue, however, lies with the soft tissue, including inaccurate or incomplete diagnosis (particularly in relation to the PLC), technical errors of surgery [16], and the challenges of rehabilitation. These issues have been discussed in detail above. In a case-series, Noyes and Barber-Westin [47] noted that 56% of failed PCL reconstructions were due to multiple factors, but that the most common errors appear to be PLC insufficiency (40%) and poor tunnel placement (33%). Cooper and Stewart [48] followed up their cohort for an average of 3 years after either an isolated or MKLI PCL injury requiring reconstruction showing all had residual laxity present, although this was slightly less in the MKLI group. Many other studies have shown similar outcomes with post-operative laxity on both subjective (e.g. IKDC and Lysholm) and objective scoring (e.g. KT-1000), however, many of these have not correlated with clinical outcomes such as return to work or sports. In the authors experience, a small amount of laxity is significantly more preferable than residual stiffness in terms of patient outcomes. Our data (unpublished) induced us to implement a more aggressive post-operative rehabilitation as a result.

Ultimately, Fanelli et al. summarised it best by stating that postoperatively these knees are not normal, but are functionally stable [27].

Summary

PCL injuries in the context of multi-ligament knee injuries are uncommon, but complex injuries. Their relative scarcity, heterogeneity of injury pattern, and complexity of the treatment options available, makes them difficult to study. There are few high quality, comparative studies and little true consensus, but there are broad principles which emerge from the existing literature which can help guide management of these injuries:

- Have a high index of suspicion in diagnosis. Be alert to the possibility of a spontaneously reduced knee dislocation, with the associated risk of neurovascular injury, and poorer outcomes
- Associated injuries will frequently dictate the timing of surgery, which should be done with a mind to the definitive ligamentous surgery that will be required
- Surgery has better outcomes than non-operative management
- Early surgery has better outcomes than delayed surgery
- The optimal timing for surgery is 10-20 days post injury
- Generally all damaged structures should be addressed at a single surgery
- Reconstructions do better than repairs
- Double-bundle reconstruction has biomechanical benefits in the lab, but in the clinical setting single bundle reconstruction is easier to perform with lower risk of complication and equivalent clinical outcomes
- Allograft may be potentially biologically inferior, but its technical advantages but its technical advantages and clinical outcomes makes it a common graft choice where it is available.
- Pure synthetic grafts have poor results, and novel techniques like synthetic internal

bracing may offer some advantages, but are yet to be clinically proven

• Controlled rehabilitation using a dynamic force brace restoring range of motion as early as possible minimises the risk of stressing the new reconstructions while maximising range of movement and lowering complications of a stiff knee.

• Stiffness tends to be more problematic than minor residual laxity.

There continues to be the need for further research in this area, and an emphasis should be made on co-operation and the use of standardised replicable and comparable methods in order to extrapolate outcomes from different groups researching this rare but significant injury.

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