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Multiligament Knee Injuries: An Evidence-Based Review of Surgical and Non-Surgical Management

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ABSTRACT

Multiligament knee injuries (MLKIs), involving damage to two or more major knee ligaments, are complex injuries typically caused by high-energy trauma. They often present with associated soft tissue, neurovascular, or joint instability issues, making diagnosis and treatment particularly challenging. Management options range from non-operative approaches in select cases to stage or single-stage surgical reconstructions in active individuals. Non-surgical management is considered in specific situations, such as in patients with low functional demands, severe co-morbidities that preclude surgery, or extensive soft tissue damage. While conservative management is possible, it is generally not expected to produce the same level of functional recovery or stability as surgical treatment. Decisions depend on factors like patient activity level, injury severity, and timing. However, due to the rarity of MLKIs and limited high-level evidence, standardized treatment protocols remain unclear. This review provides an evidence-based overview of both surgical and non-surgical management strategies, aiming to guide clinicians in optimizing care for this challenging condition.

Keywords: Knee Injuries; Surgical Management; Choice of Grafts; Outcomes

Introduction

Multiligament knee injuries (MLKIs) represent a complex and challenging subset of orthopedic trauma, often resulting from high-energy mechanisms such as motor vehicle accidents, sports-related trauma, or falls from height. These injuries involve the disruption of two or more of the major knee stabilizing ligaments typically the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) and are frequently associated with significant soft tissue damage, neurovascular compromise, and potential knee dislocation. Given their complexity, MLKIs require a high index of suspicion, prompt diagnosis, and a multidisciplinary management approach [1,2].

The optimal management of MLKIs remains a topic of ongoing debate and evolving evidence. Treatment strategies vary widely, ranging from conservative (non-operative) approaches in low-demand or medically unfit patients to stage or single-stage surgical reconstruction in young individuals [3] Key considerations include the timing of intervention, choice of grafts, surgical techniques, and the role of rehabilitation in restoring function and stability. Compounding these challenges is the relatively low incidence of MLKIs, which has limited the availability of high-quality randomized controlled trials, making evidence-based decision-making difficult [4].

This review aims to indicate both surgical and non-surgical management of multiligament knee injuries. By analyzing clinical outcomes, surgical timing, and rehabilitation protocols, we seek to provide a comprehensive and practical overview that can guide clinicians in tailoring treatment strategies to individual patient needs.

Surgical versus nonsurgical management

Current literature has shown significantly better functional outcomes with operative treatment of MLKI compared with non- operative treatment. Non-operative treatment is only reserved for patients who are unfit for surgery, non-ambulatory or advanced age. They are treated with a short period of immobilization and non-weight bearing followed by mobilization in a hinged knee brace [2].

Timing of surgery

Although there is general consensus on surgical treatment providing better outcomes, there is ongoing debate and controversy on the timing of surgery. There are three approaches to the timing of surgery for MLKI: emergent, acute or chronic [5].

Emergent surgery is defined as surgery performed within few hours after the trauma that includes open fracture dislocation, vascular compromise, compartment syndrome, and irreducible knee dislocation [6].

Causes of Irreducible knee dislocation

It is includes PLC with dimple, KD III L with popliteal muscle interposition, and KD V with tibial spine fracture that prevent adequate reduction [4].

Acute reconstruction/repair is defined as surgery performed within three weeks of injury. Although this time frame is arbitrary, this is considered to be the critical time frame within which soft tissue planes are still definable without significant scarring. The damaged ligaments can also be repaired as they are identifiable and not significantly retracted. Authors who advocate acute surgery argue that by repairing/reconstructing all the damaged ligaments acutely, normal knee kinematics is more likely to be restored. In addition, the risk of further meniscal or chondral damage is lower. However, acute surgery carries the risk of arthrofibrosis and knee stiffness. If arthroscopic repair/reconstruction is undertaken acutely, a delay of 1-2 weeks to allow capsular healing is recommended to prevent fluid extravasation [7].

Absolute indications for acute surgery involved associated fractures, distal MCL roll up (Stener type), isolated LCL avulsion, and isolated MCL femoral avulsion [8]. Relative indications for acute surgery included first stage ligament or tendon injury, and four ligament reconstruction/repair at single stage [9].

Delayed reconstruction or chronic surgery is undertaken more than three weeks after injury. Reconstruction is typically performed as scarring and retraction of damaged structures would prevent satisfactory repair. However, delayed reconstruction offers the advantage of better range of movement of the knee and avoiding unnecessary repair/reconstruction of structures which may heal with sufficient stability without surgery [10]. Indications for chronic surgery are second stage ligament or tendon injur, unhealthy skin or soft tissue swelling, associated vascular repair, delayed referral, and polytraumatized patient [11].

Graft choice

Graft selection can be challenging in multiligament knee reconstruction. Surgeons have the option of using autograft, allograft or synthetic graft. Each of these options has its advantages and disadvantages (Table 1). The decision on graft choice usually depends on the number of ligaments requiring reconstruction/augmentation, graft availability, surgeon preference and the chosen surgical technique for reconstruction (certain techniques require longer grafts) [12].

Autograft options include hamstring (gracilis and semitendinosus) tendon, PT (peroneus longus), BPTB (bone-patella tendon-bone) and quadriceps tendon (with or without a distal bone block). These grafts can be harvested from the injured knee or from the contralateral knee [13].

PT graft has been employed for diverse ligament reconstructions within the knee joint. It has been considered as a promising autograft, with diverse purported benefits like simple harvesting technique, larger graft diameter, and minimal complication rates (including preservation of ankle joint functions) [14].

Table (1): Graft choices in multiligament knee reconstruction

Graft type	Uses	Advantages	Disadvantages
Hamstring tendon (gracilis and semitendinosus)	ACL, PCL, PLC, PMC, sMCL	Length of graft Can be quadrupled to increase diameter Easy to harvest Low donor site morbidity	Soft tissue fixation Some patients have small hamstring tendons Graft harvesting increases operating duration
BPTB autograft	ACL, PCL	Bone-to-bone fixation on both ends of graft Thick and strong graft	Anterior knee pain Patella fracture (rare) Patella tendon rupture (rare) Cannot be used if quadriceps tendon (QT) graft harvested from same knee Graft harvesting increases operating duration
Quadriceps tendon (QT) autograft	ACL, PCL	Bone-to-bone fixation on one end of graft Thick and strong graft Low donor site morbidity	Patella fracture (rare) Quadriceps rupture (rare) Cannot be used if BPTB graft harvested from same knee Graft harvesting increases operating duration
Peroneal tendon (PT) Autograft	ACL, PCL, PLC, PMC, sMCL	long graft Easy to harvest	Donor site morbidity Soft tissue fixation
Achilles tendon allograft	ACL, PCL, PLC	Length and width of graft Bone-to-bone fixation on one end of graft No donor site morbidity Less operating time	Possible disease transmission Expensive May not be readily available
Tibialis anterior allograft	ACL, PCL, PLC	Good length No donor site morbidity Less operating time	Soft tissue fixation Possible disease transmission Expensive May not be readily available
BPTB allograft	ACL, PCL	Same as BPTB autograft No donor site morbidity Less operating time	Possible disease transmission Expensive May not be readily available
LARS	ACL, PCL, PLC, PMC, sMCL	No donor site morbidity Less operating time Readily available, inexpensive	Possible reactive synovitis

Note. ACL, anterior cruciate ligament; PCL, posterior cruciate ligament; PLC, posterolateral corner; PMC, posteromedial corner; sMCL, superficial medial collateral ligament; BPTB, bone-patella tendon-bone; LARS, Ligament Augmentation and Reconstruction System.

Common allografts used in multiligament knee reconstruction include Achilles tendon, extensor mechanism apparatus, BPTB or tibialis anterior tendon. Allograft is expensive and may not be readily available. Synthetic grafts such as the Ligament Augmentation and Reconstruction System (LARS) can also be used in multiligament knee reconstruction [12].

The LARS device is made from polyethylene terephthalate (PET) that is treated post-manufacture to remove a fat emulsion necessary in the processing phase. The LARS ligament can function as both an independent synthetic ligament if there are enough tissue remnants of the ruptured ligament or as a scaffold to augment the use of other kinds of ligament graft. It is one of a growing number of synthetic ligaments that are attempting to improve on the failures of past artificial devices [14].

Internal bracing during reconstruction

Over recent years, the addition of an internal brace to primary ligament repairs has gained popularity. The internal brace concept seeks to create a “seat belt” across both ligament repairs and reconstructions.

The internal brace allows the tissues to be physiologically loaded whilst creating a stress shielding effect at higher loads, which would ordinarily have led to mechanical failure of the repair/reconstruction, best reported in relation to ACL injuries. Bracing potentially provides additional stability in these unstable injuries, which may, in turn, promote an earlier return to rehabilitation and pre-injury levels of activity [15].

In the pursuit of improving surgical success, its utilisation within the management of ligament injuries around the knee has been advocated. Conceptually, the internal brace concept seeks to improve the mechanobiological environment, facilitating early mobilisation and stress shielding repairs and reconstructions in the first six months of surgery [16].

Repair vs. reconstruction

In general, injured ligaments around the knee can only be repaired if surgery is performed acutely within three weeks of injury. If surgery is undertaken later than three weeks, reconstruction of the ligaments is preferred due to lack of integrity of the soft tissues and poor definition of soft tissue planes [17].

Medial collateral ligament (MCL)

Isolated MCL injury can often be treated conservatively with a period of immobilization in a hinged knee brace. Surgery is performed if there is ongoing laxity or instability. However, a damaged MCL in the context of MLKI should be repaired / reconstructed if it is found to be unstable during examination under anesthesia. In addition, location of the tear and quality of tissue also determines whether it can be repaired or reconstructed. Mid-substance tears of MCL often cannot be repaired satisfactorily and will require augmentation. In combined anterior cruciate ligament (ACL) and MCL injury, conservative treatment of the MCL with ACL reconstruction has been shown to provide good outcomes [18].

Posteromedial corner

The posteromedial corner is a structure located between the posterior longitudinal fibres of superficial MCL and PCL on the medial aspect of the knee. The important structures in this area contributing to the posteromedial corner include the posterior oblique ligament (POL), expansions of semimembranosus, the oblique popliteal ligament and the posterior horn of the medial meniscus [19]. POL is the most commonly injured structure of the posteromedial corner. It is a primary stabilizer for internal rotation of the tibia during knee flexion. The POL ligament can be repaired or reconstructed in the setting of MLKI after MCL repair or reconstruction. Several techniques have been described to repair or reconstruct the POL but there is no evidence to show that one technique is superior to the other [20].

Among the current techniques, independent anatomic reconstruction of both the sMCL and POL to their precise **(Fig. 1)**, respective native attachment sites is infrequent. This can be done using the distally attached gracil and/or semitendinosis to the medial femoral epicondyle with or without suturing it to the superficial MCL. While some techniques claim to restore both the sMCL and POL to their respective anatomic footprint, with two separate tendon grafts and separate fixation screws as described by LaPrade [21].

Posterolateral corner (PLC)

Multiple techniques to repair or reconstruct the PLC of the knee have been described in the literature. However, recent studies have shown a significantly higher failure rate of PLC repair as compared to reconstruction. Although different techniques have been described to reconstruct the PLC **(Fig. 2)**, there is a paucity of high-level evidence to recommend the best reconstructive method. Avulsion of the lateral collateral ligament (LCL) from femoral and fibular attachment can be repaired acutely but midsubstance tears have to be reconstructed [22].

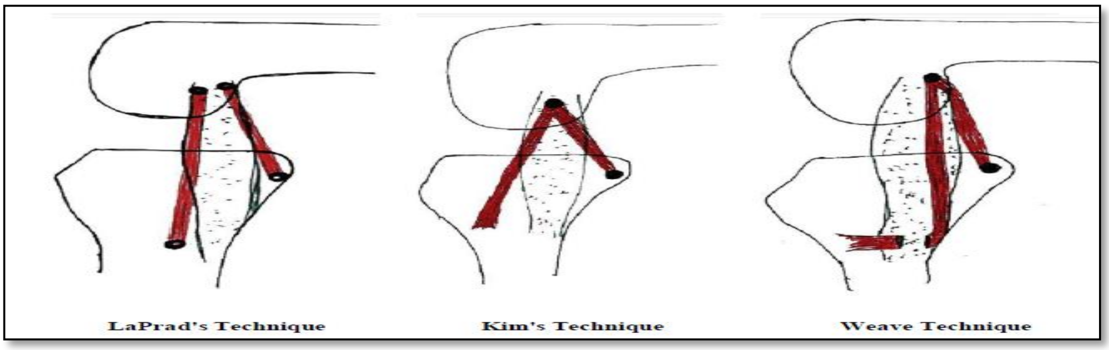

Fig.(1): Common techniques of MCL and POL reconstruction [19].

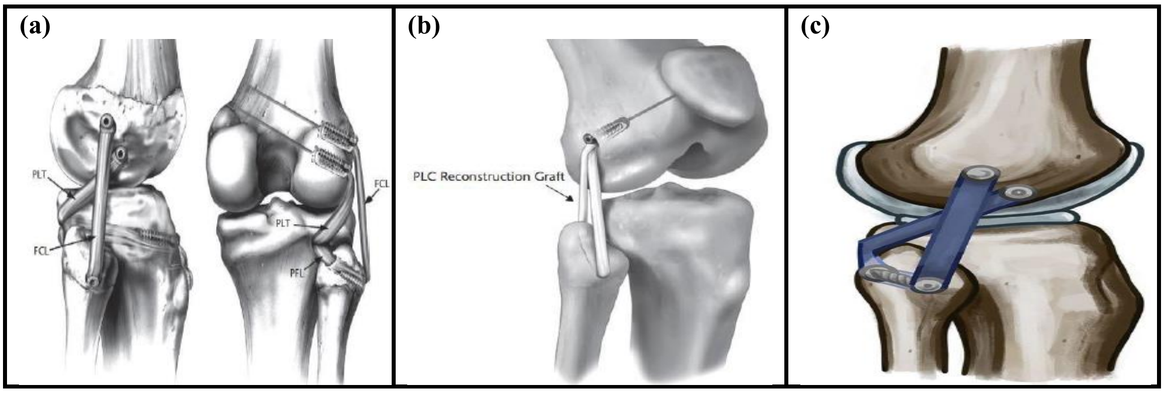

Fig.(2): Showing (a) anatomic posterolateral corner reconstruction (LaPrade); (b) Fibular sling reconstruction with one femoral (Larson); (c) Arciero's posterolateral corner reconstruction technique [22].

Anterior cruciate ligament (ACL)

The preferred strategy to manage ACL rupture in the setting of MLKI is to perform an anatomical single bundle reconstruction using semitendinosus and gracilis autografts from the ipsilateral or contralateral knee. Some authors advocate double bundle ACL reconstruction, but studies have shown similar outcomes with single bundle reconstruction [23].

Posterior cruciate ligament

Several methods have been described to reconstruct the PCL. These include transtibial or tibial inlay single bundle reconstructions and transtibial or tibial inlay double bundle reconstructions. In recent studies, double bundle reconstructive techniques have been shown to more closely restore knee kinematics and to have less residual posterior translation as compared with single bundle reconstruction. However, there was no difference in clinical outcomes. Bony avulsions should be repaired if possible [24].

Tunnel Convergence of the Reconstructed Ligaments

The distal femur and proximal tibia are structures of limited bone volume and density. Therefore, during knee ligamentous reconstruction it is imperative to avoid tunnel convergence which may result in compromise of reconstruction graft integrity and knee stability **(Fig. 3)**.The POL tunnels be aimed to a point 15mm medial to Gerdy´s tubercle to reduce risk of convergence with the PCL, and that the superficial medial collateral ligament (sMCL) tunnel be aimed 30° distally to avoid convergence with the PCL [25].

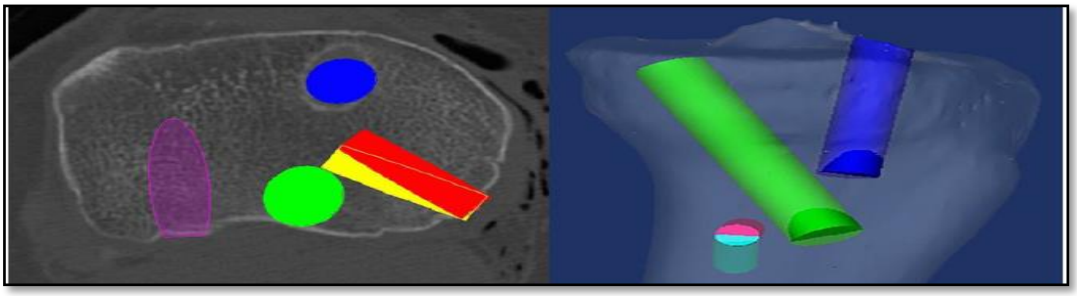

Fig.(3): A CT of a right proximal tibia demonstrating different reconstruction tunnels. POL tunnel towards Gerdy's tubercle (yellow) increases the convergence risk with PCL tunnel (green). POL tunnel to a point 15 mm medial to Gerdy's tubercle (red) the convergence risk with PCL tunnel (green) can be reduced. sMCL tunnel 30° distally (light blue), the risk of convergence with PCL tunnel can be reduced [25].

To avoid convergence with the ACL tunnel, the fibular collateral ligament (FCL) tunnel should be aimed at 35º to 40º in the axial plane and 0º is the coronal plane **(Fig. 4)** for the patient in the supine position. On the medial side of the knee, avoidance was maximized in sMCL and PCL reconstruction when the sMCL tunnel was aimed at 40º proximally and 20º to 40º anteriorly. When considering a POL reconstruction, the femoral tunnel for the posterior oblique femoral tunnel and the sMCL should be drilled 20º/20º and 40º/40º in the axial and coronal planes, for the patient in the supine position **(Fig. 5)** [26].

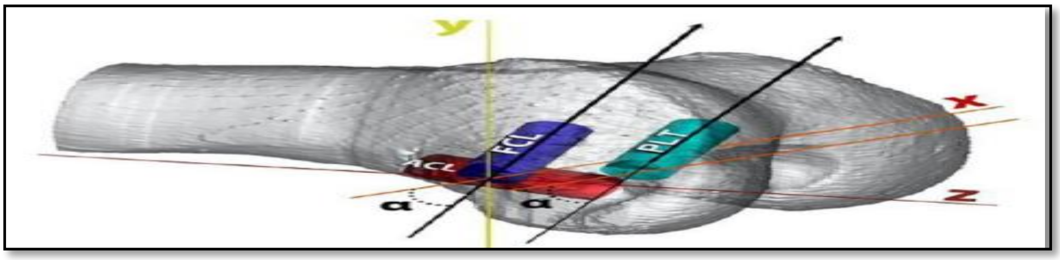

Fig.(4): FCL tunnel should be 35° anteriorly (α= 35°) to avoid tunnel convergence with ACL. The popliteus tendon (PLT) tunnel is drilled parallel to the FCL tunnel, at a 35° angle anterior (α= 35°) to the horizontal plane (x-axis) [26].

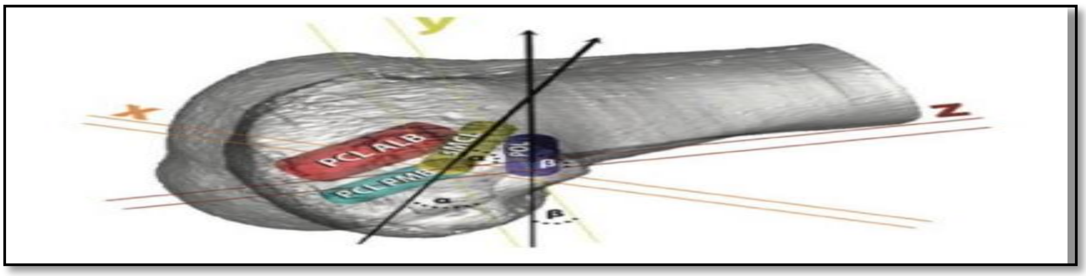

Fig.(5): sMCL) tunnel should be aimed 40° anteriorly and proximally (α= 40°) to avoid collision with the posteromedial bundle (PMB) of PCL. To avoid the sMCL tunnel, POL should be aimed 20° anteriorly and proximally (α= 20°). PCL ALB, posterior cruciate ligament anterolateral bundle; PCL PMB, Posterior cruciate ligament posteromedial bundle [26].

The tensioning sequence in multiligament injuries is a topic of debate. Different tensioning sequences have been reported in the literature. Some authors advocate for starting with the PCL in 90 degrees to restore the central pivot and tibial step-off, followed by the ACL in extension to ensure the knee can be fully extended, posterolateral corner and the posteromedial corner last. In a posterolateral corner deficient knee, tension during fixation of the ACL graft increased external tibial rotation of the tibia. Therefore, there are authors that advocate for fixing the posterolateral corner prior to the ACL to avoid external tibial rotation [26].

Postoperative Rehabilitation

Due to the various patterns of injury and extensive damage to the soft tissue structures of the knee, rehabilitation following multiligament reconstruction is challenging. Critical rehabilitation goals in the early recovery period include protecting the reconstructions through bracing and weight bearing (WB) precautions, symptom management, early range of motion (ROM), quadriceps muscle activation, and patient education regarding precautions and expectations. Patients remain non-weight bearing (NWB) for the first 6 weeks following surgery with a knee immobilizer to stabilize the joint. Patients with PCL reconstruction (PCLR) will transition into a dynamic PCL brace to support the healing grafts as soon as swelling reduces sufficiently for proper brace fit. Bracing is advocated until stress x-rays demonstrate satisfactory joint stability 6 months after surgery and throughout the first year after surgery for patients returning to sports [22].

Starting on day one after surgery, the patient can initiate ROM gradually working up to, but not beyond, 90° of flexion within the critical period of the first two weeks after surgery. Flexion progresses beyond 90° after 2 weeks. Hyperextension is avoided in the first 8 weeks following reconstruction of structures that natively restrict knee hyperextension (PCL, PLC and FCL) to avoid graft elongation [11]. Moreover, a recent trend towards single-staged concurrent ligament reconstruction has allowed for early knee mobilization which helps avoid graft failure and decrease joint stiffness. In the case of PCLR, a prone passive range of motion is advocated in the first 2 weeks after surgery to minimize excessive posterior tibial sag-related limb position and excessive posterior tibial translation (PTT) associated with hamstring muscle activation [2].

Conclusion:

Multiligament knee injuries are complex and relatively rare, requiring a nuanced, patient-specific approach to management. While surgical reconstruction remains the mainstay for restoring joint stability and function in most active patients, non-operative management may be appropriate in selected low-demand or medically compromised individuals. Key factors influencing outcomes include the timing of surgery, injury pattern, presence of neurovascular injury, and adherence to structured rehabilitation protocols.

Despite advances in surgical techniques and postoperative care, long-term functional outcomes vary, and complications such as stiffness, instability, and osteoarthritis remain concerns. Given the lack of large-scale randomized trials, treatment decisions should be guided by available evidence, surgeon experience, and patient goals.

Future research should focus on standardized treatment algorithms and long-term comparative studies to optimize outcomes in this challenging patient population.

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Author contribution: Authors contributed equally in the study.

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