Current Concepts in the Management of Multiligament Knee Injuries

Hossam Fathi Mahmoudm, Ahmed Mohamed Kamal *, Mohamed Nagy Elalfy, Walid Faisal, Ahmed Mashour Gaber, Amr Mohamed Eladawy

Orthopedic Surgery Department, Faculty of Medicine, Zagazig University, Egypt.
Corresponding author: **Ahmed M. Kamal, Email: AM.Kamal@medicine.zu.edu.eg*

Received: 21-6-2024; **Accepted**: 09 -10- 2024; **Published**: 28- 10- 2024

ABSTRACT

Multiligament knee injuries (MLKIs) are among the most complex and challenging injuries encountered in orthopedic trauma. Involving the disruption of two or more major knee ligaments, these injuries often arise from high-energy trauma such as motor vehicle collisions, sports injuries, or knee dislocations. The inherent complexity of MLKIs lies not only in the severity of ligamentous damage but also in the frequent involvement of surrounding soft tissues, neurovascular structures, and joint cartilage. Managing MLKIs presents significant challenges. Accurate diagnosis is complicated by swelling, pain, and potential vascular or nerve injuries, which require urgent attention. Treatment timing is controversial, balancing early stabilization with the risk of stiffness and wound complications. Surgical reconstruction demands meticulous planning due to the need to restore multiple ligament functions while minimizing additional trauma. Despite advances in surgical techniques and rehabilitation protocols, patients remain at high risk for complications, including joint stiffness, persistent instability, neurovascular injury, infection, and long-term osteoarthritis. These challenges underscore the need for a multidisciplinary, individualized approach and continued research to optimize outcomes in this difficult-to-treat patient population.

Keywords: Knee Reconstructions; Single Stage Multiple Ligament; Functional Outcomes

1. Introduction

Understanding management of multiligament knee injuries is essential. These injuries involve complete tears of two or more of the knee's four main ligaments: anterior cruciate, posterior cruciate, medial collateral, and lateral collateral. High-energy trauma often causes these injuries, in younger patients, while chronic cases may follow unsuccessful treatment programs. Vascular and neurological damage is common and can be limb-threatening. Major trauma complicates musculoskeletal injuries, leading to delayed management and poor outcomes [1].

A clinical assessment through history and examination is essential for diagnosis. Routine imaging techniques such as radiographs, vascular studies, and MRI are vital. Despite surgical advances, debates regarding timing, repair options, and graft tensioning continue. Managing a multidisciplinary team poses challenges, focusing on enhancing functional outcomes in multiligament knee injuries and concepts in soft-tissue knee trauma [2].

2. Anatomy of the Knee

The knee joint is complex, involving the tibia, femur, and patella, and its stability relies on bone congruency, menisci, the joint capsule, ligaments, and muscles. Key static stabilizers are the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL). Injuries often lead to

ruptured ligaments and collateral damage, typically resulting in multiple ligament failures, meniscal tears, cartilage issues, and fractures. Treatment options include ligament reconstruction, osteotomy, and cartilage resurfacing. Restoring stability in chronic injuries is crucial for patients to return to pre-injury activities, but the complexity of cases presents challenges. The knee also has posterior ligaments that are essential for stability, as injuries, like a torn posterolateral ligament, can lead to instability. Comprehensive anatomical knowledge is vital for managing significant ligamentous damage [3].

The knee ligaments are essential stabilizers, categorized into cruciate, lateral, and medial. Cruciate ligaments, ACL and PCL, face high loads and often incur complex injuries alongside collateral ligament damage. Multiple ligament ruptures are more frequent than single ones and can affect menisci and bones. Treatment aims for biomechanical stability, possibly requiring reconstruction. Recognizing knee instability promptly is crucial to prevent complications [4].

Multiligament knee injuries involve the complete rupture of two or more key ligaments, presenting serious challenges for orthopedic surgeons and patients. Management strategies remain under debate. The knee's movements depend on its ligament structures. Understanding the roles of crucial ligaments aids in anatomical classification, clinical assessment, and shaping reconstructive strategies for healing [2].

3. Classification of Multiligament Knee Injuries

Kennedy classified knee dislocations in terms of tibial position with respect to the femur for example an anterior knee dislocation implies that the tibia is dislocated straight anterior to the femur. He noted 5 main types of dislocation: anterior, posterior, lateral, medial, and rotatory (Fig. 1). Rotatory dislocations are classified into 4 groups: anteromedial, anterolateral, posteromedial, and posterolateral, with posterolateral being the most frequently described type of rotatory knee dislocation [1].

Multiligament knee injuries involve dislocations and multiple ligament tears, categorized into five classes. Class 1 is a unicruciate tear with collateral damage; Class 2 has bicruciate tears without collateral injuries; Class 3 includes bicruciate tears with one collateral injury; Class 4 features bicruciate tears with both collateral injuries; Class 5 comprises periarticular fractures with any ligament tears. These classifications help predict neurovascular complications and guide surgical planning and outcomes [5].

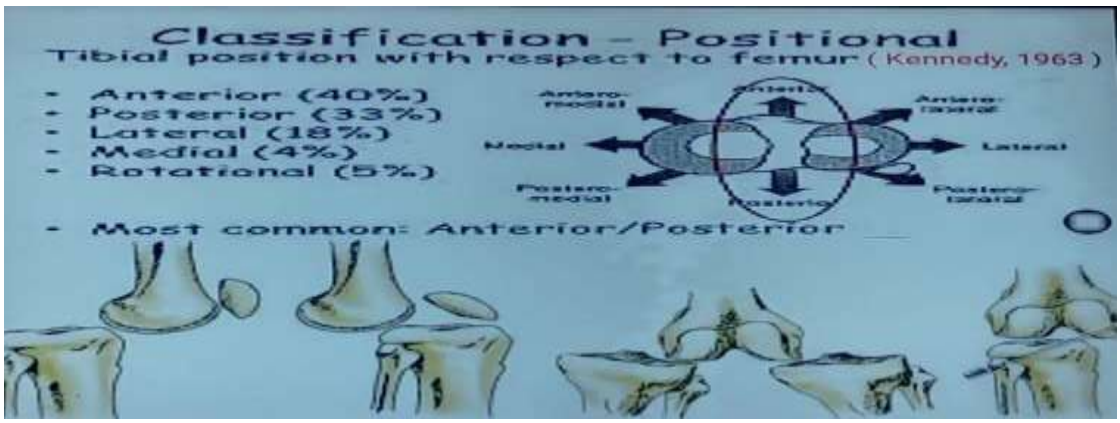

Fig. (1): Kennedy classification of knee dislocations [1].

The type and stage of injury greatly impact diagnosis and treatment. The Schenck classification handles multiple ligament injuries, while Kennedy emphasizes dislocation direction. An expanded classification factors in complications and fractures. Early surgical intervention improves outcomes over delayed treatment. Repair yields better results than conservative methods, especially with LCL and MCL suturing. For ACL and PCL injuries, prioritizing PCL reconstruction is crucial for stability [6].

I. Acute Injuries

Acute injuries often involve ligament tears and joint effusion. Symptoms might be mild even with intact knee structures, allowing early weight-bearing. Different injury patterns indicate varying joint instability levels. In polytrauma cases, assessing vascular and neurological injuries through a detailed clinical exam focused on pathomechanics is crucial. If pulse diminishment occurs after dislocation, the Ankle-Brachial Index (ABI) supports further vascular evaluation, especially if below 0.9. Lack of vascular injury doesn't exclude serious intimal lesions, which may require redo-angiography or CT-angiography for hematomas. MRI is vital for suspected multiligament injuries. Knee dislocations present severe injury risks, so thorough pre-operative assessment is essential. Surgical intervention typically yields better recovery than conservative treatment, though the latter can be suitable for some. Rehabilitation and patient commitment greatly affect outcomes, and the osteoarthritis risk post-multiligament injuries necessitates careful planning regarding timing, grafting choices, techniques, and rehab strategies [2].

II. Chronic Injuries

Surgical intervention is crucial for chronic multiligament knee injuries. While bracing is an option, effective management is necessary for stability, as these injuries can be overlooked. Chronic conditions may lead to joint contracture, making recovery critical before surgery, which could include mobilisation or arthroscopic release. Common issues include posteromedial rotary instability and varus-flexion malalignment [3].

Reconstruction is often preferred over repair in chronic cases, especially with injured ligament midsubstance, as it helps re-establish anatomic attachments. Single-stage procedures allow for a quicker recovery, while staged approaches may be better when multiple surgeries are not well tolerated. Various techniques exist for treating chronic multiligament knee injuries [6].

III. Associated Injuries

Fractures around the knee, meniscal tears, and neurological injuries frequently occur in multiligament-injured knees. Ipsilateral femur, tibia, or fibula fractures can obscure underlying multiligamentous injuries. Meniscal tears happen in as many as 55% of these cases, while 65% may also involve peroneal nerve injuries. Up to 33% of affected nerves cannot be restored through reconstruction [6].

4. Clinical Evaluation

Effective treatment of multiligament knee injuries requires thorough clinical assessment, including history, physical exams, and possible imaging studies. Identifying surgical indications helps clinicians guide patients on treatment options and expectations.

A comprehensive clinical assessment is invaluable in determining the extent of injury in a multiligament injury (Table 1). When a multiligament knee injury is suspected, several clinical

tests must be used in conjunction with a history of the injury and radiologic evaluation to arrive at an optimal treatment strategy [5].

In polytrauma, a complete knee wound survey is essential to reduce distractions from other injuries. Analyzing the injury mechanism helps identify unstable factors, and past knee problems matter as well. Evaluating the uninjured limb aids in comparing stability. For conscious patients, weight-bearing and gait assessments are vital, with pain characteristics distinguishing instability from soft-tissue or cartilage damage [3].

Complete dislocation of the tibiofemoral joint is a rare, limb-threatening injury, complicated by transient dislocations that reduce before evaluation. In knee dislocations, 33 to 50% of patients have multiple-ligament knee injuries (MLKI), often as a sub-dislocation. A multiligament injury indicates instability in two or more major knee ligaments: ACL, PCL, PMC, and PLC [4].

A systematic approach is essential for examining multiligament knee injuries. Initial inspections assess skin lesions, effusions, and the extensor apparatus. Tests start with the patient supine, flexed at 15°–30° to lessen hamstring tension. The Manuel L. Malvar Pereira maneuver evaluates menisci and collateral ligaments, complemented by retro-patellar and drawer tests for a comprehensive assessment [2].

Table (1): Clinical Assessment of Knee Ligament Injuries [5].

Structure	Test
ACL	Lachman's Test, pivot shift test
PCL	Posterior drawer, posterior sag sign
MCL	Valgus stress test performed at 0° and 30° of flexion; dial test; anteromedial drawer test
LCL (FCL)	Varus stress test performed at 30° of flexion
PLC	Posterolateral drawer, dial tests

Radiographs are crucial for assessing multiligament knee injuries, revealing bone damage and urgent fractures. Stress exams identify lateral and posterior instabilities. Emergent MRI is crucial for diagnosing knee dislocations and identifying ligamentous, meniscal, and neurovascular injuries. It differentiates between partial and complete MCL, ACL, and PCL tears and combines PCL and PLC injuries. Other techniques are crucial in polytrauma. Emergency ultrasound detects joint effusions, but arthrography and CT arthrography are superior for meniscal tears [7].

5. Surgical Indications &Surgical Techniques

The timing of multiligament reconstruction ranges from early surgery within 3 weeks to delayed methods. Urgent procedures are vital for open injuries, compartment syndrome, and vascular injuries. Factors affecting timing include comorbidities and age [8].

Vascular interventions vary by injury type, requiring exploration for low ABI or expanding hematoma. High mortality and amputation rates in knee dislocations with vascular injury favor external fixation for open cases [9].

Patient selection for surgical reconstruction is based on injury severity, activity level, age, and comorbidities. Total knee dislocations with multiligament involvement often necessitate surgery. For low-demand individuals, like the elderly or those with major health issues,

nonsurgical options may be appropriate. Restoring knee stability is crucial to minimize long-term complications, including osteoarthritis and instability [10].

I. Arthroscopic Approaches

Arthroscopic techniques are vital for managing multiligament knee injuries. Fluid transmission during arthroscopy can cause compartment extravasation, compromising the safety of posteromedial portals. Thus, treatment typically starts with an open medial or lateral approach, allowing decompression. Arthroscopic reconstruction and treatment of intra-articular structures follow [11].

During arthroscopic graft tensioning for cruciate ligament reconstruction, the knee should be flexed between 60° to 90° to protect against damage to the tibial tunnels and nearby structures. This positioning preserves native tibial insertion sites, crucial in multiligament reconstructions. Care is needed in the posterior compartment, as not attaching the posterior horn of the lateral meniscus can be seen on MRI. Evaluating the lateral meniscus' posterolateral facet guides procedures on specific lesions. MRI signs like the arcuate sign may indicate posterolateral corner injuries, often associated with ACL or PCL lesions [12].

Posteriorly placed tibial tunnels that respect the native ligamentous inserts enhance neurovascular safety. The pathway from the medial femoral condyle to the anteromedial proximal tibia is used for the posterior oblique ligament and MCL graft, while the lateral collateral ligament and popliteus route from the lateral epicondyle to the anterior tibia's flat spot. Advances in open approaches and arthroscopic guidance have improved the reproducibility of multiligament reconstructions [13].

II. Open Surgical Techniques

Open surgery is essential when arthroscopy isn't an option. Graft choices like autografts, allografts, and synthetics vary in benefits depending on patient and surgeon needs. Single-bundle is preferred for ACL, while double-bundle for PCL improves knee movement and reduces posterior translation, but results are similar. The decision for single- or two-staged surgeries depends on resources and preferences, with single-stage allowing early mobilization and reduced stiffness. External fixation may be required for severe instability or vascular repair [3].

Three operative strategies for multiple ligament-injured knees have been extensively reported. Staged procedures are advocated for dislocated knees, single-stage protocols for fractures around the knee, and three-stage approaches for mid-substance ligament ruptures. Preference is expressed for single-stage procedures when no access to a knee arthrometer is available and when skin conditions permit early mobilization. The early and aggressive rehabilitation programme made possible by routinely applied external fixators supports this choice [2].

III. Reconstruction Strategies

Multiligament injured knees may be treated via suture repair or graft reconstruction, ideally within three weeks post-injury, with reconstruction possible at various stages. Staged surgery begins with collateral ligament repair, followed by cruciate ligament reconstruction once motion is restored. A meta-analysis shows that collateral ligament repair should coincide with cruciate ligament reconstruction to avoid altered joint

kinematics and increased graft failure risks. Single-stage reconstructions are preferred to ensure early mobilization [9].

Comparisons of repair versus nonoperative options show unclear advantages, especially in bicruciate injuries, complicating outcome assessments when ACL isn't addressed during PCL repair. Due to the diversity of multiligament injuries, individualized treatment plans are essential. Generally, reconstruction yields better stability and motion, though some analyses show similar functional results for both methods. A combined repair-reconstruction strategy is advised for cases involving collateral ligaments and extra-articular structures[7].

Posterolateral corner reconstruction has lower reoperation rates, while repair often fails more frequently. Recent studies reveal no significant differences between techniques for specific injuries. Repair is preferred for avulsion fractures or ligament detachments with internal bracing. In developing areas, conservative management with staged reconstruction is common, while developed regions favor early, single-stage arthroscopic methods [11].

7. Postoperative Management

Rehabilitation following multiligament knee injury necessitates a balance between protecting the surgical construct and restoring function. Early remobilization beginning in the first week postoperatively is advised, with passive range of motion typically restricted to 0–90 degrees during the initial phase. Hinged knee braces are often utilized to mitigate posterior tibial translation and rotational instability, with modifications implemented based on the concomitant ligaments reconstructed [3].

Physical therapy protocols are an essential component of the postoperative management of multiligament knee reconstruction. These injuries require well-defined rehabilitation to moderate stresses on the healing tissues while restoring motion, strength, and function. Protocols should be individualized based on the pattern and severity of injury and the fixation quality obtained during surgery. Rehabilitation is often divided into four phases, with criteria for progression grounded in clinical milestones rather than fixed time points. Careful monitoring during all stages of rehabilitation is critical to detect and address complications as re-rupture, arthrofibrosis, and persistent joint instability [14].

Immobilizing the limb with a posterior long leg splint at 10° knee flexion is vital for protecting the surgical repair and providing stability. A knee brace then promotes gradual mobility while safeguarding the repaired structures. Early isometric quadriceps exercises, especially straight leg raises, help prevent muscle atrophy and improve venous return via the calf muscle pump, lowering deep vein thrombosis risk during recovery. Collaboration with a physical therapist is essential for a tailored rehabilitation program focused on restoring knee function. Effective pain management postoperatively is critical; unmanaged pain can impede physiotherapy adherence and limit recovery range of motion. Coordinating with pain specialists ensures patient comfort during recovery. While complications such as infection and re-rupture may occur, thorough preoperative assessment and careful monitoring can reduce their incidence [13].

An inclusive discussion of all appropriate therapeutic alternatives remains the ethical foundation of the patient/clinician relationship. Hence, clinicians should inform patients when multiple valid treatment approaches exist and should transparently present relevant harms and benefits of each alternative. Interprofessional collaboration with nurses, athletic trainers, physical therapists, and pain specialists forms the basis of a

comprehensive, organized, and effective treatment regimen. Although clinical decision-making ultimately requires surgeon discretion, consensus regarding the fundamental importance of the patient/clinician relationship continues to influence the development of operative guidelines and protocols [15].

Conclusion:

Multiligament knee injuries pose a formidable challenge to the acute care provider. Early diagnosis and prompt surgical intervention yield the best clinical results.

Management of multiligament knee injuries is controversial, with surgery now being standard. Options include arthroscopic and open techniques. Most injuries can be treated arthroscopically, but multiligament cases often need open surgery. Reconstruction is generally preferred over repair, although repair may work for acute avulsion injuries.

A range of surgical techniques and treatment protocols are described in the literature, but no single strategy has gained ascendancy. Selected patients with chronic instability may also benefit from surgical reconstruction, and all patients should receive close clinical supervision until the injury is definitively resolved.

References:

1- Ng, J. W. G., Myint, Y., Ali, F. M. (2020). Management of multiligament knee injuries. *EFORT open reviews*, *5*(3), 145-155.
2- Skendzel, J. G., Sekiya, J. K., Wojtys, E. M. (2012). Diagnosis and management of the multiligament-injured knee. *journal of orthopaedic & sports physical therapy*, *42*(3), 234-242.
3- Scheepers, W., Khanduja, V., & Held, M. (2021). Current concepts in the assessment and management of multiligament injuries of the knee. *SICOT-J*, *7*, 62.
4- Vicenti, G., Solarino, G., Carrozzo, M., De Giorgi, S., Moretti, L., De Crescenzo, A., Moretti, B. (2019). Major concern in the multiligament-injured knee treatment: a systematic review. *Injury*, *50*, S89-S94.
5- Pardiwala, D. N., Subbiah, K., Thete, R., Jadhav, R., Rao, N. (2021). Multiple ligament knee injuries: Clinical practice guidelines. *Journal of Arthroscopic Surgery and Sports Medicine*, *3*(1), 40-49.
6- Braaten, J. A., Schreier, F. J., Rodriguez, A. N., Monson, J., LaPrade, R. F. (2022). Modern treatment principles for multiligament knee injuries. *Archives of Bone and Joint Surgery*, *10*(11), 937.
7- Constantinescu, D. S., Curtis, E., Satalich, J. R., Vap, A. R. (2021). Reconstruction and/or Repair of The Multi-Ligament Knee Injury: A Systematic Review. *Global Journal of Orthopedics Research*, *3*(2).
8- Zhang, H., Sun, Y., Han, X., Wang, Y., Wang, L., Alquhali, A., Bai, X. (2014). Simultaneous reconstruction of the anterior cruciate ligament and medial collateral ligament in patients with chronic ACL-MCL lesions: a minimum 2-year follow-up study. *The American Journal of Sports Medicine*, *42*(7), 1675-1681.
9- Fortier, L. M., Stylli, J. A., Civilette, M., Duran, N. S., Hanukaai, S., Wilder, H., Kaye, A. D. (2022). An evidence-based approach to multi-ligamentous knee injuries. *Orthopedic Reviews*, *14*(3), 35825.
10- Cook, S., Ridley, T. J., McCarthy, M. A., Gao, Y., Wolf, B. R., Amendola, A., & Bollier, M. J. (2015). Surgical treatment of multiligament knee injuries. *Knee Surgery, Sports Traumatology, Arthroscopy*, *23*(10), 2983-2991.
11- Peskun, C. J., & Whelan, D. B. (2011). Outcomes of operative and nonoperative treatment of multiligament knee injuries: an evidence-based review. *Sports Medicine and Arthroscopy Review*, *19*(2), 167-173.

12- Fanelli, G. C., Stannard, J. P., Stuart, M. J., MacDonald, P. B., Marx, R. G., Whelan, D. B., Levy, B. A. (2010). Management of complex knee ligament injuries. *JBJS*, *92*(12), 2235-2246.

13- Helito, P. V., Peters, B., Helito, C. P., Van Dyck, P. (2018). Imaging evaluation of the multiligament injured knee. *Annals of joint*, *3*(9), UNSP-80.

14- Vinyard, T. R., Boyd, J., & MacDonald, P. B. (2012). Initial evaluation of the acute and chronic multiple ligament injured knee. *The journal of knee surgery*, *25*(04), 275-286.

15- Hohmann, E., Glatt, V., & Tetsworth, K. (2017). Early or delayed reconstruction in multi-ligament knee injuries: a systematic review and meta-analysis. *The Knee*, *24*(5), 909-916.