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Evaluating Surgical Strategies and Functional Outcomes in Multi-Ligamentous Knee Injuries: A Prospective Study in Indian Patients

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Learning Point of the Article:

Early, well-planned single-stage reconstruction tailored to individual injury patterns leads to excellent functional recovery and outcomes in multi-ligamentous knee injuries.

Abstract

Background and Aims: Multiligamentous knee injuries (MLKIs) are uncommon yet complex, presenting challenges in diagnosis, treatment, and rehabilitation. This study aims to evaluate the incidence, causes, surgical techniques, and functional outcomes of MLKI cases in Indian patients.

Materials and Methods: A prospective study was conducted at a tertiary care center. Patients underwent surgical intervention based on clinical evaluation, employing both single-stage and staged reconstruction strategies. The sequence of ligament repair and graft selection was tailored to each case. Post-operative outcomes were assessed using the knee society score (KSS) and Lysholm score.

Results: 70 MLKI cases were treated between January 2021 and July 2023, with two patients lost to follow-up, all patients had anterior cruciate ligament injuries, with additional ligament involvement observed in posterior cruciate ligament (24%), medial collateral ligament (32%), and posterolateral corner (27%). Meniscal injuries were noted in 40% of cases. Graft selection included semitendinosus and gracilis tendons (54%) and peroneus longus (46%), with an average graft diameter of 8 ± 1 mm. No significant differences in outcomes were found between graft types ($P > 0.05$). At 6 months post-surgery, the mean KSS improved from 51 ± 10 to 80 ± 5, while Lysholm scores increased from 60 ± 10 to over 80. Notably, 90% of patients achieved excellent results.

Conclusion: Early, well-planned single-stage reconstruction emerges as an effective strategy for managing MLKIs, yielding favorable functional outcomes. Tailoring surgical approaches based on individual injury profiles significantly optimizes recovery.

Keywords: Knee injuries, multi-ligamentous injuries, anterior cruciate ligament, surgical procedures, operative, rehabilitation.

Introduction

The knee joint, a complex synovial hinge, is stabilized by several intra- and extra-capsular ligaments, including the anterior cruciate ligament (ACL), the posterior cruciate ligament (PCL), the medial collateral ligament (MCL), and the lateral collateral ligament (LCL). Multiligamentous knee injuries (MLKIs), which involve the disruption of two or more of these stabilizing structures, represent severe forms of knee trauma. These injuries are most commonly the result of high-energy trauma, such as road traffic accidents (RTAs), falls from height, or contact sports injuries [1,2,3]. Despite their rarity – estimated globally at 0.072/100,000 person-years – their functional and surgical complexity is significant [1].

MLKIs pose substantial challenges in diagnosis, surgical planning, and post-operative rehabilitation. There remains an ongoing debate regarding the optimal treatment timing (early vs.

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Table 1: MRI findings after the injury, showing the combination of knee ligament injuries

MRI findings	No. of patients	Percentage
ACL tear	34	50
ACL+Lateral meniscal tear (LM)	10	15
ACL+Medial meniscal tear (MM)	5	7
ACL+Both meniscal tears	7	10
ACL+Lateral collateral ligament tear (LCL)	2	3
ACL+PCL+LCL	4	6
Both cruciate+both collaterals+LM tear	3	4.5
ACL+PCL	3	4.5

MRI: Magnetic resonance imaging, ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, MCL: Medial collateral ligament, LCL: Lateral collateral ligament, LM: Lateral meniscus, MM: Medial meniscus

delayed), surgical strategy (single-stage vs. staged reconstruction), order of ligament repair, and the ideal graft choice [4,5,6,7]. Furthermore, the heterogeneity of injury patterns complicates the establishment of standardized treatment protocols [8]. Although recent literature supports early surgical intervention for better outcomes, there remains a limited consensus on surgical sequencing and graft selection tailored to specific injury combinations [6,9].

Functional outcomes following MLKI surgery are also variable. While tools, such as the knee society score (KSS) and Lysholm score are widely used to assess post-operative success, long-term data across diverse populations remain sparse [10]. Moreover, existing studies are often retrospective or limited by small sample sizes, highlighting a need for prospective research.

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{d^2}$$

This single-center prospective study aims to close the gaps pertaining to surgical approaches and functional outcomes of MLKI cases. The study focuses on decision-making in treatment sequencing and graft selection, comparing outcomes with those reported in the present literature and aiming to provide evidence to inform future clinical best practices.

Materials and Methods

This was a prospective interventional study conducted in the Department of Orthopedics at a tertiary care center between January 2021 and July 2023. Sample size was decided based on statistical Cochran's formula to power the study.

- n = the required sample size
- Z = the z-value (or Zα/2), which is a constant from the standard normal distribution corresponding to the desired confidence level (e.g., 1.96 for a 95% confidence level, which is standard)
- p = the expected proportion of the attribute in the population (obtained from previous studies or a pilot study; if unknown, 0.5 is often used as it yields the largest sample size)
- d = the desired precision or margin of error (e.g., 0.05 for a ±5% margin of error).

Ethical approval was obtained from the institutional review board. Patients aged 18–60 years with clinical and radiological evidence of MLKI (defined as injury to two or more ligaments, including the ACL, PCL, MCL, LCL or posterolateral corner (PLC) were included. Exclusion criteria were open knee injuries, isolated meniscal tears without ligament injury, or patients unwilling to consent.

Pre-operative assessment included detailed history taking, physical examination using standard tests (Lachman, anterior/posterior drawer, varus/valgus stress, dial test), magnetic resonance imaging (MRI), and stress radiographs. Surgery was planned based on clinical findings and confirmed by MRI.

All patients underwent arthroscopic or combined open-assisted single-stage reconstruction, depending on the structures involved. ACL and PCL reconstructions were done arthroscopically. MCL or PLC injuries requiring surgical

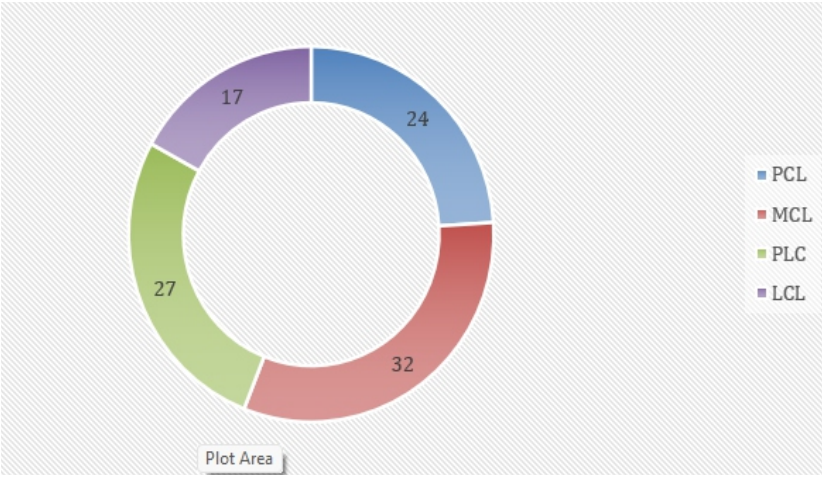

Figure 1: Pattern and percentage incidence of associated injuries.

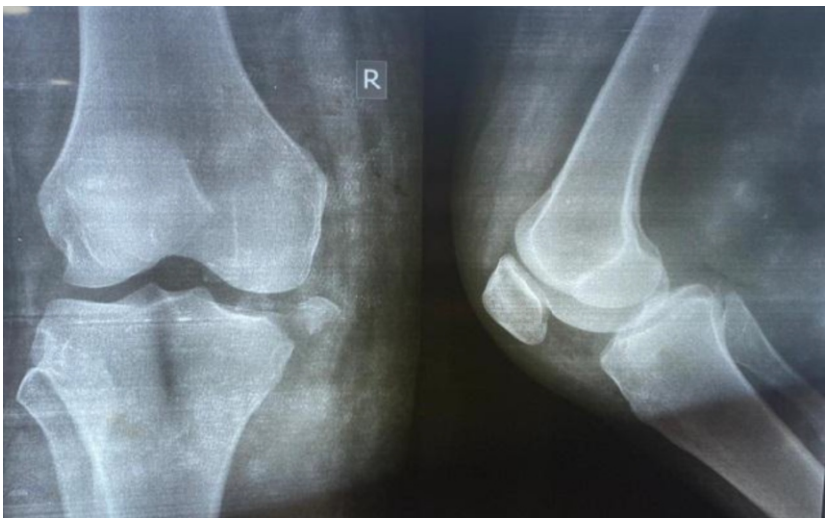

Figure 2: Anteroposterior and lateral view of radiograph of the knee showing medial condyle fracture with medial collateral ligament avulsion.

management were addressed using open techniques. Grafts used included ipsilateral semitendinosus-gracilis (STG) autografts or peroneus longus (PL) autografts when hamstring quality was poor. Graft fixation methods included suspensory (cortical button) and aperture (interference screw) devices.

Post-operatively, patients were placed in hinged knee braces. Weight-bearing was allowed as tolerated from day 2 with the brace locked in extension. Gradual range-of-motion exercises began within the 1st week after surgery. Standardized rehabilitation protocols were followed.

Patients were assessed at 6 weeks, 12 weeks, and 6 months using the KSS and Lysholm score.

The KSS system [33] is divided into two primary components – the knee score and the functional score, each with a maximum of 100 points, giving a total possible score of 200.

- The knee score (0–100 points) evaluates pain (50 points), range of motion (25 points), and stability (25 points), with deductions for deformities, such as flexion contracture, extension lag, or misalignment.
- The functional score (0–100 points) assesses the patient's ability to walk and climb stairs (50 points each), with deductions for the use of walking aids, such as canes or crutches.

Table 2: Knee severity score (KSS) pre- and post-operative intervals

KSS score	Pre-operative	1 month	2 months	3 months	6 months
40–50	14	0	0	0	0
51–60	50	26	6	0	0
61–70	4	38	42	0	0
71–80	0	4	16	10	4
>80	0	0	4	58	64

Scores are typically interpreted as follows: 85–100 points indicate excellent results, 70–84 good, 60–69 fair, and below 60 poor. This structured scoring system provides a standardized and objective method to quantify both clinical and functional outcomes after knee surgeries, including ligament reconstruction.

The Lysholm KSS [34] is a patient-reported outcome measure (PROM) widely used to assess knee function, particularly following ligamentous injuries and reconstructive surgeries. It consists of eight parameters – limp, support, locking, instability, pain, swelling, stair climbing, and squatting – with a total score of 100 points. Higher scores indicate better knee function and stability. Based on the total score, results are graded as excellent (95–100), good (84–94), fair (65–83), and poor (<65). The Lysholm score provides a simple yet comprehensive assessment of a patient's functional recovery and subjective satisfaction after treatment.

Complications were recorded and divided into major (recurrent or residual instability, deep infection) and minor (superficial infection).

Results

Seventy patients were included. Two patients were lost to follow-up. The mean age was 30.1 ± 8.4 years (range, 18–58 years). with 85% of the participants being male. The

Figure 3: Post-operative anteroposterior and lateral view of radiograph of the knee showing medial condyle fracture fixed with cannulated cancellous screws in the distal femur and proximal tibia.

Figure 4: Patient attained full flexion and extension at 6 months post-operatively.

predominant mode of injury was RTAs (80%), followed by sports injuries (15%) and falls (5%). Right-sided injuries were more frequent (58%). The average time between injury and surgery was 8.25 ± 5 weeks. Chronic injuries (>6 months duration) were seen in 12 patients, all of whom exhibited thigh muscle wasting.

ACL injuries were present in all patients. PCL involvement was noted in 16 (24%), MCL in 22 (32%), and PLC in 18 (27%). LCL injuries occurred in 12 patients (17%) (Fig. 1). Meniscal injuries were observed in 40% of cases, with medial meniscus involvement being more common.

The tendon grafts used included STG in 54% and PL in 46%. The average graft diameter was 8 ± 1 mm. No significant difference in outcome was observed between graft types or fixation methods ($P > 0.05$).

Clinical assessments revealed that the Lachman test was positive in 89% and the anterior drawer test in 86% of cases pre-operatively. MRI could not detect ligament injuries in six patients who had positive clinical test results, underscoring the importance of thorough examination.

Figure 5: Patient performing squatting and sitting cross-legged at 6-months post-operatively.

At 6 months, the mean KSS improved from 51 ± 10 to 80 ± 5. Lysholm scores improved from 60 ± 10 to over 80. Sixty-three patients (90%) had excellent results; seven had good outcomes. Two patients developed superficial infections (resolved with antibiotics), and one required revision for instability.

Discussion

MLKIs are relatively rare injuries but clinically significant due to their complexity, potential for long-term instability, and high functional demands from an often young, active patient population. The incidence in our series mirrors recent epidemiological data from Westermann et al. [1] and Lindsey et al. [3], with young adult males predominating and RTAs accounting for the majority of cases. This injury pattern is particularly relevant in low- and middle-income countries (LMICs), where the increasing use of high-speed vehicles has been associated with a rise in MLKI incidence [23]. Public health interventions, including road safety campaigns and the adoption of protective sports equipment, remain crucial in preventing these serious knee injuries.

Accurate diagnosis of MLKIs requires a combination of thorough clinical evaluation and imaging. While MRI is an invaluable tool, our data, similar to Al Mohammad et al. [2] and Fischenich et al. [12] – show that it may fail to identify certain ligament injuries, particularly in chronic or partially healed cases (Table 1). This underscores the continued importance of validated clinical tests, such as Lachman, posterior drawer, and dial tests. Scoping reviews [23] recommend that in resource-limited settings, clinical diagnosis should be prioritized when imaging is inconclusive or unavailable.

The optimal timing for surgery remains a subject of ongoing debate. Our findings are consistent with those of Harner et al. [6] and Mook et al. [19], as well as the recent meta-analysis by Vaishya et al. [24,32], support early reconstruction – ideally within 3 weeks – to facilitate graft placement and reduce arthrofibrosis risk. However, in cases with severe soft tissue compromise or delayed presentation, often seen in rural LMIC contexts, delayed surgery may be unavoidable. Yoon et al. [8] highlights that while delayed intervention can still yield acceptable results, early timing is associated with faster neuromuscular recovery.

In our cohort, single-stage reconstruction yielded excellent functional outcomes without increasing complication rates, aligning with the findings of

Table 3: Lysholm scores at pre- and post-operative intervals

Lysholm score	Pre-operative	1 month	2 months	3 months	6 months
50–60	30	0	0	0	0
61–70	38	28	4	0	0
71–80	0	34	24	4	0
>80	0	6	40	64	68

Ishibashi et al. [5] and Joutoku et al. [4]. Recent systematic reviews [26, 29] indicate that single-stage procedures reduce hospital stay, rehabilitation time, and costs – critical advantages in LMIC settings. Staged approaches remain indicated for cases with severe swelling, vascular repair, or open injuries [14, 16], but their higher rehabilitation demands and resource implications make them less feasible in many environments.

Graft selection remains a critical factor in MLKI reconstruction. The STG autografts were our primary choice; PL autografts were used when the quality of the hamstring was found to be suboptimal, a finding also supported by Goyal et al. [10]. Moreover, a recent systematic review [31] demonstrates comparable biomechanical strength and functional outcomes. Our findings of no significant difference in outcomes between fixation methods are consistent with those of Crum et al. [11] and recent biomechanical analyses [25]. Graft choice should remain individualized, taking into account the patient's anatomy, prior surgeries, and the availability of suitable grafts.

We followed a medial or posterolateral repair-first strategy, followed by reconstruction of the PCL and ACL. Excellent clinical outcomes were seen with this approach (Fig. 2, 3, 4, 5). This sequence, supported by Kim et al. [9] and LaPrade et al. [18], restores coronal stability before addressing sagittal stability, minimizing graft tension imbalances. Literature suggests that sequencing errors can compromise biomechanical restoration [27], emphasizing the need for standardized, biomechanically informed protocols.

Our accelerated rehabilitation program – with early passive mobilization and progressive weight-bearing – produced significant improvements in KSS (Table 2) and Lysholm scores (Table 3) at 6 months, consistent with global best practices [20, 28]. Indian series [24,25] and recent rehabilitation-focused reviews [26] confirm that structured, multidisciplinary rehabilitation is essential for optimal outcomes, particularly to prevent stiffness. Notably, 90% of our patients achieved excellent results, exceeding the pooled return-to-function rates reported by King et al. [21].

Limitations of this study include its single-center design, relatively short follow-up, and absence of a control group. However, strengths include its prospective design, consistent surgical techniques, and uniform rehabilitation protocols. Future research should include multicentric randomized trials, longer follow-up to assess osteoarthritic progression, and incorporation of PROMs [23,29]. Technological advances, such as 3D gait analysis and imaging biomarkers could further refine the assessment of biomechanical restoration [27, 30].

Conclusion

This study reinforces that early and well-planned single-stage reconstruction is a reliable and effective approach for managing MLKIs. By aligning surgical strategies with the specific injury pattern and patient profile, optimal stability and function of the knee can be restored. The findings highlight the importance of individualized surgical planning and graft selection in achieving favorable outcomes. Overall, a tailored, patient-centric approach to MLKI reconstruction fulfills the aim of improving knee function and long-term recovery, supporting its adoption as a preferred management strategy.

Clinical Message

- Early diagnosis and timely surgical intervention are crucial for optimal recovery in MLKIs
- A single-stage, well-planned reconstruction provides excellent functional outcomes and reduces rehabilitation time
- Tailoring the surgical approach – including graft choice and repair sequence – to the specific injury pattern enhances stability and recovery
- Clinical examination remains indispensable, as MRI may miss certain ligament injuries
- A structured, multidisciplinary rehabilitation protocol is key to regaining full knee function and preventing stiffness.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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