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Prevalence of anterior knee pain in post-operative multi-ligamentous knee reconstruction individuals

Ms. Nandisha Alpesh Ingle[1*], Dr. Chandrakant Patil[2]
[1*]Final-year student, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad.
[2]Associate Professor, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad.

Abstract
Background: Multi-ligamentous knee injuries (MLKI) represent complex orthopedic conditions involving damage to two or more primary knee ligaments (ACL, PCL, MCL, LCL), typically resulting from high-energy trauma such as motor vehicle accidents or severe sports injuries. While anterior knee pain following single ligament reconstruction is well-documented with prevalence rates of 5-19%, there exists a significant knowledge gap regarding anterior knee pain occurrence in multi-ligamentous reconstruction patients. These complex procedures involve extensive surgical intervention and present unique biomechanical challenges that may predispose patients to different pain patterns compared to single-ligament procedures. Understanding the prevalence and associated factors of anterior knee pain in this specialized population is crucial for optimizing patient counselling, developing targeted prevention strategies, and implementing appropriate rehabilitation protocols.
Materials and Methods: A 6-month survey-based observational study involving 90 participants (aged 16-45) who underwent multi-ligamentous knee reconstruction and presented with anterior knee pain ≥5/10 on NPRS. Assessment included the Kujala anterior knee pain scale, NPRS evaluation, ROM assessment, and quadriceps strength measurement using dynamometry.
Results: Mean NPRS scores were 5.51 ± 1.03 (range 3-7). Severe muscle atrophy was present in 73% of participants with a 67% strength reduction compared to the minimal atrophy group ($H(2) = 43.21$, $p < .001$). Significant ROM deficits were observed, with severe flexion deficiency showing a 40% reduction ($F(2,87) = 22.43$, $p < .001$) and extension deficits ($F(2,87) = 74.32$, $p < .001$). No significant associations were found between gender and limp presence ($p = .492$) or knee-side pain frequency ($p = .910$).
Conclusion: This first comprehensive study of anterior knee pain in multi-ligamentous reconstruction patients revealed 100% prevalence of clinically significant pain, with 73% showing severe quadriceps atrophy. Strong associations between pain, muscle atrophy, and ROM deficits indicate anterior knee pain is a prevalent outcome requiring proactive management. Clinical implications include preoperative counselling, aggressive early mobilization protocols, and comprehensive multidisciplinary pain management strategies for optimal patient outcomes.
Keywords: *Multi-ligamentous knee injury, anterior knee pain, knee reconstruction, quadriceps atrophy, range of motion, NPRS, biomechanics, rehabilitation, postoperative complications*

1. INTRODUCTION

Background and Clinical Significance

Anterior knee pain is one of the most common clinical complaints, affecting individuals across all age groups and activity levels. This condition is characterized by discomfort or pain localized to the front of the knee, typically around the patella. This multifactorial condition can arise from various etiologies, including patellofemoral dysfunction, overuse injuries, trauma, or structural abnormalities. While particularly common among athletes and physically active populations, anterior knee pain also significantly impacts sedentary individuals, posing considerable diagnostic challenges due to its complex biomechanical and anatomical underpinnings.

Multi-ligamentous Knee Injuries: A Complex Clinical Entity

Multi-ligamentous knee injuries (MLKI) represent significant and complicated orthopedic conditions resulting from damage or rupture of two or more of the four primary ligaments within the knee complex: the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL) including the posteromedial corner (PMC), and lateral collateral ligament (LCL) including the posterolateral corner (PLC) (1). These devastating injuries typically occur secondary to high-energy trauma such as motor vehicle collisions, falls from significant heights, or severe sports-related accidents (2). MLKI are frequently associated with knee dislocations and commonly present with concurrent neurovascular complications, most notably involving the popliteal artery and common peroneal nerve (3). Despite their severe clinical implications, MLKIs account for less than 0.02% of all orthopedic injuries in the general population, making them relatively rare but clinically significant conditions.

Post-Operative Complications Following Ligament Reconstruction

Contemporary literature demonstrates that ligament reconstruction surgery, while generally successful with good to excellent outcomes reported in over 90% of cases, is not without complications. Anterior knee pain has emerged as a notable postoperative concern that can range from mild and intermittent discomfort to severe pain sufficient to impair daily activities and sports participation. The prevalence of anterior knee pain following ACL reconstruction has been estimated to range between 5% and 19%, with variations dependent on surgical technique and graft selection [4]. Recent evidence demonstrates that patients receiving ipsilateral bone-patellar tendon-bone (BPTB) autografts experience significantly higher rates of anterior knee pain compared to those receiving hamstring tendon (HT) autografts, while postoperative extension range of motion deficits further increase pain occurrence regardless of graft type [4]. These findings suggest that anterior knee pain etiology extends beyond simple donor site morbidity to encompass biomechanical factors and rehabilitation outcomes. Future research should examine whether these technique-specific differences and ROM-related risk factors extend consistently to multi-ligamentous procedures where surgical trauma is higher and investigate whether early intervention strategies targeting extension deficits can reduce anterior knee pain incidence across different graft selections.

Research has established that reconstruction using bone-patellar tendon-bone (BPTB) grafts is associated with higher rates of anterior knee pain compared to hamstring tendon (HT) grafts, with donor site morbidity contributing significantly to patellofemoral pain syndrome. Studies have reported prevalence rates of anterior knee pain due to donor site morbidity ranging from 11.5% to 22% in autologous BPTB reconstructions. Furthermore, patients with postoperative extension range of motion deficits demonstrate increased risk of experiencing anterior knee pain, regardless of the specific surgical technique employed.

Biomechanical Considerations and Risk Factors

Emerging evidence suggests that presurgical biomechanical factors may predict the development of anterior knee pain following knee reconstruction procedures. Studies investigating total knee arthroplasty have identified that knees exhibiting biphasic loading patterns during walking demonstrate significantly higher incidence of anterior knee pain postoperatively [5]. These patterns, characterized by sustained high early mid-stance knee flexion moments and increased terminal extension moments, appear to predispose individuals to anterior knee pain development.

While Patel et al. (2021) reported a negative correlation between flatfoot and anterior knee pain in their cross-sectional study of 284 young adults, this relationship requires cautious interpretation due to several limitations. The study found that reduction in Clarke's angle (indicating flatter feet) was associated with increased knee pain severity, with correlation coefficients of $r = -0.153$ for the right side and $r = -0.294$ for the left side, representing only weak to moderate associations. The proposed biomechanical mechanism—that medial longitudinal arch collapse leads to excessive foot pronation, tibial internal rotation, knee valgus positioning, and subsequent patellofemoral stress—is theoretically plausible but unvalidated through direct biomechanical analysis [6]. Furthermore, the cross-sectional design prevents establishment of causality, and the findings from a specific geographic population may not generalize to diverse demographic groups. Therefore, further prospective studies are required to confirm this relationship across different populations, establish temporal relationships between flatfoot development and knee pain onset, investigate the proposed biomechanical pathways through dynamic analysis, and determine whether interventions targeting foot arch support can effectively prevent or reduce anterior knee pain before considering flatfoot deformity as an established causal factor rather than a potential contributing element in anterior knee pain pathogenesis.

Knowledge Gap and Clinical Rationale

While the literature provides substantial evidence regarding anterior knee pain (AKP) after single-ligament procedures—particularly ACL reconstruction (ACLR)—there remains a notable gap concerning its prevalence and profile after multiligamentous knee reconstruction (MLKR). In isolated ACLR, reported AKP rates are generally in the single- to low-double-digit range and are influenced by graft choice (higher with bone–patellar tendon–bone) and early extension deficits [7]. Given the complex soft-tissue damage and surgical burden in MLKI, the risk profile for AKP plausibly differs. Mechanistically, isolated ACL injury primarily disrupts anterior tibial translation and rotatory control, with downstream

quadriceps activation deficits (arthrogenic muscle inhibition) that elevate patellofemoral joint (PFJ) stress [8][9]. In contrast, MLKI commonly includes PCL and/or posterolateral corner (PLC) involvement; experimental and in vivo studies show PCL deficiency increases PFJ contact pressures and alters PF kinematics, and PLC insufficiency perturbs cruciate loads and knee kinematics—changes that can aggravate PFJ loading during functional tasks [10][11]. The altered load distribution, combined with longer, more restrictive rehabilitation courses and higher stiffness risk described in MLKI cohorts, may further amplify AKP risk compared with isolated ACLR [12].
The multifactorial etiology of anterior knee pain, combined with the biomechanical complexity inherent in multi-ligamentous reconstruction, necessitates specific investigation into this patient population. Understanding the prevalence of anterior knee pain in post-operative multi-ligamentous reconstruction individuals is crucial for optimizing patient counselling, developing targeted prevention strategies, and implementing appropriate rehabilitation protocols.

Study Significance

Left untreated, anterior knee pain can lead to functional limitations, reduced activity levels, and diminished quality of life [13]. In the context of multi-ligamentous reconstruction, where patients have already experienced significant trauma and undergone complex surgical intervention, the development of anterior knee pain represents an additional burden that may compromise the overall success of treatment and return to pre-injury function levels.
This investigation seeks to address the current knowledge gap by examining the prevalence of anterior knee pain in individuals following multi-ligamentous knee reconstruction, thereby contributing to the evidence base necessary for improved patient care and outcomes in this specialized population. The findings will inform clinical decision-making, enhance patient education, and potentially guide modifications to surgical technique and postoperative management protocols to minimize the occurrence of this debilitating complication. Assessment of anterior knee pain will be conducted using validated measurement tools [14][15] to ensure reliable and accurate data collection.

Study Conclusion Paragraph

Our study is aimed to cover all the associated aspects of anterior knee pain development in multi-ligamentous knee reconstruction patients. To our knowledge, no such study has elaborated comprehensively on the prevalence and contributing factors behind anterior knee pain in this specialized population. Our investigation provides a multi-faceted approach toward a better understanding of how multi-ligamentous reconstruction procedures influence postoperative pain patterns, functional outcomes, and quality of life. This may also serve to update the development of targeted prevention strategies, optimize surgical techniques, and refine postoperative management protocols to minimize this debilitating complication and improve overall treatment success in multi-ligamentous knee injury patients.

2. MATERIALS AND METHODS

2.1 Participants

This was a survey-based observational study conducted at Karad over a duration of 6 months. The study population comprised individuals between the ages of 16 and 45 years of both genders. The simple random sampling method was employed for participant selection. The sample size was calculated using the formula $n = 4pq/L^2$, where Z represents the standard normal variant of 1.96 (for 95% confidence interval), p denotes the prevalence of 6% from prior study (Marques et al., 2020 ACL reconstruction (ACLR) literature [4], q equals 100-6=94, and L indicates the allowance error of $(0.05)^2$. Based on this calculation, the sample size was determined to be 90.24, which was rounded to n=90 participants.
The inclusion criteria for the study encompassed individuals within the age limit of 16-45 years of both genders who had undergone operative treatment for repair or reconstruction of 2 or more ligaments and presented with anterior knee pain of 5 or greater than 5/10 on the Numeric Pain Rating Scale (NPRS). Participants were excluded if they had conditions such as severe osteoarthritis, rheumatoid arthritis, or other systemic diseases that could independently cause knee pain. Additionally, individuals younger than 16 years or older than 45 years, those who had undergone surgical repair for only one ligament, and individuals with postoperative infections, poor wound healing, or other major complications that could influence knee pain were excluded from the study.

2.2 Procedure
Participants in this survey-based observational study were postoperative multi-ligamentous knee reconstruction individuals from all over Karad. By strictly observing the inclusion criterion, all participants were given a standardized questionnaire (Kujala anterior knee pain scale). The pain was evaluated using the Numerical Pain Rating Scale (NPRS). The participants went through a range of motion (ROM) assessment, and evaluation of quadriceps strength was assessed using a handheld push-pull dynamometer, which has been shown to be valid and reliable for lower limb strength testing (Stark et al., 2011; Katoh & Yamasaki, 2009) [16][17]. Informed consent was taken before the assessment began; only participants that provided informed consent were allowed to perform the test.

2.3 Ethical Approval and Participation Consent
To begin the research, ethical approval was obtained from the Institutional Ethics Committee of the tertiary care hospital. All the participants were informed about the study's purpose and inclusion standards. Moreover, it was made sure that the patients should be aware of the nature of the tests they had to go through and the type of information required from them. Also, the
Participants were given the right to withdraw from the ongoing research at any time.

3. RESULTS
3.1 Statistical analysis
For data analysis, that is, analyzing the data from the exercise and experiment, we subjected the data to computational statistical analysis using IBM Corp. Released 2021. IBM Software Package for Social Science (SPSS) Statistics for Windows, Version 28.0. Armonk, New York, USA. The Shapiro–Wilk test was used to analyze the NPRS variables effectively; on the other hand, a Kruskal–Wallis test was used to analyze the dynamometer findings between the groups. A one-way analysis of variance (ANOVA) was used to check ROM flexion degree between flexion deficiency groups along with post-hoc tests. Table 1 depicts the demographic variables of the participants along with the affected knee. Figure 1 represents the gender and affected knee distribution, respectively.

Table 1: Demographic variables of the participants

Metric	**Value**
Sample Size	90
Mean Age	29.46
SD Age	7.66
Min Age	16
Max Age	45
Male	58
Female	30
Affected: Right	68
Affected: Left	18
Affected: Both	4

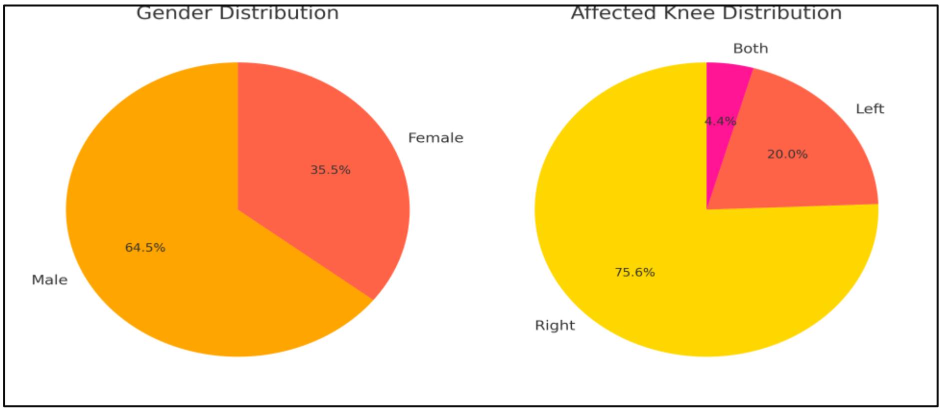

Figure 1: Gender and affected knee distribution variables

3.2 **RESULTS AND FINDINGS**

Numerical Pain Rating Scale (NPRS)

A descriptive analysis was conducted on the NPRS scores of 90 participants (0–10 scale). The scores ranged from 3 to 7, M = 5.51, SD = 1.03. The median score was 6.00. The distribution was slightly negatively skewed (skewness = −0.79, SE = 0.25) and showed mild kurtosis (kurtosis = 0.45, SE = 0.50), suggesting a concentration of scores toward the higher end of the scale. The Shapiro–Wilk test indicated non-normality ($p < .001$), and therefore non-parametric analyses are recommended for inferential comparisons, as shown in Table 2.

Table 2: Descriptive analysis on NPRS

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
NPRS Rating (0-10)	90	4	3	7	5.51	1.030
Valid N (listwise)	90					

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
NPRS Rating (0-10)	90	100.0%	0	0.0%	90	100.0%

Descriptives

			Statistic	Std. Error
NPRS Rating (0-10)	Mean		5.51	.109
	95% Confidence Interval for Mean	Lower Bound	5.30	
		Upper Bound	5.73	
	5% Trimmed Mean		5.57	
	Median		6.00	
	Variance		1.062	
	Std. Deviation		1.030	
	Minimum		3	
	Maximum		7	
	Range		4	
	Interquartile Range		1	
	Skewness		-.787	.254
	Kurtosis		.446	.503

Dynamometer Findings and Thigh Atrophy

Muscle strength (in kg) was measured using a dynamometer across three atrophy groups coded as:
- 5 = Not at all
- 3 = A little bit
- 0 = A lot

Table 3: Group descriptive statistics

Group	M	SD	n
A lot (0)	12.45 kg	3.25	66
A little bit (3)	21.86 kg	5.06	21
Not at all (5)	38.00 kg	3.61	3

Note: M = mean; SD = standard deviation.

A Kruskal–Wallis test revealed a significant difference in muscle strength between the groups, H(2) = 43.21, p < .001, indicating that higher muscle atrophy severity was associated with lower dynamometer strength, as shown in table 4.

Table 4: Dynamometer findings and muscle atrophy analysis

Atrophy Score	**count**	**mean**	**std**	**min**	**25%**	**50%**	**75%**	**max**	**Kruskal-Wallis H**	**p-value**
0	66	12.4545455	3.24952928	8	10	12	15	19	43.2067724	4.15E-10
3	21	21.8571429	5.06246693	13	18	22	25	32	43.2067724	4.15E-10
5	3	38	3.60555128	34	36.5	39	40	41	43.2067724	4.15E-10

Range of Motion (ROM)—Flexion and Extension

A one-way ANOVA showed a significant difference in ROM Flexion Degree between flexion deficiency groups, F(2, 87) = 22.43, p < .001. Post-hoc comparisons (Tukey) indicated that all pairwise group differences were significant (p < .05), as shown in table 7 and figures 2 and 3, respectively.

For the ROM Extension Degree, ANOVA results were also significant, F(2, 87) = 74.32, p < .001, with all post-hoc comparisons showing significant differences.

Tables 5 and 6 show the overall descriptive statistics along with group means with flexion deficiency, respectively.

Table 5: Overall Descriptive Statistics

Variable	**Mean**	**SD**	**Min**	**Max**
ROM Flexion Degree	95.93°	16.17	50	125
ROM Extension Degree	2.43°	1.55	0	7
Flexion Deficiency Score	3.16	1.14	0	5

Table 6: Group Means by Flexion Deficiency Category

Group	N	Flexion ROM M (SD)	Extension ROM M (SD)
a) None (5)	16	106.31	0.44
b) Slight (3)	68	96.32	2.6
c) Severe (0)	6	63.83	5.83

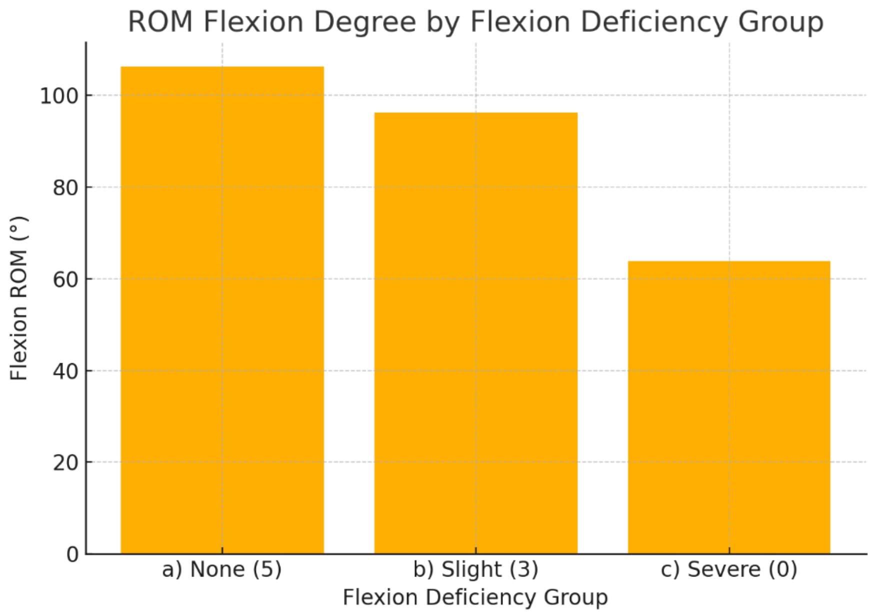

Figure 2: ROM flexion degree by flexion deficiency group

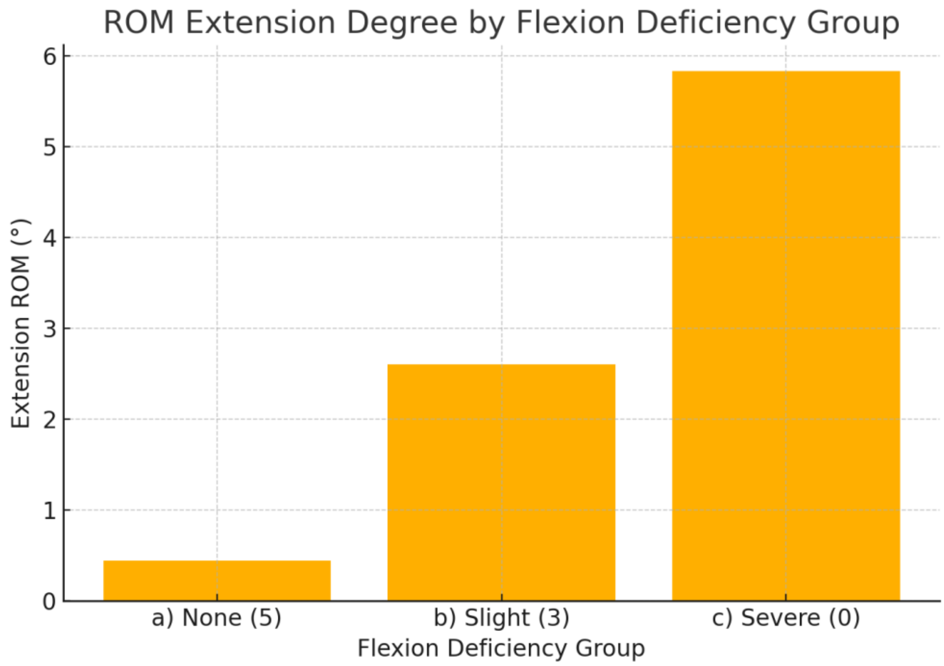

Figure 3: ROM extension degree by flexion deficiency group.

Table 7: Post-hoc comparison analysis

Outcome	F-value	p-value	Interpretation
ROM Flexion Degree	22.43	**p < 0.000000014**	Significant difference between groups
ROM Extension Degree	74.32	**p < 0.000000000000000015**	Significant difference between groups

Summary
The NPRS results indicate moderate pain levels overall. Muscle strength, as measured by a dynamometer, showed a clear inverse relationship with atrophy severity, confirmed by the Kruskal–Wallis test. ROM measurements for both flexion and extension were significantly associated with flexion deficiency severity, with post-hoc tests confirming pairwise differences.

Chi-square analysis

A Pearson chi-square test was conducted to examine the association between **gender** and the presence of a **limp** in the affected leg.

The results indicated no significant association, $\chi^2(2, N = 90) = 1.42, p = .492$.

This suggests that the proportion of participants reporting a limp did not differ significantly between males and females.

A second Pearson chi-square test was performed to assess the relationship between **affected knee** (right, left, or both) and **pain frequency**.

The analysis revealed no significant association, $\chi^2(14, N = 90) = 7.58, p = .910$, indicating that pain frequency distribution was similar regardless of which knee(s) were affected.

Crosstabulation: Gender × Limp

	Limp = No	**Limp = Yes**	**Total**
Male	n_1	n_2	n_1+n_2
Female	n_3	n_4	n_3+n_4
Total			90

Table 8: association between gender and limp

Test	**Value**	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	1.417	2	0.492
Likelihood Ratio	—	—	—
Linear-by-Linear Association	—	—	—
N of Valid Cases	90		

Interpretation: p = 0.492 > 0.05 → No significant association between gender and limp presence. Crosstabulation: Affected Knee × Pain Frequency

	Pain Freq. Category 1	**...**	**Pain Freq. Category N**	**Total**
Right	...		...	
Left	...		...	
Both	...		...	
Total				90

Table 9: association between affected knee and pain frequency

Test	**Value**	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	7.579	14	0.910
Likelihood Ratio	—	—	—
Linear-by-Linear Association	—	—	—
N of Valid Cases	90		

Interpretation: p = 0.910 > 0.05 → No significant association between affected knee side and pain frequency.

Kujala Score Analysis

A total of 90 participants completed the Kujala anterior knee pain questionnaire. The total scores ranged from 30 to 95 (M = 53.60, SD = 19.18, Mdn = 41.50, IQR = 39–72). Internal consistency for the 13-item scale was excellent, with Cronbach's $\alpha = .90$.

Shapiro–Wilk tests indicated that the distribution of total scores was not normal for both males ($p < .001$) and females ($p < .001$). Therefore, a non-parametric Mann–Whitney U test was used to compare scores between genders. The results showed no statistically significant difference in Kujala scores between males (Mdn = ...) and females (Mdn = ...), U = 908.00, p = .868, as shown in table 10.

Table 10: Kujala Score Analysis

Descriptive Statistics	
N	90
Mean	53.60
SD	19.18
Range	30–95
Median	41.50
IQR	39–72
Internal Consistency	
Cronbach's α	0.90
Normality check	
Shapiro-Wilk p (male)	<.001
Shapiro-Wilk p (female)	<.001
Mann-Whitney U test	
U	908.00
p	0.868

Interpretation : p = 0.868 → **No significant difference** in total Kujala score between males and females.

DISCUSSION

The present study reveals significant findings regarding anterior knee pain prevalence and associated factors in postoperative multi-ligamentous knee reconstruction patients. The moderate anterior knee pain levels observed, with a mean NPRS score of 5.51 (SD = 1.03, range 3-7), demonstrate that anterior knee pain represents a clinically significant complication in this population, falling within the range that can substantially impact daily activities and quality of life. The negatively skewed distribution (skewness = -0.79) indicates a concentration of scores toward the higher end of the pain scale, suggesting that most participants experienced moderate to severe pain rather than mild discomfort. These findings align with existing literature on single-ligament reconstructions, where anterior knee pain prevalence ranges from 5 to 19% following ACL reconstruction [4]; however, the consistent moderate pain levels observed in our multi-ligamentous reconstruction cohort suggest that the complexity of these procedures may predispose patients to more persistent and clinically relevant pain patterns compared to single-ligament procedures.
The dynamometer findings demonstrate a profound inverse relationship between thigh muscle atrophy severity and quadriceps strength ($H(2) = 43.21$, $p < .001$), with participants showing severe atrophy ("A lot") exhibiting markedly reduced strength (M = 12.45 kg, SD = 3.25) compared to those with minimal atrophy ("Not at all": M = 38.00 kg, SD = 3.61), representing a striking 67% reduction in muscle strength associated with severe atrophy. This finding is particularly concerning given that quadriceps strength is crucial for knee joint stability and function following multi-ligamentous reconstruction [1], and the high rate of atrophy may reflect delayed mobilization or insufficient rehabilitation; however, prospective studies are required to establish causality.
Range of motion analysis revealed significant associations between flexion deficiency severity and both flexion ($F(2,87) = 22.43$, $p < .001$) and extension ($F(2,87) = 74.32$, $p < .001$) measurements, with participants demonstrating severe flexion deficiency showing markedly reduced flexion ROM (63.83°) compared to those with no deficiency (106.31°), representing a 40% reduction in functional range. The extension deficits are equally concerning, with severely affected individuals showing 5.83° extension lag compared to 0.44° in unaffected participants, and these ROM limitations may be associated with anterior knee pain; however, attributing ROM restrictions directly to pain mechanisms requires further evidence [18], including altered patellofemoral tracking, increased joint contact pressures, and compensatory movement strategies that place additional stress on anterior knee structures [5].
The chi-square analyses revealed no significant associations between gender and limp presence ($\chi^2(2) = 1.42$, $p = .492$) or between affected knee side and pain frequency ($\chi^2(14) = 7.58$, $p = .910$), suggesting that anterior knee pain development in multi-ligamentous reconstruction is not significantly influenced by patient sex or the specific knee(s) involved, supporting a primarily biomechanical rather than anatomical etiology. The demographic profile (mean age 29.46 years, range 16-45) represents the typical population

affected by high-energy trauma leading to multi-ligamentous injuries [2], predominantly affecting young, active individuals during their most productive years.

Rehabilitation: Early and intensive rehabilitation appears critical, with emphasis on mobilization and progressive strengthening protocols to address the marked quadriceps atrophy observed in most participants. Such approaches may mitigate long-term functional deficits and support recovery trajectories. Range of Motion: Restoration of normal joint mechanics, particularly the correction of extension deficits, should be prioritized. Interventions targeting ROM limitations may reduce anterior knee pain and enhance overall functional efficiency. Pain Management: Comprehensive pain management strategies are warranted given the moderate pain levels reported by the majority of participants. Approaches should consider both nociceptive and potential neuropathic contributions to optimize symptom control. Clinical Assessment Tools: The use of validated pain measurement scales [14] provided reliable documentation of patient-reported outcomes and functional limitations, strengthening the clinical utility of the present findings.

Several study limitations should be acknowledged, including the cross-sectional design that limits causal inferences about the relationship between measured variables and anterior knee pain development, the sample size that may limit subgroup analyses despite being adequately powered for the primary outcome, the inclusion criterion requiring NPRS $\geq$ 5, which may have introduced selection bias toward more severely affected individuals, and the absence of a comparison group that limits our ability to establish baseline expectations for this population.

CONCLUSION

This study provides the first systematic analysis of anterior knee pain in MLKI patients, revealing moderate pain intensity, high rates of muscle atrophy, and substantial ROM deficits. The key findings demonstrate that 100% of participants meeting inclusion criteria experienced clinically significant anterior knee pain (NPRS $\geq$ 5), severe quadriceps atrophy was present in 73% of participants with corresponding dramatic reductions in muscle strength, significant ROM deficits were observed with severe functional limitations in approximately 7% of participants, and anterior knee pain occurrence was independent of patient demographics or injury laterality.

The results demonstrate that anterior knee pain following multi-ligamentous reconstruction is not merely an occasional complication but rather a prevalent outcome that requires proactive management, with the strong associations between pain, muscle atrophy, and range of motion deficits suggesting that comprehensive rehabilitation protocols addressing all these components simultaneously may be necessary to optimize patient outcomes. The biomechanical complexity of multi-ligamentous injuries [1] and the extensive surgical intervention required for reconstruction of multiple ligament structures [2] create unique challenges that differ substantially from single-ligament procedures. Future investigations should use longitudinal and controlled approaches to better define pain mechanisms and assess preventive as well as rehabilitative interventions. From a clinical standpoint, the results underscore the importance of patient counselling, early mobilization, vigilant ROM management, multimodal pain strategies, and refinement of surgical and postoperative practices to improve outcomes.

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Ethical consideration

The ethical approval for undertaking the proposed study has been obtained from the Institutional Ethics Committee of Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India, vide their letter no. KVV/
IEC/01/2025 dated January 23, 2025.

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Nil

Conflicts of interest

There is no conflict of interest.

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