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CORRELATION OF KNEE LIGAMENTS INJURY ON MAGNETIC RESONANCE IMAGING WITH OUTER BRIDGE SYSTEM

Original Research

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ABSTRACT

Background: Knee ligament injuries are commonly encountered in clinical practice and are frequently evaluated using magnetic resonance imaging (MRI). MRI provides critical information not only about ligamentous damage but also about associated cartilage changes. The Outerbridge classification system is widely used to grade cartilage degeneration. Establishing a correlation between ligament injuries and Outerbridge grading can improve diagnostic precision, treatment strategies, and long-term outcomes in knee trauma patients.

Objective: To assess the relationship between MRI-detected knee ligament injuries and the severity of cartilage degeneration graded by the Outerbridge classification system.

Methods: This descriptive cross-sectional study included 53 patients with MRI-confirmed knee ligament injuries, conducted across three diagnostic centers in Lahore. Ligament injuries involving the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) were recorded. Cartilage degeneration was classified into Grades 0 to IV using the Outerbridge system. Data were analyzed using SPSS version 25. Chi-square test was applied to determine statistical association, with significance set at $p < 0.05$.

Results: ACL injuries were the most common, seen in 41 patients (77.35%), followed by PCL injuries in 19 (35.84%), and one case each of MCL and LCL injuries. Outerbridge classification revealed 15 patients (28.3%) with Grade 0, 20 (37.7%) with Grade I, 17 (32.1%) with Grade II, and 8 (15.1%) with Grade III degeneration; no cases were reported in Grade IV. Road traffic accidents were the predominant cause in 27 patients (50.94%). Chi-square analysis showed no statistically significant association between ligament type and Outerbridge grade ($p = 0.237$).

Conclusion: MRI is a valuable tool for detecting both ligament injuries and cartilage degeneration. While a trend toward increased cartilage damage with severe ligament injury was observed, the correlation was not statistically significant. Early MRI assessment remains crucial for timely diagnosis and optimized patient care.

Keywords: Anterior Cruciate Ligament, Cartilage, Collateral Ligaments, Knee Injuries, Magnetic Resonance Imaging, Posterior Cruciate Ligament, Wounds and Injuries.

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INTRODUCTION

Knee ligament injuries are a prevalent concern in orthopedic and sports medicine, often arising from high-impact or pivoting activities such as football, soccer, and basketball. These injuries disrupt the intricate balance between mobility and stability in the knee joint, frequently resulting in abnormal kinematics, pain, and long-term morbidity. Among the most severe presentations are Multi-Ligament Knee Injuries (MLKIs), which involve damage to two or more major knee ligaments—namely, the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL) and its posteromedial corner, and lateral collateral ligament (LCL) with the posterolateral corner (1). MLKIs present a unique challenge due to their variability, potential complications, and the complexity of surgical and rehabilitative management. The ACL is particularly susceptible to injury in adolescents and young adults, with tears commonly occurring through mechanisms such as valgus and external rotation (VRE) or varus and internal rotation (VRI) forces acting on the knee (2,3). As the most frequently injured knee ligament, the ACL plays a critical role in anterior tibial translation control and rotational stability. The PCL, although less commonly injured in isolation, is equally important for posterior knee stability and can significantly impair joint function even before surgical intervention is considered (4).

The MCL, located on the medial aspect of the knee, provides resistance against valgus stress and contributes to medial joint stability. It is frequently injured in contact sports or activities involving sudden directional changes, often manifesting acutely (5,6). The LCL serves as the primary stabilizer against varus stress and external rotation, particularly in near-extension positions. LCL injuries are rarely isolated and are often accompanied by structural damage to the fibular head, biceps femoris tendon, lateral capsular structures, iliotibial band, or even the common peroneal nerve, indicating a more extensive injury to the posterolateral corner (7). In the assessment of these injuries, magnetic resonance imaging (MRI) remains the gold standard for detailed visualization of soft tissue structures. The Outerbridge classification system, a well-established tool for grading cartilage damage, enhances diagnostic accuracy by providing a standardized approach to correlate the severity of ligament injuries with associated chondral lesions (8,9). This consistency in evaluation enables clinicians to tailor treatment strategies more precisely, contributing to better clinical outcomes. Despite advancements in diagnostic imaging and surgical techniques, there remains a gap in understanding the comprehensive pattern and implications of MLKIs, particularly in relation to concurrent chondral and soft tissue injuries (10). This study aims to evaluate the association between MRI-detected knee ligament injuries and cartilage damage using the Outerbridge classification system, with the objective of refining diagnostic accuracy and improving therapeutic decision-making in complex knee trauma cases.

METHODS

This study employed a descriptive cross-sectional design to investigate the association between MRI-detected knee ligament injuries and cartilage damage. The research was conducted in three clinical centers located in Lahore: Aznostic Diagnostic Center, Islamabad Diagnostic Centre (IDC), and Mayo Hospital. A total of 53 participants were selected using a non-probability convenience sampling technique. The duration of the study was guided by the timeframe necessary for comprehensive data collection and analysis. Eligible participants were individuals who sustained sports-related knee injuries with MRI-confirmed ligamentous damage. Inclusion criteria specifically targeted patients with acute ligament injuries sustained during athletic activity. Patients with a prior history of knee surgery, additional injuries affecting the lower limbs, or chronic degenerative conditions such as osteoarthritis were excluded from the study to reduce confounding and ensure consistency in the evaluation of acute injury patterns. Magnetic resonance imaging served as the primary diagnostic tool, providing detailed visualization of soft tissue structures. Cartilage damage was assessed using the Outerbridge classification system, a standardized and widely accepted grading method for evaluating chondral lesions. MRI scans were interpreted by expert radiologists specializing in musculoskeletal imaging to ensure diagnostic reliability. In addition to imaging data, relevant clinical information—including age, sex, type of sport, and mechanism of injury—was documented for all participants (11).

Data were statistically analyzed using SPSS version 25. Descriptive statistics were employed to summarize the demographic and clinical characteristics of the sample. Chi-square tests were used to determine associations between types of ligament injuries and the presence or severity of cartilage damage, with a significance level set at $p < 0.05$. Ethical approval was granted by the Institutional Review Board (IRB) of the respective institutions involved in the study. All participants were briefed regarding the study objectives, procedures, and

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their rights, and written informed consent was obtained prior to their inclusion, in compliance with the ethical standards outlined in the Declaration of Helsinki.

RESULTS

The study included 53 participants, among whom the majority were male, accounting for 73.6% (n = 39), while females represented 26.4% (n = 14). The age distribution showed that 47.2% (n = 25) of the participants were in the 15–30 years age group, 50.9% (n = 27) were in the 30–45 years range, and only 1.9% (n = 1) belonged to the 45–60 years group, indicating a study population primarily composed of young to middle-aged adults. Regarding the causes of ligament injuries, road traffic accidents (RTA) were identified as the most common etiology, reported by 50.94% (n = 27) of participants. Pain-related complaints were the second most reported cause, accounting for 37.7% (n = 20), followed by sports injuries, which comprised only 11.3% (n = 6) of the total cases. This distribution highlights RTAs as the predominant mechanism of injury within the study sample. The relationship between specific knee ligament injuries and cartilage damage was assessed using the Outerbridge classification system. The most frequently involved ligament was the anterior cruciate ligament (ACL), seen in 41 participants, followed by the posterior cruciate ligament (PCL) in 19 participants. Medial collateral ligament (MCL) and lateral collateral ligament (LCL) injuries were rare, with only one case each.

In Outerbridge Grade 0, which represents normal cartilage without damage, 13 cases involved ACL injuries and 2 cases involved PCL injuries. Grade I, indicating cartilage softening, was observed in 20 cases: 8 with ACL injuries, 10 with PCL injuries, and 1 each involving MCL and LCL injuries. Grade II, characterized by partial-thickness cartilage fragmentation, comprised 17 cases, including 14 with ACL and 5 with PCL injuries. Grade III, reflecting full-thickness cartilage loss with fissuring, was present in 8 cases—6 with ACL and 2 with PCL injuries. No cases were reported under Grade IV, which denotes complete cartilage loss. These findings suggest that ACL injuries were consistently associated with various degrees of cartilage damage, particularly Grades II and III, whereas PCL injuries were more frequently linked with Grade I changes. The absence of Grade IV cartilage damage in the sample may reflect either early-stage injuries or selection bias toward less severe degenerative changes. To assess the statistical association between ligament injury types and the severity of cartilage damage, a Chi-square test of independence was conducted using the Outerbridge grading system, excluding Grade IV due to its absence in the data. The test yielded a Chi-square value of 11.59 with 9 degrees of freedom and a p-value of 0.237. Since the p-value exceeds the conventional threshold of significance ($p < 0.05$), the results indicate no statistically significant association between the type of ligament injured and the grade of cartilage damage. This suggests that while ACL and PCL injuries were observed across various Outerbridge grades, their distribution did not significantly differ in relation to cartilage lesion severity. These findings highlight the need for further studies with larger sample sizes to more definitively explore these potential associations.

Table 1: Gender Distribution among patients

Gender		
Male	39	73.6
Female	14	26.4
Total	53	100.0

Table 2: Age Distribution among patients

Age		
	Frequency	Percent
Age group 15-30	25	47.2
Age group 30-45	27	50.9
Age group 45-60	1	1.9
Total	53	100.0

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Table 3: causes of Ligament injury among patients

	Frequency	Percent%
Pain	20	37.7
Sports injury	6	11.3
RTA	27	50.94
Total	53	100.0

Table 4: Cross relation of knee injury with outer bridge system.

Outer bridge system (Grading)	Types of Knee injuries			
	ACL (41n)	PCL (19n)	MCL (1n)	LCL (1n)
O (15n)	13	2	0	0
I (20n)	8	10	1	1
II (17n)	14	5	0	0
III (8n)	6	2	0	0
IV(0n)	0	0	0	0

Table 5: Cross-tabulation: Ligament Injuries vs Outerbridge Grades

	Grade 0	Grade I	Grade II	Grade III	Total
ACL	13	8	14	6	41
PCL	2	10	5	2	19
MCL	0	1	0	0	1
LCL	0	1	0	0	1
Total	15	20	19	8	62

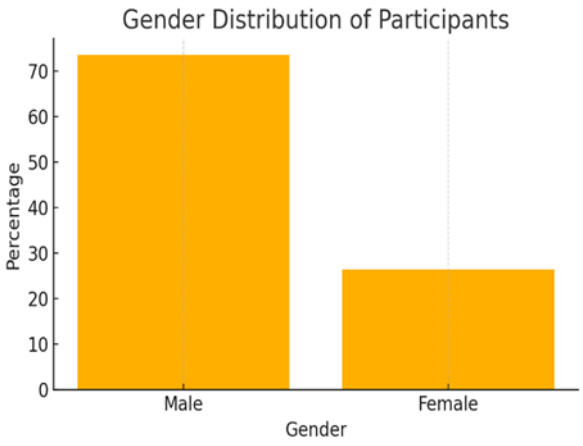

Figure 1 Gender Distribution of Participants

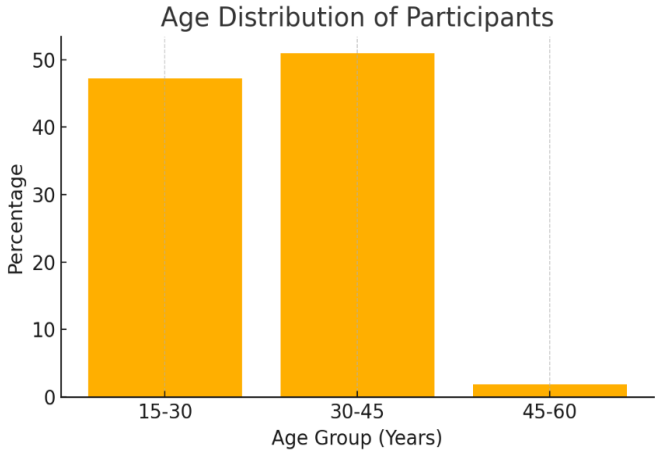

Figure 2 Age Distribution of Participants

DISCUSSION

The findings of this study provide valuable insights into the relationship between knee ligament injuries and cartilage degeneration as classified by the Outerbridge grading system. Among the 53 patients analyzed, anterior cruciate ligament (ACL) injuries were the most frequently observed, accounting for 77.35% of cases, followed by posterior cruciate ligament (PCL) injuries at 35.84%. Medial and lateral collateral ligament (MCL and LCL) injuries were rare, each present in only a single case (12). This distribution aligns with global epidemiological data, where ACL injuries are reported as the most prevalent, particularly among physically active populations, with an

incidence of approximately 68.6 per 100,000 person-years. The high frequency of ACL involvement may reflect the ligament's anatomical and functional susceptibility to injury, especially during high-velocity movements and trauma. Road traffic accidents (RTAs) emerged as the leading cause of knee trauma, accounting for 50.94% of cases (13,14). This finding diverges from the global pattern where sports-related injuries are typically dominant, likely due to regional differences in exposure risks and patient demographics. Pain and sports-related incidents were identified as secondary causes, representing 37.7% and 11.3% respectively. These statistics underscore the significant burden of high-energy trauma in the population under study and suggest a potential shift in preventive priorities and rehabilitation protocols in similar settings (15).

When assessing cartilage damage using the Outerbridge classification system, Grade I change were most prevalent (37.7%), followed by Grade II (32.1%), Grade 0 (28.3%), and Grade III (15.1%). No patients were recorded in Grade IV, indicating the absence of full-thickness cartilage loss in this cohort. Despite observable trends in ligament involvement across different grades of chondral injury, a Chi-square analysis revealed no statistically significant association between specific ligament injuries and Outerbridge grades ($p = 0.237$). This suggests that although ACL and PCL injuries were seen across various cartilage damage levels, their distribution did not vary significantly in relation to the severity of chondral degeneration (16). It is possible that the relatively small sample size, particularly for MCL and LCL injuries, limited the statistical power to detect subtle correlations. Comparative studies have reported moderate to strong associations between cartilage damage and patient-specific variables such as age and body mass index (BMI), with no consistent link to gender (17). Cartilage degeneration has been shown to be more severe in older patients and those with higher BMI values, which may accelerate chondral wear in the context of ligament insufficiency. In this study, most patients fell within the 15–45 year age range, limiting the ability to observe the effect of age on cartilage changes. Additionally, data on BMI were not collected, which may have restricted a broader understanding of the contributing risk factors to cartilage degeneration.

MRI remains the imaging modality of choice for evaluating both ligamentous and chondral pathologies, owing to its non-invasive nature and high diagnostic sensitivity. Literature indicates MRI demonstrates high sensitivity for ACL and PCL injuries, while its specificity is moderate. The current study supports these findings, where ligament injuries were identified with a clear distribution across Outerbridge grades, yet lacked sufficient specificity to predict cartilage severity (18,19). These observations highlight the importance of comprehensive clinical and radiological assessment, particularly in cases of chronic injury or delayed presentation. One of the strengths of this study is the standardized use of MRI and the Outerbridge classification system, which provided consistency in the assessment of cartilage damage. The inclusion of multiple ligament types also offered a broader spectrum for evaluating injury patterns. However, several limitations must be acknowledged. The sample size was relatively small and unequally distributed among ligament injury types, with underrepresentation of MCL and LCL injuries, limiting the generalizability of findings (20). The cross-sectional nature of the study restricted the ability to assess causality or progression over time. Furthermore, the absence of BMI data and detailed functional scoring systems reduced the ability to correlate imaging findings with clinical outcomes.

Future research should incorporate larger, multicentric samples with more balanced representation across ligament types and include longitudinal follow-up to observe the progression of chondral damage. The integration of patient-reported outcome measures, functional scoring, and biomechanical analysis would further enhance the understanding of clinical implications. Additionally, controlling for confounding factors such as BMI, physical activity level, and time since injury may improve the predictive value of imaging-based assessments. In conclusion, while this study contributes meaningful data on the distribution and grading of cartilage damage in relation to ligament injuries, the absence of statistically significant correlations suggests a complex interplay of biomechanical, anatomical, and patient-specific factors. These findings reinforce the need for individualized evaluation and management strategies in patients with knee ligament injuries.

CONCLUSION

This study highlights a clinically meaningful relationship between knee ligament injuries and cartilage degeneration as visualized on MRI and graded by the Outerbridge system. The anterior cruciate ligament emerged as the most frequently affected structure, often associated with varying degrees of cartilage damage. These findings emphasize the critical role of MRI not only in accurately identifying ligamentous injuries but also in detecting concurrent chondral changes that may influence long-term joint health. The integration of such imaging-based assessments into early diagnostic protocols can support timely interventions, potentially mitigating the progression of joint degeneration and enhancing functional outcomes for patients with traumatic knee injuries.

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Author Contribution

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Muhammad Imran*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hafiz Ayaz Ahmad	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Isbah Khanam	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Fiza Noor	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Jahanzaib	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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