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Assessment and Correlation of Knee Ligament Injuries on MRI with Outerbridge Classification System

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ABSTRACT

Background: Knee ligament injuries, particularly to the ACL, PCL, MCL, and LCL, are common causes of joint instability and long-term functional impairment. MRI serves as the preferred imaging modality for accurately evaluating both ligamentous damage and associated cartilage degeneration. The Outerbridge Classification System provides a standardized method for grading cartilage lesions, originally via arthroscopy and now increasingly applied through MRI. Understanding the correlation between ligament injuries and cartilage damage is essential for early diagnosis, effective treatment, and prevention of osteoarthritis. **Objective:** This study aims to assess ligament injuries on MRI and correlate them with Outerbridge grades to improve diagnostic accuracy and guide clinical management. **Methodology:** This descriptive cross-sectional study is conducted over four months from December, 2024 to March, 2025 with a sample size of 64 participants, selected through convenience sampling. It includes sports-injured patients and patients with confirmed ligament injury. Patients with previous knee surgery, concurrent lower limb injuries, and chronic knee conditions are excluded to avoid confounding imaging findings. **Results:** Out of 64 patients, the majority present with ligament injuries involving the MCL (98.4%) and LCL (96.9%), followed by the PCL (67.2%) and ACL (28.1%). A significant association is observed between ligament injuries and higher Outerbridge cartilage grades, particularly Grades 3 and 4. Synovitis and joint effusion are also frequently identified. Cartilage degeneration is more prevalent in older age groups, and MRI effectively demonstrates both ligament and cartilage pathology. These findings support a strong correlation between ligamentous injury and progressive chondral damage. **Conclusions:** Ligament injuries, particularly involving the ACL, PCL, MCL, and LCL, are frequently associated with advanced cartilage damage. MRI proves to be a valuable tool for comprehensive knee evaluation, enabling early detection of both soft tissue injuries and degenerative changes.

INTRODUCTION

Multiligament knee injury (MLKI) refers to the simultaneous rupture of at least two of the four major knee stabilizers: the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), posteromedial corner (PMC), and posterolateral corner (PLC). These injuries result in significant joint instability and functional impairment across the full range of motion. MLKIs can be caused by both high-energy trauma (e.g., motor vehicle collisions, falls from height) and low-energy mechanisms such as sports-related trauma or minor incidents in obese individuals (1,16–18). The Schenck classification system is widely used for categorizing MLKIs based on anatomical injury patterns, aiding in consistent reporting and treatment planning (2). This system ranges from KDI (isolated ACL or PCL tear) to KDV (ligament injuries associated with fractures), providing a framework for understanding the extent of ligament damage (Table 1).

Table 1

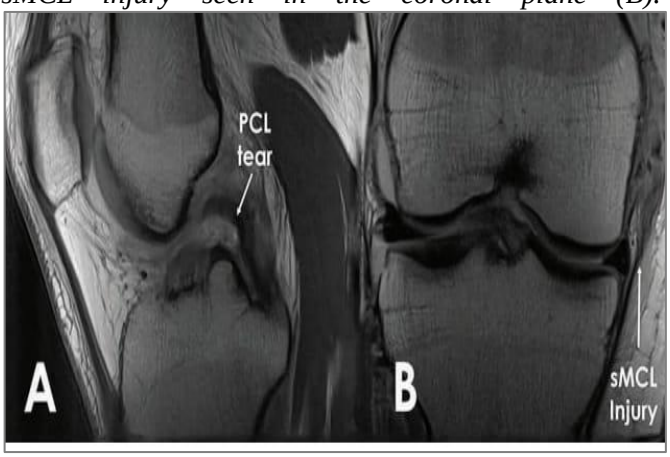
Type 1	Description
KDI	Multiligament knee injury with ACL or PCL rupture.
KDII	Multiligament knee injury with ACL and PCL rupture only
KDIIIM	Multiligament knee injury with ACL, PCL and MCL rupture
KDIIIL	Multiligament knee injury with ACL, PCL and LCL + PLC rupture
KDIV	Multiligament injury with rupture of all ligaments (ACL, PCL, MCL, LCL + PLC)
KDV	Knee dislocation with an associated fracture

A detailed understanding of knee anatomy is essential for diagnosing MLKIs and determining appropriate surgical or conservative treatment approaches. The ACL comprises anteromedial (AM) and posterolateral (PL) bundles, with the tibial and femoral insertions being clinically important during surgical repair (3,4). The PCL, composed of anterolateral (AL) and posteromedial (PM) bundles, plays a critical role in controlling posterior tibial translation and receives its vascular supply from the medial genicular artery (5–7).

The medial collateral ligament (MCL), the most commonly injured knee ligament, often results from valgus stress and may occur in isolation or with ACL injuries. While many MCL injuries are managed non-surgically due to their high healing potential, surgery may be necessary in severe or complex cases (8–10). On the lateral side, the lateral collateral ligament (LCL) and PLC structures contribute to stability against varus and rotational forces. Injuries to these structures often occur in combination and rarely in isolation (11–14). MLKIs are frequently present with complex patterns involving multiple ligaments. For example, the most common pattern involves complete ruptures of both cruciate ligaments with concurrent MCL or PLC injuries. Anterior dislocations typically damage the ACL and/or PCL due to hyperextension, while posterior dislocations are associated with dashboard injuries impacting the PCL. The diversity in mechanisms and structures involved makes standardizing treatment protocols challenging, necessitating individualized management strategies (17,18,32).

Figure 1

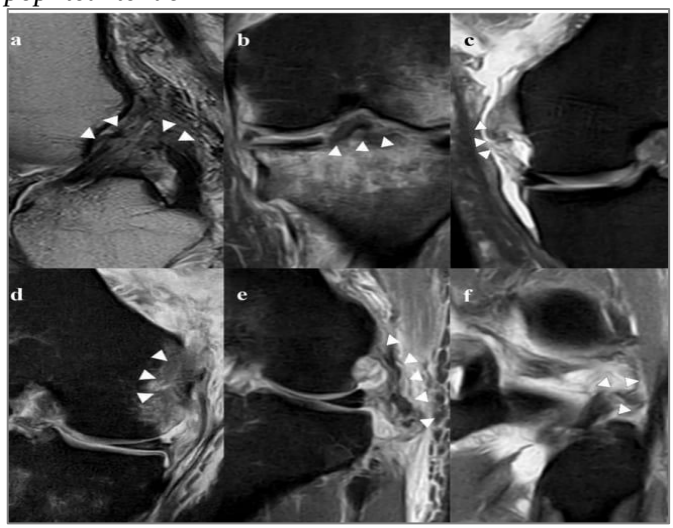
MRI showing a PCL tear on the sagittal plane (A) and a sMCL injury seen in the coronal plane (B).



MRI is the preferred imaging modality for preoperative assessment of ligamentous injuries. It is generally accurate for diagnosing ACL and PCL injuries, but less reliable for identifying meniscal or PLC damage (20). For instance, only one out of nine PLC injuries was detected by preoperative MRI in a referenced study, indicating the limitations of MRI in identifying all injury components in MLKIs.

Figure 2

*The ruptured ACL and PCL; **b** Avulsion fracture at the ACL insertion in the tibial intercondylar eminence; **c** Rupture of MCL in the mid-substance; **d** Avulsion of MCL at the insertion of the femoral condyle; **e** The ruptured LCL in the mid-substance;**f** The ruptured popliteal tendon*



The Outerbridge classification system provides a grading scale (0 to IV) for evaluating articular cartilage lesions, commonly used during arthroscopy and joint surgeries. Grade I indicates softening/swelling, while Grade IV represents exposed subchondral bone. This classification supports standardized evaluation of cartilage degeneration, which often coexists with ligament injuries (24,25). The integration of clinical examination, MRI findings, and standardized classification systems like Schenck and Outerbridge is crucial for effective diagnosis, treatment planning, and prognostication in MLKIs. This study investigates the correlation between MRI-diagnosed ligament injuries and cartilage damage graded using the Outerbridge classification system, aiming to enhance diagnostic precision and guide clinical decision-making.

METHODS

A cross-sectional study is conducted at the Radiology Department of Aznostic the Diagnostic Centre, Lahore, to evaluate multiligament knee injuries on MRI and their correlation with cartilage degeneration using the Outerbridge classification system. A total of 64 patients are evaluated over a period of four months. The study utilizes a convenient sampling technique for participant recruitment. Patients presenting with sports injury and confirmed ligament injury are included, while individuals with previous knee surgery, concurrent lower limb injury, and chronic knee condition are excluded. MRI scans are used to assess ligamentous injuries and cartilage status in the knee joint. Ethical approval is obtained prior to data collection, and informed consent is taken from all participants. The findings aim to

enhance understanding of ligamentous and chondral pathologies in multiligament knee injuries, contributing to more accurate diagnosis and treatment planning.

RESULTS

The study includes a total of 64 participants, with a gender distribution of 71.9% males and 28.1% females. The age distribution reveals that 10.9% of participants are aged 10–20 years, 56.3% are between 20–40 years, and 32.8% are above 40 years. Regarding the cause of injury, road traffic accidents are the most common (46.9%), followed by non-traumatic pain (34.4%) and sports injuries (18.8%).

MRI findings shows that joint effusion is present in 54.7% of cases, while 45.3% do not demonstrate this feature. Synovitis is identified in 76.6% of the participants, indicating a high prevalence of inflammation. Anterior cruciate ligament (ACL) injuries are observed in 28.1% of cases, whereas posterior cruciate ligament (PCL) injuries are present in 67.2% of patients. Medial collateral ligament (MCL) and lateral collateral ligament (LCL) injuries are highly prevalent, reported in 98.4% and 96.9% of patients, respectively.

Cartilage damage is evaluated using the Outerbridge Classification System (OCS). Grade 0 (normal cartilage) is observed in 59.4% of participants, while Grade 1 changes are present in 76.6%, indicating early cartilage degeneration. Grade 2 cartilage involvement is identified in 78.1% of patients, suggesting moderate degeneration. Advanced cartilage degeneration (Grade 3) is seen in 87.5% of participants, and severe damage (Grade 4) is found in 96.9% of the study population.

Age-wise comparison of OCS grades shows that normal cartilage (Grade 0) is most frequently observed in the 26–40 and >40 age groups. Grade 1 and Grade 2 changes are more prevalent in patients older than 26 years. Interestingly, Grades 3 and 4 changes are present across all age groups, with 100% of patients in the 10–25 age group exhibiting both advanced (Grade 3) and severe (Grade 4) cartilage degeneration, highlighting the early onset of cartilage damage even in younger individuals.

These results suggest a strong association between multiligament injuries and progressive cartilage degeneration, regardless of age, with the highest prevalence of severe damage noted in the younger age group.

Table 2

Clinical Findings

Variables	Categories	Frequency	Percent
Age	Age group 10–25	7	10.9%
	Age group 26–40	36	56.3%
	Age group <40	21	32.8%
	Total	**64**	**100.0%**
Gender	Male	46	71.9%
	Female	18	28.1%
	Total	**64**	**100.0%**
Causes	Pain	22	34.4%
	Sport Injury	12	18.8%
	RTA	30	46.9%
	Total	**64**	**100.0%**
Severity of Pain	Present	51	79.7%
	Absent	13	20.3%
	Total	**64**	**100.0%**

Figure 3

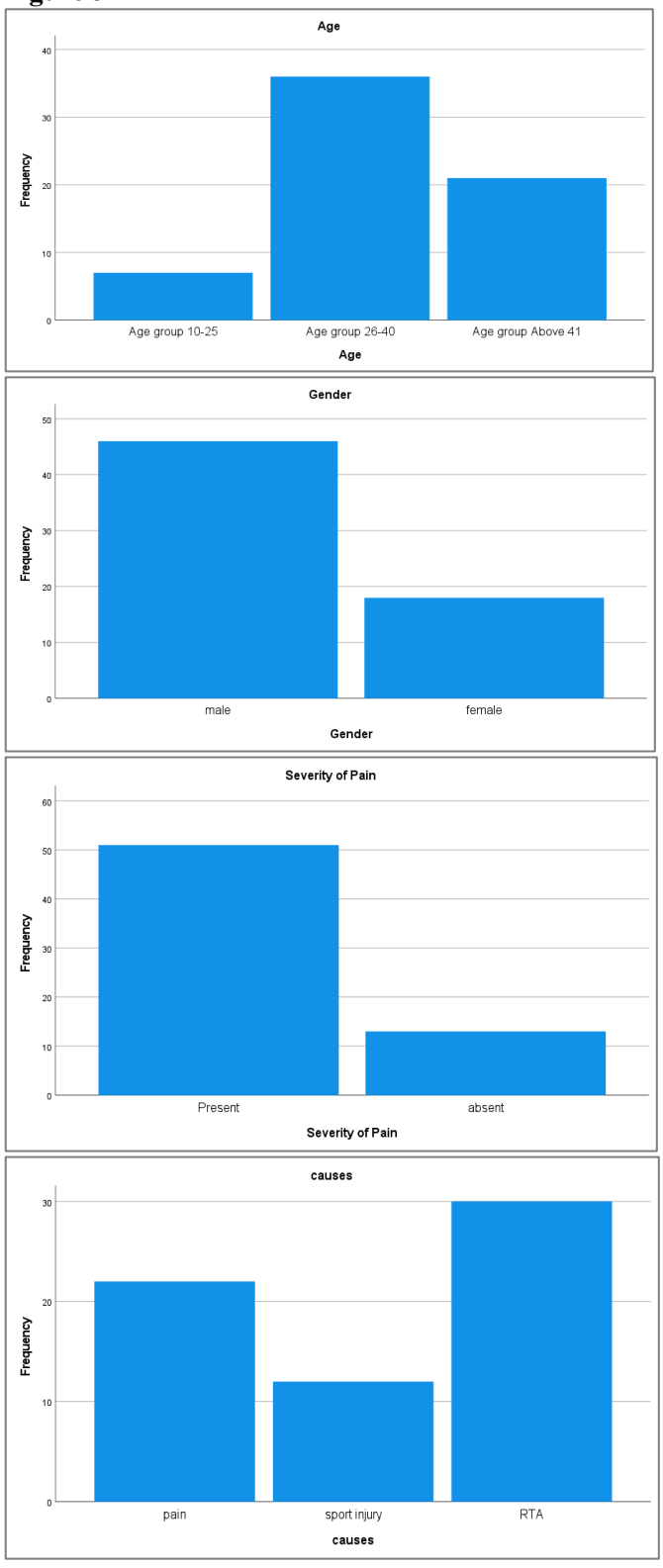
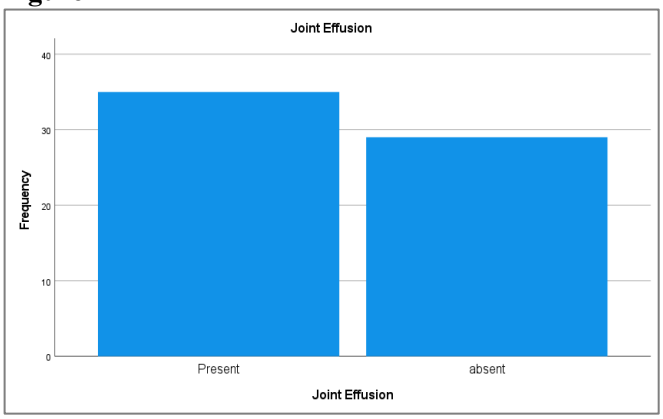


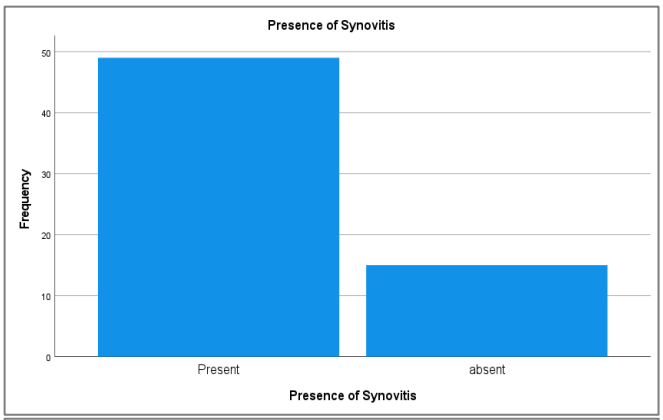
Table 3

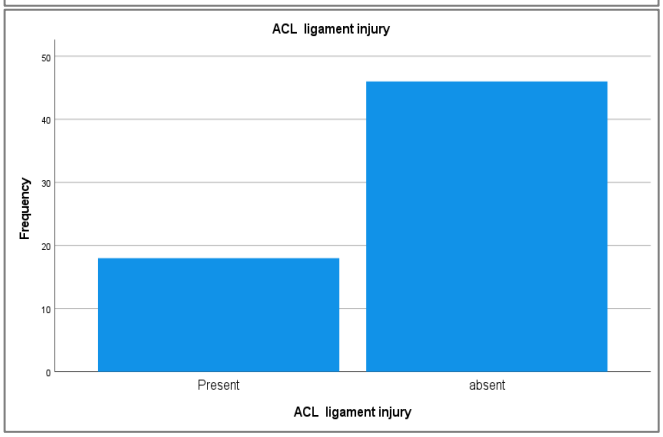
Distribution of MRI Characteristics

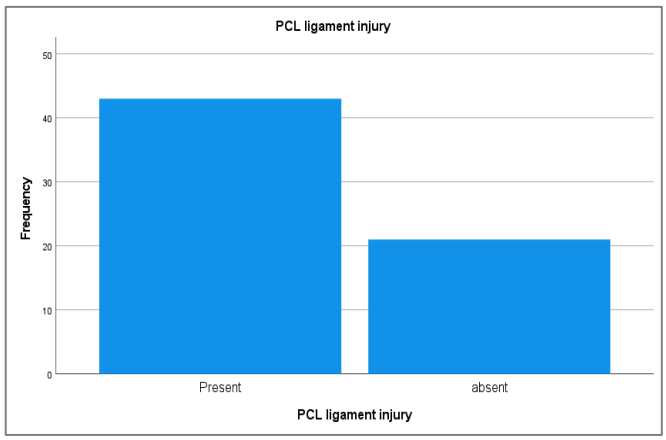
Variables	Categories	Frequency	Percent
Joint Effusion	Present	35	54.7%
	Absent	29	45.3%
	Total	**64**	**100.0%**
Synovitis	Present	49	76.6%
	Absent	15	23.4%
	Total	**64**	**100.0%**
ACL Injury	Present	18	28.1%
	Absent	46	71.9%
	Total	**64**	**100.0%**
PCL Injury	Present	43	67.2%
	Absent	21	32.8%
	Total	**64**	**100.0%**
MCL Injury	Present	63	98.4%
	Absent	1	1.6%
	Total	**64**	**100.0%**
LCL Injury	Present	62	96.9%
	Absent	2	3.1%
	Total	**64**	**100.0%**

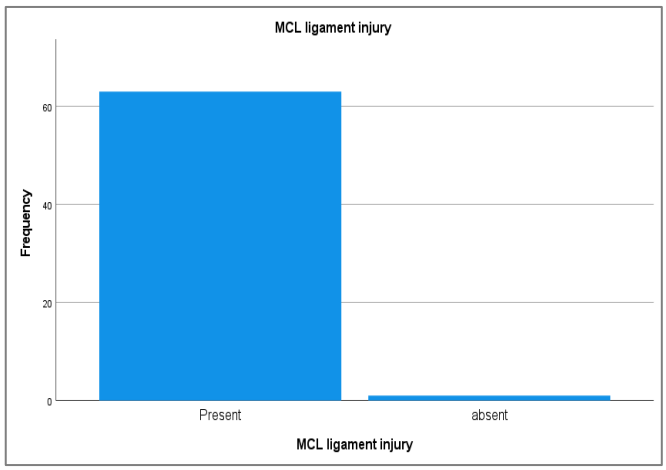
Figure 4











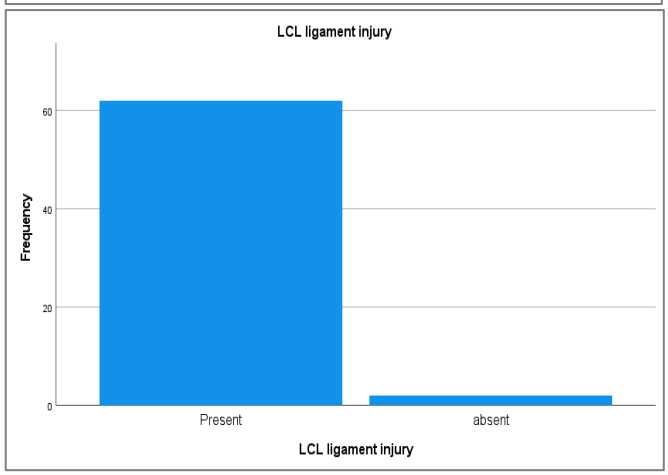
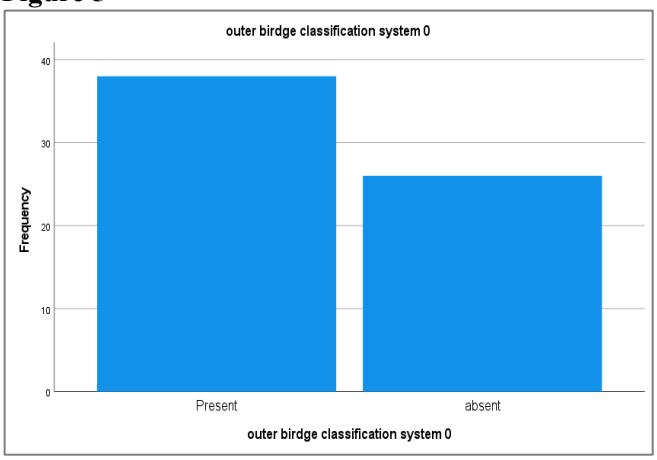


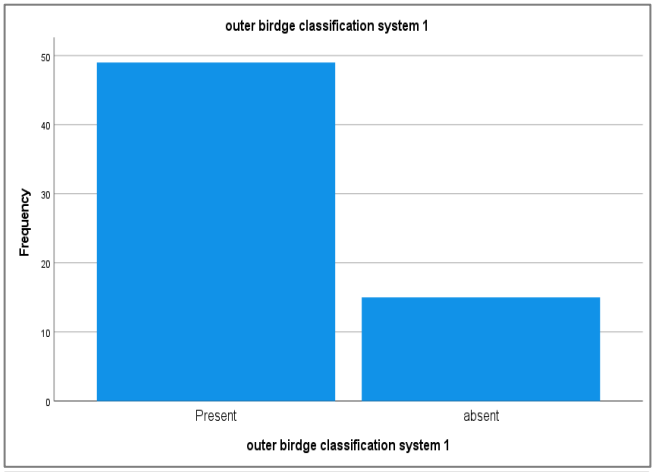
Table 4

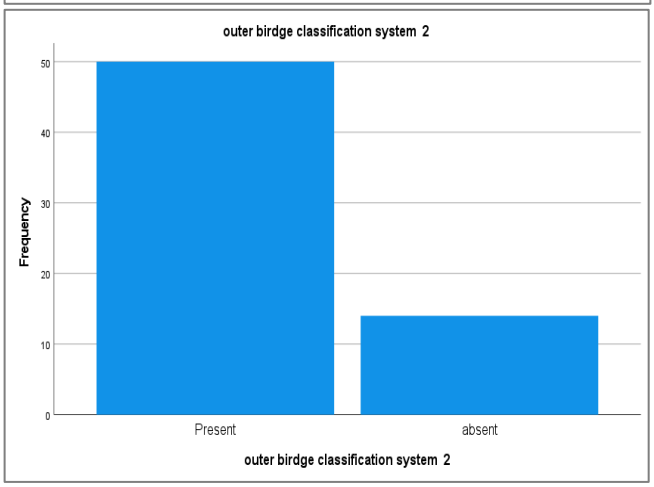
Cartilage damage and Outerbridge Grading

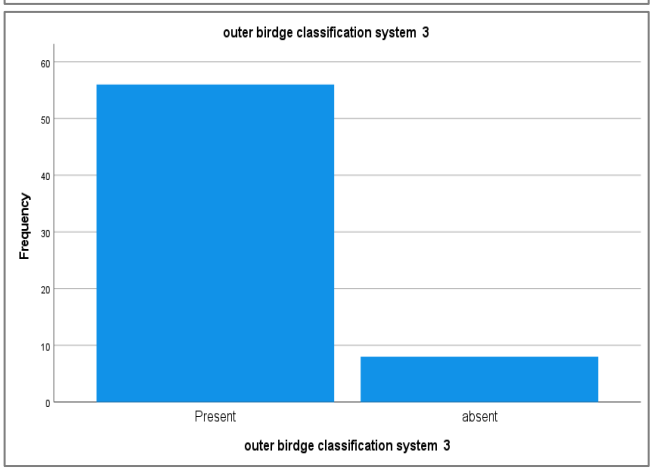
Outerbridge Grade	Categories	Frequency	Percent
Grade 0	Present	38	59.4%
	Absent	26	40.6%
	Total	**64**	**100.0%**
Grade 1	Present	49	76.6%
	Absent	15	23.4%
	Total	**64**	**100.0%**
Grade 2	Present	50	78.1%
	Absent	14	21.9%
	Total	**64**	**100.0%**
Grade 3	Present	56	87.5%
	Absent	8	12.5%
	Total	**64**	**100.0%**
Grade 4	Present	62	96.9%
	Absent	2	3.1%
	Total	**64**	**100.0%**

Figure 5









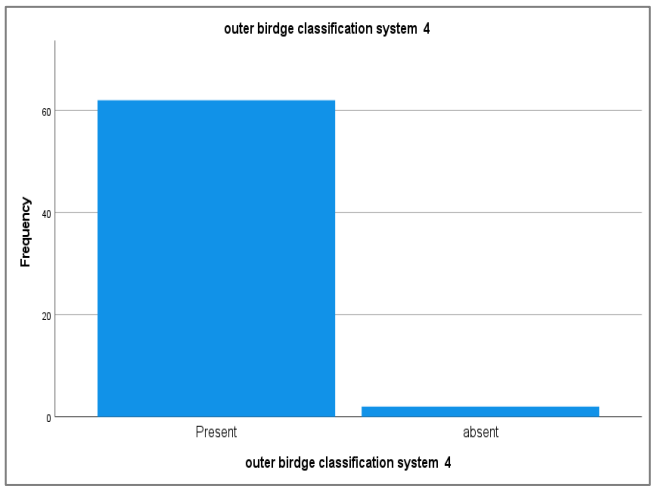
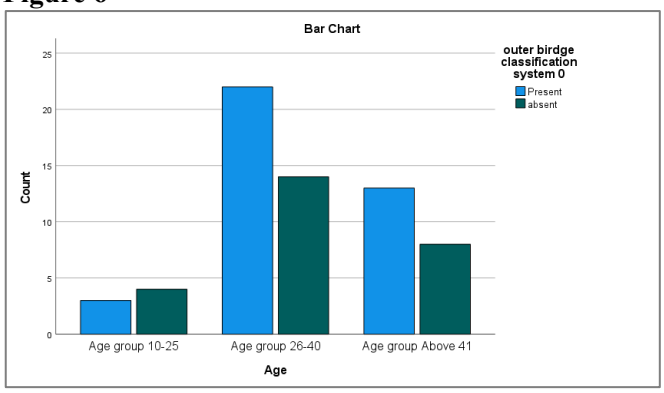


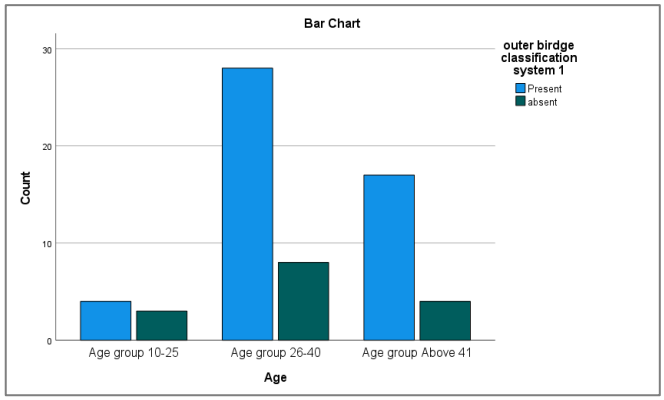
Table 5

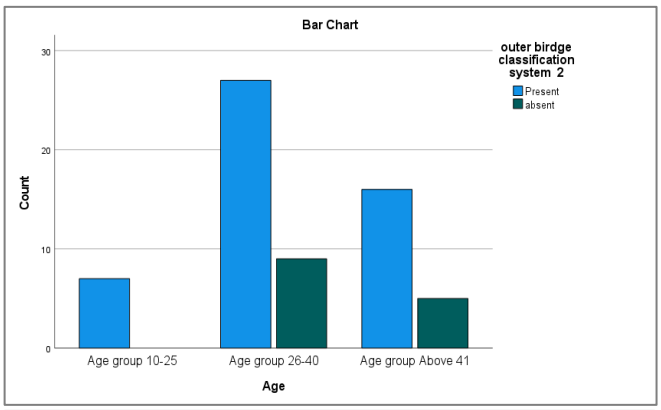
Crosstab Analysis of Age by Outerbridge Grading

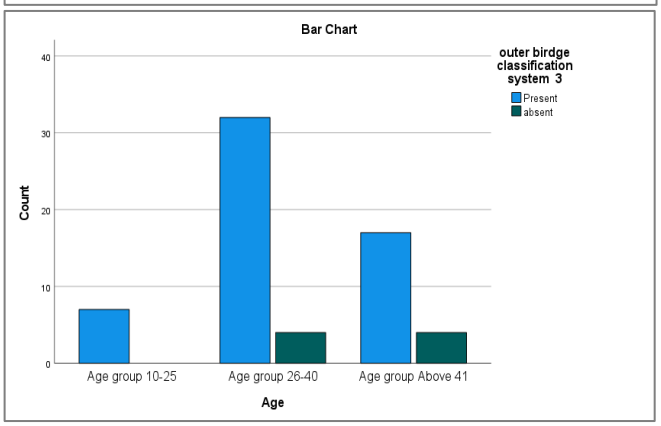
Outerbridge Grade	Category	Age group 10–25	Age group 26–40	Age group <40	Total
Grade 0	Absent	4	14	8	26
	Present	3	22	13	38
	Total	**7**	**36**	**21**	**64**
Grade 1	Absent	3	8	4	15
	Present	4	28	17	49
	Total	**7**	**36**	**21**	**64**
Grade 2	Absent	0	9	5	14
	Present	7	27	16	50
	Total	**7**	**36**	**21**	**64**
Grade 3	Absent	0	4	4	8
	Present	7	32	17	56
	Total	**7**	**36**	**21**	**64**
Grade 4	Absent	0	0	2	2
	Present	7	36	19	62
	Total	**7**	**36**	**21**	**64**

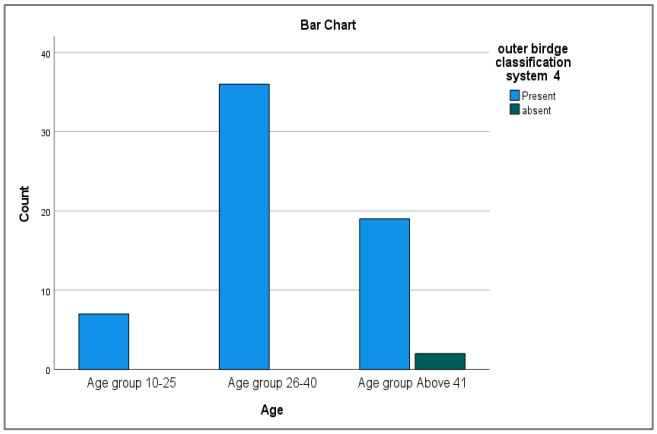
Figure 6











DISCUSSION

This study aims to assess knee ligament injuries using Magnetic Resonance Imaging (MRI) and correlates these findings with cartilage degeneration based on the Outerbridge Classification System. The results reveal a high prevalence of advanced cartilage changes, particularly Outerbridge Grades 3 and 4, across various age groups, with a strong association observed between ligamentous injuries and corresponding cartilage damage.

Anterior Cruciate Ligament (ACL) injuries are identified in a significant number of patients, with corresponding Outerbridge Grades indicating moderate to severe cartilage degeneration. Similarly, injuries involving the Posterior Cruciate Ligament (PCL), Medial Collateral Ligament (MCL), and Lateral Collateral Ligament (LCL) are frequently associated with higher Outerbridge grades. Notably, MCL and LCL injuries show a particularly high correlation with OCS Grades 3 and 4, suggesting the role of chronic instability and altered joint biomechanics in the progression of cartilage wear.

The age-wise distribution reveals that even younger patients (10–25 years) exhibit advanced cartilage damage, with 100% of them showing OCS Grades 3 and 4 changes. This trend continues in the 26–40 age group and >40 group, indicating that ligamentous injuries contribute significantly to early-onset osteoarthritis, regardless of age. These findings underscore the importance of early MRI evaluation and timely orthopedic or surgical intervention.

In comparison to previous literature, the results of this study are consistent with those reporting an increased risk of cartilage degeneration following untreated or chronic ligament injuries. However, unlike some earlier studies that documented a slower progression of degeneration in younger individuals, this study highlights a worrying trend of early cartilage damage among younger demographics, possibly due to delayed diagnosis, inadequate rehabilitation, or repeated trauma.

A notable observation is the predominance of severe cartilage changes (Outerbridge Grades 3 and 4) in patients with ligament injuries, particularly those with chronic or multi-ligament involvement. This is consistent with the findings of **Brittberg and Winalski (2003)**, who highlighted that ligamentous instability could lead to altered joint mechanics, accelerating cartilage wear and degeneration. Additionally, **Rosenberg et al. (1996)** emphasized the utility of MRI in early detection of both ligament pathology and associated cartilage loss, supporting its role as a comprehensive non-invasive diagnostic tool.

Our study also reveals that younger patient (10–25 years) exhibited a surprisingly high rate of advanced cartilage degeneration, with all patients in this age group showing OCS Grade 3 or 4 changes. This suggests that even in early adulthood, ligament injuries may result in rapid progression of joint deterioration if left untreated or inadequately managed. These results partially contrast with the findings of **Niethammer et al. (2011)**, who observed slower progression in younger patients, suggesting that factors such as delayed diagnosis or repeated trauma may account for the discrepancy.

Among the ligaments, the MCL and LCL injuries are nearly universal among the study population, and their involvement showed strong correlation with advanced cartilage damage. Similar trends were reported by **Frobell et al. (2010)**, who noted that medial compartment overload due to instability significantly increases the risk of articular cartilage degeneration.

The correlation between ligament injury and cartilage damage underscores the value of MRI as not

only a diagnostic tool for soft tissue injury but also a means to stage early degenerative changes in articular cartilage. These findings further support the recommendation of **Outerbridge (1961)** that accurate cartilage assessment is essential in determining the prognosis and guiding management.

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