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Original Research Article

Assessment of Knee Injuries Using MRI: A Retrospective Study

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Conflict of interest: Nil

Abstract:

Background: Knee injuries are common and often involve complex ligamentous, meniscal, and osseous structures. Early and accurate diagnosis is essential to guide management and prevent long-term complications. Magnetic resonance imaging (MRI) has become the preferred non-invasive modality for evaluating internal knee derangements.

Aim: To assess the spectrum and frequency of knee injuries detected on MRI in patients presenting with trauma and analyze associated age- and gender-specific patterns.

Methodology: A retrospective observational study was conducted on 90 patients who underwent knee 1.5 T MRI following trauma at the Department of Radiodiagnosis, DRPGMC, Tanda, Kangra, India. MRI scans were evaluated for ligamentous (ACL, PCL, MCL, LCL), meniscal, and osseous injuries, including bone contusions. Data were analyzed using descriptive statistics.

Results: ACL injuries were the most common ligamentous pathology, often accompanied by medial meniscus tears and bone contusions. Collateral ligament injuries were generally low-grade. Younger adults predominantly sustained ACL injuries and bone contusions, while meniscal injuries were more frequent in middle-aged patients. Males were more commonly affected, but gender did not significantly influence injury type.

Conclusion: MRI provides detailed assessment of knee injuries, enabling accurate diagnosis, detection of associated lesions, and informed clinical decision-making. It remains a crucial tool in managing traumatic knee injuries.

Keywords: Knee injuries, MRI, ACL tear, Meniscus tear, Bone contusion, Retrospective study.

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Introduction

The magnetic resonance imaging (MRI) has been an imaging modality of choice as a non-invasive method of assessing internal derangements of the knee, especially after traumatic injuries [1]. The knee joint as one of the most complicated and the most common injured joints in the human body is extremely vulnerable to the broad range of injuries in the soft tissue and bone. These injuries need to be diagnosed early and correctly to be managed and prevented to ensure the avoidance of the long-term complications of chronic instability, osteoarthritis, and functional impairments. MRI has great abilities in soft tissue contrast resolution and multiplanar imaging and can thus be useful in evaluating the ligaments, menisci, cartilage, and bone marrow abnormality without being exposed to ionizing radiations.

Many investigations have confirmed that MRI has a high diagnostic accuracy in the determination of the existence of ligamentous and meniscal injury, compared to arthroscopy results, which is considered to be the gold standard [2]. MRI has been shown to have a sensitivity of around 87 per cent and specificity of around 93 per cent in cases of anterior cruciate ligament (ACL) tear. ACL injuries are also one of the most frequent soft tissue trauma related to knee trauma and it is very widespread among young and physically active people. The injuries usually

result as a result of abrupt deceleration, pivot injuries, or direct injuries. The MRI does not only allow accurate determination of ACL tears but also gives details of any other injury that accompanies the injury like meniscal tears, collateral ligament tears and bone contusions that are common in the ACL injury patients [3].

Another very vital part of knee internal derangement is meniscal injuries, which are often related to ACL injuries [4]. The load transmission, shock absorption, and knee joint stability heavily rely on the menisci, thus, injury to them may have a huge impact on knee biomechanics. In a prospective study of patients likely to have meniscal tear, MRI showed meniscal pathology in over 57% of the symptomatic knees. Moreover, the same lesions occurred much more in symptomatic knees than contralateral asymptomatic knees, which also illustrates the diagnostic importance of MRI in patient management. The importance of early identification of meniscal tears is to ensure that tears that are not treated lead to the predisposition of patients to degenerative joint disease and continued knee dysfunction [5].

Bone oedema or bone contusion is a significant but frequently under-identified aspect of acute knee injury. These lesions cannot be identified in traditional radiographs but can be observed with MRI which can accurately identify bone contusions and oedema [6]. Patterns of bone marrow oedema are helpful in indicating the pathogenesis of injury. A systematic review indicated the existence of bone marrow oedema in more than 80% of patients with rupture of the ACL, and the bones most commonly involved were the lateral femur condyle and the posterolateral tibial plateau. The results confirm that the common valgus and rotational forces are involved in the mechanisms of ACL injuries. Other reports have indicated a further high prevalence of bone contusion rate, to 92.9 percent, in recent MRI analyses of patients with ACL injuries. These conclusions usually are related to the extent of trauma and the existence of other injuries accompanying it for example meniscal tears and collateral ligament ruptures.

Collateral ligament tears, such as those of the medial collateral ligament (MCL), lateral collateral ligament (LCL), and posterior cruciate ligament (PCL) are not as frequent as ACL and meniscal tears though they are still clinically important, especially when they occur in multi-ligament injuries [7]. MRI is important in the determination of the severity and the extent of these injuries. The literature has demonstrated MCL injuries often occur in conjunction with ACL tears, whereas the LCL injuries are relatively uncommon but can be a sign of more serious injuries in case of their combination. The accurate examination of these structures is critical to making treatment choices, which may vary between such conservative treatment and surgical intervention based on the severity of the injury and its combination with others.

Although MRI diagnostic methods have established capabilities, current research studies face limitations because they study only particular age groups and specific injury types [8]. The research results of many studies become restricted because the studies focus on younger athletic groups who exist in limited populations. Researchers have not studied how different demographic groups experience various injury patterns, which include age and gender and trauma mechanism. Some studies have suggested differences in injury prevalence and patterns based on gender and trauma history; however, comprehensive analyses across diverse populations remain limited. The research gap presents an important academic deficiency which requires research studies to perform MRI assessments of knee injuries using more comprehensive and organized evaluation methods.

Since MRI is becoming more actively incorporated in the everyday clinical practice and has the capability of offering detailed anatomical and pathological data, retrospective studies could contribute to meaningful results regarding the prevalence and trends of knee injuries in the real-world practices. This type of study can be especially helpful in comprehending the prevalence of different injuries in various demographic groups and also in determining the general patterns of injuries that tend to occur with a particular demographic. The information will be capable of helping clinicians to enhance their diagnostic accuracy, treatment strategies, and predicting patient outcomes.

In this regard, the current retrospective research is meant to determine the range of knee injuries identified on MRI among patients reporting knee trauma. This research is aimed at comparing the frequency and the type of injury to major anatomical structures, such as ACL, PCL, MCL, LCL, menisci, and bone contusion. In addition, it attempts to examine how these patterns of injury are related to patient-specific variables like age and gender. This study will help close the existing gaps in the literature and create a more detailed assessment of a bigger group of people and determine the value of MRI in helping to understand the patterns of knee injury.

Methodology

Study Design: This study was a retrospective observational study conducted to assess the spectrum and frequency of knee injuries detected on magnetic resonance imaging (MRI). The retrospective design enabled evaluation of previously recorded MRI findings and clinical data of patients presenting with knee trauma.

Study Area: The study was conducted in the Department of Radiodiagnosis, Dr. Rajendra Prasad

Government Medical College (DRPGMC), Tanda, Kangra, Himachal Pradesh, India

Study Duration: The study was carried out over a period of 1 year, during which MRI records of patients who underwent imaging for knee injuries were reviewed and analyzed.

Study Participants: The study participants included patients who underwent MRI of the knee following trauma within the defined study period.

Inclusion Criteria

- All patients who underwent MRI of the knee due to a history of trauma during the study duration
- Patients of all age groups and both genders
- Patients with complete MRI records and radiological reports available in the hospital database

Exclusion Criteria

- Patients with incomplete or missing MRI records
- Patients whose MRI findings showed only degenerative changes unrelated to trauma
- Patients with a history of previous knee surgery or chronic knee pathology not associated with acute injury

Sample Size: A total of 90 patients fulfilling the inclusion criteria were included in the study. The sample size was based on the availability of complete MRI records within the study period.

Procedure: Data for the study were collected retrospectively from the electronic radiology database and medical records of the Department of Radiodiagnosis. MRI scans of patients who presented with knee trauma and met the inclusion criteria were reviewed in detail. Relevant demographic information, including age and gender, were provided by clinical records maintained by department of Orthopedics of the institution,

All MRI examinations had been performed using 1,5 T Philips MRI Machine standard imaging protocols, including T1-weighted, T2-weighted, proton density (PD), and fat-suppressed sequences (STIR) in multiple planes (axial, sagittal, and coronal). The MRI reports were carefully evaluated by experienced radiologists.

The primary focus of the evaluation was on identifying and documenting internal derangements of the knee joint. Specific attention was given to ligamentous injuries, including anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL) injuries. Additionally, meniscal injuries (medial and lateral meniscus tears), bone contusions, joint effusion, and associated soft tissue abnormalities were assessed.

All findings were manually extracted and recorded using a structured observation sheet to maintain uniformity and consistency. Each case was categorized based on grading and combination of injuries identified on MRI. Care was taken to ensure accuracy and completeness of data during extraction and entry.

Statistical Analysis: The collected data of 90 patients was entered into Microsoft Excel for initial organization and coding. Statistical analysis was performed using appropriate statistical methods. Categorical variables, such as gender, types and grading of knee injuries, were summarized using frequencies and percentages. The association between different variables, such as age group and type of injury or gender and injury pattern, was assessed. The results were presented in tabular formats using descriptive statistical analysis to assess the frequency and percentage distribution

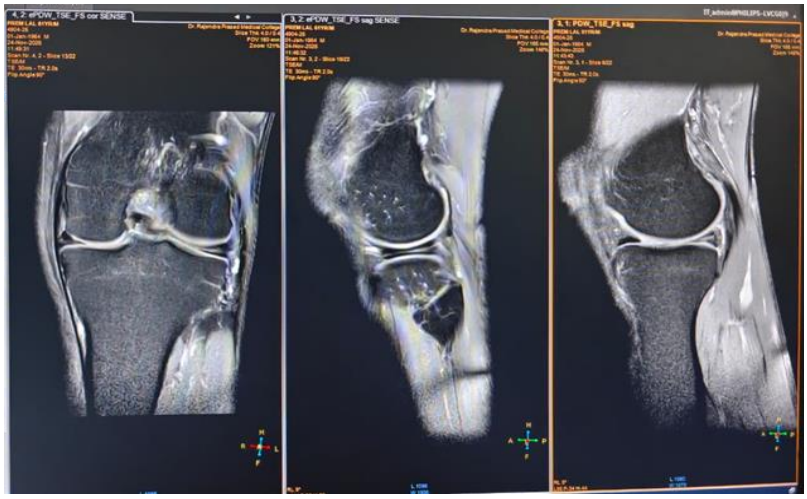

Figure 1: Bilateral meniscus injury

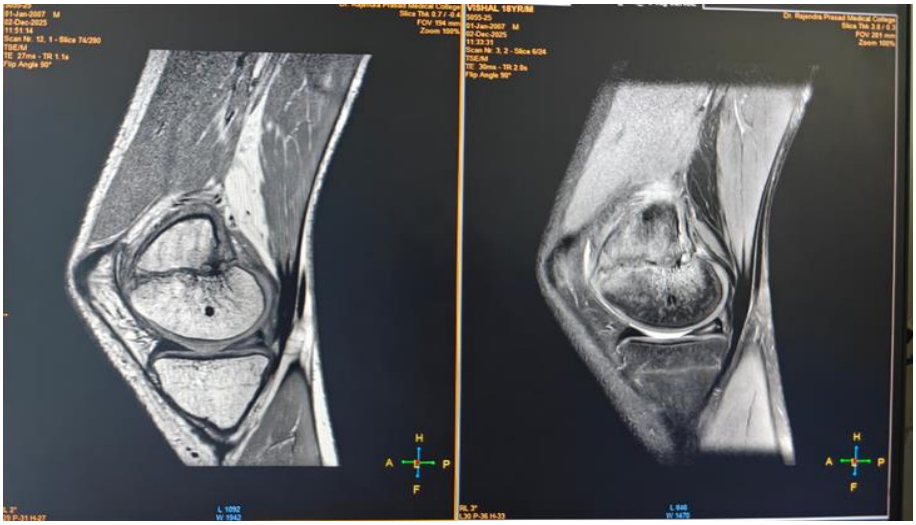

Figure 2: Grade 2 medial meniscus tear

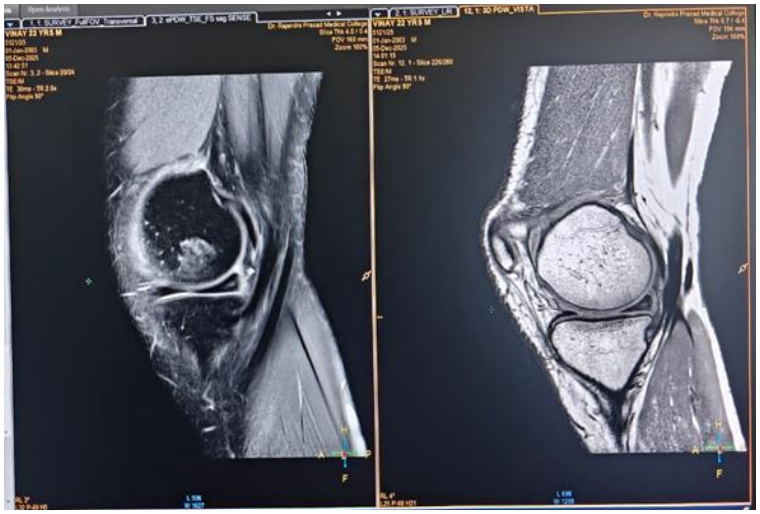

Figure 3: Grade1 meniscus injury

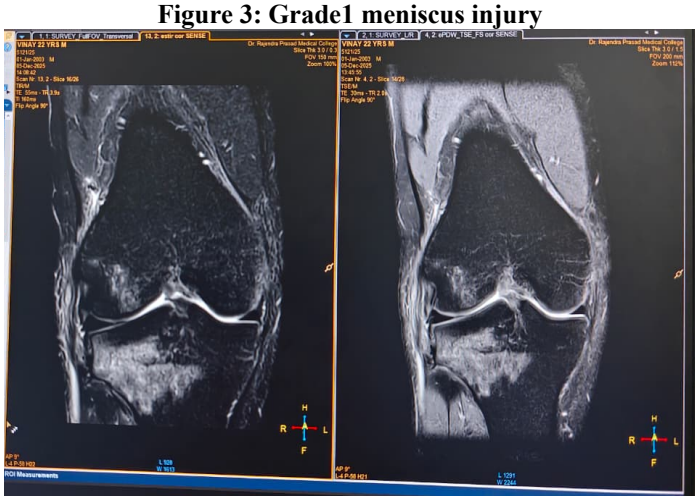

Figure 4: Lateral collateral ligament and popliteus tendon injury and bone contusion in lateral tibial and femoral condyle

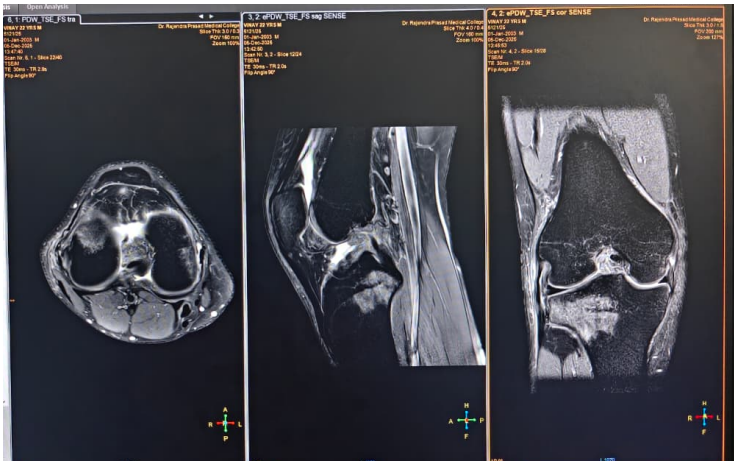

Figure 5: Anterior Cruciate ligament tear in axial. Sagittal and coronal PD FS

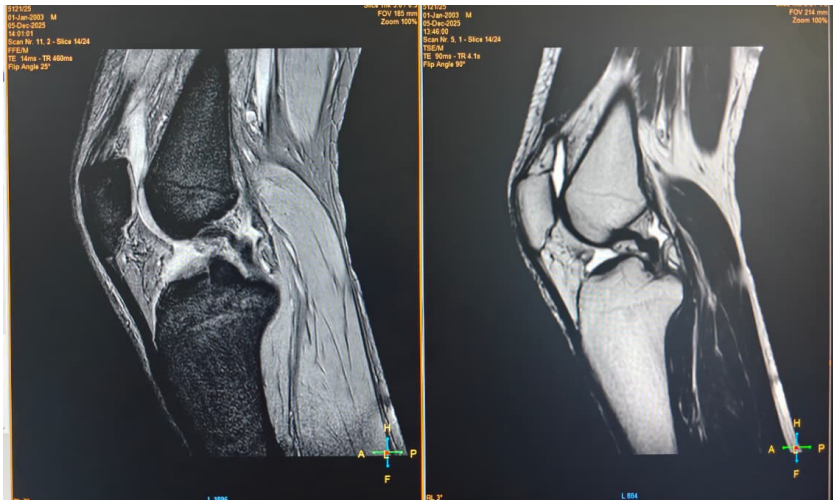

Figure 6: Buckling of Posterior Cruciate ligament

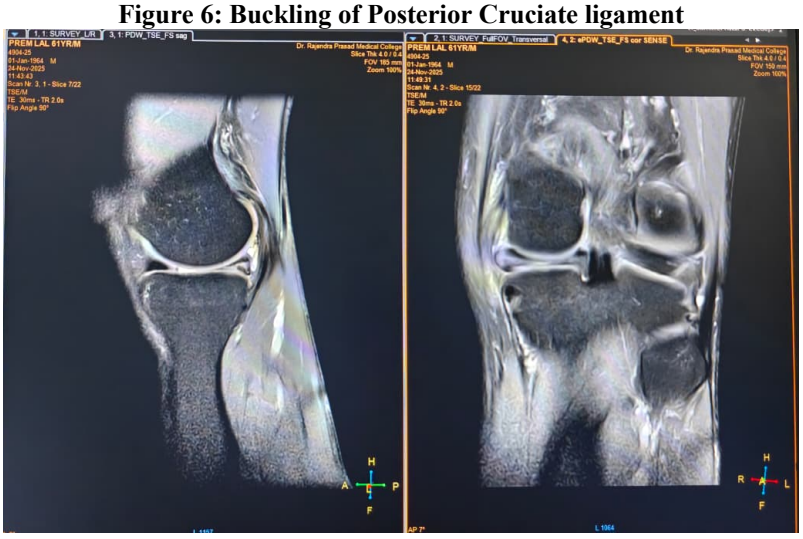

Figure 7: Grade 3 tear of medial meniscus

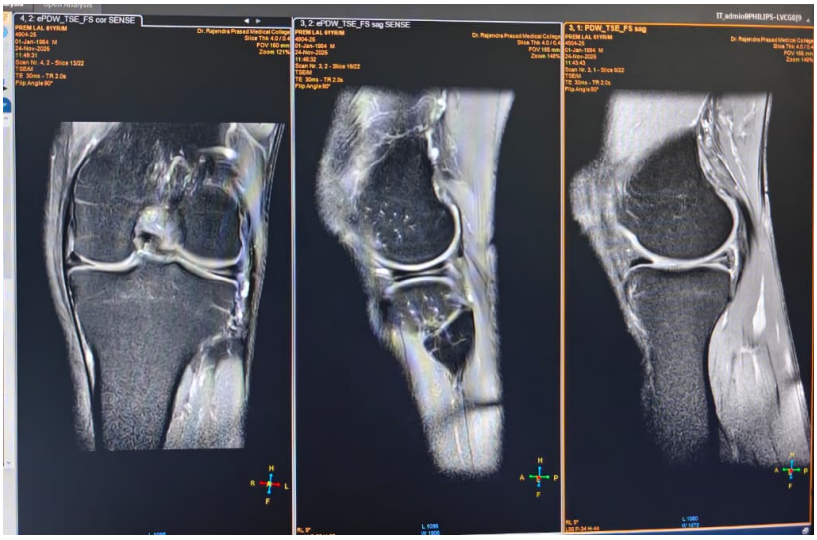

Figure 8: Horizontal/transverse tear of lateral meniscus

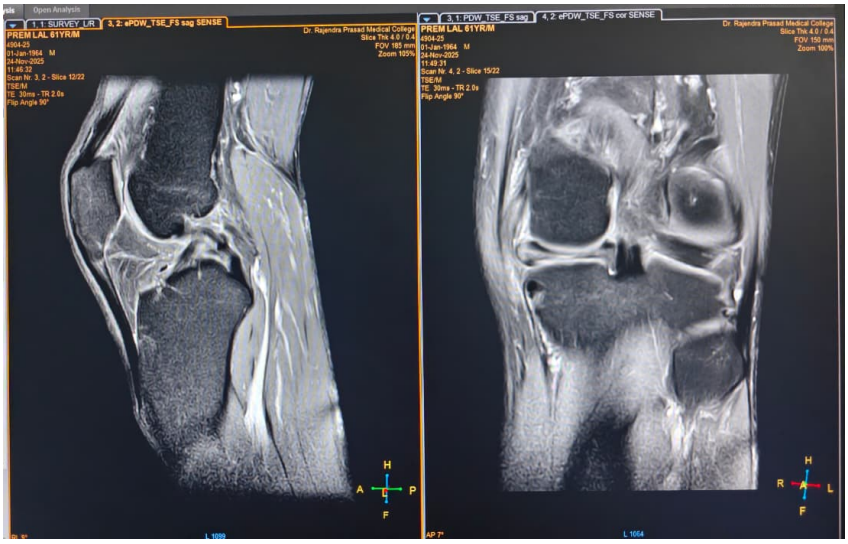

Figure 9: O'Donoghue Unhappy triad (ACL tear, MCL injury. Medial meniscus tear)

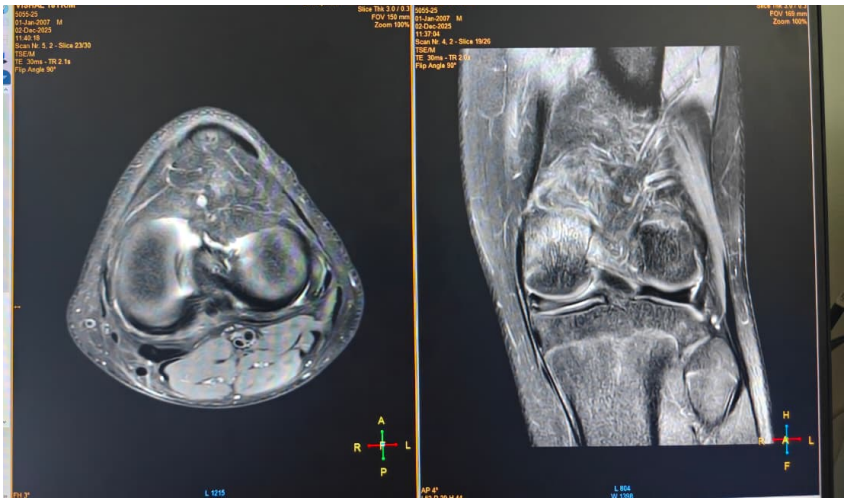

Figure 10: Popliteus tendon sheath fluid mimics lateral meniscus tear

Observation and Result

Table 1 shows the sociodemographic characteristics of the participating patients (n = 90). The majority of patients belonged to the age groups 21-40 years comprising 42.22%, while 30.00% and 27.78% were in the <21 and >40 years age group respectively, indicating that young age group formed the largest proportion of the study population. In terms of gender distribution, males constituted 75.56 % of the participants, whereas females accounted for 24.44%, showing a male predominance. Regarding the type of lifestyle, 66 patients which is 73.33% were having active lifestyle (sports / gym/manual labour work whereas 24 patients which is 26.66% were having sedentary lifestyle Socioeconomic status analysis revealed that the majority of patients (55.6%) belonged to the middle class, followed by 27.8% from the lower class and 16.7% from the upper class, indicating that most of the study population was from a middle socioeconomic background.

Table 1: Sociodemographic Characteristics of Study Participants (n = 90)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	<21	27	30.00
	21- 40	38	42.22
	>40	25	27.78
Gender	Male	68	75.56
	Female	22	24.44
Type of lifestyle	Sedentary	24	26.66
	Active	66	73.33
Socioeconomic Status	Upper	15	16.7
	Middle	50	55.6
	Lower	25	27.8

Table 2 shows the distribution of patients according to BMI categories among the total sample of 90 individuals. It is observed that half of the patients (50%) fall under the normal BMI category, representing the largest group. A considerable proportion of patients were found to be overweight (22.2%) and obese (16.7%), indicating a notable prevalence of excess body weight in the study population. Meanwhile, 11.1% of participants were categorized as underweight, representing the smallest group. Overall, the findings suggest that while the majority of participants maintain a normal BMI, a significant proportion is affected by overweight and obesity, which may have important implications for health outcomes.

Table 2: Distribution of Participants According to BMI Categories (n = 90)

BMI Category	Frequency (n)	Percentage (%)
Underweight	10	11.1
Normal	45	50
Overweight	20	22.2
Obese	15	16.7

Table 3 shows the Cruciate ligament injury patterns of the study participants (n = 90), A considerable proportion of patients sustained Grade 3 ACL injury (31.11%) followed by Grade 2 ACL injury (16.66%) while only 08.88% grade 1 injury, suggesting a high incidence of Grade 3 ACL injury. Regarding PCL injury, the majority of patients (07.77%) sustained Grade 2 injury, whereas equal proportions had Grade 1 and Grade 3 PCL injury (01.11%) . In terms of combined ACL and PCL injury 04.44% had grade 3 injury signifying severe trauma, while grade 1 and 2 combined (ACL+PCL) injury patients were 01.11%. Overall, the findings highlight a greater incidence of Anterior Cruciate Ligament injury as compared to isolated Posterior Cruciate Ligament injury and combined injury of both the cruciate ligaments Overall, the findings highlight that in a majority of the patients with knee trauma, injury of cruciate ligaments is seen in 68 out of 90 patients which is 75.55%.

Table 3: Pattern of cruciate ligament injury on MRI Participants (n = 90)		Frequency	Percentage (%)
No Cruciate lig. injury	None	22	24.44
Anterior Cruciate ligament (n=51)	Grade 1 Injury	08	08.88
	Grade 2	15	16.66
	Grade 3	28	31.11
Posterior Cruciate ligament (n= 11)	Grade 1	2	02.22
	Grade 2	7	07.77
	Grade 3	2	02.22
Combined ACL + PCL (Grade of more severely involved ligament) (n=6)	Grade 1	1	01.11
	Grade 2	1	01.11
	Grade 3	4	04.44

Table 4 shows patterns of collateral ligament injuries in knee joint. Among the study patients (n = 90), the medial collateral ligament injury was sustained by 32 patients out of which grade 1 and grade 2 injuries were more common as compared to Grade 3 Similarly , the Lateral collateral ligament injury and Combined MCL and LCL injury show higher incidence of Grade 1 and 2 severity as compared to grade 3 although the total number of cases with these injury are less as compared to MCL injury. . The patients with Medial collateral ligament injury with Grade 1 and Grade 2 are similar (17.77% and 16.66% respectively). There is a strong association of simultaneous occurrence of ACL and MCL injury. In our study there were 27 patients with combined ACL and MCL injury with high grade ACL tear (Grade 3) being most common. The findings highlight a trend towards sustenance of more severe injury to Cruciate ligaments as compared to Collateral ligaments of the knee joint.

Table 4 Collateral ligament injury (n = 90)		Frequency (n)	Percentage (%)
No collateral Lig. injury		47	52.22
MCL+LCL injury (n=2)	Grade 1 and Grade 2	1	01.11
	Grade 3	1	01.11
Medial Collateral injury (n=32)	Grade 1	16	17.77
	Grade 2	15	16.66
	Grade 3	1	01.11
Lateral collateral injury (n==9)	Grade 1	5	05.55
	Grade 2	3	03.33
	Grade 3	1	01.11

Table 5 shows the pattern of meniscal injuries and also bone oedema/ contusions The medial meniscus is more prone to injury as compared to lateral meniscus as it is less mobile and get trapped during sudden rotational motion whereas Lateral meniscus being more mobile escapes injury in most cases. In our study, with n=90 participants, 37 participants (41.11%) sustained medial meniscus injury and 20 participants (22.22%) sustained Lateral meniscus injury and 8 participants (08.88%) sustained combined Medial and Lateral meniscus injury although the degree of injury was different in the two based on mechanism of injury and the grade of more severely injured meniscus was recorded for grading. However, among the medial meniscus injury patients, grade 2 injury was seen in majority of them followed shortly by grade 3 and grade 1 injuries. MRI is useful in accurate detection of bone marrow oedema/ contusion and signifies acute trauma to knee joint. In our study of n= 90 participants, 46 had hyperintense signal on PDFS and Stir sequence suggestive of bone edema and it indicates acute trauma. the bones most commonly involved were the lateral femur condyle and the posterolateral tibial plateau.

Table 5: Meniscal injury and bone contusion (n = 90)					
No meniscal injury		**Grade 1** -	**Grade 2** -	**Grade 3** -	**Total** 25(27.77%)
Medial meniscus injury	Frequency (n)	11	14	12	37
	Percentage %	12.22	15.55	13.33	41.11%
Lateral meniscus injury	Frequency (n)	4	7	9	20
	Percentage %	04.44	07,77	10.00	22,22%
Med+Lat meniscus injury	Frequency n	2	2	4	8
	Percentage %	02.22	02.22	04.44	08.88%
Bone oedema/ contusion	Frequency n	-	-	-	46
	Percentage %	-	-	-	51.11%

Discussion

The current research identified young to middle-aged adults (21-40yrs) as the main group who experienced knee injuries, which showed greater occurrence among male individuals. This is consistent with Reddy et al. (2016) [9], who reported that 72% of patients were male, with the highest incidence occurring in the 21–30-year age group, followed by the 31–40-year cohort. The research by Umap et al. (2018) [10] showed that 80% of the subjects were male, while the most affected age group was 21–30 years, as the average age of males reached 31.7 years. The research findings indicate that young to middle-aged males face an increased risk of knee injuries because they participate in sports and work-related activities that create danger (Baker et al., 2002) [11]. Zanetti et al. (2003) [12] found that patients who suffered from bilateral meniscal tears reached an average age of 49 years, which indicates that elderly people with degenerative conditions face a higher risk of specific types of injuries. The research findings show that young adult males face the highest risk of developing acute knee injuries, which matches the age and gender distribution found in our study.

The most common ligament injury which occurred in our research study involved anterior cruciate ligament (ACL) injuries while meniscal tears and posterior cruciate ligament (PCL) injuries followed as less common ligaments injuries. This research study results show 51 total ACL tears which Yaqoob et al. (2015) [13] confirmed through MRI and arthroscopic examination while medial meniscus tears appeared in 45.3% of MRI scans. Umap et al. (2018) confirmed this trend by showing that 76% of patients suffered ACL injuries while medial meniscus tears occurred in 41.11% of cases and lateral meniscus tears appeared in 22.22% of cases. Keyhani et al. (2020) [14] found complete ACL tear rates at 72.2% while medial meniscus grade III tears occurred most frequently at 51.7%. The research studies show consistent results which demonstrate that ACL injuries constitute the primary ligament damage in traumatic knee injuries while medial meniscus tears represent the most common meniscal damage.

Our research found complete ACL tears (Grade3) to be the most common injury type while meniscus injuries showed complex or horizontal tears as their primary presentation. Grade I injuries mainly affected medial collateral ligaments and lateral collateral ligaments while tibia and femur bones suffered the most from bone contusions. Mansori et al. (2018) [15] found grade II ACL injuries to be the most common type while horizontal tears occurred in 67.9% of grade III medial meniscus lesions and 50% of grade III lateral meniscus lesions. Reddy et al. (2016) found that complete (grade III) ACL tears represented the main tear type which affected mid-fibre areas while medial meniscus (66.7%) grade III meniscal tears showed high occurrence rates. The studies demonstrate that severe ACL injuries typically occur with meniscal injuries while athletes sustain only minor collateral ligament damage.

Bone contusions in our cohort primarily involved the tibia and femur, which matched the bone bruising patterns discovered by Yoon et al. (2011) who studied ACL injuries that included meniscal and MCL damage. Patel et al. (2014) [16] reported that patients with ACL ruptures show a high occurrence of tibial and femoral bone contusions which demonstrates that bone injuries commonly result from high-energy trauma events. The research findings demonstrate that bone contusions represent an important indicator of injury severity which radiologists use to evaluate MRI scans.

Our study showed that different age groups displayed distinct patterns of behavior. ACL injuries and bone contusions were most frequent in younger adults, while meniscal injuries peaked in the 31–40-year age group. Khadka et al. (2022) [17] found that 71.8% of ACL injury patients belonged to the 21–30 years age group which shows that young people who participate in sports activities have a higher risk of ligament injuries. The older age groups showed more meniscal degeneration while they showed less acute ligamentous trauma according to the findings of Zanetti et al. (2003). The age-related distribution of injuries shows that clinicians should assess injuries according to different age groups to manage treatment and predict possible injury outcomes.

Our research discovered no connections between sex and particular injury types which we studied. Keyhani et al. (2020) found that males made up 61.8% of their study group but their research showed no differences in injury patterns between men and women. Umap et al. (2018) found that more men participated in their study yet the researchers reported no differences between male and female participants regarding injury types. The findings indicate that men experience higher knee injury rates because they engage in more physical activities yet their injuries do not show any differences between sexes.

The current study results demonstrate that MRI tests provide accurate diagnostic results for ACL injuries, meniscus injuries, and bone injuries. Phelan et al. (2016) [18] demonstrated that MRI has excellent sensitivity and specificity for ACL and meniscal tears, which is supported by the close concordance between MRI and arthroscopic findings reported by Yaqoob et al. (2015). The MRI system provides essential diagnostic functions for both acute and chronic knee injuries because it can detect complex injury patterns, which include collateral ligament tears and bone contusions.

The study discovered that findings matched previous research studies which established ACL injuries

as the main ligament injury. The medial meniscus emerged as the most common meniscal injury while bone contusions appeared as frequent accompanying injuries. Our study found three patients with complex knee injury involving triad of ACL, MCL and Medial meniscus injury known as "O 'Donoghue Triad". The study found that gender did not change injury patterns yet more males suffered from injuries than females. The research results demonstrate that MRI functions as a crucial tool for complete knee injury evaluation which enables precise treatment planning and outcome prediction.

Conclusion

This retrospective study highlights the pivotal role of MRI in the comprehensive evaluation of knee injuries following trauma. ACL injuries emerged as the most common ligamentous pathology, often accompanied by medial meniscus tears and bone contusions, while collateral ligament injuries were generally low-grade. Age-specific trends were observed, with younger adults predominantly sustaining ACL injuries and bone contusions, whereas meniscal injuries were more frequent in middle-aged individuals. Although males were more commonly affected, gender did not significantly influence the type of injury. The findings underscore that MRI provides detailed visualization of ligamentous, meniscal, and osseous abnormalities, enabling accurate diagnosis, identification of associated injuries, and informed clinical decision-making. Overall, MRI remains an indispensable tool for guiding effective management and improving outcomes in knee trauma patients.

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