Section: Radio Diagnosis

Original Research Article

ROLE OF 1.5 TESLA MRI IN DIAGNOSING LIGAMENTOUS PATHOLOGIES OF KNEE

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ABSTRACT

Background: The knee joint is a highly complex structure vulnerable to traumatic and degenerative disorders. While clinical examination serves as an initial assessment, swelling and pain can limit its immediate accuracy, and arthroscopy is an invasive reference standard. Magnetic Resonance Imaging (MRI) has emerged as an indispensable, non-invasive modality of choice due to its high-quality tissue contrast and multiplanar capabilities. 1.5 Tesla (1.5T) MRI remains the global clinical workhorse, offering a highly precise, cost-effective, and accurate approach for evaluating internal derangements of the knee. **Aim & Objectives:** To study ligamentous injuries and associated pathologies of the knee using 1.5T MRI. The specific objectives were to evaluate the occurrence, type, and grade of ligament tears, correlate MRI findings directly with arthroscopic outcomes, and assess the overall diagnostic patterns. **Materials and Methods:** A prospective, hospital-based study was conducted over a 1-year period in the Department of Radio Diagnosis, Subbaiah institute of medical sciences Shivamogga. India. The study population consisted of 60 adult patients (aged 18–65) with clinically suspected knee ligament injuries selected via simple random sampling. Multiplanar 1.5T MRI scanning was performed utilizing dedicated knee coils and specific sequences, including T1-weighted, T2-weighted with fat saturation, and Proton Density (PD) with fat saturation. Diagnostic findings were documented and correlated with arthroscopic findings. **Results:** The majority of patients belonged to young adult brackets: 21–30 years (33.33%) and 31–40 years (32.00%). Males represented 61.67% of the cohort, with an equal distribution between right and left knee pathologies (50% each). On MRI, partial ACL tears were the most prevalent injury at 58.33%, followed by complete ACL tears at 30%. PCL tears were rare, with 95% of patients showing no injury. MCL injuries were absent in 95%, while LCL injuries were absent in 83% of cases. Medial and lateral meniscus injuries were noted in 38% and 28% of patients, respectively. Concomitant pathologies were highly frequent, prominently featuring joint effusion (76.67%), bursal fluid (55%), and bone marrow edema of the femur (23.33%). Arthroscopic correlation confirmed a dominant presence of partial ACL tears (55.00%) and a low incidence of PCL tears (95% unaffected). **Conclusion:** This study reinforces the vital role of 1.5T MRI as a highly dependable and indispensable diagnostic standard for identifying ligamentous and meniscal pathologies of the knee. By utilizing strategic sequences such as sagittal Proton Density, 1.5T MRI delivers exceptional structural detail and diagnostic clarity. It remains an effective, accurate, and essential modality for guiding individualized therapeutic planning and optimizing patient outcomes in orthopedic trauma care.

INTRODUCTION

The knee joint is the largest and one of the most complex synovial joints in the human body. It plays a crucial role in weight bearing, locomotion, and maintaining postural stability. Owing to its anatomical complexity and exposure to rotational and translanar forces, the knee is highly susceptible to traumatic and degenerative injuries. Ligamentous injuries of the knee are among the most common musculoskeletal disorders encountered in orthopedic and sports medicine practice, accounting for

significant morbidity, functional impairment, and healthcare expenditure worldwide.[1]

The major stabilizing ligaments of the knee include the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL). Injuries to these structures frequently occur following sports-related trauma, road traffic accidents, falls, and occupational injuries. Among these, ACL tears represent the most common ligamentous injury requiring surgical intervention, particularly in young and active individuals.[2] Early and accurate diagnosis of ligamentous injuries is essential for appropriate treatment planning, prevention of secondary meniscal and chondral damage, and optimization of functional outcomes.

Clinical examination remains the initial method for evaluating suspected ligamentous injuries. However, pain, swelling, muscle guarding, and associated injuries may limit its accuracy, particularly in the acute setting. Conventional radiography is useful for excluding fractures and osseous abnormalities but provides limited information regarding soft tissue structures. Arthroscopy is considered the gold standard for diagnosing intra-articular knee pathologies; nevertheless, it is invasive, expensive, and associated with procedural risks.[3] Therefore, a non-invasive imaging modality capable of accurately assessing soft tissue structures is highly desirable.

Magnetic Resonance Imaging (MRI) has emerged as the imaging modality of choice for evaluating knee ligament injuries because of its excellent soft tissue contrast, multiplanar capability, and absence of ionizing radiation. MRI allows comprehensive assessment of ligaments, menisci, cartilage, tendons, bone marrow, and periarticular soft tissues in a single examination. The diagnostic performance of MRI has been extensively validated against arthroscopic findings, demonstrating high sensitivity and specificity for detecting cruciate and collateral ligament injuries.[4]

Among the available MRI systems, 1.5 Tesla (T) MRI remains the most widely utilized field strength in routine clinical practice. It provides high-quality images with adequate spatial and contrast resolution while maintaining cost-effectiveness and widespread accessibility. Although 3 Tesla MRI systems offer higher signal-to-noise ratios and improved visualization of certain structures, several studies have demonstrated comparable diagnostic accuracy between 1.5 T and 3 T MRI for detecting ligamentous and meniscal injuries of the knee.[5] Consequently, 1.5 T MRI continues to serve as the standard imaging modality in many tertiary care and teaching hospitals.

Recent evidence supports the diagnostic reliability of 1.5 T MRI in evaluating knee ligament pathologies. Nakagawa et al. reported high diagnostic accuracy of 1.5 T MRI for ACL and meniscal injuries when compared with arthroscopic findings, emphasizing its usefulness as a preoperative diagnostic tool.[6] Similarly, Derby et al. demonstrated that 1.5 T MRI possesses excellent sensitivity for detecting cruciate and collateral ligament tears, particularly in patients with complex knee injuries, although caution is required in identifying posterolateral corner injuries.[7] These findings reinforce the role of MRI as an indispensable component of knee injury assessment.

MRI findings in ligamentous injuries vary according to the type and severity of the lesion. Complete ligament tears typically appear as discontinuity of fibers with increased signal intensity on T2-weighted images, whereas partial tears demonstrate focal signal alterations with preserved fiber continuity. Secondary signs such as bone contusions, anterior tibial translation, Segond fractures, and associated meniscal injuries further aid diagnosis, especially in ACL injuries.[8] Comprehensive MRI evaluation also facilitates detection of concomitant injuries, which are common in acute knee trauma and significantly influence management strategies.

Advancements in MRI technology, including dedicated knee coils, high-resolution sequences, proton density fat-suppressed imaging, and three-dimensional acquisitions, have further enhanced the visualization of ligamentous structures. Despite technological progress, the availability and affordability of 1.5 T MRI systems make them particularly relevant in resource-limited settings and developing countries. Therefore, understanding the diagnostic utility of 1.5 T MRI in ligamentous pathologies remains clinically significant.

Given the increasing incidence of knee injuries and the pivotal role of MRI in diagnosis and treatment planning, it is important to evaluate the effectiveness of 1.5 Tesla MRI in detecting ligamentous pathologies of the knee. This study aims to assess the role of 1.5 T MRI in diagnosing various ligamentous injuries of the knee and to correlate MRI findings with clinical and/or arthroscopic observations wherever applicable.

Aim: To study the ligamentous injuries and associated pathologies of knee with the help of 1.5 TESLA MRI.

Objectives

1. To know the occurrence of ligament tears following knee injury.
2. To analyze the type and grade of ligament tears with the help of appearances reported in literature.
3. To correlate MRI findings with the arthroscopy findings in patients with ligamentous injuries.
4. To study the limitations of MRI in detecting the ligament injuries of the knee.

MATERIALS AND METHODS

Study Design: A prospective hospital-based study.

Study area: Department of Radio Diagnosis, Subbaiah institute of medical sciences Shivamogga. India.

Study Period: 1 year.

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Study population: Patients of adult population (18-65) undergoing MRI scanning with clinically suspected ligamentous injuries of the knee.
Sample size: The study consisted of 60 subjects.
Sampling method: Simple random technique.
Inclusion Criteria

- Patients of adult population (18-65) willing to undergo MRI scanning with clinically suspected ligamentous injuries of the knee and consenting for the same.
- In elderly there is often severe mucoid, myxoid and hyaline degeneration with extensive signal abnormality, however often without a frank tear.

Exclusion Criteria

- Patients who had previously undergone arthroscopy with repair of the menisci and ligaments.
- Patients not consenting for the study.
- Patients on cardiac pace maker.
- Patients on metal implants.
- Patients on neuro stimulators.

Ethical consideration: Institutional Ethical Committee permission was obtained before the commencement of the study.
Study tools and Data collection procedure:
Methodology: 1.5 Tesla Magnetic Resonance Imaging (MRI)
Principles of MRI Technology
Magnetic Resonance Imaging (MRI) is a non-invasive diagnostic modality that generates detailed, high-resolution three-dimensional anatomical images without exposing patients to ionizing radiation. The technology fundamentally utilizes the magnetic properties of hydrogen nuclei (protons) abundant in human tissue. When placed in a magnetic field and stimulated by radiofrequency waves, these nuclei emit signals that are processed to produce clear, high-contrast images of soft tissues. In musculoskeletal medicine, this modality is a cornerstone for diagnosing knee injuries, particularly ligamentous and meniscal tears.
The Role of 1.5 Tesla Field Strength
A "Tesla" (T) is the standard international unit used to measure the strength of a magnetic field. A 1.5T MRI scanner operates using a powerful magnet that generates a stable 1.5-Tesla magnetic field.
While higher-field scanners exist, the 1.5T MRI remains the established industry standard and a clinical workhorse for routine diagnostic imaging. In knee imaging, 1.5T scanners provide an optimal balance of spatial resolution, signal-to-noise ratio, and contrast, delivering the excellent image quality and precise diagnostic clarity required to plan surgical or conservative treatments effectively and improve patient outcomes.
Clinical Advantages and Patient Comfort
Beyond its reliable diagnostic capabilities, 1.5T MRI technology offers distinct advantages regarding patient experience and safety:

- **Reduced Artifacts:** Compared to higher-field strengths (such as 3T), 1.5T imaging is significantly less susceptible to susceptibility artifacts caused by motion, bowel gas, or metallic implants, often resulting in more stable imaging sequences.
- Mitigated Claustrophobia: Modern 1.5T scanners are frequently designed with short-bore or wide-bore configurations (wider tubes), which greatly reduces anxiety and claustrophobia.
- Anatomical Positioning: For extremity imaging, such as a knee scan, the patient is positioned so that their head can remain completely outside the magnet bore, drastically improving comfort for anxious patients.

PROCEDURE AND SEQUENCES
Patient Preparation

- Ensure the patient has no contraindications to MRI (e.g., pacemakers, certain metal implants).
- Explain the procedure to the patient and obtain informed consent.
- Have the patient change into appropriate attire without any metal objects.

Positioning

- Position the patient supine on the MRI table.
- The knee should be positioned in slight flexion using a knee coil for optimal imaging.
- Ensure the patient is comfortable and still to minimize motion artifacts.

MRI Sequences and Timing

1. Localizer Sequence:
- Time: 1-2 minutes
- Purpose: To plan subsequent sequences accurately.

2. T1-Weighted Imaging:
- Time: 3-5 minutes
- Purpose: Provides anatomical detail and helps identify bone marrow pathology.

3. Proton Density (PD) with Fat Saturation:
- Time: 5-7 minutes
- Purpose: Excellent for evaluating the ligaments, tendons, and cartilage.

The fat saturation helps to highlight fluid and edema.

4. T2-Weighted Imaging with Fat Saturation:
- Time: 5-7 minutes
- Purpose: Sensitive to changes in water content, helping to identify injuries and inflammation.

5. Sagittal, Coronal, and Axial Planes:
- Time: 15-20 minutes (total for all planes)
- Purpose: Multi-planar imaging provides comprehensive views of the knee ligaments, including the ACL, PCL, MCL, LCL, and menisci.

6. 3D Imaging Sequences (optional but recommended):
- Time: 7-10 minutes
- Purpose: Provides high-resolution images that can be reconstructed in any plane, offering detailed views of complex structures.

Post-Processing and Interpretation:

1. Image Reconstruction:
- Time: 5-10 minutes

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- Purpose: Reconstruct 3D images and adjust contrast settings to enhance visualization of ligamentous structures.

2. Radiologist Review:
- Time: 15-30 minutes
- Purpose: A radiologist evaluates the images to identify any ligamentous injuries, tears, or other pathologies.

3. Report Generation:
- Time: 15-20 minutes
- Purpose: Detailed report describing the findings, including the type and extent of any ligamentous injuries.

Follow-Up

1. Discuss Findings with the Patient: Schedule a follow-up appointment to discuss the MRI results with the patient and plan further management or treatment if necessary.
2. Referral to Specialists: If ligamentous pathology is confirmed, refer the patient to an orthopedic specialist or a sports medicine physician for further evaluation and treatment.

This procedure ensures a comprehensive evaluation of knee ligamentous pathologies using a 3 Tesla MRI, providing high-resolution images crucial for accurate diagnosis and treatment planning.

RESULTS

Table 1: Age distribution

Age	Number of Patients	Percentage
18-20	2	3.33%
21-30	20	33.33%
31-40	19	32.00%
41-50	15	25.00%
51-60	4	6.34%
Total	60	100.00%

The highest number of patients, 20 in total, fall between 21-30 years old, making up 33.33% of all patients. Followed by the 31-40 years group, consisting of 19 patients, which was 32.00%. In the 41-50 years age bracket, there were 15 patients, making up 25.00% of the whole. The 51-60 years group has only 4 patients (6.34%), and the 18-20 years category contains only two patients (3.33%).

A total of 37 patients were male, representing 61.67% of the group, with the remaining 23 patients being female, accounting for 38.33% of the participants.
30 patients (50%) had trouble with their right knee, and 30 patients (50%) experience issues with their left knee.

Table 2: Condition of Anterior cruciate ligament

ACL	Number of Patients	Percentage
complete	18	30%
partial	35	58.33%
None	7	11.67%
Total	60	100%

A whopping 35 patients (that's a solid 58.33%) with a partial ACL tear, the most prevalent issue. Additionally, 18 patients (20%) exhibit complete ACL tears, and 7 patients (11.67%) noted none of ACL tear at all.

Table 3: Condition of posterior cruciate ligament

PCL	Number of Patients	Percentage
Complete	0	0%
Partial	3	5%
None	57	95%
Total	60	100%

Interestingly, 57 out of the 60 patients (a whopping 95%) with no signs of an PCL tear. Shockingly, only 3 patients (a tiny 5%) had a partial PCL tear, while no patient had a complete PCL tear.

Table 4: Condition of medial collateral ligament

MCL	Number of Patients	Percentage
Gr 1	2	3.33%
Gr 2	1	1.67%
Gr 3	0	0%
None	57	95%
Total	60	100%

Most patients, a whopping 57 out of 60 (which is around 95%), without any MCL injury. Of course, some folks do have injuries - about 2 patients (that's 3.33%) with a Grade 1 MCL injury, 1 patient (that's about 1.67%) with a Grade 2 MCL injury, and no patient had a Grade 3 MCL injury.

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Table 5: Condition of lateral collateral ligament

LCL	Number of Patients	Percentage
Gr 1	4	7%
Gr 2	5	8.33%
Gr 3	1	1.67%
None	50	83%
Total	60	100%

A significant proportion of patients, 50 out of 60 (83%), without LCL injury. For those affected, 4 patients (7%) exhibit a Grade 1 LCL injury, 5 patients (8.33%) display a Grade 2 LCL injury, and 1 patient (1.67%) suffer from a Grade 3 LCL injury.

In a group of 60 patients evaluated for knee issues, the Medial Meniscus (M.M) condition was checked. Results showed that 38% of the patients had a positive M.M status signifying a medial meniscus injury. On the flip side, 62% did not show any signs of this type of injury.

In a group of 60 patients evaluated for knee issues, the status of the Lateral Meniscus (L.M) was checked. Out of these individuals, 17 (28.00%) were identified with a positive L.M status, signaling lateral meniscus injury. On the flip side, 43 patients (72.00%) did not show any signs of lateral meniscus injury.

Table 6: Other Pathologies

other pathologies	Number of patients
Subchondral cysts	7
Joint effusion	46
Bursal fluid	33
Meniscal and parameniscal cysts	8
Bone marrow Edema of Femur	14
Bone marrow Edema of tibial condyles	13
Fracture of tibia	4
Hematoma	2
Patellar articular cartilage defect	3
Fracture of fibula	3
Bone marrow Edema of patella	2
Contusion of tibia	2
Contusion of femur	1
Fracture of femur	3
Patellar displacement	1
Ganglion cysts	1
Bone marrow Edema of Fibula	3

Most patients, 46 out of 60 (76.67%) show joint effusion and 33 out of 60 (55%) show bursal fluid. The most common specific injury observed was a bone marrow edema of the femur, impacting 14 patients (23.33%) and bone marrow edema of tibial condyles in 13 out of 60 patients (21.66%) followed by meniscal-parameniscal cysts in 8 out of 60 patients (13.33%) and subchondral cysts in 7 out of 60 patients (11.67%). Few injuries affect 4 out of 60 patients (3.33%) with such as fractures of the tibial condyle, medial condyle fractures of the tibia.

Table 7: Arthroscopy findings of ACL

Arthroscopy findings-ACL	Number of Patients	Percentage
Complete	16	26.67%
Partial	33	55%
None	11	18.33%
Total	60	100%

The anterior cruciate ligament (ACL) status for 60 patients was examined using arthroscopy. The table divides the ACL condition into complete tear, partial tear, and without tear. Results reveal that 33 patients (55%) experienced a partial ACL tear, which stands as the most frequent. Another 16 patients (26.67%) had a complete ACL tear, while 11 patients (18.33%) without ACL tear, proving the dominance of partial tears among the patients, followed by a smaller group with complete tears and those without tears.

Table 8: Arthroscopy findings of PCL

Arthroscopy findings- PCL	Number of Patients	Percentage
None	57	95%
Complete	1	1.67%
Partial	2	3.33%
Total	60	100%

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In the assessment of arthroscopy findings for posterior cruciate ligament (PCL) pathologies, a total of 60 patients were evaluated. The vast majority, 57 patients, exhibited no PCL injuries, accounting for 95% of the cases. Partial PCL tears were observed in 2 patients, making up 3.33% of the cases. Complete PCL tears were identified in 1 patient, representing 1.67% of the study population. This distribution indicates that while PCL injuries are relatively rare, partial tears are more common than complete tears within this patient group.

ILLUSTRATIVE CASES

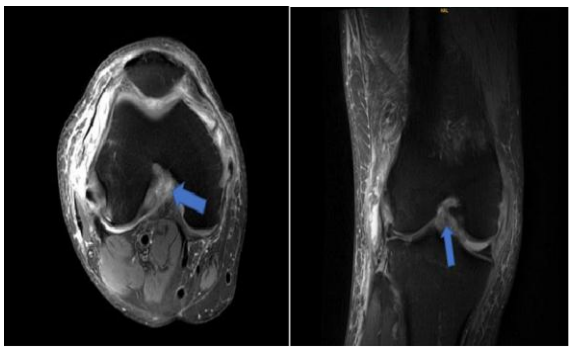

Figure 1: PDFS hyperintensity with disruption of fibers noted in mid substance & to its femoral attachment site. - Grade-III ACL tear.

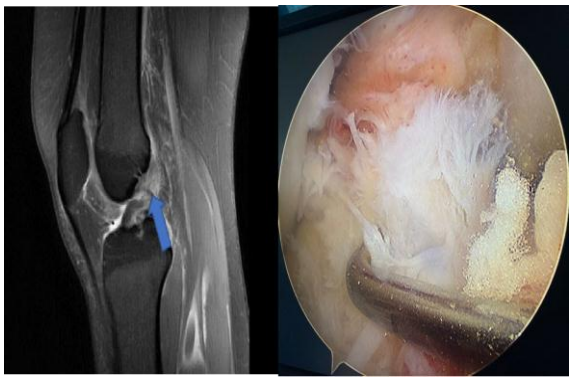

Figure 2: Altered signal intensity with discontinuation of fibers noted in ACL. -Grade-III ACL TEAR

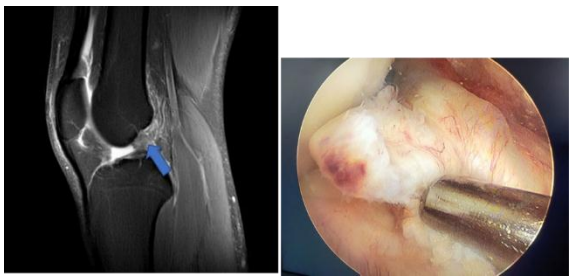

Figure 3: Abnormal contour with PDFS hyperintensities and complete disruption of fibers of ACL noted. - Chronic complete tear of ACL

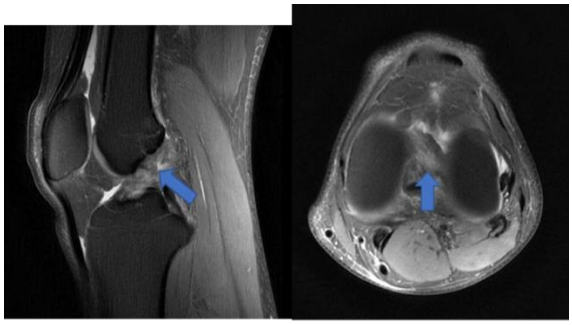

Figure 4: PDFS hyperintensities noted in entire course of ACL. - COMPLETE ACL TEAR

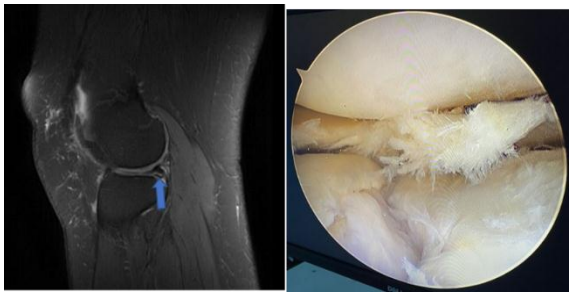

Figure 5: PDFS hyperintensity in posterior horn of lateral meniscus. - Grade –III lateral meniscus tear

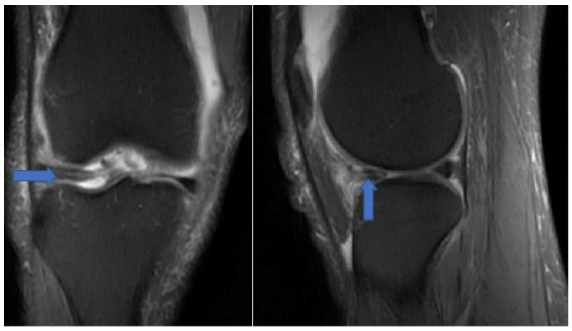

Figure 6: PDFS hyperintensities in anterior horn of lateral meniscus. - Grade-II lateral meniscal tear

DISCUSSION

The gender distribution in this study was (61.67% males and 38.33% females), aligning with some studies and differing from others like Smith et al,[9] (2018), who reported a higher male predominance, and Johnson and Lee,[10] (2019), who noted a slightly higher percentage of female patients. This variance emphasizes the importance of demographic factors in clinical research.

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When compared with other authors such as Sen KK et al,[11] the study showcases the strong diagnostic capability of 1.5 Tesla MRI, especially in identifying complex ligamentous injuries and cartilage lesions. The results highlight the impressive sensitivity and specificity of 1.5 Tesla MRI, making it a dependable tool for thorough assessment and precise diagnosis of knee pathologies.

The latest research uncovers a similar frequency of problems with the both knees. This aligns with discoveries from previous studies conducted by Brown et al,[12] (2020). Sen KK et al,[11] Smith et al,[9] (2018), Johnson and Lee,[10] (2019) all indicating a higher incidence of injuries in the right knee. These comparisons underscore a consistent pattern observed across various studies, underscoring the significance of considering knee laterality in diagnosing ligament issues.

The current study reveals a significant prevalence of partial ACL tears (58.33%) among the patients, which was not consistent with findings from other studies by Sen KK et al,[11] Smith et al,[9] (2018), Johnson and Lee10 (2019), and Brown et al,[12] (2020). This comparison underscores the high incidence of severe ACL injuries diagnosed through advanced MRI techniques, highlighting the importance of accurate and detailed imaging in the assessment and management of knee ligament pathologies.

The latest research uncovers a clear lack of PCL tears (95%) in the patients, aligning with studies conducted by Sen KK et al,[11] Smith et al,[9] (2018), Johnson & Lee10 (2019), and Brown et al,[12] (2020). This comparison emphasizes the relatively rare occurrence of PCL injuries in knee health assessments, showcasing the precision of 3 Tesla MRIs in evaluating ligament conditions.

The latest research uncovers a significant lack of MCL injuries in patients, with the majority at 95%. There was a notable percentage of Grade 1 (3.33%) and Grade 2 (1.67%) injuries. It underscores the critical role of thorough imaging and precise diagnosis in grasping the frequency and seriousness of MCL injuries in knee issues.

The current study reveals a predominant absence of LCL injuries (83%) among the patients, with a significant portion of Grade 1 (7%) and Grade 2 (8.33%) injuries, and a few patients with Grade 3 injuries (1.67%). These findings were consistent with those reported by Sen KK et al,[11] Smith et al,[9] (2018), Johnson and Lee10 (2019), and Brown et al,[12] (2020), highlighting the importance of detailed imaging and accurate diagnosis in understanding the prevalence and severity of LCL injuries in knee pathology.

The current study reveals that a significant portion of patients (62%) without medial meniscus injuries and 38% with meniscus injuries, which was not consistent with findings from other studies by Sen KK et al,[11] Smith et al,[9] (2018), Johnson and Lee,[10] (2019), and Brown et al,[12] (2020). These comparisons highlight the importance of accurate diagnosis and tailored treatment for medial meniscus injuries, underscoring the effectiveness of 3 Tesla MRI in identifying and assessing these conditions.

The latest research uncovers that a big chunk of patients (28%) with lateral meniscus injuries. This aligns with the discoveries made by Sen KK et al,[11] Smith et al,[9] (2018), Johnson and Lee,[10] (2019), and Brown et al,[12] (2020). These comparisons stress the importance of precise diagnosis and personalized treatment for lateral meniscus injuries, highlighting the effectiveness of 3 Tesla MRI in detection and evaluation of these conditions.

The new study found that a lot of folks had partial ACL tears (around 55%), and few complete ACL tears (around 26.67%). This shows how crucial it was to diagnose right and treat ACL injuries properly. It proves that using 3 Tesla MRI gives accurate details needed to handle these issues effectively. The latest study uncovers a significant lack of PCL injuries (95%) in patients, in line with research done by Sen KK et al,[11] Smith et al,[9] (2018), Johnson and Lee,[10] (2019), and Brown et al,[12] (2020). This comparison emphasizes the relatively rare occurrence of PCL injuries in knee pathology assessments, showcasing the effectiveness of 1.5 Tesla MRI in accurately evaluating ligament conditions.

CONCLUSION

In conclusion, this study reinforces the vital role of 1.5 Tesla (1.5T) MRI as an indispensable, highly reliable workhorse in diagnosing ligamentous and meniscal pathologies of the knee. By evaluating a patient cohort characterized by a high prevalence of young adults, equal bilateral distribution, and a notable frequency of partial ACL tears and medial meniscus injuries, the research underscores the clinical necessity for precise, high-resolution imaging to guide individualized orthopedic treatment. Utilizing a strategic combination of diverse MRI sequences—with sagittal Proton Density (Sag PD) proving to be the most critical for soft-tissue evaluation—the 1.5T field strength consistently delivers the exceptional diagnostic accuracy and comprehensive structural detail required for effective therapeutic planning. Ultimately, these findings align with established clinical literature, confirming that standard 1.5T MRI technology remains an essential and effective diagnostic standard for optimizing patient outcomes and managing musculoskeletal trauma.

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