Section: Radio-Diagnosis

Original Research Article

MRI CORRELATION WITH ARTHROSCOPIC FINDINGS IN ASSESSING INTERNAL DERANGEMENT OF TRAUMATIC KNEE JOINT

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ABSTRACT

Background: This study aims to evaluate ligamentous and meniscal injuries in traumatic knee joints using Magnetic Resonance Imaging (MRI), analyze injury patterns in relation to the mechanism of trauma, and correlate MRI findings with arthroscopic evaluation to assess its diagnostic accuracy.

Materials and Methods: A prospective observational study was conducted at Department of Radiodiagnosis, Aster CMI Hospital, Bangalore, over 12 months (June 2022 to June 2023). 75 patients with suspected internal knee injuries underwent MRI evaluation followed by arthroscopic examination. MRI scans were performed using a PHILIPS INGENIA ELITION 3T scanner with optimized sequences. Arthroscopic findings served as the reference standard. Diagnostic accuracy parameters, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated. P-value<0.05 was considered statistically significant.

Results: The study population had a mean age of 32.33 years, predominantly male (77.3%). Sports injuries accounted for 45.3% of cases. MRI demonstrated excellent diagnostic accuracy in detecting medial and lateral meniscus tears, anterior cruciate ligament (ACL), and posterior cruciate ligament (PCL) injuries. Sensitivity and specificity for medial meniscus tears were 100% and 97.44%, respectively; for ACL tears, 97.92% and 100%, respectively. The overall diagnostic accuracy of MRI for internal knee derangements was 98%.

Conclusion: MRI is a highly sensitive and specific non-invasive modality for diagnosing internal derangements of the knee. It shows excellent correlation with arthroscopy and can serve as an effective preoperative diagnostic tool, minimizing the need for invasive procedures.

Keywords: MRI Knee, Arthroscopy, Meniscal Tears, Cruciate Ligament, Diagnostic accuracy.

INTRODUCTION

The knee joint is a complex, weight-bearing synovial joint stabilized by various ligamentous and tendinous structures.[1] Injuries to the knee, particularly in young and active individuals, are a significant source of morbidity, often leading to functional impairment if not promptly diagnosed and managed.[2,3] Anterior cruciate ligament (ACL) tears are the most frequently encountered, often associated with other soft tissue injuries.[4] Early and precise evaluation is thus crucial for guiding treatment decisions and improving patient outcomes.

Magnetic Resonance Imaging (MRI) has become the imaging modality of choice for assessing traumatic knee injuries due to its superior soft tissue contrast, multi-planar imaging capabilities, and non-invasive nature.[4] It allows for comprehensive evaluation of internal derangements, including ligamentous, meniscal, and chondral injuries, aiding in diagnosis, grading and treatment planning [4].

Since its introduction in the 1980s, MRI has advanced with improved signal-to-noise ratios, higher resolution, faster scan times, and greater diagnostic accuracy.[4,5] It avoids ionizing radiation and joint manipulation required in procedures like arthrography.[6] Techniques such as MR Cartigram further enhance the assessment of articular cartilage lesions.[6]."

While conventional imaging modalities such as radiography, ultrasonography, arthrography, and computed tomography (CT) have been employed in evaluating knee pathologies, they are limited in their ability to delineate internal structures in detail.[7-9] Arthroscopy, considered the gold standard for diagnosing intra-articular knee lesions, offers direct visualization of joint structures. However, it is invasive, requires anaesthesia, and carries potential complications [10,11]. Additionally, certain complex tears, such as inferior surface meniscal tears, may remain elusive even during arthroscopy.[12]

Despite MRI's high diagnostic value, its findings do not always correlate perfectly with arthroscopic observations. Therefore, correlation between MRI and arthroscopy remains essential for confirming diagnoses, planning surgical interventions, and ensuring optimal patient management.[13,14] Combining both modalities offers a robust diagnostic approach, particularly in complex injury patterns or when surgical intervention is considered.

In view of the above, the present study aims to evaluate ligamentous and meniscal injuries in traumatic knee joints using Magnetic Resonance Imaging (MRI), analyze injury patterns in relation to the mechanism of trauma, and correlate MRI findings with arthroscopic evaluation to assess its diagnostic accuracy.

MATERIALS AND METHODS

The study was a prospective observational investigation conducted at the Department of Radiodiagnosis, Aster CMI Hospital, Bangalore, over a period of 12 months from June 2022 to June 2023. The study population comprised 75 patients who were referred for MRI knee evaluation due to suspected internal injury and subsequently underwent arthroscopy. The sample size was determined based on an estimated agreement rate of 87.2%,[15] with an allowable error of 8% using the formula:

$Z\alpha^2 p (1-p) / e^2$

Where, n = sample size; Zα = 1.96 at 95% confidence interval; and e = allowable error".

$n = (1.96)^2 \times 0.87 (1-0.87) / (0.08)^2 = 67 \sim 68.$

Therefore, the sample size for this study was taken as, n=75.

Patients meeting the inclusion criteria—those referred for MRI knee evaluation with suspected knee injury and who later underwent arthroscopy—were enrolled. Exclusion criteria included refusal to consent, age-related, infectious, or degenerative arthrosis, and a prior history of knee arthroscopy. Ethical clearance was obtained, and written informed consent was secured from all participants.

MRI studies were performed using a PHILIPS INGENIA ELITION 3T scanner, with optimized field strength, coil configuration, slice thickness, and matrix size to enhance signal-to-noise ratio while minimizing motion artifacts. Various MRI sequences, including PDW SPAIR (transverse, coronal, sagittal), T1W TSE (coronal), and T2W TSE (sagittal), PDW STIR (axial), 3d WATSc (sagittal) were employed to assess ligamentous and meniscal injuries. Metal artifact reduction techniques were applied where necessary. The arthroscopic procedure was conducted by an orthopaedic specialist, and findings were recorded systematically. MRI data were compared with arthroscopic findings to evaluate diagnostic accuracy. Statistical analyses were performed using SPSS trial version 23.0, employing sensitivity, specificity, positive predictive value, and negative predictive value to assess the diagnostic performance of MRI against arthroscopy.

RESULTS

Table 1 presents the age distribution of the study participants. The mean age was 32.33 ± 10.312 years, with the majority (38.7%) falling in the 21-30 years age group.

The gender distribution showed a predominance of males (77.3%) compared to females (22.7%). In terms of laterality, injuries on the left knee were more common (64.0%) than on the right (36.0%). Regarding clinical presentation, 56.0% of patients reported joint pain, 26.7% had swelling, while 17.3% experienced both symptoms. The most common mode of injury was sports-related (45.3%), followed by self-fall (28.0%) and road traffic accidents (26.7%). Table 2 presents a comparative analysis of MRI and arthroscopy findings in the evaluation of meniscal and cruciate ligament injuries in 75 patients. MRI detected no medial meniscus tear in 50.7% of cases, closely matching arthroscopy (52.0%). Vertical, horizontal, and complex tears of the medial meniscus showed comparable findings, with bucket handle tears demonstrating perfect concordance (14.7%). In lateral meniscus injuries, MRI and arthroscopy findings were largely consistent, though MRI detected a higher number of radial tears (14.7% vs. 6.7%), while arthroscopy identified more complex tears (12.0% vs. 6.7%). Cruciate ligament assessment revealed high agreement between modalities. Complete ACL tears were reported in 32.0% by MRI and 33.3% by arthroscopy, with similar rates for partial tears. PCL injuries were less frequent, with complete tears found in 5.3% of cases by both methods. Buckling was identified in 29.3% on MRI and 30.7% during arthroscopy, reflecting a strong correlation in detecting ligamentous instability. 72% of the study participants were found to have articular contusion.

68% of the study participants were found to have joint effusion. Table 3 examines the correlation between MRI and arthroscopy in the detection of meniscal and ligamentous tears. For the medial meniscus, MRI and arthroscopy demonstrated near-equivalent detection rates of tears, present in 49.3% and 48.0% of cases, respectively, with the correlation achieving statistical significance ($p < 0.005$). Similarly, lateral meniscus tears were identified by MRI in 46.7% of cases and by arthroscopy in 48.0%, again with a significant correlation ($p < 0.005$). Anterior cruciate ligament tears were detected in 62.7% of MRI studies and 64.0% of arthroscopies, while PCL tears were identified in 45.3% and 46.7%, respectively, both with significant correlation ($p < 0.005$). Table 4 highlights the high diagnostic performance of MRI compared to arthroscopy. MRI demonstrated excellent sensitivity and specificity for detecting medial meniscus (100% and 97.44%) and lateral meniscus injuries (94.44% and 97.44%). For ACL tears, MRI showed a sensitivity of 97.92% and specificity of 100%, while PCL injuries were detected with 97.14% sensitivity and 100% specificity. Positive and negative predictive values were consistently high across all structures assessed. Table 5 summarizes the overall diagnostic accuracy of MRI in evaluating internal knee derangements, with a sensitivity of 97.42%, specificity of 98.62%, and an overall accuracy of 98%. The high positive likelihood ratio (70.63) and low negative likelihood ratio (0.03) underscore MRI's reliability in confirming or excluding knee injuries.

Table 1: Demographic and Clinical Profile of Patients

Parameter	Frequency	Percentage
Age (in years)		
18-20	7	9.3%
21-30	29	38.7%
31-40	25	33.3%
41-50	8	10.7%
51-60	6	8.0%
Mean±S.D.	*32.33±10.312*	
Gender		
Male	58	77.3%
Female	17	22.7%
Laterality of lesion		
Right side	27	36.0%
Left side	48	64.0%
Symptoms		
Joint pain	42	56.0%
Swelling of knee	20	26.7%
Both	13	17.3%
Mode of injury		
Road traffic accident	20	26.7%
Self-fall	21	28.0%
Sports injury	34	45.3%
Total	75	100.0%

Table 2: Comparison of MRI and Arthroscopy Findings for Meniscal and Cruciate Ligament Injuries (n = 75)

Radiological findings	MRI		Arthroscopy	
	Meniscus			
	Medial Meniscus	Lateral Meniscus	Medial Meniscus	Lateral Meniscus
No tear	38 (50.7%)	40 (53.3%)	39 (52.0%)	39 (52.0%)
Vertical tear	7 (9.3%)	7 (9.3%)	6 (8.05)	6 (8.0%)
Horizontal tear	7 (9.3%)	9 (12.0%)	4 (5.3%)	8 (10.7%)
Radial tear	2 (2.7%)	11 (14.7%)	3 (4.0%)	5 (6.7%)
Flap tear	3 (4.0%)	2 (2.7%)	6 (8.0%)	7 (9.3%)
Bucket handle tear	11 (14.7%)	1 (1.3%)	11 (14.7%)	1 (1.3%)
Complex tear	7 (9.3%)	5 (6.7%)	6 (8.0%)	9 (12.0%)
	Cruciate Ligaments			
Radiological findings	Anterior Cruciate Ligament	Posterior Cruciate Ligament	Anterior Cruciate Ligament	Posterior Cruciate Ligament
No tear	28 (37.3%)	41 (54.7%)	27 (36.0%)	40 (53.3%)
Intact (sprain)	3 (4.0%)	2 (2.7%)	6 (8.0%)	2 (2.7%)
Low grade partial tear	11 (14.7%)	4 (5.3%)	6 (8.0%)	4 (5.3%)
High grade partial tear	9 (12.0%)	2 (2.7%)	11 (14.7%)	2 (2.7%)
Complete tear	24 (32.0%)	4 (5.3%)	25 (33.3%)	4 (5.3%)
Buckling	-	22 (29.3%)	-	23 (30.7%)
Total	**75 (100%)**	**75 (100%)**	**75 (100%)**	**75 (100%)**

Table 3: Correlation between MRI and Arthroscopy in Meniscal and Ligamentous Tears (n = 75)

Structure	Condition	MRI	Arthroscopy	p-value
Medial meniscus	Tear absent	38 (50.7%)	39 (52.0%)	<0.005
	Tear present	37 (49.3%)	36 (48.0%)	
Lateral meniscus	Tear absent	40 (53.3%)	39 (52.0%)	<0.005
	Tear present	35 (46.7%)	36 (48.0%)	
Anterior cruciate ligament	Tear absent	28 (37.3%)	27 (36.0%)	<0.005
	Tear present	47 (62.7%)	48 (64.0%)	
Posterior cruciate ligament	Tear absent	41 (54.7%)	40 (53.3%)	<0.005
	Tear present	34 (45.3%)	35 (46.7%)	

Table 4: Diagnostic Performance of MRI in Comparison with Arthroscopy (n = 75)

Structure	Diagnostic performance			
	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Medial Meniscus	100.00%	97.44%	97.30%	100.00%
Lateral Meniscus	94.44%	97.44%	97.14%	95.00%
Anterior Cruciate Ligament	97.92%	100.00%	100.00%	96.43%
Posterior Cruciate Ligament	97.14%	100.00%	100.00%	97.56%

Table 5: Overall Diagnostic Accuracy of MRI in Internal Derangement of the Knee Joint (n = 75)

Diagnostic Index	Value	95% C.I.
Sensitivity	97.42%	93.52% to 99.29%
Specificity	98.62%	95.11% to 99.83%
Positive Likelihood Ratio	70.63	17.83 to 279.78
Negative Likelihood Ratio	0.03	0.01 to 0.07
Positive Predictive Value	98.69%	95.36% to 99.84%
Negative Predictive Value	97.28%	93.17% to 99.25%
Accuracy	98.00%	95.70% to 99.26%

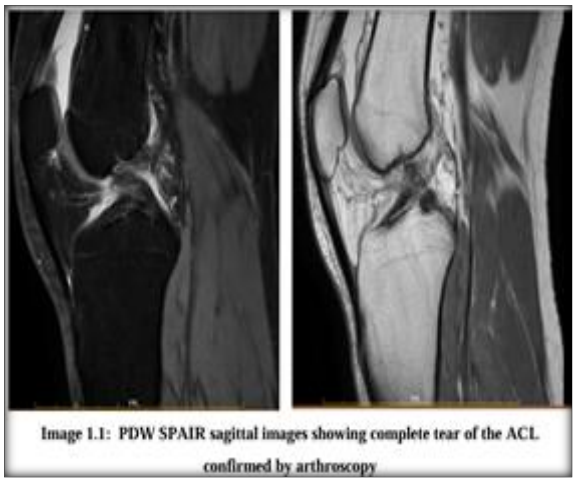

Image 1.1: PDW SPAIR sagittal images showing complete tear of the ACL confirmed by arthroscopy

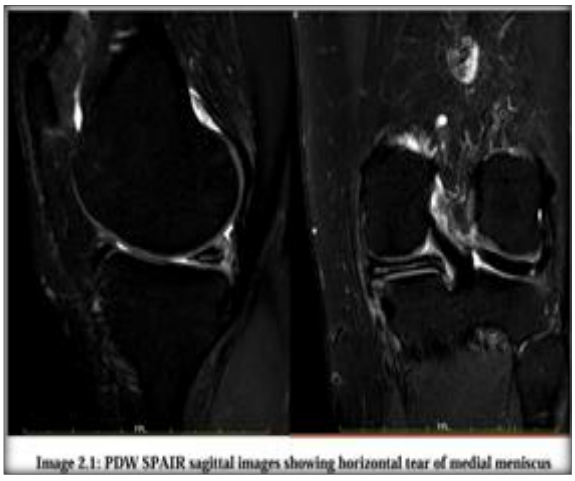

Image 2.1: PDW SPAIR sagittal images showing horizontal tear of medial meniscus

Image 1.2: Arthroscopy image of above case showing complete tear of ACL

Image 2.2: Arthroscopy showing horizontal tear of medial meniscus

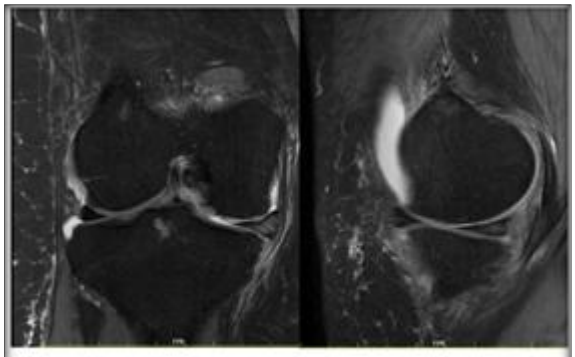

Image 3: PDW SPAIR sagittal images showing vertical tear of medial meniscus which was confirmed on arthroscopy

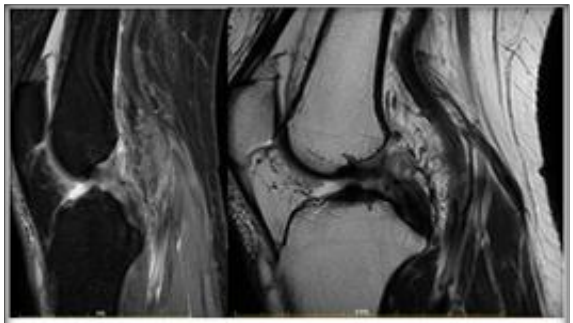

Image 4: Sagittal images showing complete tear of mid substance of PCL which was confirmed with arthroscopy

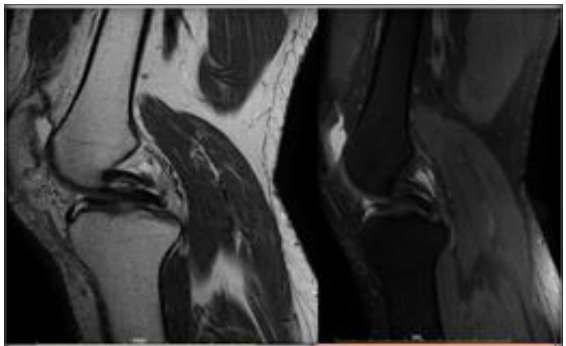

Image 5:T2W TSE and PDW SPAIR sagittal images showing bucket handle tear of medial meniscus ("double PCL" sign) which was confirmed with arthroscopy

Image 6: PDW SPAIR sagittal image showing complex tear of posterior horn of lateral meniscus with associated tibial contusions confirmed with arthroscopy

DISCUSSION

Arthroscopy remains the gold standard for diagnosing internal knee derangements; however, its accuracy is highly operator-dependent and not devoid of limitations.[16-19] Magnetic Resonance Imaging (MRI), being non-invasive and providing excellent soft tissue resolution, has emerged as the first-line diagnostic modality for knee injuries [20]. Despite its advantages, MRI interpretation depends on the observer's expertise and the equipment's sensitivity.[21]

The present study evaluated 75 participants, correlating MRI findings with arthroscopic observations. The mean age of participants was 32.33±10.31 years, consistent with findings by Russu O et al. (32.8±11.41 years),[22] Hussain MM et al. (30.8±6.93 years),[23] and Moorthy J et al. (33.30 years).[24] This emphasizes that knee injuries predominantly affect the active, working-age group (20-40 years). A male predominance was observed (77.3%) in the present study, aligning with studies by Hashemi SA et al. (73%),[25] Madurwar AU et al. (76%),[26] and Khadka T et al. (male:female ratio of 69:45).[27]

Left knee involvement (64%) was higher in this study, which is in agreement with Kucha VA et al. (54%),[28] but contrasts with Hashemi SA et al,[25] where the right knee was more frequently affected (61.6%). Joint pain was the most common symptom (56%) in the present study, similar to Shenoy KS et al. (51.8%),[29] and Kucha VA et al. (69%).[28] Sports injuries accounted for 45.3% of cases, comparable to findings by Hashemi SA et al. (66%) [25] and Moorthy J et al. (50.6%),[24] highlighting sports activities as a common cause of knee trauma.

Joint effusion (68%) and articular contusion (72%) were commonly observed in this study, aligning with Kucha VA et al. (82% joint effusion) [28], though higher than the 50% joint effusion reported by Anshuman R et al.[30]

In the present study, with respect to medial meniscus, MRI and arthroscopy both identified no tears in approximately half of the cases (50.7% and 52% respectively). Bucket handle tears were similarly detected (14.7%). Arthroscopy was more sensitive in detecting radial and flap tears. Comparable results were reported by Russu O et al. (Kappa coefficient 0.96),[22] Khadka T et al. (MRI detected 8 out of 11 bucket handle tears),[27] and Moorthy J et al. (MRI missed many bucket handle tears).[24] In terms of lateral meniscus, in the present study, no tears were found in 53.3% (MRI) and 52% (arthroscopy). MRI tended to over-report radial tears, while complex and flap tears were better identified on arthroscopy. These findings are similar to those reported by Russu O et al. (Kappa coefficient 0.74),[22] and Moorthy J et al.[24]

With regards to ACL, in the present study, absence of tears was reported in 37.3% (MRI) and 36% (arthroscopy). MRI over-reported low-grade partial tears, while arthroscopy detected high-grade tears and sprains more reliably. Similar findings were noted by Russu O et al. (Kappa 0.90),[22] and Moorthy J et al. [65].[24] In terms of PCL, no tears were found in 54.7% (MRI) and 53.3%

(arthroscopy). MRI and arthroscopy showed high concordance in detecting sprains and tears, consistent with Khadka T et al. (100% accuracy),[27] Moorthy J et al,[24] and Russu O et al.[22]

In this study, the sensitivity, specificity, PPV, and NPV for medial meniscus tears were 100%, 97.44%, 97.30%, and 100%, respectively. These values are higher than those reported by Anshuman R et al. (sensitivity 68.42%, specificity 86.66%),[30] Baghel AS et al. (sensitivity 87.5%, specificity 85.71%),[31] and Khadka T et al. (sensitivity 88.46%, specificity 88.70%),[27] For lateral meniscus tears, sensitivity and specificity were 94.44% and 97.44%, respectively. This is higher than Anshuman R et al. (sensitivity 69.23%),[30] and in line with Shenoy KS et al. (sensitivity 90%, specificity 100%).[29] ACL tears showed sensitivity and specificity of 97.92% and 100%, respectively, corroborating results from Madurwar AU et al. (97.2% sensitivity),[26] and exceeding Anshuman R et al. (sensitivity 94.59%, specificity 80%).[30] For PCL tears, sensitivity was 97.14%, specificity 100%, consistent with Khadka T et al. (sensitivity 96.42%, specificity 100%),[27] and Anshuman R et al. (100% for both).[30]

MRI achieved an overall sensitivity of 97.42%, specificity of 98.62%, PPV of 98.69%, and NPV of 97.28%, with 98% diagnostic accuracy. These findings align with Moorthy J et al. (sensitivity 90.62%, specificity 84.55%),[24] and Hashemi SA et al. (sensitivity 93.7%, specificity 96.3%),[25] but contrast with Ahmad Khan H et al. (sensitivity 74.42%, specificity 93.10%) [32] and Patel I et al. (specificity 55.56%).[32]

This study had several limitations. The sample size was small, and a larger group would enhance the validity of the findings. Categorization of meniscal tears based on tear types introduced subjectivity, reducing sensitivity and specificity. Additionally, orthopaedic surgeons had access to MRI reports during surgery, which may have influenced arthroscopic classification. An obstructed view of arthroscopic instruments further limited accurate assessment.

CONCLUSION

MRI is the best non-invasive modality for evaluating patients with knee injuries, particularly for diagnosing meniscal and ligament tears. It provides excellent visualization of both intra-articular and extra-articular structures of the knee. Moreover, MRI findings generally correlate well with arthroscopy results. However, MRI should always be interpreted in conjunction with a thorough clinical history and physical examination to ensure an accurate and comprehensive diagnosis. In this study, we observed various patterns of knee injuries and their associations. Therefore, it is important for radiologists to be familiar with these patterns when interpreting MRI scans. Even when arthroscopy yields negative results, MRI findings can raise suspicion of underlying injuries and help guide appropriate patient management.

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