Original Article

A Prospective Study on the Role of Magnetic Resonance Imaging in Evaluation of Internal Derangement of Knee with Arthroscopic Correlation

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ABSTRACT

Introduction: Magnetic resonance imaging (MRI) has revolutionized diagnostic imaging of knee injuries since its introduction to musculoskeletal imaging in the early 1980s. It has now become the modality of choice in the evaluation of intra-articular structures of the knee such as cruciate ligaments, menisci, and articular cartilage thereby replacing diagnostic arthroscopy.

Aim: To evaluate the clinical efficacy of MRI in internal derangement of the knee using arthroscopy as the gold standard.

Materials and Methods: A prospective study was conducted from May 2014 to April 2015 on 50 patients who were referred to Department of Radiodiagnosis suspected to have internal derangement of the knee. All the patients underwent MRI initially and then followed by arthroscopy. Using statistical methods, sensitivity, specificity, positive and negative predictive values, accuracy, *P* value were calculated to test the efficacy of MRI in comparison with arthroscopy.

Results: Knee joints of 50 patients belonging to the age from 19 to 52 years were studied. The sensitivity, specificity, positive and negative predictive values, and accuracy of MRI for detecting menisci and ligament tears were, respectively, as follows: 86%, 82%, 86%, 82%, and 84% for medial meniscus; 82%, 79%, 67%, 90%, and 80% for lateral meniscus; 91%, 89%, 93%, 84%, and 90% for anterior cruciate ligament; 75%, 98%, 75%, 98%, and 96% for posterior cruciate ligament. MRI also diagnosed injuries that could not be assessed on arthroscopy, including 15 medial collateral ligament tears, 10 lateral collateral ligament tears, and 29 bone bruises.

Conclusion: MRI is an excellent, accurate and non-invasive modality for the assessment of menisci and ligament injuries with high sensitivity and negative predictive value. It is a valuable tool especially in the setting of composite injury of the knee.

Keywords: Arthroscopy, Knee injury, Ligament, Magnetic resonance imaging, Menisci

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INTRODUCTION

The knee joint injury is commonly prevalent in our daily life and in many sports. A comprehensive modality is needed to diagnose all the pathologic conditions of the traumatic knee including that of the ligaments, fibrocartilages, and articular cartilages. The information obtained from conventional skiagrams, ultrasound or computed tomography of the knee is limited. Since its introduction to musculoskeletal imaging in the early 1980s, magnetic resonance imaging (MRI) has revolutionized diagnostic imaging of the knee.[1,2]

Internal derangement of the knee is the term used to cover a group of disorders involving disruption of the normal functioning of ligaments or cartilages

of knee joint thereby impairing its normal mobility.[1] Knee arthroscopy, an invasive procedure is used since the 1970s as a diagnostic and therapeutic tool in the management of acute, subacute and chronic knee complaints. Being a non-invasive modality, MRI has become an alternative to diagnostic arthroscopy.[3] MRI diagnoses injuries of the intra-articular structures like cruciate ligaments and menisci with high sensitivity and specificity as compared to the gold standard arthroscopy.

Aims and Objectives

To evaluate the clinical efficacy of MRI in internal derangement of the knee using arthroscopy as the gold standard.

To find how MRI influences clinicians' diagnoses, diagnostic confidence and management plans in patients with internal derangement of the knee.

MATERIALS AND METHODS

A prospective study was conducted on 50 patients (median age - 26.5 years, min - 19, max - 78) who were referred to Department of Radiology with clinical suspicion of ligament or cartilage or any other related pathology of the knee joint from January 2014 to April 2015. Patients with the history of joint diseases such as inflammatory arthritis or previous knee operations were excluded. All patients were subjected to MRI followed by arthroscopy. The study duration of investigations for each patient was not more than a week.

All the MRI of the knee in this study was performed using 1.5 Tesla Siemens Magnetom Essenza MR machine with knee coil. MR contrast agent was not given to any of the patients. The following sequences were employed in all patients with standard protocol-PDFS axial, sagittal and coronal, T2 sagittal and axial, T1 sagittal, coronal short tau inversion recovery with a slice thickness of 3.5 mm and interslice gap of 1 mm.

Grading of meniscal and ligamentous injuries was done. The absence of an intrameniscal high signal was considered as a normal meniscus. The presence of a globular or linear intrameniscal high signal not extending to the articular surface was considered as Grade 1 and 2 degeneration of the menisci. When intrameniscal high signal intensity extends to the articular surface, then it was regarded as tear.

The anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) were considered normal when it appeared as a band of fibers of low or intermediate signal intensity on both sagittal and coronal images. It was considered partially torn when it seemed fuzzy with an ill-defined outline and abnormal signal intensity within, and as completely torn if there was disruption of all fibers, discontinuity or avulsion from its attachment.

Arthroscopies were done within 1 week of MRI after the patients had provided signed consent. The orthopedic surgeons were aware of the MRI results as we thought it was better to emphasize MRI findings to decrease the time needed to revise the videotapes in cases of contradictory results.

Structures included in the study were medial meniscus, lateral meniscus, anterior, and PCLs. Meniscal tear and degeneration were categorized as one group and compared against the normal menisci. Cruciate ligaments were studied considering the complete and partially torn ligaments as one group and compared against the normal.

Data were entered in Microsoft Excel sheet and comparison between qualitative variables was done using the two by two tables and Yates corrected Chi-square test with OpenEpi online software. $P < 0.001$ was considered as statistically significant. Sensitivity, specificity, positive and negative predictive values, accuracy, P value were calculated to test the validity of MRI as compared to arthroscopy.

RESULTS

Of the 50 patients, 80% were males and 20% were females. ACL tear was the most common injury followed by the medial meniscus tear in both MRI and arthroscopy (Table 1 and Figure 1). Composite injuries were detected in 62% cases in MRI and 56% in arthroscopy.

MRI showed 31 ACL tears and 19 normal ACL. However, arthroscopy diagnosed 32 tears and 18 normal ACL. Of the 31, ACL tears diagnosed by MRI, 29 were confirmed by arthroscopy, and 2 were false positive. Of the 19 cases which were considered as normal by MRI, 16 were confirmed by arthroscopy, and 3 were found to have tears (Table 2). MRI and arthroscopy diagnosed 4 tears and 46 normal PCL. There was 1 false positive case and 1 false negative case diagnosed by MRI confirmed by arthroscopy (Table 3 and Figure 4a).

A total of 28 cases of the medial meniscal tear were diagnosed by MRI, of which there were 4 false positives and 4 false negatives in comparison with arthroscopy (Table 4 and Figure 2). Regarding the lateral meniscus, MRI diagnosed 21 tears/degenerations, of which 7 were false positives and 3 were false negatives (Table 5 and Figure 3).

Table 1: MRI and arthroscopic findings

Injury	Number of cases (%)	
	MRI	Arthroscopy
ACL tear	31 (62)	32 (64)
PCL tear	4 (8)	4 (8)
MM tear/degeneration	28 (56)	28 (56)
LM tear/degeneration	17 (34)	21 (42)
Composite injuries	31 (62)	28 (56)

MRI: Magnetic resonance imaging, ACL: Anterior cruciate ligament, PCL: Posterior cruciate ligament, MM: Medial meniscus, LM: Lateral meniscus

Table 2: Correlation between MRI and arthroscopic diagnoses of ACL tear and normal ACL

MRI	Arthroscopy		Total
	Tear	Normal	
Tear	29	2	31
Normal	3	16	19
Total	32	18	50

MRI: Magnetic resonance imaging, ACL: Anterior cruciate ligament

Table 3: Correlation between MRI and arthroscopic diagnoses of PCL tear and normal PCL

MRI	Arthroscopy		Total
	Tear	Normal	
Tear	3	1	4
Normal	1	45	46
Total	4	46	50

MRI: Magnetic resonance imaging, PCL: Posterior cruciate ligament

Table 4: Medial meniscus tear/degeneration versus normal medial meniscus-in MRI and arthroscopy

MRI	Arthroscopy		Total
	Tear	Normal	
Tear	24	4	28
Normal	4	18	22
Total	28	22	50

MRI: Magnetic resonance imaging

Table 5: Lateral meniscus tear/degeneration versus normal lateral meniscus-in MRI and arthroscopy

MRI	Arthroscopy		Total
	Tear	Normal	
Tear	14	7	21
Normal	3	26	29
Total	17	33	50

MRI: Magnetic resonance imaging

The sensitivity, specificity, positive and negative predictive values, and accuracy of MRI for detecting menisci and ligament tears were, respectively, as follows: 91%, 89%, 93%, 84%, and 90% for ACL; 75%, 98%, 75%, 98%, and 96% for PCL; 86%, 82%, 86%, 82%, and 84% for medial meniscus; 82%, 79%, 67%, 90%, and 80% for lateral meniscus (Table 6). There is a good correlation between MRI and arthroscopy in ligament and meniscal injuries with the $P < 0.001$. MRI also diagnosed injuries that could not be identified in arthroscopy, including 15 medial collateral ligament tears, 10 lateral collateral ligament tears, 29 bone bruises and 3 Baker's cyst (Table 7 and Figure 4b and c).

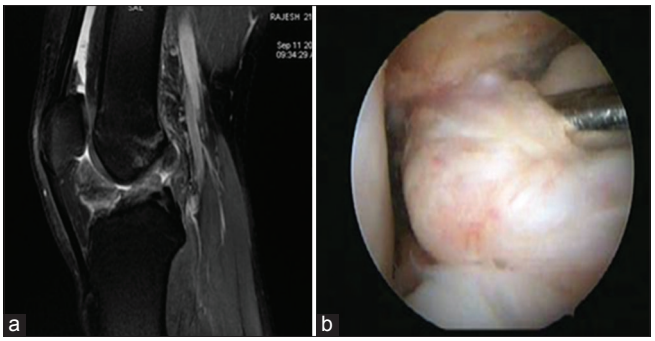

Figure 1: Sagittal proton density fat sat image showing anterior cruciate ligament tear and confirmation by arthroscopy

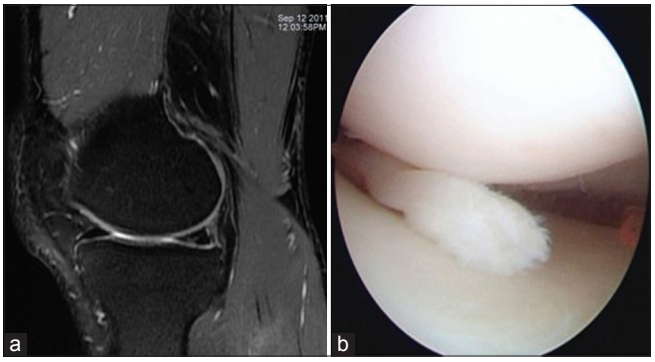

Figure 2: Sagittal proton density fat sat image showing medial meniscus posterior horn Grade 3 tear and confirmation by arthroscopy

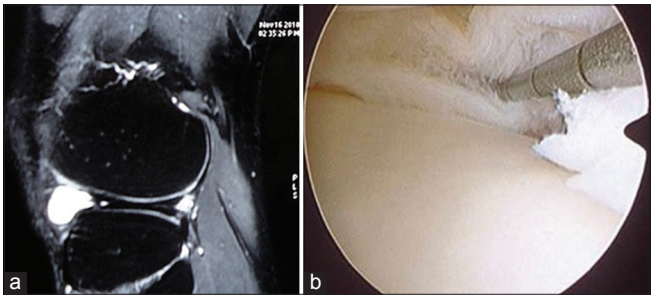

Figure 3: Sagittal proton density fat sat image showing horizontal tear of lateral meniscus with meniscal cyst

DISCUSSION

The knee injury is a common problem affecting all age groups. MRI can be used as the first line of investigation in internal derangement of the knee. MRI avoids the surgical risks involved in arthroscopy, and hence, it is preferred in most patients.[4]

ACL tear was the most common in both MRI (62%)

Table 6: Validity of MRI

Index	ACL	PCL	Medial meniscus	Lateral meniscus
Sensitivity %	91	75	86	82
Specificity %	89	98	82	79
Positive predictive value %	93	75	86	67
Negative predictive value %	84	98	82	90
Accuracy %	90	96	84	80
P value (1-tail)	<0.0000001	0.00001402	0.000003590	0.00005979

MRI: Magnetic resonance imaging, ACL: Anterior cruciate ligament, PCL:Posterior cruciate ligament

Table 7: Additional MR findings that were not detected by arthroscopy

MR findings	Number of patients
MCL tear	15
LCL tear	10
Bone bruise	29
Fracture	2
Baker's cyst	3

MCL: Medial collateral ligament; LCL: Lateral collateral ligament, MR: Magnetic resonance

and arthroscopy (64%) followed by medial meniscus tear (56% in both MRI and arthroscopy). MRI has high sensitivity for detecting ACL tears. A study by Khanda *et al*.,[5] on 50 patients also showed the sensitivity of 86.67% for MRI in detecting ACL tears. The most accurate and reliable sign of an ACL tear was the discontinuity of the ACL in the sagittal and axial planes. PCL tears detected in MRI correlate well with the arthroscopy having high sensitivity and specificity.[6]

Posterior horns of menisci are frequently injured than the anterior horns.[7] Reduction in false positive meniscal tears in MRI can be achieved by correlating peripheral meniscal signal intensity in the sagittal plane with the coronal plane, especially while interpreting the posterior horn of the medial meniscus. Lateral meniscal injuries are commonly associated with cyst formation. A study by De Smet and Graph[8] concluded that the presence of associated ACL tears markedly reduced the sensitivity for detecting meniscal injuries. This may be the cause of the low sensitivity detected in medial meniscal tears in the present study as most of the cases had associated ACL injuries. Effusion or hemarthrosis does not weaken the diagnostic validity of MRI.[9]

Regarding menisci, the sensitivity and specificity differ significantly for the medial and the lateral meniscus.[10] The accuracy of imaging is not the same for the medial and lateral menisci as there is an anatomical difference in meniscocapsular attachment between the lateral and medial menisci as the popliteus tendon passes through a hiatus at the posterolateral attachment of the lateral meniscus resulting in an increase in false positive results for the lateral meniscus.

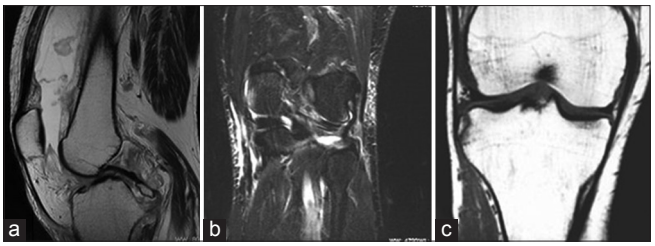

Figure 4: (a) Avulsion tear of posterior cruciate ligament with hemarthrosis, (b) lateral collateral ligament tear, (c) Segond fracture

MRI is good enough, especially when using the concept of composite injury and to appropriately identify patients who require arthroscopic therapy. Composite injuries were detected in 62% cases in MRI and 56% cases in arthroscopy. Behairy *et al*.[11] in their study of the accuracy of MRI in ligament and meniscal injuries of the knee in 70 patients in Cairo observed that composite injuries were seen in 40% cases in MRI and 48.5% in arthroscopy. It showed arthroscopy detected more composite injuries, unlike the present study where MRI detected more composite injuries than arthroscopy. The predominant pattern was the medial meniscal injury with ACL tears followed by ACL tear with the lateral meniscus injury. MRI also helped in identifying injuries that could not be diagnosed on arthroscopies such as bone bruises and collateral ligament injuries.[12]

Errors can be classified as unavoidable errors, errors related to equivocal MR findings and interpretation errors.[8,13] Even in the retrospective review, 8% of the meniscal tears could not be diagnosed. Interpretation errors are also attributed to the normal MR variants that were mistaken for a meniscal tear. A small (3%) false-positive diagnosis is attributed to healed tears or tears overlooked at arthroscopy. Increased observer experience may improve accuracy with subtle or equivocal MR findings. Familiarity with the normal anatomy and common pitfalls reduces false interpretations but does not eliminate them entirely. Differences in the learning curves of radiologists in interpreting MR signal intensities, false interpretation of areas of fibrillation or fraying as meniscal tears, inability of arthroscopy to detect intrasubstance degenerative cleavage tears, and variability in examinations using different MRI equipment and surface coils at a variety of field strengths also contribute to the variations in the accuracy rates of MRI.

Controversies exist regarding the better sequence between gradient recoiled echo and fat suppressed proton density sequences for detecting meniscal injuries, thereby, requiring more studies to draw a definitive

conclusion. MRI using 3T MRI would be of greater utility in diagnosing small meniscal tears and distinguishing tears and degeneration with high precision. Data using 3T MRI in knee imaging is currently limited and needs further studies to prove its efficacy.

MRI, when used in all patients with high clinical suspicion of intra-articular knee pathology, instead of direct arthroscopy can reduce the need for arthroscopy in up to 42% of patients.[14] MRI is the most appropriate screening tool before arthroscopy. MRI has also helped in pre-operative planning providing a road map for the surgeons.[4]

CONCLUSION

MRI is the best non-invasive modality used to evaluate the patients with internal derangement of the knee for the diagnosis of meniscal and ligament tears.

MRI of the knee is considered efficacious, especially in the setting of indeterminate clinical findings and can stratify patients, thereby increasing the diagnostic confidence of the clinicians leading to appropriate surgical planning and management. MRI is preferred to diagnostic arthroscopy in the most patients as it avoids surgical morbidity. The diagnostic accuracy of MRI, although variable for different individual structures, is good enough, especially when using the concept of a composite knee injury and to appropriately identify patients who require arthroscopic therapy.

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