Original Article

MRI evaluation of internal derangement of knee with arthroscopic correlation

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Since the introduction to musculoskeletal imaging in the early 1980, MRI has been revolutionized as a diagnostic imaging tool for the evaluation of internal joint structures of the knee like menisci, cruciate ligaments and articular cartilage. The aim of the present study was to evaluate the Clinical efficacy of magnetic resonance imaging (MRI) in internal derangement of the knee using arthroscopy as a gold standard. This was a prospective study conducted on 50 patients, referred to Department of Radiodiagnosis, suspected to have internal derangement of knee. All the patients underwent MRI and followed up with arthroscopy. The MRI sequences included sagittal & PD fat sat, sagittal T1 & T2W FSE images, coronal STIR images and axial T2W FSE images. The result of the study showed that the sensitivity, specificity, positive & negative predictive values and accuracy of MRI for detecting menisci and ligament tears were respectively as follows: 86%, 82%, 86%, 82% & 84% for medial meniscus; 82%, 79%, 67%, 90% & 80% for lateral meniscus; 91%,, 89%, 93%, 84% & 90% for anterior cruciate ligament; 75%, 98%, 75%., 98% & 96% for posterior cruciate ligament. MRI also identified injuries that could not be assessed on arthroscopy including 15 medial collateral ligament tears, 10 lateral collateral ligament tears and 29 bone bruises. Thus it can be concluded that MRI can be used as a first line investigation in patients with suspected internal derangement of knee before proceeding for arthroscopy.

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Key words **: Knee injury, magnetic resonance imaging, arthroscopy, ligament, menisci.**

Knee joint is one of the most commonly injured joint in day to day life and in many popular sports. A comprehensive modality is needed to diagnose all the pathological conditions of the injured knee including that of the soft tissues, ligaments, fibrocartilages & 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, MRI has revolutionized diagnostic imaging of the knee[1].

MRI is currently the imaging modality of choice for nearly all clinical indications concerning the knee. MRI assists in distinguishing pathologic knee conditions that may have similar clinical signs and symptoms. Soft tissue discrimination with MR imaging is excellent and differentiations can be made among cortex, marrow, ligaments, tendons, muscle, synovium and vascular and cartilage elements thereby obviating the need for multiple imaging procedures[2]. Other advantages of MR imaging are assessment in multiplanar and thin section and ability to evaluate subchondral bone and marrow.

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- **MRI has been revolutionized as a diagnostic imaging tool for the evaluation of internal joint structures of the knee like menisci, cruciate ligaments and articular cartilage.**
- **MRI can be used as a first line investigation in patients with suspected internal derangement of knee before proceeding for arthroscopy.**

Internal Derangement of the Knee (IDK) 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. Being a non-invasive modality, MRI is now routinely used to assess wide spectrum of internal knee derangements and articular disorders. Compared with computed tomography (CT) scans. MRI provides superior anatomic and pathologic definition of both intra articular and extra articular structures including soft tissues, ligaments, fibrocartilage and articular cartilage. The developments and advancements in MRI and the introduction of high resolution coils have provided a non-invasive, non-operator dependent, cost effective means to diagnose knee pathology[3].

MRI has virtually replaced conventional arthrography in evaluation of menisci and cruciate ligaments. With conventional arthrography, intra-articular injection of contrast agent permits visualization of surface anatomy but does not allow delineation of fibro cartilaginous structure or

subchondral bone. Arthroscopy of the knee has been used since the 1970s as a diagnostic and therapeutic tool in the management of acute, sub-acute and chronic knee complaints. Arthroscopy of the knee is an invasive procedure with associated risks and leading to discomfort for the patient. Therefore it should primarily be used for treatment and the fraction of diagnostic arthroscopies should be limited. Injuries to the intra-articular structures like menisci and cruciate ligaments are diagnosed with high sensitivity and specificity by MRI as compared with arthroscopy, which is still regarded as the reference standard[4].

In the past 15 years, MRI of the knee has become available as an alternative to diagnostic arthroscopy. The overall assessment of the entire joint, also called composite diagnosis is more important than accurate diagnosis of all specific lesions of the various anatomic structures. It is good enough, especially when using the concept of composite injury, to appropriately identify patients, who require arthroscopic therapy. In addition to diagnostic benefits, MRI has also proved valuable in selection of surgical candidates and in preoperative planning providing a road map for the surgeons. 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 patient. By influencing the management received by a patient, MRI also has the ability to influence excellent outcome and societal cost.

The objectives of the present study was to describe the magnetic resonance imaging (MRI) features in various ligament and cartilage pathologies causing internal derangement of the knee joint, to evaluate the clinical efficacy of MRI in internal derangement of the knee using arthroscopy as a gold standard and to find how MRI influences clinicians' diagnosis, diagnostic confidence and management plans in patients with internal derangement of knee.

Material and Methods

This was a prospective study which included 50 patients who were referred to Department of Radiodiagnosis with clinical suspicion of ligament or cartilage or any other related pathology of knee joint. Institutional ethical clearance and patients consent was obtained.

Patients experiencing pain, popping, locking, click, instability and swelling were included in the study. Patients with joint disease, eg, rheumatoid arthritis or previous knee operations, were excluded.

All patients were subjected to MRI and arthroscopy. MRI scans of the knee in this study were performed using GE Signa HDX MR Machine with a 1.5 tesla field strength magnet in a closely coupled extremity. No contrast agent was given. Meniscal and ligamentous injuries were evaluated and graded. Absence of an intrameniscal high signal was considered as a normal meniscus. Presence of an intrameniscal high signal not extending to the articular surface was considered grade 1 and 2 degeneration of the menisci, while intrameniscal high signal intensity reaching the articular surface was regarded as a tear (Fig 1).

The ACL was considered normal when it appeared as a band of fibres of low or intermediate signal intensity on both sagittal and coronal images. It was considered partially torn when it appeared fuzzy with ill-defined outline and abnormal signal intensity within, and as completely torn if there was disruption of all fibres, discontinuity or avulsion from its attachment.

Arthroscopies were done in a hospital environment with complete operative care, in the outpatient surgery department. A Stryker 3 CCD video camera is used with a 4mm Karl Storz arthroscope and at 30° angle. Standard materials were used: superomedial portal for outflow, inferolateral for the arthroscope and interomedial for instrumentation. During arthroscopy, a systematic examination was performed with a complete evaluation of the joint. Arthroscopies were done within 2 months of MRI after the patients had provided signed consent.

ACL or PCL tear was diagnosed if the ligament was absent in the notch region, or if there was loss of ligament continuity with only ligament remnants at each end or presence of discontinuity at least in one of the bundle (Fig 2).

Menisci were considered degenerated when fibrillation was present and trimming was done. A meniscal tear was diagnosed when there was discontinuity of its cartilage and the surgeon proceeded to partial meniscectomy according to the size and shape of the tear (Figs 3&4).

Statistical Analysis

Structures included in the study were medial and lateral menisci and anterior and posterior cruciate ligaments. We considered meniscal tear and degeneration as one group compared against the normal menisci. ACL was studied considering the complete and partially torn ACLs as one group compared against the normal.

Data were coded and entered using the Statistical Pack-

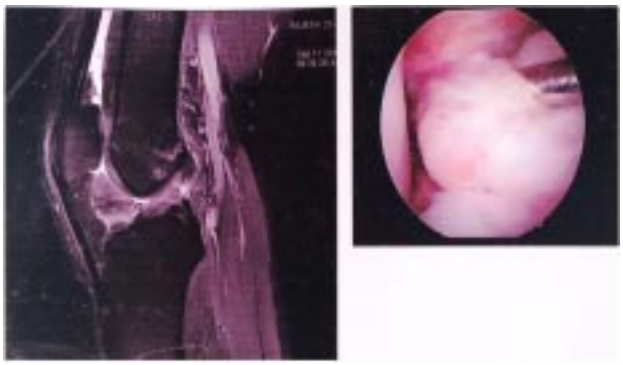


Fig 1 — Sagittal PD fat sat image showing ACL tear and confirmation by arthroscopy

age for the Social Sciences (SPSS) version 22. Data were summarised using percentage for qualitative data. Comparisons between qualitative variables were done using the chi-square test. P values of <0.001 were considered as statistically significant. Sensitivity, specificity, positive and negative predictive values, accuracy, P value were calculated to test validity of MRI against arthroscopy.

Fig 2 — Sagittal T2WI image Showing PCL avulsion tear

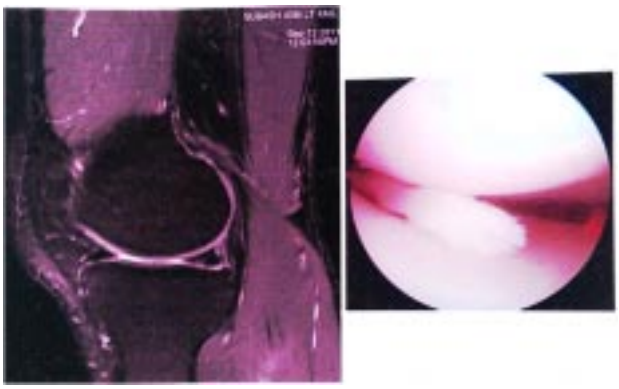


Fig 3 — Sagittal PD fat sat image showing medial meniscus posterior horn grade 3 tear and confirmation by arthroscopy

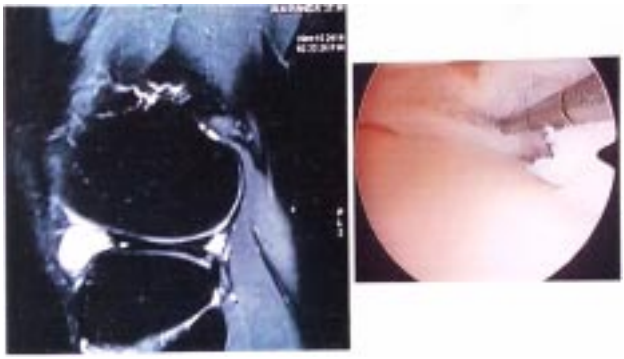


Fig 4 — Sagittal PD fat sat image showing horizontal tear of lateral meniscus with meniscal and confirmation by arthroscopy

Result

In our study 50 patients with age ranging from 19-52 years were included. Out of which 84% of study population belonged to 20-40 years of age group with 80% being male. In 88% of patients presented with complaint of knee pain followed by swelling of joint in 40% of patients.

MRI finding revealed ACL tear being the most common (62%) injury followed by medial meniscus tear (56%) and composite injuries were detected in 62% of cases (Table 1). Also arthroscopy showed 64% of ACL tear followed by 56% of medial meniscus tear and 56% of composite injuries (Table 2).

Correlating MRI and arthroscopic finding it was found that MRI showed 91% of sensitivity and 89% of specificity in diagnosing ACL tear with 90% accuracy and 93% positive predictive value and 84% of negative predictive value (p<0.001) (Graph 1).

In diagnosing PCL tear and normal tear MRI showed 75% sensitivity, 98% specificity, 75% positive predictive value and 98% negative predictive value with 96% accuracy (Graph 2).

In cases of medial meniscus tear, MRI showed 86% sensitivity, 82% specificity, 86% positive predictive value and 82% negative predictive value with 84% of accuracy in comparison to arthroscopy (Table 3).

Similar observations were noted for diagnosis of lateral meniscus tear and degeneration with MRI being 80% accurate and having sensitivity of 82% and specificity of 79% (Table 4).

Additionally 15 MCL tears, 10LCL tears, 29 bone bruises, 1 case of tibial plateau, 32 cases

Table 1 — *MRI findings*

MRI	No of cases	Percentage
ACL tear	31	62
PCL tear	4	8
MM tear/ Degradation	28	56
LM tear/ Degradation	17	34
Composite injuries	31	62

Table 2 — *Arthroscopic finding*

Arthroscopy	No of cases	Percentage
ACL tear	32	64
PCL tear	4	8
MM tear/ Degradation	28	56
LM tear/ Degradation	21	42
Composite injuries	28	56

Table 3 — *Correlation between MRI & arthroscopy diagnosis of medial meniscal lesions*

MRI	Arthroscopy		
	Tear (26)	Degeneration (2)	Normal (22)
Tear (23)	21	0	2
Degeneration (5)	1	2	2
Normal (22)	4	0	8

Table 4 — *Correlation between MRI & arthroscopy diagnosis of lateral meniscal lesions*

MRI	Arthroscopy		
	Tear (15)	Degeneration (2)	Normal (33)
Tear (16)	12	0	4
Degeneration (5)	1	1	3
Normal (29)	2	1	26

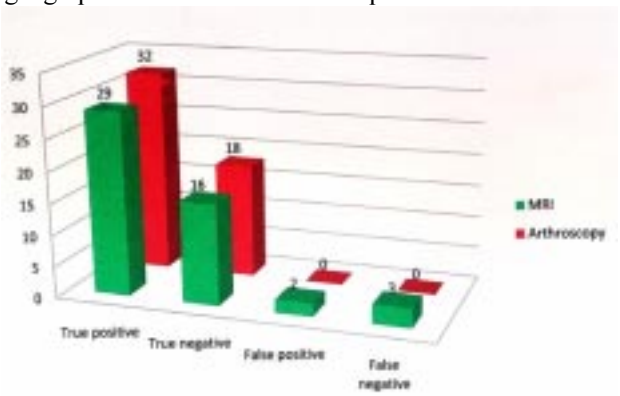
of joint effusion and three cases of Bakers cyst were diagnosed by MRI only.

Overall sensitivity and specificity of MRI was found to be more for ACL tears than meniscus. However MRI has high negative predictive value for meniscus (Table 5).

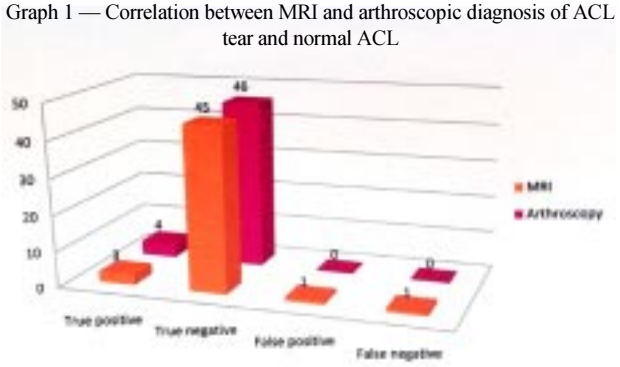
Discussion

Majority of the patients suspected to have internal derangement of knee belonged to the age group of 20-40 years with mean age of 31.6 years. This correlated with the study done by Esmaili Jah *et al* in which the mean age was 27.9 years[5]. This could be attributed to the fact that young and middle aged were more susceptible to trauma. Also younger people showed more internal derangement of knee as compared to the old age where degenerative symptoms are more predominant.

In our study 80% of the patients were males and only 20% were females. These findings were in contrast with the study done by Khanda GE *et al*[6]. This could be due to geographical factor and small sample size. The reason for male predominance is that males are more susceptible to trauma than females in day to day life.



Graph 1 — Correlation between MRI and arthroscopic diagnosis of ACL tear and normal ACL



Graph 2 — Correlation between MRI and arthroscopic diagnosis of PCL tear and normal PCL

Table 5 — *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

In the present study pain was the most common symptom seen in 88% of the patients followed by swelling of the knee joint seen in 40% of the patients. Rest of the symptoms in decreasing order of frequency are joint instability (36%), locking (26%), click (18%) and restricted movement (16%).

In our study anterior cruciate ligament (ACL) tear was most common in both MRI (62%) and arthroscopy (64%) followed by medial meniscus tear (56% in both MRI and arthroscopy). Composite injuries were detected in 62% cases in MRI and 56% cases in arthroscopy. The results were contradictory to the study done by Noha H Behairy *et al*, in which composite injuries were seen in 40% cases in MRI and 48.5% in arthroscopy. It showed arthroscopy detected more number of composite injuries[7].

The sensitivity, specificity, positive & negative predictive values and accuracy of MRI for detecting ACL tears were 91%, 89%, 93%, 84% & 90% respectively. These values almost coincided with the study done by Khanda GE *et al*[6]. Robertson *et al* in their study of multiple signs of anterior cruciate ligament on MR imaging in 103 patients found that the most accurate and reliable sign of an ACL tear was discontinuity of the ACL in the sagittal and axial planes which was taken as the main criteria for ACL tear in our study[8]. Isolated ACL tears were rare. Isolated injury of the ACL was only detected in 7 (14%) cases by arthroscopy and in 8 (16%) cases by MRI in our study. Patrice *et al* suggested that sensitivity and specificity of MRI for ACL tears considerably increased when normal and partially torn ligaments were considered as one group and complete tears as another group. In our 32 cases of ACL tears, 22 (68.7%) cases were associated with bone bruise. Rosen et al in a study of acute ACL injuries further delineated the location of bone bruises. They noted that 85 per cent of 75 patients with an acute ACL rupture had bony changes on MRI imaging[9].

The sensitivity, specificity, positive & negative predictive values and accuracy of MRI for detecting PCL tears were 75%, 98%, 75%, 98% & 96% respectively. A study done by Khanda GE *et al* in Karachi on 50 patients showed the sensitivity, specificity, positive & negative predictive values and accuracy of MRI for detecting PCL tears were 86.67%, 91.43%, 81%, 94% & 96% respectively[6]. The discrepancy in statistical values between both studies may be due to less incidence of PCL tears.

A study done by Ismael Silva *et al* showed that maximum number of tears involving the medial meniscus were of grade 3. Statistical analysis was done considering meniscal tear and degeneration as one group compared against the normal menisci[10]. The sensitivity, specificity, positive & negative predictive values and accuracy of MRI

for detecting medial meniscal lesions were 86%, 82%, 86%, 82% & 84% respectively. A study done by Crues *et al* using 1.5T MRI machine showed the sensitivity, specificity, positive & negative predictive values of MRI for detecting medial meniscal tears were 87%, 91%, 93%, 91% respectively. Majority of the tears were in posterior horn both in MRI (21 cases, 75%) and arthroscopy (21 cases, 75%). In 2 cases had bucket handle tears in MRI confirmed by arthroscopy. Crues *et al* in their study also found meniscal tears involving the posterior horns which accounts for 57% compared to the 16% involving the anterior horn. 1 rare case of discoid meniscus with tear was found in arthroscopy which was reported only as grade 3 tear. In the study by DeSmet and Graph the sensitivity for meniscal injuries decreased markedly in cases associated with ACL tears. This may be the cause of the low sensitivity detected in medial meniscal tears in our study as most of the cases had associated ACL injuries[11].

The sensitivity, specificity, positive & negative predictive values and accuracy of MRI for detecting lateral meniscal lesions were 82%, 79%, 67%, 90% & 80% respectively. A retrospective study done by Reicher et al. showed the sensitivity, specificity, positive & negative predictive values of MRI for detecting lateral meniscal tears were 78%, 88%, 78%, 88% respectively. Majority of the tears were in posterior horn both in MR (16 cases, 76%) and arthroscopy (10 cases, 59%). Meniscal cysts were seen in 5 cases accompanying lateral meniscal tears. A study by NR Boeree *et al* on 203 patients, 12 patients had meniscal cysts of which 6 with lateral meniscus and 6 with medial meniscus. 2 cases of discoid meniscus were found in MR and were confirmed in arthroscopy[12].

Regarding the menisci, our results demonstrated that the sensitivity and specificity differ significantly for the medial and the lateral meniscus. 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 more false positive results for the lateral meniscus. Oei *et al* stated that MRI is more sensitive in the diagnosis of the medial meniscus and that the specificity is higher for the lateral meniscus, Our results were contradictory with a higher sensitivity and higher specificity for the medial meniscus[13].

Boeve BF *et al* in their study of magnetic resonance imaging in the evaluation of knee injuries found high negative predictive values ranging from 95-100% for ACL and menisci. However the present study showed relatively lower negative predictive values ranging from 80-90%[14].

Arthroscopy revealed 28 cases(56%) with composite injury. The predominant pattern was medial meniscal (mainly posterior horn of the medial meniscus) with ACL tear (14 cases) followed by combined ACL with lateral meniscal injury and ACL with both menisci injury — 5 cases each. MRI detected 31 (62%) cases of composite injuries. The predominant pattern was medial meniscal injury with ACL tears, while 7 cases showed ACL tear with lateral meniscus injury and 7 other cases showed combined medial and lateral meniscal injuries. 4 other cases showed lateral and medial meniscal injuries plus ACL tear. Noha H Behairy *et al* in their study of accuracy of MRI in ligament & meniscal injuries of knee in 70 patients in Cairo observed that the predominant pattern was medial meniscal injury with ACL tear in both MRI (24 cases) and arthroscopy (19 cases).

MRI detected 15 MCL tears & 10 LCL tears, 29 bone bruises & 1 case with tibial plateau fracture, 32 cases with joint effusion and 3 cases with incidental small Baker's cyst. Among 15 MCL tears, 14 were Grade 1 and 1 was Grade 2 tear. Among 15 LCL tears, 6 were Grade 1, 3 were Grade 2 and 1 was Grade 3 tear. Munshi M *et al* found that MRI also identified injuries that could not be assessed on arthroscopy, including 14 bone bruises, nine MCL tears, and one LCL tear[15].

The clinical problem is to avoid MRI for patients who definitely need therapeutic arthroscopy and to prevent invasive arthroscopy when there is no surgically treatable lesion. If there are no mechanical symptoms MRI may be indicated to exclude any treatable pathology.

We agree with Crawford et al who stated that MRI is the most appropriate screening tool before arthroscopy. It is preferable to diagnostic arthroscopy in most patients because it avoids the surgical risks. Also concerning the economic burden especially in a country like India, MRI may decrease unjustified arthroscopies[16].

Conclusion

Magnetic resonance imaging is an accurate, non-invasive technique for examination of the soft tissue and osseous structures of a knee. Studies have shown that it is the best non-invasive & cost effective modality used to evaluate patients with internal derangement of knee for the diagnosis of meniscal and ligament tears. Its accuracy in the diagnosis of meniscal tears is high as well as in the evaluation of ACL. Familiarity with the normal anatomy and common pitfalls reduces false interpretations but does not eliminate them entirely. In patients with ACL tear, the accuracy of MR imaging for meniscal tears, especially lateral tears, diminishes, but still surpasses that of physical examination. MR imaging depicts the anatomy of the knee joint without need for intravenous contrast agents or joint manipulation.

MR imaging of the knee is considered efficacious especially in the setting of indeterminate clinical findings

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and can stratify patients, thereby increasing the diagnostic confidence of the clinicians leading to appropriate surgical planning and management. It is the most appropriate screening tool for therapeutic arthroscopy. It is preferable to diagnostic arthroscopy in most patients because it is faster and avoids surgical morbidity. The diagnostic accuracy of MRI, although variable for different individual structures, is good enough, especially when using the concept of composite knee injury, to appropriately identify patients who require arthroscopic therapy. MRI of the knee joint has effectively replaced arthroscopy and others as the imaging modality of choice in the evaluation of internal derangement of knee. Despite its cost, MR imaging has been readily accepted by both patients and referring clinicians.

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