Original Article

Correlation of Magnetic Resonance Imaging and Arthroscopic Findings in Meniscal Tears at a Tertiary Healthcare Centre

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Abstract

Background: Meniscal tears are common causes of pain, locking and functional limitation of the knee following trauma. Magnetic resonance imaging (MRI) is commonly used for non-invasive assessment. Arthroscopy allows direct visualisation and remains the reference standard for diagnosis and treatment. The objective is to evaluate the relationship between MRI and arthroscopic findings of meniscal tears and to assess the limitations of both diagnostic tools in a tertiary healthcare centre. **Material and Methods:** This prospective observational study included 46 patients with suspected traumatic meniscal injury. All patients underwent MRI followed by knee arthroscopy. Medial and lateral menisci were evaluated separately giving 92 meniscal assessments. MRI findings were compared with arthroscopic findings. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated. Agreement was assessed using Cohen's kappa coefficient and McNemar's test. **Results:** The mean age was 36.74 ± 10.58 years and 65.2% of patients were males. MRI detected medial meniscal tears in 54.3% while arthroscopy confirmed tears in 52.2%. Lateral meniscal tears were detected in 10.9% on MRI and 8.7% on arthroscopy. Overall, there were 26 true-positive, 60 true-negative, four false-positive and two false-negative findings. The combined sensitivity was 92.86% and specificity was 93.75%. Positive predictive value was 86.67% and negative predictive value was 96.77%. Overall diagnostic accuracy was 93.48%. Cohen's kappa was 0.849, indicating almost perfect agreement. McNemar's test showed no significant difference between MRI and arthroscopy positivity rates (p=0.683). **Conclusion:** MRI showed high diagnostic accuracy and good agreement with arthroscopy for meniscal tears. It is a useful non-invasive investigation for preoperative assessment. Arthroscopy remains important for definitive diagnosis and treatment when clinical and MRI findings are inconclusive or discordant.

Keywords: Arthroscopy, diagnostic accuracy, knee injury, magnetic resonance imaging, medial meniscus, meniscal tear, lateral meniscus.

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Introduction

The menisci are important fibrocartilaginous structures of the knee joint. They help in load transmission, shock absorption and joint stability. They also contribute to protection of the articular cartilage. Meniscal tears can produce pain, swelling, locking and limitation of knee movements. These injuries are frequently seen following twisting trauma, sports injuries and other traumatic events.[1,2]Clinical examination remains the first step in the assessment of a suspected meniscal injury. However, clinical findings may be affected by pain, swelling and associated ligament injury. Magnetic resonance imaging (MRI) provides a non-invasive assessment of the menisci and other intra-articular structures. It can identify the site and morphology of the tear and can also demonstrate associated ligament or cartilage abnormalities. Recent evidence has shown good diagnostic performance of MRI for meniscal tears, although accuracy differs between the medial and lateral meniscus.[3,4]

Arthroscopy allows direct visualisation of the meniscus and remains the reference standard for confirmation of meniscal tears. It also permits treatment during the same procedure. However, arthroscopy is an invasive procedure and requires anaesthesia. The role of MRI is therefore important in selecting patients who are likely to benefit from arthroscopic intervention. Recent studies have reported good agreement between MRI and arthroscopic findings, but false-positive and false-negative findings are still observed.[5,6]The diagnostic accuracy of MRI may also vary according to tear type, tear location, magnetic field strength and MRI sequence. Posterior horn and complex tears may present specific diagnostic difficulties. Associated anterior cruciate ligament injury can also influence MRI accuracy.[6,7] A recent comparative study reported high sensitivity and specificity of MRI when arthroscopy was used as the reference standard. However, some discordance remained between the two modalities.[8]Considering these variations, correlation of MRI with arthroscopic findings remains clinically relevant. The

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present study was conducted to evaluate the relationship between MRI and arthroscopic findings of meniscal tears in patients treated at a tertiary healthcare centre. The study also aimed to assess the limitations of MRI and arthroscopy in the diagnosis of meniscal injuries.

Materials and Methods

Study design and setting: This prospective observational study was conducted in the Department of Orthopaedics and Traumatology at Mahatma Gandhi Memorial Medical College and Maharaja Yashwantrao Hospital, Indore, Madhya Pradesh. The study was carried out over a period of one year. Patients presenting with clinical features suggestive of meniscal injury were evaluated by MRI followed by arthroscopy.

Study participants: Patients with a history of knee trauma and clinical suspicion of meniscal injury were considered for inclusion. Symptoms included knee pain, locking, clicking and instability. Patients with previous knee surgery, contraindication to MRI, contraindication to arthroscopy, advanced degenerative arthritis and non-traumatic knee pain were excluded.

A consecutive sampling method was used. A total of 46 patients who underwent both MRI and arthroscopic evaluation were included in the final analysis.

MRI assessment: MRI of the affected knee was performed using the standard institutional protocol. All MRI examinations were interpreted by a senior radiologist. The medial and lateral menisci were assessed separately. Presence or absence of tear, location and tear morphology were recorded. Associated intra-articular abnormalities were also noted.

The meniscal tears were classified according to the involved region and morphological appearance. Findings included posterior horn tear, body tear, root tear, bucket-handle tear and complex tear.

Arthroscopic assessment: Knee arthroscopy was performed by an experienced orthopaedic surgeon. Arthroscopy was considered the reference standard for comparison with MRI. Both medial and lateral menisci were systematically examined. Presence of tear, site and morphology were documented at the time of procedure.

MRI findings were compared independently with the arthroscopic findings. Each meniscal evaluation was classified as true positive, true negative, false positive or false negative.

Outcome measures: The primary outcome was agreement between MRI and arthroscopy for detection of meniscal tears. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy.

The secondary assessment included discordant findings between the two modalities and the practical limitations of MRI and arthroscopy.

Statistical analysis: Data were analysed using R version 4.5.2. Continuous variables were expressed as mean ± standard deviation or median with interquartile range. Categorical variables were presented as frequency and percentage. Diagnostic performance of MRI was calculated separately for medial and lateral menisci and for all meniscal evaluations combined. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were calculated using arthroscopy as the reference standard. Agreement between MRI and arthroscopy was assessed using Cohen's kappa coefficient. McNemar's test was used to evaluate differences in paired diagnostic results. Pearson chi-square test or Fisher's exact test was used where appropriate. A p-value of <0.05 was considered statistically significant.

Results

Table 1: Demographic and injury characteristics of the study participants

Characteristic	Category	n (%)
Age group	18–20 years	2 (4.3)
	21–30 years	12 (26.1)
	31–40 years	14 (30.4)
	41–50 years	14 (30.4)
	>50 years	4 (8.7)
Age, years	Mean ± SD	36.74 ± 10.58
	Median (IQR)	36.5 (28.2–44.0)
Sex	Male	30 (65.2)
	Female	16 (34.8)
Mechanism of injury	Road traffic accident	22 (47.8)
	Fall from height/stairs	12 (26.1)
	Twisting injury	8 (17.4)
	Sports injury	4 (8.7)
Side involved	Left knee	26 (56.5)
	Right knee	20 (43.5)

The mean age of the 46 patients was 36.74 ± 10.58 years. The median age was 36.5 years. Most patients belonged to the 31–50 year age group. Males were more common and constituted 65.2% of the study population.

Road traffic accident was the most common mechanism of injury and was seen in 22 patients (47.8%). This was followed by fall from height or stairs in 12 patients (26.1%). Twisting injury was present in 17.4% and sports injury in 8.7%. The left knee was involved in 26 patients (56.5%) while the right knee was involved in 20 patients (43.5%) [Table 1].

Table 2: Comparison of MRI and arthroscopic findings for medial and lateral meniscal tears

Meniscus	Finding	MRI, n (%)	Arthroscopy, n (%)
Medial	Normal	21 (45.7)	22 (47.8)
	Posterior horn tear	13 (28.3)	11 (23.9)
	Body tear	5 (10.9)	5 (10.9)
	Root tear	4 (8.7)	4 (8.7)
	Bucket-handle tear	3 (6.5)	3 (6.5)
	Other tear*	0	1 (2.2)
	Any medial tear	25 (54.3)	24 (52.2)
Lateral	Normal	41 (89.1)	42 (91.3)
	Posterior horn tear	3 (6.5)	2 (4.3)
	Complex tear	2 (4.3)	2 (4.3)
	Any lateral tear	5 (10.9)	4 (8.7)

MRI detected a medial meniscal tear in 25 of 46 knees (54.3%) while arthroscopy confirmed a medial meniscal tear in 24 knees (52.2%). Posterior horn tear was the most common medial meniscal lesion. It was detected in 13 patients (28.3%) on MRI and in 11 patients (23.9%) on arthroscopy.Body tears were detected in five patients by both modalities. Root tears were found in four patients by MRI and arthroscopy. Bucket-handle tears were identified in three patients by both methods.Lateral meniscal tears were less frequent. MRI detected lateral tears in 5 patients (10.9%) while arthroscopy confirmed tears in 4 patients (8.7%). Posterior horn and complex tears were the main lateral meniscal abnormalities [Table 2].

Table 3: Correlation of MRI findings with arthroscopy for detection of meniscal tears

Meniscus	True positive	False positive	False negative	True negative	Total	p-value
Medial	22	3	2	19	46	<0.001
Lateral	4	1	0	41	46	<0.001
Combined	26	4	2	60	92	<0.001

For the medial meniscus, MRI correctly identified 22 true-positive and 19 true-negative findings. Three false-positive and two false-negative findings were observed. The association between MRI and arthroscopy was statistically significant ($p<0.001$).

For the lateral meniscus, four true-positive and 41 true-negative findings were recorded. One false-positive result was present and no false-negative result was observed. When both menisci were analysed together, there were 26 true-positive, 60 true-negative, four false-positive and two false-negative observations. MRI correctly classified 86 of the 92 meniscal evaluations. The overall association between MRI and arthroscopy was statistically significant ($p<0.001$) [Table 3].

Table 4: Diagnostic performance of MRI for medial, lateral and combined meniscal tear detection

Diagnostic parameter	Medial meniscus	Lateral meniscus	Combined
Sensitivity, %	91.67	100.00	92.86
Specificity, %	86.36	97.62	93.75
Positive predictive value, %	88.00	80.00	86.67
Negative predictive value, %	90.48	100.00	96.77
Diagnostic accuracy, %	89.13	97.83	93.48
LR+	6.72	42.00	14.86
LR−	0.096	0.000	0.076

MRI showed a sensitivity of 91.67% and specificity of 86.36% for medial meniscal tears. The positive predictive value was 88.00% and negative predictive value was 90.48%. Diagnostic accuracy for the medial meniscus was 89.13%. For lateral meniscal tears, MRI showed a sensitivity of 100% and specificity of 97.62%. The diagnostic accuracy was 97.83%. However, only four lateral meniscal tears were confirmed on arthroscopy. For all 92 meniscal evaluations combined, MRI showed a sensitivity of 92.86%, specificity of 93.75%, positive predictive value of 86.67% and negative predictive value of 96.77%. The overall diagnostic accuracy was 93.48% [Table 4].

Table 5: Overall agreement and discordance between MRI and arthroscopic findings

Diagnostic parameter	Medial meniscus	Lateral meniscus	Combined
Sensitivity, %	91.67	100.00	92.86
Specificity, %	86.36	97.62	93.75
Positive predictive value, %	88.00	80.00	86.67
Negative predictive value, %	90.48	100.00	96.77
Diagnostic accuracy, %	89.13	97.83	93.48
LR+	6.72	42.00	14.86
LR−	0.096	0.000	0.076

MRI and arthroscopy showed concordant findings in 86 of 92 evaluations (93.48%). Only six evaluations were discordant. These included four false-positive and two false-negative MRI findings. Cohen's kappa coefficient was 0.849 with a 95% confidence interval of 0.732–0.966. This indicated almost perfect agreement between MRI and arthroscopy. McNemar's test showed no significant difference between the overall positivity rates of the two modalities (χ^2=0.167, p=0.683). The overall association between MRI and arthroscopy was statistically significant (p<0.001) [Table 5].

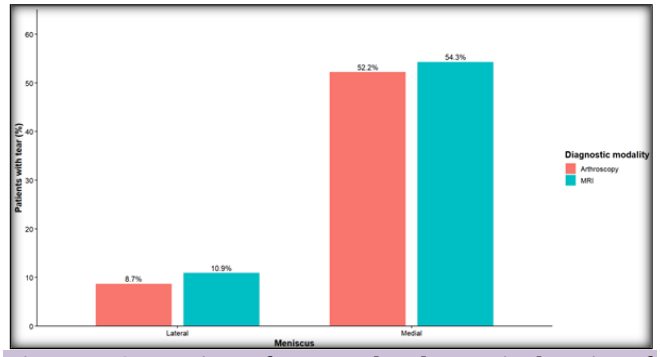


Figure 1: Comparison of MRI and arthroscopic detection of medial and lateral meniscal tears

Discussion

The present study showed good agreement between MRI and arthroscopy for detection of meniscal tears. MRI correctly classified 86 of 92 meniscal evaluations. The overall sensitivity was 92.86% and specificity was 93.75%. The diagnostic accuracy was 93.48%. Cohen's kappa was 0.849. These findings indicate that MRI is a useful investigation for preoperative assessment of suspected meniscal injury.

The mean age of the patients was 36.74 ± 10.58 years. Most patients were between 31 and 50 years of age. Males constituted 65.2% of the study population. Road traffic accident was the most common mechanism of injury and was present in 47.8% of patients. Falls accounted for 26.1%. This pattern may be related to the trauma-based population presenting at a tertiary healthcare centre. The left knee was involved in 56.5% and the right knee in 43.5% of patients.

The medial meniscus was more commonly involved than the lateral meniscus. MRI detected medial meniscal tears in 54.3% while arthroscopy confirmed tears in 52.2%. Lateral meniscal tears were detected by MRI in 10.9% and confirmed by arthroscopy in 8.7%. Porter and Shadbolt also compared MRI with arthroscopy in a large prospective study. They found that MRI performance differed between medial and lateral meniscal tears and reported only moderate agreement with arthroscopic findings.[9]

Posterior horn tear was the most frequent medial meniscal finding in the present study. It was detected in 28.3% on MRI and in 23.9% on arthroscopy. Body, root and bucket-handle tears were less frequent. MRI was therefore useful for identifying the probable location and pattern of the tear. However, identification of tear morphology on MRI may not always correspond completely with arthroscopic findings. Strawbridge et al. reported that even 3-T MRI had limited ability to predict the arthroscopic characteristics and reparability of meniscal tears. Interobserver agreement for individual tear features was also low.[10]

Root tears formed a smaller proportion of medial meniscal injuries in the present study. These tears are clinically important because loss of root function can markedly affect meniscal biomechanics. Guimarães et al. described the MRI findings of meniscal root tears and stressed the importance of careful assessment of the root attachment and associated secondary signs. They also noted the role of arthroscopic correlation in confirming the lesion.[11]

For medial meniscal tears, MRI showed a sensitivity of 91.67%, specificity of 86.36% and accuracy of 89.13%. These findings are close to the values reported in recent literature. The updated meta-analysis cited in the Introduction reported pooled sensitivity of 91.0% and specificity of 87.7% for medial meniscal tears.[4] The present findings therefore fall within the expected diagnostic performance of MRI for medial meniscal pathology.

For lateral meniscal tears, MRI showed sensitivity of 100%, specificity of 97.62% and accuracy of 97.83%. These values appear better than many previous studies. However, only four lateral tears were confirmed by arthroscopy. The 100% sensitivity should therefore be interpreted cautiously. A small change in the number of missed tears would markedly alter this estimate. This is important because MRI performance for lateral meniscal tears has generally been less consistent than for medial tears.[4,9]

When both menisci were analysed together, sensitivity was 92.86% and specificity was 93.75%. The PPV was 86.67% and NPV was 96.77%. Overall diagnostic accuracy was 93.48%. The high NPV suggests that a negative MRI considerably reduces the probability of a meniscal tear in this study population. However, MRI cannot be considered completely equivalent to arthroscopy. There were six discordant observations in the present study. Four were false-positive MRI findings and two were false-negative findings. Van Dyck et al. specifically evaluated discordance between 3-T MRI and arthroscopy. They identified both false-positive and false-negative interpretations and found that many errors were related to equivocal or unavoidable imaging appearances rather than simple reporting errors.[12] Their findings explain why a small degree of disagreement can remain even with good-quality MRI.[12]

Nakasa et al. also demonstrated that disagreement may occur between MRI and direct examination of the meniscus. They reported variation in diagnostic performance according to the medial or lateral meniscus and according to tear location and pattern.[13] This supports the need to interpret MRI along with the clinical findings rather than using the MRI report alone for operative decision-making.[13]

The observed agreement between MRI and arthroscopy in the present study was 93.48%. Cohen's kappa was 0.849 which indicates a high level of agreement beyond chance. The McNemar test was not significant (p=0.683). This indicates that the overall positive detection rates of MRI and arthroscopy

were not significantly different. Zhang et al. also found high diagnostic performance and good agreement of MRI when compared with operative findings in patients evaluated for meniscal and ACL injuries.[14]

The performance of MRI may change when meniscal tears are associated with ACL injury. Vo et al. evaluated MRI and arthroscopic findings in patients with ACL tears. They reported an overall MRI accuracy of 69.2% for detecting meniscal injuries and only minimal to moderate agreement for some locations and morphological patterns.[15] This was lower than the accuracy observed in the present study. Associated ligament injury may therefore be one reason for variation between different studies.[15] False-positive and false-negative findings also depend on tear morphology and location. Chahwan et al. studied patients with concomitant ACL injury and identified several factors associated with incorrect MRI diagnosis of medial and lateral meniscal tears.[16] This indicates that diagnostic accuracy should not be expressed only as a single overall percentage. The type of tear, its location and associated knee pathology also influence MRI performance.[16]

MRI has several advantages in the evaluation of suspected meniscal injury. It is non-invasive and provides information regarding the menisci, cruciate ligaments, cartilage and other intra-articular structures. It can assist in operative planning and may avoid unnecessary diagnostic arthroscopy in selected patients. However, MRI findings are influenced by imaging technique, tear orientation and reader experience. Some small or hidden lesions may not be clearly visible.

Arthroscopy remains the reference standard because it permits direct visualisation and probing of the meniscus. It also allows definitive treatment during the same procedure. Arthroscopy itself is not without limitations. It is invasive and requires anaesthesia and an operative setup. Some concealed meniscal injuries may also be difficult to recognise by visual inspection alone. Ibañez et al. described hidden intrameniscal lesions which required careful arthroscopic probing for diagnosis.[17] This shows that systematic examination of the entire meniscus remains important even during arthroscopy.[17] The present findings suggest that MRI and arthroscopy should be considered complementary tools. MRI provides reliable preoperative assessment and showed high sensitivity, specificity and NPV in the present study. Arthroscopy remains important when MRI and clinical findings are discordant, when symptoms persist despite a negative MRI or when therapeutic intervention is required.

The present study has some limitations. The sample size was relatively small. Only four lateral meniscal tears were confirmed on arthroscopy which limits the precision of the lateral meniscus sensitivity estimate. The study was conducted at a single tertiary healthcare centre. Only patients undergoing both MRI and arthroscopy were evaluated. This may introduce selection or verification bias. The number of individual tear types was also small. Larger studies with adequate representation of different tear patterns would provide more precise diagnostic estimates.Overall, MRI showed a strong relationship with arthroscopic findings for meniscal tears. The overall diagnostic accuracy was 93.48% with almost perfect agreement. However, false-positive and false-negative findings were present. MRI remains an effective non-invasive preoperative investigation while arthroscopy continues to have an important role for definitive confirmation and treatment.

Conclusion

MRI showed a strong relationship with arthroscopic findings in the diagnosis of meniscal tears. It demonstrated high sensitivity, specificity and overall diagnostic accuracy. The high negative predictive value also supports its role as an effective non-invasive investigation before arthroscopy. However, false-positive and false-negative findings were observed and complete agreement regarding tear morphology cannot always be expected. Arthroscopy remains important for definitive confirmation and treatment but has the limitation of being invasive. Clinical examination, MRI and arthroscopic findings should therefore be considered together while planning management of suspected meniscal injuries.

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Conflicts of interest

There are no conflicts of interest.

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