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Research Article

What Magnetic Resonance Imaging Can Miss Around the Knee? Correlation of Imaging Results with Arthroscopic Findings

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ABSTRACT

Objective: Magnetic resonance imaging (MRI) is a non-invasive and extensively used diagnostic tool for evaluating intra-articular knee pathologies. Nevertheless, the diagnostic concordance between MRI and arthroscopic findings remains a matter of debate. This study aimed to assess the correlation between MRI and arthroscopic findings in patients with intra-articular knee pathologies.

Methods: This retrospective study included 203 patients who underwent knee arthroscopy between 2020 and 2022 for suspected intra-articular pathology. MRI and intraoperative findings were compared for the anterior cruciate ligament, medial and lateral menisci, chondral lesions, and plica structures.

Results: The mean age of patients was 42.0 ± 12.87 years; 62.1% were male. MRI findings demonstrated a strong correlation with arthroscopy for anterior cruciate ligament injuries ($\kappa = 0.75$, $P < 0.001$) and a moderate correlation for medial meniscal tears ($\kappa = 0.60$, $P < 0.001$). However, reliability was weak to very weak for lateral meniscal tears and chondral lesions ($\kappa < 0.49$, $P < 0.05$); no significant reliability was observed for lateral femoral condyle cartilage ($\kappa = 0.03$, $P = 0.644$) or for the presence of plica ($\kappa = 0.01$, $P = 0.771$) between MRI and arthroscopic findings.

Conclusion: Although MRI is a valuable diagnostic tool for evaluating intra-articular knee pathologies, its correlation with arthroscopy was weak for detecting lateral meniscal injuries, chondral lesions, and the presence of plica. The use of MRI as the sole diagnostic tool may be inadequate, potentially resulting in failure to diagnose patients with persistent or unexplained knee symptoms. Although MRI plays an important role in the diagnosis of intra-articular knee pathologies, arthroscopy remains the definitive gold standard for confirming these lesions.

Keywords: Knee, MRI, arthroscopy, anterior cruciate ligament, meniscus, cartilage, plica

INTRODUCTION

The knee joint is one of the most frequently affected sites in musculoskeletal disorders presenting to primary care and orthopedic clinics.[1] Knee pain is a common problem in clinical practice and one of the primary causes of activity limitation in daily life. Over the past 20 years, the prevalence of knee pain has increased by nearly 65% and has resulted in approximately 4 million primary care visits each year.[2,3]

Anterior cruciate ligament (ACL) injuries are frequently observed in sports and may be caused by contact or non-contact mechanisms.[4] According to several studies, the annual incidence of ACL injuries has been reported as 25-78 per

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100.000 person-years. About 70% of these injuries are reported to occur, and ACL rupture is among the most common knee injuries requiring treatment in younger patients.[5,6] Meniscal tears have an average annual incidence of 60-70 per 100.000 population, with a consistent male predominance observed across all age groups, as reflected in a male-to-female ratio ranging from 2.5:1 to 4:1.[7,8] Furthermore, chondral lesions are relatively common among the pathologies observed during arthroscopy. While prevalence rates differ across studies, large series involving 25,124 arthroscopies documented chondral lesions in 60% of cases.[9]

Diagnosis of intra-articular knee pathologies begins with a meticulous clinical assessment, including the patient's history and a physical examination. When deemed necessary, these are followed by advanced imaging modalities to confirm and characterize the pathology. Magnetic resonance imaging (MRI) is a diagnostic imaging modality that provides high soft-tissue resolution, facilitating accurate visualization of intra-articular structures of the knee.[10] MRI is most frequently indicated in patients with possible injuries to the cruciate ligaments, menisci, and soft tissues. Although MRI has been documented to exhibit high diagnostic sensitivity, specificity, and accuracy, the true sensitivity and specificity of the test remain challenging to ascertain.[11] A considerable number of studies evaluating the accuracy of MRI are vulnerable to bias, possibly resulting in diagnostic tests showing inaccurately high sensitivity estimates.[12-14]

The primary objective of the present study was to evaluate the correlation between MRI-based diagnoses and arthroscopic findings of intra-articular knee lesions, with a view to providing a more precise and reliable diagnostic outcome.

MATERIAL AND METHODS

Study Population and Data Collection

The present retrospective study included patients who underwent knee arthroscopy at our institution between January 2020 and May 2022 for suspected meniscal pathology, ACL injury, or chondral lesions, with approval from the institutional Ethics Committee of Ankara Bilkent City Hospital Clinical Research (decision no.: E1-22-3070, date: 30.11.2022). All arthroscopies were performed at the same hospital by the same senior surgeon (Ö.D.), who had 15 years of experience in arthroscopic knee surgery, using standardized approaches and portals as described in the literature.[15] As part of our clinic's routine practice, the primary surgeon reviews all patients' MRI images and reports following the physical examination. Preoperative planning and surgical indications are then determined based on these evaluations. The indication for surgery was determined based on MRI and physical examination findings. All preoperative MRI scans were performed within six weeks of arthroscopic surgery.

The exclusion criteria were as follows:

- Patients diagnosed with oncological or infectious diseases,
- Patients who have previously undergone meniscus surgery,
- Patients who have previously suffered a fracture in the same knee,
- Patients for whom MRI data or intraoperative records were unavailable for any reason.

Initially, 220 patients were evaluated; 203 met the inclusion and exclusion criteria and were enrolled in the study. A retrospective review of the demographic, radiological, and intraoperative data of the included patients was conducted using the hospital's digital archive system.

Radiological and Clinical Evaluation

The same standard protocol was applied to all knee MRI examinations performed on a 1.5-T MR system (Signa Pioneer, GE Healthcare, ABD). Coronal, sagittal, and axial images were assessed using T1- and T2-weighted sequences with a 3 mm slice thickness. MRI examinations were reported by radiologists specializing in musculoskeletal imaging in the study hospital's Radiology Department; evaluations were performed based on these reports, which were recorded in the system. The radiologists responsible for reporting had no knowledge of the patients' clinical symptoms or surgical outcomes.

The MRI evaluation encompassed the ACL, the medial and lateral menisci, the articular cartilage of the medial and lateral femoral condyles and of the medial and lateral tibial plateaus, the patellofemoral joint, and the synovial plicae. Chondral damage detected on the MRI was graded according to the International Cartilage Repair Society (ICRS) criteria, which have been validated for use in this context.[16,17] The ICRS Grading System is a validated classification method used to evaluate the severity of cartilage damage. Cartilage of "Grade 0" is characterized by the absence of any discernible defects. The term "Grade 1" denotes superficial lesions, including cartilage softening and surface cracks and fissures. Grade 2 lesions involve cartilage loss of less than 50% of the total cartilage thickness. Grade 3 lesions are characterized by defects that traverse more than 50% of the cartilage thickness. However, these lesions do not extend to the subchondral bone. The presence of complete-thickness cartilage loss that extends into the subchondral bone is indicative of "Grade 4" lesions. A meniscal tear was

MAIN POINTS

- The reliability of magnetic resonance imaging (MRI) in detecting intra-articular knee pathologies varies significantly depending on the anatomical structure being evaluated.
- MRI demonstrates a moderate-to-strong correlation with arthroscopic findings for anterior cruciate ligament and medial meniscus injuries, but performs poorly in detecting damage to the lateral femoral condyle, lateral meniscus tears, and the medial plica.
- Although MRI remains a valuable non-invasive imaging modality, it should not be used in isolation; combining MRI results with thorough physical examination—and confirming uncertain cases via arthroscopy—ensures more accurate diagnosis.

defined on sequential MRI slices as an abnormal signal reaching the articular surface, loss of meniscal tissue, or a displaced fragment.[18,19] Accordingly, ACL injuries were classified as intact, partial, or complete. Medial meniscal status was categorized as intact, posterior root rupture, anterior root rupture, bucket-handle tear, or combined bucket-handle and root lesions. Lateral meniscal status was classified as intact, posterior root rupture, anterior root rupture, or discoid meniscal lesion.

Intraoperative assessment was based on documentation recorded in the operative theatre and routinely reviewed and approved by the most senior surgeon involved in the procedure. The surgeon had access to the MRI scans before the operation. The ICRS Grading System was again used to evaluate the severity of cartilage damage. The documentation of meniscal injuries was conducted in accordance with their anatomical location and the tear pattern, as determined by direct visualization and probing. In a similar manner, the ACL integrity was evaluated using a probe and subsequently categorized as intact, partially torn, or completely ruptured.

Statistical Analysis

The statistical analyses were performed using IBM® Statistical Package for the Social Sciences (SPSS) for Windows, version 26.0 (Armonk, NY: IBM Corp., USA). The Kolmogorov-Smirnov test was used to analyze whether the continuous data were normally distributed or skewed. Skewed continuous data were expressed as medians, interquartile ranges, and minimum-maximum values, while categorical data were presented as frequencies and percentages. To evaluate the reliability of the MRI and arthroscopic findings, Cohen's kappa coefficient was used. A *P* value less than 0.05 was considered statistically significant. The strength of the correlation coefficient (κ) was classified as follows: very weak (0.00-0.25), weak (0.26-0.49), moderate (0.50-0.69), strong (0.70-0.89), or very strong (0.90-1.00). Negative correlations were indicated by r values ($r < 0$).

RESULTS

The mean age of the 203 patients (77 females, 126 males) was 42 ± 12.87 years. The ACL was intact on MRI in 141 patients (69.5%); partial ACL rupture was predicted in 17 patients (8.4%) and complete ACL rupture was predicted in 45 patients (22.2%). Perioperatively, the ACL was found to be intact in 141 patients (69.5%), while partial rupture was observed in 15 patients (7.4%) and complete rupture was observed in 47 patients (23.2%). The demographic data and radiological characteristics of the patients are set out in Table 1, while operative characteristics are presented in Table 2.

A reliability analysis was conducted to assess the agreement between MRI and intraoperative findings. The MRI operation reliability was strong for ACL ruptures (κ = 0.75, $P < 0.001$) and moderate for medial meniscopathy (κ = 0.60, $P < 0.001$). However, reliability was weak to very weak for lateral meniscal tears and chondral lesions (κ < 0.49, $P < 0.05$ for each). The reliability between MRI findings and operative findings regarding the presence of plica and lateral femoral condyle cartilage lesion was not statistically significant (κ = 0.01, $P = 0.771$ and κ = 0.03, $P = 0.644$, respectively) (Table 3).

Table 1. Demographic Data and Radiological Characteristics of the Patients

		Number of patients (%)
Age	42 ± 12.87 (16-68)	
Gender	Female	77 (37.9%)
	Male	126 (62.1%)
Side	Right	106 (52.2%)
	Left	97 (47.8%)
Anterior cruciate ligament	Intact	141 (69.5%)
	Partial Rupture	17 (8.4%)
	Complete Rupture	45 (22.2%)
Medial meniscus	Intact	65 (32%)
	Posterior horn rupture	121 (59.6%)
	Anterior horn rupture	7 (3.4%)
	Bucket handle rupture	8 (3.9%)
	Bucket handle + root lesion	2 (1%)
Lateral meniscus	Intact	162 (79.8%)
	Posterior horn rupture	17 (8.4%)
	Anterior horn rupture	9 (4.4%)
	Bucket handle rupture	5 (2.5%)
	Discoid	10 (4.9%)
Medial femoral condyle cartilage lesion	Intact	161 (79.3%)
	Grade 1-2	2 (1%)
	Grade 3-4	40 (19.7%)
Lateral condyle cartilage lesion	Intact	194 (95.6%)
	Grade 1-2	1 (0.5%)
	Grade 3-4	8 (3.9%)
Medial tibial plateau cartilage lesion	Intact	179 (88.2%)
	Grade 1-2	0
	Grade 3-4	24 (11.8%)
Lateral tibial plateau cartilage lesion	Intact	202 (99.5%)
	Grade 1-2	0
	Grade 3-4	1 (0.5%)
Patellar cartilage lesion	Intact	145 (71.4%)
	Grade 1-2	22 (10.8%)
	Grade 3-4	36 (17.7%)
Plica existence	None	123 (60.6%)
	Notch	1 (0.5%)
	Suprapatellar	47 (23.2%)
	Medial	32 (15.8%)

Table 2. Operative Characteristics of the Patients

		Number of patients (%)
Anterior cruciate ligament	Intact	141 (69.5%)
	Partial rupture	15 (7.4%)
	Complete rupture	47 (23.2%)
Medial meniscus	Intact	70 (34.5%)
	Posterior horn rupture	105 (51.7%)
	Anterior horn rupture	11 (5.4%)
	Bucket handle rupture	12 (5.9%)
	Bucket handle + root lesion	5 (2.5%)
Lateral meniscus	Intact	143 (70.4%)
	Posterior horn rupture	30 (14.8%)
	Anterior horn rupture	12 (5.9%)
	Bucket handle rupture	3 (1.5%)
	Discoid	15 (7.4%)
Medial femoral condyle cartilage lesion	Intact	89 (43.8%)
	Grade 1-2	27 (13.3%)
	Grade 3-4	87 (42.9%)
Lateral condyle cartilage lesion	Intact	186 (91.6%)
	Grade 1-2	3 (1.5%)
	Grade 3-4	14 (6.9%)
Medial tibial plateau cartilage lesion	Intact	176 (86.7%)
	Grade 1-2	10 (4.9%)
	Grade 3-4	17 (8.4%)
Lateral tibial plateau cartilage lesion	Intact	194 (95.6%)
	Grade 1-2	2 (1%)
	Grade 3-4	7 (3.4%)
Patellar cartilage lesion	Intact	129 (63.5%)
	Grade 1-2	30 (14.8%)
	Grade 3-4	44 (21.7%)
Plica existence	None	146 (71.9%)
	Notch	40 (19.7%)
	Suprapatellar	7 (3.4%)
	Medial	10 (4.9%)

Table 3. Comparison of the Reliability of Radiological and Perioperative Observation

	Reliability		
	κ	*P*	Level of agreement
Anterior cruciate ligament	0.75	**< 0.001**	Strong
Medial meniscus	0.60	**< 0.001**	Moderate
Lateral meniscus	0.35	**< 0.001**	Weak
Medial femoral condyle cartilage lesion	0.32	**< 0.001**	Weak
Lateral femoral condyle cartilage lesion	0.03	0.644	None
Medial tibial plateau cartilage lesion	0.32	**< 0.001**	Weak
Lateral tibial plateau cartilage lesion	0.2	**< 0.001**	Very weak
Patellar cartilage lesion	0.27	**< 0.001**	Weak
Plica existence	0.01	0.771	None

κ, *P*, and level of agreement were calculated using Cohen's Kappa Variable.

DISCUSSION

MRI is a non-invasive procedure; arthroscopy is an invasive technique. Consequently, radiological imaging, in conjunction with physical examination, is considered an integral component of preoperative evaluation. While other studies have highlighted the validity of MRI for diagnosing knee lesions, our analysis focused on its reliability compared with arthroscopy and found it to be limited for identifying specific clinically important findings. In the present study, it was also observed that certain critical findings may be overlooked on MRI. While MRI findings were inconsistent with arthroscopic findings in cases of lateral femoral condyle lesions and the presence of plica (both potential causes of chronic knee pain), there was a high level of concordance between MRI and arthroscopy in detecting medial meniscus pathologies and ACL injuries.

MRI showed a strong correlation with intraoperative findings for ACL rupture (κ = 0.75, $P < 0.001$) and a moderate correlation for medial meniscopathy (κ = 0.60, $P < 0.001$). The strong correlation between MRI and arthroscopic findings in ACL and medial meniscal pathologies may be explained by well-defined imaging criteria, high anatomical visibility and biomechanical vulnerability of these structures. Numerous studies in the literature have also emphasized the adequacy of MRI for diagnosing ACL ruptures and medial meniscus tears.[18,20,21]

In the present study, arthroscopic evaluation revealed lateral femoral condyle cartilage damage classified as grade 1-2 in 3 patients (1.5%) and grade 3-4 in 14 patients (6.9%). However, MRI detected such lesions in only one patient (0.5%) with grades 1-2 and in eight patients (3.9%) with grades 3-4, suggesting a limitation in radiological detection. Consistent with our findings, Vaz et al.[21] reported that MRI is a satisfactory diagnostic tool for evaluating meniscal and ligamentous lesions of the knee; however, it does not clearly identify articular cartilage lesions. Von Engelhardt et al.[22] furthermore highlighted that the positive predictive value was low for all grades of articular cartilage lesions. In a separate study, Figueroa et al.[23] demonstrated that a significant proportion of cartilage lesions remained undetected at arthroscopy. Porter and Shadbolt[24] demonstrated that MRI exhibited a relatively poor correlation with arthroscopic grading of cartilage damage. In the study by Schnaiter et al.[25], the medial femoral joint surface was accurately evaluated in 81% of cases; 15% were overestimated and 4% were underestimated. With regard to the lateral cartilage,

classification was correct in 73% of cases, while 21% were overestimated and 6% were underestimated. An examination of the rationale underlying this relationship suggests that cartilage damage may have been exacerbated between the imaging procedure and the arthroscopy. Consequently, a lesion that is not visible on an initial MRI may become more apparent during arthroscopy. Furthermore, low-grade cartilage lesions are often superficial and may not produce significant signal changes on MRI, making them difficult to detect. Anatomically, the lateral femoral condyle exhibits a more convex and more inclined surface morphology than the medial condyle. This observation complicates full-thickness, perpendicular visualization of cartilage with conventional MRI sequences.

In our study, as shown in Tables 1 and 2, MRI demonstrated lower diagnostic reliability for lateral meniscal injuries compared with arthroscopic findings. Similarly, Esmaili Jah et al.[26] reported that the correlation between MRI and arthroscopy for lateral meniscus pathology was the weakest. Ben-Galim et al.[10] also reported similar findings, noting that the sensitivity of MRI differs between the medial and lateral menisci. As a result, lateral meniscal tears are often underdiagnosed, whereas medial tears tend to be overdiagnosed. Furthermore, Blake et al.[27] reported that MRI evaluation of the lateral meniscus is less sensitive, which may lead to diagnostic errors, including false-negative results. Therefore, the use of confirmatory arthroscopy may be beneficial. In our study, MRI findings did not correlate with arthroscopy findings regarding the presence of plicae. Plica findings were routinely evaluated in the initial MRI reports; no re-evaluation was performed as part of this study.

Study Limitations

The major strength of this study is its systematic assessment of multiple intra-articular structures of the knee, including the often-overlooked medial plica, by correlating MRI and arthroscopic findings. However, this study has several limitations, including its retrospective design, limited sample size, the fact that not all MRIs were evaluated by a single radiologist within a similar time frame, and the lack of standardized MRI-to-injury time intervals. Moreover, the primary surgeon's review of the preoperative MRI images for all patients may have introduced bias. However, preoperative evaluation of all imaging studies is an integral part of routine clinical practice, as it is essential for patient safety and successful surgical planning. Prospective randomized studies could help obtain results independent of this potential source of bias.

CONCLUSION

In conclusion, this study demonstrated that, while MRI remains a non-invasive and valuable diagnostic tool for assessing intra-articular knee lesions, its diagnostic reliability varies significantly depending on the structure being evaluated. Although MRI showed moderate-to-strong correlation with arthroscopic findings in ACL and medial meniscal injuries, MRI findings correlated poorly with arthroscopic findings in identifying lateral femoral condyle damage, lateral meniscal injuries, and medial plica. These findings emphasize that although MRI remains an essential non-invasive imaging tool, it should not be relied upon solely in cases of persistent or unexplained knee pain. Therefore, an integrated approach encompassing MRI evaluation alongside physical examination is recommended. Arthroscopy is considered the gold standard for definitive diagnosis of intra-articular knee lesions.

Ethics

Ethics Committee Approval: Ankara Bilkent City Hospital Clinical Research Ethics Committee decision number: E1-22-3070, date: 30.11.2022.

Informed Consent: Written and verbal informed consent were obtained from all patients for their data to be used in scientific research.

Footnotes

Author Contributions

Concept Design – İ.S.D., T.B.Y., B.G., Ö.D.; Data Collection or Processing – İ.S.D., T.B.Y., B.G., Ö.D.; Analysis or Interpretation – İ.S.D., Ö.D.; Literature Review –İ.S.D., T.B.Y., B.G., Ö.D.; Writing, Reviewing and Editing – İ.S.D., T.B.Y., B.G., Ö.D.

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