



# A Comparison Study of Findings in Magnetic Resonance Imaging of the Knee Versus Arthroscopic Surgery

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## Abstract

**Purpose:** Arthroscopy and Magnetic Resonance Imaging (MRI) are frequently used diagnostic modalities in knee pain cases. Arthroscopic surgery, while invasive, is considered the gold standard, while MRI is non-invasive imaging that has gained popularity over several decades; it is typically considered the first-choice imaging modality.<sup>[1]</sup> This study compares the diagnostic performance of MRI and arthroscopy in knee injury assessment, and aims to provide valuable clinical practice recommendations.

**Methods:** This is a retrospective cohort study examining patients over 18 years old, who underwent knee MRI and arthroscopy between 2017 and 2022. We focused on pathologies of 3 structures– the Anterior Cruciate Ligament (ACL), medial meniscus, and lateral meniscus.<sup>[2]</sup> Results were gathered from arthroscopic records and perioperative MRI results, A division of the population into two groups was made, those with or without a mismatch result (false negative or false positive), in order to assess risk factors for MRI misdiagnosis using univariate tests and a multivariable logistic regression model.

**Results:** The accuracy of MRI compared to arthroscopy for ACL, medial meniscus, and lateral meniscus injuries were 96%, 84%, 71% respectively; sensitivity was 98%, 93%, 67%; specificity was 99%, 95%, 98%; positive predictive value 96%, 98%, 92%; and negative predictive value 100%, 84%, 89%. In the multivariable regression model, the number of findings on physical examination was significantly associated with a lower risk of false positive or false negative results in MRI (OR=0.34, 95%CI: 0.15-0.79, P-value = 0.01), adjusted to age and sex.

**Conclusion:** The findings suggest that arthroscopy may be needed more frequently for evaluation of suspected lateral meniscus injuries, and that a comprehensive physical examination plays a crucial role in reducing MRI misdiagnosis. Further studies are necessary in order to provide clear guidelines on the appropriate use of MRI, arthroscopy, or a combination of both for the diagnosis of knee injuries.

**Keywords:** Anterior Cruciate Ligament; Arthroscopy; Gold Standard; Knee Injuries; Meniscus; MRI; Physical Examination

## Introduction

The knee is a complex joint that is highly susceptible to injury, due to its large articulating surface and complex soft tissue component structures. Knee pain can result from various causes, including musculoskeletal injury from acute trauma, overuse, or a combination of these factors, especially in athletes and physically active adults [1]. The differential diagnosis of knee pain can be challenging, and often requires a practical approach that combines the patient's history, major symptoms, and special tests, such as Thessaly's, McMurray's, Apley's, drawer test, and others. These tests may help in the diagnostic procedure for the source of knee pain and evaluation of joint stability and function [2]. In addition to physical examination and testing, arthroscopy and MRI are common procedures used to complete the investigation of knee pain and determination of appropriate care [3]. Arthroscopy is considered the gold standard for diagnosing traumatic intra-articular lesions [4] and is performed by an orthopedic surgeon under general or spinal anesthesia. During the procedure, different compartments of the knee are examined, including the patellofemoral joint, medial gutter, suprapatellar pouch, medial compartment, intercondylar notch, posteromedial compartment, lateral compartment, lateral gutter, and posterolateral compartment [5]. However, arthroscopy is an invasive procedure that requires hospitalization and anesthesia and is associated with potential complications. In contrast, MRI is a non-invasive, radiation-free imaging modality that provides detailed visualization of knee injuries and surrounding soft tissue [6]. Although MRI is a technically advanced scanning method, images can be challenging to interpret and are dependent on interpreter experience. The diagnostic yield of MRI can be improved with proper use of sequences and appropriate analysis of images in all planes. With its high level of certainty, virtually all ligamentous and meniscal injuries can be diagnosed using MRI [6]. The purpose of this study is to compare the diagnostic performance of clinical MRI reports, both hospital reports and community reports, for the assessment of knee injuries with arthroscopy findings. Based on the results of our study, we will be able to provide valuable recommendations and guidelines for clinical practice, determining the most appropriate approach in terms of utilizing MRI alone, combining it with arthroscopy, or proceeding directly with arthroscopy, in the diagnosis and assessment of knee injuries [7,8].

## Methods

### Study Design

The study is a retrospective cohort study, conducted between 2017-2022. Our institutional Helsinki review board approved the

study, informed consent was not required; the data were extracted from the institutional database and kept anonymized and encoded.

### Study Population

Patients above the age of 18 years, who underwent an MRI and arthroscopy of the knee during the study years were included in the study. We excluded patients who underwent a previous arthroscopy or knee surgery and patients with limited data.

### Data Collection

Electronic medical records of the patients were manually reviewed from the "Camelion" program for demographic and medical characteristics, injury classification, findings in physical examination, MRI finding, arthroscopy findings and arthroscopic procedures. We focused on 3 constructs of the knee – Anterior Cruciate Ligament (ACL), medial meniscus and lateral meniscus. Demographic and medical characteristics included age, sex, weight, and sports prior the injury. Injury classification included the mechanism (direct/fall/rotational), physical examination including presence of effusion, anterior and posterior draw tests, McMurray's, Apley's and the total number of positive findings in the examination. The MRI findings included complete/partial/nonspecific ruptures of the ACL tendon, bucket handle/longitudinal/radial/transverse ruptures for the medial and lateral meniscuses. Arthroscopy findings included the same as MRI's findings. Arthroscopy procedures included reconstruction of the ACL tendon, meniscal debridement, and meniscal repair.

### Outcomes

Arthroscopy was defined as the gold standard. We compared the findings in the MRI test to findings at arthroscopy. We further defined a misdiagnosis (false positive or negative) as a primary outcome.

### Statistical Analysis

The calculation of the diagnostic performance measures was based on the comparison of the results obtained from MRI and arthroscopy. Arthroscopy was considered the gold standard for the evaluation of knee injuries. The following diagnostic performance measures were calculated: True Positive (TP), True Negative (TN), False Positive (FP), False Negative (FN), Positive Predictive Value (PPV), Negative Predictive Value (NPV), sensitivity, specificity, accuracy, and kappa. To calculate TP, the number of patients who had a positive result on both MRI and arthroscopy was counted. TN was calculated as the number of patients who had a negative result on both MRI and arthroscopy. FP was determined by counting the number of patients who had a positive result on MRI but a negative result on arthroscopy. FN was calculated as the number

of patients who had a negative result on MRI but a positive result on arthroscopy. PPV was calculated as TP divided by the sum of TP and FP. NPV was calculated as TN divided by the sum of TN and FN. Sensitivity was determined as TP divided by the sum of TP and FN, while specificity was calculated as TN divided by the sum of TN and FP. Accuracy was determined as the sum of TP and TN divided by the total number of patients. Finally, Kappa was calculated as (Observed Accuracy - Expected Accuracy) / (1 - Expected Accuracy), representing the degree of agreement between MRI and arthroscopy results beyond what would be expected by chance. We presented categorical covariates by their frequencies and percentages, parametric variables by their means ± Standard Deviations (SD) and quantitative nonparametric variables by their medians and Interquartile Range (IQR). We further divided the population into two groups: those with a misdiagnosis on MRI (FN or FP) vs. those without, to assess risk factors for a misdiagnosis on MRI. We used the Chi square test for the categorical variables, unpaired T-test for the parametric variables and Mhan Whitney test for the quantitative nonparametric covariates and assessed the demographic and medical characteristics along with the injury data, physical examination findings and time from complaints to MRI. We further performed univariable and multivariable logistic regression models to check for a misdiagnosis in MRI as the dependent variable and other risk factors variables as independent covariates. Risk factors in the multivariable regression were selected according to the literature, clinical considerations, and the univariate analysis. The regressions' results were presented by the Odds Ratios (ORs), 95% confidence intervals (95%CI) and

p-values. All statistical analyses were performed using Rstudio software version 4.1.2, and results were considered significant when p-value<0.05.

## Results

The study included 304 patients who underwent MRI and arthroscopy for knee complaints. The majority of the patients were male (204, 68.8%) and had an average age of 45.87 years (SD 14.79). Nearly one quarter of the patients (73, 24.3%) had a positive Appley test result, while 221 patients (72.4%) had a positive McMurray test result. The median time from initial complaint to MRI was 6 months (IQR 3-24). MRI findings revealed that 258 patients (83.9%) had normal ACLs, while 44 patients (14.5%) had complete ruptures, and 5 patients (1.6%) had partial ruptures. For the medial meniscus, 171 patients (56.6%) had injuries, and 96 patients (31.9%) were normal. For the lateral meniscus, 242 patients (79.9%) were normal, and 47 patients (15.8%) had injuries. Arthroscopy findings showed that 257 patients (84.2%) had normal ACLs, while 44 patients (14.5%) had complete ruptures, and 4 patients (1.3%) had partial ruptures. For the medial meniscus, 198 patients (65.8%) had ruptures, and 85 patients (28.0%) were normal. For the lateral meniscus, 220 patients (72.7%) were normal, and 71 patients (23.4%) had ruptures. In terms of arthroscopy procedures, 40 patients (13.2%) underwent ACL reconstruction, while 202 patients (66.4%) underwent medial meniscus debridement/repair, and 74 patients (24.3%) underwent lateral meniscus debridement/repair (Table 1).

Overall		
	N	304
Demographic	Age (mean (SD))	45.87 (14.79)
	Sex (%)	
	Female	93 (30.6)
	Male	209 (68.8)
	Weight (mean (SD))	83.01 (15.96)
	Sports (%)	27 (9.2)
	Sports type (%)	
	Not mentioned	2 (0.7)
	Running	1 (0.3)
	Soccer	21 (6.9)

Injury	Injury mechanism (%)	
	Direct injury	55 (18.1)
	Fall from height	9 (3.0)
	No injury	172 (56.6)
	Rotational injury	55 (18.1)
Physical examination	Effusion in physical exam (%)	7 (2.3)
	Anterior drawer test (%)	26 (8.6)
	Posterior drawer test (%)	3 (1.0)
	McMurray (%)	220 (72.4)
	Appley (%)	74 (24.3)
	Number of findings in physical exam (%)	
	0	50 (16.4)
	1	253 (83.2)
	2	1 (0.3)
MRI findings	Number of months from complaint to MRI (median [IQR])	6.00 [3.00, 24.00]
	ACL in MRI (%)	
	Complete rupture	44 (14.5)
	Normal	255 (83.9)
	Partial rupture	5 (1.6)
	Medial meniscus MRI (%)	
	Bucket handle rupture	14 (4.6)
	Longitudinal rupture	6 (2.0)
	Normal	97 (31.9)
	Radial rupture	15 (4.9)
	Rupture	172 (56.6)
	Lateral meniscus MRI (%)	
	Bucket handle rupture	4 (1.3)
	Longitudinal rupture	2 (0.7)
	Normal	243 (79.9)
	Radial rupture	7 (2.3)
	Rupture	48 (15.8)

Arthroscopy findings	ACL arthroscopy (%)	
	Complete rupture	44 (14.5)
	Normal	256 (84.2)
	Partial rupture	4 (1.3)
	Medial meniscus arthroscopy (%)	
	Bucket handle rupture	14 (4.6)
	Longitudinal rupture	3 (1.0)
	Normal	85 (28.0)
	Rupture	200 (65.8)
	Transverse rupture	2 (0.7)
	Lateral meniscus arthroscopy (%)	
	Bucket handle rupture	8 (2.6)
	Normal	221 (72.7)
	Radial rupture	1 (0.3)
	Rupture	71 (23.4)
	Transverse rupture	3 (1.0)
Arthroscopy procedures	ACL reconstruction procedure in arthroscopy (%)	40 (13.2)
	Medial arthroscopy procedure in arthroscopy (%)	
	Debridement	202 (66.4)
	No procedure	93 (30.6)
	Stitching	9 (3.0)
	Lateral arthroscopy procedure in arthroscopy (%)	
	Debridement	74 (24.3)
	No procedure	218 (71.7)
	Stitching	12 (3.9)

**Table 1:** patient characteristics.

(Table 2) reports the performance of MRI and arthroscopy in assessing pathologies of the ACL and meniscus tendons. The results show that MRI had a high accuracy, with a sensitivity of 0.98 and a specificity of 0.99 for the ACL, resulting in a positive predictive value of 0.96 and a negative predictive value of 1.00. The accuracy for the ACL was 99%. For the medial meniscus, the sensitivity was 0.93 and the specificity was 0.95 with a positive predictive value of 0.98 and a negative predictive value of 0.84; the accuracy for the medial meniscus was 93%. For the lateral meniscus, the sensitivity was 0.67 and the specificity was 0.98, with a positive predictive value of 0.92 and a negative predictive value of 0.89. The accuracy for the lateral meniscus was 89%.

	True positive	True negative	False positive	False negative	Positive predictive value	Negative predictive value	Sensitivity	Specificity	Accuracy	Kappa
ACL	47	254	2	1	0.96	1	0.98	0.99	0.99	0.96
Medial meniscus	203	81	4	16	0.98	0.84	0.93	0.95	0.93	0.84
Lateral meniscus	56	216	5	27	0.92	0.89	0.67	0.98	0.89	0.71

**Table 2:** performance of MRI vs. arthroscopy for assessing pathologies of the ACL and meniscus tendons.

(Table 3) compares patients with a false positive or false negative diagnosis to those with a true negative and true positive diagnosis using demographic information, injury information, physical examination results, and time between complaint and MRI. Demographic information such as age, sex, and weight demonstrated no significant differences between the two groups (p-values 0.184, 0.186, and 0.139, respectively). The same was found for sports type and sports participation frequency (p-value 0.687 and 0.943, respectively). The injury mechanism also showed no significant differences between the two groups (p-value 0.127). In the physical examination, there were no significant differences between the two groups for effusion in physical examination (p-value 0.768) or results from the anterior drawer test (p-value 1.0). However, there was a significant difference in the number of findings in physical examination, with 11 out of 32 (34.4%) of the FP or FN group having 0 findings compared to only 39 out of 272 (14.3%) of the TN and TP group (p-value 0.015). Additionally, there was a significant difference in the results of the McMurray test, with 16 out of 32 (50%) of the FP or FN group showing a positive result compared to 204 out of 272 (75%) of the TN and TP group (p-value 0.005). The median time between complaint and MRI was also significantly different, with the FP or FN group having a median of 12 months compared to 6 months for the TN and TP group (P-value 0.02).

		TN and TP	FP or FN	P-value
	n	272	32	
Demographic	Age (mean (SD))	45.48 (14.73)	49.16 (15.04)	0.184
	Sex (%)			0.186
	Female	83 (30.5)	10 (31.2)	
	Male	188 (69.1)	21 (65.6)	
	Weight (mean (SD))	82.55 (15.63)	87.17 (18.53)	0.139
	Sports (%)	0.09 (0.29)	0.07 (0.26)	0.687
	Sports type (%)			0.943
	Not mentioned	2 (0.7)	0 (0.0)	
	Running	1 (0.4)	0 (0.0)	
	Soccer	19 (7.0)	2 (6.2)	

Injury	Injury mechanism (%)			0.127
	Direct injury	49 (18.0)	6 (18.8)	
	Fall from height	8 (2.9)	1 (3.1)	
	No injury	154 (56.6)	18 (56.2)	
	Rotational injury	52 (19.1)	3 (9.4)	
P h y s i c a l examination	Effusion in physical exam (%)	7 (2.6)	0 (0.0)	0.768
	Anterior drawer test (%)	23 (8.5)	3 (9.4)	1
	Posterior drawer test (%)	3 (1.1)	0 (0.0)	1
	McMurray (%)	204 (75.0)	16 (50.0)	0.005
	Appley (%)	67 (24.6)	7 (21.9)	0.9
	Number of findings in physical exam (%)			0.015
	0	39 (14.3)	11 (34.4)	
	1	232 (85.3)	21 (65.6)	
	2	1 (0.4)	0 (0.0)	
MRI findings	Number of months from complaint to MRI (median [IQR])	6.00 [3.00, 24.00]	12.00 [6.00, 27.00]	0.02

**Table 3:** comparison between patient with a FP or FN vs. patient with TN and TP.

The results of the univariable and multivariable logistic regression analyses are presented in (Table 4). In the univariable logistic regression, it was found that the positive McMurray test was significantly associated with a lower risk of false positive or false negative results in MRI (OR=0.33, 95%CI: 0.16-0.71, P-value <0.001). The number of findings in the physical examination was also found to be significantly associated with a lower risk of false positive or false negative results in MRI (OR=0.32, 95%CI: 0.15-0.73, P-value = 0.01). The other factors, such as age, male sex, weight, sports, injury mechanism, positive anterior drawer test, positive posterior drawer test, and positive Appley test, were not found to be significantly associated with the risk of false positive or false negative results in MRI. In the multivariable logistic regression, it was found that the number of findings in the physical examination was significantly associated with a lower risk of false positive or false negative results in MRI (OR=0.34, 95%CI: 0.15-0.79, P-value = 0.01), adjusted to age and sex.

		OR	95%CI	P-value
Uni variable	Age	1	1.00-1.00	0.2
	Male sex vs. female	0.93	0.43-2.14	0.85
	Weight	1.02	0.99-1.04	0.14
	Sports	0.74	0.11-2.67	0.69
	Injury mechanism fall from height vs. direct injury	1.02	0.05-7.17	0.99
	Injury mechanism no injury vs. direct injury	0.95	0.38-2.75	0.93
	Injury mechanism rotational injury vs. direct injury	0.47	0.1-1.89	0.31
	Positive anterior drawer test	1.12	0.25-3.48	0.86
	Positive posterior drawer test	0	NA-5.63	0.99
	Positive McMurray test	0.33	0.16-0.71	<0.001
	Positive Appley test	0.86	0.33-1.97	0.73
	Number of findings in physical exam	0.32	0.15-0.73	0.01
	Number of months from complaint to MRI	1.02	0.99-1.04	0.22
Multi variable	(Intercept)	0.13	0.02-0.7	0.02
	Age	1.01	0.99-1.04	0.29
	Male sex vs. female	1.01	0.44-2.42	0.99
	Number of findings in physical exam	0.34	0.15-0.79	0.01

**Table 4:** logistic regression assessing the risk for a FP or FN in MRI.

## Discussion

The study analyzed the results of MRI and arthroscopy in 304 patients with knee complaints. Overall, MRI demonstrated high accuracies: 99% for assessing ACLs, 93% for the medial meniscus, and 89% for the lateral meniscus. Arthroscopy results showed consistency with MRI findings for ACLs (84.2% normal), medial meniscus (65.8% with ruptures), and lateral meniscus (72.7% normal), with most patients undergoing debridement procedures. Multivariable logistic regression analyses found that the number of findings in physical examination was significantly associated with a lower risk of false positive or false negative results in MRI. Although it is acknowledged that MRI and arthroscopy are valuable diagnostic tools that assist medical professionals to identify and diagnose a variety of conditions, it is important to avoid their overutilization, as these tests can have significant associated wait times and costs [9,10]. On average, an MRI can cost anywhere between \$500 to \$3,000 [11], while an arthroscopy can cost between \$5,000 and \$10,000 [12]. By avoiding overuse of these tests, we can ensure that they are available when they

are truly needed, and that patients and their treating doctors receive the diagnostic information they need in a timely manner. Furthermore, this can help to reduce overall healthcare costs and make healthcare more accessible [13]. However, it is important to note that while MRI is exceptionally good at detecting the presence of knee injuries, it may not always accurately determine the extent or severity of the injury. This is where arthroscopy can be particularly useful [14]. Arthroscopy allows a direct visualization of the joint and is often used to confirm the findings from an MRI and to evaluate the extent of the injury in greater detail [15]. In general, the combination of MRI and arthroscopy provides the most comprehensive evaluation of knee injuries, allowing for an accurate diagnosis and appropriate treatment plan [16]. However, MRI may be sufficient for the evaluation of some knee injuries, particularly if the injury is straightforward and the MRI findings are clear and unequivocal. For example, in cases of a simple meniscal tear, an MRI may be enough to make the diagnosis and determine the extent of the injury [14].

In some cases, arthroscopy may be the only test needed to evaluate a knee injury, particularly if the injury is suspected to be related to the articular cartilage. Additionally, if a foreign body is suspected to be present in the joint, arthroscopy may be the best diagnostic option [17]. The choice of using MRI, arthroscopy, or a combination of the two, to diagnose knee injuries is based on the individual patient and the nature of their injury [4]. Further research is needed to establish guidelines for when MRI alone, arthroscopy alone, or a combination of both, should be used, to avoid overutilization [18]. According to our findings, reducing the number of False Positive (FP) and False Negative (FN) results can be achieved by increasing the reliability of physical examination. The results suggest that a thorough physical examination can provide valuable information and reduce the need for additional imaging tests such as MRI and arthroscopy. The results emphasize the need for proper training and experience of the orthopedic doctor performing the physical examination [19]. Regular evaluations of the physical examination techniques and ongoing education to stay up to date with the latest advancements in the field can also help to reduce the risk of FP and FN results. In general, MRI is accepted as a highly accurate and non-invasive method for detecting knee pathologies. However, the accuracy of MRI in detecting meniscal and ACL pathologies can vary, depending on the specific conditions and the criteria used for interpretation [20]. The results of our study are generally in line with what has been reported in the literature [21,22]. The reason the lateral meniscus had a lower sensitivity score may be related to its structure. It is crescent-shaped [23]. The sensitivity of MRI to visualize the lateral meniscus is lower as compared to the medial meniscus due to its thinner structure and lower contrast with surrounding tissues [22,24]. The lower signal intensity of the lateral meniscus on MRI can make it difficult to accurately assess its structural integrity, particularly in cases of injury or degeneration. However, advances in MRI technology have improved the ability to visualize the lateral meniscus, and MRI remains a valuable diagnostic tool in the evaluation of knee conditions [25].

### Limitations

The current study has certain limitations that should be considered when interpreting the results. First, the study was conducted retrospectively using a database, which may have resulted in insufficient data being available, such as the patient's BMI and the location of the injury within the meniscus. BMI could have been considered a confounder, as the presence of fat in the knee may alter the MRI findings. Additionally, the location of the injury could have been a valuable piece of information, as various locations within the meniscus may have different sensitivities on MRI. This aspect has been evaluated in previous literature, however, due to the retrospective nature of our study and insufficient available

information, we were unable to assess this factor. Furthermore, the limited sample size also prevented us from evaluating other knee structure pathologies, such as the posterior cruciate ligament (PCL), bones, and cartilage. Therefore, more studies with larger sample sizes and complete patient data are needed to provide more robust guidelines on when to use MRI alone, when to use arthroscopy alone, and when to use both, in order to reduce overuse of diagnostic procedures.

### Conclusion

Our study found that the MRI tests had a high accuracy rate of 99% for assessing ACL injuries, 93% for medial meniscus injuries, and 89% for lateral meniscus injuries. Our results also indicated that a thorough physical examination was significantly associated with a lower risk of false positive or false negative results on MRI. These findings suggest that arthroscopy may be considered for the evaluation of suspected lateral meniscus injuries even with normal MRI findings, and that a comprehensive physical examination plays a crucial role in reducing misdiagnosis in MRI results. **Level of Evidence III** [26]. However, further studies are necessary to provide clear guidelines on the appropriate use of MRI, arthroscopy, or a combination of both for the diagnosis of knee injuries.

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