

Accuracy of Magnetic Resonance Imaging in Diagnosis of Internal Derangement of the Knee

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Abstract

The current study aims to assess the sensitivity and specificity of magnetic resonance imaging by reference to arthroscopy in the pre-operative diagnosis of knee pathologies. In this retrospective study, pre-operative knee magnetic resonance imaging reports of 70 patients were reviewed by a blinded musculoskeletal radiologist and compared with the respective arthroscopic findings recorded in the operative notes. Pre-operative magnetic resonance imaging demonstrated a sensitivity level of 92.7% and 61.3% and specificity level of 33.3% and 53.9% in detecting pathologies of the medial and lateral menisci, respectively. With respect to the cases of complete anterior cruciate ligament tear, sensitivity was 76.7% with 92.5% specificity. On the other hand, magnetic resonance imaging demonstrated 100% sensitivity and 90.7% specificity in the diagnosis of posterior cruciate ligament partial tear. Relatively better sensitivity in detecting cruciate ligaments pathology and better specificity in detecting menisci pathology was reported using magnetic resonance imaging. Almost 25% of complete anterior cruciate ligament injuries may remain undetected in pre-operative magnetic resonance imaging reports, while they represent the most prevalent knee injury. Magnetic resonance imaging should be used with caution in knee pathology and arthroscopy continues to be the gold standard.

Keywords

Arthroscopy; Cruciate ligaments; Knee; Magnetic resonance imaging; Meniscus

Introduction

Musculoskeletal (MSK) imaging and in particular magnetic resonance imaging (MRI) is an important diagnostic, teaching and research tool for health care providers^[1]. In knee surgery, it has often been regarded as a promising noninvasive alternative

to diagnostic arthroscopy. Thus, clinicians prefer performing MRI scan to support the diagnosis of knee pathology, prior to recommending arthroscopic examination and the surgery. A small randomized controlled trial in the National Health Service in England suggested that conducting an MRI-based diagnosis of knee disorders might curtail the need for performing

arthroscopy. This could reduce arthroscopy rates, which in turn, improves the overall patient outcome^[2].

A systematic meta-analysis including 29 articles published between 1991 and 2000 reported that MRI is an appropriate screening tool for therapeutic arthroscopy; eliminating the need for diagnostic arthroscopy in most cases^[3].

Other observational non-randomized studies in the United Kingdom, Austria, and the United States also concluded that an MRI scan presents a more cost-effective presurgical diagnostic tool, as compared to knee arthroscopy. Owing to this, almost 25% to 50% of patients on a waiting list for surgery avoided arthroscopy by the prior use of MRI^[4].

Madhusudhan *et al.*^[5] and Ercin *et al.*^[6] found that using MRI as a routine supplement to the clinical examination is unnecessary, as thorough clinical assessment can allow the experienced surgeon to make a definite primary diagnosis. Moreover, based on a retrospective study of 288 knee arthroscopies in a community setting, Hardy *et al.*^[7] also concluded that in case of suspected meniscal pathology, MRI should be requested only when the orthopedic clinical diagnosis is ambiguous. Recently, a rampant trend has been observed in clinical practice to order MRI after clinical examination and radiographs in the diagnosis of potential knee soft tissue and articular cartilage abnormalities^[8].

Although arthroscopy is a highly sensitive and specific procedure with both diagnostic and therapeutic advantages, it is an invasive procedure and entails several potential intraoperative and postoperative complications^[9,10]. Thus, the decision to perform an arthroscopy warrants the need of a risk-benefit analysis on a case-to-case basis. The current study was conceptualized to assess the diagnostic value of pre-operative MRI in internal knee derangement, and whether it can be reliably used to screen for or rule out knee lesions. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of pre-operative MRI were analyzed, by reference to arthroscopy in the diagnosis of different interior knee lesions, with focus on tears of the menisci and cruciate ligaments.

Methods

Ethical approval for the current study was obtained from the Biomedical Ethics Committee (No. 888-12)

at King Abdulaziz University Hospital (KAUH), Jeddah, Saudi Arabia. Patients who had undergone an MRI examination of the knee in KAUH and subsequent arthroscopy, during an 8-year period from May 11, 2004 to March 11, 2012, were included in the study. A retrospective search of the hospital database was conducted, identifying 70 patients who fulfilled the inclusion criterion.

Magnetic resonance images were obtained with a dedicated knee coil at either 1.5 T (MAGNETOM Symphony Tim, Siemens Medical Systems, Erlangen, Germany) or with 3T MRI system (MAGNETOM Verio, Siemens Medical Systems, Erlangen, Germany) with a standard protocol.

After data collection, a blinded radiologist with interest in musculoskeletal radiology examined and analyzed the reports of all MRI scans that were performed prior to knee arthroscopy (average duration between the MRI and the arthroscopy was eight months). The criteria used to define a cruciate ligament tear were discontinuity, abnormal signal intensity, and indistinct margins of the ligament. The diagnostic criterion for meniscal tear was abnormal signal intensity within the meniscus that extended to the meniscal articular surface or abnormal morphology of the meniscus^[11].

Arthroscopic findings were extracted from the operative notes of the 70 patients by using the hospital information system.

In this study, meniscal tear was considered as one group and compared against the degenerative and the normal menisci. In addition, the complete anterior cruciate ligament (ACL) tear was considered as one group compared against the normal and partially torn ACLs.

Data was entered and analyzed using the Statistical Package for Social Sciences version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) of MRI in the diagnosis of cruciate ligaments (anterior and posterior) and menisci (medial and lateral) tears were analyzed by comparison with knee arthroscopy results, the gold standard. Sensitivity and specificity were measured as the proportion of actual positive and negative findings that were correctly identified, respectively. Sensitivity was calculated as the number of true positives divided

by the number of cases that had positive arthroscopy; and specificity as the number of true negatives divided by the number of cases that had negative arthroscopy. Positive predictive value (PPV) was calculated as the proportion of patients with positive test results (positive MRI) who were correctly diagnosed (positive arthroscopy); and negative predictive value (NPV) as the proportion of patients with negative test results (negative MRI) who were correctly diagnosed (negative arthroscopy). Accuracy was measured as the percentage of patients in whom MRI scans revealed correct findings, which included both true positive and true negative results.

Results

A total of 70 patients with mean (SD) age of 39.26(16.81) years, who were suspected to have either meniscus or ligament injury were included in the study.

Anterior Cruciate Ligament (ACL) Tear

There were 30 (42.86%) cases diagnosed as complete ACL tear with arthroscopy, and no case of partial ACL tear. In MRI, 26 knees were classified as complete tear and 8 as partial tears. Consequently, MRI helped detecting ACL tear (partial or complete) with 86.7% (95% CI = 69.3%; 96.2%) sensitivity, 80.0% (64.4; 91.0%) specificity, 76.5% (63.3; 86.0%) PPV and 88.9% (76.0;

95.3%) NPV. Regarding detection of complete ACL tear (versus no complete tear), MRI was less sensitive and more specific; sensitivity = 76.7% (57.7; 90.1%); specificity = 92.5% (79.6; 98.4%) (Table 1).

Posterior Cruciate Ligament (PCL) Tear

Posterior cruciate ligament tear was diagnosed in 27 (38.57%) cases, in arthroscopy; all being correctly detected as such in MRI, while 4 others were falsely detected as PCL tear. Consequently, MRI helped diagnosing PCL tear with 100% sensitivity (87.2; 100.0%), 90.7% (77.9; 98.4%) specificity; 87.1% (72.6; 94.5%) PPV, and 100.0% NPV (Table 2).

Medial Meniscal (MM) Tear

Medial meniscal tear was diagnosed in arthroscopy in 55 (78.57%) cases, of which 51 were correctly detected in MRI. Thus, MRI helped diagnosing MM tear with 92.7% (82.41; 98.0%) sensitivity, 33.3% (11.8; 61.6%) specificity, 83.6% (78.0; 88.0%) PPV, 55.6% (27.7; 80.3%) NPV, and 80.0% accuracy (Table 3).

Lateral Meniscal (LM) Tear

A total of 31 (44.29%) patients had lateral meniscus (LM) tear, of which only 19 were correctly identified and 18 were falsely identified as LM tear in MRI. Thus, MRI

Table 1. Diagnostic value of magnetic resonance imaging in anterior cruciate ligament tear.

Parameter	Partial or Complete ACL Tear		Complete ACL Tear	
	Value	95%CI	Value	95%CI
Sensitivity	86.67%	69.28% to 96.24%	76.67%	57.72% to 90.07%
Specificity	80.00 %	64.35% to 90.95%	92.50%	79.61% to 98.43%
Positive Likelihood Ratio	4.33	2.30 to 8.18	10.22	3.38 to 30.90
Negative Likelihood Ratio	0.17	0.07 to 0.42	0.25	0.13 to 0.49
Accuracy	82.85%	-	85.71%	-
Positive Predictive Value	76.47%	63.25% to 85.99%	88.46%	71.72 to 95.86%
Negative Predictive Value	88.89%	76.02% to 95.28%	84.09%	73.31 to 91.05%

ACL: Anterior Cruciate Ligament; CI: Confidence interval

Table 2. Diagnostic value of magnetic resonance imaging in posterior cruciate ligament tear.

Parameter	Value	95% CI
Sensitivity	100.00%	87.23% to 100.00%
Specificity	90.70%	77.86% to 97.41%
Positive Likelihood Ratio	4.33	2.30 to 8.18
Negative Likelihood Ratio	0.17	0.07 to 0.42
Accuracy	89.9%	-
Positive Predictive Value	87.10%	72.64% to 94.49%
Negative Predictive Value	100.00%	-

CI: Confidence interval

Table 3. Diagnostic value of magnetic resonance imaging in medical meniscus tear.

Parameter	Value	95% CI
Sensitivity	92.73%	82.41% to 97.98%
Specificity	33.33 %	11.82% to 61.62%
Positive Likelihood Ratio	1.39	0.97 to 2.00
Negative Likelihood Ratio	0.22	0.07 to 0.71
Accuracy	80.00%	-
Positive Predictive Value	83.61%	77.97% to 88.02%
Negative Predictive Value	55.56 %	27.66% to 80.34%

CI: Confidence interval

Table 3. Diagnostic value of magnetic resonance imaging in medical meniscus tear.

Parameter	Value	95% CI
Sensitivity	61.29%	42.19% to 78.15%
Specificity	53.85 %	37.18% to 69.91%
Positive Likelihood Ratio	1.33	0.86 to 2.06
Negative Likelihood Ratio	0.72	0.42 to 1.22
Accuracy	57.14%	-
Positive Predictive Value	51.35%	40.48% to 62.10%
Negative Predictive Value	63.64%	50.75% to 74.83%

CI: Confidence interval

had 61.3% (42.2; 78.2%) sensitivity, 53.9% (37.2; 69.9%) specificity, 51.4% (40.5; 62.1%) PPV and 63.6% (50.8; 74.8%) NPV in diagnosing LM tear, with 57.1% accuracy (Table 4).

Medial and Lateral Collateral Ligaments (MCL and LCL) tear

Among the 70 cases, only one case of MCL tear was diagnosed in arthroscopy, which was also detected in MRI in addition to another false positive. No case of LCL tear was diagnosed.

Discussion

The knee was the first joint to be examined with arthroscopy in 1919^[11], while the first MRI scan of the knee was performed in 1985. The current retrospective study was focused on tears of the menisci and cruciate ligaments. In this study, MRI had relatively low sensitivity, especially in meniscus pathology (61.3% to 92.7%); and low specificity, especially in cruciate ligaments pathology (33.3% and 53.9%). These results are inferior to most of previous studies. In a meta-analysis, which comprised of a review of 29 articles evaluating diagnostic performance of MRI of the menisci and cruciate ligaments, Oei *et al.*^[3] found a pooled weighted sensitivity and specificity of about 93% and 88%, respectively for medial meniscus tears;

about 79% and 96% for lateral meniscus tears and about 94% and 94% for ACL tear. In this study, an inferior diagnostic performance of MRI may be attributable to a different patient population, different lesions types, pulse sequences used, study design criteria and lack of experienced radiologists to interpret the results. It is believed that the experience level of the radiologist and their expertise is one of the most important factors in maximizing MRI accuracy^[8].

The current study demonstrated a higher accuracy of the MRI technique in detecting cruciate ligaments tears than in meniscal tears. Anterior cruciate ligament is one of the most frequently encountered knee ligament injuries. In the United States, there are about 175,000 ACL reconstructions done yearly, while in France 15,000 ACL tears occur per year^[12]. Therefore, accuracy of the radiological report is a crucial factor in the management of ACL as it impacts the clinical and surgical decision, which conditions knee functional outcomes and may expose to medico-legal issues. In other words, relying on the radiological report for surgery may result in unnecessary procedures in case of false positive imaging finding, which carries additional risks for the knee^[13]. Considering these risks, orthopedists and surgeons are urged to combine radiological findings with scrupulous clinical examination to improve preoperative diagnostic accuracy and avoid unnecessary arthroscopy. In a

prospective study carried out using a 0.5T MRI machine without using a specific imaging protocol, Behairy *et al.*^[14] concluded that the arthroscopy should be done in cases where MRI report does not match with clinical findings or in cases clinically diagnosed as complete ACL tears.

The current study showed a notable difference in the sensitivity and specificity of MRI for detecting medial and lateral meniscal tears. Greater sensitivity was observed in the detection of MM tears, while specificity was relatively higher for LM tears. De Smet *et al.*^[15] found that LM tears are more likely to be missed at MRI diagnosis if the tear involves only one third of the meniscus or is limited to the posterior horn^[15]. Longitudinal tears of the posterior horn were the most commonly missed tears, as observed retrospectively. The lower sensitivity of MRI in diagnosing LM tears may also be attributable to small tear size, oblique visualization of the posterior horn, the magic angle effect and arterial pulsation artifact^[16]. In an arthroscopic study of 1086 medial meniscal tears, the posterior horn was involved in 98% of the torn medial menisci^[17]. Due to this tear distribution, De Smet^[18] believed that radiologists should be cautious in diagnosing a medial meniscus tear that does not involve the posterior horn. On the other hand, Magee and Williams^[16] have shown that the sensitivity of diagnosing meniscal tears using 3-Tesla (3-T) fast spin echo MRI with 2mm-thick cuts was 96% among a sample of 66 medial and 46 lateral meniscal tears. Hence, using thin slices with a higher signal-to-noise ratio could improve MRI-based diagnosis of meniscal tears.

Diagnostic accuracy of MRI in meniscal tears is comparable between older (50 years old and above) and younger patients when the diagnosis is exclusively based on definite MRI findings^[19]. However, the equivocal abnormalities involving the free edge of the LM should not be misdiagnosed as tears. This will help prevent unnecessary surgical procedures.

The viewpoint put forth by this study is similar to conclusions drawn from other previous studies. This indicates that, although MRI is a frequently employed presurgical diagnostic method, it is unlikely to replace clinical diagnosis and diagnostic arthroscopy. The use and interpretation of MRI is recommended in conjunction with clinical findings and history to provide a more elaborate and complete preoperative picture of the existing knee pathology.

Improving diagnostic accuracy of MRI in knee pathology would result in inestimable clinical benefits; however, recently improved MRI quality has not consistently enhanced diagnostic precision in meniscal lesions^[20]. A few measures can be used to improve the overall quality of MRI as a pre-surgical diagnostic technique. Furthermore, MRI scans can be interpreted by 2 different radiologists, which should always be combined with input and feedback obtained from orthopedic surgeons. The diagnostic quality of MRI can also be enhanced by optimizing pulse sequences and using 3-T high field MRI machines.

Limitations of the study include single-center setting, which conditions the findings with the radiological and surgical teams' experience, in addition to MRI scans being interpreted by a single radiologist. Moreover, there was a significant time gap between some MRI examinations and respective arthroscopic procedures.

Conclusion

Magnetic resonance imaging has inadequate accuracy in preoperative diagnosis of knee pathology including ligament and meniscus injuries. It has moderate sensitivity in diagnosing ligament injuries, especially complete ACL tears and very low specificity in meniscal injury.

In ligament injuries, MRI had higher diagnostic value in posterior ligament injuries including PCL tears, with 100% sensitivity and 90.7% specificity, as compared with 86.7% and 80.0% in ACL. In meniscal tear, MRI showed higher sensitivity in detecting medial meniscus tear as compared to tears of the lateral meniscus.

Arthroscopy continues to be the gold standard in the diagnosis of knee pathologies, and preoperative MRI findings should always be interpreted in conjunction with clinical findings and history to provide a more elaborate and complete picture of the knee pathology.

Conflict of Interest

The authors have no conflict of interest.

Disclosure

The authors did not receive any type of commercial support either in forms of compensation or financial

for this study. The author have no financial interest in any of the products or devices, or drugs mentioned in this article.

Ethical Approval

Obtained.

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منظار الركبة مقابل الرنين المغناطيسي لتشخيص قطع الرباط الصليبي والغضاريف

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المستخلص. التصوير بالرنين المغناطيسي يعد أداة مهمة قبل الإجراء الجراحي وخاصة في تنظير المفاصل. هدف هذه الدراسة هو تقييم حساسية ودقة الرنين المغناطيسي لتشخيص إصابات مفصل الركبة، بالمقارنة مع نتائج المنظار الجراحي. في هذه الدراسة الرجعية، تم استعراض تقارير الرنين المغناطيسي لركبة ٧٠ مريض وتم مراجعتها من قبل استشاري أشعة متخصص في الجهاز العضلي الحركي والذي لم يكن على اطلاع بنتائج المنظار الجراحي، بعد ذلك تم مقارنتها بنتائج تقارير عمليات المنظار لنفس المرضى. بلغت حساسية الرنين المغناطيسي في تشخيص إصابات الغضروف الهلالي الداخلي ٩٢,٧% ونسبة خصوصية ٣٣,٣% في حين كانت نسبة الحساسية ٦١,٣% والخصوصية ٥٣,٩% بالنسبة للغضروف الهلالي الخارجي. في حالات القطع الكامل للرباط الصليبي الأمامي بلغت نسبة الحساسية ٧٦,٧% و ٩٢,٥% كنسبة خصوصية، أما بالنسبة للإصابات الجزئية للرباط الصليبي الخلفي فقد كانت نسبة الحساسية ١٠٠% ونسبة الخصوصية ٩٠,٧%. قد تظل بعض إصابات الرباط الصليبي الأمامي غير مشخصة في تقارير أشعة الرنين المغناطيسي ولذلك يبقى المنظار الوسيلة المثلى لتشخيص إصابات الركبة.