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Original Article

Use of MRI by radiologists and orthopaedic surgeons to detect intra-articular injuries of the knee☆

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ABSTRACT

Objective: Magnetic resonance imaging (MRI) is paramount in the assessment of knee pathology, particularly when planning for a surgical procedure. This study compared the diagnostic accuracy in MRI reading of pathological knees by radiologists and orthopaedic surgeons.
Materials and methods: Cross-sectional study comprising 80 randomly selected patients previously submitted to arthroscopic surgery after clinical examination and MRI. A diagnosis by MRI interpretation was requested from the two teams, one of radiologists and another of orthopaedic surgeons. The conclusions of each team were later compared. Statistical significance was considered for $p < 0.05$.
Results: The radiologists' findings achieved statistical significance regarding osteochondral injuries, ACL, and medial meniscus ($p < 0.05$), and orthopaedic surgeons regarding ACL injuries and menisci ($p < 0.05$). ACL injuries demonstrated a statistically significant association between teams ($p < 0.001$).
Conclusions: MRI appears to offer reliable readings of ACL injuries, regardless the specialty of the observer. The lateral compartment is scarcely well read.

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Uso de ressonância magnética por radiologistas e cirurgiões ortopédicos para detectar lesões intra-articulares do joelho

Palavras-chave:
Artroscopia
Ressonância magnética
Menisco

RESUMO

Objetivo: A ressonância magnética (RM) é primordial na avaliação de patologias do joelho, particularmente no planejamento de um procedimento cirúrgico. Este estudo comparou a precisão diagnóstica na leitura dos resultados da RM de joelhos patológicos por radiologistas e cirurgiões ortopédicos.

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Ligamento cruzado anterior
Joelho

Materiais e métodos: Este foi um estudo transversal com 80 pacientes, selecionados aleatoriamente, previamente submetidos à cirurgia artroscópica após exame clínico e RM. Foi solicitado um diagnóstico por RM a duas equipes, uma de radiologistas e outra de cirurgiões ortopédicos. As conclusões de cada equipe foram comparadas posteriormente. A significância estatística considerada foi de $p < 0,05$.

Resultados: Os achados dos radiologistas obtiveram significância estatística para lesões osteocondrais, do LCA e do menisco medial ($p < 0,05$); os achados dos cirurgiões ortopédicos, para lesões no LCA e meniscos ($p < 0,05$). Uma associação estatisticamente significativa entre equipes foi demonstrada para lesões do LCA ($p < 0,001$).

Conclusões: A RM parece oferecer leituras confiáveis para lesões do LCA, independentemente da especialidade do observador. O compartimento lateral é de difícil leitura.

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Introduction

Magnetic resonance imaging (MRI) of the pathological knee, although a popular examination, has not yet completely proved to be worthy against a properly performed physical examination. Studies vary widely regarding its accuracy. In a trial with 100 patients, MRI interpretation achieved accuracy rates of 76% and 69% for both medial and lateral menisci injuries, when compared with rates of 82% and 76%, respectively, for physical examination alone.[1] The opposite was observed in another study of 26 patients in which the MRI accuracy rate was of 84.1% and the physical examination accuracy rate of 63.3%.[2] It is also known that MRI interpretation accuracy may decrease in the existence of multiple injuries, particularly when the anterior cruciate ligament (ACL) is torn.[3,4] All this variation may be reasoned by different skills in observation of the MRI, as well as its quality. Our objective was to compare the diagnostic accuracy in MRI reading of the pathological knee for both radiologists and orthopaedic surgeons.

Materials and methods

We performed a cross-sectional study by randomly selecting 80 patients from all of those who for any reason were submitted to knee arthroscopy in our institution for any primary procedure, in a time frame of three years [2013; 2015], after clinical examination and MRI observation. Simple randomization followed sequential selection within a patients' list using intervals randomly given by dice throwing (ranging from 1 to 6), until a total of 80 individuals was achieved. Data collected from these patients came from both their imaging resources as well as reports performed at the time of surgery. The latter follows, for quite some time, a systematic approach, naming injuries in the three compartments on about osteochondral injuries (specifying its grade according to Outerbridge's classification and the surface that was affected), meniscal injuries (regarding its type and extension, when applicable), cruciate ligament injuries (regarding its type and extension, either partial or complete) as well as the presence or absence of synovitis. Two teams of 3 elements each, one composed of radiologists and the other composed of orthopaedic surgeons, were gathered to interpret the 1.5 T MRIs previously gathered. None of the teams was particularly keen on knee analysis, although radiologists had some experience with musculoskeletal imaging. We therefore considered the elements as equal in regards of advantage in reading images of the knee. The patient's clinical information was not given at any moment, in order to eliminate diagnosis bias coming from suggestion. Diagnostic conclusions for any of the aforementioned topics were selected by a matter of majority within each team. The surgical reports were for exclusive observation of an independent individual, and were never given to neither the radiologists nor to the orthopaedic surgeons.

Comparison between what was observed by any of the teams and the respective surgical findings was made using Chi-squared tests for all the selected topics. The similarity between teams' findings was sought running Cochran–Mantel–Haenszel's tests. Positive and negative predictive values, sensitivity, specificity and accuracy were calculated whenever possible. Statistical significance was considered whenever a p-value under 0.05 was found. Data analysis was performed using IBM SPSS Statistics version 20.0.0.

Results

The selected patients had a mean age at the time of the surgery of 41.57 [confidence interval at 95%: 38.77; 44.36] years old, with women representing 40% (32) of cases. The time-lapse between MRI and knee arthroscopy was 6.34 [confidence interval at 95%: 5.22; 7.47] months. The left side was affected in 48 (60.0%) of cases.

The radiologists achieved statistically significant readings in chondral surface lesions of the lateral compartment (condyle: $p < 0.001$; plateau: $p = 0.044$), ACL ($p < 0.001$) and medial meniscus ($p < 0.001$). The diagnosis accuracy followed these trends, particularly for the ACL (74.3%) and the medial meniscus (75.3%).

The orthopaedic surgeons overdiagnosed lesions to any chondral surface, but were quite successful in detecting injuries to the ACL ($p = 0.003$) and menisci (medial: $p < 0.001$;

Table 1 – Discriminated diagnosis data for the radiologists' team.

Radiologists	*p*-value	PPV	NPV	Sensitivity	Specificity
Osteochondral lesions					
Medial condyle	0.125	0.778	0.522	0.389	0.857
Medial Plateau	0.360	0.714	0.480	0.278	0.857
Lateral Condyle	0.001	0.727	0.754	0.333	0.942
Lateral Plateau	0.044	1.000	0.400	0.318	1.000
Patello femoral	–	–	1.000	–	0.727
Ligamentary lesions					
ACL (yes/no)	<0.001	0.552	0.827	0.762	0.723
ACL (specified)	<0.001	–	–	–	–
Meniscal lesions					
Medial (yes/no)	<0.001	0.857	0.688	0.894	0.611
Medial (specified)	0.150	–	–	–	–
Lateral (yes/no)	0.079	0.500	0.717	0.458	0.750
Lateral (specified)	0.002	–	–	–	–
Synovitis	0.673	0.667	0.500	0.333	0.800

PPV, positive predictive value; NPV, negative predictive value; ACL, anterior cruciate ligament; "specified", by injury time, for both the ACL and the menisci.
Statistically significant findings were observed for the lateral osteochondral lesions, ligamentary and medial meniscus injuries; patellofemoral data lacks in *p*-value, positive predictive value and sensitivity as all imaging diagnosis made were negative; specified lesions data for the anterior cruciate ligament and menisci lacks in sensitivity and specificity as it was evaluated as a whole.

lateral: $p = 0.004$). For the aforementioned, diagnosis accuracy variated from 68.0% for the lateral meniscus and 74.2% for the medial meniscus. Success in discriminating menisci injuries was also higher in orthopaedic surgeons (medial: $p = 0.003$; lateral: $p = 0.014$).

Discriminated data may be observed in Tables 1 and 2.

Despite similarities in medial meniscus readings, significant findings between specialty teams were only found for ACL injuries, according to Cochran–Mantel–Haenszel's test ($p < 0.001$). A trend towards statistically significant findings was also discovered for both medial and lateral menisci ($p = 0.089$ and $p = 0.084$, respectively). Discriminated data may be found in Table 3.

Discussion

Formerly mandatory whenever a suspected intraarticular injury suggested arthroscopic treatment, MRI has been critized on the basis of its non-constant readings.[5] On the other hand, most of the studies seeking for a correlation between MRIs and arthroscopic reports, do not refer what is the skill or specialty of the MRIs observer.[6,7] It seems logical that while radiologists are better trained in imaging interpretation, they lack proper perception on how knee injuries look like *in vivo*. This is known to eventually interfere with the surgeon's decision to change the treatment plan.[8,9]

The several hypotheses being tested in this study, that is, if there was resemblance between radiologists and surgeons in reading pathological knee MRIs, was only confirmed for ACL injuries, although menisci injuries detection also came close to statistical significance. The same did not occur on chondral surface injuries, in which orthopaedic surgeons constantly over-estimated its frequency. As a sum, however, none offered more than modest sensitivity and specificity rates in their readings for all the categories. This does not differ from what has been published so far, with extreme variations particularly regarding sensitivity.[10–12] What was previously thought about the lower value of physical examination against MRI seems not to be confirmed in recent trials in which the former has proved to be equal, and sometimes superior, to the latter.[2,11] The extent of chondral surface injuries also seems to be misdiagnosed by MRI.[10,13]

Poor readings of the lateral femorotibial compartment are not uncommon, with lateral meniscus injury detection presenting a sensitivity range as wide as 44.0–91.0% and a specificity range of 70.0–100.0%, independently of the pattern of injury or meniscal variances.[4,6,11,14–19] Our readings fall within these limits, with better performance from orthopaedic surgeons in sensitivity (79.2%) and from radiologists to the specificity (75.0%). As the sample was composed of patients suffering from a large spectrum of pathologies, it did not exclude meniscal injuries in the presence of an ACL rupture, for example, which is known to decrease the accuracy of diagnosis for the first.[3,20] The chondral surface, even if lateral, was much better accessed by the radiologists when considering sensitivity alone, at the price of an extremely low sensitivity. This may be related to reasonably poor cartilage visualization on Tesla 1.5 MRIs, in comparison to more sophisticated image capturing devices, although only the lateral compartment seems to take an advantage on diagnosis using Tesla 3.0 MRIs, and not in all trials.[7,21–23] Another option to increase its accuracy would be to perform a magnetic resonance arthrography, although not without increased risks and costs.[24]

Lesions referred to the anterior cruciate ligament are usually correctly diagnosed. Once again orthopaedic surgeons performed better in regards of sensitivity, with 85.7%, and radiologists achieved a better specificity at 72.3%. These results correspond to the lower end of what has been published.[14,17,22,25,26] One should consider that neither one team nor the other had previous access to each patient's clinical information. Several studies have already addressed the importance of physical examination in increasing the likelihood for a diagnosis, or on diagnosis establishment *per*

Table 2 – Discriminated diagnosis data for the orthopaedic surgeons' team.

Orthopaedic surgeons	*p*-value	PPV	NPV	Sensitivity	Specificity
Osteochondral lesions					
Medial condyle	0.284	0.650	0.538	0.684	0.500
Medial plateau	0.383	0.562	0.000	0.947	0.000
Lateral condyle	0.946	0.318	0.690	0.333	0.942
Lateral plateau	0.299	0.654	0.143	0.739	0.100
Patello femoral	–	–	1.000	–	0.727
Ligamentary lesions					
ACL (yes/no)	0.003	0.450	0.893	0.857	0.532
ACL (specified)	<0.001	–	–	–	–
Meniscal lesions					
Medial (yes/no)	<0.001	0.854	0.647	0.872	0.611
Medial (specified)	0.003	–	–	–	–
Lateral (yes/no)	0.004	0.500	0.833	0.792	0.568
Lateral (specified)	0.014	–	–	–	–
Synovitis	0.673	0.333	0.500	–	0.909

PPV, positive predictive value; NPV, negative predictive value; ACL, anterior cruciate ligament; "specified", by injury time, for both the ACL and the menisci.
Statistically significant findings were achieved for the anterior cruciate ligament and both menisci; patellofemoral data lacks in *p*-value, positive predictive value and sensitivity as all imaging diagnosis made were negative; specified lesions data for the anterior cruciate ligament and menisci lacks in sensitivity and specificity as it was evaluated as a whole.

Table 3 – Comparison between radiologists' and orthopaedic surgeons' findings in MRI-based diagnosis.

Orthopaedic surgeons	Radiologists' accuracy	Orthopaedic surgeons' accuracy	CMH test (*p*-value)
Osteochondral lesions			
Medial condyle	0.623	0.592	0.130
Medial plateau	0.568	0.474	0.620
Lateral condyle	0.638	0.638	0.276
Lateral plateau	0.659	0.420	0.681
Patello femoral	–	–	–
Ligamentary lesions			
ACL (yes/no)	0.743	0.695	<0.001
Meniscal lesions			
Medial (yes/no)	0.753	0.742	0.089
Lateral (yes/no)	0.604	0.680	0.084
Synovitis	0.567	–	–

CHM test, Cochran–Mantel–Haenszel test; ACL, anterior cruciate ligament.
Although menisci readings were nearly the same between radiologists and orthopaedic surgeons, only ACL injuries achieved statistically significant association ($p < 0.001$); patellofemoral lesions have no data as accuracy could not be calculated; orthopaedic surgeons' synovitis accuracy could not be calculated, hence the absence of a *p*-value in the Cochran–Mantel–Haenszel test.

se.[16,18,27–29] Interestingly, knee flexion at 30° or 55° also seems to add diagnostic accuracy for ACL rupture in the MRI.[30]

This study presents some limitations, chief among which the chosen sample of patients. As all of them were submitted to arthroscopic surgery, a radiological diagnosis had already to exist. Consequently, both radiologists and orthopaedic surgeons had the urge to point out positive findings that may have compromised their evaluation. It may be a possible explanation for the overestimation of chondral surface injuries in the orthopaedic group, for example.

Secondly, although, by option, no clinical information was given, we admit that it would most likely positively aid in establishing the correct diagnosis. This is particularly true for the orthopaedic surgeons, as their practice relies on a conjoint analysis of both patient and imaging observation. Therefore, our results may underestimate the reality in our setting. A way to overcome this issue would be to perform a prospective randomize trial, in which both teams would have access to clinical information and the chance to perform physical examination before surgery. This would later be performed by an independent group, in a way to eliminate description bias.

Thirdly, neither the radiologists were firmly confined to musculoskeletal observation in their duty, nor the orthopaedic surgeons were fully dedicated to knee's arthroscopy. Better results would eventually arise in the presence of higher specialization. By choosing these teams' composition, on the other hand, we increased this study's generalization and reproducibility.

This study presents some strengths as well, as it clearly distinguishes what to expect when observations are performed by a radiologist or an orthopaedic surgeon, which in the end is its purpose. Data was also randomly selected, not favouring any kind of condition (although undoubtedly meniscal tears are far more common), thus reproducing reality as much as possible. In its essence, and due to our standardized approach in reporting knee arthroscopy, it is hard for any given injury to be missed, although it is still possible.

Conclusions

Summarizing, in our study the radiologists seem to perform better in detecting osteochondral injuries while the orthopaedic surgeons take advantage in menisci tears. Torn ACLs are similarly read by both specialties.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Rose NE, Gold SM. A comparison of accuracy between clinical examination and magnetic resonance imaging in the diagnosis of meniscal and anterior cruciate ligament tears. Arthroscopy. 1996;12(4):398–405.
2. Khan HA, Ahad H, Sharma P, Bajaj P, Hassan N, Kamal Y. Correlation between magnetic resonance imaging and arthroscopic findings in the knee joint. Trauma Mon. 2015;20(1):e18635.
3. Nam TS, Kim MK, Ahn JH. Efficacy of magnetic resonance imaging evaluation for meniscal tear in acute anterior cruciate ligament injuries. Arthroscopy. 2014;30(4):475–82.
4. Wong KP, Han AX, Wong JL, Lee DY. Reliability of magnetic resonance imaging in evaluating meniscal and cartilage injuries in anterior cruciate ligament-deficient knees. Knee Surg Sports Traumatol Arthrosc. 2016. PMID: 27342983 [Epub ahead of print].
5. Rangger C, Klestil T, Kathrein A, Inderster A, Hamid L. Influence of magnetic resonance imaging on indications for arthroscopy of the knee. Clin Orthop Relat Res. 1996;(330):133–42.
6. Rappeport ED, Wieslander SB, Stephensen S, Lausten GS, Thomsen HS. MRI preferable to diagnostic arthroscopy in knee joint injuries. A double-blind comparison of 47 patients. Acta Orthop Scand. 1997;68(3):277–81.
7. Reed ME, Villacis DC, Hatch GF 3rd, Burke WS, Colletti PM, Narvy SJ, et al. 3.0-Tesla MRI and arthroscopy for assessment of knee articular cartilage lesions. Orthopedics. 2013;36(8):10060–4.
8. Bergkvist D, Dahlberg LE, Neuman P, Englund M. Knee arthroscopies: who gets them, what does the radiologist report, and what does the surgeon find? An evaluation from southern Sweden. Acta Orthop. 2016;87(1):12–6.
9. Bridgman S, Richards PJ, Walley G, MacKenzie G, Clement D, McCall I, et al. The effect of magnetic resonance imaging scans on knee arthroscopy: randomized controlled trial. Arthroscopy. 2007;23(11):1167–73.
10. Campbell AB, Knopp MV, Kolovich GP, Wei W, Jia G, Siston RA, et al. Preoperative MRI underestimates articular cartilage defect size compared with findings at arthroscopic knee surgery. Am J Sports Med. 2013;41(3):590–5.
11. Dutka J, Skowronek M, Skowronek P, Dutka L. Arthroscopic verification of objectivity of the orthopaedic examination and magnetic resonance imaging in intra-articular knee injury. Retrospective study. Wideochir Inne Tech Maloinwazyjne. 2012;7(1):13–8.
12. Harris JD, Brophy RH, Jia G, Price B, Knopp M, Siston RA, et al. Sensitivity of magnetic resonance imaging for detection of patellofemoral articular cartilage defects. Arthroscopy. 2012;28(11):1728–37.
13. Zhang M, Min Z, Rana N, Liu H. Accuracy of magnetic resonance imaging in grading knee chondral defects. Arthroscopy. 2013;29(2):349–56.
14. Bari AA, Kashikar SV, Lakhkar BN, Ahsan MS. Evaluation of MRI versus arthroscopy in anterior cruciate ligament and meniscal injuries. J Clin Diagn Res. 2014;8(12):RC14–8.
15. Grubor P, Asotic A, Grubor M, Asotic M. Validity of magnetic resonance imaging in knee injuries. Acta Inform Med. 2013;21(3):200–4.
16. Navali AM, Bazavar M, Mohseni MA, Safari B, Tabrizi A. Arthroscopic evaluation of the accuracy of clinical examination versus MRI in diagnosing meniscus tears and cruciate ligament ruptures. Arch Iran Med. 2013;16(4):229–32.
17. Phelan N, Rowland P, Galvin R, O'Byrne JM. A systematic review and meta-analysis of the diagnostic accuracy of MRI for suspected ACL and meniscal tears of the knee. Knee Surg Sports Traumatol Arthrosc. 2016;24(5):1525–39.
18. Timotijevic S, Vukasinovic Z, Bascarevic Z. Correlation of clinical examination, ultrasound sonography, and magnetic resonance imaging findings with arthroscopic findings in relation to acute and chronic lateral meniscus injuries. J Orthop Sci. 2014;19(1):71–6.
19. Yilgor C, Atay OA, Ergen B, Doral MN. Comparison of magnetic resonance imaging findings with arthroscopic findings in discoid meniscus. Knee Surg Sports Traumatol Arthrosc. 2014;22(2):268–73.
20. Sharifah MI, Lee CL, Suraya A, Johan A, Syed AF, Tan SP. Accuracy of MRI in the diagnosis of meniscal tears in patients with chronic ACL tears. Knee Surg Sports Traumatol Arthrosc. 2015;23(3):826–30.
21. LaPrade RF, Ho CP, James E, Crespo B, LaPrade CM, Matheny LM. Diagnostic accuracy of 3.0 T magnetic resonance imaging for the detection of meniscus posterior root pathology. Knee Surg Sports Traumatol Arthrosc. 2015;23(1):152–7.
22. Smith C, McGarvey C, Harb Z, Back D, Houghton R, Davies A, et al. Diagnostic efficacy of 3-T MRI for knee injuries using arthroscopy as a reference standard: a meta-analysis. AJR Am J Roentgenol. 2016;207(2):369–77.
23. Van Dyck P, Vanhoenacker FM, Lambrecht V, Wouters K, Gielen JL, Dossche L, et al. Prospective comparison of 1.5 and 3.0-T MRI for evaluating the knee menisci and ACL. J Bone Joint Surg Am. 2013;95(10):916–24.
24. Babaei Jandaghi A, Mardani-Kivi M, Mirbolook A, Emami-Meybodi MK, Mohammadzadeh S, Farahmand M. Comparison of indirect MR arthrography with conventional MRI in the diagnosis of knee pathologies in patients with knee pain. Trauma Mon. 2016;21(2):e20718.
25. Boeve BF, Davidson RA, Staab EV Jr. Magnetic resonance imaging in the evaluation of knee injuries. South Med J. 1991;84(9):1123–7.
26. Orlando Junior N, Souza Leão MG, Carvalho de Oliveira NH. Diagnosis of knee injuries: comparison of the physical examination and magnetic resonance imaging with the findings from arthroscopy. Rev Bras Ortop. 2015;50(6):712–9.
27. Ercin E, Kaya I, Sungur I, Demirbas E, Ugras AA, Cetinus EM. History, clinical findings, magnetic resonance imaging, and arthroscopic correlation in meniscal lesions. Knee Surg Sports Traumatol Arthrosc. 2012;20(5):851–6.
28. Rayan F, Bhonsle S, Shukla DD. Clinical, MRI and arthroscopic correlation in meniscal and anterior cruciate ligament injuries. Int Orthop. 2009;33(1):129–32.
29. Venu KM, Bonnici AV, Marchbank NDP, Chipperfield A, Stenning M, Howlett DC, et al. Clinical examination, MRI or arthroscopy: which is the gold standard in the diagnosis of significant internal derangement in the knee? J Bone Joint Surg Br. 2003;85 Suppl. 2:167.
30. Muhle C, Ahn JM, Dieke C. Diagnosis of ACL and meniscal injuries: MR imaging of knee flexion versus extension compared to arthroscopy. Springerplus. 2013;2(1):213.