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ORIGINAL ARTICLE

Comparison of clinical, MRI and arthroscopic assessments of chronic ACL injuries, meniscal tears and cartilage defects

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Abstract

Purpose The aim of this study was to compare the accuracy of clinical examination to that of MRI evaluated by two independent radiologists for the diagnosis of meniscal tears and chronic anterior cruciate ligament injuries and to assess the MRI accuracy in the diagnosis of cartilage defects.

Methods Seventy-six consecutive patients with suspected intra-articular knee pathology were prospectively evaluated by objective examination, 1.5 T MRI, re-examined by trained radiologist and arthroscopy. Accuracy, sensitivity, specificity, positive predictive value and negative predictive value were calculated. Agreement analysis with kappa (K) coefficient values was performed for meniscal and ACL tears.

Results No differences were found between diagnostic accuracy of clinical examination, the first and second MRI reports in diagnosis of medial meniscus (84 vs 96 vs 97 %) and anterior cruciate ligament injuries (93 vs 78 vs 89 %). For the lateral meniscal tears, the accuracy of the second radiologist was significantly higher than those of the first (96 vs 75 %; $p < 0.01$) and clinical examination (96 vs 86 %; $p = 0.02$). High diagnostic values were obtained for the diagnosis of full-thickness chondral defects with sensitivity of 100 %, specificity of 95 % and accuracy of 95 %.

Conclusion Clinical and MRI evaluations have no differences in the diagnosis of medial meniscus and anterior cruciate ligament injuries. A trained radiologist obtained better sensitivity, specificity and accuracy in the diagnosis of lateral meniscus. 1.5 T MRI does not represent the technique of choice in the evaluation of chondral defect but demonstrated high diagnostic accuracy for detection of full-thickness chondral defects.

Level of evidence Diagnostic prospective study, Level II.

Keywords Arthroscopy · MRI · Knee · Cartilage · Meniscus · Meniscal tears · ACL · Anterior cruciate ligament injury

Introduction

The correct preoperative diagnosis of knee pathology is not always easy, even for experienced orthopaedic surgeons, and therefore, meniscal, ligament tears and cartilage defects can be misdiagnosed.

Magnetic resonance imaging (MRI) is currently the non-invasive technique of choice in clinical decision making for meniscal and anterior cruciate ligament (ACL) injuries [1, 2]. Nevertheless, the clinical examination and MRI interpretation for intra-articular knee pathology can be difficult especially in cases of acute ACL injury due to the presence of hemarthrosis, pain and decreased range of motion with decreased diagnostic accuracy [3–5].

The literature reports an accuracy of clinical examination of the knee to detect meniscal tears between 64 and 85 % [6–9] and diagnostic accuracy rate of 90–100 % for ACL injury [6, 7, 9].

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However, MRI allows assessing occult bone bruise and soft tissue damages and it represents a useful investigation to understand traumatic mechanism [10]. MRI correctly detects meniscus tears in 48–94 % of cases and ACL injuries in 90–100 % of cases [2, 11, 12], but the diagnostic accuracy is related to the sensitivity of the scanner [13, 14].

The aim of this study is to compare the accuracy of clinical examination to that of MRI evaluated by two independent radiologists for the diagnosis of meniscal tears and chronic ACL injuries and to assess the diagnostic accuracy of 1.5 T MRI in the diagnosis of cartilage defects with arthroscopic confirmation as gold standard.

Materials and methods

Ethics committee approval was requested and obtained from the institutional review board (IRB) for the present study (protocol number 249—REG 2015 approved on 07.10.2015).

From January 2015 to July 2015, we prospectively evaluated 76 consecutive patients with suspected intra-articular knee pathology. Inclusion criteria were chronic ACL injury (>6 weeks) and traumatic meniscal tears. Exclusion criteria were cases of previous knee surgery, degenerative meniscal tears, degenerative knee joint disorders, acute ACL injuries (<6 weeks), medial or lateral collateral ligament injuries, posterior cruciate ligament (PCL) injuries, new sprain or trauma occurred between objective examination and surgery. Patients with low-magnetic-field MRI scans (<1.5 T) were excluded as well.

All patients were evaluated with objective examination performed by expert knee surgeon (senior author) in all cases. The eligible patients were included for 1.5 T MRI evaluation in three different radiologic centres, and finally arthroscopy was performed by the same surgeon (L.F.).

The objective examination was systematically conducted following International Knee Documentation Committee (IKDC) criteria and was performed before MRI evaluation in all instances. The knee objective evaluation was conducted with meniscus clinical tests (joint-line tenderness, Mc Murray test, Apley test and Thessaly test) and sign of ligament laxity (Lachman test, anterior and posterior drawer test, pivot shift-test, varus and valgus stress). ACL and/or meniscal injuries were diagnosed if one or more clinical tests were positive.

The MRI protocols included axial, sagittal and coronal sequences in all cases; each sequence included T1-weighted, T2-weighted, fat-suppressed T2-weighted.

All the MRI reports from 3 different radiologic centres were recorded, and images of all the scans were gathered and converted in anonymous form. All the collected scans without report were finally delivered to 15-year musculoskeletal trained radiologist to obtain a second report. All the radiologists were given access only to each patient's clinical data to avoid the hypothetical decrease in MRI accuracy without clinical information and to maintain the true diagnostic process in common medical practice.

Meniscus changes were evaluated with Crues grading system [15]. A meniscus was considered torn if there was abnormal intrameniscal signal extending to either its superior or inferior surface, gross disruption of the normal meniscal profile or complete absence of any part of the meniscus (grade 3).

All reported grade 1 or 2 meniscal changes (globular and linear intrameniscal signal not extending to the articular meniscal surface) were considered as negative for meniscal tears.

The ACL was considered torn if the normal homogeneous low-intensity signal crossing the intercondylar notch from origin to insertion was absent, variable, non-homogeneous, discontinuous or if the signal did not proceed from its normal origin to insertion [16].

Partial ACL rupture was considered if hyper-intense signal within the ACL fibres was found on MRI [17, 18] and confirmed by arthroscopic evaluation as described by Crain et al. [19].

Analysing the reports from different radiologic centres, the articular cartilage damage has been considered as "present" or "absent" because of the heterogeneity of the descriptions reached. For this reason, it was asked to the second observer radiologist to classify the chondral damage with the grading described by Sonin et al. [20]. Data were correlated with arthroscopic findings. The MRI grading system comprised three levels: normal cartilage surface, partial-thickness chondral defects and full-thickness defect.

Cartilage defects were assessed by arthroscopy and classified using the International Cartilage Repair Society (ICRS) criteria [21]. Grade 0 indicated normal joint surface; grade I was considered nearly normal cartilage with soft indentation, superficial cracks or fissures; grade II was considered abnormal cartilage defect extending down to less than 50 % of cartilage depth; grade III was considered cartilage defect extending down for more than 50 % and not extended through the sub-chondral bone, calcified layer or blisters; grade IV was considered full-thickness cartilage defect extending through the subchondral bone. If the joint surface was described with two different grades (e.g., "grades II–III"), the more severe grade was recorded.

A result was considered a true positive (TP) if the clinical or MRI finding was confirmed by knee arthroscopy. A result was considered a true negative (TN) if the diagnosis of no injuries was confirmed by arthroscopy. A result was considered a false positive (FP) if the clinical or

MRI finding was not confirmed by knee arthroscopy. A false negative (FN) was considered if the clinical or MRI finding was negative, but the arthroscopy detected articular damage.

Accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were evaluated considering the arthroscopic finding as the standard of reference. The confidence intervals were calculated using modified Wald method.

Statistical analysis was performed separately for medial meniscus (MM), lateral meniscus (LM), ACL and cartilage surfaces considering the arthroscopic findings as "gold standard". Clinical examination and MRI results were analysed by McNemar's test.

Agreement analysis between clinical examination and the first MRI report, clinical examination and the second MRI report and between the first and second MRI reports was performed for meniscal and ACL tears. Kappa (K) coefficient values were interpreted as poor ($K = 0.0$–0.20), fair ($K = 0.21$–0.40), moderate ($K = 0.41$–0.60), good ($K = 0.61$–0.80) or excellent ($K = 0.81$–1.0).

Results

We consecutively evaluated 76 patients with suspected intra-articular knee pathology in this prospective study. The study population was composed by 48 males (63 %) and 28 females (37 %) with a mean age of 33.4 ± 7.4 years. Arthroscopy revealed 60 MM tears (79 %), 20 LM tears (26 %), and 38 ACL injuries (50 %). Four ACL injuries (11 %) were partial rupture upon probing. Fifty-two cartilage defects (68 %) were detected by arthroscopy.

The incidence of meniscus tears as isolated pathology in the current study was 50 %. We detected ACL injury with meniscal tear in 39 % of patients and isolated ACL injury in 11 % of cases.

The average injury to surgery interval was 3.7 ± 0.9 months, and the average MRI to surgery interval was 2.9 ± 0.8 months.

Table 1 summarizes the seven pathological patterns of MM, LM and ACL injuries with respective clinical and MRI observations and lists in detail the frequencies and

Table 1 Frequencies of tears at time of arthroscopic evaluation and suspected injuries at the clinical examination, at time of the first MRI scan and at the second evaluation by trained radiologist

Site of injury	Arthroscopy	Clinical examination	MRI (1st report)	MRI (2nd report)	
MM	26	35	20	31	
LM	2	2	4	4	
MM + LM	10	4	15	7	
ACL[a]	8 (–)	19	6 (–)	11 (4)	
ACL[a] + MM	22 (4)	11	15 (–)	13 (2)	
ACL[a] + LM	6 (–)	3	7 (–)	3 (–)	
ACL[a] + MM + LM	2 (–)	2	9 (2)	7 (–)	
Cartilage damage	**Medial compartment (femur + tibia)**	**Medial femoral condyle**	**Lateral femoral condyle**	**Medial tibial plateau**	**Patello-femoral joint**
Grade I	–	1	2	–	1
Grade II	7	14	4	2	9
Grade III	5	4	–	–	1
Grade IV	1	1	–	–	–
Tot. (52)	13	20	6	2	11
MRI 1st report					
Cartilage damage	6	4	–	–	22
Tot. (32)					
MRI 2nd report					
Partial thickness	2	12	4	2	8
Full thickness	4	1	–	–	–
Tot. (33)	6	13	4	2	8

Frequencies and grades of cartilage defects classified by ICRS classification detected at time of arthroscopy and reported cartilage damages at time of the first and second MRI observation graded with Sonin grading system [18]

MM medial meniscus, *LM* lateral meniscus, *ACL* anterior cruciate ligament

[a] Partial ACL injuries

Table 2 True positive (TP), true negative (TN), false positive (FP) and false negative (FN) for each type of pathology

	MM			LM			ACL		
	Clinical examination	MRI 1st	MRI 2nd	Clinical examination	MRI 1st	MRI 2nd	Clinical examination	MRI 1st	MRI 2nd
TP	50	58	58	10	18	19	34	29	32
TN	14	15	16	55	39	54	37	30	36
FP	2	1	–	1	17	2	1	8	2
FN	10	2	2	10	2	1	4	9	6

grades of cartilage defects at the time of arthroscopy and results of the first and second radiologist reports.

The total numbers of TP, TN, FP and FN for MM, LM and ACL tears are presented in Table 2.

The sensitivity, specificity, PPV, NPV and accuracy of clinical examination, the first and second MRI reports for meniscal tear and ACL rupture are summarized in Table 3.

Table 4 summarizes sensitivity, specificity, PPV, NPV and accuracy of MRI for partial-thickness chondral defects and full-thickness defects.

Medial meniscus

The first and second MRI reports had better sensitivity (97 vs 97 vs 83 %), specificity (94 vs 100 vs 88 %), PPV (98 vs 100 vs 96 %) and NPV (88 vs 89 vs 58 %), if compared to clinical examination. The second MRI report had more frequently the correct diagnosis than the first. Diagnostic accuracies of both MRI reports were higher in comparison with clinical examination (96 vs 97 vs 84 %), but no statistically significant differences were found.

The K values between clinical examination and MRI results were 0.48 (first report) and 0.42 (second report), respectively, to be considered as moderate agreement. Furthermore, there was no statistical significant difference between the two different reports with excellent strength of agreement ($K = 0.82$).

Lateral meniscus

For clinical examination, the first and second MRI reports' sensitivity (50 vs 90 vs 95 %), specificity (98 vs 70 vs 96 %), PPV (91 vs 51 vs 90 %), NPV (85 vs 95 vs 98 %) and diagnostic accuracy (86 vs 75 vs 96 %) in diagnosis of LM tears were assessed. Diagnostic accuracy of the second MRI report was significantly higher than those of clinical examination ($p = 0.02$) and the first MRI report ($p < 0.01$).

The level of agreement between the second MRI report and clinical examination was fair ($K = 0.38$), while between the first and second MRI reports was poor ($K = 0.16$). Diagnostic accuracy of clinical examination was higher than that of first MRI report ($p < 0.01$) with fair level of agreement ($K = 0.29$).

Anterior cruciate ligament

Between clinical examination and the second MRI report, there was marginal difference in sensitivity (89 vs 84 %, respectively), specificity (97 vs 95 %), PPV (97 vs 94 %), NPV (90 vs 86 %) and diagnostic accuracy (93 vs 89 %). No statistically significant difference in diagnostic accuracy was noted, and a good agreement was pointed out ($K = 0.76$). The first MRI report had a sensitivity of 76 %, a specificity of 79 %, a PPV of 78 %, a NPV of 77 % and a diagnostic accuracy of 78 % in diagnosis for ACL tears. Nevertheless, no differences were found between clinical examination and the second MRI report. Kappa coefficient (K) was 0.25 between clinical examination and the first MRI report (fair agreement) and 0.37 between two MRI results (fair agreement).

Cartilage

Analysing the reports from different radiologic centres, we noted heterogeneity of descriptions for the articular cartilage damage. For this reasons, we have been considered as "present" or "absent" the chondral defects. In the first MRI report were noted a sensitivity of 56 %, a specificity of 88 %, a PVP of 91 %, a VPN of 48 % and a diagnostic accuracy of 66 %. We asked to the second observer radiologist to classify the cartilage damage as: normal cartilage surface (ICRS grades 0–I), partial-thickness chondral defects (ICRS grades II, III) and full-thickness defects (ICRS grade VI). MRI had better sensitivity (100 vs 48 %), specificity (95 vs 80 %), PPV (33 vs 79 %), NPV (100 vs 50 %) and diagnostic accuracy (95 vs 61 %) in diagnosis for full-thickness chondral defects in comparison to partial-thickness defects.

Discussion

The role of MRI in the diagnosis of knee pathology has become essential, and it represents the investigation of choice for most of the intra-articular lesions of the knee in the current clinical practice. Nevertheless, several papers demonstrated that clinical examination and MRI evaluation

Table 3 Results of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy for each type of pathology

	MM			LM			ACL		
	Clinical examination	MRI 1st	MRI 2nd	Clinical examination	MRI 1st	MRI 2nd	Clinical examination	MRI 1st	MRI 2nd
Sensitivity (95 % IC)	83 % (72–91)	97 % (88–100)	97 % (88–100)	50 % (30–70)	90 % (69–98)	95 % (75–100)	89 % (75–96)	76 % (61–87)	84 % (69–93)
Specificity (95 % IC)	88 % (62–98)	94 % (70–100)	100 % (77–100)[a]	98 % (90–100)	70 % (57–80)	96 % (87–100)	97 % (85–100)	79 % (63–89)	95 % (82–99)
PPV (95 % IC)	96 % (86–100)	98 % (91–100)	100 % (93–100)[a]	91 % (60–100)	51 % (36–67)	90 % (70–99)	97 % (84–100)	78 % (63–89)	94 % (80–99)
NPV (95 % IC)	58 % (39–76)	88 % (64–98)	89 % (66–98)	85 % (73–92)	95 % (83–100)	98 % (90–100)	90 % (77–97)	77 % (61–88)	86 % (72–94)
Accuracy (95 % IC)	84 % (74–91)	96 % (89–99)	97 % (90–100)	86 % (76–92)	75 % (64–83)	96 % (89–100)	93 % (85–98)	78 % (67–86)	89 % (80–95)

[a] To be considered 97.5 % IC

have no significant differences in diagnostic accuracy for meniscal and ACL injuries [7, 8, 22].

The risks of overtreatment and the problems of excessive medicalization have been recently highlighted [23]; nevertheless, the MRI requests dramatically increase over time and consequently the numbers of knee arthroscopies and related health costs [24–26].

Kocabey et al. [11] did not show real advantages of MRI over clinical examination for routine use in diagnosis of meniscus and ACL pathology before knee arthroscopy. Authors in their paper recommend to consider knee MRI only in selected cases: to define the return to sport in professional athletes, for detailed differential diagnosis or to define the size and location of meniscal tear in perspective of potential repair, especially in young patients. Nevertheless, MRI is often reported to be the non-operator-dependent gold-standard diagnostic procedure before knee arthroscopy [1, 2, 27].

MRI has decreased diagnostic accuracy for intra-articular pathology in cases of acute trauma with hemarthrosis because of the paramagnetic properties of blood and catabolic processes in meniscal and chondral tissues during the haemoglobin degradation process [4]. On the other hand, clinical examination in cases of acute knee sprain may be difficult and inaccurate because the presence of pain restricted range of motion and swelling [4]; moreover, the ACL remnant and the related intraarticular synovitis could increase the rate of false positives, simulating meniscal tears [6]. Nam et al. [3] demonstrated that MRI has lower diagnostic accuracy for the detection of meniscal tears in cases of acute ACL rupture. For these reasons, we chose to exclude the acute ACL injuries in the setting of the present study. We reserved acute MRI evaluation only in cases of professional athletes injuries. All cases of ACL injuries in the present study were classified as chronic because the time between trauma and our observation was more than 6 weeks similarly to Sharifah et al. [46].

In our series, no statistical differences were found between diagnostic accuracy of clinical examination, the first and second MRI reports in diagnosis of MM (84 vs 96 vs 97 %) and ACL injuries (93 vs 78 vs 89 %).

For the LM tears, the accuracy of the second radiologist was significantly higher than those of the first (96 vs 75 %; $p < 0.01$) and clinical examination (96 vs 86 %; $p = 0.02$). Clinical examination accuracy has also been significantly superior to that of the first MRI report for the detection of LM tears (86 vs 75 %; $p < 0.01$).

In our series, the LM was reported as isolated tear in only two cases. The clinical examination of LM underestimated the presence of tear, and 50 % of patients with LM tears were asymptomatic before arthroscopic evaluation (20 LM tears confirmed by arthroscopy and 10 among them with positive LM clinical tests). Clinical examination had

Table 4 Results of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy for full- and partial-thickness chondral defects

	Partial-thickness chondral defects	Full-thickness chondral defects
Sensitivity (95 % IC)	48 % (34–62)	100 % (30–100)[a]
Specificity (95 % IC)	80 % (62–91)	95 % (87–98)
PPV (95 % IC)	79 % (60–90)	33 % (9–70)
NPV (95 % IC)	50 % (37–63)	100 % (94–100)[a]
Accuracy (95 % IC)	61 % (49–71)	95 % (87–98)

[a] To be considered 97.5 % IC

low sensitivity (50 %), but demonstrated high specificity (98 %) with accuracy of 86 % in diagnosis of LM tears.

Analysing the arthroscopic features of the LM tears of this study, we can justify this discrepancy because among asymptomatic patients seven had peripheral tears of less than one-third of the meniscus located at the posterior horn and three had small radial tears of body of the lateral meniscus. All detected tears had associated injuries (ACL and/or MM). The only two isolated LM tears were symptomatic and correctly diagnosed by clinical examination, the first and second MRI reports. This feature can justify the low K values and fair agreement between clinical examination and the second MRI report and poor agreement between the first and second radiologists. The evaluation of LM tears by the second radiologist obtained the highest sensitivity, specificity and diagnostic accuracy (95, 96 and 96 %, respectively). In our series, the trained radiologist obtained less FP and higher detection rate of LM tears in the setting of combined injuries (ACL and/or MM). The pattern of longitudinal peripheral tears is frequently associated with chronic ACL deficiency [34, 46, 47]. High false positive rate is expected for the posterior horn of lateral meniscus, and possible causes are the misinterpretation of the signal coming from the inferior knee artery, the Wrisberg ligament and differentiation of simple degenerative changes, especially if isolated inferior or superior meniscus articular surface is involved [28, 29, 46]. Different authors hypothesized that spontaneous healing of peripheral longitudinal meniscus tears can justify the high false positive rate of peripheral meniscus tears [2, 30, 31]. Nevertheless, in our paper the large difference between the two reports in PPV and FP for the LM could be explained as over-diagnosis of the first radiologist and not as spontaneous healing of the meniscus tear.

Some authors have been reported that detection rate of meniscus is higher if the meniscus tear is isolated and that reduction in sensitivity of MRI scan in the presence of ACL tears is expected (from 97 to 88 % for MM and from 94 to 69 % for LM) focusing attention to high missing rate of LM tears (reported to be 19 %) [5, 13, 32, 33]. De Smet et al. [33] reported that 11 % of missed LM had radial pattern and 16 % had longitudinal peripheral patter with vertical orientation. The closed connection of the menisco-femoral ligaments arising just medial to this peripheral tears may cause incorrect interpretation of MRI. A particular emphasis should be given to this pattern of tear to potential evolution into bucket-handle or complex pattern. Therefore, orthopaedic surgeons should pay specific attention to early identify and repair this pattern of injury, especially in young patients or professional players, or to leave them in situ if stable and sub-centimetric [34].

The posterior horn tears can be easily missed on MRI due to several pitfalls. The oblique course of the posterior horn relative to the coronal, sagittal planes on MRI, the presence of anatomical structures in closed connection with menisci (popliteal tendon and ligaments of Humphrey and Wrisberg), arterial pulsation artefacts, the “magic angle effect” and meniscal flounce commonly present additional problems in correct MRI interpretation [33, 35–37]. In cases of unclear injuries, it is essential to have radiologic and orthopaedic consult to carefully correlate clinical information, objective findings and radiological aspects and to avoid unnecessary procedures.

However, in the literature from 5.6 to 36 % of patients have asymptomatic MRI findings and the diagnostic error rate of MRI for knee pathology is reported between 10 and 20 %. The inaccuracies are significantly higher in patients older than 40 years [11, 38–40]. Results of the present study are aligned with that reported in the literature.

The clinical examination of ACL had the highest values of sensitivity (89 %), specificity (97 %) and diagnostic accuracy (93 %) with good agreement between orthopaedic surgeon and the second radiologist ($K = 0.76$). No significant differences between clinical examination and MRI were found. The first MRI evaluation obtained the worst values of sensitivity (76 %), specificity (79 %) and accuracy (78 %) with fair agreement with clinical examination ($K = 0.25$) and the second MRI observation ($K = 0.37$). There was no possibility to obtain significant data for the detection of partial ACL rupture due to the lack of detected cases; however, the arthroscopic incidence of 11 % of partial ACL rupture of the present study is within the range of 10–28 % reported in the literature [41].

The use of routine 1.5 T knee MRI in the evaluation of chondral defect is not widely accepted because of the limitation in contrast resolution. Controversies exist regarding different imaging techniques for different grades of chondral lesion with low sensitivity in diagnosing cartilage defects [42, 43].

In the present study, the routine 1.5 T MRI had sensitivity of 48 %, specificity of 80 % and accuracy of 61 % in diagnosis of partial-thickness chondral defects. Higher values were obtained for the diagnosis of full-thickness chondral defects with sensitivity of 100 %, specificity of 95 % and accuracy of 95 %. Although the routine 1.5 T MRI evaluation did not represent the technique of choice in evaluation of cartilage defects, high values of sensitivity, specificity and accuracy have been obtained in evaluation of advanced chondral damage by an expert radiologist.

Van Dyck et al. [44] reported that 3.0 T MRI significantly improves diagnostic accuracy in detecting cartilage lesions within the knee joint, when compared with a similar protocol performed at 1.5 T. Moreover, the addition of 3D-DESS cartilage-specific sequences to MRI protocol at 3.0 T can improve diagnostic performance in the detection of early defects [45].

The present study has some limitations: First, the absence of data related to orthopaedic evaluation of knee MRI. Data and imagines are routinely evaluated by orthopaedic surgeon before every procedure in our practice, but the aim of this study is focused on clinical evaluation without other suggestions. Second, study population is relatively limited. Third, the heterogeneity of the first MRI report, especially in description of cartilage defects, represents a potential selection bias of the study, but it represents the real aspect of common medical practice. We choose to maintain the variability of the first “random” radiologist to evaluate changes between different levels of experience.

Conclusion

Clinical and MRI evaluation have no differences for the diagnosis of MM and ACL injuries. A trained radiologist has better sensitivity, specificity and accuracy in diagnosis of LM in the setting of combined injuries. 1.5 T MRI does not represent the technique of choice in the evaluation of the chondral defect but has high diagnostic accuracy for the detection of full-thickness chondral defects. For the detection of partial-thickness defects, 1.5 T MRI demonstrated low specificity, sensitivity and diagnostic accuracy.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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