Knee Surg, Sports Traumatol, Arthroscopy (1995) 3:157–162

Knee Surgery
Sports Traumatology
Arthroscopy


*Patella*

# Comparison between magnetic resonance imaging and arthroscopy in the diagnosis of patellar cartilage lesions

## A prospective study

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Received: 17 February 1995; accepted: 11 July 1995

**Abstract.** A blind and prospective study was conducted to assess the accuracy of magnetic resonance imaging (MRI) for diagnosing patellar cartilage lesions. Thirty-three consecutive patients undergoing knee arthroscopy were examined by MRI prior to surgery. Imaging was performed in the axial plane on a 1.5-Tesla unit with spin-echo and gradient-echo T1 and T2 sequences. The MRI and arthroscopic data were compared using a four-grade classification and a patellar map which divided the patellar surface into four quadrants. The overall sensitivity of MRI was 84.7% and the specificity 97.2%. The same pitfall led to two MRI false positives. A perfect correlation of grading was obtained in 76.5%. When discordance was found, the tendency with MRI was commonly to underestimate the grade of the lesions. The MRI accuracy was high in this study in spite of a high rate of low-grade lesions which are difficult to assess. Related criteria for cartilage assessment with MRI and arthroscopy are suggested for further studies.

**Key words:** Articular cartilage – Patella – Magnetic resonance imaging – Arthroscopy

## Introduction

Lesions of the cartilage are thought to be a common cause of joint pain [14, 17, 21]. However, the severity of symptoms is often poorly correlated with the extent of cartilage damage, especially in cases of anterior knee pain [9, 21]. To find the relationship between pain und abnormal cartilage, accurate methods of determining the extent and grade of lesions are needed. Among these, arthroscopy and magnetic resonance imaging (MRI) are the most commonly used ones at the moment, but no classification exists that can be applied to both methods.

Currently, arthroscopy is considered as the "gold standard" in the diagnosis of cartilage lesions. Arthroscopy permits direct visual inspection and palpation of suspected lesions. The utility of this technique is limited by its invasiveness, expense and inability to detect lesions beneath the surface [4] or in the posterior joint [19].

Magnetic resonance imaging (MRI) is non-invasive and accurate for the diagnosis of meniscal, ligamentous and other soft-tissue injuries of the knee [6, 10, 20]. MRI assessment of hyaline articular cartilage, however, is less defined. The experience of the interpreter, the strength of the magnetic field, the use of specialised receiving coils and the presence of a joint effusion may affect the accuracy of MRI for cartilage assessment [3, 5, 18]. Also, the choice of MRI sequences is important, but no combination has been generally approved [2, 5, 6, 16, 18].

Prior studies which compared MRI and articular cartilage of the patella have yielded conflicting results [4, 9, 11, 21]. In most cases, the criteria for grading MRI and

**Table 1.** Study scheme for grading articular lesions with both magnetic resonance imaging (MRI) and arthroscopy and Noyes grading system

| Noyes scheme | Arthroscopic findings | MRI findings | Study scheme |
|---|---|---|---|
| 0 | Normal | Normal | 0 |
| IA | Cartilage surface intact, definite softening, resilience remaining | Cartilage surface intact, hypo- or hyper-signal | I |
| IB | Cartilage surface intact, extensive softening, loss of resilience | Cartilage surface intact, hypo- or hyper-signal | I |
| IIA | Cartilage surface damaged, lesion < 50% thickness | Mild surface irregularity and/or focal loss < 50% thickness | II |
| IIB | Cartilage surface damaged, lesion > 50% thickness | Severe surface irregularity, focal loss > 50% thickness | III |
| IIIA | Bone exposed, bone intact | Focal loss 100% thickness, bone intact | III |
| IIIB | Bone damaged | Bone reaction | IV |

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arthroscopy were poorly compatible. Our aim was to develop a classification which can be applied to both MRI and arthroscopic findings. Deriving from the analysis and synthesis of the prior arthroscopic classification, the Noyes and Graig scheme [12] served as the reference for grading lesions at arthroscopy. This classification was compared with updated MRI criteria [16] and modified according radiologists' suggestions in order to obtain the closest correlation for both methods (Table 1).

The purposes of the present study were, on the one hand, to evaluate the sensitivity, specificity and accuracy of MRI in determining the presence of patellar cartilage lesions, using arthroscopy as the reference, and on the other, to establish accurate criteria that could be applied to both methods for grading the lesions.

## Patients and methods

Thirty-three consecutive patients (18 men and 15 women) gave informed consent and were examined by MRI before arthroscopy. Their mean age was 32 years (range 18–50 years). Considering the indications for arthroscopy (Table 2), only six patients suffered from pain consistent with a patellar problem.

The radiologists were blinded to the indication for arthroscopy, and the surgeons were blinded to the MRI diagnosis prior to arthroscopy.

Arthroscopy was performed by the authors using standard procedure. Arthroscope and probe were inserted through anterior portals. Lesions were graded according with the "study scheme" defined in Table 1 using arthroscopic criteria defined by Noyes and Graig [12].

The arthroscopic data were collected during the procedure and were recorded on videotapes. A second orthopaedic surgeon trained in arthroscopy independently reviewed the operative videotapes and graded the lesions. Assessment was obtained by consensus. There was minor discrepancy in the interpretation in four cases, and the difference was resolved in favour of the surgeon who had performed the arthroscopy.

MRI was performed in the axial plane on a 1.5-Tesla unit (Magnetom SP 4000, Siemens, Erlangen, Germany) with an extremity surface coil, section thickness of 3 mm, 10% interslice gap and imaging matrix of 256 × 256. T1- and T2-weighted images were obtained using the spin-echo (SE) and two-dimensional gradient-echo (GRE) pulse sequences. T1-weighted images were obtained with SE 540/15/2 (repetition time ms/echo time ms/acquisition) pulse sequences, examination time of 4.7 min and GRE 420/10/3, 73° flip angle, examination time of 5.5 min. T2-weighted images were obtained with SE 2100/20-80/1 pulse sequences, examination time of 9 min and GRE 544/18/3, 18° flip angle, examination time of 7 min.

MRIs were assessed by two experienced radiologists together. Chondral lesions were graded according to MRI criteria defined in Table 1 (Figs. 1 and 2).

**Table 2.** Indications for arthroscopy

| | *n* |
|---|---|
| Suspicion of a medial meniscus lesion | 15 |
| Suspicion of a lateral meniscus lesion | 5 |
| Anterior cruciate ligament rupture | 6 |
| Suspicion of a medial patellar plica | 2 |
| Anterior aspecific knee pain | 4 |
| Osteochondritis dissecans | 1 |

Radiologists and surgeons have reported their data using a patellar map, which divided the patellar surface into four quadrants. The patellar crest was included in the medial quadrants and the tip of the patella in the inferomedial quadrant.

The sensitivity and specificity of the MRI were obtained by the correlation quadrant per quadrant of both methods (normal or abnormal cartilage). Subsequently, the correlation of the grading was analysed. The sensitivity of the MRI was compared using the chi-square test. A *P*-value < 0.05 was considered significant.

## Results

Three of 33 patellae were normal at arthroscopy and had normal MRIs. On 30 patellae, 59 quadrants of abnormal cartilage were found at arthroscopy and 52 in MRI. Considering patellae, abnormal cartilage was found in only one quadrant 12 times in arthroscopy and 17 in MRI, in two quadrants 12 times in arthroscopy and 8 in MRI, in three quadrants once for both methods, and in four quadrants 5 times in arthroscopy and 4 in MRI. The distribution relating to the grade of the lesions and the results quadrant per quadrant are reported in Table 3.

The overall sensitivity of MRI was 84.7% (50/59) and the specificity 97.2% (71/73). The positive predictive value of MRI was 96.1% (50/52) and the negative predictive value 88.7% (71/80). The accuracy of MRI was 91.6% (121/132). No significant difference between both methods was found with chi-square test.

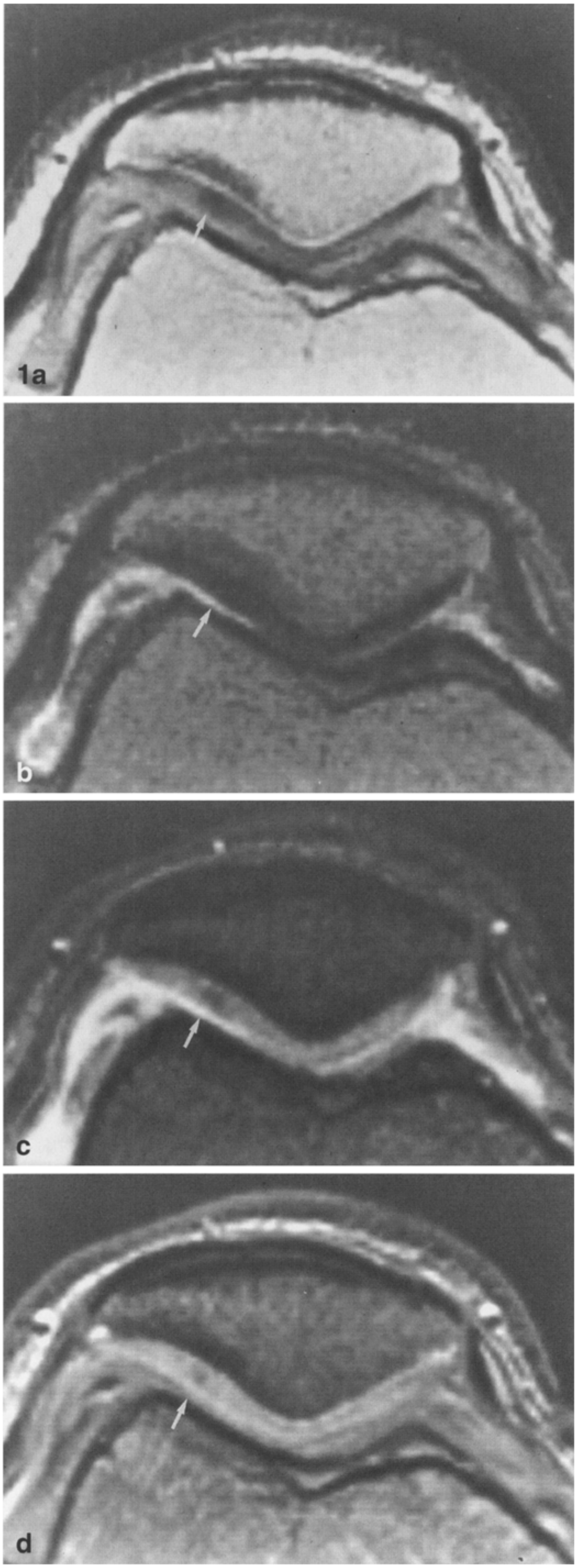
The two MRI false positives localised in the medial quadrants were explained by the "step pitfall" (Fig. 3) characterised by a sharp end of the medial facet that can be mistaken for a lesion in MRI. Among the MRI false negatives, a grade III lesion was missed on the tip of the patella, and a grade II localised lesion found arthroscopically as a horizontal deep fissure was not seen. In these two cases, MRI sagittal cuts probably would have been helpful to detect these lesions.

Considering grade I lesions, localised lesions were found occupying only one quadrant at arthroscopy in six patellae and were seen as well on MRIs. In seven false negatives, grade I lesions were seen at arthroscopy when other quadrants of pathologic cartilage were present on the same patellae. In these cases, lesions were detected in contiguous quadrants on MRIs, but the lesion size was underestimated.

A perfect correlation of grading was obtained in 76.5%. When a discordance was found, the MRI tendency was commonly to underestimate the grade of the lesions. However, two grade IV lesions in MRI were graded III at arthroscopy. Regarding the MRIs, arthroscopy may have underestimated the lesion depth in these two cases.

## Discussion

MRI assessment for cartilage lesion has been described in clinical reports analysing chondral lesions in knee pain or knee injuries [4, 6, 13, 18]. Assessing the MRI sensitivity in 28 injured knees, Speer et al. [18] reported on partial versus full cartilage thickness lesions and noted a signifi-



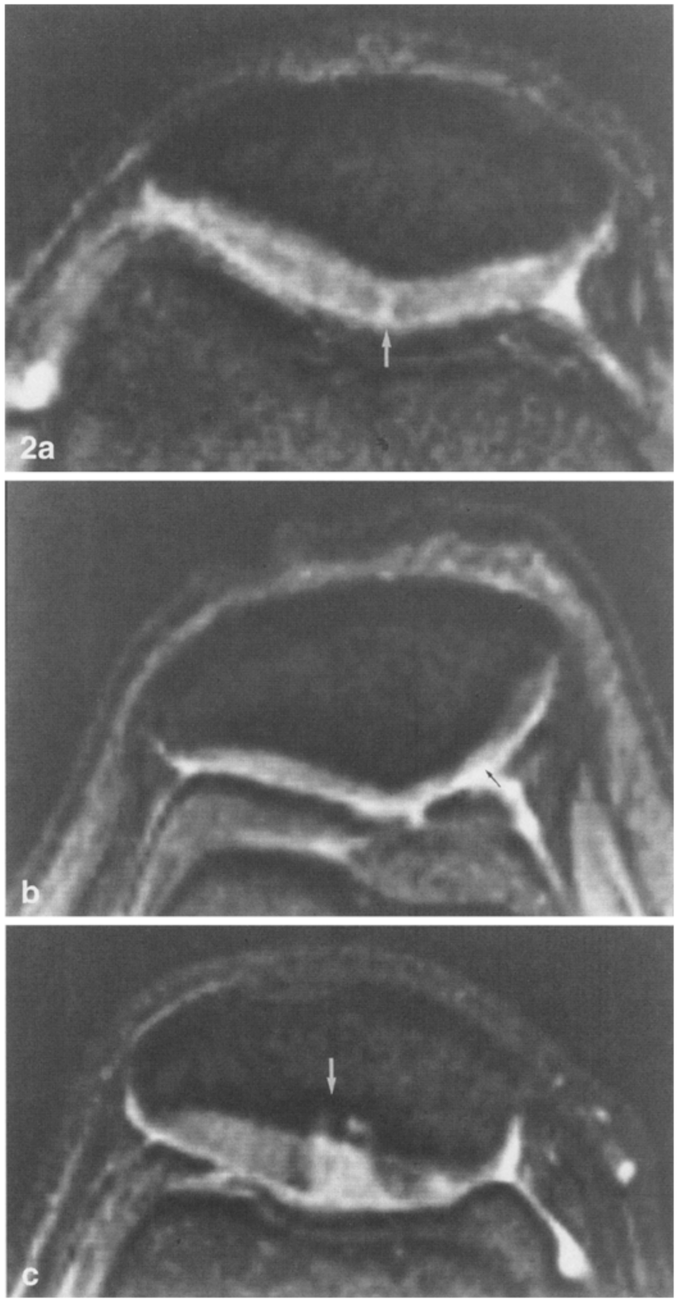
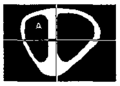
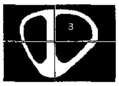
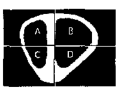




**Fig. 1 a–d.** Grade I lesion *(arrow)* shown as an hyposignal without discontinuity of the surface of the cartilage: **a** spin-echo T2 first echo; **b** spin-echo T2 second echo; **c** GRE T2; **d** GRE T1

**Fig. 2 a–c.** GRE T2 of grade II, III, IV lesions: **a** grade II, small, hyperintense lesion surrounded by hypointensity involving less than half of the depth of the cartilage *(arrow)*; **b** large grade III lesion *(arrow)* involving the deep layer of the cartilage; **c** extensive grade IV lesion *(arrow)* with the reaction of the subchondral bone

**Table 3.** Correlation between MRI and arthroscopy: quadrant A, supero-lateral; quadrant B, supero-medial; quadrant C, infero-lateral; quadrant D, infero-medial

| | MRI | | | | | |
|---|---|---|---|---|---|---|
|  | Grade | 0 | I | II | III | IV |
| Quadrant A | 0 | 24 | | | | |
| | I | 3 | 3 | | | |
| Arthroscopy | II | | 1 | 2 | | |
| | III | | | | | |
| | IV | | | | | |
|  | | | | | | |
| Quadrant B | 0 | 19 | | 2 | | |
| | I | 1 | 5 | | | |
| Arthroscopy | II | | 1 | 2 | | |
| | III | | | | 4 | |
| | IV | | | | | |
|  | | | | | | |
| Quadrant C | 0 | 21 | | | | |
| | I | 3 | 3 | | | |
| Arthroscopy | II | 1 | | 1 | | |
| | III | 1 | | 2 | 1 | |
| | IV | | | | | |
|  | | | | | | |
| Quadrant D | 0 | 7 | | | | |
| | I | | 7 | 1 | | |
| Arthroscopy | II | | 3 | 5 | | |
| | III | | | | 7 | 2 |
| | IV | | | | | |
|  | | | | | | |
| Quadrants A B C D | 0 | 71 | | 2 | | |
| | I | 7 | 18 | 1 | | |
| Arthroscopy | II | 1 | 5 | 10 | | |
| | III | 1 | | 2 | 12 | 2 |
| | IV | | | | | |

cant difference between prospective (range 15%–41%) and retrospective (range 55%–83%) values. Ochi et al. [13] underlined this trend and observed on 65 knees a MRI retrospective sensitivity of 14% for softening, 57% for cartilage fragmentation, 75% for erosion and 100% for loss of cartilage.

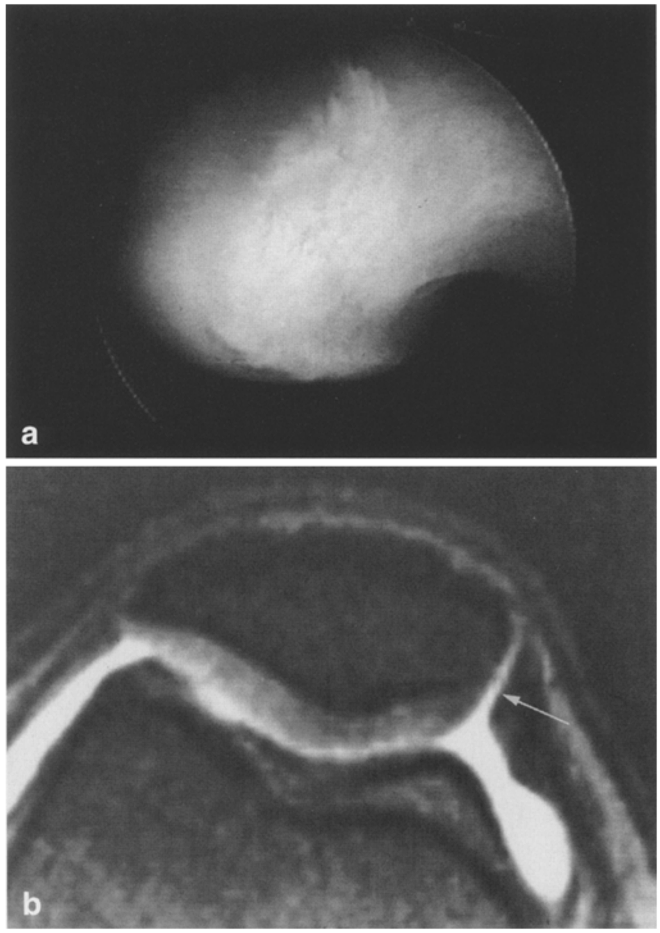



**Fig. 3 a, b. a** Arthroscopic image showing the sharp end of the medial facet of the patella that can be mistaken for a lesion on MRI. **b** T2 GRE MRI in the transverse plane showing the "step pitfall" *(arrow)*

MRI assessment for patellar cartilage lesions has been performed specifically [8, 9, 11, 21]. McCauley et al. [9] found in 52 patients with chondromalacia a MRI sensitivity of 86% and specificity of 74%. The results were not influenced by grade. Nakanishi et al. [11] studied 77 knees with patellar subluxation and found a MRI sensitivity of 50% for thickening, 85% for surface irregularity and 100% for loss of cartilage.

High MRI sensitivity "in vitro" has also been demonstrated for lesions affecting the cartilage surface in several studies [2, 3, 5, 16, 20]. However, cartilage softening cannot be appreciated with MRI in cadaveric knees.

In prior studies, the accuracy of MRI was poor for low-grade cartilage lesions [6, 11, 13, 18]. To investigate this issue, the inclusion criteria of this study did not specifically include patients with known patellar symptoms. As a result, more than two-thirds of the quadrants which were abnormal in our study had grade I or II lesions at arthroscopy. As shown in Table 3, a good correlation between MRI and arthroscopy was demonstrated in grade I and II lesions. However, MRI underestimated the lesion size in several cases when abnormal cartilage was detected in contiguous quadrants at arthroscopy. We considered arthroscopy as a "gold standard" and called these cases MRI false negatives. Nevertheless, to state precisely the border of a grade I lesion remains difficult for both methods.

Assessment of the patellar articular surface may be best accomplished using axial and sagittal views [6, 13, 18]. In the present study, only axial images were obtained, which limited our ability to detect horizontal or patellar tip lesions. Sagittal views consequently are recommended to complete patellar cartilage evaluation.

The choice of imaging sequences for cartilage evaluation has been controversial [4, 5, 6, 9, 16, 21]. T1-weighted images were found sufficient for observing anatomic detail by Yulish et al. [21]. In a further clinical study, Handelberg et al. [4] obtained a MRI accuracy of 81.5% using only T2 spin-echo pulse sequences in 70% of cases. The complementarity of T1- and T2-weighted images for predicting articular injury using MRI was demonstrated by Hayes et al. [5], and the criteria were improved. Gradient-refocused spin-echo sequences were advocated for cartilage assessment and were added to T1- and T2-weighted spin-echo sequences to improve MRI evaluation of the knee [6, 18]. In our study, T2-weighted GRE images were particularly effective in demonstrating low-grade lesions. However, we did not find abnormalities confined in the deep cartilage layer without surface lesions such as Handelberg et al. [4] described. Recht et al. [16] reported a blinded evaluation of several sequences on cadaveric knees and showed a high sensitivity of fat-suppressed spoiled gradient-recalled echo (SPGR) pulse sequences. More recently, magnetic transfer contrast (MTC) and subtractive techniques were also advocated for cartilage [15]. Further clinical studies are needed to confirm these promising results.

MR arthrography and joint compression have been advocated to improve MRI assessment for articular cartilage. The results of MR arthrography are controversial [2, 18] and, in our experience, an "arthrogram" effect produced in some cases by joint effusion was not helpful. Because arthrography is an invasive method, its benefits need to be clearly demonstrated prior to further use. Compression of the joint was suggested by Konig et al. [8] to provide a better diagnosis in grade I chondral lesions of the patella, but it was not found to be necessary in our study.

The main problem in correlating MRI and arthroscopic findings lies in the choice of a well-defined classification that could easily be used for both methods. Since Outerbridge and Dunlop [14], many classifications [1, 7, 12, 17] have been proposed to grade cartilage lesions at arthroscopy and, as originally described or with modifications, served in several MRI comparative studies [4, 9, 13]. Fibrillation, fragmentation, ulceration, fissuring, erosion and many others words were used to differentiate chondral lesions and were also variously translated into foreign languages. This formulation is inaccurate, and unequivocal criteria are needed.

We modified the Noyes and Craig scheme [12] according to MRI findings, and our study scheme applied to both techniques appeared reliable considering the MRI accuracy shown in this study. However, grade II and III lesions would be anatomically better differentiated by reference to a basal cartilage layer (either intact or damaged). In practical terms, estimation of the fraction of cartilage lost in reference to a cartilage thickness of greater than or less than 50% is correlated with anatomic damage despite variation of cartilage depth between patients and between regions of the patella. This reference makes classification easier for both radiologists and surgeons and should be recommended for future studies.

In conclusion, the accuracy of MRI in the diagnosis of chondral lesions was higher in this study than in previous investigations [9, 11, 13, 21]. This was not due to the patient population studied, because we included more patients with low-grade lesions, which are difficult to assess. Rather, our accuracy may have been the result of improved imaging sequences and the usefulness of our classification method.

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