Accuracy of T2-Weighted Fast Spin-Echo MR Imaging With Fat Saturation in Detecting Cartilage Defects in the Knee: Comparison with Arthroscopy in 130 Patients

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OBJECTIVE. The purpose of this study was to assess the accuracy of routine T2-weighted MR imaging in detecting and grading articular cartilage lesions in the knee compared with arthroscopy.

SUBJECTS AND METHODS. We examined 130 consecutive patients who underwent MR imaging and arthroscopy of the knee for suspected internal derangement. MR imaging consisted of axial and coronal T2-weighted fast spin-echo sequences with fat saturation and sagittal T2-weighted spin-echo sequences. Each single plane was evaluated and graded for the presence and appearance of articular cartilage defects using a standard arthroscopic grading scheme adapted to MR imaging.

RESULTS. Of the 86 arthroscopically proven abnormalities, 81 were detected on MR imaging. Sensitivity of the T2-weighted fast spin-echo sequence with fat saturation was 61% for the coronal plane alone and 59% for the axial plane alone. Specificity for each plane was 99%. Sensitivity for the sagittal T2-weighted spin-echo sequence was 40%, and specificity was 100%. Sensitivity of the combination of axial and coronal T2-weighted fast spin-echo sequences with fat saturation and sagittal T2-weighted spin-echo sequence compared with arthroscopy for revealing cartilage lesions was 94%, specificity was 99%, and accuracy was 98%. Sensitivity of coronal and axial T2-weighted fast spin-echo sequences with fat saturation was 93%, and specificity was 99%. Fifty-five lesions (64%) were identically graded on MR imaging and arthroscopy. Seventy-eight lesions (90%) were within one grade using MR imaging and arthroscopy, and 84 lesions (97%) were within two grades using MR imaging and arthroscopy.

CONCLUSION. T2-weighted fast spin-echo MR imaging with fat saturation is an accurate and fast technique for detecting and grading articular cartilage defects in the knee. The combination of the axial and coronal planes offers sufficient coverage of articular surfaces to provide a high sensitivity and specificity for chondral defects.

Hyaline cartilage is vital in maintaining normal joint function. The recent development of treatment methods for articular cartilage abnormalities and new insights into the pathophysiology of arthritic disorders have created a need for better ways of noninvasively evaluating diarthrodial joint structures, particularly articular cartilage [1, 2]. Special attention in this regard has focused on MR imaging because of its noninvasiveness, multiplanar capability, and excellent soft-tissue discrimination [3, 4]. Numerous MR imaging techniques are capable of delineating articular cartilage [5–18]; however, determining the most appropriate technique depends on the clinical or research question to be answered, and inherent trade-offs in availability, imaging time, spatial resolution, anatomic coverage, and sensitivity to early matrix damage always exist.

T2-weighted spin-echo and T2-weighted fast spin-echo imaging techniques are used in the routine evaluation of internal derangement of the knee [1, 5, 18, 19]. T2-weighted fast spin-echo imaging offers high contrast between the cartilage and adjacent synovial fluid and is sensitive to early matrix damage [1, 3, 19]. The sequence is routinely used in many centers to acquire T2 information about bone structure and ligament abnormalities.

The purpose of this study was to determine the diagnostic accuracy of these routine MR pulse sequences used in clinical practice for evaluating articular cartilage in the knee. We evaluated various combinations of coronal and axial T2-weighted fast spin-echo sequences with fat saturation and sagittal T2-weighted spin-echo sequences to assess chondral abnormalities and then compared the results with arthroscopy as the standard of reference.

Received September 16, 1998; accepted after revision October 14, 1998.

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AJR 1999;172:1073–1080

0361–803X/99/1724–1073

Subjects and Methods

During an 18-month period we prospectively studied 130 of 800 consecutive patients (48 women and 82 men; age range, 23–72 years old [mean, 41 years old]) who were referred for MR imaging of the knee and subsequently underwent arthroscopy. Those patients who were examined with MR imaging but who did not undergo arthroscopy were not included in the study. MR imaging was performed with a 1.5-T magnet (Signa; General Electric Medical Systems, Milwaukee, WI) using a commercially available transmit–receive extremity coil. Sequences included sagittal T2-weighted spin-echo images (TR/TE, 2000/80), coronal T2-weighted fast spin-echo images (3000/38), and axial T2-weighted spin-echo images (3200/54) with an echo train length of eight and frequency-selective fat presaturation. The different TEs of the coronal and axial plane of the T2-weighted fast spin-echo sequences were approximated by the scanner for given TRs and TEs that were entered. This variation of the TEs resulted in good image quality on our scanner. Coronal T1-weighted spin-echo (600/12) and sagittal proton density–weighted (2000/29) images were also included in the routine clinical protocol but not assessed in this study. Section thickness was 4 mm, intersection gap was 1 mm, field of view was 14 cm, and the matrix was 256 × 192 pixels. Two acquisitions were used for T1-weighted spin-echo and T2-weighted fast spin-echo sequences, and one acquisition was used for T2-weighted spin-echo sequences. Imaging time for the T2-weighted fast spin-echo sequences was 2.35 min for the coronal plane and 2.47 min for the axial plane; imaging time for the sagittal T2-weighted spin-echo sequence was 7.05 min.

The MR images were prospectively evaluated and graded by one experienced musculoskeletal radiologist at the time of each patient's initial examination. A general description of cartilage abnormalities with the location of the lesion but without exact grading was included in the report sent to the orthopedists. Exact MR imaging grading was recorded separately on a different database.

Six articular surfaces were assessed: patella, trochlear groove, medial and lateral femoral condyles, and medial and lateral tibial plateaus. The following grading system was applied: grade 0, normal; grade 1, signal intensity abnormality only; grade 2, surface irregularity; grade 3, partial-thickness loss not down to bone; grade 4, full-thickness loss down to bone. This grading system represents an adaptation of a commonly used arthroscopic grading system. Mild increased signal intensity within the hyaline cartilage oriented at 55° to the external magnetic field was believed to be caused by the magic angle phenomenon if the surface was regular and was considered to be normal.

All patients in this study underwent conventional knee arthroscopy, which was performed within 6 weeks after the MR examination. Each orthopedic surgeon had the MR imaging report with the location of the lesion but without the exact grading available to them at the time of surgery. On arthroscopy, the cartilage of each surface was graded on a 5-point scale: grade 0, normal; grade 1, softening; grade 2, shallow ulceration or blisterlike swelling; grade 3, deep ulceration or fibrillation not extending to bone; grade 4, ulceration with exposure of subchondral bone.

We also arbitrarily divided the grading system into early stages of chondromalacia (grades 1 and 2 together) and advanced stages of chondromalacia (grades 3 and 4 together).

After arthroscopy the MR images were compared with the arthroscopic reports together with the orthopedic surgeons to identify the exact location of the lesion on MR imaging and arthroscopy. The arthroscopic results were used as the standard of reference to determine sensitivity, specificity, and accuracy of each individual plane and the combination of planes for detecting and grading cartilage defects on MR imaging.

Results

Normal hyaline cartilage showed an intermediate signal intensity on T2-weighted fast spin-echo images with fat saturation that was easily differentiated from the high signal intensity of joint fluid and low signal intensity of the underlying subchondral endplate (Fig. 1). Mild increased signal intensity within the hyaline cartilage oriented at 55° to the external magnetic field was believed to be caused by the magic angle phenomenon if the surface contour was normal (Fig. 2). Our relatively short TEs (38 and 54 msec) on the T2-weighted fast spin-echo sequences incorporate a considerable short-TE effect, thus accounting for the magic angle phenomenon [20].

Eighty-six articular cartilage abnormalities were diagnosed in 36 of 130 patients on arthroscopy (Table 1). Using all sequences together and considering only detection of an arthroscopically observed defect, three false-positive results and five false-negative results were found on MR imaging. The five false-negative results on MR imaging involved three medial tibial plateau lesions and two trochlear groove lesions. The three

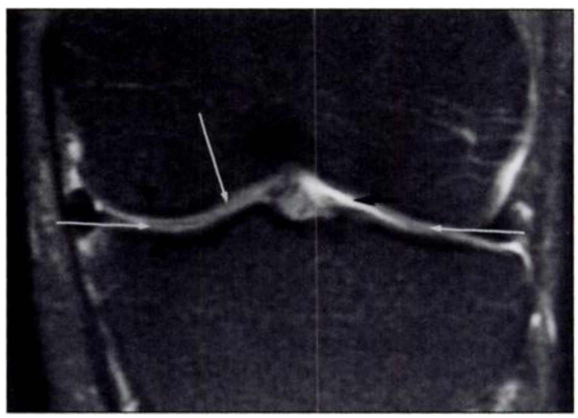

Fig. 1.—35-year-old man with normal articular cartilage. Coronal T2-weighted fast spin-echo image with fat saturation (TR/TE, 3000/38) shows intermediate signal intensity of normal articulator cartilage (*white arrows*) that can be easily differentiated from high signal intensity of joint fluid (*black arrow*) and low signal intensity of subchondral endplate (*arrowheads*).

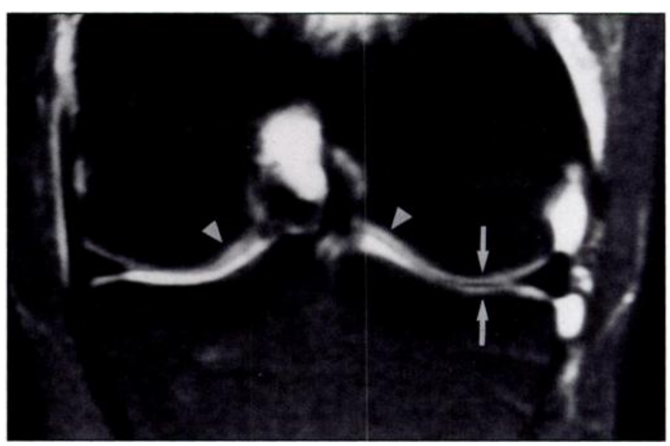

Fig. 2.—Normal hyaline cartilage in 23-year-old woman. Coronal T2-weighted fast spin-echo image with fat saturation (TR/TE, 3000/38) reveals normal thickness and signal intensity of hyaline articular cartilage of weight-bearing surfaces of lateral compartment (*arrows*). Increased signal intensity within curved portions of otherwise normal-thickness cartilage (*arrowheads*) is believed to represent magic angle phenomenon.

TABLE 1 Location and Grading of 86 Cartilage Lesions on Arthroscopy in 36 Patients

Site	Grade 1	Grade 2	Grade 3	Grade 4	Total
Lateral femoral condyle	2	2	6	2	12
Medial femoral condyle	4	4	11	4	23
Patella	7	8	7	6	28
Trochlear groove	3	3	2	3	11
Lateral tibial plateau	0	1	1	1	3
Medial tibial plateau	2	2	2	3	9

false-positive results involved the medial tibial plateau in one case, the medial femoral condyle in one case, and the patellar cartilage in one case.

Each imaging plane was evaluated separately for cartilage defects. Sensitivity for the detection of abnormal articular cartilage with T2-weighted fast spin-echo MR imaging with fat saturation was 61% for the coronal plane and 59% for the axial plane. Sensitivity for the sagittal T2-weighted spin-echo sequence was 40%. A high sensitivity could be obtained using the coronal and axial planes combined (93%). Sensitivity was 65% for the coronal and sagittal planes together and 69% for the axial and sagittal planes. The overall sensitivity of axial and coronal T2-weighted fast spin-echo sequences with fat saturation and sagittal T2-weighted spin-echo sequence together compared with arthroscopy in the detection of cartilage abnormalities was 94%, the specificity was 99%, and the accuracy was 98% (Table 2).

A total of 780 articular surfaces in 130 patients were graded on MR imaging and arthroscopy; 694 (89%) of these were considered normal (grade 0), and 86 (11%) were considered abnormal on the basis of arthroscopic findings (Figs. 3–7). Grading for the 86 abnormal surfaces was as follows: 18 were grade 1, 20 were grade 2, 29 were grade 3, and 19 were grade 4. Eighty-one of the 86 arthroscopically proven abnormal surfaces were detected on MR imaging; the five lesions that were not detected involved two grade 1 lesions, one grade 2 lesion (Fig. 8), one grade 3 lesion, and one grade 4 lesion. The three lesions that were false-positive on MR imaging consisted of one grade 1 lesion (Fig. 9), one grade 2 lesion, and one grade 3 lesion.

Of the 86 arthroscopically proven lesions, 55 (64%) were graded identically on arthroscopy and MR imaging. The 31 lesions that were not graded identically on MR imaging and arthroscopy differed by one grade in 23 cases, by two grades in six cases, and by more than two grades in two cases. Thus, 90% of the lesions were graded within one grade and 97% were within two grades. The 31 lesions that were not identically graded involved seven grade 1 lesions, 10 grade 2 lesions, five grade 3 lesions, and nine grade 4 lesions (Table 3).

Ten lesions were overgraded and 21 lesions were undergraded on MR imaging. The highest rates of disagreement between MR imaging and arthroscopic grades involved predominately the medial compartment of the knee. Six (26%) lesions of the medial femoral condyle and four (44%) lesions of the medial tibial plateau were not graded identically on MR imaging and arthroscopy.

T2-weighted fast spin-echo MR imaging with fat saturation showed a low sensitivity (61%) but a high specificity (93%) and accuracy (86%) in correctly grading early stages of chondromalacia (grade 1). Similar results were seen for grade 2 lesions (sensitivity, 50%; specificity, 86%; accuracy, 78%). T2-weighted fast spin-echo MR imaging with fat saturation was sensitive (83%) and specific (77%) in assessing grade 3 lesions. The accuracy for grade 3 lesions was 79%. For advanced stages of chondromalacia (grade 4), T2-weighted fast spin-echo MR imaging with fat saturation was specific (97%) and accurate (76%) but showed a relatively low sensitivity (53%) (Table 4).

Regarding grade 1 and grade 2 lesions together as early stages of chondromalacia, the sensitivity for correctly grading these lesions was 74%, specificity was 85%, and accuracy was 80%. For advanced stages of chondromalacia (grades 3 and 4 together), a high sensitivity (85%), specificity (80%), and accuracy (83%) could be obtained.

Fig. 3.—50-year-old man with grade 1 chondral defect. Axial T2-weighted fast spin-echo image with fat saturation (TR/TE, 3200/54) shows focus of high signal intensity in otherwise normal-thickness cartilage (*arrowhead*) that was interpreted as grade 1 lesion and confirmed by arthroscopy.

TABLE 2 Diagnostic Power of T2-Weighted MR Imaging for Revealing Cartilage Abnormalities in 130 Patients

Technique	Sensitivity (%)	Specificity (%)	Accuracy (%)
Axial and coronal T2-weighted fast spin-echo sequence with fat saturation and sagittal T2-weighted spin-echo sequence	94	99	98
Coronal T2-weighted fast spin-echo sequence with fat saturation	61	99	96
Axial T2-weighted fast spin-echo sequence with fat saturation	59	99	96
Sagittal T2-weighted spin-echo sequence	40	100	94
Axial and coronal T2-weighted fast spin-echo sequence with fat saturation	93	99	98
Coronal T2-weighted fast spin-echo sequence with fat saturation and sagittal T2-weighted spin-echo sequence	65	99	96
Axial T2-weighted fast spin-echo sequence with fat saturation and sagittal T2-weighted spin-echo sequence	69	99	97

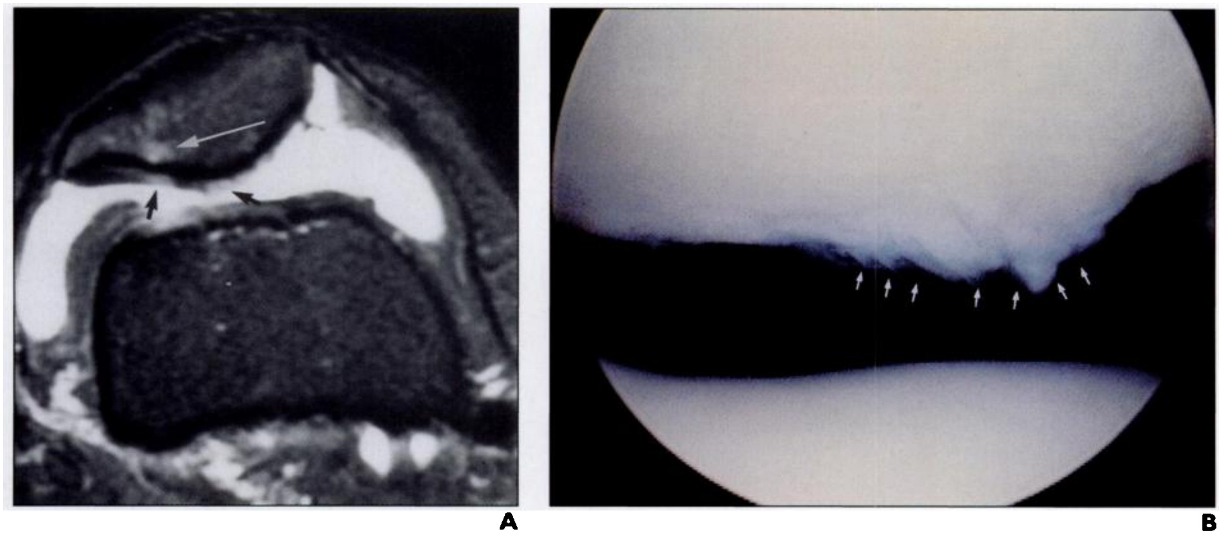

Fig. 4.—39-year-old woman with grade 2 patellar chondral lesion.
A, Axial T2-weighted fast spin-echo image with fat saturation (TR/TE, 3200/54) shows surface irregularity and increased signal intensity within patellar cartilage (*black arrows*) that was interpreted as grade 2 lesion and confirmed by arthroscopy. Note underlying bone marrow edema (*white arrow*) that is believed to represent early arthritic changes.
B, Arthroscopic photograph reveals fraying of patella (*arrows*) consistent with grade 2 chondromalacia.

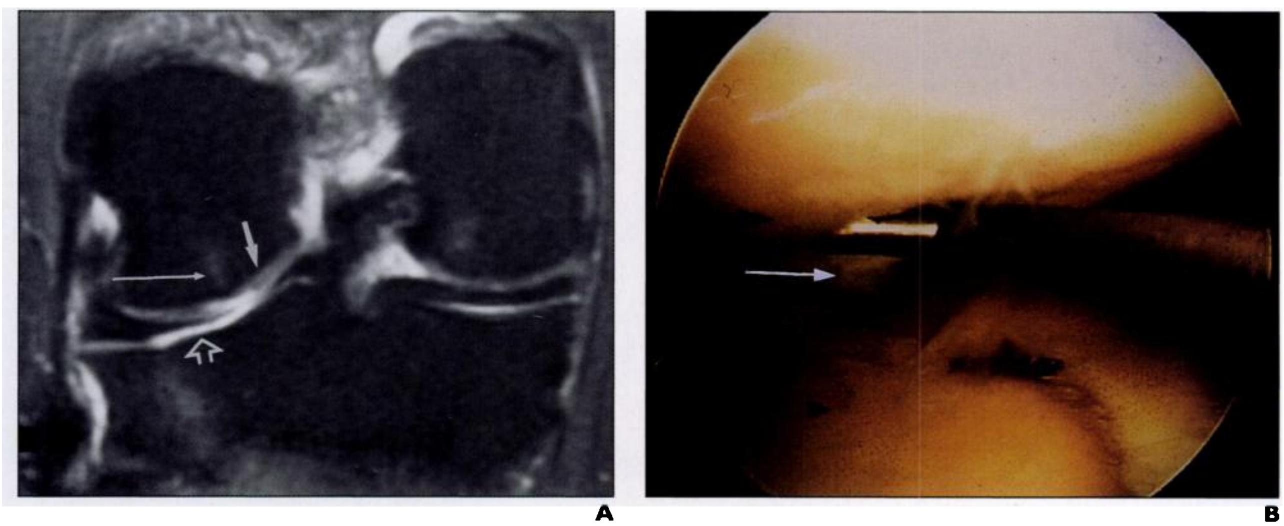

Fig. 5.—60-year-old woman with grade 3 chondromalacia.
A, Coronal T2-weighted fast spin-echo image with fat saturation (TR/TE, 3000/38) shows partial-thickness loss of hyaline cartilage of weight-bearing surface of lateral femoral condyle consistent with grade 3 lesion (*thick solid arrow*). Note small amount of bone marrow edema (*thin solid arrow*) indicating reactive change. Note chondromalacia of tibial plateau (*open arrow*) that was called grade 3 at MR imaging and grade 2 on arthroscopy.
B, Arthroscopic photograph shows flap of cartilage (*white arrow*) of lateral femoral condyle (*black arrow*) that is consistent with grade 3 chondromalacia. Arrowhead indicates lateral tibial plateau.

Eight patients (22%) had an isolated cartilage abnormality without other knee abnormalities. The remaining patients had meniscal tears (22 patients), abnormalities of the anterior and posterior cruciate ligaments (five patients), and abnormalities of the medial collateral ligament (one patient) associated with the cartilage defect.

Discussion

With the development of new therapeutic options for the treatment of hyaline cartilage defects [2, 21, 22], it becomes increasingly important to accurately and noninvasively diagnose cartilage lesions and monitor them after treatment. Cartilage integrity may have prognostic significance for patients undergoing meniscal surgery, and cartilage status may influence patient selection for chondrocyte transplantation or drug therapy [2, 21, 22]. Also, cartilage defects are sometimes the only abnormality found on arthroscopy and can be clinically confused with other types of injuries [21].

Accurate MR imaging evaluation of articular cartilage requires several conditions: good spatial resolution to detect small cartilage defects, good image contrast for signal intensity changes in cartilage, and reliable distinction of cartilage from adjacent joint fluid and subchondral bone to enable evaluation of thickness and contour of cartilage [23].

Many studies have been performed with various MR pulse sequences to evaluate hyaline cartilage, including T1-weighted, proton

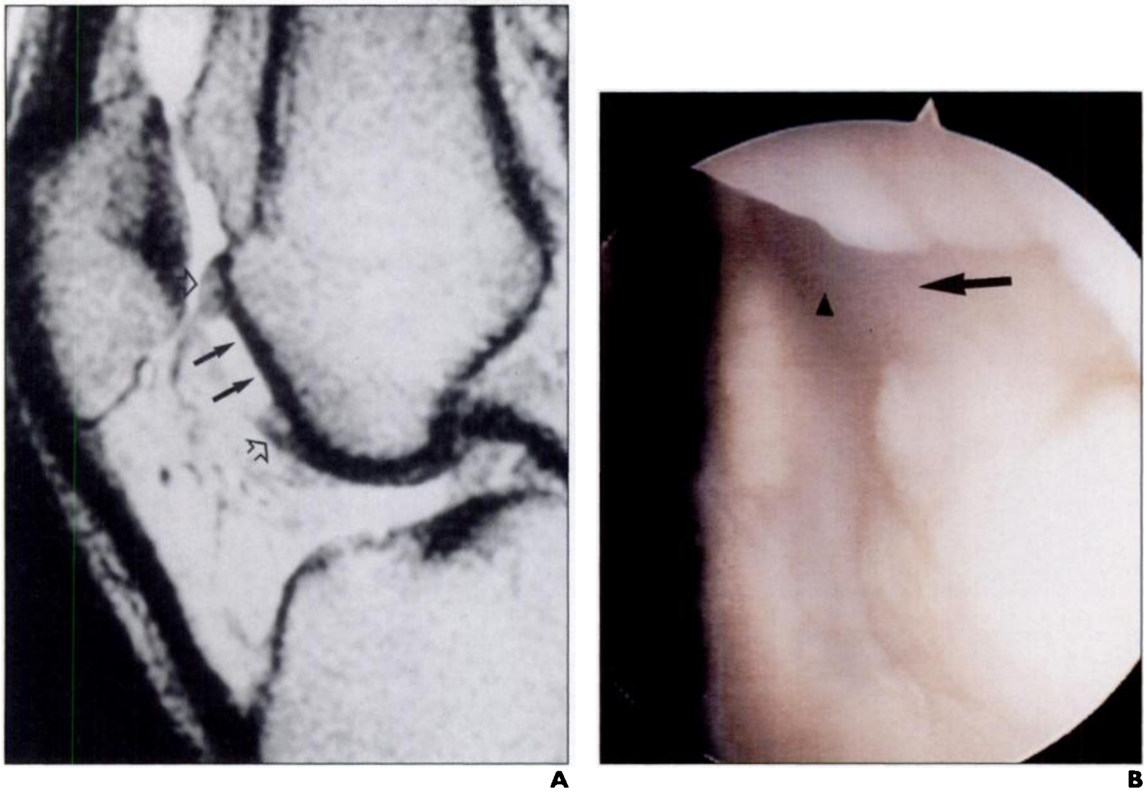

Fig. 6.—55-year-old man with grade 4 chondral lesion.
A, Sagittal T2-weighted spin-echo image (TR/TE, 2000/80) reveals large grade 4 chondral defect of femoral trochlear groove (*solid arrows*). Note normal-appearing cartilage of remainder of trochlear groove (*open arrows*).
B, Arthroscopic photograph of trochlear groove (*arrow*) reveals cartilage lesion with exposure of underlying subchondral endplate (*arrowhead*) that is consistent with grade 4 chondromalacia.

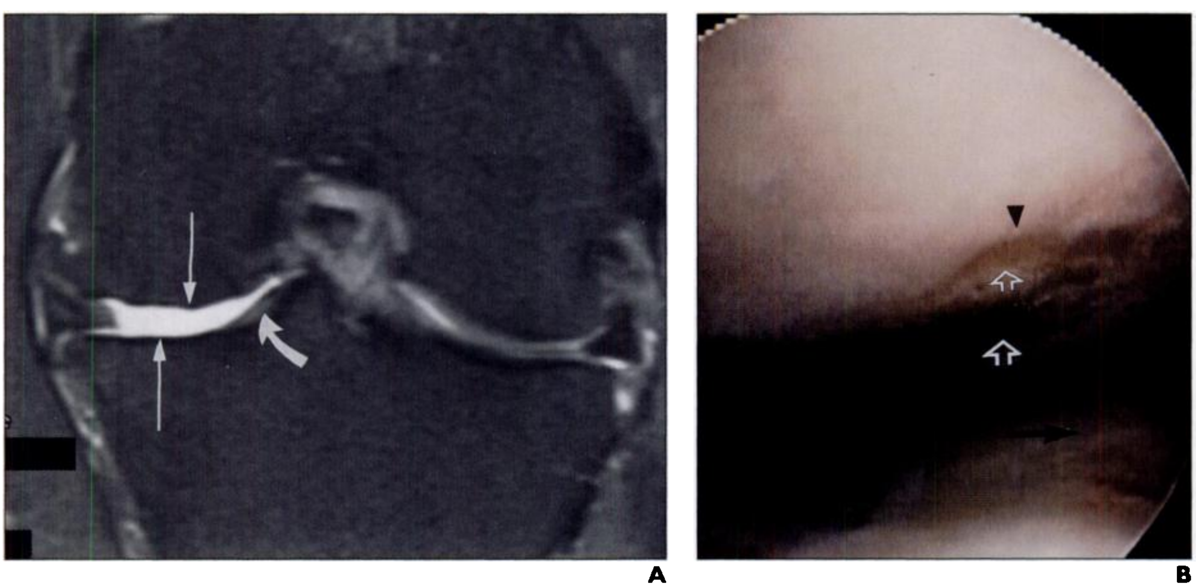

Fig. 7.—Grade 4 lesion in 67-year-old man.
A, Coronal T2-weighted fast spin-echo image with fat saturation (TR/TE, 3000/38) shows no evidence of hyaline cartilage along weight-bearing surfaces of medial tibial plateau and medial femoral condyle (*straight arrows*). Note remaining cartilage adjacent to tibial spine (*curved arrow*).
B, Arthroscopic photograph shows cartilage lesion of medial femoral condyle (*arrowhead*) down to bone (*open arrows*) that is consistent with grade 4 chondromalacia. Black arrow indicates medial tibial plateau.

Fig. 8.—Missed chondral defect in 40-year-old woman. Axial T2-weighted fast spin-echo image with fat saturation (TR/TE, 3200/54) reveals fluid filling chondral defect (*straight arrow*) reported as grade 3 arthroscopically but missed on MR imaging. Note normal-appearing hyaline cartilage covering remainder of posterior medial femoral condyle (*curved arrow*). Lesion is clearly visible but was not appreciated at initial MR interpretation.

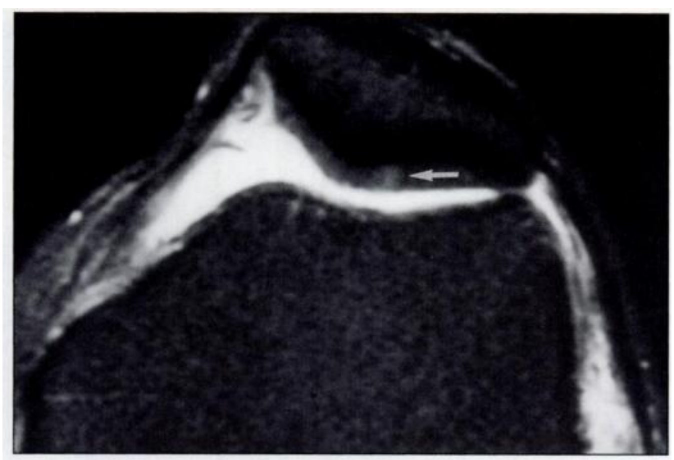

Fig. 9.—38-year-old man with medial knee pain. Axial T2-weighted fast spin-echo image with fat saturation (TR/TE, 3200/54) reveals area of increased signal intensity without surface irregularity of patellar cartilage (*arrow*) that was interpreted as grade 1 lesion on MR imaging but was not reported on arthroscopy.

TABLE 3 Grading of Articular Cartilage Lesions on MR Imaging and Arthroscopy in 130 Patients

Arthroscopy	MR Imaging					Total
	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	
Grade 0	691	1	1	1	0	694
Grade 1	2	11	4	1	0	18
Grade 2	1	3	10	4	2	20
Grade 3	1	1	3	24	0	29
Grade 4	1	0	1	7	10	19
Total	696	16	19	37	12	780

density–weighted, and T2-weighted spin-echo sequences, fat-suppressed sequences, two- and three-dimensional gradient-recalled echo sequences, and magnetization transfer contrast sequences [5–8, 10, 14, 15, 17, 24, 25].

However, the optimal sequence is still uncertain. Of the techniques most applicable to in vivo use with clinical scanners, fat-suppressed three-dimensional gradient-echo sequences have been reported to be the most useful for morphometric analysis of articular cartilage [5, 6, 16]. Disler et al. [5] found a sensitivity of 93% and a specificity of 94% in detecting cartilage defects in a study using fat-suppressed three-dimensional spoiled gradient-echo MR imaging. In a follow-up study with a larger patient group, Disler et al. [6] found a sensitivity of 75–85% and a specificity of 97% in detecting cartilage abnormalities in the knee. Sixty-three percent of the articular cartilage lesions were graded identically on MR imaging and arthroscopy, and 96% were within one grade. Recht et al. [15] reported a high sensitivity (81%) and specificity and accuracy (97%) using fat-suppressed three-dimensional spoiled gradient-echo sequences with a fast low-angle shot; 77% of their articular cartilage lesions were graded identically on MR imaging and arthroscopy.

Although fat-suppressed three-dimensional spoiled gradient-echo MR imaging has been shown to be sensitive and specific in detecting hyaline cartilage defects in the knee and can be reformatted into different planes, the sequence can be time-consuming, offers poor sensitivity for isolated matrix damage in the early stages of cartilage degeneration, and is vulnerable to metallic artifacts and uneven fat suppression [5, 6, 16].

Our study showed that the presence or absence of hyaline cartilage defects of the knee can be accurately assessed on T2-weighted spin-echo and fast spin-echo sequences that are routinely used in clinical practice. Conventional T2-weighted spin-echo sequences are time-consuming and generally offer an insufficient signal-to-noise ratio to support a high spatial resolution. However, T2-weighted fast spin-echo images provide heavy T2 weighting and high resolution in only a fraction of the time required for conventional spin-echo imaging [1, 3, 19, 26]. T2-weighted fast spin-echo images can offer greater contrast between cartilage and fluid than fat-suppressed T1-weighted images. However, the spatial resolution is generally lower than that possible with fat-suppressed three-dimensional spoiled gradient-echo MR

TABLE 4 Sensitivity, Specificity, and Accuracy[a] in Correctly Grading Chondromalacia in 36 Patients

Grade	Sensitivity (%)	Specificity (%)	Accuracy (%)
1	61	93	86
2	50	86	78
3	83	77	79
4	53	97	76

[a]Of T2-weighted spin-echo and T2-weighted fast spin-echo MR imaging.

imaging and, therefore, may be less accurate in depicting subtle morphologic changes. T2-weighted imaging is sensitive at detecting the early changes associated with chondromalacia. Collagen loss and increased water content in degenerating cartilage are associated with decreased T2 relaxation and increased proton density, both of which result in increased signal intensity on T2-weighted images [27]. Fat saturation is usually included in clinical imaging protocols to increase sensitivity for marrow abnormalities, but it also expands the dynamic range of T2-weighted images for subtle variations in cartilage signal and reduces chemical shift artifacts.

In our study T2-weighted fast spin-echo with fat saturation and T2-weighted spin-echo sequences were sensitive in detecting the presence of hyaline cartilage defects in the knee. The overall sensitivity of T2-weighted fast spin-echo with fat saturation and T2-weighted spin-echo sequences in detecting articular cartilage abnormalities was high (94%). However, each individual plane was insensitive when viewed in isolation. The most powerful combination was axial and coronal T2-weighted fast spin-echo sequences with fat saturation. These planes offered good coverage of the patellar and tibial cartilage and the weight-bearing and posterior femoral surfaces, leaving only portions of the femoral trochlea not well covered. The sagittal plane visualized each of these surfaces relatively well and offered good contrast between cartilage and adjacent structures, suggesting that its poor sensitivity for morphologic changes was caused by the intrinsically lower contrast than that of the T2-weighted fast spin-echo sequence. However, this is speculative because no direct comparison of sagittal T2-weighted fast spin-echo and T2-weighted spin-echo sequences was made.

T2-weighted fast spin-echo MR imaging with fat saturation was particularly sensitive to the early stages of chondromalacia. Sixteen of 18 arthroscopically proven grade 1 lesions were detected on MR imaging, but only 11 were graded identically: Four were believed to be grade 2 and one was interpreted as grade 3 on MR imaging. Fifty percent of grade 2 lesions and 83% of grade 3 lesions were graded identically on MR imaging and arthroscopy.

In the diagnosis of advanced stages of chondromalacia, T2-weighted fast spin-echo sequences with fat saturation were sensitive in detecting grade 4 lesions. Eighteen (95%) of 19 lesions were detected; however, only half (53%) of the lesions were graded the same as on arthroscopy.

We used a standard arthroscopic grading system adapted to MR imaging. This grading system is used widely. However, it is based purely on morphology, and the watershed for clinical decision making is undetermined and will vary for different types of treatment.

Depending on the clinical or research question being investigated, it might be important to differentiate between patients whose cartilage abnormalities are still superficial (grades 1 and 2) and who might profit from drug therapy and patients with advanced stages of chondromalacia (grades 3 and 4) in whom definite cartilage loss has already occurred and for whom treatment might require a chondrocyte transplantation or other surgical procedure [2, 21, 22]. We arbitrarily divided the grading system into early stages of chondromalacia (grades 1 and 2 together) and advanced stages of chondromalacia (grades 3 and 4 together). For superficial changes of articular cartilage (grades 1 and 2 together), the sensitivity and specificity were higher (74% and 85%, respectively) than for each grade alone. For advanced stages of chondromalacia (grades 3 and 4 together), the sensitivity was 85% and the specificity 80%. These findings indicate that the power of the technique and the interpretation of the data depend on the clinical or research question and could influence patient selection for different treatment options that might be available in the near future.

If it is clinically important to be sensitive and specific in differentiating between grade 1 and grade 2 lesions or between grade 3 and grade 4 lesions, the use of an additional imaging sequence such as fat-suppressed three-dimensional spoiled gradient-echo MR imaging can be useful. Thus, the choice of the imaging sequence is also dependent on the clinical or research question.

Cartilage abnormalities were more often undergraded than overgraded on the basis of MR imaging findings. We undergraded 21 surfaces; five surfaces interpreted as normal on MR imaging were given arthroscopic grades of 1 ($n = 2$), 2 ($n = 1$), 3 ($n = 1$), and 4 ($n = 1$).

In our study, the tendency of cartilage abnormalities to be underestimated with T2-weighted fast spin-echo MR imaging with fat saturation should be noted when using this technique in clinical practice—especially in advanced stages of chondromalacia (grade 4), where we undergraded nine (47%) of 19 lesions. In these cases, the subchondral endplate may not have been identified reliably, thus leading to false assumptions of the actual depth of the cartilage abnormality.

Our study had several limitations. The first is that the orthopedic surgeons had the MR imaging reports available to them at the time of surgery, which was a potential source of bias. Second, arthroscopy is an imperfect standard of reference, and its accuracy in the evaluation of cartilaginous disorders has been questioned [28]. Arthroscopy may be successful in detecting surface chondral lesions, but because it visualizes only surfaces unless the subchondral bone is exposed, estimating the depth of a lesion is inherently inaccurate. In addition, blind spots in the joint are difficult to assess properly on arthroscopy.

Another limitation of our study was the lack of inter- and intraobserver reproducibility because the MR images were evaluated by one experienced radiologist. However, excellent inter- and intraobserver reproducibility in the assessment of cartilage abnormalities has been reported [11, 13].

It would have also been interesting to include sagittal T2-weighted fast spin-echo imaging with fat saturation and fat-suppressed three-dimensional spoiled gradient-echo MR imaging for more thorough comparative evaluation.

In conclusion, our study shows that routine imaging techniques may offer more than the prevailing opinion would suggest in assessing articular cartilage. T2-weighted fast spin-echo imaging with fat saturation is a noninvasive and rapid imaging method that offers high sensitivity in detecting hyaline cartilage defects in the knee. As the importance of disorders affecting the articular cartilage gains wider appreciation and new therapies for these disorders approach clinical use, the usefulness of T2-weighted fast spin-echo sequences for evaluating the integrity of cartilage will become increasingly important.

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