MRI preferable to diagnostic arthroscopy in knee joint injuries

A double-blind comparison of 47 patients

Eli D Rappeport[1], Steen B Wieslander[1], Snorre Stephensen[2], Gunnar S Lausten[2] and Henrik S Thomsen[1]

We compared the findings of low-field MRI of the knee with those of subsequent arthroscopy. In a double-blind set-up, 47 patients with knee joint injuries were enrolled. Two radiologists independently interpreted the MRI examinations and consensus was obtained in case of discrepancy. Arthroscopy was performed without knowledge of the MRI findings.

The accuracy rates of MRI for evaluating the medial meniscus, lateral meniscus and anterior cruciate ligament were 77%, 91% and 96%, respectively, when arthroscopy was considered the "golden standard". When MRI was considered the standard, the figures for arthroscopy were 74%, 91% and 96%. MRI found the indication for treatment in 18 of 21 patients who were treated at the arthroscopy. In 17 patients, neither MRI nor arthroscopy detected any lesion. In the remaining 9 patients, MRI demonstrated a lesion, but no lesion was found at the subsequent arthroscopy.

Our conclusion is that low-field MRI can be used as a first-line diagnostic examination in patients with suspected meniscus or cruciate ligament injuries and thus a substantial number of negative diagnostic arthroscopies can be avoided.

Departments of [1]Diagnostic Radiology and [2]Orthopedics, Herlev Hospital, University of Copenhagen, Herlev Ringvej, DK-2730 Herlev, Denmark. Tel +45-44 53 53 00. Fax -42 91 04 80 (after July 29, 1997 -44 91 04 80). Correspondence: Dr. Henrik S. Thomsen
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MRI is now well established as the best imaging for noninvasive evaluation of the knee (Glashow et al. 1989, Fischer et al. 1991, Heron and Calvert 1992, Heron 1993), but the question of diagnostic and/or economic superiority has been much disputed as regards the field strength of the magnet (Parizel et al. 1995, Ziedses des Plantes and Koster 1995). High-field MRI systems theoretically provide a better signal-to-noise ratio and permit shorter acquisition times than low-field MRI systems do but the latter seem to be fully or partially able to overcome these limitations since their technology improved (Kersting-Sommerhoff et al. 1995). Therefore we undertook a prospective study comparing the findings of low-field MRI of the knee with those of subsequent arthroscopy in patients having knee joint injuries, in order to assess how far MRI can reduce the need for diagnostic arthroscopy.

Patients and methods

50 patients (age 19–54 years; 34 men) with suspected meniscus/cruciate ligament injuries of the knee and/or suspected intraarticular loose bodies scheduled to undergo arthroscopy during the period October 1994–January 1996 participated in this study after giving informed consent. The study was approved by the local ethics committee. After signing informed consent, 3 patients refused arthroscopy, mainly because of improvement in symptoms before arthroscopy was scheduled. Therefore, 47 patients were evaluable at the end of the study.

MRI-examination

All participants had an MRI examination prior to arthroscopy. The examinations were performed on a 0.1 Tesla (T) resistive magnetic imager (Merit®, Picker Nordstar Co., Helsinki, Finland), using a commercially available quadrature coil for knees.

The following sequences were performed:

a) sagittal gradient-echo 3D T1-weighted and Repetition time (TR)/Echo time (TE) of 115/25 ms, slice thickness 4.0 mm, acquisition time 11:47,
b) coronal gradient-echo 3D T1-weighted and TR/TE of 115/25 ms, slice thickness 4.0 mm, acquisition time 11:47,
c) sagittal gradient-echo 2D T2-weighted and TR/TE

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Table 1. Sensitivity, specificity and accuracy of MRI and arthroscopy. Figures for MRI calculated using arthroscopy as the standard. Figures for arthroscopy calculated using MRI as the standard

	Medial meniscus		Lateral meniscus		ACL	
	MRI	Arthroscopy	MRI	Arthroscopy	MRI	Arthroscopy
True positives	12	12	2	2	8	8
True negatives	24	23	41	41	37	37
False positives	9	2	1	3	1	1
False negatives	2	10	3	1	1	1
Sensitivity (%)	86	55	40	67	89	89
Specificity (%)	73	92	98	93	97	97
Accuracy (%)	77	74	91	91	96	96

ACL anterior cruciate ligament, MRI magnetic resonance imaging
Sensitivity true positives/(True positives+False negatives) × 100%
Specificity true negatives/(True negatives+False positives) × 100%
Accuracy (True positives+True negatives)/Total number of patients × 100%

of 1500/40 ms, slice thickness 5.0 mm, acquisition time 9:36.

The MRI interpretation was conducted by two radiologists (SBW) and (EDR). They performed their interpretations independently of each other and without any knowledge of the patient's clinical history, suspected diagnosis or radiographs of the knee. In case of discrepancy between the two radiologists, a third evaluation was performed by a third radiologist (HST).

The status of the menisci, cruciate ligaments, cartilage and subchondral bone was registered. A meniscal tear was considered present if a high intensity signal was present in the meniscus and this extended to the surface on two contiguous slices or if the overall contour of the meniscus was disrupted. A diagnosis of cruciate ligament lesion required at least one of the following findings: the ligament was in an abnormal position, it could not be identified, it was discontinuous or there was an abnormally high intensity signal in the course of the cruciate ligament.

Arthroscopy

Arthroscopy was performed by specialists in orthopedics, using a standard approach without knowledge of the result of the MRI examination.

MRI and arthroscopy findings were correlated only at the end of the study.

Statistics

Sensitivity, specificity and accuracy of MRI and arthroscopy were calculated using arthroscopy and MRI as golden standards, respectively.

Sensitivity was calculated as true positives/(true positives+false negatives) × 100%.

Specificity was calculated as true negatives/(true negatives+false positives) × 100%.

Accuracy was calculated as (true positives+true negatives)/total number of patients × 100%.

Interobserver agreement was evaluated with kappa-testing.

Results

Medial meniscus

Arthroscopy revealed 14 tears of the medial meniscus in 47 patients (Table 1, Figure 1), whereas the 2 radiological observers found 21 tears. The radiological observers agreed on 9 lesions which were not seen at arthroscopy. The 2 tears seen at arthroscopy, but not at MRI, were a flap tear in the posterior horn and a lesion described as a sequela from an older lesion on the outer edge of the meniscus.

Lateral meniscus

Arthroscopy revealed 5 tears of the lateral meniscus whereas the two radiological observers found 3 (Table 1). The radiologists diagnosed 2 bucket-handle tears. The remaining 3 tears seen at arthroscopy but not at MRI were all tears of the posterior horn. 2 of these 3 tears not seen at MRI were in patients who had a bucket-handle tear of the medial meniscus and a complete lesion of the anterior cruciate ligament. These lesions were correctly diagnosed at MRI in both patients.

Cruciate ligaments

Arthroscopy revealed 7 complete and 2 partial lesions of the anterior cruciate ligament, whereas at MRI 9 complete lesions were found (Table 1). There was total agreement in 6 patients with complete lesions (Figure 2). MRI overlooked 1 anterior cruciate ligament lesion which was found to be complete at ar-

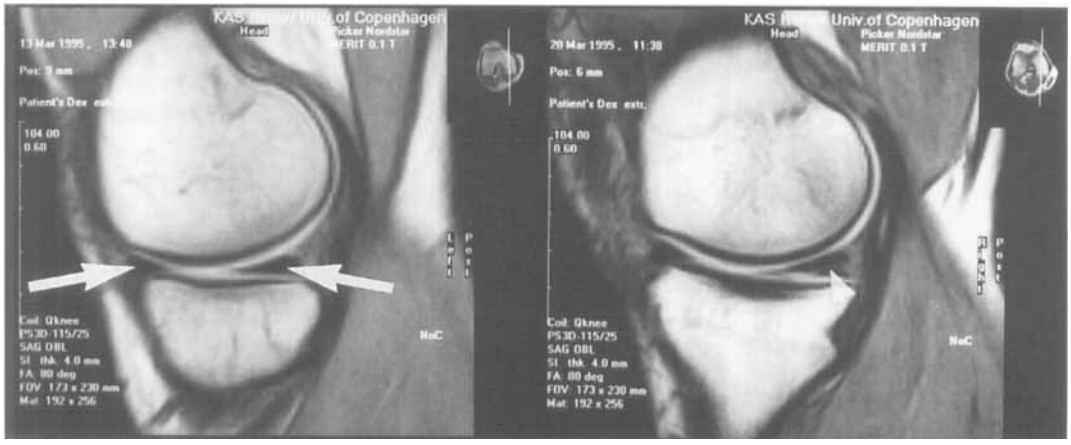

Figure 1. Sagittal T1-weighted image which shows the normal medial meniscus as a triangular structure of low signal intensity. Anterior and posterior horns (arrows).

Sagittal T1-weighted image showing a meniscal tear in the posterior horn of the medial meniscus. The tear appears as a line of high signal intensity, extending to the meniscal surface (arrowhead).

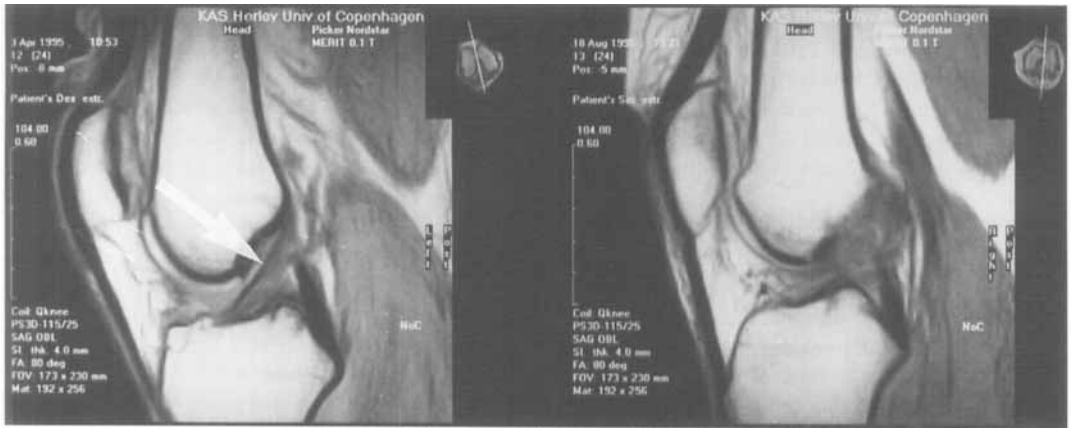

Figure 2. Sagittal T1-weighted image showing the normal anterior cruciate ligament as a band of low signal intensity (arrow), almost parallel to the femoral intercondylar roof.

Sagittal T1-weighted image showing a complete lesion of the anterior cruciate ligament which is not visible in its normal position.

throscopy, whereas the 2 lesions classified as partial at arthroscopy were considered as complete at MRI. Furthermore, MRI revealed 1 other lesion of the anterior cruciate ligament. The anterior cruciate ligament of this patient was considered intact at arthroscopy. Neither arthroscopy nor MRI revealed any lesions of the posterior cruciate ligament.

Other findings

Arthroscopy revealed 3 cases of osteochondritis dissecans of the medial femoral condyle, which were all detected at MRI. The radiologists classified 1 additional lesion of the medial femoral condyle as osteochondritis dissecans but whereas no abnormality was demonstrated at arthroscopy. 2 cases of chondromalacia patellae were diagnosed at arthroscopy, but none of the lesions was diagnosed at MRI. MRI revealed 1 additional chondromalacia patellae lesion not seen at arthroscopy. In the remaining patients, no cartilage lesions of importance were found either at arthroscopy or at MRI.

MRI detected 1 of 2 suprapatellar medial plicae seen at arthroscopy. 3 patients had intraarticular loose bodies at arthroscopy, of which the loose bodies in 1 patient were detected at MRI.

1 patient at MRI had a depressed fracture of the lateral tibial condyle, with extensive intramedullary edema. At arthroscopy, this patient had an older healed lesion of the lateral meniscus not requiring surgical treatment and no bony lesion was recognized.

17 of the 47 patients would have avoided a diagnostic arthroscopy in which no surgically treatable le-

Table 2. Sensitivity, specificity and accuracy (%) of MRI for menisci and ACL in the literature. The references are listed in order of magnetic field strength (Tesla) of the MRI-system

		Medial meniscus			Lateral meniscus			ACL		
Reference	Tesla	A	B	C	A	B	C	A	B	C
D'Erme et al. 1992 [a]	0.064	92	86	85			100	80	82	
Kinnunen et al. 1994	0.100	88	80	82	25	97	88	83	85	85
Grevitt et al. 1992	0.200	92	90	91	88	98	96	100	80	82
Kersting-Sommerhoff et al. 1995 [b]	0.200	73	76	75	33	98	85	95	87	90
	1.500	87	87	85	44	94	90	86	87	85
Glashow et al. 1989	0.350	77	71	74	93	94	94	61	82	72
Barronian et al. 1989	0.350	88	72	78						
Raunest et al. 1991	1.500	94	37	72	78	69	72			
Spiers et al. 1993	1.500	100	71		100		92	100	98	

ACL anterior cruciate ligament
Calculations of sensitivity, specificity and accuracy, as specified in Table 1: A Sensitivity, B Specificity, C Accuracy.
[a] No distinction made between medial and lateral menisci in the reference
[b] All patients underwent both 0.2 T and 1.5 T MRI

sion was found if MRI had been performed instead of diagnostic arthroscopy. 21 patients had lesions which were treated surgically at arthroscopy. MRI found indications for therapeutic arthroscopy in 18 of these patients. In 9 patients, MRI demonstrated a lesion but at a subsequent arthroscopy no lesion was present.

Interobserver agreement

Regarding the medial meniscus, the 2 radiologists agreed in 83% of patients. With kappa-testing, which takes agreement by chance into account, a kappa-value of 0.66 was found. Regarding the lateral meniscus, there was agreement in 96% of patients; the kappa-value was 0.77. Regarding the anterior cruciate ligament, the agreement was 98% and the kappa-value 0.94.

Discussion

Several double-blind studies comparing MRI and arthroscopy of the knee have been published (Barronian et al. 1989, Glashow et al. 1989, Raunest et al. 1991, D'Erme et al. 1992, Grevitt et al. 1992, Spiers et al. 1993, Kinnunen et al. 1994, Kersting-Sommerhoff et al. 1995). 4 of the studies used magnets with a field strength of less than 0.3 T, ranging from 0.064 T (D'Erme et al. 1992) to 0.2 T (Kersting-Sommerhoff et al. 1995). In general, the results of these 4 studies are not different from results of the double-blind studies using high- and intermediate field magnets (Barronian et al. 1989, Glashow et al. 1989, Raunest et al. 1991, Spiers et al. 1993). In one of the studies (Kersting-Sommerhoff et al. 1995), all 20 patients underwent two MRI examinations, one with a 0.2 T dedicated joint MRI-system and one with a 1.5 T whole-body scanner. No major differences in diagnostic accuracy were detected between the two MRI examinations. The literature reveals (Table 2) no clear-cut relationship between magnetic field strength and diagnostic performance. Our findings are in accordance with this. 10 meniscal tears were seen at MRI, but not at arthroscopy. All were very sucpiciously like meniscal tears, fullfilling the MRI criteria, but the arthroscopy records all described the meniscus as intact. 1 patient with a normal arthroscopy and a tear of the medial meniscus seen at MRI agreed to re-arthroscopy and the tear was found.

MRI very easily detected intact lateral menisci and the specificity was 98%. However, only 2 of 5 arthroscopically-proven tears of the lateral meniscus were detected at MRI. Both tears were of bucket-handle type. The remaining 3 tears were described at arthroscopy as very small flap tears (2 cases) and a possible older tear (1 case).

The lower sensitivity of detecting tears of the lateral meniscus by MRI is well known (Table 2), although the numbers are conflicting, with sensitivity ranging from 25% to 100%. One study concluded that, if a tear of the lateral meniscus is suspected, MRI cannot be recommended (Kinnunen et al. 1994). On the other hand, it is well known that the clinical examination of the knee is often inaccurate (Simonsen et al. 1984, Fowler and Lubliner 1989). This is substantiated in our study by the fact that only 1 of the 5 tears of the lateral meniscus was suspected clinically and 5 other patients with suspected tears had intact lateral menisci at arthroscopy.

There is no relationship between magnetic field strength and diagnostic performance with regard to

the cruciate ligaments (Table 2). Our MRI accuracy rate of 96% for evaluating the status of the anterior cruciate ligament is about the same as in these studies. The 2 arthroscopically-proven partial lesions of the anterior cruciate ligament were diagnosed at MRI as complete lesions, illustrating the difficulty of distinguishing between complete and partial lesions of the anterior cruciate ligament with this technique. The high specificity of MRI of 97% emphasizes that a the diagnosis of an intact anterior cruciate ligament is a very reliable finding. 1 patient with a complete lesion of the anterior cruciate ligament at arthroscopy was judged as having an intact anterior cruciate ligament at MRI. In 1 patient with a normal anterior cruciate ligament, both radiologists independently described a complete lesion of the anterior cruciate ligament.

Chondromalacia patellae is diagnosed at MRI when the cartilage shows changes in signal intensity, when the cartilage is irregular and thinned, when joint fluid extends into the cartilage or there is focal bone exposure (Berquist 1996). The relatively low rate of detection of chondromalacia patellae in this study can partly be explained because it did not include MRI images in the axial plane, which is the best for evaluating the femoropatellar joint.

It has been shown that arthroscopy cannot detect all meniscal lesions (Gillies and Seligson 1979) and probably is highly dependent on the experience and skills of the arthroscopist. It is probable that some of the false-positive meniscal lesions found at MRI would have been found at arthroscopy, if the surgeon had been advised preoperatively by the radiologist to look for that lesion. This raises the problem of comparing MRI with a potential—not perfect standard—but the only one available in practice. Therefore we also calculated the sensitivity, specificity and accuracy of arthroscopy, considering the MRI findings to be the standard (Table 1). It is striking that the accuracy figures are almost identical, independently of the standard used.

Regarding interobserver agreement, kappa-values below 0.40 are considered to show poor agreement, values between 0.40 and 0.75 fair-to-good agreement and values exceeding 0.75 excellent agreement. Using these guidelines, the interobserver agreement in the MR evaluation of the menisci and anterior cruciate ligament was good-to-excellent and highest for the anterior cruciate ligament.

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