# MRI of the knee cost-efffective use

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# CHAPTER 4

## Only MR can safely exclude Patients from Arthroscopy

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## 4.1. Abstract

*Objective* The aim of this study was to determine in patients with subacute knee complaints and normal standardized physical examination the fraction of magnetic resonance imaging (MRI) studies showing arthroscopically treatable intra-articular pathology.

*Materials and methods* There were 290 consecutive patients (between 16 and 45 years) with at least 4 weeks of knee complaints and low clinical suspicion of intra-articular pathology based on physical exam. Two hundred seventyfour patients were included. Sixteen patients with prior knee surgery, rheumatic arthritis, or severe osteoarthritis were excluded. MRI was used to assign patients to group 1 (treatable abnormalities) or group 2 (normal or no treatable findings), depending on whether MR demonstrated treatable pathology. Arthroscopy was performed in group 1 patients. If symptoms persisted for 3 months in group 2 patients, cross over to arthroscopy was allowed.

*Results* MR showed treatable pathology in 73 patients (26.6%). Arthroscopy was performed in 64 patients of 73 patients (group 1). In 52 patients (81.3%, 95% confidence interval (CI) 71.4-91.1%), arthroscopy was therapeutic. Of the 13 arthroscopies (6.5%) in group 2, four were therapeutic (30.8%, 95% CI 1.7-59.8). The highest fraction of MR studies showing treatable pathology was found in males, aged over 30 years, with a history of effusion (54.5%, six of 11 patients).

*Conclusion* Authors believe that the negative predictive value of clinical assessment in patients with subacute knee complaints is too low to exclude these patients from MR. MR should at least be considered in male patients aged 30 years and over with a history of effusion.

## 4.2. Introduction

The decision to perform arthroscopy or magnetic resonance (MR) imaging of the knee is based on clinical assessment. Diagnostic and/or therapeutic procedures are scheduled based on clinical assessment that is equivocal or that reveal abnormal findings. If clinical assessment is normal and the suspicion for intra-articular pathology is therefore low or absent, MR imaging is not indicated since the yield is expected to be low. This strategy relies on good positive and negative predictive values of clinical assessment of the knee. Among others, Terry et al. concluded that '…a thorough clinical assessment can provide sufficient information for the surgeon to make a definitive primary operative diagnosis...' without additional imaging in patients with knee complaints [(1)]. Ruwe et al. were one of the first to show that the positive predictive value of clinical assessment is limited [(2)]. These authors and others only studied patients undergoing arthroscopy based on abnormal clinical findings. Patients with a negative clinical assessment and therefore no arthroscopy were not included. The results are consequently skewed by verification bias [(3)].

The purpose of this study was to determine prospectively the fraction of MR imaging studies showing arthroscopically treatable intra-articular pathology in patients with subacute knee complaints who should, according to guidelines established by the Dutch Orthopedic Society and the Dutch Institute for Health Care Improvement [(4)], not proceed to additional diagnostic procedures because of normal standardized physical examination. In addition, we tried to identify clinical (sub-) groups with an above or below average yield of these MR studies.

## 4.3. Materials and methods

The internal review board of each participating hospital approved the study. We obtained written informed consent from all patients. During the first visit, the (orthopedic) surgeon took a standardized interview, including assessment of pain, history of trauma, joint effusion, instability, and locking. The impact of these data and the impact of gender and age (divided in two groups -30 years or younger and older than 30 years) of patients on the outcome of MR were studied using logistic regression (SPSS statistical package, version 10.0; SPSS Statistical Package, version 10.0).

Inclusion criteria were at least 4 weeks of knee complaints (pain, swelling of the joint, feeling of instability or giving way, history of locking), age between 16 and 45 years, and low clinical suspicion on intra-articular pathology based on normal standardized physical exam. A negative physical exam was defined as no soft tissue swelling, no marked joint effusion (no 'bulge sign' [ie, a visible bulge next to the patella caused by displacement of fluid and indicative for effusion]), no quadriceps muscle

atrophy, no ligamental instability, no loss of range of joint motion, and negative meniscal provocation tests. Ligament instability was considered to be present if there was instability of the knee when applying varus and/or valgus stress. Joint instability was also considered to be present when the anterior and/or posterior drawer test and/or Lachman's test were positive [5]. Loss of range of motion was considered to be present when there was a difference of maximum flexion of more than 20° or extension of more than 10° between the symptomatic and asymptomatic extremity. Meniscal provocation tests were performed according to McMurray and Apley [5]. Pain in the popliteal fossa during hyperflexion (squad test) was also regarded as a positive meniscal provocation test.

Arthroscopy should not be performed in patients with a negative physical exam according to criteria established by the Dutch Orthopedic Society and the Dutch Institute for Health Care Improvement [4].

Exclusion criteria were previous surgery of the affected knee (including arthroscopy), fracture, rheumatoid arthritis, osteoarthritis Kellgren grade 4 [6], clinical retropatellar pain syndrome, previous MR imaging, or MR imaging unavailable for evaluation.

A total of 962 consecutive patients with at least 4 weeks of knee complaints visited the participating (orthopedic) surgical department of two general and one university hospital. Physical exam was performed by one of 17 (orthopedic) surgeons (with 1-21 years experience) or by residents under their supervision. Two hundred ninety patients had a negative physical examination according to the guidelines of the Dutch Orthopedic Society and thus were eligible for inclusion. Twenty-six patients (9.5%) were excluded because of the aforementioned exclusion criteria, leaving 274 patients as our study population. Mean age of the 274 included patients was 31.2 (standard deviation 7.8) years; 103 patients (37.6%) were female. Minimum duration of knee complaints was 4 weeks. Median duration of knee complaints was 29 weeks (95 percentile 254 weeks). The median interval between inclusion in the study and MR imaging was 8 days (95 percentile 26 days).

MR imaging was performed using three similar 0.5-T systems (Philips Medical Systems, Best, The Netherlands). The standardized scanning protocol consisted of three sequences: a sagittal and a coronal dual spin-echo (SE) sequence and a sagittal T1-weighted 3D gradiëntecho (GE) sequence with frequency selective fatsuppression. The following parameters were identical for both SE sequences: 140-160 mm field of view and 20/80 ms echo time (TE). The coronal dual SE had a repetition time (TR) of 2,100 ms, a 256×205 matrix, and a slice thickness of 5 mm with a 0.5-mm interslice gap. The sagittal dual SE had a TR of 2,350 ms, a 256×179 matrix, and a slice thickness of 4 mm with a 0.4-mm interslice gap. The parameters for the sagittal frequency selective fat-suppressed T1-weighted 3D GE were TR 70 ms, TE 13 ms, 45° flip angle, 160 mm field of view, 256×205 matrix, and 4 mm slice thickness with 2 mm overlap.

The total imaging time of the standard protocol (including the initial survey

sequence) was 26 min. One of the six available radiologists, all with at least 5 years experience, used a case record form to evaluate the MR images according to established criteria [7-9].

We divided pathology found by MR imaging into two categories and patients were treated accordingly: group 1, abnormal findings requiring arthroscopic treatment (meniscal tears (≥5 mm), meniscal cysts, severe chondromalacia (grade 4 according to Recht [7]), osteochondritis dissecans with disrupted cartilaginous surface, loose bodies, or intraarticular pigmented villonodular synovitis). Group 2 consisted of patients without abnormalities or with findings not requiring arthroscopic treatment (small meniscal tears (< 5 mm), slight to moderate chondromalacia (grades 1 to 3 according to Recht [7]), isolated cruciate or collateral ligament tears, synovitis, synovial plicae, or bone bruises). We used the cutoff point of 5 mm in grading meniscal tears because our orthopedic surgeons regard tears smaller than 5 mm to be stable tears, whereas they consider tears larger than 5 mm to be unstable in the majority of cases. Patients with pathology equivocally requiring arthroscopic treatment such as osteochondritis dissecans with intact cartilaginous surface or capsular tear combined with ruptured collateral ligament could not be categorized initially. In these patients, the decision to perform arthroscopy was made after consulting the referring (orthopedic) surgeon. These patients were subsequently assigned to either group 1 or group 2.

According to protocol, arthroscopy had to be performed within 21 days after MR in all group 1 patients, but the time interval between MR and arthroscopy was not an exclusion criterion. If symptoms persisted for 3 months in group 2 patients, cross over to arthroscopy was allowed. All arthroscopic examinations were videotaped and were performed in the three participating hospitals by an experienced orthopedic surgeon or by a resident supervised by an orthopedic surgeon. A total of 17 surgeons participated in the study. Just like the radiologist, the surgeon was informed of the patient's history and of the findings at physical examination. The surgeon, however, was informed only of the diagnostic category at MR imaging, not the detailed MR diagnosis.
The arthroscope, which had a 30° viewing angle, was introduced into the knee through an anterolateral or transpatellar portal. All structures were probed as well as visualized. Chondromalacia was graded according to Outerbridge [10]. After the diagnostic part of the examination, the arthroscopist recorded the arthroscopic diagnosis and therapeutic intentions, if any. To this end, a case record form was used that was identical to that used at the interpretation of the MR images. Subsequently, one of the authors (P.W.J.V. or B.P.M.t.B.), who was present at the arthroscopic examination, revealed the detailed diagnosis at MR imaging to the arthroscopist. In case of a discrepancy, the arthroscopist took a second look at the area during the same arthroscopic session. Next, depending on the diagnostic findings, the arthroscopist terminated the procedure or continued with the therapeutic part of the procedure. Results of arthroscopies were analyzed.

In the patients undergoing arthroscopy, assessment of knee function at study entry

and at follow-up after at least 6 months was obtained using Noyes and Tegner questionnaires for assessing work-related and sport-related activities and functional limitations [11-13]. Clinical outcome was assessed after at least 6 months.

## 4.4. Results

MR showed unequivocal abnormalities that required arthroscopy by protocol in 71 patients (25.9%). MR showed pathology equivocally requiring arthroscopic treatment in six patients (2.2%). After consulting the referring (orthopedic) surgeon, according to protocol, two of these six patients (0.7%) were assigned to group 1 (arthroscopy required). The other four patients (1.5%) were assigned to group 2 (conservative treatment). After assigning these six patients to the two groups, 73 patients (26.6%) were included in group 1 and 201 patients (73.4%) in group 2. Meniscal tear was the most frequent finding (Table 1); 76 tears were found with MR in 72 patients (26.2%). Of these tears, 68 in 65 patients were larger than 5 mm.

Table 1
MR imaging findings in 274 patients without abnormal findings at physical exam

| | | MR Group | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | | 2 | | Total | |
| Number of patients | | 73 | (100.0) | 201 | (100.0) | 274 | (100.0) |
| Effusion | | 37 | (50.7) | 91 | (45.3) | 128 | (46.7) |
| Medial meniscus | Small tear (< 5 mm) | 0 | (0.0) | 3 | (1.5) | 3 | (1.1) |
| | Large tear (≥ 5 mm, including bucket handle tears)* | 44 | (60.3) | 0 | (0.0) | 44 | (16.1) |
| | Discoid meniscus with* or without tear | 1 | (1.4) | 0 | (0.0) | 1 | (0.4) |
| | Meniscal cyst* | 9 | (12.3) | 0 | (0.0) | 9 | (3.3) |
| Lateral meniscus | Small tear (< 5 mm) | 2 | (2.7) | 3 | (1.5) | 5 | (1.8) |
| | Large tear (≥ 5 mm, including bucket handle tears)* | 24 | (32.9) | 0 | (0.0) | 24 | (8.8) |
| | Discoid meniscus with* or without tear | 4 | (5.5) | 2 | (1.0) | 6 | (2.2) |
| | Meniscal cyst* | 5 | (6.8) | 0 | (0.0) | 5 | (1.8) |
| Bone bruises | | 6 | (8.2) | 18 | (9.0) | 24 | (8.8) |
| Severe chondromalacia* | | 5 | (6.8) | 1 | (0.5) | 6 | (2.2) |
| Loose body* | | 2 | (2.7) | 0 | (0.0) | 2 | (0.7) |
| Medial collateral ligament tear | | 7 | (9.6) | 16 | (8.0) | 23 | (8.4) |
| Lateral collateral ligament tear | | 0 | (0.0) | 1 | (0.5) | 1 | (0.4) |
| Anterior cruciate ligament tear | | 9 | (12.3) | 10 | (5.0) | 19 | (6.9) |
| Posterior cruciate ligament tear | | 1 | (1.4) | 2 | (1.0) | 3 | (1.1) |

MR Group 1, pathology requiring arthroscopic treatment. MR Group 2, pathology not requiring arthroscopic treatment or normal knees. Ligamental tears include partial and total tears. Findings are not mutually exclusive. Percentage given in brackets
*Finding requiring arthroscopy as defined by our protocol.

A total of 77 arthroscopies were performed. Arthroscopy was performed in 64 of the 73 patients ofMR group 1 (87.7%; Table 2). The remaining nine patients of MR group 1 (12.3%) refused arthroscopy, mainly because of subsiding symptoms.

Table 2
Arthroscopy findings in 77 patients with negative physical exam who underwent arthroscopy.

| | | MR Group 1 | | 2 | | Total | |
|---|---|---|---|---|---|---|---|
| Number of patients | | 64 | (100.0) | 13 | (100.0) | 77 | (100.0) |
| Medial meniscus | Small tear (< 5 mm) | 4 | (6.3) | 0 | (0.0) | 4 | (5.1) |
| | Large tear (≥ 5 mm, including bucket handle tears)* | 30 | (46.9) | 0 | (0.0) | 30 | (39.0) |
| | Discoid meniscus with* or without tear | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| | Meniscal cyst* | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| Lateral meniscus | Small tear (< 5 mm) | 0 | (0.0) | 1 | (7.7) | 1 | (1.3) |
| | Large tear (≥ 5 mm, including bucket handle tears)* | 17 | (26.6) | 1 | (7.7) | 18 | (23.4) |
| | Discoid meniscus with* or without tear | 2 | (3.1) | 0 | (0.0) | 2 | (2.6) |
| | Meniscal cyst* | 5 | (7.8) | 0 | (0.0) | 5 | (6.5) |
| Severe chondromalacia* | | 9 | (14.1) | 1 | (7.7) | 10 | (13.0) |
| Loose body* | | 1 | (1.6) | 0 | (0.0) | 1 | (1.3) |
| Anterior cruciate ligament tear | | 13 | (20.3) | 4 | (30.8) | 17 | (22.1) |
| Posterior cruciate ligament tear | | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |

MR Group 1, pathology requiring arthroscopic treatment. MR Group 2, pathology not requiring arthroscopic treatment or normal knees. Ligamental tears include partial and total tears. Findings are not mutually exclusive. Percentage given in brackets.
*Finding requiring arthroscopy as defined by our protocol.

The median interval between MR and arthroscopy in group 1 patients was 24 days (95 percentile 118 days).

In 13 of the 201 MR group 2 patients (6.5%), arthroscopy was performed. The median interval between MR and arthroscopy in these patients was 120 days (95 percentile 458 days). The study protocol was violated in four patients of group 2 (2.0%) who underwent arthroscopy within 3 months after normal MR.

The fraction of therapeutic arthroscopies in MR group 1 was 81.3% (95% confidence interval (CI) 71.4-91.1%) and this fraction was in MR group 2 statistically lower (30.8%, 95% CI 1.7-59.8, p value < 0.05). All but two of the 52 meniscal tears found at arthroscopy were present in MR group 1.

All but four of the 17 anterior cruciate ligament (ACL) ruptures seen at arthroscopy were present in MR group 1. All four patients with ACL ruptures diagnosed in MR group 2 were found to be isolated at arthroscopy. Because isolated ACL ruptures were no indication to perform arthroscopy in our study, these patients were rightly categorized as group 2.

Using binary logistic regression, gender, age (divided in two groups - 30 years or younger and older than 30 years), and a history of knee effusion appeared to be independent predictors of the fraction of MR studies showing arthroscopically treatable intra-articular pathology (chi-squared tests, p value < 0.05). The odds ratios of these three independent parameters for presence of intraarticular treatable pathology are 2.8 (95% CI 1.5-5.2) for male gender, 2.8 (95% CI 1.6-5.1) for age over 30 years, and 2.3 (95% CI 1.2-4.6) for a history of effusion. Combining gender, age, and a history of effusion, we found the highest fraction of MR studies showing

arthroscopically treatable intra-articular pathology in male patients, aged over 30 years with a history of effusion - 54.5% (six of 11 patients). We found the lowest fraction of MR studies showing arthroscopically treatable intraarticular pathology in female patients aged 30 years or less without a history of effusion - 6.7% (three of 45 patients).

A history of trauma, pain, instability or locking proved not to be predictors of the fraction of MR studies showing arthroscopically treatable intra-articular pathology (p value > 0.05). We were able to assess functional outcome in 57 of 77 patients who underwent arthroscopy and to compare these data with data obtained at study entry. Mean interval between study entry and follow-up was 18 months. All scores improved significantly (p value < 0.05) after (therapeutic) arthroscopy.

## 4.5. Discussion

Normally, patients with subacute knee complaints but negative clinical tests do not proceed to additional diagnostic procedures. We found, however, in 26.6% of these patients abnormalities on MR that required arthroscopy. All these patients improved clinically following arthroscopy. The most frequent finding was meniscal tear. Arthroscopic treatment was performed in 81.3% (95% CI 71.4-91.1) of these patients.

In the literature, reported sensitivities and specificities of commonly used clinical tests of the knee, range from 10% to 95% and from 5% to 100%, respectively [5,14,15]. A review by Scholten et al. stresses the poor methodological quality of the studies addressing diagnostic accuracy and limited clinical value of these tests [14]. These tests perform worse in the ACL deficient knees [16] and also in the presence of effusion of the knee [14]. The wide range of these test results is an indication of the limited clinical value of these tests.

Others report that more experienced examiners perform better than inexperienced examiners [17]. This may be true, but we feel that the mixture of experienced and less experienced (orthopedic) surgeons, participating in this study, reflects usual care. It has also been suggested that a combination of test results improves the diagnosis of meniscal tears [5,14-16]. In our study, we used a combination of six clinical tests. Although all six tests used were negative, we still found that 26.6% of patients had abnormalities on MR that required arthroscopy.

In a separate cost-effectiveness study [18], we included patients with high clinical suspicion on intra-articular knee pathology based on the aforementioned standardized physical exam (at least one of six tests positive). In this study group, 50.3% of patients had abnormalities on MR that required arthroscopy. So clinical assessment based on physical examination has only limited value in selecting patients for additional diagnostic procedures.

In the Dutch situation until recently, a general practitioner had no direct access to

MR of the knee. However, because of the limited additional value of (orthopedic) clinical assessment, direct access to MR and thus selection of patients for referral to an orthopedic surgeon could be a cost-effective policy [19, 20].

Not outcome of clinical assessment but gender, age, and history of effusion of the knee proved to be predictors for abnormal MR. We found the highest fraction of MR studies depicting arthroscopically treatable intra-articular pathology in male patients aged 30 years and over (54.5%). The importance of history taking in patients with knee complaints is stressed in textbooks. We could identify only one study reporting accuracy of medical history questions concerning intra-articular pathology [21]. Based on 30 questions that were not described, a diagnostic accuracy for intra-articular pathology of 85% was reported.

Assessing functional outcome of patients was not the primary goal of this study because we expected the frequency of arthroscopies required to be much lower than the observed 26.6%. We were able to analyze functional outcome using Noyes and Tegner questionnaires for assessing work-related and sport-related activities and knee limitations [11-13] in 57 of 77 patients who underwent arthroscopy and were able to compare these data with data obtained at study entry. Mean interval between arthroscopy and follow-up was 18 months. All scores improved statistically significantly after arthroscopy, suggesting that therapeutic arthroscopies were effective.

Isolated ACL tears in patients without high level sports activity are initially treated conservatively in The Netherlands. Arthroscopy is therefore not a routine procedure when an isolated ACL tear is diagnosed. A different treatment strategy does, in view of the accuracy of MR for diagnosing ACL tears, not affect our results. Twelve of the 17 knees with ACL tears, diagnosed at arthroscopy, had other findings requiring arthroscopy and were thus group 1 patients. The only isolated complete ACL tear in group 2 was diagnosed on MR; the others were partial tears.

A limitation of this study was that 12.3% of patients with positive MR did not proceed to arthroscopy mainly because of subsiding symptoms. These patients may have had false positive MRs or the findings on MR were not symptomatic to begin with. Another possibility is the well-known phenomenon of subsiding symptoms of patients on a waiting list [22]. In our study, patients waited on average 24 days (95 percentile 126 days). Another limitation was that a control group was not present since arthroscopy was only performed in patients with abnormal MR results. However, performing arthroscopy in patients with negative clinical assessment and negative MR results would have been considered unethical. A further limitation was the limited group of patients in which knee function at study entry and at follow-up was obtained. In conclusion, we believe that the negative predictive value of clinical assessment in patients with subacute knee complaints is too low to exclude these patients from MR. MR should at least be considered in male patients aged 30 years and over with a history of effusion, especially when symptoms do not subside within approximately 1 month.

## 4.6. References


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