MRI of the knee cost-efffective use

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CHAPTER 3

Effectiveness and costs regarding triage of patients with non-acute knee complaints

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3.1. Abstract

Purpose To prospectively evaluate the cost and effectiveness of magnetic resonance (MR) imaging performed to exclude the need for arthroscopy in patients with nonacute knee symptoms who are highly suspected clinically of having intraarticular knee abnormality.

Materials and methods The study was approved by the institutional review boards of three hospitals; informed patient consent was obtained. All 584 included patients (406 male, 178 female; mean age, 31.1 years ± 8.0 [standard deviation]) underwent MR imaging. Patients with an MR result positive for the diagnosis of intraarticular knee abnormality underwent arthroscopy (group A). Patients with a negative MR result were randomly assigned to undergo either conservative (group B) or arthroscopic (group C) treatment. Treatment was considered effective if the Noyes function score had increased 10% or more at 6 months. A cost analysis was performed from a societal perspective to compare the treatment strategy involving MR imaging with the strategy not involving MR imaging.

Results Of the 584 patients, 294 (50.3%) were assigned to group A; 149 (25.5%), to group B; and 141 (24.1%), to group C. At 6 months, the number of patients effectively treated in group B (conservative treatment) was a mean of 5.1% ± 10.0 larger than the number of patients effectively treated in group C (arthroscopy). Owing to savings in productivity costs, total societal costs were lower with use of the strategy involving MR imaging by a mean of $153 ± 488 (P = 0.54).

Conclusion MR imaging can be used without additional costs or disadvantageous effects on function to obviate arthroscopy in patients with nonacute knee symptoms who are highly suspected of having intraarticular knee abnormality.

3.2. Introduction

Arthroscopy of the knee is frequently used to diagnose and treat intraarticular abnormalities. Despite clinical selection by the orthopedic surgeon, based on history and physical examination findings, 39%-73% of arthroscopies remain diagnostic and are not used for therapy [1-4]. The objective is to use this invasive procedure primarily for treatment and to limit the number of nontherapeutic arthroscopies performed. During the past 15 years, magnetic resonance (MR) imaging of the knee has become available as an alternative to diagnostic arthroscopy. The purpose of our study was to prospectively evaluate the cost and effectiveness of MR imaging performed to exclude the need for arthroscopy in patients with nonacute knee symptoms who are highly suspected clinically of having intraarticular knee abnormality.

3.3. Materials and Methods

3.3.1. Patients

The study was approved by the institutional review boards of the three participating hospitals; informed patient consent was obtained. Between March 1997 and October 1999, consecutive patients aged 16-45 years who had had knee symptoms -specifically, pain, swelling, instability, and/or locking- for at least 4 weeks (nonacute) and were referred to one of the three participating nonaffiliated hospitals (one academic [Leiden University Medical Center], two teaching [MCH Westeinde Hospital and Leyenburg Hospital]) were eligible for the study. All patients underwent a standardized physical examination that consisted of, at least, knee inspection, instability and meniscal provocation tests, and measurement of the circumference of both legs 15 cm above the medial joint line. In addition, anteroposterior and lateral radiographs of the knee were obtained.

Exclusion criteria were known joint disease, abnormality diagnosed earlier with MR imaging or arthroscopy, contraindication to MR imaging or arthroscopy, locked knee at presentation, a combination of locked knee and either extension deficit or positive McMurray test results, prior knee surgery, a radiographically confirmed fracture, severe osteoarthritis of the knee (Kellgren grade 4), and/or a clinical diagnosis of retropatellar chondromalacia.

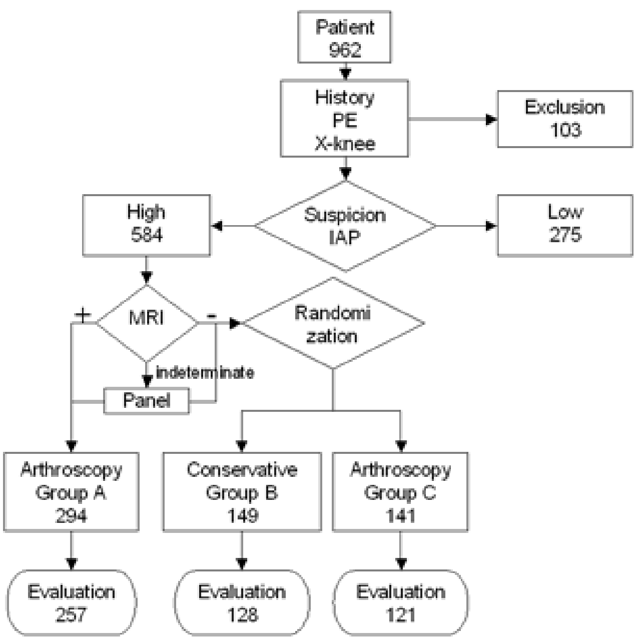
Patients were included in the study if they were highly suspected clinically of having an intraarticular knee abnormality and thus arthroscopy was indicated according to the guidelines of the Dutch Orthopedic Society [5]. Arthroscopy is warranted if at least one of the following clinical criteria is met at physical examination: substantial joint effusion (more than bulging sign), passive extension deficit of at least 10°, passive flexion deficit of at least 20°, instability (ie, positive varus and valgus stress, Lachman, anterior and

posterior drawer, and Pivot test results), a positive result of at least one meniscal provocation test (ie, McMurray, Apley, or squat test), and atrophy of at least 2 cm relative to the contralateral leg measured 15 cm above the medial joint line.
The threshold for arthroscopy is kept relatively low by the Dutch Orthopedic Society to avoid the rendering of too many falsenegative diagnoses on the basis of physical examination results.

3.3.2. Study Design

After study inclusion, all patients first underwent MR imaging. Patients with a positive MR result (ie, in which arthroscopy was indicated on the basis of the MR findings, in concordance with high clinical suspicion) were referred for arthroscopy (group A). Patients with a negative MR result (ie, in which arthroscopy was not indicated on the basis of the MR findings alone, despite high clinical suspicion, but rather on the basis of the Dutch Orthopedic Society guidelines) were randomly assigned, by using permuted block randomization, to undergo conservative (group B) or arthroscopic (group C) treatment. The MR result was reported to the central study center by telephone, after which the patients were assigned to the groups (Figure) by one of two research physicians (A.P.M.t.B., P.W.J.V.).

The mean interval between MR imaging and arthroscopy in groups A and C was 37.3 days ± 37.5 (standard deviation) (median, 28.0 days; range, 1-371 days). During the time intervals between study inclusion, MR imaging, and subsequent



Study design and number of patients enrolled in the study.
Note.- IAP = Intra Articular Pathology

arthroscopy or randomization (to conservative or arthroscopic treatment group), the patients received no treatment except analgesics. The regimen for conservative therapy was not standardized but rather left to the discretion of the orthopedic surgeon and/or the patient.

All MR findings were prospectively and individually evaluated by one of five available musculoskeletal radiologists (including J.L.B., W.M.C.M., T.P.W.d.R., and E.G.C., with 2-12 years experience in musculoskeletal MR imaging). The medical history, physical examination findings, and radiographs of each patient at study entry were available to the radiologist. All MR findings were recorded on a standardized case record form. The MR result was categorized as negative (arthroscopy not indicated), equivocal, or positive (arthroscopy indicated) according to the criteria outlined in Table 1. The term negative MR finding in this context does not imply that there was no intraarticular abnormality but rather that there was no intraarticular abnormality that necessitated therapeutic arthroscopy. By using all available information, a panel consisting of the radiologist who evaluated the MR result and the orthopedic surgeon assigned the patients with equivocal MR findings to group A or randomized group B or C.

Table 1
Classification of pathology on MR

	Negative MR diagnosis (i.e. arthroscopy not indicated)	Equivocal MR diagnosis	Positive MR diagnosis (i.e. arthroscopy indicated)
Menisci (Classification according to Lotysch)	Normal Meniscal tear < 5mm Meniscal degeneration without tear Discoid meniscus		Meniscal tear ≥ 5mm Meniscal cyst
Cartilage (Classification according to Recht)	Normal Chondromalacia grade 1-3 Non-isolated chondromalacia grade 4 Isolated chondromalacia grade 4 of a none-weight bearing surface	OD with intact cartilage	Isolated chondromalacia grade 4 of a weight bearing surface OD with cartilage fissure Loose body
Cruciate ligaments	Normal Isolated tear cruciate ligament Partial tear cruciate ligament	Isolated tear cruciate ligament with instability	Tear cruciate ligament in combination with meniscal tear
Collateral ligaments	Normal Isolated tear collateral ligament	Tear collateral ligament with capsule-lesion	Tear collateral ligament in combination with meniscal tear
Synovia	Normal Plica Synovitis		Intra-articular PVNS
Other structures	Normal Bone bruise	Tumor Extra-articular PVNS	

Note.- OD = Osteochondritis dissecans; PVNS = Pigmented Villonodular Synovitis

Patients who were treated conservatively (group B) were scheduled for arthroscopy if their symptoms had not diminished 3 months after the first clinical evaluation. Our analyses were based on the intention-to-treat principle, meaning that the patients in group A or C who did not undergo arthroscopy and the patients in group B who did undergo arthroscopy despite not having indications for it according to the protocol criteria remained in their respective designated group for the analyses.

3.3.3. MR Imaging

The MR examinations were performed at all three hospitals by using the same 0.5-T system (Gyroscan T5; Philips Medical Systems, Best, the Netherlands) and the same software with a dedicated transmit-receive knee coil.

The standardized MR imaging protocol consisted of three sequences: sagittal dual spin echo, coronal dual spin echo, and sagittal T1-weighted threedimensional gradient echo with frequency-selective fat suppression. A 140-160 mm field of view and an echo time of 20 or 80 msec were used for both spin-echo sequences. For coronal dual spin-echo imaging, a repetition time of 2100 msec, matrix of 256 × 205, and section thickness of 5 mm with a 0.5 mm intersection gap were used. For sagittal dual spin-echo imaging, a repetition time of 2350 msec, matrix of 256 × 179, and section thickness of 4 mm with a 0.4 mm intersection gap were used. The parameters for sagittal frequency-selective fat-suppressed T1-weighted three-dimensional gradient-echo imaging were 70-msec repetition time, 13-msec echo time, 45° flip angle, 160 mm field of view, 256 × 205 matrix, and 4 mm section thickness with a 2 mm overlap. The total imaging time for the standard MR imaging protocol (including the initial survey sequence) was 26 minutes.

3.3.4. Arthroscopy

All arthroscopic examinations were performed by an orthopedic surgeon or a resident supervised by an orthopedic surgeon. A total of 17 surgeons (including S.d.L., R.M.B., L.N.J.E.M.C., and P.A.v.L., with 1-21 years experience) participated in the study. At each participating hospital, one orthopedic surgeon was assigned to the panel that decided the diagnosis in the cases of equivocal MR findings.

Like the radiologist, the surgeon was informed of the patients' medical history and physical examination findings. The surgeon, however, was informed of the MR category (positive or negative findings) only -not the detailed MR diagnosis. An arthroscope with a 30° viewing angle was introduced into the knee through an anterolateral or transpatellar portal. All structures were not only visualized but also probed. After the standardized diagnostic part of the arthroscopic examination, the arthroscopist reported an arthroscopic diagnosis and the therapeutic intentions, if any. For this report, a standardized case record form identical to that used to record the MR findings was used. The researcher then revealed the detailed MR diagnosis to the arthroscopist. In cases of discrepancy, the arthroscopist then examined the joint again. Then, depending on the second-look findings, the arthroscopist either terminated the procedure or continued to the therapeutic portion of the examination.

3.3.5. Outcome Measures

All patient demographic data, clinical characteristics, MR findings, and findings of arthroscopy (if performed) were recorded. The MR and arthroscopic findings were considered to be intermediate outcome measures.

Effectiveness. -Knee function and symptoms were assessed during interviews with the patients at the time of MR imaging and at 3- and 6-month intervals by using Noyes function scores, which ranged from 200 (indicating poor function) to 550 (indicating good function), and Noyes symptom scores, which ranged from 0 (indicating serious symptoms) to 400 (indicating no symptoms) [6,7]. The patients were interviewed by one of two research physicians (A.P.M.t.B., P.W.J.V.).

The Noyes scale for symptoms was used in group B to determine whether the treatment for some patients should be changed to arthroscopy after 3 months of conservative treatment. Patients were scheduled for arthroscopy if the initial Noyes symptom score had not increased at least 10% at 3 months. The mean interval between MR imaging and arthroscopy in group B was 136.3 days ± 57.2 (median, 126.0 days; range, 83-321 days).

The Noyes function score at 6 months was chosen as the primary outcome parameter for determining the effectiveness of each treatment strategy. We considered a treatment strategy to be effective if the initial Noyes function score had increased at least 10% at 6 months. The orthopedic surgeons who were involved in the study design considered this value, on the basis of their experience, to be a realistic increase during a period of 6 months after successful therapy, whether this be conservative or arthroscopic treatment. The cutoff value was therefore empirically determined.

Costs. -The economic evaluation was performed from a societal perspective and included assessment of the medical and productivity costs during the initial 6 months after randomization to the treatment groups. Costs are reported in U.S. dollars and were updated to the 2005 price level by using the Dutch consumer price index (www.cbs.nl). The cost analyses involved the evaluation of volumes (ie, numbers of procedures and other cost elements) and prices.

Volumes were determined from the study registrations for initial consultation with the orthopedic surgeon, MR examination (including subsequent consultations), and arthroscopy (including hospital stays and postoperative consultations). These data were supplemented by volumes of secondary medical care (ie, consultations, physiotherapy sessions, hospitalizations, medications, and out-of-pocket expenses) and days of absenteeism (from work) reported by the patients in two quarterly cost diaries. These diaries were handed in and discussed with the patients at 3 and 6 months.

Detailed cost analyses of MR imaging and arthroscopy were performed at the three participating centers and included assessment of the costs of different staff members, equipment, material, housing, and overhead items and of the costs in time and travel of the patients. The money spent on medical aids was gleaned from the diaries. The costs of other health care entities were determined according to standard Dutch prices that were designed to reflect societal costs and standardize economic evaluations [8,9]. The time and travel costs for medical care were based on national averages for the duration of health care and the travel distances calculated from postal codes. The costs for absenteeism were calculated by using the patients' reported actual gross income per day according to the friction cost method; for our study duration of 6 months, these values amounted to the costs for all reported absenteeisms.

3.3.6. Data and Statistical Analyses

All performed analyses were based on the intention to treat principle.
The effectiveness of different treatment strategies was compared by using χ^2 tests. Costs were compared by using standard unequal-variance t tests. All analyses were performed by using SPSS for Windows (release 11.5.0; SPSS, Chicago, Ill).

Effectiveness. -We compared the effectiveness of the treatments performed in groups B (conservative treatment) and C (arthroscopy) to determine whether treatment B would not be inferior to treatment C. We expected treatment C to be effective in 90% of the patients. We allowed a noninferiority margin of 15% and accepted an effectiveness of 75%.

We computed a sample size of 91 patients per group (α = 5% one sided, $1 - \beta = 0.90$) for the case in which treatment B was actually as effective as treatment C. Since we expected about 50% of the patients to be randomly assigned between groups B and C, we needed to include a total of 364 patients (two groups times two times 91 patients). To establish noninferiority of treatment B, we reported confidence intervals for the differences between treatments B and C.

Costs. -In our economic evaluation, we compared the results of a treatment scenario involving MR imaging with the results of a scenario not involving MR imaging. If in the strategy involving MR imaging φ denotes the fraction of patients with a negative MR examination result who do not require arthroscopic treatment, the difference in costs between the two strategies is calculated as follows:

$$
\begin{aligned}
&\{[(1 - \varphi) \cdot C_{A,in}] + (\varphi \cdot C_{B,in})\} \\
&- \{[(1- \varphi) \cdot C_{A,ex}] + (\varphi \cdot C_{C,ex})\} \\
&= C_{MR} + [\varphi \cdot (C_{B,ex} - C_{C,ex})],
\end{aligned}
$$

Where $C_{A,in}$ represents the costs for group A with MR imaging included; $C_{A,ex}$, the costs for group A with MR imaging excluded; $C_{B,in}$, the costs for group B with MR imaging included; $C_{B,ex}$, the costs for group B with MR imaging excluded; $C_{C,ex}$, the costs for group C with MR imaging excluded; and CMR, the costs for MR imaging.

The power calculation for the economic evaluations was based on the break-even fraction (φ_0), for which the difference in costs between the strategy with and the strategy without MR imaging is zero. On the basis of a priori data on average costs per patient, we estimated a φ_0 of 0.4. For larger values,the strategy with MR imaging is costeffective.

The sample size calculation was based on the results of testing φ equals φ_0 versus φ is greater than φ_0. To show a difference of 10%, we needed 206 patients (α = 5% one sided, $1- \beta = 0.90$). In practice, we would not use estimated average costs but rather the actual costs per patient. Differences in cost between the strategy with and the strategy without MR imaging are reported as 95% confidence intervals of the mean costs.

The width of these intervals around the difference in costs between the strategies was calculated as φ times the width of the standard 95% confidence interval of the mean difference in costs between treatment groups B and C. This approach ignores the uncertainty in the estimated MR-negative fraction φ. Ignoring this uncertainty is justified because the much larger uncertainty in the cost difference dominates the uncertainty in their independent product.

Study sample size and sensitivity analysis. -On the basis of the computations described for effectiveness and costs, we determined that we needed to include about 400 patients. We performed univariate sensitivity analysis of our data on the percentage of negative-result MR examinations and the costs of MR imaging and arthroscopy.

3.4. Results

Of the 962 patients who agreed to participate in the study, 378 either were excluded (103 patients) or had negative physical examination findings according to the Dutch Orthopedic Society guidelines (275 patients). In the remaining 584 patients (178 female, 406 male; mean age, 31.1 years ± 8.0 [standard deviation]), arthroscopy was indicated according to Dutch Orthopedic Society guidelines. The data regarding 430 of these patients (those included between March 1997 and October 1998) had been used in a prior study [10]. The mean interval between study inclusion and MR imaging was 10.9 days ± 9.2 (median, 8.0 days; range, 0-77 days).

3.4.1. Effectiveness

All 584 patients were interviewed at the time of MR imaging (Figure). Initially, 289 patients had MR findings positive for intraarticular knee abnormality, 285 had negative MR findings, and 10 had equivocal MR findings. The panel concluded that five of the patients with equivocal findings needed arthroscopy (group A) and five did not (randomly assigned to group B or C). Thus, 294 (50.3%) patients were assigned to undergo arthroscopy (group A). The remaining 290 patients were randomly assigned to undergo conservative (group B, 149 [25.5%] patients) or arthroscopic (group C, 141 [24.1%] patients) therapy (Table 2). Two hundred seventy-seven (94.2%) group A patients, 126 (89.4%) group C patients, and 28 (18.8%) group B patients underwent arthroscopy. Seventeen group A patients and 15 group C patients did not undergo arthroscopy. Of these 32 patients, 17 were lost to follow-up and 15 refused to undergo or delayed undergoing arthroscopy for various reasons, including sufficient subsiding of symptoms during wait to undergo arthroscopy (eight patients).

The most prevalent abnormalities at MR imaging and arthroscopy are listed in Table 3. Furthermore, pigmented villonodular synovitis was suspected on the basis of MR imaging findings in two patients; one of these cases was confirmed at arthroscopy.

In one patient, a complete tear of the posterior cruciate ligament was found at MR imaging.

Table 2
Demographic and clinical characteristics at baseline

Group	Group A (n=294)	Group B (n=149)	Group C (n=141)
Mean age in years (SD); medians	33.0 (8.0); 34.0	29.6 (7.4); 30.0	28.5 (8.0); 31.0
No (%) of women	53 (18.0)	65 (43.6)	56 (39.7)
Duration of complaints in weeks (SD); medians	53.3 (107.6); 16.7	70.0 (176.4); 16.7	55.4 (125.9); 16.0
Trauma	175 (59.5)	93 (62.4)	93 (66.0)

Note.- Data in parentheses are percentages unless stated otherwise; n = number of patients

Table 3
Most important pathology found at MR imaging and arthroscopy. Results of arthroscopy are divided in patients that underwent arthroscopy because of a positive MR (group A) and patients with a negative MR (group B and C)

	MR (n=584)	Arthroscopy (n=431)	
		Group A (n=277)	Group B/Group C (n=154)
Medial meniscal tear	199 (34.1)	157 (53.4)	12 (7.8)
Lateral meniscal tear	90 (15.4)	77 (26.2)	8 (5.2)
Tear anterior cruciate ligament	75 (12.8)	38 (12.9)	11 (7.1)
Chondromalacia grade 4 (weight bearing surface)	19 (3.3)	23 (7.8)	4 (2.8)
Osteochondritis dissecans	10 (1.7)	5 (1.7)	0 (0.0)

Note.- Data in parentheses are percentages; n = number of patients

After undergoing MR imaging, 506 (86.6%) of the 584 patients were available for follow-up 6 months later: 257 (87.4%) patients in group A, 128 (85.9%) in group B, and 121 (85.8%) in group C. The majority of patients lost to follow-up had moved or did not provide correct addresses. At 6 months (Table 4), 105 (82.0%) of the 128 patients available for follow-up in group B were effectively treated according to our criteria. In group C, 93 (76.9%) of 121 patients who were available for follow-up were treated effectively. Therefore, the mean difference in effectiveness between the two groups, 5.1% ± 10.0, favored the conservative treatment (group B), with a 95% confidence interval of - 4.9% to 15.1% (P = 0.314). Thus, our data revealed conservative treatment to be noninferior to arthroscopic treatment in patients with negative MR findings.

3.4.2. Costs

Seventy-nine (13.5%) of the 584 patients did not return both cost diaries and thus were excluded from the cost analyses. The estimated medical and productivity costs in groups A and C were very similar (Table 5). Patients in group B underwent conservative treatment initially. As a result, their medical costs were considerably lower because only 18.8% of them subsequently underwent arthroscopy. Also, the absenteeism in group B was lower than that in group C by about 8 days. The costs of absenteeism were valued, on average, at $138 per day.

Table 4
Effectiveness of treatment strategy in randomization groups. Therapy is considered effective if Noyes function score increases more than 10% in six months.

Strategy	Group A	Conservative treatment (group B)	Arthroscopy (group C)	Difference between randomization groups
n	257	128	121	
Mean Noyes function score at t=0 (SD)	341.2 (65.4)	336.9 (67.7)	340.4 (70.4)	
Mean Noyes function score at t=6 (SD)	430.8 (85.1)	415.9 (84.7)	412.1 (89.4)	
% of treatment effective	84.4%	82.0%	76.9%	5.1% (-4.9;15,1)

Note.- Data in parentheses are 95% CIs unless stated otherwise; n = number of patients; Conservative treatment group = High clinical suspicion and negative MRI; randomized for conservative treatment (intention to treat); Arthroscopy group = High clinical suspicion and negative MRI; randomized for arthroscopy (intention to treat). Treatment is considered effective in case of a 10% increase in Noyes function score.

Table 5
Medical and productivity costs in study groups

		Group A (n=256)		Group B (n=125)		Group C (n=124)	
	unit prices	volume	costs	volume	costs	volume	costs
Medical costs							
Primary							
MR imaging (consultation not included)	593	100 %	593	100 %	593	100 %	593
Arthroscopy	889	94 %	835	19 %	169	89 %	791
Consultations (orthopedic) surgeon (including MR related consultation)	77	2.94 ×	227	2.19 ×	169	2.89 ×	222
Subtotal costs primary treatment			1,655		930		1,607
Secundary							
Physiotherapy		52%		62%		43%	
Physiotherapy 0-3 months	73	2.35 hr	172	4.50 hr	330	3.64 hr	267
Physiotherapy 3-6 months	73	2.63 hr	194	1.95 hr	143	1.81 hr	133
Consultations (orthopedic) surgeon (not scheduled)	77	0.66 x	50	0.91 x	70	0.69 x	53
General practitioner	31	0.72 ×	22	0.64 ×	21	0.69 ×	22
Other consultations	46	0.03 ×	1	0.02 ×	1	0.02 ×	1
Admissions	542	0.30 days	173	0.13 days	64	0.13 days	64
Medical aids		41 %	19	25 %	14	47 %	24
Medication		20 %	3	23 %	2	30 %	5
Subtotal costs secondary treatment			634		645		567
Total costs medical treatment			2,289		1,575		2,173
Productivity costs							
Employment		79 %		78 %		77 %	
Sick leave		56 %		32 %		60 %	
Sick leave 0-6 months		14.5 days	2,127	9.2 days	1,222	17.1 days	2,280

Note.- Costs in 2005 US Dollars; n = number of patients; number = mean number of hours/days per patient, mean number of consultations per patient, percentage of patients that underwent procedure or received treatment, percentage of patients that was employed / had sick leave or mean number of days of sick leave per patient; these results are calculated for each group as a whole, including patients without employment and therefore without sick leave; Group A = High clinical suspicion and positive MRI; Group B = High clinical suspicion and negative MRI; randomized for conservative treatment (intention to treat); Group C = High clinical suspicion and negative MRI; randomized for arthroscopy (intention to treat)

The projected costs for the strategy with and the strategy without MR imaging triage (Table 6) indicate that medical costs were significantly lower ($P < 0.001$) for the strategy without MR imaging because the MR costs outweighed the savings gained by not performing arthroscopy. However, productivity costs were significantly lower (P = 0.023) for the strategy with MR imaging. The aggregated results indicate that there was a nonsignificant mean difference in total societal costs of $153 in favor of the strategy involving MR imaging (P = 0.539).

Table 6
Frequency distribution of procedures and events and their associated costs for for strategies with and without MR imaging

	Strategy with MRI	Strategy without MRI	Difference	95% CI	
				Lower threshhold	Upper threshhold
MR imaging	100 %	0 %	100 %	100 %	100 %
Arthroscopy	57 %	92 %	-35 %	-39 %	-31 %
Costs primary treatment	1,296	961	334	294	375
Costs secundary treatment	640	600	39	-67	144
Subtotal costs medical care	1,934	1,561	373	255	490
Sick leave	44 %	58 %	-14 %	-20 %	-8 %
Sick leave	11.8 days	15.8 days	-4.0 days	-7.2 days	-0.7 days
Subtotal productivity costs	1,678	2,203	-525	-980	-72
Total costs society	3,612	3,765	-153	-641	335

Note.- Costs in 2005 US Dollars; Costs and percentages are arrived at using figures for group A, B and C as mentioned in table 4; Difference = Scenario with MRI triage - Scenario without MRI triage

3.4.3. Sensitivity Analysis

Univariate sensitivity analysis revealed that the estimated societal costs became more favorable without MR imaging triage (a) when the estimated 50% MR-negative fraction decreased to less than 40% -and became significantly more favorable when the fraction decreased to less than 25%, (b) when the costs of MR imaging increased from $593 to more than $746 -and became significantly more favorable when these costs increased to more than $1233, or (c) when the costs of arthroscopy decreased from $889 to less than $449 -but not significantly more favorable.

3.5. Discussion

MR imaging of the knee in patients with nonacute knee symptoms who are highly suspected clinically of having an intraarticular knee abnormality can be used to obviate arthroscopy, with nonsignificant differences in total societal costs. On the basis of the negative MR findings in our study, arthroscopy and conservative management had similar effectiveness and costs at 6 months.

To our knowledge, no other multicenter prospective randomized studies in which clinical outcome was used and total societal costs (including medical and productivity costs) were calculated have been published. However, investigators in several studies have addressed the question of whether MR imaging can be used cost effectively or assessed the value of MR imaging as a diagnostic examination [1-4,11-17]. In these studies, intermediate outcome parameters (eg, diagnostic accuracy of MR imaging) or the influence of MR imaging on therapy was used to assess the value of MR imaging.

We also used part of our patient group (those included between March 1997 and October 1998, hence the difference in the number of reported patients between the present study and our previous investigation) to compare the diagnostic accuracy of MR imaging with that of arthroscopy [10]. One study involving the use of clinical outcome was a single-center randomized controlled trial conducted by Bryan et al [18] in which 118 patients were randomly assigned to be examined with MR imaging or arthroscopy. That study had similar results: The use of MR imaging led to a decreased number of arthroscopies without increased overall costs or associated worsened outcomes.

Knowing the prevalence of treatable knee abnormalities in the given population is critical to the efficient application of MR imaging to exclude patients for arthroscopy. In our study population, which was selected by the orthopedic surgeon on the basis of clinical examination findings, the prevalence of treatable abnormalities seen at MR imaging was only 50%. The prevalences of abnormalities in other studies have been similar to the prevalence in our study. Ruwe et al [2] found, in a group of 103 patients with clinical findings that necessitated diagnostic arthroscopy, MR abnormalities in 41 (40%) patients. Rappeport et al [12] found in 47 patients suspected of having intraarticular knee injuries 27 (57%) patients with MR abnormalities. To our knowledge, only Bui-Mansfield et al [4] have observed, in a group of 50 patients, a prevalence of knee abnormality that was substantially higher (35 [70%] patients) than that observed in our study. The fact that their study population consisted predominantly of male military personnel might explain this difference.

The results of sensitivity analysis of our data suggest that use of the strategy involving MR imaging will significantly reduce societal costs when the prevalence of MR abnormalities is lower than 75%. The percentage of positive-result MR examinations in all of the preselected populations described was lower than 75%. Our economic evaluations were based on conditions in the Netherlands, and the generalization to other settings may be influenced by differences in economic climate and treatment patterns. However, our sensitivity analysis revealed that the costs of MR imaging can more than double, to $1233, before the societal costs of the strategy not involving MR imaging are significantly preferred, whereas lowering the costs of arthroscopy will not lead to a significant preference for the strategy not involving MR imaging.

Other considerations, in addition to effectiveness and cost, may guide the decision to use or not to use the MR imaging strategy. For instance, the wait to undergo both procedures may have a decisive role. When the wait to undergo arthroscopy is long, MR imaging can be used to reduce the number of arthroscopies performed and shorten the wait. On the other hand, if the wait to undergo MR imaging is long, no such gain is expected. In the Netherlands, MR units are commonplace in hospitals and waiting lists for MR imaging of the knee are short compared with these lists some years ago, when the wait to undergo this examination could be several months.

Apart from the societal considerations used to decide whether MR imaging should be performed to select patients for arthroscopy, on an individual level, the ability to prevent unnecessary arthroscopy by using MR imaging also may have a role in this decision. When an arthroscopic procedure is not performed for therapeutic purposes, no health gain can be expected from it. The prolonged morbidity after diagnostic arthroscopy, compared with that after MR imaging, and the risk of complications with arthroscopy may guide the decision of the orthopedic surgeon and the patient to use MR imaging initially.

There were some limitations in our study. As mentioned earlier, the generalization of our present study findings to other settings may be influenced by differences in not only the economic climate but also the treatment patterns of different countries. For instance, in the Netherlands, an isolated tear of the anterior cruciate ligament is not considered an indication for therapeutic arthroscopy for the general population because the initial therapy of choice is physiotherapy. In other countries, however, early anterior cruciate ligament reconstruction is considered the therapy of choice for certain patients, and, thus, isolated tear of the anterior cruciate ligament is an indication for arthroscopy. However, the number of these patients with isolated tears of the anterior cruciate ligament would be small, and these differences would not substantially alter our results.

Other possible limitations were our use of a 0.5-T MR system and the probability that MR and arthroscopy techniques have changed since 2000 (the year in which the last arthroscopies were performed in our study). A comprehensive review [19] revealed that the magnetic field strength does not significantly affect the performance of MR systems in the detection of meniscal abnormalities. In our study population, the majority of arthroscopies (90%, for 265 of 294 positive-result MR examinations) were indicated because of a meniscal abnormality [10]. To our knowledge, no important developments in the diagnosis and treatment of meniscal tears have been reported in the last couple of years. The most promising changes reported have been in the diagnosis and treatment of cartilage lesions, which were not prevalent in our study population.

We therefore conclude that in patients with nonacute knee symptoms who are highly suspected clinically of having an intraarticular knee abnormality, MR imaging can be used to obviate arthroscopy, without additional societal costs or disadvantageous effects on function.

3.6. References

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