Does MRI add value in general practice for patients with traumatic knee complaints? A one year randomised controlled trial

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ABSTRACT

Background: To determine whether referral to magnetic resonance (MR) imaging by the general practitioner (GP) is non-inferior to usual care (no access to MR imaging by GPs) in patients with traumatic knee complaints regarding knee-related daily function.

Methods: This was a multi-centre, non-inferiority randomised controlled trial with 1-year follow-up. GPs invited eligible patients during or after their consultation. Eligible patients (18-45 years) consulted a GP with knee complaints due to a trauma during the previous 6 months. Patients allocated to the MR group received MR examination at (median) 7 (IQR 1-33) days after the baseline questionnaire. Patients in the usual care group received information on the course of knee complaints, and a referral to a physiotherapist or orthopaedic surgeon when indicated. The primary outcome measure was knee-related daily function measured with the Lysholm scale (0 to 100; 100=excellent function) over 1 year, with a non-inferiority margin of 6 points.

Results: A total of 356 patients were included and randomised to MR imaging (n=179) or usual care (n=177) from November 2012 to December 2015. MR imaging was non-inferior to usual care concerning knee-related daily function during 1-year follow-up, for the intention-to-treat (overall adjusted estimate: 0.33; 95% CI -1.73 to 2.39), and per-protocol (overall adjusted estimate: 0.06; 95% CI -2.08 to 2.19) analysis. There were no differences between both groups in the amount of patients visiting other healthcare providers.

Conclusions: MR imaging in general practice in patients with traumatic knee complaints was non-inferior to usual care regarding knee-related daily function during 1-year follow-up.

Trial registration number: Dutch Trial Registration: NTR3689.

INTRODUCTION

Patients with traumatic knee complaints often consult a general practitioner (GP).[1] In the Netherlands, the usual care of the GP consists of information on the course of knee complaints, advice regarding pain medication, and (when indicated) referral to a physiotherapist. In case of persistent knee complaints patients are referred to an orthopaedic surgeon.[2] However, MR imaging is increasingly used in general practice, allowing a more specific diagnosis to be made based on an MR scan than on history taking and physical examination. For anterior cruciate ligament (ACL) tears, MR imaging has a sensitivity of 87% and a specificity of 93%; for medial meniscal tears this is 89% and 88%, respectively; and for lateral meniscal tears this is 78% and 98%, respectively in patients with suspected ACL and/or meniscal tears.[3] In addition, MR imaging in secondary care decreases the number of diagnostic arthroscopies.[4,5] MR imaging might also be a valuable diagnostic tool for GPs, preventing unnecessary orthopaedic referrals. On the other hand, MR imaging of the knee in general practice may lead to incidental asymptomatic findings, especially in case of degenerative meniscal lesions[6], with subsequent unnecessary healthcare costs as well as worried patients.

Although GPs increasingly use MR imaging for patients with traumatic knee complaints, the efficacy of adding an MR scan in general practice has not yet been determined. Whether (or not) MR imaging should enter the diagnostic pathway in primary care through direct access by the GP depends on if it is not therapeutically worse than the usual care in conjunction with the influence on subsequent management. Therefore, the primary aim of this randomised controlled trial (RCT) was to determine whether MR imaging requested by the GP was non-inferior to usual care in patients with persistent traumatic knee complaints with regard to knee-related daily function over a 1-year period.

METHODS

Design, study population and patient involvement

This study was approved by the Medical Ethical committee of the Erasmus Medical Center, University Medical Centre with file number NL40296.078.12. The study protocol was published earlier.[7]

There were some changes to the study protocol after the trial commenced:

- The concurrent observational cohort to assess the generalisability of the findings, where we planned to invite patients who were eligible but declined randomisation, was terminated during the recruitment period. Providing patients with a choice between the RCT and the observational cohort was not feasible in the clinical practice of the GPs responsible for inviting potential patients to participate in the trial, which resulted in fewer inclusions than anticipated.

- Based on the clinical guideline 'Traumatic knee complaints' issued by the Dutch College of GPs and expert consensus in the research group (consisting of GPs, radiologists, and orthopaedic surgeons), we planned to include patients with 'persistent' knee complaints, which we defined as knee complaints present for at least 4 weeks. This time constraint was abandoned since, according to the participating GPs, it did not reflect daily practice.
- During the recruitment period, the sample size was reduced from a total of 520 to 360 patients (see: 'Sample size calculation').

In this multi-centre, open labelled, randomised controlled non-inferiority trial, 150 GPs from the western part of the Netherlands were asked to invite eligible patients during their consultation to participate in the trial. Additionally, patients were invited after searching the electronic records of GPs for knee classification codes, thereby identifying potential participants which were missed during the consultation. Eligible patients were aged 18-45 years, who (re)consulted their GP with knee complaints (pain and/or disability) due to a trauma or a sudden onset (e.g. rotational trauma, or trauma during fall) in the preceding 6 months. Excluded were patients with: i) an indication for direct referral to an orthopaedic surgeon (i.e. fracture or acute locked knee), ii) knee complaints already treated in secondary care, iii) previous surgical intervention of the affected knee, iv) knee osteoarthritis diagnosed by a medical specialist, v) other non-traumatic arthropathy (i.e. isolated patellofemoral joint pain), vi) a previous MR scan for current knee complaints, or vii) contra-indications for MR imaging.

Patients were not involved in the design, recruitment or conduct of this study.

Randomisation and masking

Patients who signed informed consent and finished the baseline questionnaire were randomly assigned to usual care or to MR imaging by one of the researchers (KvO or NS), with random blocks of 4 and 6. A randomisation table generated by the computer was made by an independent person and was not accessible for the researchers, assuring concealed allocation. Due to the study procedures, blinding of the patients, caregivers, and researchers conducting the analyses was not possible.

Interventions

Patients in the usual care group received treatment according to the clinical guideline 'Traumatic knee complaints' issued by the Dutch College of GPs (without MR imaging). This guideline advises to inform the patient about the course of the knee complaints, to load the knee within the pain threshold, and to refer the patient to a physiotherapist when indicated.[2] In case of persistent knee complaints, the GP can refer the patient to an orthopaedic surgeon, who may request an MR scan or perform an arthroscopy or surgery.[8]

Patients allocated to MR imaging were referred to one of the participating MR centres, where images were made on a 1.5 Tesla system in the coronal, sagittal and transversal plane. T1 and

PD-weighted sequences were used, with or without fat suppression. The radiologists used a standardised report to classify the MR findings. The standardised report generated a treatment/referral advice for the GP; to refer the patient to an orthopaedic surgeon or to continue treatment in primary care. The GP received the details of possible pathology together with the treatment advice and decided, in conjunction with the patient, whether or not referral was indicated, based on the advice of the radiologist and the clinical findings. For more details on the interventions and the standardised report, see the previously published study protocol.[7]

Outcomes

At baseline, data were collected on age, gender, weight, educational level, co-morbidity, the time from trauma to study inclusion, previous knee complaints, trauma characteristics and MR findings. Primary and secondary outcomes were collected at baseline, at 6 weeks, and at 3, 6, 9, and 12-months follow-up.

Primary outcome

Patients' knee-related daily function during the first year measured with the Lysholm scale was the primary outcome. The Lysholm scale comprises eight items (effusion, locking, walking, use of crutches, stair climbing, kneeling, instability, and pain) on symptoms and limitations in activities. Scores range from 0 to 100, with higher scores indicating better knee function.[9]

Secondary outcomes

Patients' generic quality of life was measured with the EuroQol 5-Dimensions (EQ-5D). The EQ-5D contains five items enquiring mobility, self-care, usual activities, pain/discomfort, anxiety/depression, and a visual analogue scale to assess the general health status. A score is calculated on a scale from -0.329 to 1, with higher scores indicating a better health status.[10]

The Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to measure the disability due to knee complaints. The KOOS contains five dimensions: pain, symptoms, function in daily living, function in sport and recreation, and knee-related quality of life. For each dimension, a score is calculated on a scale from 0 to 100, with higher scores indicating better knee function.[11]

The severity of knee pain during the previous 48 hours was measured with the numeric pain rating scale (NPRS), on a scale from 0 to 10; a higher score indicated more severe knee pain.[12]

Perceived recovery and patient satisfaction were measured on a 7-point Likert scale[13] and dichotomised to recovered (completely recovered and much improved) or not recovered (slightly improved, improved nor deteriorated, slightly deteriorated, much deteriorated, and completely deteriorated) and satisfied (absolutely satisfied or very satisfied) or not satisfied (slightly satisfied, satisfied nor dissatisfied, slightly dissatisfied, very dissatisfied, and absolutely dissatisfied).

The dichotomised (yes/no) provided healthcare was measured using the Medical Consumption Questionnaire from the Institute for Medical Technology Assessment (iMCQ). The iMCQ includes questions concerning contacts with healthcare providers and was adjusted to fit our population.[14]

Sample size calculation

Initially, we choose a non-inferiority margin of 4.8 points on the Lysholm scale, as the 95% CI in the reference study lies within 4.8 points from the mean difference.[15] However, the margin was adapted to 6 points on the Lysholm scale in dialogue with the funding party (the Netherlands Organisation for Health Research and Development), because the number of included patients during the recruitment period of the study was too low. Six points is still substantially lower than the 10 to 15 point difference considered to be clinically relevant on the Lysholm scale.[16] To detect non-inferiority of MR imaging to usual care with 80% power, a 2-sided alpha of .05, a non-inferiority margin of 6 points and a response rate of 95%, 180 patients for each trial group were needed.

Statistical analyses

Success of the randomisation and distribution of the baseline variables was assessed. Non-inferiority of MR imaging over usual care was accepted if the upper bound of the 95% CI around the estimated difference on the Lysholm scale between the groups during the 1-year follow-up was below 6 points. Linear mixed models (LMM) with repeated measurements were used to calculate group differences over time for the continuous outcomes. An unstructured covariance structure was chosen, based on the lowest number regarding the Akaike's information criterion. Effect sizes were calculated by dividing the estimates derived from the LMM with repeated measurements by the pooled SD of the baseline scores. Generalized estimation equations (GEE) were used to calculate group differences for perceived recovery and patient satisfaction, presented as odds ratios (OR) with a 95% CI. All analyses were adjusted for clinically relevant baseline differences of 10% or more between the groups. Group differences for the total number of patients referred to other healthcare providers were assessed with survival analyses according to the Kaplan-Meier method with two-sided log-rank statistics. For non-inferiority trials, the deficiencies in study conduct may bias the study toward a conclusion of non-inferiority.[17] Therefore, both intention-to-treat and per-protocol analyses were performed for the outcomes. Per protocol was defined as receiving an MR scan requested by the GP (initiated by the study protocol) in the MR group versus receiving no MR scan requested by the GP in the usual care group. In the per-protocol analyses, also patients who received an MR scan in the usual care group, but for whom it was unknown who requested the MR scan, were removed (n=10). Missing values were not explicitly imputed, since LMM and GEE take missing values into account. All analyses were performed using SPSS 21 (SPSS Inc., Armonk NY, USA).

RESULTS

Participant flow

From November 2012 to December 2015, 356 patients were included and randomised to MR imaging (n=179) or usual care (n=177) (figure 1). In the MR group, 174 patients received the protocol-initiated MR scan with a median time from baseline to MR imaging of 7 (IQR 1-33) days. Reasons for not receiving the MR imaging were 'no show' (n=3), 'pregnancy' (n=1), and 'personal circumstances' (n=1). Five patients (3%) were lost to follow-up; reasons for this were 'no time to fill in questionnaires' (n=1), and 'lost motivation' (n=5).

In the usual care group, 157 patients received usual care and 20 patients received an MR scan. From the 20 patients receiving an MR scan, in 10 patients the MR scan was requested by the GP, and in 10 patients, the information on the requester was missing). Nineteen patients (11%) were lost to follow-up; reasons for this were 'no time to fill in questionnaires' (n=5), 'dissatisfied' (n=8), and 'lost motivation' (n=6). For the intention-to-treat analyses, 179 patients were analysed in the MR group and 177 in the usual care group. For the per-protocol analyses, 174 patients were analysed in the MR group and 157 in the usual care group.

Baseline data and MR findings

The baseline characteristics of the patients are presented in table 1. The mean age was 32.8 (SD 8.3) years in the MR group and 32.4 (SD 8.0) years in the usual care group. In the MR group, 112 patients (63%) were male, and in the usual care group 110 patients (62%) were male. The mean Lysholm scores were 68.1 (SD 19.6) and 70.5 (SD 19.1) in the MR and usual care group, respectively. There were no clinically relevant differences between the groups at baseline, except for the time from trauma to study inclusion; with a median of 34 (IQR 12-75) days in the MR group, and 44 (IQR 19-82) days in the usual care group, for which the analyses were adjusted.

The MR findings of the patients randomised to receive MR imaging are presented in appendix 1. In 89 patients (51%) there were positive MR findings, resulting in an advice to refer the patient to an orthopaedic surgeon. The most frequent findings seen on MR imaging were effusion (71 patients, 41%), a bone bruise (60 patients, 35%), a medial meniscal tear (42 patients, 24%), an ACL tear (38 patients, 22%), and cartilage abnormalities (39 patients, 22%).

Primary outcome

Appendix 2 shows the observed course of the Lysholm scale. The results for the adjusted LMM analyses with repeated measurements for the intention-to-treat and per-protocol approach are presented in table 2. MR imaging was non-inferior to usual care concerning knee-related daily function measured with the Lysholm scale, during the 1-year follow-up for the intention-to-treat (overall adjusted estimate: 0.33; 95% CI -1.73 to 2.39) and per-protocol analysis (overall adjusted estimate: 0.06; 95% CI -2.08 to 2.19) (figure 2).

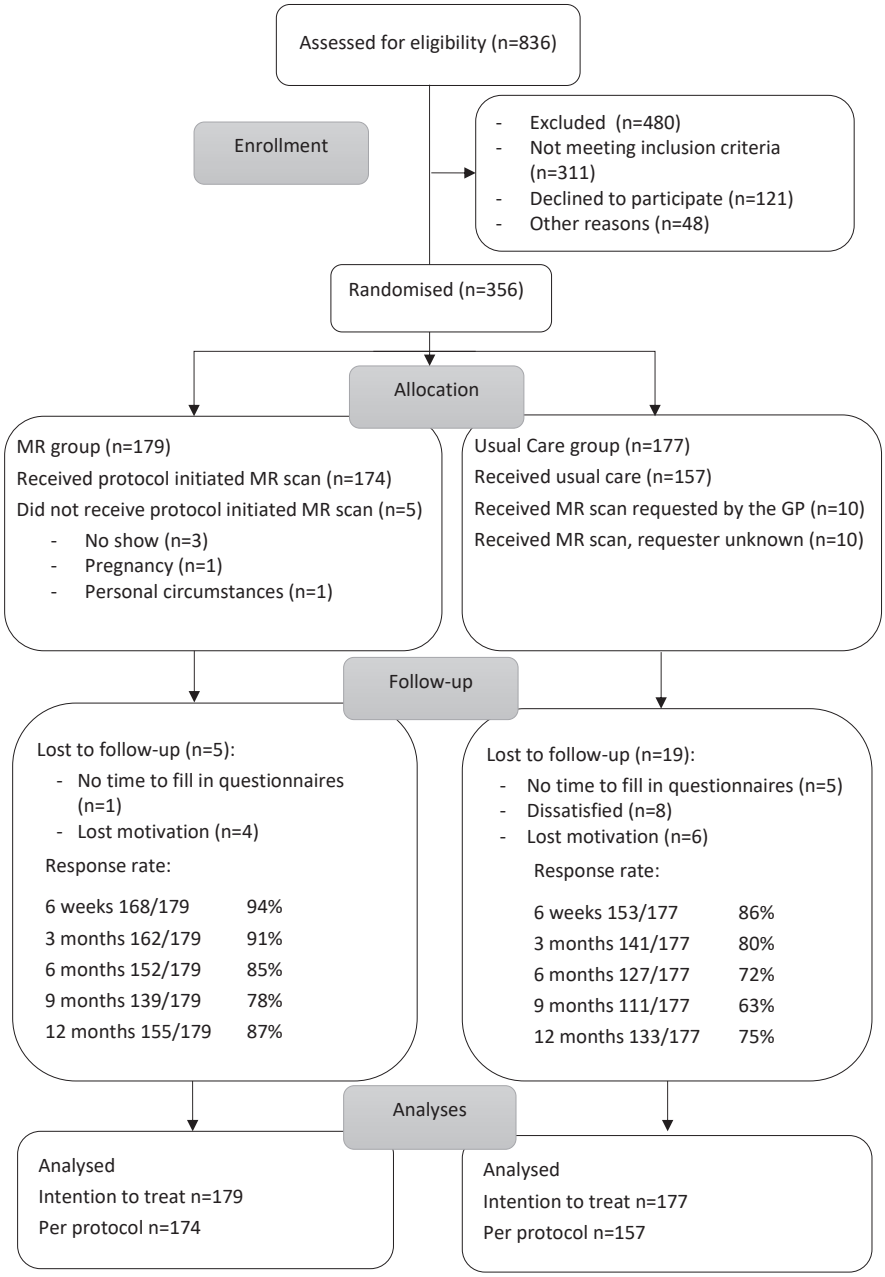

Figure 1 Flowchart of the study

Table 1 Baseline characteristics of the study population

	MR group (n=179)	UC group (n=177)
Participant and trauma characteristics		
Age years, mean (SD)	32.8 (8.3)	32.4 (8.0)
Male gender, n (%)	112 (63)	110 (62)
Body Mass Index, mean (SD)	25.3 (3.9)	25.6 (4.0)
Low educational level, n (%)†	114 (64)	114 (64)
Musculoskeletal co-morbidities, n (%)‡	42 (24)	42 (24)
Symptom side right, n (%)	86 (48)	73 (41)
Time from trauma to study inclusion in days, median (IQR)	34.0 (11.5 to 74.5)	44.0 (19.0 to 82.0)
Previous knee complaints, n (%)	73 (41)	74 (42)
Effusion during previous week, n (%)	73 (41)	74 (42)
Trauma during sport, n (%)	107 (60)	95 (54)
Mechanism of trauma		
Fall on the knee, n (%)	49 (27)	46 (26)
Rotational trauma, n (%)	71 (40)	69 (39)
Bump of the knee, n (%)	12 (7)	11 (6)
Squatting, n (%)	15 (8)	17 (10)
Other, n (%)	30 (17)	33 (19)
Immediate pain at trauma, n (%)	130 (73)	128 (72)
Immediate effusion at trauma, n (%)	44 (25)	44 (25)
Continuation activity impossible, n (%)	127 (71)	112 (63)
Popping sensation during trauma, n (%)	66 (37)	61 (35)
Primary outcome		
Knee-related daily function; Lysholm Scale, mean (SD)	68.1 (19.6)	70.5 (19.1)
Secondary outcome		
Quality of life; EQ-5D, mean (SD)	0.776 (0.174)	0.788 (0.171)
KOOS pain, mean (SD)	58.1 (20.3)	59.7 (20.9)
Participant characteristics		
KOOS symptoms, mean (SD)	61.5 (19.6)	65.3 (21.4)
KOOS function in daily living, mean (SD)	65.8 (23.2)	68.6 (22.4)
KOOS sport and recreation, mean (SD)	35.3 (27.0)	38.2 (29.3)
KOOS quality of life, mean (SD)	44.8 (13.0)	45.7 (12.2)
Severity of knee pain; NPRS during previous 48 h, mean (SD)	4.7 (2.3)	4.5 (2.3)

MR: Magnetic resonance. UC: usual care. SD: standard deviation. IQR: Interquartile range. KOOS: Knee injury and Osteoarthritis Outcome Score ranging from 0 to 100, with a higher score indicating less problems. Lysholm scale scored from 0 to100, with a higher score indicating less problems. EQ-5D: EuroQol 5-Dimensions scored from -0.329 to 1, with a higher score indicating less problems. NPRS: numeric pain rating scale with scores from 0 to 10, with a higher score indicating more pain. †Defined as no education, basic education or secondary education. ‡ Defined as pain in the back, or one or both hip(s), feet or ankle(s).Missing values ranged up to 1.1%.

Table 2 Results of the linear mixed models analyses with repeated measurements for differences MR imaging and usual care for the primary outcome, adjusted for the time from trauma to study inclusion of complaints at inclusion

		Mean (SD)*				
		MR group	UC group			
Intention-to-treat		(n=179)	(n=177)	Coefficient (95% CI)	p-value	ES
Knee	6 w	76.4 (17.6)	78.7 (16.7)	-0.42 (-3.52 to 2.69)	.792	-0.02
function;	3 m	82.3 (14.6)	83.8 (16.8)	0.54 (-2.69 to 3.76)	.743	0.03
Lysholm	6 m	86.9 (13.6)	86.9 (13.4)	0.55 (-2.43 to 3.53)	.716	0.03
scale	9 m	90.1 (11.3)	89.8 (11.7)	1.22 (-1.42 to 3.86)	.362	0.06
(0-100)	12 m	89.5 (12.8)	91.4 (10.4)	-0.24 (-2.78 to 2.30)	.851	-0.01
	Overall			0.33 (-1.73 to 2.39)	.753	0.02
Per-protocol		(n=174)	(n=157)	Coefficient (95% CI)	p-value	ES
Knee	6 w	76.3 (17.6)	79.7 (15.9)	-1.30 (-4.49 to 1.89)	.423	0.07
function;	3 m	82.3 (14.7)	84.1 (17.0)	0.67 (-2.68 to 4.02)	.694	0.03
Lysholm	6 m	86.9 (13.6)	87.4 (13.1)	0.20 (-2.84 to 3.24)	.895	0.03
scale	9 m	90.1 (11.3)	89.8 (12.2)	1.47 (-1.31 to 4.24)	.299	0.06
(0-100)	12 m	89.5 (12.8)	92.1 (10.1)	-0.77 (-3.36 to 1.83)	.561	-0.01
	Overall			0.06 (-2.08 to 2.19)	.959	0.02

MR: magnetic resonance. UC: usual care. SD: standard deviation. CI: confidence interval. ES: effect size. w: weeks. m: months. Lysholm scale scored from 0 to 100, with a higher score indicating less problems. *The means and SDs are unadjusted.

Secondary outcomes

There were no differences between MR imaging and usual care concerning: i) generic quality of life (overall adjusted estimate: -0.001; 95% CI -0.021 to 0.019) measured with the EQ-5D, ii) KOOS pain (overall adjusted estimate: 1.64; 95% CI -1.22 to 4.49), iii) KOOS symptoms (overall adjusted estimate: 1.99; 95% CI to -0.65 to 4.63), iv) KOOS function in daily living (overall adjusted estimate: 1.52; 95% CI -1.07 to 4.11), v) KOOS sport and recreation (overall adjusted estimate: 2.64; 95% CI -1.78 to 7.05), and vi) KOOS quality of life (overall adjusted estimate: 0.43; 95% CI -2.19 to 3.06) during the 1-year follow-up (table 3). Similarly, there were no differences during the 1-year follow-up between MR imaging and usual care concerning the severity of knee pain during the previous 48 hours, measured with the NPRS (overall adjusted estimate: -0.20; 95% CI -0.54 to 0.14).

Patients' perceived recovery and satisfaction with treatment

The results of the adjusted GEE analyses with repeated measurements regarding differences in patient perceived recovery and satisfaction with the treatment are presented in appendix 3. Patients more often perceived to be recovered in the MR group compared with the usual care group during the 1-year follow-up (overall adjusted OR: 1.49; 95% CI 1.10 to 2.02). Also, patients in the MR group were more often satisfied compared with patients in the usual care group during the 1-year follow-up (overall adjusted OR: 1.84; 95% CI 1.31 to 2.57).

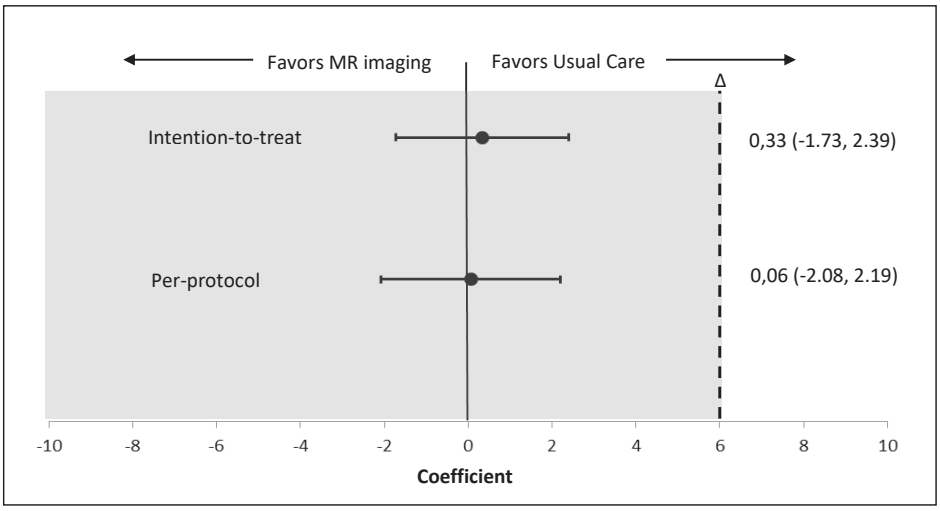

Figure 2 Differences between MR imaging and usual care on the Lysholm scale during 1-year follow-up Estimate and 2-sided 95% CI for the intention-to-treat and per-protocol analyses, and the non-inferiority margin (dotted line). Adjusted for the time from trauma to study inclusion

Number of patients visiting a healthcare provider

The number of patients visiting a healthcare provider during the 1-year follow-up is presented in table 4. There were no differences between the groups in the number of patients revisiting the GP and the number of patients visiting other healthcare providers, however there was a difference between the groups in patients visiting any healthcare provider (i.e. revisit to GP or visit to a physiotherapist or visit to an orthopaedic surgeon or visit to another specialist).

Table 3 Results of the linear mixed models intention-to-treat analyses with repeated measurements for differences between MR imaging and usual care for the secondary outcomes, adjusted for the time from trauma to study inclusion

		Mean (SD)* MR group (n=179)	UC group (n=177)	Coefficient (95% CI)	p-value	ES
Quality of	6 w	0.828 (0.153)	0.856 (0.133)	-0.020 (-0.049 to 0.009)	.185	-0.12
life;	3 m	0.891 (0.130)	0.887 (0.137)	0.020 (-0.009 to 0.049)	.184	0.12
EQ-5D	6 m	0.905 (0.135)	0.921 (0.098)	-0.003 (-0.030 to 0.024)	.825	-0.02
(-0.329-1)	9 m	0.909 (0.155)	0.925 (0.142)	-0.006 (-0.043 to 0.030)	.730	-0.03
	12 m	0.933 (0.137)	0.936 (0.114)	0.007 (-0.023 to 0.036)	.654	0.04
	Overall			**-0.001 (-0.021 to 0.019)**	**.959**	**-0.01**
KOOS	6 w	68.7 (19.2)	71.1 (19.9)	-0.94 (-4.44 to 2.56)	.597	-0.05
pain	3 m	77.3 (18.5)	77.7 (20.7)	2.31 (-1.65 to 6.28)	.251	0.11
(0-100)	6 m	84.2 (16.7)	83.0 (17.9)	1.93 (-1.81 to 5.68)	.310	0.09
	9 m	86.4 (15.2)	85.7 (16.3)	1.87 (-1.76 to 5.50)	.311	0.09

Table 3 Results of the linear mixed models intention-to-treat analyses with repeated measurements for differences between MR imaging and usual care for the secondary outcomes, adjusted for the time from trauma to study inclusion (continued)

		Mean (SD)* MR group (n=179)	UC group (n=177)	Coefficient (95% CI)	p-value	ES
	12 m	86.5 (17.9)	85.7 (17.2)	3.00 (-0.87 to 6.87)	.128	0.15
	Overall			**1.64 (-1.22 to 4.49)**	**.260**	**0.08**
KOOS	6 w	69.4 (18.0)	72.2 (19.9)	-0.36 (-3.72 to 3.00)	.834	-0.02
symptoms	3 m	77.2 (17.2)	77.2 (19.9)	2.70 (-0.91 to 6.32)	.143	0.13
(0-100)	6 m	82.8 (15.4)	80.8 (17.1)	2.88 (-0.78 to 6.54)	.123	0.14
	9 m	85.0 (16.1)	85.0 (15.6)	1.50 (-2.25 to 5.25)	.431	0.07
	12 m	84.6 (15.9)	83.5 (16.1)	3.22 (-0.42 to 6.86)	.083	0.16
	Overall			**1.99 (-0.65 to 4.63)**	**.140**	**0.10**
KOOS	6 w	76.9 (20.5)	80.5 (18.6)	-2.24 (-6.00 to 1.51)	.240	-0.10
function in	3 m	85.2 (16.8)	84.5 (19.4)	3.24 (-0.49 to 6.97)	.089	0.14
daily living	6 m	90.2 (14.0)	89.4 (15.4)	1.80 (-1.52 to 5.13)	.286	0.08
(0-100)	9 m	92.3 (13.2)	91.1 (14.1)	2.55 (-0.67 to 5.76)	.120	0.11
	12 m	92.0 (14.9)	91.4 (14.9)	2.25 (-1.14 to 5.64)	.192	0.10
	Overall			**1.52 (-1.07 to 4.11)**	**.250**	**0.07**
KOOS	6 w	46.0 (29.3)	50.6 (31.1)	-1.60 (-6.47 to 3.27)	.519	-0.06
sport and	3 m	59.0 (30.5)	59.9 (32.1)	4.15 (-1.65 to 9.95)	.160	0.15
recreation	6 m	68.0 (30.4)	68.5 (29.0)	1.71 (-4.24 to 7.67)	.572	0.06
(0-100)	9 m	74.3 (27.2)	72.4 (28.0)	4.33 (-1.73 to 10.38)	.161	0.15
	12 m	76.5 (25.6)	74.9 (27.0)	4.60 (-1.16 to 10.37)	.117	0.16
	Overall			**2.64 (-1.78 to 7.05)**	**.241**	**0.09**
KOOS	6 w	48.5 (13.4)	50.5 (14.1)	-1.22 (-3.92 to 1.49)	.377	-0.10
quality of	3 m	53.0 (16.0)	54.7 (15.0)	-0.10 (-3.39 to 3.18)	.950	-0.01
life	6 m	58.1 (15.4)	58.5 (15.4)	0.28 (-3.14 to 3.71)	.871	0.02
(0-100)	9 m	61.8 (15.8)	60.3 (15.0)	1.51 (-2.20 to 5.23)	.424	0.12
	12 m	61.7 (15.8)	61.2 (16.2)	1.68 (-1.94 to 5.31)	.362	0.13
	Overall			**0.43 (-2.19 to 3.06)**	**.747**	**0.03**
Severity of	6 w	3.8 (2.2)	3.7 (2.4)	-0.06 (-0.51 to 0.39)	.785	-0.03
knee pain;	3 m	2.6 (2.2)	2.8 (2.6)	-0.27 (-0.77 to 0.22)	.283	-0.12
NPRS	6 m	1.9 (2.1)	2.0 (2.1)	-0.18 (0.65 to 0.29)	.457	-0.08
(0-10)	9 m	1.6 (2.0)	1.8 (2.0)	-0.19 (-0.65 to 0.27)	.413	-0.08
	12 m	1.6 (2.2)	1.7 (2.1)	-0.31 (-0.79 to 0.18)	.212	-0.13
	Overall			**-0.20 (-0.54 to 0.14)**	**.241**	**-0.09**

MR: magnetic resonance. UC: usual care. SD: standard deviation. CI: confidence interval. ES: effect size. w: weeks. m: months. EQ-5D: EuroQol 5-Dimensions scored from -0.329 to 1, with a higher score indicating less problems. KOOS: Knee injury and Osteoarthritis Outcome Score ranging from 0 to 100, with a higher score indicating less problems. NPRS: severity of knee pain during the previous 48 hours, measured with the numeric pain rating scale with scores from 0 to 10, with a higher score indicating more pain. *The means and SDs are unadjusted.

Table 4 Results of the Kaplan-Meier survival analysis regarding differences in the total number of patients having received the healthcare between the MR and usual care group during the 1-year follow-up

	MR group (n=179)	UC group (n=177)	p-value*
Revisit general practitioner	63	59	.987
Visit physiotherapist	93	66	.065
Visit orthopaedic surgeon	67	50	.247
Arthroscopy†	35	20	.051
Visit other specialist‡	10	9	.963
Any healthcare consumption¶	122	91	.031

MR: magnetic resonance. UC: usual care. *Assessed with the Log Rank test. †Arthroscopy also included in the number of visits to an orthopaedic surgeon. ‡Rehabilitation physician, neurologist, surgeon or internist. ¶Revisit to GP or visit to a physiotherapist or visit to an orthopaedic surgeon or visit to another specialist.

DISCUSSION

Main findings

During the 1-year study period, direct access to MR imaging by the GP was non-inferior to usual care regarding knee-related daily function in patients aged 18-45 years with traumatic knee complaints. Also, MR imaging had no impact on knee pain, knee symptoms, function in daily living, sport and recreation, and quality of life. On the other hand, an MR scan requested by the GP showed a positive effect on patients' perceived recovery, and on patients' satisfaction with the treatment. If MR imaging of the knee enters the diagnostic pathway in primary care, it is unlikely that the amount of referrals to other healthcare providers will be reduced. Alongside the non-inferiority analyses, a cost-effectiveness analyses was performed, showing that MR imaging referral by the GP was not cost-effective in patients with traumatic knee complaints; in fact, MR imaging led to more healthcare costs, mainly due to higher costs on MR imaging.[19]

Clinical relevance

The GP should not refer patients (18-45 years) with traumatic knee complaints to MR imaging to improve clinical outcomes, since MR imaging resulted in increased healthcare provider involvement and increased healthcare costs without improvement of clinical outcomes. In the particular situation that the GP desires to request an MR scan to improve patient satisfaction regardless of the costs, the GP has to be aware that he/she needs to refer 5 to 7 patients with traumatic knee complaints to MR imaging to yield 1 more satisfied patient. Also, the influence of the increased contact with the healthcare providers as a result of the MR scan remains unclear. The treatment by the GP may be refined by enhanced information about the prognosis and policy targeted on the specific knee complaints.

Study strengths and limitations

This is the first large RCT concerning the additional value of an MR scan in general practice in patients with traumatic knee complaints, with a high internal and external validity.[18] The study showed consistent results in the intention-to-treat and per-protocol analyses for non-inferiority of GPs' request for an MR scan in patients with traumatic knee complaints during the 1-year follow-up. Also, superiority of MR imaging was ruled out, since the 95% CI of the overall adjusted estimates of the intention-to-treat and per-protocol analyses excluded the 6 points margin on both sides of the interval.

Our study has some limitations. Initially, we planned to include patients with knee complaints persisting for at least 4 weeks; however, this inclusion criterion was abandoned in dialogue with the participating GPs (see 'Design, study population and patient involvement'). Explorative subgroup analysis in the originally defined 'persistent' knee complaints (n=218) showed that MR imaging was also non-inferior to usual care during the 1-year follow-up (appendix 4). A second limitation is the lack of blinding in our study. Since blinding of the participants was not possible, bias may have accounted for the significant effects, mainly on patients' satisfaction and perceived recovery. Finally a third limitation was the use of the Lysholm scale which was originally developed for anterior cruciate ligament injury to assess the patients' knee-related daily function. However, all secondary clinical outcomes point in the direction of no differences between usual care and MR imaging.

Comparison with literature

Only one previous RCT regarding MR imaging in patients with traumatic knee complaints in general practice has been published.[20] Patients with suspected internal derangement of the knee were randomised to MR imaging with a provisional orthopaedic consult or to an orthopaedic consult only. In that study, access to MR imaging by the GP yielded no clinically relevant differences in physical functioning and quality of life.[21] The selection of patients with suspected internal derangement complicated the generalisability of that study. Another article emerging from the same study reported a considerably higher amount of arthroscopies (40%) in the MR group than in the orthopaedic group (28%), evaluated by questionnaires filled in by the GPs.[22] Combined, these prior studies' results are consistent with the present study, indicating no additional benefit of MR imaging by the GP concerning clinical outcomes or in preventing from referral to secondary care.

MR imaging was observed to have benefits in a prior observational cohort study in patients with knee complaints aged 48 (IQR 35-59) years.[23.] A decreased intention of the GP to refer to an orthopaedic surgeon after an MR scan compared to before the MR scan was detected, evaluated by questionnaires filled in by the GP. In 75% of the patients referred to MR imaging by the GP in the above-mentioned observational cohort, a meniscal injury was suspected. In these patients, the need of an MR scan or referral to an orthopaedic surgeon can be questioned, because the effectiveness of arthroscopic meniscal surgery is still debated.[24] Moreover, of the 101 patients

whom the GP did not intend to refer prior to MR imaging, 48 were referred to an orthopaedic surgeon based on the MR findings.[23] This confirms the hypothesis of incidental findings resulting in an increase in the amount of healthcare provided.

Future research

In our study, GPs were instructed to invite all patients with traumatic knee complaints. However, in daily practice, GPs tend to identify patients who are in need of additional diagnostics. These selection criteria are currently unclear, and should be further investigated. Subsequently, the efficacy of MR imaging in that subgroup of patients' needs to be established.

Patients' needs, expectations and preference of their treatment by the GP should also be the focus of future research. More insight into which variables influence patients' satisfaction is needed to improve the treatment of patients with traumatic knee complaints in general practice. For example, the increased contact with the healthcare providers or the patients perception of their diagnosis and prognosis may be important mediators of the increased patient satisfaction after MR imaging.

Until that, our study provides high quality evidence confirming that MR imaging in the hands of the GP for patients with traumatic knee complaints (aged 18-45 years) did not improve clinical outcomes or reduce the amount of referrals to other healthcare providers.

CONCLUSIONS

MR imaging in general practice in patients (aged 18-45 years) with traumatic knee complaints was both non-inferior and non-superior to usual care regarding knee-related daily function during 1-year follow-up. After adding MR imaging, although more patients perceived to be recovered and more were satisfied, the amount of patients visiting other healthcare providers did not decrease.

What are the new findings?

- This multicentre, randomised controlled trial provides new evidence that MRI in general practice for patients aged 18-45 years with traumatic knee complaints was not worse, but also not better than usual care, regarding knee-related daily function during 1-year follow-up.
- Adding an MRI scan requested by the general practitioner improved perceived recovery and patient satisfaction, but it also decreased the involvement of healthcare providers and the healthcare costs.

How might it impact on clinical practice in the future?

- The recommendation for the GP not to refer patients with traumatic knee complaints to MRI is strengthened with robust scientific evidence.
- The GP is faced with the challenge to consider patients' satisfaction without referral to MRI in patients with traumatic knee complaints.
- The treatment by the GP may be refined by enhanced information about the prognosis and policy targeted on the specific knee complaints.

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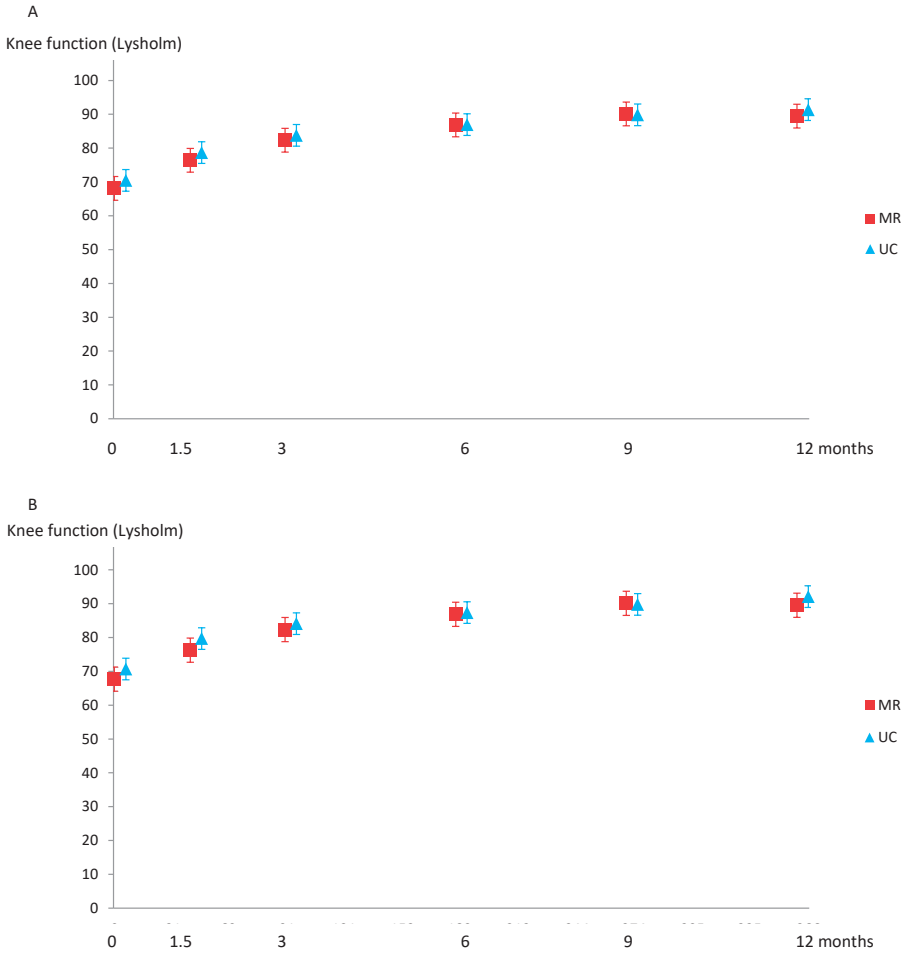
Appendix 1 MR findings of the patients randomised to receive MR imaging

MR finding	Study population (n=174)
Abnormalities present	145 (83)
Positive findings*	89 (51)
Contusion (effusion, no ligament or meniscal lesion)	25 (14)
Effusion	71 (41)
Bone bruise femorotibial joint	60 (35)
Trabecular fracture	12 (7)
Abnormalities medial meniscus	54 (31)
Mucoid degeneration	12 (7)
Tear	42 (24)
Traumatic	17 (10)
Degenerative (horizontal)	25 (14)
Abnormalities lateral meniscus	26 (15)
Mucoid degeneration	4 (2)
Tear	22 (13)
Traumatic	13 (8)
Degenerative (horizontal)	9 (5)
ACL abnormalities	40 (23)
Mucoid degeneration	2 (1)
Tear	38 (22)
PCL abnormalities	2 (1)
Mucoid degeneration	0
Tear	2 (1)
MCL sprain	27 (16)
LCL sprain	2 (1)
Cartilage abnormalities	39 (22)
Grade I-III	30 (17)
Grade IV	9 (5)
Combinations	
ACL tear and bone bruise femorotibial joint	27 (16)
Traumatic meniscus tear and bone bruise femorotibial joint	13 (8)
Traumatic meniscus tear and ACL tear	12 (7)
MCL/LCL sprain and bone bruise femorotibial joint	12 (7)

Data are presented as numbers (percentages). MR: magnetic resonance. ACL: anterior cruciate ligament. PCL: posterior cruciate ligament. MCL: medial collateral ligament. LCL: lateral collateral ligament. *Positive findings: trabecular fracture, a complete rupture of the collateral ligament, a meniscus tear, a cruciate ligament rupture or a full thickness cartilage defect.



Appendix 2 Course of the Lysholm scale
Mean and standard error of the mean of the Magnetic Resonance (MR) and usual care group (UC).
A: intention-to-treat. B: per protocol.

Appendix 3 Results of the generalized estimation equations with repeated measurements regarding differences in patient satisfaction and recovery between the MR and usual care group, adjusted for the time from trauma to study inclusion

		MR group* (n=179)	UC group* (n=177)	OR (95% CI)	p-value
Recovery	6 w	65 (36)	51 (29)	1.34 (0.87 to 2.07)	.191
	3 m	100 (56)	69 (39)	1.70 (1.10 to 2.62)	.017
	6 m	108 (60)	81 (46)	1.46 (0.90 to 2.35)	.122
	9 m	109 (61)	73 (41)	1.84 (1.10 to 3.10)	.021
	12 m	120 (67)	95 (54)	1.46 (0.88 to 2.42)	.142
	Overall			1.49 (1.10 to 2.02)	.011
Satisfaction	6 w	75 (42)	37 (21)	2.36 (1.49 to 3.73)	<.001
	3 m	84 (47)	49 (28)	1.82 (1.16 to 2.87)	.010
	6 m	85 (48)	59 (33)	1.44 (0.92 to 2.27)	.110
	9 m	87 (49)	56 (32)	1.62 (1.02 to 2.55)	.039
	12 m	92 (51)	62 (35)	1.70 (1.09 to 2.67)	.020
	Overall			1.84 (1.31 to 2.57)	<.001

MR: magnetic resonance. UC: usual care. Data are presented as numbers of recovered/satisfied patients (percentages). OR: odds ratio. CI: confidence interval. w: weeks. m: months. Recovery indicates scores completely recovered and much improved. Satisfaction indicates scores absolutely satisfied and very satisfied. The procedure models 'No' as the response, treating 'Yes' as the reference category. *The numbers and percentages are unadjusted.

Appendix 4 Results of the linear mixed models analysis with repeated measurements for differences between MR and usual care in the patients with knee complaints for at least 4 weeks, adjusted for the time from trauma to study inclusion

		Intention-to-treat					Per-protocol				
		Mean (SD)					Mean (SD)				
		MR group (n=102)	UC group (n=116)	Coefficient (95% CI)	p-value	ES	MR group (n=99)	UC group (n=105)	Coefficient (95% CI)	p-value	ES
Knee function; Lysholm scale (0-100)	6 w	81.8 (14.0)	81.0 (15.0)	0.67 (-2.68 to 4.01)	.695	0.04	81.6 (13.9)	81.1 (15.5)	0.53 (-2.98 to 4.04)	.767	0.03
	3 m	83.0 (15.9)	86.1 (14.4)	-1.92 (-5.68 to 1.84)	.315	-0.10	83.0 (15.9)	86.7 (14.2)	-2.34 (-6.18 to 1.51)	.232	-0.12
	6 m	88.7 (11.6)	87.6 (13.4)	1.10 (-2.18 to 4.39)	.507	0.06	88.7 (11.6)	88.6 (12.3)	0.21 (-2.97 to 3.39)	.896	0.01
	9 m	91.7 (9.7)	89.7 (12.8)	2.19 (-0.93 to 5.31)	.168	0.11	91.7 (9.7)	89.8 (13.3)	2.09 (-1.13 to 5.32)	.201	0.11
	12 m	90.2 (12.4)	91.9 (10.1)	-0.81 (-3.89 to 2.27)	.606	-0.04	90.5 (12.3)	93.0 (9.6)	-1.90 (-4.95 to 1.16)	.222	-0.10
	Overall			**0.25 (-2.18 to 2.67)**	**.842**	**0.02**			**-0.28 (-2.75 to 2.19)**	**.823**	**-0.01**

MR: magnetic resonance. UC: usual care. SD: standard deviation. CI: confidence interval. w: weeks. m: months. Lysholm scale scored from 0 to 100, with a higher score indicating less problems.