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ORIGINAL ARTICLE

The added prognostic value of MRI findings for recovery in patients with low back pain in primary care: a 1-year follow-up cohort study

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Abstract

Purpose Information on the prognostic value of MRI findings in low back pain patients in primary care is lacking. The objective of this study is to investigate the added prognostic value of baseline MRI findings over known prognostic factors for recovery at 12-month follow-up in patients with low back pain referred to MRI by their general practitioner.

Methods Patients referred by their general practitioner for MRI of the lumbar spine were recruited at the MRI Center. The questionnaires at baseline and at 3 and 12-months follow-up included potential clinical predictors from history taking and the outcome recovery. The MRI radiology reports were scored. Analysis was performed in 3 steps: derivation of a predictive model including characteristics of the patients and back pain only (history taking), including reported MRI findings only, and the addition of reported MRI findings to the characteristics of the patients and back pain.

Results At 12-months follow-up 53 % of the patients reported recovery ($n = 683$). Lower age, better attitude/beliefs regarding back pain, acute back pain, presence of neurological symptoms of the leg(s), and presence of non-continuous back pain were significantly associated with recovery at 12-months follow-up: area under the curve (AUC) 0.77. Addition of the MRI findings resulted in an AUC of 0.78.

Conclusions At 12-months follow-up, only 53 % of these patients with low back pain referred for MRI in general practice reported recovery. Five clinic baseline characteristics were associated with recovery at 12-months follow-up; adding the MRI findings did not result in a stronger prediction of recovery.

Keywords Low back pain · Low back pain/diagnosis · Magnetic resonance imaging · Primary health care · Outcome · Predictive value of tests · Area under curve · Logistic models

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Introduction

In recent years, general practitioners (GPs) in the Netherlands can refer low back pain (LBP) patients for MRI of the lumbar spine themselves. Despite the recommendations of the guidelines to use MRI only in specific cases, the use of MRI as the initial imaging for LBP seems to become more common in general practice in countries such as the USA and Australia [1, 2]. However, data on the use of MRI by GPs in the Netherlands are still lacking.

When used in the appropriate clinical context, MRI can detect or exclude specific pathologies and guide subsequent management. International guidelines recommend the use of imaging only when there is suspicion of serious pathology (fracture, malignancy and discitis), or in patients with severe sciatica for whom surgery is indicated because they fail to respond to conservative care for at least 6–8 weeks [1, 3]. However, the role of MRI in general practice remains controversial and the diagnostic accuracy of MRI for patients with LBP in general practice is still unknown.

The ultimate goal of any diagnostic test is to improve the clinical outcome of the patient. Well-conducted randomized trials are the top of the diagnostic evidence hierarchy, because they provide the most direct information on the clinical benefits and harms of alternative testing strategies. However, in daily practice most studies on diagnostic tests estimate how accurately they can identify a disease or condition, or how well the test provides prognostic information. Understanding of the prognostic factors in LBP and their relative importance may allow to identify patients who are at a higher risk for developing chronic LBP. Identification of prognostic factors predicting recovery, persistent pain, and disability are important for better understanding of the clinical course, to inform patients and physicians and support therapeutic decision making [4]. A diverse range of prognostic factors (demographics, physical factors, and psychological factors) has been studied in relation to persistent LBP [5]. The prognostic value of MRI findings in relation to recovery has mainly been studied in patients with sciatica in secondary care [6–11]; however, these results may differ from studies performed in patients with LBP in general practice.

The aim of this study was to investigate the course and the added prognostic value of baseline MRI findings over known prognostic factors for recovery at 12-months follow-up in patients with LBP referred to MRI by their GP.

Methods

This study is a prospective, observational cohort study in general practice, with a 12-month follow-up.

Eligible patients were enrolled between June 2010 and September 2011. The study protocol was approved by the Medical Ethics Committee of the Erasmus Medical Center, Rotterdam.

Study population

Consecutive eligible adults who were already referred by their GP for MRI of the lumbar spine were recruited at the MRI Center. The inclusion criteria for the study were: aged ≥18 years and referred by their GP for MRI of the lumbar spine. Patients were excluded from the study if there were contraindications for undergoing MRI, or if the patient had insufficient understanding of the Dutch language and/or was incapable of understanding the ramifications of participation.

Eligible patients received written information about the study at the time they made an appointment for their MRI at the MRI Center, and were given the opportunity to ask questions about the study up until the MRI appointment date. When the patient was interested, informed consent was given.

MRI findings

All patients underwent MRI (1.5 Tesla, Siemens, Erlangen, Germany), as scheduled. The MRI protocol consisted of sagittal and transverse T1 and T2 weighted sequences. We performed transverse imaging through affected disks and vertebrae plus a three-dimensional (3D) steady state sequence (CISS). The MRIs were assessed by one of seven radiologists of the MRI Center. As this study was designed to reflect daily general practice as closely as possible, we scored only the findings described in the MRI radiology reports retrieved from the MRI Center, which were identical copies of the reports sent to the referring GPs. There was no interference with the care given by the GP or other healthcare providers with respect to advice, diagnostics or treatment.

A single reader [EdS], who was trained by a radiologist [EO] and blinded to the participants' clinical data, extracted data from the MRI reports regarding the presence or absence of the following findings at each lumbar level (T12-L1 through L5-S1): intervertebral disc bulging, disc herniation (protrusion/extrusion), nerve root compression, spinal stenosis, spondylolisthesis, and serious pathology (fracture, malignancy and/or discitis).

Outcomes and potential predictors

After inclusion, the baseline measurement included validated questionnaires, for which participants were invited by email containing a secured link to the online questionnaires. The follow-up period was 12 months, with follow-up measurements at 3 and 12 months. Reminders were sent by email after 2 and 3 weeks of non-response.

The primary outcome measure was recovery, defined as a score of 'strongly improved' or 'completely recovered' on the global perceived effect (GPE) scale [12]. No recovery was defined as a GPE score of 'somewhat improved', 'stayed the same', 'somewhat worsened', 'strongly worsened', or 'worse than ever'. Secondary outcome measures included severity of back pain measured on an 11-point numerical rating scale (NRS) in which 0 represents 'no pain' and 10 represents 'unbearable pain' [13]; disability measured using the Roland Disability Questionnaire (RDQ), with scores ranging from 0 (no disability) to 24 (severe disability) [14]; and surgery during follow-up (determined with the question: "Did you undergo surgery because of your low back pain in the last 3/9 months?"). Recovery of the secondary outcomes was defined as 'severity of back pain <3 (NRS)' or 'disability score <4 (RDQ)' at 12-months follow-up [15].

The baseline questionnaire included measurements of potential predictors for recovery. We chose 21 candidate predictors reported to be prognostic and/or deemed clinically relevant, taking into account the rule of thumb that logistic regression models require a minimum of ten events per predictor [16]. These factors were divided into three categories: (1) patient characteristics: age, gender, body mass index (BMI), level of education, employment status, and attitude/beliefs about low back pain at baseline (BBQ, range 9–45) [17]; (2) back pain characteristics: duration of back symptoms, history of back pain, severity of back pain at baseline (NRS), presence of radiating pain in the legs below the knee, neurological symptoms of the legs, morning stiffness of the back, presence of continuous back pain independent of posture or activity, disability at baseline (RDQ, range 0–24), and history of back surgery; (3) MRI findings: bulging, disc herniation, nerve root compression, spinal stenosis, spondylolisthesis, and serious pathology (fracture, malignancy and/or discitis). Neurological symptoms were determined with the question: "did you have any complaints of numbness or tingling of the leg(s), and/or weakness of the leg(s) during the last week" (answer yes/no).

Statistical analysis

Descriptive analyses were used to report the characteristics of the patients and the course of back pain over the 12-month follow-up period using the mean and standard deviation (SD) for continuous data, and proportions for categorical data. Data were screened for inconsistencies and missing baseline data were imputed using multivariate imputation resulting in five imputed datasets [18]. Visual inspection of the linear relationship of all continuous variables and the primary outcome revealed nonlinearity between BMI and RDQ score at baseline with the outcome. Therefore, BMI was dichotomized into <25 and $\geq$25 and RDQ score into <18 and $\geq$18. To enable easy interpretation of predictors in a clinical setting, we dichotomized the following categorical variables: education was dichotomized in low (lower secondary school or compulsory education) and high level education; and duration of back pain in acute ($\leq$3 months) and chronic back pain.

A correlation matrix was observed for all potential predictors to check for co-linearity, setting the cut-off value for Pearson's correlation coefficient (R) at 0.70. None of the predictors were highly correlated. Multiple (backward) logistic regression analyses were performed (entry 0.05, removal 0.10) to determine which baseline factors were associated with the primary outcome.

The analyses were carried out in three steps: derivation of a predictive model (1) including patients' and back pain characteristics only (history taking), (2) including reported MRI findings only, (3) including both patients' and back pain characteristics and MRI findings. If potential predictors were selected in at least three of five imputed databases in the multivariate analysis, they were included in the final model (enter method; $p < 0.05$). To evaluate the discriminative ability of the models, a receiver operating characteristic curve was generated for the predicted probabilities and the area under the curve (AUC) was calculated [19]. The predictive value of the MRI findings was evaluated by observing the increase in discriminative ability (AUC) with the DeLong test [20]. Analyses were performed using SPSS version 20.0 (SPSS Inc., USA) and MedCalc version 12.4.0.0 (MedCalc Software bvba).

Additional analyses: sciatica and surgery

Additional exploratory analyses were carried out:

1. in the subgroup of patients for which clinical practice guidelines actually recommend imaging (specified as patients with pain radiating in the leg below the knee ($\geq$7 NRS) for $\geq$6 weeks at baseline);
2. in the subgroup of patients who did not underwent surgery during the 12-month follow-up;
3. with the secondary outcomes 'severity of back and leg pain <3 (NRS)' and 'disability score <4 (RDQ)' at 12-months follow-up.

Results

A total of 683 referred patients participated in the study (Fig. 1). During follow-up, 547 (80 %) patients returned the 3-month follow-up questionnaire and 474 (69 %) returned the 12-month follow-up questionnaire. Information on BMI at baseline was missing in eight patients (1 %).

The baseline characteristics of the patients are presented in Table 1. The mean age of the patients was 49.9 (SD 12.5; range 19–80) years. In total, 53 % of the patients were male. At baseline, 33 % of the patients reported acute back pain. Of all patients, 66 % reported radiating pain in the leg below the knee; 77 % reported neurological symptoms of the leg(s).

The MRI reports described disc herniation in 72 % of the patients; 69 % of the MRI reports mentioned signs of nerve root compression. Spinal stenosis was reported in 13 % of the patients. Serious pathologies (fractures, malignancies and discitis) were reported in 3 % of the patients.

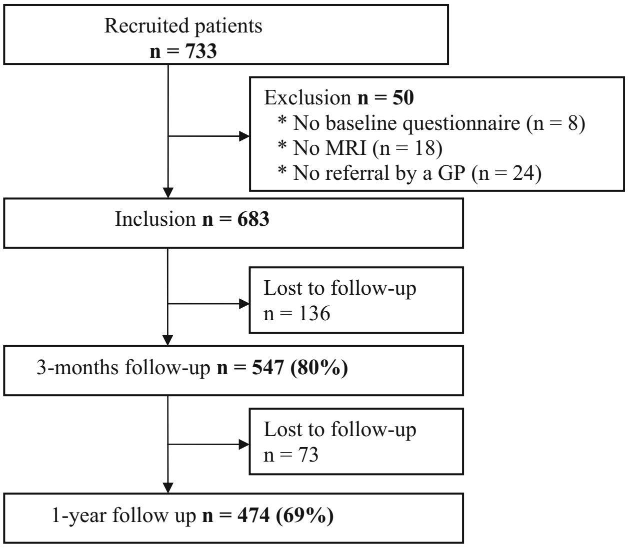

Fig. 1 Flow chart of the study population

Course

At 3-months follow-up, the mean back pain severity had decreased from 6.6 (SD 2.0) to 3.8 (SD 2.6) on the 11-point NRS, and 44 % of the patients reported recovery (Table 2). At 12-months follow-up, the mean back pain severity was 3.8 (SD 2.8), and 53 % of the patients reported recovery. The mean disability score was 13.5 (SD 5.2) at baseline, 8.5 (SD 6.0) at 3-months, and 6.5 (SD 5.7) at 12-months follow-up.

Predictors of recovery

Table 3 shows the results of the multivariate logistic regression analysis regarding the potential predictors on the primary outcome recovery. In the first model that included patient and back pain characteristics as potential predictors, the variables associated with recovery were: age [odds ratio (OR) 0.98; 95 % confidence interval (CI): 0.96–0.99], the BBQ score (OR 1.1; CI: 1.0–1.1), acute back pain (OR 3.0; CI: 1.9–4.8), neurological symptoms of the leg(s) (OR 2.3; CI: 1.4–3.9), and continuous back pain independent of posture or activity (OR 0.3; CI: 0.2–0.5). The AUC for this model was 0.77 (Table 3).

The second model was calculated with the MRI findings. The variables associated with recovery were: discus hernia (OR 1.6; CI 1.1–2.6), and nerve root compression (OR 2.2; CI 1.4–3.5). The AUC for this model was 0.63.

When model two (the MRI findings) was added to the first model, the AUC increased to 0.78 and the variables associated with recovery were: age (OR 0.98; CI: 0.96–1.0), the BBQ score (OR 1.1; CI: 1.0–1.1), acute back pain (OR 2.8; CI: 1.7–4.5), neurological symptoms of the legs (OR 2.0; CI: 1.2–3.5), continuous back pain independent of posture or activity (OR 0.3; CI: 0.2–0.5), and nerve root compression (OR 2.2; CI: 1.4–3.4). The discriminative ability (AUC) of model 1 and 3 showed no significant difference ($p = 0.086$).

Additional analyses: sciatica and surgery

One of the main groups for which clinical practice guidelines recommend imaging is the group of sciatica patients with an indication for surgery, specified as sciatica patients with severe leg pain for ≥6 weeks. Additional analyses in this group of patients ($n = 259$) showed an AUC of 0.78 for the first model (Supplemental Digital Content 1). When the MRI findings were added to the first model, the AUC remained 0.78. Again, the discriminative ability (AUC) of model one and model three showed no significant difference ($p \geq 0.05$).

To study the possible influence of surgery during follow-up, additional analyses in patients without surgery during follow-up ($n = 559$) were performed (Supplemental Digital Content 2). The analyses showed an AUC of 0.80 for the first model. When the MRI findings were added to the first model, the AUC (0.80) showed no significant difference.

Secondary analyses with the outcome ‘severity of back and leg pain <3 (NRS)’ at 12-months follow-up showed an AUC of 0.73 for the first model (Supplemental Digital Content 3). When the MRI findings were added to the first model, the AUC (0.74) showed no significant difference. Secondary analyses with the outcome ‘disability score <4 (RDQ)’ at 12-months follow-up showed an AUC of 0.76 for the first model (Supplemental Digital Content 4). When the variables of the MRI findings were added (model 3), none of the MRI findings were significant predictors.

Discussion

This study presents the course of low back pain in 683 patients who were referred for MRI of the lumbar spine by their GP and identified predictors for recovery at 12-months follow-up. Back pain severity of the patients decreased from a mean of 6.6 (SD 2.0) at baseline to 3.8 (SD 2.6) at 3-months follow-up and to 3.8 (SD 2.8) at 12-months follow-up. At 12-months follow-up 53 % of the patients reported recovery. Lower age, better attitude/beliefs regarding back pain, acute back pain, presence of

Table 1 Baseline characteristics of the included 683 patients and of the 251 patients that reported recovery at 12 months follow-up

	Study population ($n = 683$)	Recovered at 12 months ($n = 251$)
Patient characteristics		
Age in years, mean (SD)	49.9 (12.5)	49.8 (12.4)
Male	365 (53)	146 (58)
BMI, mean (SD)	25.9 (3.8)	26.0 (3.6)
BMI ≥25	390 (57)	150 (60)
Education level low	244 (36)	72 (29)
Employed (paid job)	479 (70)	183 (73)
Attitude and beliefs about back pain (BBQ), mean (SD)	26.3 (6.1)	28.0 (5.8)
Back pain characteristics		
Acute back pain (<3 months)	228 (33)	118 (47)
History of back pain	549 (80)	198 (79)
Severity of back pain (NRS), mean (SD)	6.6 (2.0)	6.1 (2.3)
Pain radiating in the leg below the knee	450 (66)	185 (74)
Neurological symptoms in legs	525 (77)	206 (82)
Morning stiffness of the back	353 (52)	117 (47)
Continuous back pain	347 (51)	91 (36)
Disability (RDQ), mean (SD)	13.5 (5.2)	13.6 (4.8)
RDQ ≥18	173 (25)	58 (23)
History of back surgery	112 (16)	38 (15)
MRI findings		
Bulging	308 (45)	109 (43)
Disc herniation	492 (72)	200 (80)
Nerve root compression	472 (69)	200 (80)
Spinal stenosis	87 (13)	29 (12)
Spondylolisthesis	56 (8)	18 (7)
Serious pathology[a]	22 (3)	9 (4)

Data are presented as numbers (percentages) unless otherwise indicated

SD standard deviation; *BBQ* back beliefs questionnaire (range 9–45), a higher score indicates better attitude/belief regarding back pain, *NRS* numeric rating scale (range 0–10, 0 means no pain), *RDQ* Roland disability questionnaire (range 0–24), a higher score indicates worse health

[a] Serious pathology: impression fracture, malignancy and/or discitis

Table 2 Outcomes at baseline, and at 3 and 12-months follow-up

	Baseline ($n = 683$)	3-months follow-up ($n = 547$)	12-months follow-up ($n = 474$)
Recovery (GPE), *n* (%)	–	240 (44)	251 (53)
Severity of back pain (NRS), mean (SD)	6.6 (2.0)	3.8 (2.6)[a]	3.8 (2.8)[a]
Disability (RDQ), mean (SD)	13.5 (5.2)	8.5 (6.0)[a]	6.5 (5.7)[a]

GPE global perceived effect, *7* point Likert scale, dichotomized in *1–2* recovery, *3–7* no recovery, *NRS* numeric rating scale (range 0–10, 0 means no pain), *RDQ* Roland disability questionnaire (range 0–24, 0 means no disability), a higher score indicates worse health, *SD* standard deviation

[a] A statistical significant difference ($p < 0.01$) between baseline and follow-up

neurological symptoms of the leg(s), and presence of non-continuous back pain were significantly associated with recovery at 12-months follow-up (AUC 0.77). Addition of the reported MRI findings did not add to the predictive value of the prognostic model with clinical factors only.

Comparison with existing literature

To our knowledge, this is the first prospective cohort study of patients with LBP referred for MRI in a primary care setting. Baseline back pain severity scores were higher than

Table 3 Results of multivariate logistic regression analysis regarding potential predictors and recovery at 12-months follow-up ($n = 474$)

Recovery (GPE)	Pooled OR (95 % CI)	*p* value	AUC
Patient and back pain characteristics			0.77
Age	0.98 (0.96–0.99)	<0.01	
Attitude and beliefs about back pain (BBQ)	1.1 (1.0–1.1)	<0.01	
Acute pain at baseline (yes)	3.0 (1.9–4.8)	<0.01	
Neurological symptoms in legs (yes)	2.3 (1.4–3.9)	<0.01	
Continuous back pain (yes)	0.3 (0.2–0.5)	<0.01	
MRI findings			0.63
Disc herniation (yes)	1.6 (1.1–2.6)	<0.05	
Nerve root compression (yes)	2.2 (1.4–3.5)	<0.01	
Patient and back pain characteristics + MRI findings			0.78
Age	0.98 (0.96–1.0)	<0.05	
Attitude and beliefs about back pain (BBQ)	1.1 (1.0–1.1)	<0.01	
Acute pain at baseline (yes)	2.8 (1.7–4.5)	<0.01	
Neurological symptoms of legs (yes)	2.0 (1.2–3.5)	<0.01	
Continuous back pain (yes)	0.3 (0.2–0.5)	<0.01	
Nerve root compression (yes)	2.2 (1.4–3.4)	<0.01	

GPE global perceived effect, *7* point Likert scale, dichotomized in *1–2* recovery, *3–7* no recovery, *OR* odds ratio, *AUC* area under the curve, *BBQ* back beliefs questionnaire (range 9–45), a higher score indicates better attitude/beliefs regarding back pain, *MRI* magnetic resonance imaging

reported in earlier LBP cohort studies [5, 21–23]. Disability scores are similar to those in two studies that included patients with LBP referred for MRI or radiography by their primary physician [21, 24].

Back pain severity mainly decreased during the first 3 months and then remained relatively stable between 3 and 12 months. A similar pattern was found in other (back) pain studies [24–27]. In the review by Pengel et al. only studies investigating patients with acute back pain were included [25]. In our cohort study the pattern was also visible in patients reporting chronic back pain. A possible explanation for this observation could be that the chronic back pain patients visited their GP during a flare-up of their back pain and therefore showed a pain pattern similar to patients with acute back pain. Another explanation for the improvement of patients over time may be regression to the mean, which is a consequence of random variation over time [27].

In our cohort, MRI reports showed disc herniation in 72 % and nerve root compression in 69 % of the patients. Both these prevalences are higher than reported in other cohorts that included patients with LBP [24, 28]. As expected, of the serious pathologies (fractures, malignancies and discitis), the most frequently observed serious pathology was vertebral fracture (3 %). This is consistent with a recent study on the prevalence of serious spinal pathology in primary care [29].

In the field of LBP, previous studies presented inconsistent conclusions regarding important prognostic factors for recovery [30]. Only a small number of important prognostic factors were consistently reported; of these, both lower age and acute back pain were also related to recovery at follow-up in our cohort. Negative beliefs about LBP was only reported in one other study as an independent risk factor for poor recovery [31], and was associated with high back pain intensity levels in a cross-sectional study [32]. Continuous back pain was reported as a factor for poor recovery in only one study [33]. The question about the presence of continuous back pain independent of posture or activity is often used in primary care, but is not often examined in prognostic studies.

A recent review reported that the presence of pain radiating down the leg, with neurological findings, was associated with a poor prognosis in patients with LBP [34]. In our model, neurological symptoms of the legs were positively associated with recovery. An explanation for this could be that the included patients without neurological symptoms of the legs tend to be worse off in terms of pain, disability and duration of complaints.

The AUC of the multiple regression model remained similar when the variables of the MRI findings were added to the model that included characteristics of the patients and of back pain. This indicates no additional value of the reported MRI findings with regard to the discriminative value to predict recovery at 12-months follow-up. The only MRI finding that remained in the model was ‘nerve root compression’ and, when it is was included, the association of the variables ‘acute pain’ and ‘neurological symptoms’ diminished. Additional analyses in patients with an indication for surgery and in patients who did not underwent surgery during follow-up again showed that adding MRI findings did not result in a stronger prediction of recovery at 12 months follow-up.

Strengths and limitations

Strengths of the present study are that it included a relatively high number of patients, had low dropout rates despite the use of online questionnaires, and had almost no missing data (1 %). However, some limitations need to be considered when interpreting the results. One limitation is that the presence of several MRI findings might be underestimated (in particular spinal stenosis) due to using the MRI reports only instead of standardized scoring of the MR images. Furthermore, in the included MRI reports, there was no systematically reporting of Modic changes or facet arthritis. This way it was unfortunately not possible to include these in our analyses. Further research may be needed to assess the discriminative value of systematically scored MRIs. However, use of the MRI reports only reflects daily general practice as closely as possible.

Implications for clinicians

Understanding of the prognostic factors in LBP and their relative importance may allow to identify patients at a higher risk for developing chronic complaints. Predictors for recovery were lower age, acute back pain at baseline, the presence of neurological symptoms of the leg(s), the presence of non-continuous back pain, and better attitude/beliefs regarding back pain. Adding MRI findings did not result in a stronger prediction of recovery at 12-months follow-up. These findings suggest that GPs can provide a moderately good prediction of the prognosis of their patients with LBP based on their characteristics and complaints (history taking); information from the MRI reports does not offer added prognostic value. However, the real diagnostic accuracy of lumbar MRI in this group of primary care patients is still unknown; for this a well-designed randomized controlled trial is required.

Compliance with ethical standards

This study is partly funded by a program grant of the Dutch Arthritis Foundation. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

Conflict of interest I(we) certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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