

# Diagnostic value of history and physical examination in patients suspected of lumbosacral nerve root compression

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**Objective:** To evaluate patient characteristics, symptoms, and examination findings in the clinical diagnosis of lumbosacral nerve root compression causing sciatica.

**Methods:** The study involved 274 patients with pain radiating into the leg. All had a standardised clinical assessment and magnetic resonance (MR) imaging. The associations between patient characteristics, clinical findings, and lumbosacral nerve root compression on MR imaging were analysed.

**Results:** Nerve root compression was associated with three patient characteristics, three symptoms, and four physical examination findings (paresis, absence of tendon reflexes, a positive straight leg raising test, and increased finger-floor distance). Multivariate analysis, analysing the independent diagnostic value of the tests, showed that nerve root compression was predicted by two patient characteristics, four symptoms, and two signs (increased finger-floor distance and paresis). The straight leg raise test was not predictive. The area under the curve of the receiver-operating characteristic was 0.80 for the history items. It increased to 0.83 when the physical examination items were added.

**Conclusions:** Various clinical findings were found to be associated with nerve root compression on MR imaging. While this set of findings agrees well with those commonly used in daily practice, the tests tended to have lower sensitivity and specificity than previously reported. Stepwise multivariate analysis showed that most of the diagnostic information revealed by physical examination findings had already been revealed by the history items.

Disc herniation often does not cause symptoms.<sup>1</sup> On the other hand, it may cause sciatica by compressing the nerve roots. Diagnostic procedures such as magnetic resonance (MR) imaging help to establish disc herniation as the anatomical basis for sciatica. Several treatments, especially discectomy, have been advocated for patients with sciatica, but are indicated only if nerve root compression is considered to be the cause.<sup>2–4</sup> Therefore, an accurate initial clinical diagnosis of nerve root compression is highly desirable.<sup>5–6</sup>

In one systematic review of the value of history and physical examination in radicular syndromes it was concluded that none of the tests used had a high sensitivity or specificity.<sup>7</sup> Unfortunately, various symptoms and some commonly assessed clinical signs were not reviewed in that study. It was concluded in two other reviews<sup>8–9</sup> that the diagnostic value of many signs and symptoms had not been thoroughly investigated.

The most common methodological drawbacks in previous studies have been the choice of a suboptimal gold standard, selection bias, and univariate analysis.<sup>9</sup> In many studies disc herniation rather than nerve root compression was used as the gold standard. However, disc herniation need not result in nerve root compression and has been found to be asymptomatic in many subjects.<sup>1–10</sup> Also, in several previous studies the history and physical examination findings probably affected the selection of the patients for the study.<sup>9</sup> This so called "sequential ordering bias" occurs when patients with positive findings are more likely to be selected for study than patients with negative findings.<sup>11–14</sup> Finally, previous analytical methods have used univariate analysis; multivariate analysis, however, allows one to assess the contribution of separate clinical findings to the overall diagnosis, taking into account the high degree of correlation between clinical findings.

With these factors in mind, we undertook a cross sectional study examining the value of history and physical examina-

tion in the diagnosis of nerve root compression. We studied patients presenting to a primary care physician with a new episode of pain radiating into the leg, and we used MR imaging to establish the presence of nerve root compression.

## METHODS

### Study population

Fifty general practitioners in Maastricht and surrounding villages referred patients with a new episode of pain radiating into the leg below the gluteal fold to the neurology department of the Maastricht University Hospital. In this study we only included patients with pain sufficiently severe to justify further action (defined as pain that might justify bed rest for 14 days, because part of the study population was involved in a trial of bed rest<sup>15</sup>). Exclusion criteria were previous spinal surgery, pregnancy, severe comorbidity, or contraindication to MR imaging (metal containing prostheses, pacemakers).

### Investigations

Eligible patients gave their written informed consent for the study within two days of the first general practitioner consultation. Clinical findings were then established in a standardised fashion based on good clinical practice, standard textbook sections, and published reports. The methods and interobserver consistency of the history and physical examination have been reported elsewhere.<sup>16</sup>

The gold standard in all patients was MR imaging of the lumbar spine within 24 hours after the clinical examination.<sup>17</sup> This was performed using a 0.5 T system according to the following scanning protocol: first, sagittal and transverse T<sub>1</sub> weighted sequences (TR/TE 400–600/20 ms) with 4 and 5 mm slice thickness, respectively; and second, a sagittal dual echo proton density and T<sub>2</sub> weighted sequence (fast spin echo

**Table 1** Baseline patient characteristics and their relation to nerve root compression (n=274)

| Characteristic                         | MRI+ (n=152) | MRI- (n=122) | Odds ratio (95% CI)      |
|--|--------------|--------------|--------------------------|
| Age (years) (mean (SD), 46 (12) years) |              |              |                          |
| 16–40                                  | 43           | 48           |                          |
| 41–50                                  | 50           | 44           | 1.3 (0.7 to 2.3)         |
| 51–81                                  | 59           | 30           | <b>2.2 (1.2 to 4.0)</b>  |
| Male sex                               | 67           | 72           | <b>1.8 (1.1 to 3.0)</b>  |
| Duration of disease (median 19 days)   |              |              |                          |
| 14 days or less                        | 70           | 55           |                          |
| 15–30 days                             | 41           | 19           | 1.7 (0.9 to 3.2)         |
| >30 days                               | 41           | 48           | 0.7 (0.4 to 1.2)         |
| Living alone                           | 29           | 19           | 1.3 (0.7 to 2.4)         |
| High education level                   | 45           | 25           | 1.6 (0.9 to 2.9)         |
| Job type                               |              |              |                          |
| No job                                 | 66           | 43           |                          |
| Cognitive                              | 42           | 26           | 1.1 (0.6 to 2.0)         |
| Standing/walking/lifting               | 28           | 36           | <b>0.5 (0.3 to 0.95)</b> |
| Physically demanding                   | 16           | 17           | 0.6 (0.3 to 1.3)         |
| Any comorbidity                        | 64           | 44           | 1.3 (0.8 to 2.1)         |
| Smoking                                | 65           | 63           | 0.7 (0.4 to 1.1)         |
| Sports activities                      | 67           | 51           | 1.1 (0.7 to 2.2)         |
| Exercised back/abd muscles             | 60           | 54           | 0.8 (0.5 to 1.3)         |
| Family history sciatica                | 51           | 38           | 1.1 (0.7 to 1.9)         |
| Queflet index (mean (SD))              | 25.5 (5.1)   | 25.6 (4.0)   | p=0.79                   |

Values in bold indicate significant effect.

Abd, abdominal; CI, confidence interval; MRI+/-, magnetic resonance imaging positive or negative.

TR/TE 4500/25–150 ms) with 5 mm slice thickness. We also carried out MR radiculography, consisting of two heavily T2 weighted fast spin echo sequences (TR/TE 6000/450 ms) with 4 mm slice thickness, oriented parallel to the emerging L5 root, about 20° left and right oblique to the coronal plane, reformatted with a maximum intensity projection protocol.<sup>18</sup>

A standardised assessment of all MR imaging studies was done by a neuroradiologist (JW) experienced in spinal magnetic resonance imaging. The assessment focused on the presence or absence of nerve root (sleeve) compression. Criteria used for grading included the presence of a protruding annulus or extruded nucleus material, or lateral recess narrowing on standard MR imaging, and flattening and compression of the ventrolateral border of the dural sac or emerging nerve root sleeve, with obliteration of the surrounding epidural fat. In the MR radiculography images, positive criteria included dural impressions, kinking, and swelling of the intradural nerve root and cut off of the root sleeve filling.

The clinical investigator was unaware of the MR findings, while the neuroradiologist was unaware of the clinical findings.

#### Statistical analysis

For the analysis the statistical package for the social sciences (SPSS) was used. A bivariate analysis was based on 2 × 2 tables relating history and physical examination items to nerve root compression on MR imaging. Sensitivity, specificity, and likelihood ratios for positive and negative test results (LR+ and LR-) were calculated, as well as the diagnostic odds ratio (DOR, with DOR = LR+/LR-).<sup>19–20</sup> The statistical significance of the association was assessed using Pearson's  $\chi^2$  statistic.

In a backward stepwise logistic regression analysis,<sup>21–22</sup> the likelihood ratio test was used for each step at a significance level of 0.05. First, a set of general patient characteristics (all variables in table 1) was modelled, leading to model A.

**Table 2** Diagnostic accuracy of the history (n=274)

| Characteristic  | MRI+ (n=152) | MRI- (n=122) | Odds ratio (95% CI)     |
|---|--------------|--------------|-------------------------|
| Pain worse in leg than in back                                | 125          | 56           | <b>5.5 (3.2 to 9.4)</b> |
| Typically dermatomal distribution                             | 136          | 84           | <b>3.8 (2.0 to 7.3)</b> |
| Pain worse on coughing/sneezing/straining                     | 76           | 40           | <b>2.1 (1.3 to 3.4)</b> |
| Dermatomal cold sensations in leg                             | 47           | 24           | <b>1.8 (1.0 to 3.2)</b> |
| More pain on sitting  | 82           | 69           | 0.9 (0.6 to 1.5)        |
| Less pain standing or walking                                 | 31           | 26           | 0.9 (0.5 to 1.7)        |
| Less pain on lying down                                       | 91           | 69           | 1.1 (0.7 to 1.9)        |
| Sudden onset  | 60           | 51           | 0.9 (0.6 to 1.5)        |
| Paroxysmal pattern  | 67           | 47           | 1.3 (0.8 to 2.0)        |
| Pain worse at night   | 47           | 42           | 0.9 (0.5 to 1.4)        |
| With known cause  | 38           | 37           | 0.8 (0.5 to 1.3)        |
| Subjective muscle weakness                                    | 41           | 46           | 0.6 (0.4 to 1.0)        |
| Subjective sensory loss                                       | 60           | 51           | 0.9 (0.6 to 1.5)        |
| Dermatomal paraesthesiae                                      | 78           | 72           | 0.7 (0.5 to 1.2)        |
| Previous back pain episodes                                   | 113          | 85           | 1.3 (0.7 to 2.1)        |
| Previous sciatica   | 55           | 52           | 0.8 (0.5 to 1.2)        |
| History indicating root compression according to investigator | 118          | 64           | 3.1 (1.9 to 5.3)        |

Values in bold indicate significant effect.

CI, confidence interval; MRI+/-, magnetic resonance imaging positive or negative.

**Table 3** Diagnostic accuracy of the physical examination (n=274)

| Characteristic  | MRI+ (n=152) | MRI- (n=122) | Odds ratio (95% CI)      |
|---|--------------|--------------|--------------------------|
| Paresis   | 41           | 8            | <b>5.2 (2.4 to 11.7)</b> |
| Finger-floor distance $\geq 25$ cm  | 68           | 32           | <b>2.4 (1.4 to 4.0)</b>  |
| Absence of ankle/knee tendon reflex   | 22           | 8            | <b>2.4 (1.0 to 5.6)</b>  |
| Positive SLR  | 97           | 53           | <b>2.3 (1.4 to 3.7)</b>  |
| Sensory loss  |              |              |                          |
| Hypesthesia   | 43           | 42           | 0.8 (0.5 to 1.3)         |
| Hypalgesia  | 26           | 19           | 1.2 (0.6 to 2.1)         |
| History and examination indicating root compression according to investigator | 123          | 59           | <b>4.5 (2.6 to 7.8)</b>  |

Values in bold indicate significant effect.

CI, confidence interval; MRI+/-, magnetic resonance imaging positive or negative; SLR, straight leg raise.

Second, a set of history items (all variables in table 2) was modelled (model B), also including the variables in model A that were significantly predictive. Third, all physical examination findings in table 3 and the significant predictors of model B were modelled into the final reduced model C (presented in table 4).

The neuroradiologist assessed 60 scans twice to allow calculation of a  $\kappa$  value for intraobserver variability.<sup>21</sup>

The probability of nerve root compression on MR imaging predicted by the various reduced models was calculated for each patient. Subsequently, to evaluate the predictive power of each model, receiver-operating characteristic (ROC) curves were plotted, displaying the sensitivity  $\nu$  (1 – specificity) for each cut off point of predicted posterior probability.<sup>23–24</sup> The areas under the ROC curves were calculated. The probability cut off with the maximum expected gain was determined as the point with the highest sum of sensitivity and specificity.<sup>25</sup> As a reference, the sensitivity and specificity of the observer's summary statement on the presence of nerve root compression are shown (at the bottom of tables 2 and 3).

## Ethics

The procedures of this study were in accordance with the ethical standards of the revised Helsinki declaration of 1983 and were approved by the Maastricht University Hospital ethics committee.

**Table 4** Predictors of nerve root compression on magnetic resonance imaging: results of multiple logistic regression analysis (n=274)

| Test                                      | Adjusted diagnostic OR | 95% CI      |
|---|------------------------|-------------|
| <i>History</i>                            |                        |             |
| Age (years)                               |                        |             |
| 41–50 $\nu$ 16–40                         | 1.8                    | 1.3 to 2.6  |
| 51–81 $\nu$ 16–40                         | 2.8                    | 1.9 to 4.2  |
| Duration of disease (days)                |                        |             |
| 15–30 $\nu$ <15                           | 2.2                    | 1.5 to 3.3  |
| >30 $\nu$ <15                             | 0.8                    | 0.6 to 1.1  |
| Paroxysmal pain                           | 1.8                    | 1.3 to 2.5  |
| Pain worse in leg than in back            | 4.5                    | 3.3 to 6.2  |
| Typical dermatomal distribution           | 3.2                    | 2.2 to 4.7  |
| Pain worse on coughing/sneezing/straining | 2.0                    | 1.4 to 2.7  |
| <i>Physical examination</i>               |                        |             |
| Finger-floor distance (cm)                |                        |             |
| 5–24 $\nu$ 0–4                            | 1.1                    | 0.7 to 1.6  |
| >25 $\nu$ 0–4                             | 2.8                    | 1.9 to 4.3  |
| Missing $\nu$ 0–4                         | 1.0                    | 0.4 to 2.1  |
| Paresis                                   | 5.2                    | 3.3 to 11.6 |
| Intercept                                 | –3.511                 |             |

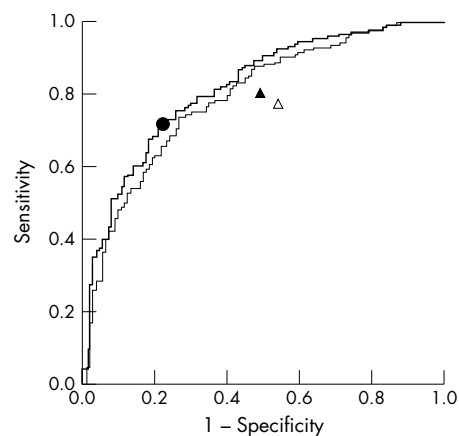
CI, confidence interval; OR, odds ratio.

## RESULTS

In all, 338 patients were referred for the diagnostic study. Sixty four were excluded (35 because of insufficient pain and 29 because of previous spinal surgery or contraindications to MR imaging). Thus the investigations were carried out in 274 patients. The intraobserver consistency of the MR imaging diagnosis of nerve root compression was high ( $\kappa$  value 0.83).

Table 1 shows the most important patient characteristics. Root compression was found on 56% of the MR imaging studies. The pain radiating into the leg was clinically diagnosed as sciatica in 67% of patients, while other diagnoses included coxarthrosis, spondylolisthesis, regional neoplastic growth, peripheral neuropathy, and pain of tendomyogenous or other origin. The sample included sciatica patients both with and without various degrees of neurological deficit. Two patients suffered from urinary incontinence and saddle anaesthesia.

In the univariate analysis, there was an association between nerve root compression on MR imaging and three patient



**Figure 1** Upper curve: diagnostic value of history and physical examination (variables in table 4; area under the curve = 0.83). Lower curve: diagnostic value of history (area under the curve = 0.80). • Maximum diagnostic gain of model according to Connell and Koepsell.<sup>25</sup>  $\Delta$  Sensitivity and 1 – specificity for the observer's diagnosis after history.  $\blacktriangle$  Sensitivity and 1 – specificity for the observer's diagnosis after history and physical examination. A physician makes a diagnosis of nerve root compression when he feels that the clinical findings indicate disease with a high enough probability. The latter is the physician's intrinsic cut off probability of disease. For example, the intrinsic cut off probability for the observer is shown by the black triangle in the figure. The logistic models allows an estimation of diagnostic properties for all possible probability cut off points. Plotting these properties results in the receiver-operating characteristic. The area under the curve represents the overall diagnostic value of the model regardless of cut off probability. Maximum diagnostic gain might be estimated as the point in the upper left hand corner or as the highest sum of sensitivity and specificity as proposed by Connell and Koepsell.<sup>19–25</sup>

characteristics: age, sex, and having a job with a predominance of standing, walking, or lifting activities (table 1). MR imaging was also associated with three symptoms: typical dermatomal pain, coldness in the leg, and increased pain on coughing, sneezing, or straining (table 2). Four physical examination items were discriminative: paresis, a finger-floor distance of more than 25 cm, absence of knee or ankle tendon reflex, and a positive straight leg raise test (table 3).

However, in diagnosing nerve root compression clinical findings are not considered separately but in combination. This is reflected in multiple logistic regression models, which allow calculation of the independent predictive value of patient characteristics and clinical findings and predict the probability of nerve root compression. Table 4 shows that two general patient characteristics (age and duration of disease), four symptoms from the history, and two signs from the physical examination were independent predictors of nerve root compression. The straight leg raise test was not a significant predictor, while an increased finger-floor distance and paresis were significant predictors.

The area under the curve of the ROC for the model using history findings alone was 0.80. This increased to 0.83 when the examination findings were added (fig 1). Maximum predictive gain of the model occurred at a predicted probability value of 0.625 with a sensitivity and specificity of 72% and 80%, respectively.

## DISCUSSION

In our 274 primary care patients with leg pain, three patient characteristics, three symptoms, and four signs were associated with nerve root compression on MR imaging. However, the sensitivity and specificity values we found in this study were lower than previously reported.<sup>7</sup> Different study populations and designs may explain this.<sup>13</sup>

Positive clinical findings were not the reason for referral in our study and therefore we have avoided the verification bias<sup>25, 26</sup> and spectrum bias<sup>27</sup> of previous studies. There are also indirect clues that the participating patients were indeed an unbiased primary care population. For example, both sexes were equally represented, while previous secondary care patient series have included nearly twice as many men as women. Also, neurological deficits were far less common in our patient sample than in previous series.<sup>9</sup> To avoid including asymptomatic or minor conditions, we accepted only those patients who had severe pain radiating into the leg. We felt that a clinical diagnosis of nerve root compression in patients with no leg pain was probably rare and in any case should not lead to discectomy.

MR imaging was used as the state of the art procedure to demonstrate nerve root compression.<sup>17, 28–30</sup> Sensitivity and specificity values of MR imaging in the diagnosis of disc herniation range from 71% to 100% and from 50% to 86%, respectively.<sup>17, 31, 32</sup> Several investigators have reported disc herniation in asymptomatic subjects using MR imaging,<sup>1, 33</sup> computed tomography,<sup>34</sup> and caudography.<sup>35</sup> However, none of these related the disc herniation to the presence of nerve root compression. Some false negative diagnoses may be explained by changes in the pathological anatomy of the nerve root with posture and over time.<sup>36</sup> The additional value of MR radiculography has yet to be unequivocally demonstrated.<sup>18</sup>

The only history item that could be compared with a previous report was the typical dermatomal pain distribution. This had a 90% sensitivity in our study, compared with 99% sensitivity in a study by Kerr and colleagues.<sup>37</sup> Strikingly, subjective muscle weakness and sensory loss actually diminished the likelihood of nerve root compression. These findings are at variance with current opinion and with our previous beliefs. The selection bias in previous studies may have affected our understanding of the true relation of these complaints to

nerve root compression. It is possible that subjective weakness and sensory loss have no neurological basis in most patients.

Table 3 shows that four physical examination items were related to nerve root compression, and that even before the physical examination, the a priori likelihood of disease is altered by the history. Rather than considering only one or two tests, one should use history and physical examination as two batteries of tests, and interpret the items in each battery simultaneously. The independent and simultaneous contributions of tests to the diagnostic work up of the sciatica patient have not been studied previously. Table 4 and the ROC curve in fig 1 indicate that, after the history has been taken, few signs in the physical examination contribute to a more accurate diagnosis. Typically, a dermatomal distribution of pain, an increase in pain on coughing, sneezing, or straining, paroxysmal pain, and predominant leg pain are indicators of nerve root compression. This is in agreement with clinical experience. The predictive value of paresis also accords with general beliefs.<sup>8</sup> A surprising predictor was an increased finger-floor distance. The action of bending over to touch the floor with the fingers not only stretches the nerve roots and the sciatic nerve but also cancels the lordosis of the lumbosacral spine; the latter action may accentuate the mechanical effect of the disc herniation on the nerve root. We were struck by the fact that the straight leg raise test was not a predictor of root compression. This test may indicate nerve root tension or irritation, but not necessarily nerve root compression.

## Conclusions

The main component in the diagnosis of sciatica caused by disc herniation is the history. Few physical signs add useful additional information or result in alteration of a diagnosis made on the basis of the history.

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