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Nerve Root Signs on Postoperative Lumbar MR Imaging
A Prospective Cohort Study with Contrast Enhanced MRI in Symptomatic and Asymptomatic Patients one Year After Microdiscectomy

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Summary

The association between postoperative nerve root signs and outcome was investigated in 54 out of one hundred patients operated on by lumbar microdiscectomy in a prospective cohort study with one year follow up. The patients were classified as failures or successes at the 12 month follow up according to a clinical overall score. All the 14 failures were investigated with MRI at the one year follow up, and 40 patients classified as successes were picked at random for MRI. Three patients with signs of recurrent disc herniation on MRI were excluded from the study. The MRI scans were independently read by two neuroradiologists who were ignorant of treatment outcome. No association between nerve root thickening, nerve root enhancement or nerve root displacement and the clinical outcome was found when patients with recurrent disc herniation were excluded.

Keywords: Lumbar disc herniation; lumbar microdiscectomy; MR imaging; lumbar nerve root.

Introduction

The significance of nerve root signs (nerve root thickening, nerve root enhancement and nerve root displacement) on pre-operative magnetic resonance imaging (MRI) in patients with clinical radiculopathy is still debated [1, 6, 11, 12]. Few studies have investigated nerve root signs on postoperative MRI and their association with the clinical outcome, and the results are contradictory [3, 4, 7, 13]. The clinical value of these nerve root signs is of interest to the radiologist and the surgeon. Further, changes in the nerve root may reflect different pathomechanisms involved in the residual or recurrent sciatica after lumbar disc surgery. The purpose of the present study was to investigate the association between nerve root signs and clinical outcome in a prospective cohort study using contrast enhanced MRI.

Patients and Methods

Patients

One hundred patients were originally included in the study. The patients were referred to the Department of Neurosurgery, University Hospital of Tromsø, Norway in the period 1993–1995. Three patients were re-operated on for symptomatic recurrent disc herniation, and one patient developed a deep vein thrombosis in the symptomatic leg within the first year after surgery. These four patients were excluded from the study. Furthermore, two patients chose not to participate, thus at the one year follow up the number of patients comprised 94. All the 16 patients classified as failures at the one year follow up were referred to MRI. From the 78 patients classified as successes 45 patients were picked at random for MRI. One patient was pregnant and two patients refused to participate in the MRI and these were excluded from the study. Recurrent disc herniation on MRI was found in 3 patients (one of the failures, and two of the successes) and these were excluded from the study. One additional patient was excluded from the failure group due to incomplete MRI study. The final study thus included 54 patients (14 failures and 40 successes). The time from surgery to MRI was 16 $\pm$ 2 (range 12–22) months. The clinical demographics of the patients investigated with MRI are given in Table 1.

Clinical Criteria

The diagnostic criteria of nerve root compression were as follows: typical pain distribution and/or motor symptoms from compression of only one lumbar nerve root, positive Lasegue's test, unequivocal diagnosis of unilateral disc herniation at the corresponding level on lumbar computerized tomography (CT) or MRI, and confirmation of the diagnosis of lumbar nerve root compression due to disc herniation at the time of surgery. Exclusion criteria were as follows: 1) previous back surgery, percutaneous discectomy or chymopapain

Table 1. *Clinical Demographics of 54 Patients Investigated with Postoperative*

		Patients	% of total
Gender: male		38	70%
female		16	30%
Age		36 ± 7 years	
Duration of sciatica		45 ± 41 weeks	
Operative level	L4/L5	22	41%
	L5/S1	32	59%

injection 2) osseous stenosis or other disease of the lumbosacral spine, 3) other neurological disease and 4) age over 60 years.

Clinical Assessment

To evaluate the clinical state of the patient an overall examination as described by Haaland *et al.* [5] was performed before the operation and at the 12 months follow up. The 12 months follow up examination was performed by an independent observer. The following subsets were included: pain (VAS scales for back and leg pain), clinical examination, functional status (Oswestry Low Back Pain Disability Questionnaire), and use of analgesics. The results of all subsets were combined to make a clinical overall score (COS) for each patient. Pain is the most important symptom in sciatica. A weighting procedure was therefore performed whereby the pain intensity score counted four, while each of the other three subsets counted two. The maximum COS when adding the four weighted scores was 1000 and represented the maximum of pain, clinical symptoms and signs. According to the results of the clinical score at the 12 months follow up the patients were divided into two groups: successes (COS$<$250) and failures (COS$>$250).

Surgical Procedure

The surgery was performed using Caspars self retaining retractors and the operating microscope. After the flavectomy and the arcotomy was performed, the nerve root was identified and if necessary dissected free from the herniation. The disc herniation was removed and the disc space evacuated. In addition the root canal was opened to further decompress the root.

MRI

The MRI were carried out with a Philips Gyroscan T5, 0.5 T using a quadrature T/L spine coil. Sagittal T1 weighted imaging (WI) was performed with turbo spin echo sequence TSE, TR/TE 775/13, with slice thickness (SL)/interspace (SI) 4.0/0.4, matrix 230 × 256 and field of view (FOV) 320. Axial T1WI was performed with TSE, TR/TE 585/21 with SL/SI 4.0/0.4, matrix 179 × 256 and FOV 250. The axial T1WI were obtained through the lower 3 intervertebral disc spaces and repeated within 3 minutes after intravenous injection of Gadolinium-diethylenetriaminepenta-acetic acid (Gd-DTPA) 0.1 mmol pr kg.

The level of which the mircodiscectomy had been performed was especially evaluated for nerve root thickening, nerve root enhancement and nerve root displacement.

Nerve root thickening was present if its diameter was increased by more than 50% based on a comparison with the contralateral nerve root at the same level. In order to avoid the misinterpretation of adjacent scar tissue, nerve root thickening was assessed only on post-contrast images. Further, care was taken to distinguish true thickening from apparent thickening caused by obliqueness of the slices, close relation to the ganglion or conjoined nerve roots.

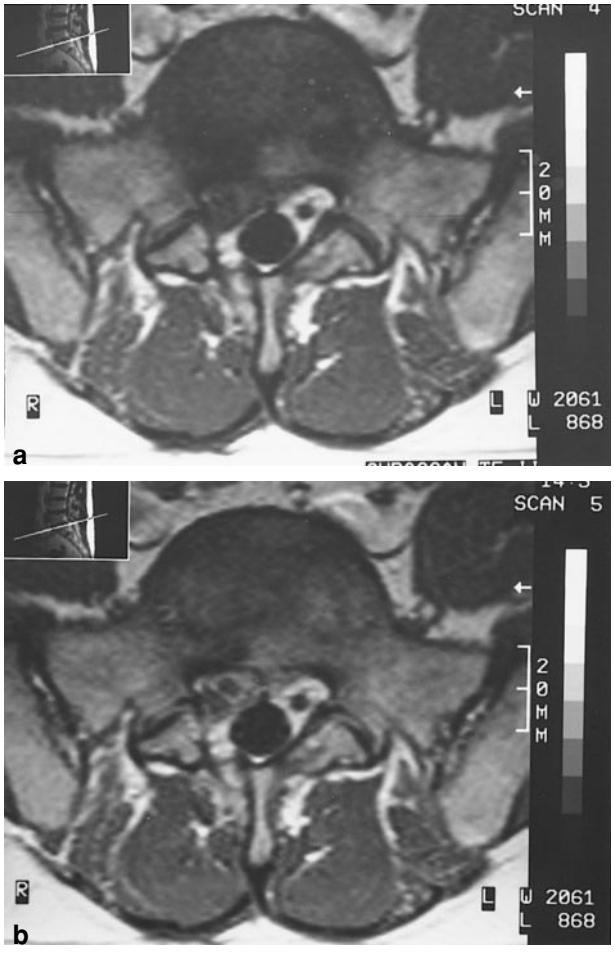

Fig. 1. (a) Nonenhanced T1-weighted axial MRI at L5-S1 level shows a mass anteriorly and to the right in the spinal canal. The left S1 root is clearly seen (surrounded by bright fat tissue). The right S1 root can not be identified. (b) Post contrast scan reveals an anteriorly displaced nerve root surrounded by moderately inhomogenous enhancing tissue consistent with scar formation. Enhancement in the periphery of the nerve root is clearly seen

Nerve root enhancement was assessed as present or absent by mere inspection. Measurement of signal intensity was not performed due to the risk of partial volume effect of adjacent scar tissue. A nerve root was considered enhanced when brighter compared with the precontrast image and brighter compared with the contralateral nerve root in the same image/level.

Nerve root displacement was considered present if the position of the nerve root was different from its excpected course by comparison with the position of the contralateral nerve root in the same image.

Figures 1 and 2 illustrates the different nerve root signs on non-enhanced and enhanced axial T1WI MRI.

All MRI examinations were evaluated independently by two neuroradiologists. Both were ignorant of patient outcome. In cases with disagreement between the observers, the classification of the most experienced (RD) was chosen as the final result. The study was approved by the regional ethics committee of the University of Tromsø, Norway.

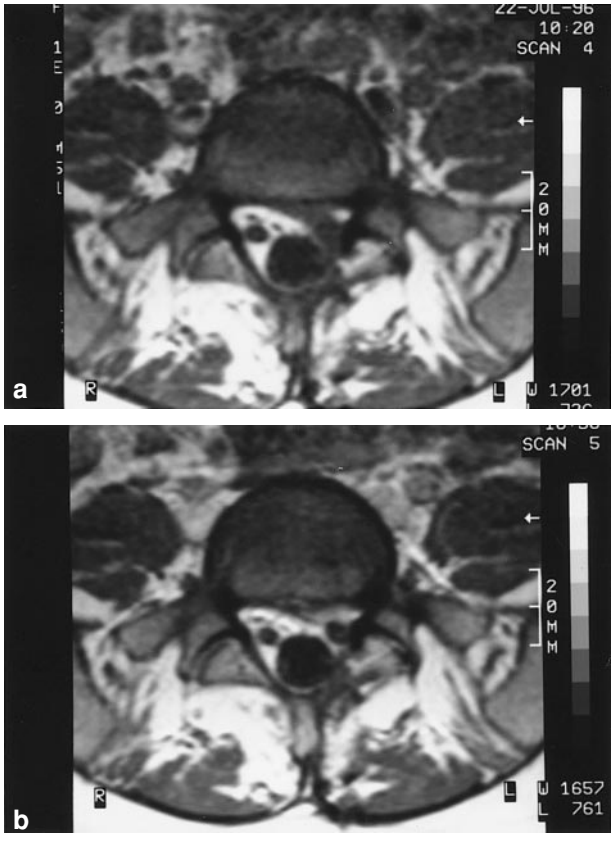

Fig. 2. (a) Nonenhanced T1-weighted axial MRI at L5-S1 shows a mass anteriorly and to the left in the spinal canal, which blurr the contours of the left S1 nerve root. The right nerve root is surrounded by bright fat tissue. (b) Post contrast scan reveals homogenous enhancing tissue consistent with scar tissue and thickening of the left nerve root

Statistics

The association between the nerve root signs and COS were analysed using the Mann-Whitney U test. Interobserver variation was assessed using the Kappa test. Data are given as mean ± SD. $P < 0.05$ was considered statistically significant.

Results

Interobserver Variability

There was good interobserver agreement in assessment of nerve root enhancement and nerve root displacement. Moderate agreement was found in the assessment of nerve root thickening. The Kappa scores are given in Table 2.

Nerve Root Thickening

Thirty patients had nerve root thickening. The COS were higher in the group of patients with root thickening (171 ± 171 vs 132 ± 118), however this difference was not significant ($p = 0.63$).

Table 2. *Interobserver Variations in the Assessment of Nerve Root Signs*

	Kappa	P value
Nerve root thickening	0.50	<0.001
Nerve root enhancement	0.66	<0.001
Nerve root dislocation	0.62	<0.001

Nerve Root Enhancement

Eight patiens had nerve root enhancement. No statistical differences were found but patients with root enhancement had slightly higher COS (174 ± 175 vs 148 ± 147, $p = 0.64$).

Nerve Root Displacement

Nerve root displacement was seen in 13 patients. These patients had a higher clinical score than patients without root displacement (236 ± 180 vs 128 ± 131), however this difference was not statistically significant ($p = 0.05$).

Discussion

The present study demonstrates no association between nerve root thickening or nerve root enhancement on MRI and the outcome one year after microdiscectomy. Limit values of statistical significance were found between nerve root displacement and clinical outcome. This displacement was not due to recurrent disc herniation since these patients were excluded from the study. The displacement may be due to scar tissue in the spinal canal. However there was no association between the amount of scar tissue and the clinical outcome one year after microdiscectomy as shown in a recent study of the same cohort [10]. It is possible that micro-adhesions between the nerve root and structures in the spinal canal are of importance and that these adhesions may displace the nerve root. Further studies in larger series are needed to elucidate this association.

Our results are consistent with two previous studies which also demonstrated lack of association between the clinical outcome and nerve root thickening and nerve root displacement, respectively [4, 13].

Thickening of nerve roots is supposed to be caused by oedema [2, 8]. Thirty of our patients had thickening of nerve roots one year after the operation, and ten of these had a good clinical result. Thus oedema of the nerve root is probable not involved in the pathomechanisms causing persistent sciatica one year after surgery.

The association between nerve root enhancement and the clinical outcome was investigated in a recent study by Grane *et al.* [3]. The authors claim that nerve root enhancement or nerve root displacement combined with disc herniation are significant MRI findings in the postoperative spine, and that these two nerve root signs may strengthen the indication for repeat surgery. However this study included only patients with residual or recurrent symptoms after surgery and the time span from surgery to MRI investigation varied from 1 day to 34 years. In addition the outcome was assessed retrospectively form the MRI request forms and from surgical reports, and not from the patients directly. Jinkins *et al.* [7] explored the association between nerve root enhancement and clinical result in a retrospective study. Enhancement was found in 21% of the 120 patients with recurrent symptomatology after lumber disc surgery. Only 10 asymptomatic patients were investigated and contrast enhancement was not found in any of these patients. Furthermore the time from surgery to MRI was not standardized.

We did not use pixel values in the determination of nerve root enhancement, furthermore we did not attempt to assess the intradural nerve root enhancement. In our opinion these assessments on our equipment are not technically feasible. Hence, we merely classified nerve root enhancement as present or absent based on the radiologists visual impression. Gd-containing contrast media serve as markers of damage to the blood-nerve barrier [9]. Since no association between nerve root enhancement and the clinical result was seen, blood-nerve barrier damage is probably not an important part of the pathophysiology in persistent sciatica after microdiscectomy. However the dose of contrast media used in our study may be too low to give contrast enhancement in some of the patients.

We have not investigated the predictive value of the combination of nerve root signs and recurrent disc herniation. It is however possible that different combinations of postoperative findings on MRI may further strenghten the indications for repeat surgery. Further studies are however needed to answer this question.

The time-window in the present study is limited. It is therefore possible that MRI at other time intervals after surgery may demonstrate different results. However it is most important that the time from surgery to MR imaging is standardized as in the present study.

We conclude that when recurrent disc herniation is excluded there is no association between the investigated nerve root signs on MRI and outcome one year after microdiscectomy for lumbar disc herniation.

Acknowledgement

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Comments

Since the authors have excluded recurrent disc patients and concluded that nerve root displacement, nerve root thickening, and nerve root enhancement were not statistically related to failure, why did these patients fail surgery?

V. Sonntag

Author's Reply

The reason why 16 patients were failures is not easy to answer. We know that this is not due to recurrent disc herniation since these patients were excluded from the study. These 16 patients are «Failed back surgery patients» and the purpose of this study was to investigate if changes in the nerve root detectable on MRI could explain the clinical result. We did not find any statistical association, however there was a weak not statistical association between nerve root displacement and bad surgical outcome. This may suggest that adhesions between the nerve root and the surrounding tissues may cause persistent radiculopathy. However the most probable explanation is probable sensitization of central pathways due to chronic stimulation of pain fibers.

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