Estanislao Arana
Luis Martí-Bonmatí
Ruben Montijano
Daniel Bautista
Enrique Molla
Salvador Costa

Relationship between Northwick Park neck pain questionnaire and cervical spine MR imaging findings

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E. Arana (✉) · L. Martí-Bonmatí
R. Montijano · E. Molla · S. Costa
Department of Radiology, Clínica
Quirón, Valencia, Spain
E-mail: aranae@uv.es
Tel.: +34-961-041613
Fax: +34-963-391147

D. Bautista
Preventive Medicine,
Hospital Universitario Dr. Peset,
Valencia, Spain

Abstract The study was aimed at determining the association between the self-report of pain and disability by means of Northwick neck pain questionnaire (NPQ) and cervical spine MR imaging findings. A random sample of 251 patients, 132 men and 119 women aged 43 ± 13 years, submitted with neck pain were investigated. Patients with previous discitis, surgery, neoplasm or hospitalized for cervical spine trauma were excluded. All patients completed the NPQ and were studied with sagittal gradient-echo T1 and turbo spin-echo T2, axial gradient-echo T2* and heavily T2 weighted MR myelographic weighted images. MR images of the two most affected disc levels were read, offering an MR imaging score from 0 to 30. There was no statistically significant cor-

relation between NPQ and MR imaging scores. From the NPQ items, only difficulty in sleeping and numbness were related to the MR imaging score. Disc extrusion was the only MR finding almost significantly associated with NPQ ($P=0.054$). Neck injury did not increase NPQ scores. In patients with neck pain, NPQ scores do not correlate with MR imaging findings. NPQ and cervical spine MR imaging show different facets of the multidimensional complex of neck pain.

Keywords Neck pain · Northwick neck pain questionnaire · Disability · Quality of life · Magnetic resonance imaging · Disc degeneration

Introduction

Several studies have concluded that neck pain is a complex physiological, psychological, and behavioural phenomenon, which is difficult to measure or quantify [24, 26]. The relation between anatomic impairment and symptoms, with few exceptions, remain speculative and controversial [31]. There is a growing consensus that neck pain severity requires assessment of neck pain-related interference with activities as well as pain intensity [23]. Among the different questionnaires available for outcome measures, the Northwick neck pain questionnaire (NPQ) has proved to be a useful tool in neck pain studies, correlating with objective measurements [4]. It has been validated in patients with neck pain in several countries

and languages, and also with acceptable test-retest reliability [4, 9, 13, 22]. Some investigators have related radiographic findings to disability scores [22]. However, there is limited data relating neck pain and disability with MR imaging [30, 31].

The purpose of this cross-sectional study was to determine the association between the self-report of pain and disability with a standardized questionnaire's findings and cervical spine MR images.

Material and methods

During a six-month period, a random sample of 358 patients were assessed for eligibility in a general hospital.

They were submitted by orthopaedic surgeons and neurosurgeons because of neck pain with or without radiculopathy. Exclusion criteria were previous cervical spine surgery, current or previous evidence of neoplasm or discitis, hospitalized for cervical spine trauma, decreased ability to communicate, and general MR imaging contraindications. Thirty-two patients did not meet the inclusion criteria. Another 16 refused to participate and 59 were not included for other reasons (incomplete questionnaire and patients who knew their imaging diagnosis). Eventually, 251 patients (132 men and 119 women, aged 43 ± 13 years) were evaluated.

Questionnaire

The NPQ consists of nine items related to pain intensity, duration of symptoms, numbness at night, pain affecting sleep, effect on social life, carrying, reading/watching television (TV), working/housework, and driving [13]. It is widely used with good sensitivity to change, although it does not cover emotional and some social issues [9]. For each item, there are five potential responses describing a greater degree of difficulty (from 0 = no difficulty to 4 = severe difficulty). An overall NPQ score percentage is calculated by adding together the score for each item (0–36) (total score/36 $\times$ 100%). If an item is not applicable, the score is calculated as [(total score/32) $\times$ 100 %]. Questionnaires were not valid if sections were incorrectly completed or more than one item is omitted.

For direct comparison with radiological findings, all patients completed the questionnaire on the day of their imaging appointment immediately before their MR examination. Two additional questions related to cervical spine problems were added: “Did you visit a doctor because of a neck or whiplash injury?” and “How many days have elapsed since your doctor requested this examination?”

MR imaging

MR scans were performed on a 1.5 T Intera Gyroscan unit employing a head and neck multielement phased-array coil (Philips Medical Systems, The Netherlands). All patients were studied with the following imaging protocol: (1) sagittal T1-weighted out-of-phase gradient echo sequence (TR = 375 ms; TE = 6.3 ms, flip angle = 90°) imaging of the cervical and upper thoracic spine with a 217 $\times$ 512 matrix, four signals averages, 23 cm FOV, and 3 mm thickness with 0.3 mm gap; (2) sagittal T2-weighted turbo spin-echo imaging (TR = 2,737 ms; effective TE = 110 ms) with 12 echo train length, a 228 $\times$ 512 matrix, four signals averaged, 23 cm FOV, 3 mm thickness with 0.3 mm gap; and (3)

axial T2* weighted gradient-echo sequence (TR = 919 ms; TE = 18, flip angle = 23°) with a 175 $\times$ 256 matrix, two signals averaged, 23-cm FOV and 3 mm thickness with 0.3 mm gap. Sagittal images covered from the clivus to at least the T4 vertebral body, (4) MR-Myelography was obtained with a multi-shot turbo spin-echo T2-weighted single slice sequence (4,000/250 ms, fat suppression), 400 $\times$ 512 acquisition matrix, 26 cm FOV and 55 mm thickness, with four different radial orientations within a single preparation phase.

As interobserver agreement in the assessment of cervical disc degeneration has been stated as moderate [29, 30], the MR images were reviewed by the consensus of at least two radiologists, unaware of the patient's disability score. Cases with discrepancies were not collected. Disc degeneration, defined as a continuum from disc dehydration, signal loss, to disc displacement [1], was reviewed with our usual report schedule, non-linearly categorized (Appendix). Readers were specifically requested to evaluate the two most affected disc spaces and classify them into four categories: normal, dehydration, protrusion (bulge) or extrusion (herniation). Radiologists used previously published definitions for each category [1], as follows: (1) normal, no disc extension beyond the interspace (DEBIT) with signal intensity preserved; (2) dehydrated, signal intensity loss with unchanged or slightly decreased height; (3) protrusion, including circumferential, symmetrical DEBIT (bulge or protrusion) and focal or asymmetrical DEBIT; (4) extrusion, focal obvious DEBIT with the base against the parent disc narrower than the diameter of the extruding material itself, or no connection to parent disc and extension into the spinal canal. Anular fissures were defined as high-intensity zones in the outer anular disc fibers [1] and were rated as disc extrusion, due to reports suggesting they are distinctly uncommon in asymptomatic individuals [27]. Facet osteoarthritis was graded according to Fujiwara et al. [3], whose grades 3 and 4 were grouped in a single category. When there was a difference in the severity of facet joint osteoarthritis between the right and the left at the same level, the worst grade was recorded. Spinal stenosis was rated according to Lo et al. [14]. Other findings, rated as 3, were mutually exclusive.

An ad hoc disease severity score was constructed from the sum of every imaging finding, as similarly described by Sambrook et al. [27]. MR imaging score ranged from 0 (normal) to 30, representing progressive degrees of abnormality.

Since NPQ and MR imaging scores were not normally distributed (Kolmogorov–Smirnov Z: 1.6 and 3.19, $P=0.008$ and $P=0.001$, respectively), the Mann–Whitney and Kruskal–Wallis tests were used to compare the distributions of independent samples derived from these variables. The Spearman's Rho correlation coefficients between quantitative variables was

also calculated, while the chi-square test was performed to compare proportions. The MR imaging score was studied by multiple linear stepwise regression analysis using the items from NPQ, injury and waiting list items and the rest of demographic variables to determine the most important predictive factors. For the regression model, R^2 , β -value and standard error were used. The R^2 is the proportion of variation in the dependent variable that is explained by the independent variables. The β -value is the regression coefficient, which reveals the influence of every independent variable on the dependent variable. P values <0.05 were considered statistically significant.

Results

There were no statistically significant differences among different symptomatic groups (Table 1). There was neither gender prevalence nor correlation between NPQ score and age (Spearman's Rho: -0.017 , $P=0.785$). The NPQ and MR imaging scores did not correlate (Spearman's Rho: 0.07 , $P=0.08$; Table 2). Although the possible MR imaging score was between 0 and 30, the maximum points recorded was 23, with 91% of population below 17 points.

In the bivariate analysis, only sleeping and numbness items were positively related to MR imaging score (Kruskal–Wallis, $\chi^2=14$ and 18.6 , $P=0.007$ and $P=0.001$, respectively). NPQ score increased with degenerative disc disease reaching almost statistically significant results (Kruskal–Wallis, $\chi^2=7.6$, $P=0.054$; Fig. 1). NPQ score rose as the disc level was located more caudally, but with no statistical significance (Kruskal–Wallis, $\chi^2=1.3$, $P=0.84$). No other MR imaging finding was related to symptoms questionnaire. Regarding other non-degenerative diseases, these patients presented higher NPQ scores with no statistical relevance compared to the degenerative groups. A multiple regression model for NPQ score could not be developed due to incomplete fit.

Although the NPQ score was higher in patients with a history of injury, it did not reach statistical significance (Table 2) ($P=0.08$). On the contrary, patients who referred history of trauma showed a lower MR imaging score; and were younger (Mann–Whitney

Table 2 Disability and MR imaging profile of the study population according to mean and 25th/75th percentiles range score of NPQ sections and MRI score. Total scores below

	NPQ items (possible score 0–4)	MR imaging score (possible score 0–30)
Pain intensity	2, 1–2	7.42, 1.53–13.87
Sleeping ^a	1, 1–2	8.35, 3.05–14.18
Numbness ^a	1, 0–2	8.35, 3.05–14.18
Duration	2, 1–4	7.81, 1.06–13.67
Carrying	1, 1–3	8.02, 1.53–13.68
Reading	2, 1–3	7.4, 2.17–14.57
Work	1, 0–3	8.46, 2.22–14.42
Social activities	1, 0–2	6.92, 1.64–14.54
Driving	1, 1–2	6.93, 1.84–14.57
Neck injury (total score) ^b	40.63, 27.78–53.47	4.5, 0.75–12.5
No neck injury (total score)	33.33, 25–50	10, 2–14
Male (total score)	36.11, 22.22–52.08	9, 2–14
Female (total score)	38.89, 27.78–52.78	6, 1–14
Total score	36.11, 25–52.78	7, 1–14

^a Items related to increased MR imaging score. Kruskal–Wallis, $\chi^2=4$ and 18.6 , $P=0.007$ and $P=0.001$, respectively

^b MR imaging score, Mann–Whitney U test $z=-2.3$, $P=0.02$

U -test, $z=-2.39$, 44.1 ± 13.2 vs. 40.1 ± 13.1 years, $P=0.01$).

Table 3 shows multiple regression analysis of MR imaging score. This model explained 42.8% of the variation in imaging score. Disc level, age, waiting list and work interference were positively correlated with MR imaging score while the pain intensity was negatively correlated.

No relationship was found between NPQ and MR imaging score, and days off work.

Discussion

Despite the use of a standardized protocol to assess physical examination of the cervical spine, it is difficult to achieve reasonable agreement and reliability [24]. The relation between symptoms, physical exploration and imaging is elusive [20, 31]. The definitions of neck pain and the period of the assessment vary and, consequently, so do the reported prevalence figures [6]. Our NPQ

Table 1 Disability and MRI scores by patients symptoms

	Neck pain	Cervical radiculopathy	Neck pain and radiculopathy
Patients (%)	109 (43.4)	22 (8.7)	120 (47.8)
Gender (M/F)	49/60	10/12	50/70
Age (mean, range)	44, 34–70	45, 37–67	46, 38–69
MR imaging score (mean, range)	9, 1–21	11, 2–20	12, 1–21
NPQ score (mean, range)	32.12, 25–52.7	33.23, 26.75–51.01	35.09, 27.2–52.78

M male, F female

Fig. 1 Relationship between NPQ score and disc degeneration (Kruskal–Wallis, $\chi^2=7.6$, $P=0.054$). Scores are presented as median values, including the 25th/75th and 5th/95th percentiles

scores (median 36.11, range 25–52.78) were similar to the only previous study of the Spanish version of NPQ questionnaire, ranging from 45.9 before treatment to 28.9 after treatment [4]. That group comprised patients with neck pain of more than 4 months submitted to physiotherapy following the failure of other treatments.

Sleeping and numbness items on the NPQ were related to higher MR imaging score. In a recent study of whiplash-associated disorders, sleep disorder had the best correlation with the problem elicitation technique [9]. This interviewer administered instrument was found to show a wider spectrum of disabilities judged to be important by the patient [9]. Numbness is the most relevant symptom correlated with radiculopathy [18, 26]. It has been shown that patients complaining of numbness have a higher probability of medullary signal alteration on MR imaging [25]. The selection of patients with higher scores for sleeping and numbness would probably decrease the number of negative MR examinations [8].

Our study shows the relation between a disability score and MR imaging findings in a private clinical practice. Degenerative disc disease was the only imaging

finding that was almost significantly associated with higher NPQ score. This result agrees with a recent study of MR imaging of cervical spine, where extrusion was the only finding marginally associated with disability [31]. No other imaging finding was related to NPQ score. Therefore, the clinical significance of facet joint degeneration in pain syndromes remains controversial [11].

The fact that was impossible to develop a multiple regression model for NPQ reflects that cervical spine findings on MR imaging explain only part of the occurrence of neck and arm pain [26]. These data agree with a recent study on female twins [16] where lumbar disc degeneration was related to low back pain, whereas no relationship was found for neck pain and cervical discs. In that work, the strongest neck pain association was reported in the general health questionnaire (GHQ).

Previous radiographic studies have attempted to establish a link between cervical degeneration and neck pain [5, 7, 22]. Although Marchiori et al. [19] found a relationship between more cervical degenerated discs and higher disability rating in women, other authors [5, 22] do not support these findings, and no gender predominance was found in our study. These plain film studies showed no correlation between severity of degeneration in any of the joints in the cervical spine and pain or disability. Gore [5] found increased pain to be statistically related to C6–C7 degenerative changes. Although our work depicted that NPQ score increased with a lower disc level, no statistical relevance was found. Disc herniation at lower cervical levels and ligamentum flavum hypertrophy with spinal stenosis at C7, are recognized as increasing the probability of cord impingement in dynamic extension studies on MR imaging [2].

Patients with a history of injury also demonstrated significantly less cervical spine degeneration than the non-injury group, which agrees with previous reports using radiography [22]. By far, the lower frequency of degenerated changes was found in injured younger patients [22]. On the contrary, non injury subjects presented more spinal stenosis and higher MR imaging score, due to their older age, with no symptomatic relevance. Whiplash injuries seem to have a substantial impact on health complaints, even a long time after the accident. As these symptoms may be revealed neither by exploration [9] nor imaging, there is a need to identify

Table 3 Stepwise multiple regression analysis of MR imaging score

	β coefficient	Standard error	CI 95%	<i>b</i>	<i>P</i> value
Intercept	0.24	1.25	–2.24, 2.73	0.19	0.84
Disc level	3.93	0.30	3.33, 4.52	13.1	0.001
Age	0.09	0.02	0.03, 0.14	3.33	0.001
Waiting list	0.02	0.01	0.01, 0.04	2.53	0.01
Intensity	–0.89	0.30	–1.50, 0.28	–2.89	0.004
Work interference	0.54	0.22	0.09, 0.98	2.38	0.01

factors that accurately predict their outcome by means of a self-administered questionnaire [12].

A score of MR imaging for cervical spondylosis is useful, mainly due to the presence of clinically silent cord compression at multiple levels on MR imaging and for assessing operative outcomes [10, 14]. Although a similar MR index has been previously used to show genetic relationships in cervical and lumbar disc disease [16], its non-linear structure should be kept in mind (i.e., it may count the same for an annular tear as an extrusion). For the multiple regression model MR imaging score, disc level, waiting list, pain intensity and work interference were included. As noted above, disc degeneration has been shown to progressively increase in the lower levels of the cervical spine. Patients on a longer waiting list for examination and higher interference with work also presented more MR imaging severity. In contrast, pain intensity was not related to MR abnormalities. This is probably related to the fact that most patients with higher pain levels did not have significant MR imaging findings. This agrees with a recent study reporting factors influencing neck pain with generic and disease-specific questionnaires [15]. Patients with cervical disc disorders had better physical health than those without such diagnoses, with no explicable reason.

This study has some strengths and limitations. We have used the NPQ score because it is the only version available in the Spanish language among similar neck pain questionnaires [4] and a questionnaire tailored according to the target population is encouraged [23]. Questionnaires such as the NPQ are useful in monitoring disability after conservative treatment [4] or outcome scores after surgery [21]. However, there are functional limitations not evident from the scores. The generic and disease-specific functional outcome measures reflect part of the complexity of the problem [15]. One of the strong points of the study is that it is based on a pragmatic and detailed MR imaging score and comprehensive data on possible confounders of disability. To our knowledge, other studies correlating MR imaging and symptoms have not included this full spectrum of imaging findings [28, 30, 31]. Although a graded disc disease diagnosis seems reliable in classifying disc alterations on MR images [1], MR imaging performed with current techniques and criteria does not clearly distinguish symptomatic from incidental findings [1, 28]. On the other hand, the part of this scale dealing with spinal stenosis has recently been shown to be related to myelopathy by transcranial magnetic stimulation [14]. However, a gold standard for diagnosis of cervical radiculopathy/myelopathy is difficult to establish [26].

The relatively low adjusted R^2 of the imaging model suggests that other factors, such as psychological and stress related factors, occupation and leisure time not included in the questionnaire, may be important predictors of imaging and outcome. Nevertheless, cervical

spine MR imaging offers some ideas about particular aspects of neck pain, giving relevant information. It has been shown that more extensive degeneration at multiple levels is correlated with chronicity of symptoms [17]. Moreover, foraminal impingement findings depicted on MR imaging can predict the outcome of cervical nerve root blocks [32].

Conclusions

Our investigation indicates that in patients with neck pain, MR imaging only marginally correlates with sleeping and numbness items on the NPQ questionnaire but not with other physical self-report disabilities.

Appendix

MR imaging score

Disc (two most affected levels)

(0) Normal (1) Dehydrated (2) Protrusion (3) Extrusion

Annular fissure

(0) No (3) Yes

Facet joint

(0) Normal (2) Joint space narrowing, mild osteophyte or articular effusion (3) Marked osteophyte with/without sclerosis

Spinal stenosis

(0) Normal or cervical spondylosis with or without contact with the cord, but cord deformity is absent.

(1) Mild indentation or flattening of the cord with anteroposterior (AP) cord diameters not less than two-thirds of the original.

(2) Significant cord indentation by osteocartilaginous elements with resultant AP cord diameters less than two-thirds of its original, but not associated with hyperintense T2 signal within the cord.

(3) Significant cord indentation by osteocartilaginous elements with resultant AP cord diameters less than two-thirds of its original and associated with hyperintense T2 signal within the cord.

Other findings (3)

Degenerative spondylolisthesis, Spondylolysis

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