Change in Functioning Profile After Cervical Surgery

Short title: Functioning Profile After Cervical Surgery

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ADDRESS FOR CORRESPONDENCE

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ABSTRACT

Objectives 1) to introduce an approach to use the Neck Disability Index (NDI) in a way, which is different and more International Classification of Functioning, Disability and Health (ICF) -oriented than a common practice – focusing on functional profile instead of composite score only and 2) to describe the changes in functioning experienced by patients undergoing cervical surgery.

Methods This was a register-based study of almost 400 patients undergoing different cervical surgical procedures in a university hospital between 2018 and 2021. The patients responded to repeated surveys preoperatively and 3, 12 and 24 months postoperatively. Linear regression test was performed to analyze the change of the Neck Disability Index score.

Results The changes in scores during a follow-up were statistically significant (p<0.001) for all the Neck Disability Index items as well as for the total score. Each item demonstrated significant improvement postoperatively and a slight worsening between one and two years after the surgery. The observed slight decline in functioning at the end of follow-up remained below the baseline level for all the items.

Conclusions While the change in the composite score of the Neck Disability Index was able to describe the overall change in functioning after the surgery, different areas of functioning were affected by the surgery differently. The results suggest that the use of functional profiles, in addition to composite scores, is justified among patients with cervical pathologies.

KEYWORDS: Neck Disability Index; Neck Pain; Cervical Surgery; ICF

INTRODUCTION

Based on multiple reports from the United States and Europe, the rate of surgery for degenerative cervical spine disease has increased dramatically during the last decades [1]. Nevertheless, in many situations, the benefit of surgery over conservative treatment for degenerative cervical spine disease has been under dispute [2]. Patient-reported outcome measures (PROMs) have been used to guide clinical decision-making when identifying patients who may benefit from the surgery the most as valued by the improvement in functioning level after the surgery. In the clinical guidelines for neck pain, Blanpied et al. have recommended to measure outcome of surgery by using such validated PROMs as the Neck Disability Index (NDI). [3]

The NDI has been developed as a modification to the Oswestry Low Back Pain Disability Index – a gold standard among patients with low back pain [4]. Piloted among patients with whiplash injury, the use of the NDI has soon spread to other cervical conditions including the evaluation of the effectiveness of cervical surgery. Goyal et al. have studied how well the NDI is suitable for use when measuring change in functioning after surgical treatment of cervical spondylotic myelopathy (CSM). In that retrospective study among 118 patients with CSM, while the NDI composite score has been able to detect a change in functioning, only two items have been responsible for that detection – limitations in work and limitations in recreation. It has been concluded that although the NDI might demonstrate statistically significant improvement after the surgery, it might not necessarily show the entire spectrum of changes in functioning level. [5] Similarly, Steinhaus et al. have found that all the NDI

domains improve significantly after cervical spine surgery, but only items “work”, “recreation” and “pain intensity” were independent predictors of surgery success [6]. In 2001, The World Health Organization (WHO) has suggested the International Classification of Functioning, Disability and Health (ICF) for organizing the way of representing functioning and disability in different health situations and diverse populations [7]. One of the benefits of the use of the ICF framework is a possibility to create profiles of functioning describing wide-scale complexes of functional dimension in a standardized way. Over the past few years, the use of such functioning profiles in rehabilitation medicine has increased. The outcome of cervical spine surgery has usually been evaluated using a visual analogue scale (VAS) and the NDI [8]. In their systematic review Ferreira et al. have studied the compatibleness of different neck pain scales with ICF concluding that the NDI has a well-balanced distribution of items over the ICF-components [9].

The usual way to use the NDI is to calculate a composite score, which describes the average level of limitations across different dimensions of functioning. It is self-evident that such a practice has its benefits but may have some substantial flaws. For different patients, the same composite score of the NDI may represent a very different situation regarding their functioning. For example, in one patient the score may entirely represent limitations in first five items, while another patient may achieve the same score experiencing limitations only in the last five items of the NDI. The objective of this study was two-fold: 1) to introduce an approach to use the NDI in a way, which is different and more ICF-oriented than a common practice – focusing on functional

profile instead of composite score only and 2) to describe the changes in functioning experienced by patients undergoing cervical surgery.

METHODS

The data were obtained from the register containing data on the patients undergoing cervical surgery of any kind between June 21, 2018 and August 17, 2021 in a university hospital. The patients responded to repeated surveys a) <=2 months before the surgery (timepoint #0); 2 to 4 months after the surgery (timepoint #1); 11 to 13 months after the surgery (timepoint #2); and 23 to 25 months after the surgery (timepoint #3). The survey contained questions on demographics and the severity of disability. A patient was included if the procedure code was one of the follows: NAG40, ABC60, ABC21, NAG41, ABC30, ABC10, NAG42 or ABC50, according to the Nordic Classification of Surgical Procedures (NCSP), version 1.15 (Table 1).

Age was defined in full years at the time of surgery. Body mass index (BMI) was defined as a body weight divided by a squared height and expressed in kg/m^2. The duration of pain was defined in months preceding the time of surgery. Pain intensity was assessed by using a visual analogue scale from 0 to 100 points with 0 indicating no pain and 100 indicating most possible pain.

The NDI is a questionnaire containing 10 items covering disability caused by neck pain. Each item is assessed on a six-level ordinal scale with '0' describing 'no limitation' and '5' describing 'extreme limitation or an inability to function'. The total score is a percentage calculated by the sum of all answers divided by 50 (the maximum possible number of points) and multiplied by 100 as follows: 'Total score = (∑item scores/50) x 100'. The equation is adjusted when the responses to one or more items are missing. A score of 0% represents the highest possible level of functioning and independence

while a score of 100% represents the lowest level of functioning with total dependence.

Statistical analysis

Linear mixed models are models containing both fixed effects and random effects. They are a generalization of linear regression allowing for the inclusion of random deviations (effects) other than those associated with the overall error term. Each patient demonstrates some linear trend in the change of NDI score and that overall score measurements vary from patient to patient. The sample was treated as a random sample from a larger population and modeled the between-patient variability as a random effect (a random-intercept at the patient level). The model was extended to allow for a random slope on the time of measurement and the likelihood ratio (LR) test was employed to compare a simpler model containing only an intercept with a model including also a slope. As the LR test was statistically significant ($p<0.05$), more complex model was employed in the final analysis. All the data analyses were performed utilizing STATA 16 (College Station, Texas, U.S.).

RESULTS

A total of 392 patients completed preoperative surveys. There were (52%) women and 190 (48%) men with mean age of 54.9 years (Table 1). Mean body mass index was 28.2 kg/m^2. Of the patients, 57 (16%) had experienced neck pain for less than three months, 128 (35%) over three months and 184 (50%) over one year. The average NDI score was 44.3 (17.0) preoperatively. Of 392 procedures, 294 (70%) was anterior fusion of cervical spine without fixation. The most frequent reasons for the surgery were "M50 Cervical disc disorders" (38%) and "M47 Spondylosis" (34%).

The changes in scores during a follow-up were statistically significant (p<0.001) for all the NDI items as well as for the total score. The NDI total score was decreased 44 to 27 points during the first year after the surgery showing a slight a tendency of worsening at 30 points at the end of two-year follow-up (Table 2). Respectively, each of the NDI items demonstrated significant improvement postoperatively and a slight worsening between one and two years after the surgery. However, the observed improvement endured through the entire follow-up. The observed slight decline in functioning at the end of follow-up remained below (better functioning) the baseline level for all the items. The NDI domains sleeping, reading, and driving showed greater increase in scores (worsening functioning) at the final measurement (Figure 1 and 2). Compared to a baseline, the improvement of scores at the end of follow-up varied from 20% ("sleeping" and "headache") to 40% ("pain intensity", "personal care", lifting", and "recreation"). For the rest of the items and for the entire composite score this difference was around 30% ("reading", "concentration", and "work") (Table 4).

DISCUSSION

This was a register-based study of almost 400 patients undergoing different cervical surgical procedures. The goal was to provide some information concerning the changes in functioning in patients after different cervical surgical procedure and to introduce a new approach to describe these changes as an altered functional profile. All the scores of individual items of the NDI as well as its total score demonstrated significant improvement after cervical spine surgery through the entire two-year follow-up. All the items showed a slight worsening in functioning at the end of the follow-up, even though all these final scores remained below the baseline scores indicating better functioning. There were some differences between items in the magnitude of score changes. Items “sleeping” and “headache” were less affected by the surgery while “pain intensity”, “personal care”, lifting”, and “recreation” demonstrated twice as bigger improvement compared to “sleeping” or “headache”. The results suggested that while the change in the composite score of NDI was able to describe the overall change in functioning after the surgery, different areas of functioning might be affected by the surgery differently.

The generalizability of the findings might be affected by several issues. This study was conducted in a single university-based highly specialized spine clinic and the studied cohort might substantially differ from patients visited other clinics. The studied cohort represented a wide spectrum of clinical conditions and surgical techniques. In other words, the studied did not represent a homogenous group. For example, patients undergoing laminectomy or ACDF had different surgery indications, different

treatment goals, and dissimilar postoperative recovery. However, the majority of the procedures performed in this study was due to some degenerative cervical spine disease. Thus, it could be expected that there are many similarities in functional limitations among these patients.

In line with previous studies, the NDI total score and each of the NDI domains demonstrated significant improvement [5, 6]. Peolsson et al. have investigated predictive factors for the outcome of anterior cervical decompression and fusion (ACDF) in their prospective study of 103 patients and have found that pain severity has been the most important factor for predicting the change in the NDI composite score [10]. Kjellman et al. have studied prognostic factors for perceived pain and functioning in patients treated for non-specific neck pain and have found that disability was influenced by high pain intensity and vice versa [11]. Whitmore et al. have studied multiple outcome measures on patients undergoing surgery for cervical spondylotic myelopathy. They have found that all the measures demonstrated correlation, but the NDI had the greatest ability to discriminate favourable from adverse outcomes. [12] Khan et al. have analysed 2206 patients who underwent elective surgery for degenerative cervical radiculopathy and have demonstrated that the 12 months postoperative NDI score had the highest association with patient satisfaction when adjusted for other patient and surgical characteristics. They have also found that patients with higher baseline NDI scores required greater improvement in NDI to achieve satisfaction since the magnitude of improvement in NDI after surgery is less important for satisfaction than the final NDI scores itself. [13] Chotai et al. have acknowledged that there was a significant association between not achieving the

minimal clinically important difference (MCID) for ODI/NDI and patient satisfaction 12 months after elective surgery for degenerative spine diseases [14]. The first study with long-term correlation up to 5 years by Schroeder et al. have shown that patient satisfaction was significantly predicted by PROs including the VAS neck score and the NDI. They have concluded that the difference between their findings and those by Godil et al. indicated that the correlation between PRO and satisfaction is related to the length of follow-up. [15] The benefit of degenerative spine surgery diminishes after a few years.

While there has been a growing interest in creating ICF-based functional profiles across different health conditions, the process is just at the beginning [16]. Only a few medical conditions have been studied from this point of view so far. The ICF-based profiles have been used among people with migraine [17], multiple sclerosis [18, 19], visual impairment [20], children with microcephaly associated with congenital Zikavirus infection [21] and cerebral palsy [22]. Such profiles have not previously been created among people with neck pain. A profile of a modified Brief ICF Core Set for chronic widespread musculoskeletal pain has been created to meet the needs of the clinical setting, including high tempo and giving an overall view of the patient's problems [23].

Although the composite scores of multi-item scales may describe the overall level of functioning, these composite scores maybe formed by different set of scores obtained from individual items. E.g., in one case, the NDI composite score may entirely be formed of the elevated scores of five items while other items remain intact at zero

level. In another case, the composite score has the same estimate as the first one, but it is formed entirely by different items. In other words, the same composite scores may reflect very different underlying functional profiles, making these total scores hardly comparable. The use of composite scores is well justified when screening or analysing data on a population level. On an individual level, a functional profile may be much more informative. The findings of this study suggest that different domains of functioning may behave differently after the cervical surgery. E.g., difficulties in sleeping or headache might be less affected by the surgery than pain intensity.

Future research might want to investigate functional profiles among people with neck pain in different settings and across more specifically delineated groups. Also, associations between different patient characteristics and changes in functional profiles should be assessed.

Conclusions

All the scores of individual items of the NDI as well as its total score demonstrated significant improvement after cervical spine surgery through the entire two-year follow-up. All the items showed a slight worsening in functioning at the end of the follow-up. Items “sleeping” and “headache” were less affected by the surgery while “pain intensity”, “personal care”, lifting”, and “recreation” demonstrated twice as bigger improvement compared to “sleeping” or “headache”. While the change in the composite score of NDI was able to describe the overall change in functioning after the surgery, different areas of functioning were affected by the surgery differently. The

results suggest that the use of functional profiles, in addition to composite scores, is justified among patients with cervical pathologies.

TABLES AND FIGURES

Table 1. Basic characteristics of the sample

Demographics, pain severity, NDI [a] score	Mean	Standard deviation	N
Age, years	54.9	11.3	392
Body mass index, kg/m^2	28.2	5.5	392
Pain intensity, points			
Baseline	53.8	28.5	215
3 months	30.1	26	171
1 year	32.5	27.8	208
2 years	39.5	26.9	103
NDI [a] total score, points			
Baseline	44.3	17	338
3 months	26.8	18.4	163
1 year	27	19	202
2 years	29.2	19.3	93
Pain duration before surgery		N	%
<6 weeks		21	6
6-12 weeks		36	10
3-12 months		128	35
>1 year		184	50
Surgery codes [b]		N	%
NAG40 Anterior fusion of cervical spine without fixation		274	70
ABC60 Decompression of cervical spinal cord		45	11
ABC21 Anterior cervical decompression with interbody fixating implant		30	8
NAG41 Anterior fusion of cervical spine with fixation		14	4
ABC30 Decompression of cervical nerve roots		12	3
ABC10 Microsurgical excision of cervical intervertebral disc displacement		8	2
NAG42 Posterior fusion of cervical spine with or without fixation		7	2
ABC50 Decompression of cervical spinal canal and nerve roots		2	1
Main diagnoses [c]		N	%
M50 Cervical disc disorders		147	38
M47 Spondylosis		134	34
G99 Other disorders of nervous system		59	15
G55 Nerve root and plexus compressions		18	5
M48 Spondylopathies		14	4
M51 Intervertebral disc disorders		14	4
Other		6	2

[a] Neck Disability Index; [b] Nordic Classification of Surgical Procedures NCSP;

International Classification of Diseases ICD-10

Table 2. The Neck Disability scores at 2 months before the surgery (timepoint #0); 2 to 4 months after the surgery (timepoint #1); 11 to 13 months after the surgery (timepoint #2); and 23 to 25 months after the surgery (timepoint #3).

Timepoints	Items	Scores	0.95% CI		N	Items	Scores	0.95% CI		N
0	Pain intensity	2.27	2.16	2.37	392	Concen-tration	1.71	1.61	1.82	389
1		1.27	1.13	1.41	191		1.05	0.91	1.19	189
2		1.34	1.21	1.48	217		1.11	0.98	1.25	217
3		1.47	1.28	1.65	105		1.19	1.01	1.37	105
0	Personal care	1.41	1.30	1.51	391	Work	2.75	2.60	2.91	371
1		0.82	0.68	0.96	191		1.85	1.65	2.05	186
2		0.74	0.61	0.87	219		1.75	1.56	1.93	218
3		0.81	0.63	0.98	105		1.92	1.67	2.17	103
0	Lifting	2.35	2.21	2.49	390	Driving	2.36	2.22	2.49	361
1		1.72	1.53	1.90	189		1.29	1.11	1.47	179
2		1.43	1.25	1.60	218		1.32	1.15	1.49	209
3		1.44	1.21	1.68	104		1.60	1.37	1.84	98
0	Reading	2.21	2.08	2.33	388	Sleeping	2.32	2.19	2.45	390
1		1.36	1.19	1.52	188		1.48	1.31	1.65	189
2		1.35	1.19	1.50	218		1.53	1.37	1.69	218
3		1.61	1.40	1.82	104		1.89	1.67	2.11	104
0	Headaches	1.81	1.69	1.94	392	Recreation	2.77	2.63	2.90	376
1		1.25	1.08	1.41	192		1.68	1.49	1.87	185
2		1.37	1.22	1.53	219		1.65	1.47	1.82	216
3		1.48	1.27	1.69	104		1.73	1.48	1.98	100
0	Total score	44.17	42.27	46.06	338					
1		27.06	24.60	29.52	163					
2		27.09	24.82	29.36	202					
3		30.30	27.21	33.38	93					

Figure 1. Change in profile of functioning based on Neck Disability Index presented as a bar chart.

Figure 2. Change in profile of functioning based on Neck Disability Index presented as a radar chart.

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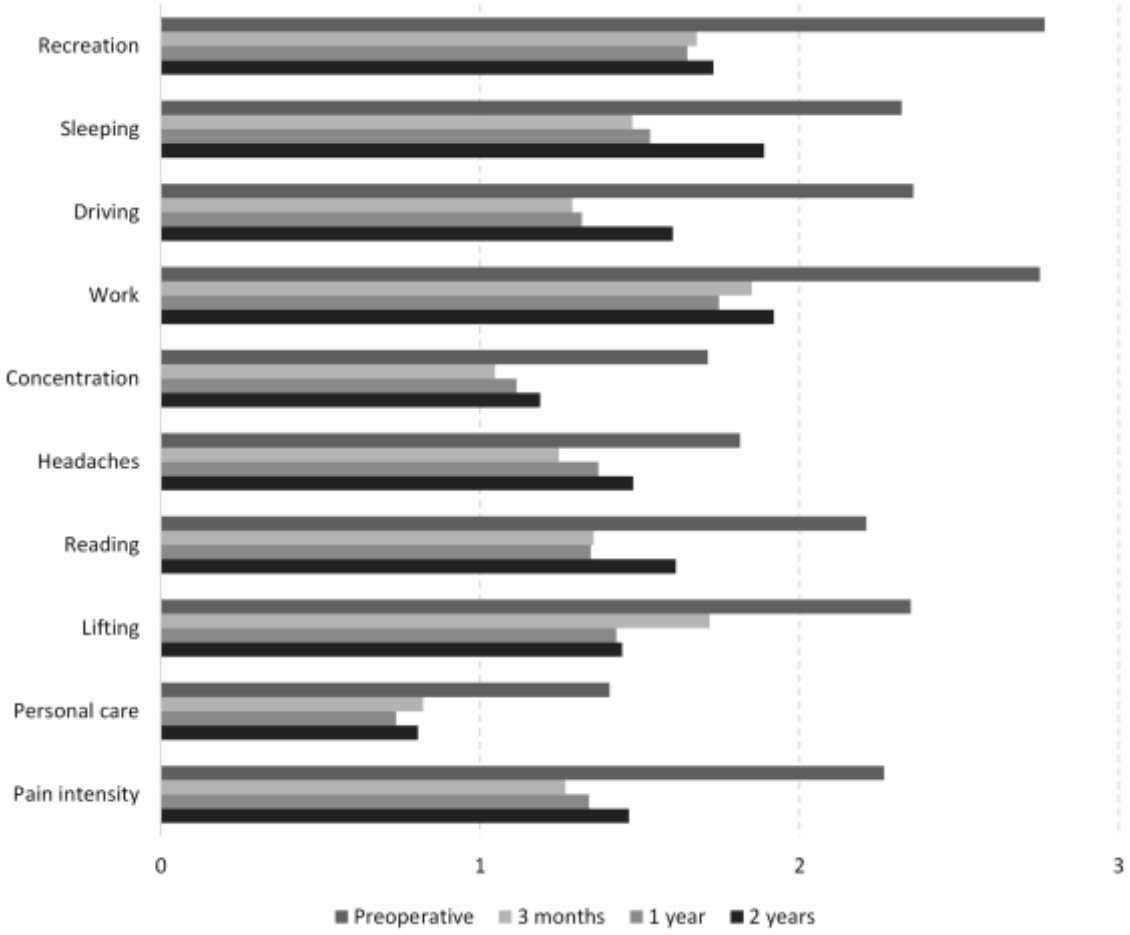
Recreation
Sleeping
Driving
Work
Concentration
Headaches
Reading
Lifting
Personal care
Pain intensity
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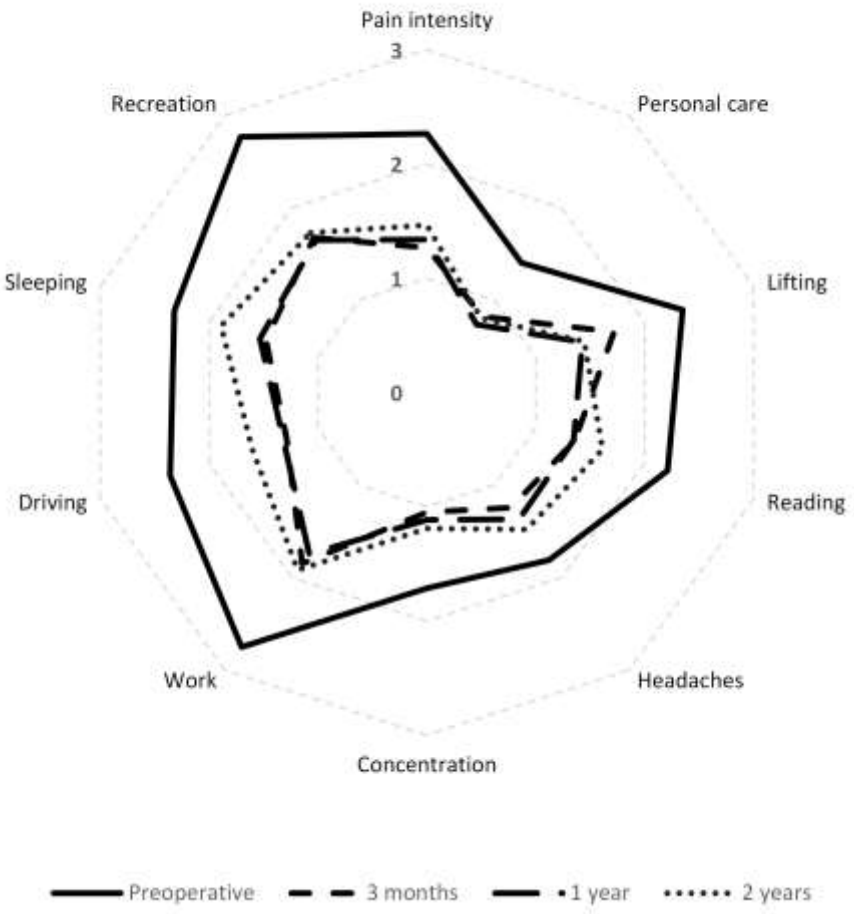
3
Preoperative
3 months
1 year
2 years

Figure 1.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2 years

Figure 2.