Sami Aaltonen

Changes in Neck and Arm Pain after Anterior Cervical Discectomy and Fusion

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This study aims to evaluate the trajectories of changes in arm and neck pain after anterior cervical discectomy and fusion (ACDF) due to degenerative cervical spine disease.

Pain severity was measured preoperatively and up to two years postoperatively among 248 consecutive patients undergoing ACDF due to radiating arm pain caused by degenerative cervical spine disease. The main statistical approach was MIXED modeling. Effects of some initial descriptive (grouping) variables on these changes were assessed by pairwise comparison of means.

Both neck and arm pain significantly reduced after surgery ($p<0.001$). Postoperatively, older patients demonstrated a greater reduction in neck pain of -4.7 (95% CI: -9.2 to -0.2) points. Substantial reduction in neck pain were observed in patients with severe preoperative neck and arm pain: -14.2 (95% CI: -19.7 to -8.7) and -12.0 (95% CI: -18.0 to -6.0) points, respectively.

Both neck and arm pain diminished significantly after ACDF during two-year follow-up. This change was greater in those with severe preoperative arm or neck pain. Older patients more likely experienced a greater postoperative reduction in neck pain comparing to younger patients.

Changes in Neck and Arm Pain after Anterior Cervical Discectomy and Fusion

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CONFLICT OF INTEREST

None to declare.

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ABSTRACT

Study Design: Retrospective register-based study.

Objective: To evaluate the trajectories of changes in arm and neck pain after anterior cervical discectomy and fusion (ACDF) due to degenerative cervical spine disease.

Methods: Pain severity was measured preoperatively and up to two years postoperatively among 248 consecutive patients undergoing ACDF due to radiating arm pain caused by degenerative cervical spine disease. The main statistical approach was MIXED modeling. Effects of some initial descriptive (grouping) variables on these changes were assessed by pairwise comparison of means.

Results: Both neck and arm pain significantly reduced after surgery ($p<0.001$). Postoperatively, older patients demonstrated a greater reduction in neck pain of -4.7 (95% CI: -9.2 to -0.2) points. Substantial reduction in neck pain were observed in patients with severe preoperative neck and arm pain: -14.2 (95% CI: -19.7 to -8.7) and -12.0 (95% CI: -18.0 to -6.0) points, respectively.

Conclusion: Both neck and arm pain diminished significantly after ACDF during two-year follow-up. This change was greater in those with severe preoperative arm or neck pain. Older patients more likely experienced a greater postoperative reduction in neck pain comparing to younger patients.

KEYWORDS

Neck Pain, Arm Pain, ACDF

INTRODUCTION

The change in the intensity of neck and upper extremity pain after cervical spine surgery has been widely studied (Widbom-Kolhanen et al., 2023; Harrop et el., 2023; Wibault et al., 2018). This also applies to the most common surgical technique for the cervical spine – anterior cervical discectomy and fusion (ACDF) (Landers et al., 2013; Massel et al., 2017; Stull et al., 2020). Furthermore, there is uncertainty in the literature as to how much the change in neck pain severity follows the change in upper extremity pain intensity (Hermansen et al., 2023; Cao et al., 2020, Asher et al.; 2019). There is also uncertainty about which factors may be related to the variation in the outcome of surgery as measured by pain intensity (Hebert J et al., 2022).

Surgery for degenerative diseases is usually expected to relieve pain, especially radiating pain in the upper extremity (Massel et al., 2017). On the other hand, previous studies have reported that postoperative neck pain may change in a slightly different magnitude compared to radiating upper extremity pain (Massel et al., 2017). The timetables for these changes are similar (Massel et al., 2017). However, simultaneous changes in the intensity of neck and upper extremity pain have been little studied (Massel et al., 2017,). Studying these changes is complicated, for example, due to ethical reasons, which greatly limit the possibilities of conducting controlled studies on the topic in question. One possibility to overcome this difficulty is through subgroup analysis, that is, identifying the factors that might influence postoperative pain change. Identifying these factors can potentially help to improve preoperative patient selection and to plan postoperative rehabilitation more precisely.

Previous studies have shown that age is not factor in change of neck pain (Lied B et al., 2010) and in both groups' changes have been substantial (Mella P et al., 2021). Likewise, gender has not been found to be a factor in change of pain (Lied B et al., 2010). Findings in how duration of preoperative pain affects change of are contradictory. Shorter duration of preoperative pain was found to be positive predictor for pain relief after ACDF (Lawless M et al., 2022; Jenkins N et al., 2020). In another study, no significant difference was found between longer and shorter pain durations (Lied B et al., 2010) Conversely, lower preoperative pain intensity was associated with greater pain relief after ACDF and lower pain scores in 6- and 12- months follow-ups (Stull et al., 2020; Adogwa et al., 2018).

The aim of this study was to evaluate the developmental trajectories of neck and upper extremity pain after ACDF surgery and to identify some descriptive factors that might influence these trajectories.

METHODS

The data were obtained from the register containing data on the patients undergoing one- to three-level ACDF between June 21, 2018 and August 17, 2021 in a university hospital. The patients responded to a repeated survey ≤ 2 months before surgery (wave #0); 2 to 4 months after surgery (wave #1); 11 to 13 months after surgery (wave #2); and 23 to 25 months after surgery (wave #3). The survey contained questions on demographics, pain and the severity of disability. A patient was included if the procedure code was "ABC21" (anterior decompression with interbody fixating implant) or "NAG40" (anterior fusion without fixation) according to the Nordic Classification of Surgical Procedures (NCSP), version 1.15. Only primary surgical procedures were included. According to the national legislation, retrospective register-based analysis does not require an explicit approval from an ethical board. The study was conducted in accordance with the Declaration of Helsinki as a statement of ethical principles for medical research involving human subjects.

Independent variables

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 before surgery was defined as <6 weeks; 6-12 weeks; 3-12 months and >1 year.

Dependent (outcome) variables

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’. Disability severity was assessed by the Neck Disability Index (NDI). 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 ‘zero’ describing ‘no limitation’ and ‘five’ 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

The descriptive characteristics were presented as means, standard deviations (SDs), and percentage, when appropriate. For the main analysis, in addition to sex, the sample was divided into equal groups based on age, pain severity and preoperative duration of neck pain. This way grouping pairs were formed: 'older' vs. 'younger', 'milder' vs. 'worse' pain, and 'preoperative pain <=1 year' vs. 'preoperative pain >1 year'.

The main analysis was performed using MIXED – a statistical model containing both fixed effects and random effects (Agresti A. Categorical Data Analysis. 3rd ed Hoboken, New Jersey: John Wiley & Sons; 2013). The method logic assumes that each patient demonstrates some linear trend in the change of outcome score and that overall score measurements vary from patient to patient. A conventional approach to assess the measurement error is to compare each individual slope to an average one. This approach does not take into account that intercept may vary for different individuals. If there is a substantial variety between intercepts, then the variance of the estimate may be overestimated leading to wide confidence intervals and to a statistically insignificant result, even if the real change would be significant if the intercepts were taken into account. A slope describes a so-called "fixed effect", while an intercept describes a "random effect". The MIXED notices both effects.

The sample was treated as a random sample from a larger population. Likelihood ratio test showed that the differences in repeated measures were not significantly affected by a slope but only by an intercept – two-tailed p-values >0.05. Thus, further MIXED analyses were conducted employing intercepts only. For both neck pain and arm pain, the change in pain severity was statistically significant with p-values <0.001. The trajectories of changes in pain over time were created using predicted estimates (margins) along with their 95% confidence intervals (95% CIs) at each time point for each grouping variable. Effects of grouping variables on these changes were assessed by pairwise comparison of means.

All the data analyses were performed utilizing Stata 18 (College Station, Texas, U.S.).

Results

Of 248 patients, 114 (54%) were men (Table 1). The mean age was 50.6 (SD 10.3) years (Table 2). Of the patients, 154 (62%) were operated due to intervertebral disc disease and 94 (38%) due to foraminal stenosis. Anterior fusion without fixation was performed in 225 (91%) and anterior decompression with interbody fixating implant in 23 (9%) cases. Preoperatively, the NDI score was 44.8 (SD 16.7) points, neck pain was 57.4 (SD 28.8) points, and arm pain was 57.2 (SD 30.4).

Average changes in neck and arm pain are presented in the Figure 1. There was a steep decline in pain intensity immediately after the surgery. After three months, pain intensity grew remaining, however, almost two-fold lower at the end of follow-up comparing to initial levels. The changes in both neck and arm pain severity were statistically significant ($p<0.001$).

Changes in neck pain severity by grouping variables

As shown in Figure 2, all the trajectories demonstrated similar initial relief in pain severity during first three months after surgery. Also, all the trajectories turned upward after that, and this increase was noticeable until the very end of the follow-up. Despite this increase, for sex, age and preoperative pain duration, pain severity remained at substantially lower level comparing to the initial rate in every group. Instead, in the groups with initially milder neck or arm pain, the increase in pain severity after three months essentially settled at the end of follow-up on the initial level.

Changes in arm pain severity by grouping variables

As shown in Figure 3, also these trajectories demonstrated initial relief in pain severity during first three months after surgery. Similarly to neck pain, all the trajectories turned upward after that, and this increase was noticeable until the very end of the follow-up. Despite this increase, for sex, age, preoperative pain duration and initial level of neck pain, the severity arm pain remained at substantially lower level comparing to the initial rate in every group. Instead, in the group with initially milder arm pain, the increase in pain severity after three months essentially settled at the end of follow-up on the initial level.

Effects of grouping variables on pain development

Older age was associated with greater relief in neck pain, even though the effect was borderline significant -4.66 (95% -9.17 to -0.15) (Table 3). Initially more severe neck and arm pain was associated with greater pain relief in both neck and arm with the most significant effect seen for pre- and postoperative arm pain -17.65 (95% -23.67 to -11.63).

Discussion

In patients undergoing ACDF primarily for arm radiculopathy, we observed a significant reduction in neck pain alongside enhanced relief in arm pain. Notably, patients with more severe preoperative neck or arm pain experienced a greater reduction in both neck and arm pain. Furthermore, older patients exhibited a more substantial reduction in neck pain compared to their younger counterparts. Interestingly, the preoperative duration of pain symptoms did not impact the reduction for either arm or neck pain.

We identified an overall significant reduction in both arm and neck pain after ACDF, aligning with findings from earlier studies (Landers et al., 2013; Massel et al., 2017; Stull et al., 2020).

Moreover, we noted that individuals with severe neck pain or arm pain experienced a more substantial reduction in both neck and arm pain following ACDF. Patients with significant neck pain have been reported to exhibit noteworthy improvements in neck pain and disability following ACDF for radiculopathy/myelopathy (Stull et al., 2020). Interestingly, higher neck disability, as opposed to preoperative neck pain or higher arm pain, predicted better postoperative improvement in neck disability in another study (Anderson et al., 2009). In contrast, Jacob et al. (2022) did not find a significant difference in arm pain or neck pain between those with severe and mild/moderate preoperative neck disability, although both groups demonstrated improvements in postoperative arm and neck pain. Differences among earlier studies may be partly explained by mixed indications and symptoms for ACDF. Additionally, studies have utilized different preoperative and PROMs to study outcomes.

Of note, we observed that older patients were more likely to experience a greater reduction in postoperative neck pain but not in arm pain. Earlier reports on age and outcomes after ACDF present conflicting findings, with some studies suggesting that older age predicts better improvement in both neck and arm pain (Peolsson et al., 2003; Toci et al., 2022) and for arm pain (Hartman et al., 2022), while others report no effect

(Hebert et al., 2022) or worse outcomes (Archer et al., 2020) for neck pain or arm pain. One plausible explanation for the observed greater reduction in neck pain among older patients is their increased likelihood of radiculopathy due to advanced disc degeneration and spondyloarthrosis at the level of radiculating symptoms (Kong et al. 2017, Bogduk et al. 2011).

Notably, our study did not find a significant effect of preoperative pain duration exceeding one year on arm pain or neck pain reduction after surgery, consistent with the findings of the Basques et al. (2019) study. However, it is noteworthy that preoperative symptom duration exceeding one year has been associated with worsened outcomes, as measured by other outcome parameters in prior research (Basques et al., 2019; Liu et al., 2023; Lawless et al., 2023).

A major strength of our study lies in its foundation as a population-based investigation utilizing a prospectively collected spinal registry. The inclusion of this registry enhances the credibility of our findings, given that a majority of ACDF procedures in our region are conducted in tertiary hospitals. Each elective ACDF surgery is systematically documented in the spinal registry, with PROMs being automatically compiled both preoperatively and postoperatively for every individual. However, it is noteworthy that despite the implementation of automated reminders, some patients do not respond to the electronic post-operative PROMs, resulting in missing data for this subset of individuals.

Moreover, a notable limitation of our study is the absence of an investigation into the impact of co-morbidities and complications on postoperative neck and arm pain. Furthermore, we did not explore the effects of re-operations and postoperative pseudoarthrosis, both of which can potentially influence postoperative neck and arm pain outcomes. These limitations underscore the need for cautious interpretation of our results and highlight areas for future research to provide a more comprehensive understanding of the factors influencing postoperative outcomes in ACDF procedures.

Conclusions

Following ACDF, both arm pain and neck pain exhibit notable reduction. Patients with initially higher levels of arm pain or neck pain experience a more pronounced reduction in both arm and neck pain following the procedure. Additionally, older patients demonstrate a greater reduction in neck pain after undergoing ACDF. These findings underscore the importance of considering preoperative pain levels and patient age in predicting postoperative outcomes, providing valuable insights for clinicians managing individuals undergoing ACDF for degenerative cervical spine conditions.

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Figure 1. Overall change in neck and arm pain.

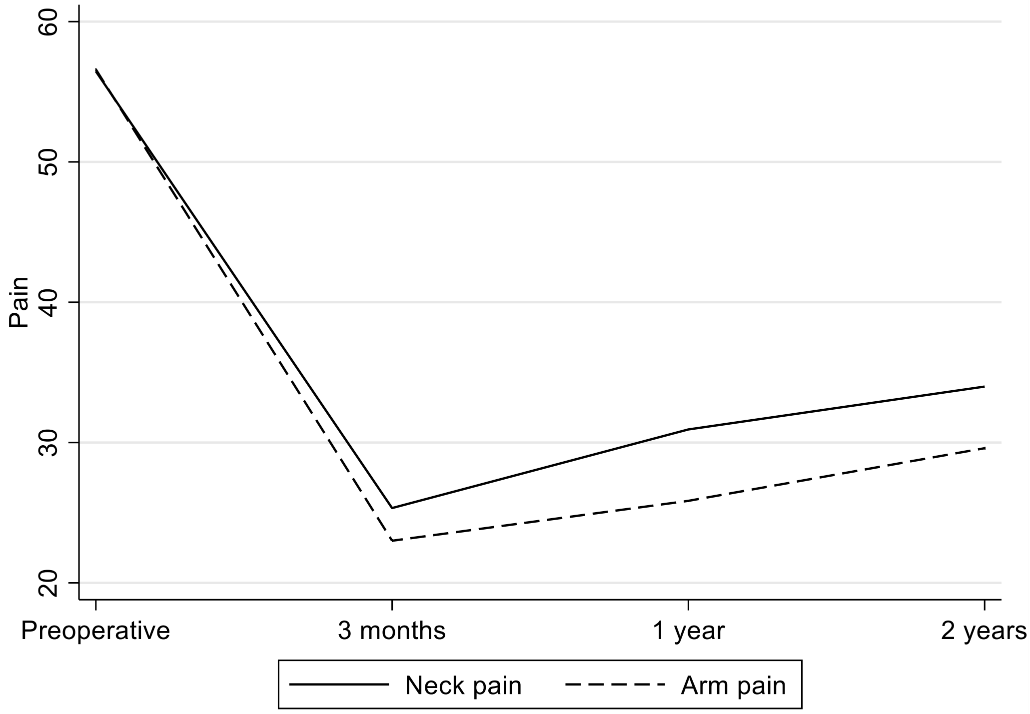

Figure 2. Change in neck pain by grouping variables.

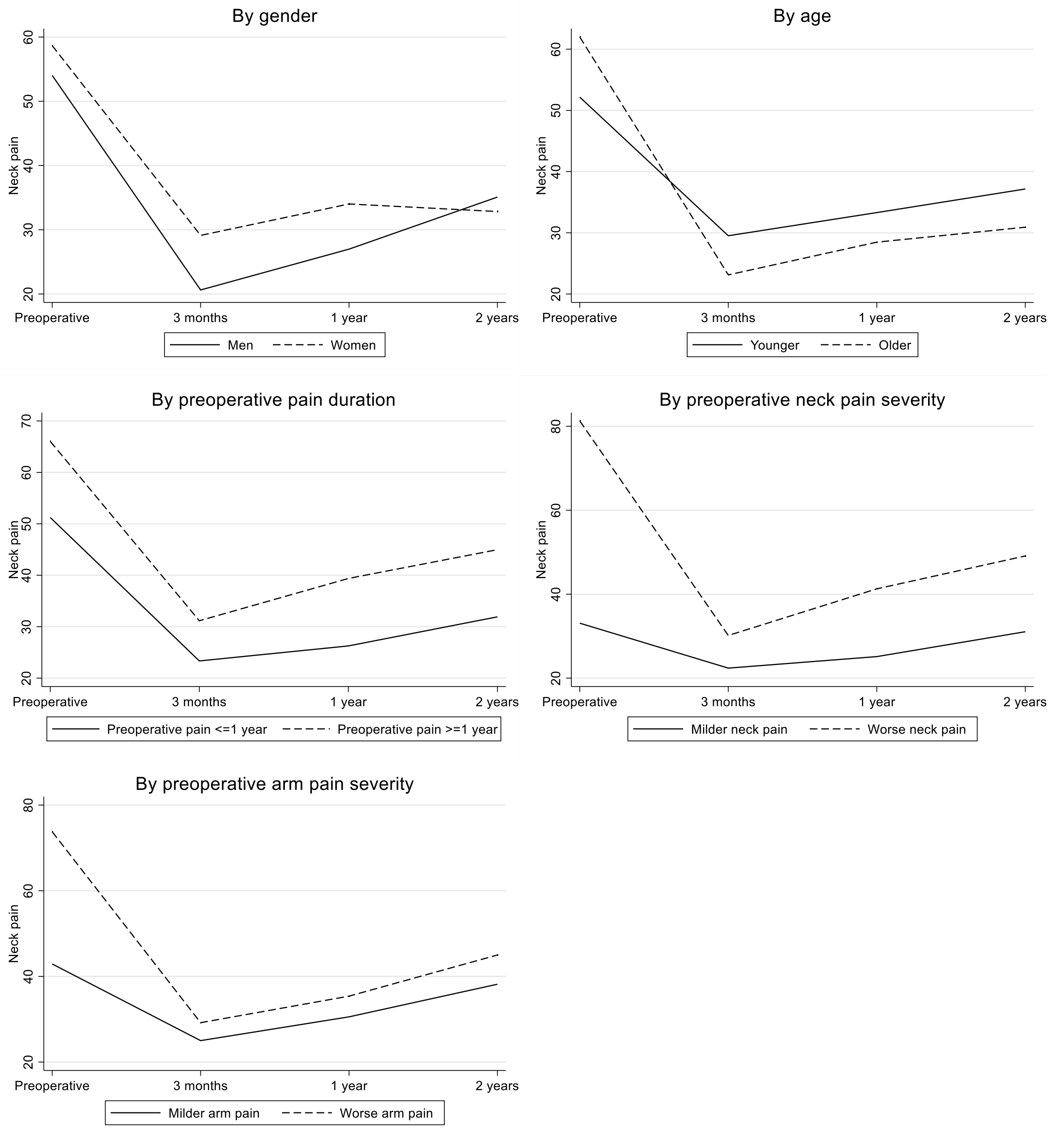

Figure 3. Change in arm pain by grouping variables.

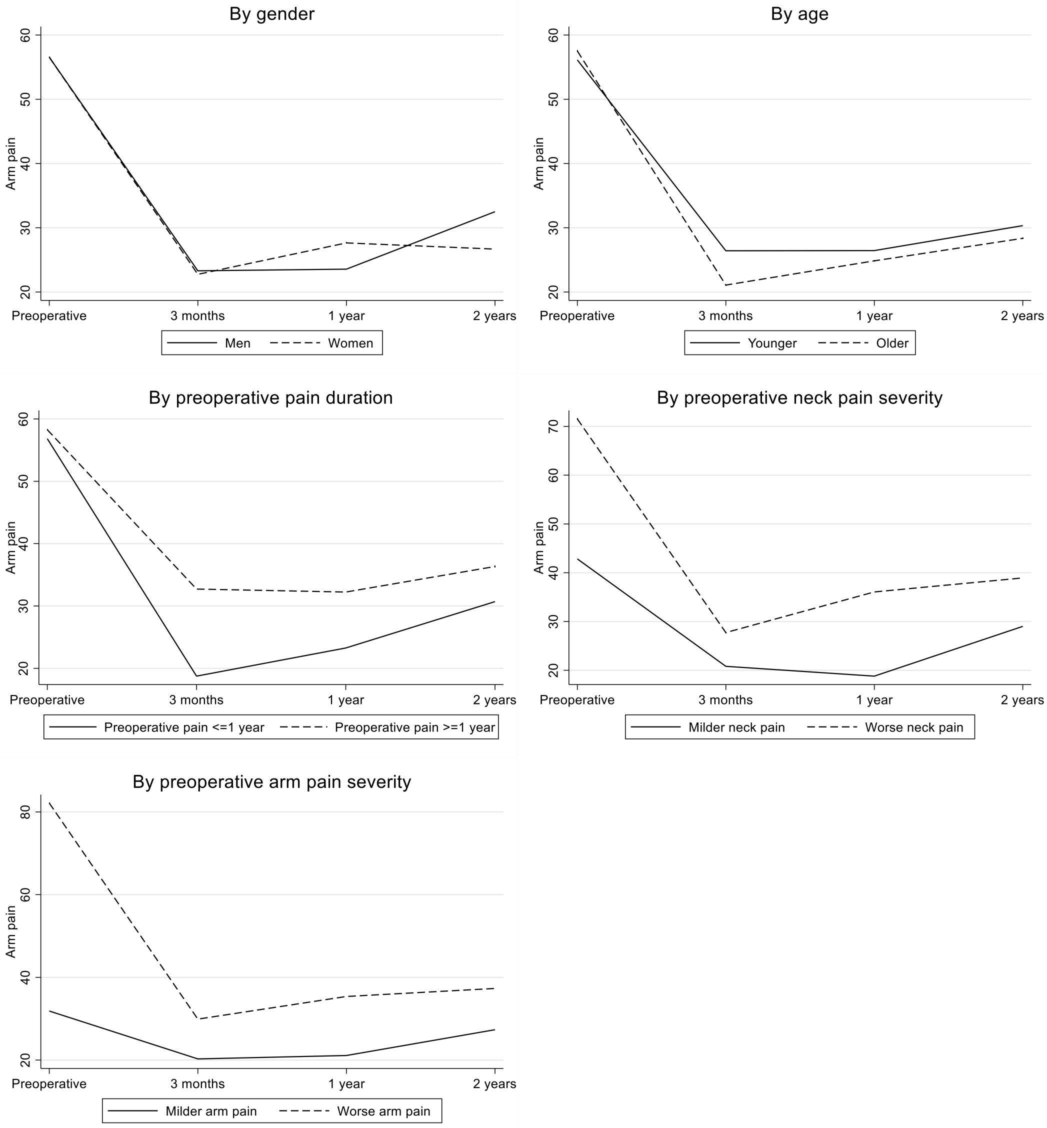

Table 1. Initial descriptive characteristics (categorical variables).

Characteristic	N	%
Sex		
Men	114	46%
Women	134	54%
DRG		
NAG40	225	91%
ABC21	23	9%
Diagnosis		
M50	128	52%
M47	86	35%
Others	34	13%
Diagnosis		
Disc degeneration	154	62%
Foraminal stenosis	94	38%
Preoperative pain duration		
<=1 year	120	60%
>1 year	80	40%

Table 2. Initial descriptive characteristics (continuous variables).

Characteristic	Mean	SD	N
Age			
Age group 1	42.6	6.0	124
Age group 2	59.1	5.9	124
Total	50.6	10.3	248
Neck Disability Index			
Preoperative	44.8	16.7	116
3 months after surgery	24.7	18.8	84
1 year after surgery	24.2	18.2	124
2 years after surgery	26.7	21.4	88
Neck pain			
Preoperative	57.4	28.8	109
3 months after surgery	25.6	24.0	94
1 year after surgery	30.8	27.2	127
2 years after surgery	33.1	28.8	89
Neck pain group 1	33.1	18.8	54
Neck pain group 2	81.3	11.6	55
Arm pain			
Preoperative	57.2	30.4	111
3 months after surgery	23.3	25.7	88
1 year after surgery	25.1	25.7	118
2 years after surgery	29.3	27.5	84
Arm pain group 1	31.9	22.1	55
Arm pain group 2	83.1	9.9	56

Table 3. Effect of grouping variables on pain development – pairwise comparisons. Statistically significant results are shown in bold.

Variable	Comparators	Contrast	95% CI	
Neck pain				
Sex	women vs. men	-1.58	-6.11	2.95
Age, groups	older vs. younger	**-4.66**	**-9.17**	**-0.15**
Preoperative pain duration	>1 year vs. <=1 year	-0.45	-5.37	4.48
Preoperative neck pain, groups	severe vs. mild	**-14.18**	**-19.66**	**-8.71**
Preoperative arm pain, groups	severe vs. mild	**-11.95**	**-17.96**	**-5.95**
Arm pain				
Sex	women vs. men	-0.93	-5.69	3.83
Age, groups	older vs. younger	-0.46	-5.22	4.30
Preoperative pain duration	>1 year vs. <=1 year	1.81	-3.51	7.13
Preoperative neck pain, groups	severe vs. mild	**-6.91**	**-13.75**	**-0.07**
Preoperative arm pain, groups	severe vs. mild	**-17.65**	**-23.67**	**-11.63**