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Clinical Article

Predictive factors for arm pain, neck pain, neck specific disability and health after anterior cervical decompression and fusion

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Summary

Background. Predictive factors for a low arm and neck pain, and good health after anterior cervical decompression and fusion (ACDF) with a cervical carbon fibre intervertebral fusion cage (CIFC) are still lacking.

Method. A prospective consecutive study to investigate which preoperative factors that could predict a good outcome with regard to arm pain, neck pain, Neck Disability Index (NDI) and general health three years after ACDF with CIFC was conducted. Thirty-four patients were included before surgery. Measurements took place the day before, six months, one year and three years after ACDF.

Findings. In multivariate analysis, to be a non-smoker before surgery was the most important factor for a low postoperative arm pain, a low pain frequency was the most important factor for low postoperative neck pain, normal rating on Distress and Risk Assessment Method (DRAM) was the most important factor for high function on NDI and a low initial pain intensity was the most important factor for good postoperative health. For all outcome variables a normal rating on DRAM was an important factor for a good outcome.

Conclusions. Non-smoking, a low pain level and normal rating on DRAM were the best preoperative predictors of a good outcome in ACDF. Inclusion criteria for surgery should be based on a bio psychosocial model and DRAM seems to be useful for including the traditional inclusion criteria.

Keywords: Cervical radiculopathy; intervertebral disc; anterior cervical disc fusion; outcome; prognostic factors.

Introduction

Few studies [17, 21, 24, 27, 31, 36] have described the surgical outcome of cervical disc disease with a broad assessment. Only Vavruch *et al.* [31] and Peolsson *et al.* [21] have evaluated the technique with a cervical carbon fibre intervertebral fusion cage (CIFC, ''Brantigan cage''). The study by Vavruch *et al.* [31] showed despite a higher pseudarthrosis rate in CIFC, no significant differences in the clinical outcome between CIFC and the Cloward procedure (CP). The study by Peolsson *et al.* [21] showed an effect of CIFC. However, about two thirds of the patients still suffered from deficits in pain intensity, Neck Disability Index (NDI), Distress and Risk assessment Method (DRAM) and general health. These results were recently verified in another study [22] where about 70% of the patients still had remaining problems with respect to pain intensity and NDI after CP or CIFC. The high frequency of remaining deficit raises the questions; who are the patients who had the greatest benefit from surgery? Could the traditional inclusion criteria for surgery be improved?

Previous research has reported predictors of a good outcome in surgery for cervical disc disease to be associated with soft disc disease [4, 7, 13] in one level [4, 6, 9, 25] greater segmental kyphosis [22], radicular pain without additional neck or lumbar pain [11, 13, 25, 34], correlation among the preoperative findings [13, 25], a short duration of symptoms [4, 9, 13], younger age [4, 9, 34], non-smoking [22], male gender [9, 22, 30], and a low pain and disability level [22]. In most analysis only pain or Odom's criteria have been used as outcome measures. According to Deyo *et al.* [8] the traditional surgical outcome measure of a single rating scale (i.e. Odom's criteria) is not sufficient, because it combines multiple dimensions of outcome, which may be poorly related. Peolsson *et al.* [22] analysed predictive factors for the outcome on disability (NDI). It is obvious that more studies with broader outcomes are needed. Another

weakness of previous reports is the statistics used. Except for Eriksen *et al.* [9] and Peolsson *et al.* [22], all previous reports have used only chi square test or bivariate correlation analysis with no potential to check interdependency between variables. The ordinary (about 0.30) adjusted R^2 suggests that other factors might be important predictors of outcome. This indicates that factors related to a biopsychosocial model are needed.

The purpose of the present study was to investigate which preoperative factors are important for a good outcome three years after ACDF with CIFC with respect to arm pain, neck pain, NDI and general health.

Methods and materials

Inclusion and exclusion criteria

Patients in the age group 25–65 years, who were on the waiting list at the Spine Clinic at the University Hospital in Linköping, Sweden, for surgical decompression and fusion with ACDF using CIFC, were consecutively included in the study after giving their informed consent. The patients in the study had been referred to the Spine Clinic because of cervical disc disease verified by magnetic resonance imaging (MRI), with arm/neck pain and a neurological deficit. Furthermore, seven patients had myelopathy.

Exclusion criteria were previous fracture or luxation of the cervical vertebrae, spine tumour, previous surgery of the cervical spine, diagnosed mental disease, and a lack of familiarity with the Swedish language.

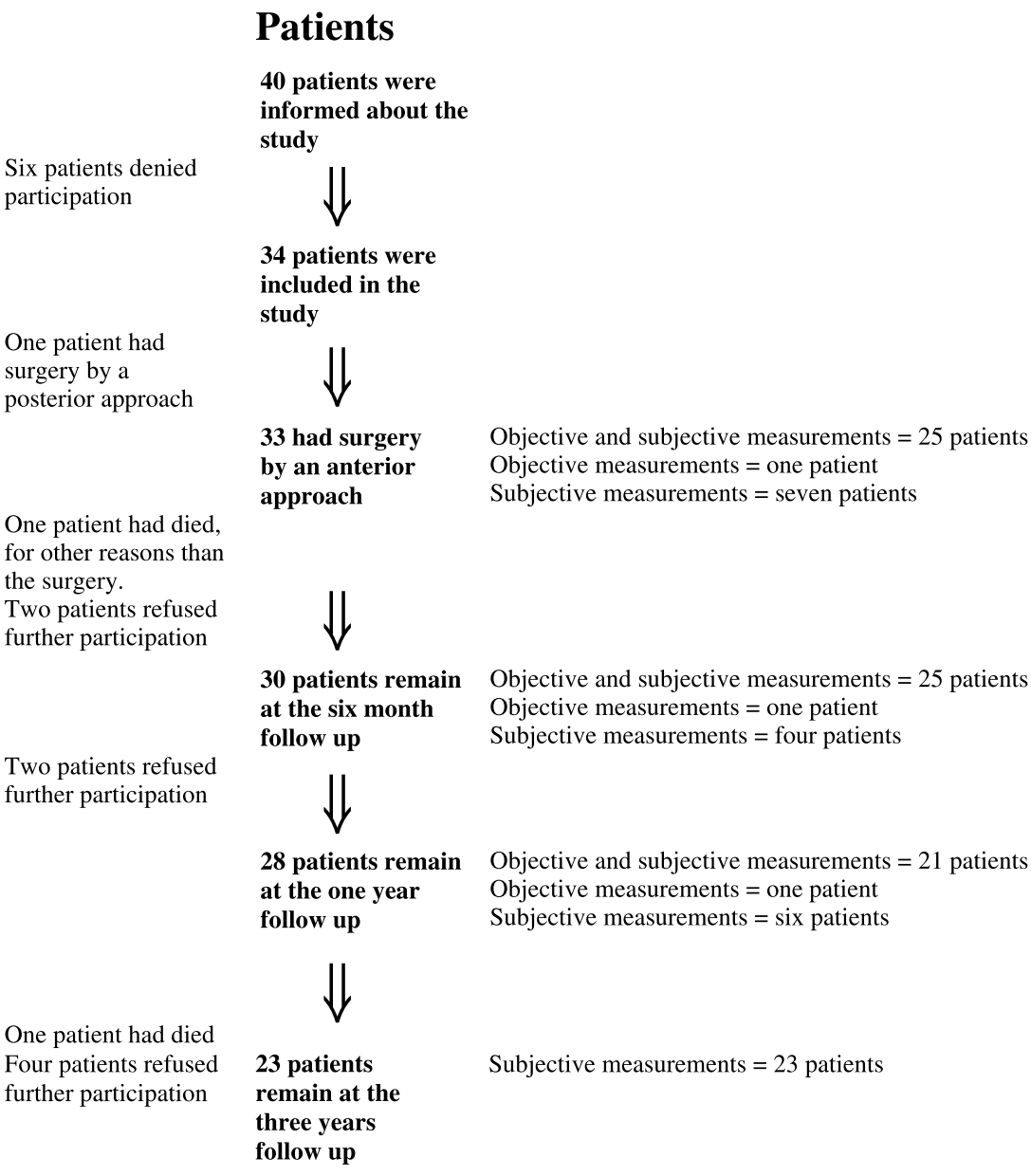

Fig. 1. Flowchart of the patients in the study, drop-outs, objective and/or subjective measurements

The Ethics Committee at the Faculty of Health Sciences, Linköping University, approved the study.

Patients

Three years after surgery a questionnaire was sent to those 28 patients who remained at one-year follow-up [21]. Twenty-three patients (15 men and 8 women) responded (mean age 51 years (SD 11.2)). Of the drop-outs; one patient had a rheumatic disease, two patients suffer a whiplash associated disorder and one has had previous (unsuccessful) neck surgery and denied further participation, one patient had died for reasons (Fig. 1) unbeknown to us.

In the analysis of the drop outs there were no significant differences in either background data or subjective measurements before surgery in those who answered the questionnaire at three years follow-up in other words, the patients who remained at three years follow-up were a representative sample of the initial population.

Measurements

Measurements took place the day before surgery, six and 12 months after surgery and three years after surgery.

Background data

Background data covered age, gender, duration of current episode in months, similar problems earlier (yes/no), and questions of back pain (apart from the neck disorders, have you had low back disorders during the past 6 months? (1 = yes, 2 = no); if back pain: duration of the back disorders on a five-point scale (1 = less than one day, 5 = daily); how the back disorders interfere with your daily life on a six-point scale (1 = not at all, 6 = almost paralysing)).

Pain and numbness

Pain intensity was measured as average pain on a horizontal visual analogue scale (VAS) (in millimetres, 0 = no pain, 100 = worst imaginable pain) [28]. Pain frequency was described as how often pain occurs, with the endpoints always (=1) and never (=5). Distribution of symptoms on a seven-point scale (0 = no symptoms, 6 = most distal (in the hand) symptoms) were measured with pain drawings [33]. Use of painkillers was measured on a four-point scale (1 = several times a day, 4 = never). Ratings of how bothersome the symptoms had been during the past 24 hours with respect to neck pain, arm pain and numbness/tingling in the arm and hand, respectively, were done on an 11-point scale (0 = not at all bothersome, and 10 = extremely bothersome) [5].

Disability

Disability was measured using the NDI. The 10 sections (pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation) are scored from 0 to 5, added together and transformed to percentages, 0% = no pain or difficulties, 100% = highest score for pain and difficulty on all items) [32].

Managing activity of daily living (ADL) despite neck problems was measured on a four-point scale (1 = yes, complete, 4 = no, not at all).

Distress

Distress was measured with the DRAM [20], which is an integration of psychosomatic (the Modified Somatic Perception Questionnaire (MSPQ)) and psychological (the modified Zung Depression Index) assessments (normal: Zung <17; at risk: MSPQ <12 and Zung 17–33; depressed distressed Zung >33; somatic distressed MSPQ ≥12 and Zung 17–33).

Sick leave

Sick leave related to the neck disorder was registered as no sick leave (=1), part-time sick leave (=2), or full-time sick leave (=3).

Expectations of treatment

Expectations of treatment were measured on a four-point scale, ranging from completely restored (=1) to no expectation of being restored or getting relief (=4).

Health

General health was measured on a horizontal VAS (in millimetres) (0 = best imaginable, 100 = worst imaginable). The scale has been shown to be reliable both in patients with acute (Intra Class Correlation Coefficient (ICC) 0.84) and chronic (ICC 0.76) non-specific neck pain, and to have a significant correlation to the EuroQuol VAS scale in ACDF patients ($r = -0.78$, $p < 0.0001$) (unpublished data).

Symptom satisfaction

Symptom satisfaction (how patients would feel about having their current neck symptoms for the rest of their lives) was rated on a seven-point scale (1 = delighted, 7 = terrible) [5].

Treatment

The ACDF was performed between 1998 until 2000 at a University hospital by two different neurosurgeons using the CIFC described by Vavruch *et al.* [31]. Most patients received general physiotherapy in primary care after removal of the collar [21].

Statistical methods

Correlations between background/preoperative factors and the post-operative outcome were determined by Spearman rank correlation coefficient analysis. For background/preoperative (independent) factors that were correlated ($p \leq 0.05$) with the three year outcome with respect to arm pain, neck pain, NDI or general health (dependent variables), a standard linear multiple regression analysis was used followed by a statistical forward step-wise regression procedure to reveal the most important factors for each model. For analysis of collinearity (inter-correlation, $r > 0.8$), Spearman rank correlation coefficient analysis was used. For the regression model adjusted R^2, Beta, b-value, and standard error b were used. The adjusted R^2 is the proportion of variation in the dependent variable is explained by the independent variables, adjusted for number of variables assigned in the analysis. The coefficient Beta for the variable X is the change in mean response per unit increase in X when all other predictors are held constant.

A p-value ≤ 0.05 was considered statistically significant.

Results

Predictive factors

Arm pain

The pre-surgery variables: non-smoking, low pain frequency and normal ratings on DRAM were shown to be significantly associated with low arm pain at follow-up

Table 1. *Spearman rank correlation coefficient analysis (r-value (r) and p-value (p)) between background/baseline data and the outcome of arm pain, neck pain, Neck Disability Index (NDI) and general health. Only significant ($p \leq 0.05$) correlations are shown*

Background/baseline data	Outcome							
	Arm pain		Neck pain		NDI		General health	
	r	p	r	p	r	p	r	p
Gender	0.59	0.02	0.59	0.02	0.69	0.004		
Age							0.49	0.02
Smoking	0.56	0.03						
Pain frequency	−0.43	0.04	−0.43	0.005				
Pain intensity			0.54	0.01	0.65	0.003	0.50	0.02
Pain radiation			0.54	0.05			0.36	0.03
Arm pain			0.49	0.04				
Neck pain					0.47	0.04		
Low back pain			−0.27	0.01				
Use of painkillers	−0.26	0.04			−0.50	0.01		
DRAM	0.56	0.02	0.59	0.02	0.80	0.0005	0.57	0.02
General health					0.52	0.02		

Table 2. *Step-wise forward regression analysis for outcome on 24-hour arm pain, 24-hour neck pain, Neck Disability Index (NDI) and general health on visual analogue scale three years after surgery for cervical disc disease (Distress and Risk Assessment Method = DRAM) (n = 23). Variables entered from Spearman rank correlation coefficient analysis were used in a standard linear multiple regression analysis and was followed by a statistical forward step-wise regression procedure to reveal the most important predictors for each outcome*

Outcome	Variables entered	Multiple regression			Step-wise regression		
		Factors	R^2	p	Important factors	Cumulative adj. R^2 by step	Beta
Arm pain	gender smoking painkillers pain frequency DRAM	smoking pain frequency DRAM	0.52	0.002	smoking DRAM	0.24 0.48	0.55 0.50
Neck pain	gender pain frequency pain distribution pain intensity arm pain low back pain DRAM	pain frequency pain distribution low back pain DRAM	0.73	<0.0001	pain frequency low-back pain DRAM	0.35 0.58 0.69	−0.46 −0.53 0.37
NDI	gender pain intensity neck pain painkillers DRAM general health	pain intensity painkillers DRAM	0.73	<0.0001	DRAM painkillers pain intensity	0.50 0.64 0.73	0.33 −0.40 0.39
General health	age pain intensity pain distribution DRAM	age pain intensity DRAM	0.38	0.01	pain intensity	0.36	0.63

and together explained 52% of this variable ($p = 0.002$) (Tables 1 and 2).

The best predictor from forward stepwise regression analysis of the postoperative arm pain was smoking (Table 2).

Neck pain

The pre-surgery variables: low pain frequency, low pain distribution, low back pain and normal ratings on DRAM were shown to be significantly associated with

low neck pain at follow-up and together explained 73% of this variable ($p < 0.0001$) (Tables 1 and 2).

The best predictor from forward stepwise regression analysis of the postoperative neck pain was pain frequency (Table 2).

NDI

The pre-surgery variables: low pain intensity, no use of painkillers and normal rating on DRAM were shown to be significantly associated with low disability on NDI at follow-up and together explained 73% of this variable ($p < 0001$) (Tables 1 and 2).

The best predictor from forward stepwise regression analysis of the postoperative NDI was DRAM (Table 2).

General health

The pre-surgery variables: younger age, lower pain intensity and a normal ratings on DRAM were shown to be significantly associated with better general health at follow-up and together explained 38% of the variance of this variable ($p = 0.01$) (Tables 1 and 2).

The best predictor from forward stepwise regression analysis of the postoperative general health was pain intensity (Table 2).

Discussion

Increased knowledge of predictive factors for a good outcome for patients with cervical disc disease could be a valuable help in selecting patients for surgery and thereby finding a more homogenous group who would benefit more from surgery. Today this knowledge is insufficient. Earlier studies have not included a broad aspect of outcome such as ''cervical-disc-specific'' arm pain, ''non-specific'' neck pain, or general health.

The question at issue in this study was whether pre-surgery factors could explain a good outcome with regard to a broad assessment.

To be a non-smoker before surgery was the most important factor for a low postoperative arm pain, a low pain frequency was the most important factor for low postoperative neck pain, normal rating on DRAM was the most important factor for high function on NDI and a low initial pain intensity was the most important factor for a good postoperative health. For all outcome variables DRAM increasing the explanation level (R^2), and support the use of DRAM as a complement to the traditional inclusion criteria for surgery. The limitations of the study with few subjects does not allow for specific advice concerning clinical usage of DRAM in selection of patients for surgery. But from the study we can say that a rating as ''normal'' in DRAM is a strong predictor for a good outcome. The classification at risk must be combined with other factors. Persson *et al.* [24] found no long-term differences in outcome of surgery and physiotherapy and Fouyas *et al.* [10] found no evidence regarding effectiveness of surgery in patients with cervical radiculopathy. Because of that and due to the results of this study it is the authors opinion that patients with several negative predictors and especially highly pathological rating on DRAM should not, if not due to severe myelopathy, have surgery. In such a case we recommend further investigation and treatment of the psychosomatic distress, physiotherapy with neck-specific exercises as well as a multi-professional rehabilitation approach including behaviour therapy [14, 15, 19, 26, 35].

Moreover, in patients with non-specific neck pain, psychological distress, psychosomatic problem [18] as well as a poor general health [16, 29] have been shown to be important predictors for a bad outcome. However, White *et al.* [34] did not find that psychological factors on the Cornell Index influenced the results on Odom after ACDF. Those differences could be due to different use of instruments and outcome variables as well as the use of different statistical analysis. In the study by Peolsson *et al.* [22] DRAM was unfortunately not used as a potential predictive variable.

Being male [9, 22], to be a non-smoker and having a low initial pain level [22] has previously been shown to be predictors for a good outcome and were verified as such in this study.

Smoking has earlier been shown to be a risk factor for developing disc disease [1]. It is controversial if smoking also is a risk factor for developing pseudarthrosis after ACDF [2, 23]. The rate of pseudarthrosis in this study is unknown. However, Peolsson *et al.* [23] found that healing status only minimally explained the variability in pain intensity, and had no explanation of the variability of NDI and Odom at least one year after CP or CIFC. Possibly, smoking habits are associated to outcome by other factors than strict biological effects of tobacco.

In addition greater segmental kyphosis before surgery has been shown to be an important factors for the outcome after surgery [22]. The role of segmental kyphosis as a predictor of outcome after surgery was, unfortunately, not evaluated in this study.

It has previously been pointed out that more than one pain localisation indicates a worse prognosis for non-specific neck and low-back patients in primary care [29]. This was also reproduced for outcome on neck pain in the present study where low back pain was an important factor in the stepwise regression analysis, a further proof that this is a heterogeneous population with symptoms of specific nerve root pain as well as more generalised problems. Andersson [3] has shown in chronic pain patients (duration >3 months, where the most common site of pain, about 30% of the population, was neck-shoulder pain) that individuals with widespread pain had higher pain intensity and more somatic symptoms, were more depressed and had low quality of life scores.

Kjellman *et al.* [15] found it was notable that different factors appeared depending on what kind of outcome variable were chosen. That could be part of an explanation of differences among studies on predictors and shows that it is important to use a broad assessment in the evaluation of predictive factors.

The patients in this study represent a group with major problems, but do not differ in comparison with other studies [4, 11, 12, 27, 34] with respect to age, duration of symptoms, or the number of ''surgery'' levels. There were no main differences in either background factors or outcome measurements between patients with or without myelopathy, or with single or multiple level surgery, respectively. In the study by Vavruch *et al.* [21] there were no differences in clinical outcome between CIFC and CP, so there are no reasons to believe that the results from the present study would be exclusive for CIFC.

To investigate relationships among several independent variables (pre-surgery variables) against a dependent variable (outcome variable of interest at three years follow-up); in order to find the most important predictive factors for a good outcome, a standard linear multiple regression analysis was used followed by a forward stepwise analysis. Only those variables which had a significant correlation with the dependent variables in bivariate analysis were included in the multiple regression analysis. Spearman rank correlation coefficient analysis alone is not sufficient to find the most important predictors because it had no possibility to define inter-correlation between variables and should therefore be seen only as a first step in the analysis.

Even if the power of the statistical forward multiple regression analysis was low, the analysis was stable with the same results in the backward selection.

The adjusted R^2 of the multiple regression models in this study was 0.52–0.73 in pain and disability and reflected the fact that most preoperative factors of importance for the surgical outcome have been included in the models. The explanatory value was lower for general health but still 0.38. Even so, it might be of importance to include other factors such as work-related factors, leisure time, and social relations in future analyses. Radiological factors have been excluded from the analysis because they had already been shown to have very limited importance for the clinical outcome in patients who undergone ACDF [23].

In conclusion the multivariate analysis shows that non-smoking, a low pain level and normal rating on DRAM were the best preoperative predictors of a good outcome in ACDF. Inclusion criteria for surgery should be based on a bio-psychosocial model and DRAM seems to be useful for including the traditional inclusion criteria. Larger studies are needed to fully confirm the clinical use of DRAM in selection of patients for ACDF. The results of the present study confirm previous reports on smoking, gender and pain for outcome on pain and disability. The new results from this study are that DRAM is a predictor of outcome irrespective of pain, disability or health.

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Comment

The authors present a prospective study attempting to identify the predictive factors for patients undergoing anterior cervical decompression and fusion using a carbon fibre cage. They specifically wished to determine those factors which would predict a good outcome for arm pain, neck pain and general health.

They selected number of ''identification'' factors including gender, age and whether the patient was a smoker; a range of clinical symptoms such as frequency, intensity and radiation of arm pain and an psychosomatic/psychological profile assessment (DRAM).

Perhaps not too surprisingly they identified a relatively large number of apparently statistically significant correlations. For instance, the absence of low back pain and low pain frequency in the arm prior to surgery were good predictors for relief of neck pain following surgery. Table 1 identifies the correlation coefficients and statistical p-values for the baseline pre-operative data and outcome.

In these times of evidence based medicine outcome studies are becoming increasingly important. However, I have reservations about the clinical relevance of identifying these fairly predictable predictors of outcome.

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