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Neck-related headache in patients with cervical disc disease after surgery and physiotherapy: a 1-year follow-up of a prospective randomized study

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Abstract

Study design: A prospective randomized multi-center trial.

Objective: To investigate the effects of surgery with either structured postoperative physiotherapy or standard postoperative approach on neck-related headache in patients with cervical radiculopathy. Secondary, to investigate associations between change in neck-related headache and change in neck muscle endurance, neck mobility or neck pain.

Summary of Background Data: The effect of physiotherapy on individuals with neck-related headache after surgery for cervical radiculopathy due to MRI-verified disc disease is unknown.

Methods: One-hundred and six patients with neck-related headache and participating in a randomized controlled trial evaluating the additional effects of physiotherapy after surgery for cervical radiculopathy were included. Patients were randomized preoperatively to structured postoperative physiotherapy (n = 51) or the standard postoperative approach (n = 55). Outcome measures were; headache intensity and neck pain intensity, neck muscle endurance, and neck mobility. Measures were obtained pre-operatively and at 6 weeks, 3 months, 6 months, and 1 year postoperatively.

Results: Headache intensity significantly changed from baseline to 1 year postoperatively ($p < 0.001$) in both groups. Post-hoc tests showed a significant difference between baseline and 6 weeks ($p \leq 0.05$). No significant differences were found between groups ($p > 0.05$) or between-group differences in changes over time ($p > 0.05$). The change in current headache intensity over time was associated with a change in current neck pain intensity over time ($p = 0.003$, $\beta = 0.40$).

Conclusion: There was a significant improvement in headache intensity 1 year postoperatively in patients with cervical radiculopathy and neck-related headache, but there

were no differences between groups over time. Change in current headache intensity was only associated with a change in current neck pain intensity.

Keywords: cervical radiculopathy, disc disease, anterior cervical decompression and fusion, foraminotomy, laminectomy, physiotherapy, headache, neck muscular endurance, neck mobility, neck pain,

Level of evidence: 2

Key points:

- Surgery combined with structured postoperative physiotherapy or the standard postoperative approach reduced headache intensity in patients with cervical radiculopathy and neck-related headache, and surgery accounts for the major part of the improvement.
- The change in pre-operative current headache intensity to the 1-year follow-up was associated with a change in current neck pain intensity.
- Some individuals had remaining headache after surgery, with no added effect of this type of physiotherapy intervention. This indicates a need for continuing research on physiotherapy interventions in patients with remaining neck-related headache after surgery due to cervical radiculopathy.

Introduction

Approximately 50-67% of individuals with cervical radiculopathy (CR) have headache,^{1, 2} commonly classified as cervicogenic headache or cervical headache.² Cervicogenic headache is associated with impaired quality of life and impaired physical function.³

Cervicogenic headache is thought to be caused by changes in one or more structures in the neck, such as the nerve roots, joints, discs, bone, muscles, and ligaments.⁴ Referred pain from shoulder muscles can also cause headache. Individuals with CR and headache report increased pain intensity and more tenderness in the affected area than individuals with CR without headache.² Some studies have found that individuals with cervicogenic headache have reduced neck mobility in the transverse and sagittal planes compared to healthy individuals.⁵ Headache can also be an important factor in the assessment of individuals with CR to explain pain and disability.⁶

Physiotherapy has been reported to be effective for neck-related headache.^{7, 8} Non-surgical interventions for neck-related headache include physical exercise, trigger point treatment, manual therapies, analgesics, and cognitive behavioral therapy.^{2, 4, 7, 8} Surgery aims to reduce the pressure on the engaged nerve root^{9, 10} and previous studies have demonstrated a reduction in headache after surgical interventions for CR.^{2, 11, 12}

Previous studies comparing the effect of structured postoperative physiotherapy (SPP) and the standard postoperative approach (SPA) on pain, impairments, global outcome, and psychosocial factors have been published. These results showed no significant group differences at 6 months of follow-up,¹³⁻¹⁴ but greater expectation fulfillment was noted in the SPP group.¹³ When those who had adherence < 50% were excluded, there was a significant

improvement in neck pain frequency, greater enablement,¹³ and decreased catastrophizing in the SPP group.¹⁴

Both physiotherapy^{7, 8} and surgery^{2, 11, 12} have been shown to be effective in treating neck-related headache. However, no previous study has investigated the effect of SPP on individuals with CR and headache. Our hypothesis was that surgery combined with SPP or SPA reduces neck-related headache in patients with CR due to degenerative disc disease, but with a superior effect in SPP. To the best of our knowledge, no previous studies have evaluated the effect of such interventions on this population. Thus, the aim of present study was to investigate the effects of surgery with either structured postoperative physiotherapy or standard postoperative approach on neck-related headache in patients with cervical radiculopathy. A second aim was to investigate associations between change in neck-related headache and change in neck muscle endurance, neck mobility or neck pain.

Patients and Methods

Design

This study consists of secondary analyses of a prospective randomized multi-center trial including individuals operated for CR between February 2009 and November 2012 at four spinal centers in Sweden (Fig. 1). The study was conducted in accordance with the Declaration of Helsinki, and approved by the regional ethical review board in Linköping (Dnr M126-08). The study protocol was registered at clinicaltrials.gov (NCT01547611). Study protocol and primary results were published previously.¹³⁻¹⁵

Participants

Individuals who pre-operatively reported neck-related headache were included in present subgroup-analyses. Inclusion criteria for the study are presented in Table 1. Patients gave

informed consent and were randomized pre-operatively to treatment with either SPP or SPA (Fig. 1). Randomization was carried out by a project manager who did not perform any tests or interventions. A randomized data list created by a statistician was used with an allocation ratio of 1:1.^{14, 15}

Interventions

Surgery and postoperative care

Surgery was performed with anterior cervical decompression and fusion (ACDF) or posterior cervical foraminotomy (PCF) with or without laminectomy as decided by the surgeon. With ACDF, the disk and osteophytes were removed and replaced with a cage filled with bone substitute or autologous bone collected during the decompression to fuse the segments. ACDF was performed at one level, two levels, and three levels. At two and three levels, a plate was usually applied in front of the operating segment to achieve more stability. In the PCF, the surgeon removes osteophytes that obstruct the nerve passing through the neuroforamen. PCF with or without laminectomy was performed on one level, two levels, and three levels.

After surgery, both groups received the same intervention, movements and exercises for the shoulders to perform twice a day. All participants also received information, including to avoid heavy lifting and maximum movements in the neck, based on the operating clinic's local guidelines. Approximately 6 weeks after surgery, the participants received a routine post-surgery examination by the surgeon and physiotherapist. After the follow-up, all individuals started their specific physiotherapy program according to group allocation. No additional follow-ups were performed at the surgical clinics after 6 weeks.¹³⁻¹⁵

Structured postoperative physiotherapy

Approximately 6 weeks after surgery, the participants in the SPP group met with a physiotherapist in primary care in their neighborhood who had received structured training and information about the program by the project leader. The program was based on previous research on treatments for neck disorders and long-standing musculoskeletal pain¹⁶⁻¹⁹ and was conducted for up to 20 weeks.¹⁵ The program consisted of graded neck-specific exercises combined with a cognitive behavioral approach with the goal of improving function and the performance of basic activities, increasing self-efficacy, and learning strategies for coping with pain and disability. During the first 6 weeks of SPP, patients met with the physiotherapist once a week, and thereafter twice a week until 20 weeks. The participants performed home exercises, which they documented in a training diary. The diary was then the basis for feedback at the visits to the physiotherapist. The neck-specific exercises started with nonresistance exercise aimed to activate the deep ventral and dorsal muscles in the neck for improved interaction between muscle layers. This was followed by isometric exercise and resistance exercises, with progression adapted individually. The behavioral approach consisted of structured patient education with the following order and content: goal settings, pain physiology, coping strategies, stress, ergonomics, and maintenance.¹³⁻¹⁵

Standard postoperative approach

Participants in the SPA group followed the usual postoperative care specific for each clinic and not specially designed for the study. If needed, patients in the SPA group were allowed to contact a physiotherapist to receive treatment specific to their own needs and not specific to the study. Patients contacted the physiotherapist without referral, which is in line with standard procedure in Sweden.¹³⁻¹⁵ The number of patients who needed additional postoperative physiotherapy was recorded.

Data collection

A researcher not involved in treatment collected the questionnaires, which included questions regarding sociodemographic variables and patient-reported outcomes. All clinical tests of physical function were performed by physiotherapists who were well-trained in the test procedures and blinded for randomization. Information about the surgeries was collected from medical journals. The background and baseline variables were gender, age, operated levels, headache frequency, headache intensity, current neck pain intensity, neck muscle endurance (NME), and active cervical range of motion (aCROM) (Table 2).

Outcome measures

Primary outcome

Patients rated their headache intensity on questionnaires given pre-operatively and 6 weeks, 3 months, 6 months, and 1 year postoperatively. A visual analog scale (VAS; 0-100 mm) with the endpoints 0 (no pain) and 100 (worst possible pain) was used to rate headache current, as best, and as worst last week. The VAS is a valid scale with good test-retest reliability in acute pain (ICC 0.97-0.99)²⁰ and good test-retest reliability (ICC 0.86-0.88) in chronic pain.²¹

Secondary outcomes

Current neck pain intensity was rated using the VAS. NME of the ventral and dorsal neck muscle was tested pre-operatively and at 6 months and 1 year postoperatively. The test for ventral muscles was performed lying on the table in the supine position and the dorsal muscles lying in the prone position with a weight (2 kg for women and 4 kg for men) hanging from the participants head just above the ears. NME was measured in seconds. The test started with patient lifting their head off the table and ended for one of three reasons: the patient released their head back to the table, was unable to sustain a good head position, or

experienced increasing radiating pain.²² The test of dorsal NME showed good inter-rater reliability for healthy individuals (ICC 0.80) and individuals with neck disorders (ICC 0.94). Intra-rater reliability was good (ICC 0.90) for both groups.²³ The ventral NME test has acceptable reliability (ICC intra-rater 0.76-0.96, ICC inter-rater 0.57-1.0).²⁴

aCROM was measured with a cervical range of motion instrument, CROM (Performance Attainment Associates, Lindstrom, MN). Patients were seated in an upright position with the head in a neutral position. Range of motion was measured in the sagittal, lateral, and frontal planes, and was recorded in degrees.²⁵ Measures were taken pre-operatively and at 3 months, 6 months, and 1 year postoperatively. This instrument has demonstrated good reliability (ICC intra-rater > 0.85, ICC inter-rater > 0.70) and positive construct validity ($r > 0.65$).²⁶

Statistical analysis

Primary outcome in the main study was neck disability index (NDI). The sample size was calculated as 60 individuals in each group^{13, 15} based on a 10% between-group difference in NDI score with an alpha of 5% and power of 80%.¹³

Descriptive data are presented as numbers and proportions for categorical variables, or means and standard deviations (SD) for numerical variables. Intervention groups were compared by the t-test or chi-squared test depending on the data level. The differences between groups, the change over time, and between-group differences in change over time for the primary outcome (i.e., headache intensity) were analyzed using repeated-measure analysis of variance (ANOVA). The Greenhouse-Geisser correction was used depending on sphericity, and only complete cases were analyzed. Normal distribution was controlled with histograms and simple dot plots. Results are presented with mean, SD, p-value, F(degrees of freedom, error), and Cohen's d (*d*).

Simple linear univariate regression analyses were used to assess associations between the independent variables (change in values of NME, aCROM, and neck pain from baseline to 1 year) and the change in current headache intensity. Results are presented as R^2 , B-coefficient (B), confidence interval (CI), standard error (SE), standardized beta coefficient (β), and p-value. Independent variables that correlated ($p \leq 0.1$) with the dependent variable were used in a standard linear multiple regression analysis. Results are presented as adjusted R^2 , B, CI, SE, β , and p-value. The significance level was $p \leq 0.05$. IBM SPSS Statistic 25 was used for all analyses.

Results

A total of 202 individuals were included in the main study but in one case, surgery was cancelled, and the patient was excluded. Of these, 106 individuals (52%) (ACDF $n = 89$, 84%, PCF $n = 17$, 16%) had preoperative neck-related headache and were included in these analyses. Fifty-one individuals received surgery with SPP and 55 with SPA (Fig 1). For patient characteristics, see table 2.

We found no significant between-group differences in background and baseline variables at baseline (Table 2). In the SPP group, 33% of patients ($n = 17$, mean age 47 years, SD 9.2 years; 10 men and 7 women) had compliance $< 50\%$ (Fig. 1). We found no significant differences between those with compliance $< 50\%$ and those with compliance $> 50\%$ ($p = 0.06-0.97$) with respect to background and baseline variables. No adverse events were reported. In the SPA group, 51% ($n = 28$) of patients received additional physiotherapy, not specific to the study, 5 at hospital and 23 at primary care.

We found no significant differences between groups or significant between-group differences in change over time regarding any of the three headache intensity outcomes ($p = 0.13 - 0.98$;

Table 3). Both groups significantly improved in headache intensity from baseline to 1 year postoperatively (current: $F(3.2, 219) = 17.1, p < 0.001$; worst last week: $F(4, 272) = 22.0, p < 0.001$; and best last week: $F(2.9, 193) = 9.3, p < 0.001$). Effect size was intermediate (best last week: $d = 0.73$) to large (current: $d = 1.0$; worst last week: $d = 1.12$).²⁷ Post-hoc tests using the Bonferroni correction showed that the significant differences over time were between baseline and 6 weeks postoperatively ($p \leq 0.05$). No additional significant improvements were seen after 6 weeks ($p > 0.05$).

Changes in current headache intensity from baseline to 1 year after surgery were significantly associated with a change in current neck pain intensity ($p < 0.001, R^2 = 0.23, B = 0.39, CI = 0.22 - 0.55, SE = 0.48, \beta = 0.48$; Table 4). In addition, NME ventral reached the criteria ($p \leq 0.1$) for inclusion in standard linear multiple regression analysis. The model explained 19% (adjusted $R^2 = 0.19, p = 0.002$) of the change in current headache intensity. Current neck pain was the only significant independent variable in the multiple regression model ($p = 0.003, B = 0.32, CI = 0.12 - 0.53, SE = 0.10, \beta = 0.40$).

Discussion

In the present study, 52% of those with CR had neck-related headache, confirming the results from previous studies.^{1, 2} More than half of individuals with neck-related headache had headache “every day” to “always”, which is similar to the results of a previous study.²

These RCT sub-group analyses primarily investigated the effect of surgery combined with SPP or SPA on headache intensity in patients with CR and neck-related headache. The results showed significant reduction in headache intensity at the 1-year follow-up compared to pre-operatively, but no between-group differences. A significant difference over time was seen between baseline and 6 weeks ($p \leq 0.05$), which indicates that surgery accounts for a major

part of the improvement. However, 6 weeks after surgery, some current headache remained (mean; VAS 15 mm, SD 21 mm), indicating a need for additional postoperative rehabilitation for some patients. Previous studies showed that physiotherapy is effective for neck-related headache.^{7, 8} The effects of physiotherapy on remaining headache might have been larger if the SPP protocol was more tailored to the patient's individual needs, or if patients with remaining headache had higher adherence to the program.

We also investigated whether the change in current headache intensity over time could be explained by changes in NME, aCROM, or current neck pain. Change in current neck pain was the only factor that significantly influenced the change in current headache ($p = 0.003$, $\beta = 0.40$), and the multiple regression model explained 19 % of the change in current headache intensity. One previous study reported a significant correlation between reduced headache intensity and reduced neck pain after nerve root blocks.²⁸

Patients were selected from four spinal centers in Sweden, and many practitioners with different professional experience performed the surgeries and provided the rehabilitation. We believe that this is strength in this study because it is representative of clinical practice, thus increasing generalizability of the results. There are no national guidelines in Sweden for the postoperative regimen after neck surgery, but local guidelines differ minimally. SPP was designed primarily to improve neck-related function in individuals with CR after surgery,¹⁵ and not specifically to improve neck-related headache. The intervention could be considered relevant based on previous studies in which physiotherapy including low-intensity neck muscle training and exercises of postural control was effective for neck-related headaches.⁷

Improvements in headache have been demonstrated for both anterior^{11, 12} and posterior surgery.¹² However, the effect of postoperative rehabilitation has not been investigated previously. Present results do not support replacing SPA with SPP in order to improve neck-

related headache after surgery. As the two interventions had similar results and no adverse events have been reported, both interventions can be considered ethical to use. Furthermore, SPP consisting of graded neck-specific exercises was harmless, which provides support for continuing research on the most effective intervention to reduce remaining headache postoperatively. The result is transferable to the selected population. However, early postoperative care can differ between regions and countries.

Patients were recruited pre-operatively, which means that even individuals who had a large effect of surgery on headache were included in the study. To better study the effect of SPP and SPA on neck-related headache, future research should include participants with residual postoperative symptoms to better evaluate the effect of rehabilitation.

Conclusion

There was a significant improvement in headache intensity 1 year postoperatively in patients with cervical radiculopathy and neck-related headache, but there were no differences between groups over time. Change in current headache intensity was only associated with a change in current neck pain intensity.

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Table 1: Inclusion and exclusion criteria for present study

Inclusion criteria	Exclusion criteria
Age 18 – 70 years	Previous surgery
Scheduled for ACDF or PCF due to CR	Fracture
Symptoms of CR for at least 2 months	Subluxation
Non-responsive to non-surgical treatment	Malignancy and/or tumor in cervical spine
Clinical findings compatible with MR-verified cervical disc disease	Spinal infection
Preoperative neck-related headache	Systemic disease with contraindication to rehabilitation
	Myelopathy
	Fibromyalgia
	Generalized myofascial pain
	Diagnosed mental disorder
	Addicted to drugs or alcohol
	Lack of knowledge of Swedish language

ACDF = anterior cervical decompression and fusion, PCF = posterior cervical foraminotomy, CR = cervical radiculopathy, MRI = magnetic resonance imaging

Table 2: Background and baseline variables of study participants

	Total		SPP		SPA		p-value
	Number of patients	Value	Number of patients	Value	Number of patients	Value	
Participants		106		51 (48%)		55 (52%)	0.70
Male	106	48 (45%)	51	22 (43%)	55	26 (47%)	0.66
Age, years	106	48 (8)	51	49 (8)	55	49 (8)	0.84
Operated levels							0.90
One		57 (54%)		29 (57%)		28 (51%)	
Two		41 (39%)		17 (33%)		24 (44%)	
Three		8 (8%)		5 (10%)		3 (5%)	
Headache frequency	103	3 (1.1)	50	3 (1.1)	53	3 (1.1)	1.00
Never		1 (1%)		1 (2%)		0 (0%)	
Occasionally		42 (40%)		20 (40%)		22 (42%)	
Every day		32 (31%)		15 (30%)		17 (32%)	
Frequently daily		12 (11%)		6 (12%)		6 (11%)	
Always		16 (15%)		8 (16%)		8 (15%)	
Headache Intensity Current VAS	106	37 (31)	51	40 (32)	55	35 (30)	0.42
Headache Intensity Worst VAS	106	62 (29)	51	62 (32)	55	62 (28)	0.98
Headache Intensity Best VAS	105	19 (25)	51	21 (25)	54	17 (24)	0.46
Neck Pain Intensity Current VAS	106	64 (21)	51	65 (22)	55	62 (20)	0.46
NME Ventral	101	35 (37)	49	32 (41)	52	37 (33)	0.12
NME Dorsal	100	54 (74)	49	50 (81)	51	59 (68)	0.15
aCROM flexion	104	38 (15)	50	35 (15)	54	40 (15)	0.28
aCROM extension	104	40 (17)	50	37 (15)	54	42 (18)	0.25
aCROM lateral flection right	103	26 (8)	49	25 (8)	54	27 (8)	0.20
aCROM lateral flection left	103	26 (9)	49	25 (9)	54	27 (9)	0.84
aCROM rotation right	104	50 (14)	50	48 (14)	54	51 (14)	0.48
aCROM rotation left	104	47 (14)	50	46 (14)	54	47 (14)	0.53

Data are given as n (%) or mean (SD).

SPP = structured postoperative physiotherapy, SPA = standard postoperative approach, SD = standard deviation, VAS = visual analog scale (0-100 mm),

NME = neck muscle endurance, aCROM = active cervical range of motion. Differences between groups were analyzed by the t-test or chi-squared depending on data level. Significance level ≤ 0.05 .

Table 3: Change in headache intensity from baseline to 1 year

	Baseline			6 weeks			3 months			6 months			1 year			Between-group differences	Changes over time	Between-group differences in changes over time
	SPP	SPA	Total	SPP	SPA	Total	SPP	SPA	Total	SPP	SPA	Total	SPP	SPA	Total			
Headache Intensity Current (VAS)																F(1, 68) = 0.001 p = 0.98	F(3.2, 219) = 17.1 p < 0.001 d = 1.00	F(3.2, 219) = 1.28 p = 0.28
Number of patients	33	37	70	33	37	70	33	37	70	33	37	70	33	37	70			
Mean (SD)	36 (32)	29 (27)	32 (30)	15 (22)	15 (21)	15 (21)	13 (23)	18 (26)	16 (25)	11 (21)	14 (24)	12 (22)	13 (23)	14 (21)	13 (21)			
Headache Intensity Worst (VAS)																F(1, 68) = 0.02 p = 0.88	F(4, 272) = 22.0 p < 0.001 d = 1.12	F(3.2, 219) = 1.28 p = 0.28
Number of patients	33	37	70	33	37	70	33	37	70	33	37	70	33	37	70			
Mean (SD)	60 (32)	58 (31)	59 (31)	31 (29)	30 (29)	30 (29)	27 (33)	29 (31)	28 (32)	27 (36)	28 (29)	27 (33)	28 (33)	31 (29)	29 (30)			
Headache Intensity Best (VAS)																F(1, 67) = 0.52 p = 0.47	F(2.9, 193) = 9.3 p < 0.001 d = 0.73	F(2.9, 193) = 1.9 p = 0.13
Number of patients	33	36	69	33	36	69	33	36	69	33	36	69	33	36	69			
Mean (SD)	22 (28)	13(18)	17 (23)	7 (14)	8 (15)	8 (14)	8 (13)	8 (18)	8 (16)	8 (18)	5 (12)	6 (15)	7 (12)	6 (14)	7 (13)			

SPP = structured postoperative physiotherapy, SPA = standard postoperative approach, VAS = visual analog scale (0-100 mm), SD = standard deviation. Differences were analyzed by repeated-measure analysis of variance (ANOVA). Results are presented as F (degrees of freedom, error), p-value, and *d* = cohen's d. Significance level ≤ 0.05.

Table 4: Associations between changes in neck function and pain and a change in current headache intensity over time from pre-operatively to 1 year postoperative

Simple linear regression							Multiple linear regression						
Independent	R ²	B	95% CI	SE	β	p-value	Adj.R ²	p-value model	B	95% CI	SE	β	p-value
Neck pain intensity current	0.23	0.39	0.22 – 0.55	0.48	0.48	< 0.001*	0.19	0.002	0.32	0.12 – 0.53	0.10	0.40	0.003
NME ventral	0.07	- 0.16	- 0.33 – 0.01	0.08	- 0.26	0.06*			- 0.11	- 0.27 – 0.06	0.08	- 0.16	0.19
NME dorsal	0.001	- 0.01	- 0.06 – 0.05	0.03	- 0.03	0.83							
aCROM flexion	0.01	- 0.14	- 0.54 – 0.25	0.20	- 0.09	0.47							
aCROM extension	0.01	- 0.16	- 0.55 – 0.24	0.20	- 0.10	0.43							
aCROM lateral flection right	0.00	0.57	- 0.07 – 1.20	0.32	0.00	0.99							
aCROM lateral flection left	0.02	0.35	- 0.35 – 1.04	0.35	0.13	0.32							
aCROM rotation right	0.01	- 0.20	- 0.61 – 0.22	0.21	- 0.12	0.34							
aCROM rotation left	0.002	0.08	- 0.41 – 0.57	0.25	0.04	0.75							

NME = neck muscle endurance, aCROM = active cervical range of motion, B = B-coefficients, CI = confidence interval, SE = standard error, β = standardized beta coefficient. Significance level ≤ 0.05 . *p < 0.01 and included in multiple analysis.

Figure 1: Flow-chart of patient inclusion