

Clinical Study

Young adults undergoing ACDF surgery exhibit decreased health-related quality of life in the long term in comparison to the general population

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ABSTRACT

BACKGROUND CONTEXT: The leading surgical treatment of cervical radiculopathy is anterior cervical discectomy and fusion (ACDF). However, it has been suggested that ACDF procedures could lead to accelerated degeneration of the adjacent cervical discs (adjacent segment disease, or ASD) and the effect of ACDF surgery on neck symptoms and quality of life in the long term is not fully understood. Patients operated on at young ages generally have a long life expectancy and a long number of working years ahead of them. Thus, this patient group is of special interest when considering the accumulation of cervical problems due to possible ASD, the overall progressive nature of cervical degeneration in the long term, and their effects on related quality of life.

PURPOSE: Our goal was to study the health-related quality of life in the long-term follow-up after ACDF surgery in the young adult population between the ages of 18 and 40.

STUDY DESIGN: A retrospective cohort study with propensity matched controls.

PATIENT SAMPLE: All patients between 18 and 40 years of age at the time of the surgery who underwent ACDF due to degenerative cervical disease at Helsinki University Hospital between the years 1990 and 2005 who had filled in the quality of life questionnaires 12 to 28 years after the surgery (281 patients), and a propensity matched control cohort of the general population selected based on age, sex, and smoking status.

OUTCOME MEASURES: Quality of life measured by the EuroQol questionnaire (EQ-5D-3L and EQ-VAS).

METHODS: The medical records of all patients who underwent ACDF due to degenerative cervical disease at the age of 18 to 40 years at Helsinki University Hospital between 1990 and 2005 were analyzed retrospectively. The EuroQol questionnaire was sent to all patients whose contact information could be obtained (443 patients) at the end of the follow-up (median 17.5 years) to assess their current quality of life. A total of 281 patients returned the questionnaires and were included in this study. Quality of life was compared to that in the general Finnish population using a similar sized control cohort selected through propensity matching.

RESULTS: The patients who had undergone ACDF surgery reported significantly more problems than the general population cohort in three out of five dimensions that were assessed in the EQ-5D questionnaire, including mobility, usual activities, and pain/discomfort. Similarly, the overall EQ-5D-3L index calculated from the dimensional values was lower (0.74 vs. 0.83, $p=.000$), depicting a generally decreased health-related quality of life among patients. Spondylosis as a primary diagnosis, clinical myelopathy, and further cervical surgeries were associated with lower quality of life in the subgroup analyses of the patients. Similarly, in the EQ-VAS assessment, patient subgroups with spondylosis as a primary diagnosis, at least one reoperation,

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operation on more than one level, and clinical myelopathy were associated with lower scores and lower quality of life. The mean EQ-VAS score among patients was 73%. Regardless of the decreased health-related quality of life, there was no statistically significant difference in the concurrent employment status between the patient and control groups.

CONCLUSIONS: The health-related life quality measured by the EQ-5D-3L was lower in the patient population than in the general population. Patients had more problems with mobility and usual activities and more pain/discomfort. However, satisfaction with the surgery was very high, and there was no significant difference in employment status between the patients and the control population. Patients with spondylosis as a primary diagnosis had lower quality of life compared to patients with disc herniation. Also, clinical myelopathy and further cervical surgeries during follow-up were associated with lower quality of life in the subgroup analyses of the patients. It must also be kept in mind that we do not know what the situation could have been without surgery and with conservative treatment only. © 2021 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Keywords:

Anterior decompression; Cervical disc herniation; Cervical spondylosis; Long-term outcome; Quality of life

Introduction

Cervical radiculopathy can be caused by either intervertebral disc herniation or spondylotic nerve root compression. Among younger patients, disc herniation is the most common cause [1]. The leading surgical treatment of cervical radiculopathy is anterior cervical discectomy and fusion (ACDF). The short-term results of ACDF surgery are robust [2,3], but the results and effects of cervical surgery on neck symptoms and life quality in the long term are not fully understood. While degenerative spine disorders are overall progressive in nature, it has also been widely proposed that the ACDF procedure may even accelerate the degeneration of adjacent cervical discs, leading to so-called adjacent segment disease (ASD). The total incidence of ASD has been evaluated to be 2.9%/year [4], the incidence of ASD requiring surgery at 0.8–2.4%/year [1,5,6], and the lifetime risk of postoperative ASD up to 25.5% [4]. Most previous studies have been conducted in unrestricted age groups. In our previous study [1] concentrating on patients operated on under the age of 40, the estimate for the annual incidence of ASD requiring surgery was 1.1% in a median 17.5 years of follow-up time. Patients operated on at a young age have a long life expectancy and a long number of working years ahead of them. Thus, this patient group is of special interest when considering the effects of degenerative cervical spine disorders in the long term. During their expectedly long lifetime, degenerative cervical disorders can become a significant burden on both the individuals' quality of life and their occupational careers.

We previously investigated the long-term results and need for further cervical surgeries in patients operated on for intervertebral disc herniation or spondylotic nerve root compression with ACDF under the age of 40 [1]. The total reoperation rate for further cervical surgeries (with acute revision surgeries excluded) during the entire follow-up period (12–28 years, median 17 years) was 19.5%, and the 10-year reoperation rate was 12.8%. The total reoperation

rate due to ASD was 16.8%, and the 10-year reoperation rate was 10.3%. Satisfaction with the surgery was high and the employment rate among patients resembled the general employment rate in Finland [7]. However, a significant number of patients seemed to experience mild but persistent neck symptoms.

In the present study, we investigated the health-related quality of life in the same patient population that was studied in the previous article [1], which was measured by the EuroQol-5D-3L questionnaire and the EuroQol-VAS. We also compared the quality of life of the patients with that in the general Finnish population using a propensity matched control sample from a large-scale national Finnish health survey (Terveys 2011, [8]). Only a few studies have evaluated patient quality of life after anterior cervical surgery in a long-term follow-up using standardized measures such as the EQ-5D [9–12]. As far as we know, the only study that compares the QoL of ACDF patients with the general population and has a follow-up of several years, has been conducted by Kienapfel et al [13]. However, their follow-up time was 7 years, making our study the first with a follow-up of more than 10 years.

Methods

The study protocol and questionnaires were approved by the Helsinki University Hospital (HUU) ethics committee (HUS/2703/2017).

Patient population

We retrospectively collected the medical records of patients between 18 and 40 years of age at the time of surgery who underwent ACDF at the Department of Neurosurgery at Helsinki University Hospital (HUU) from 1990 to 2005. Only patients with degenerative cervical disease (ie, herniated intervertebral disc and/or spondylotic nerve root compression) were included in the study. Patients who were

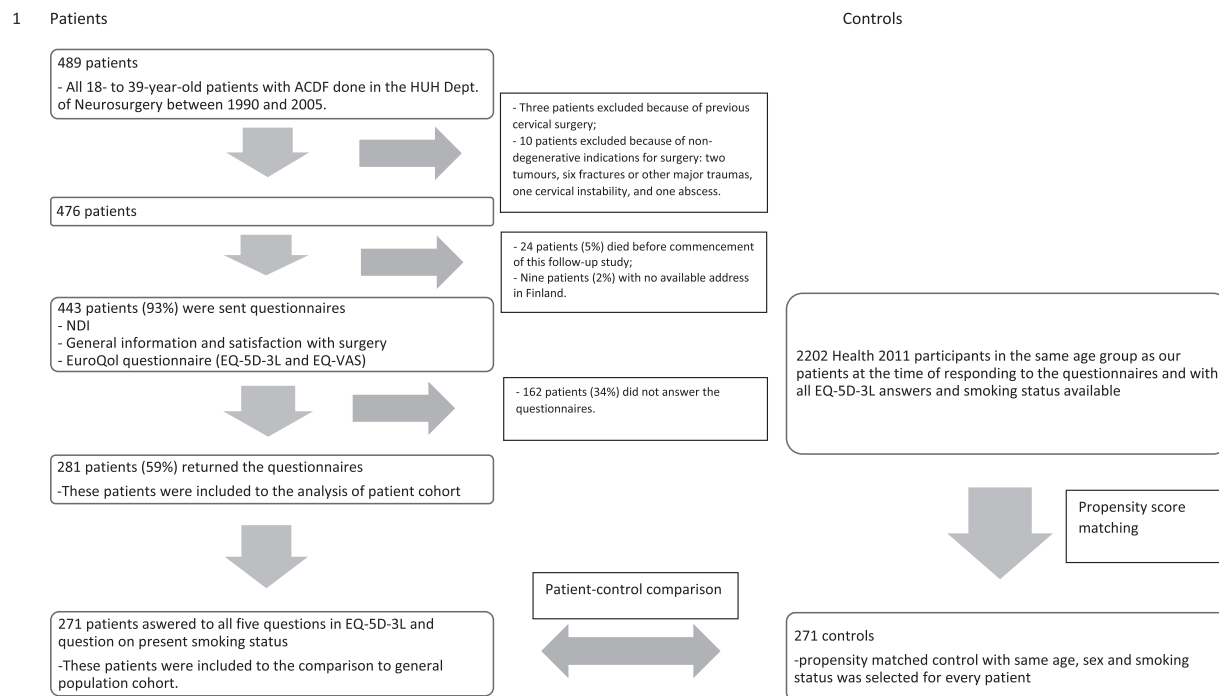


Fig. 1. Patient and control inclusion and numbers represented as a flow chart.

operated on because of other causes (ie, epidural abscess, tumor, cervical fracture, or other major trauma) were excluded. Also, patients who had already had cervical surgeries before this index surgery were excluded (ie, three patients with cervical laminectomy done previously). A total of 476 patients fulfilled these criteria (Fig. 1). Surgeries were performed with interbody fusion with either an artificial cage, bone autograft, or discectomy only [1]. The data collection from the medical records was conducted between December 2017 and February 2018.

In the health care system in Finland, each patient has a unique identification number, which makes it possible to easily follow patients in medical records and contact them even after long time intervals. Thus, a loss of follow-up data is minimal. In 2018, patients received a packet in the mail containing a general information questionnaire, a consent form, and the EuroQol quality of life questionnaire [14,15]. The packet was sent to all living patients who had an available address in Finland (443 patients). Of those patients who were sent the packet, 281 patients returned the questionnaires and were included in this study (Fig. 1). The median follow-up period was 17.7 years (min: 11.7 years, max: 27.8 years) and the median age of the patients at the end of the follow-up was 54 years (min: 36 years, max: 68 years). Information about further cervical surgeries during the follow-up period was collected from medical records [1], and patients were also asked to list possible further cervical surgeries in the questionnaire. In Finland, surgery for degenerative cervical diseases is centralized to the neurosurgical units of five university hospitals, and every unit is responsible for surgeries in its

catchment area (circa 1.6 million inhabitants in the case of HUH at the time of the study period). Thus, patients requiring a further cervical surgery or an assessment of it are generally referred back to the index department. Baseline information about the patient population is presented in Table 1.

Control group

The Finnish Institute for Health and Welfare conducted the “Health 2011” survey, a large-scale health examination survey, in 2011 [16]. This project involved the collection of a vast set of data on the health, functional capacity, and welfare of Finns [8]. A total of 10,000 Finns over 18 years of age selected by random sampling from the population register were recruited. This survey included, among other measures, the EQ-5D-3L questionnaire in either Finnish or Swedish (depending on the patient’s language preference). In the Health 2011 data set, 2,202 participants were in the same age group as our patients at the time of responding to the questionnaires (36–68 years), and all EQ-5D-3L answers and smoking status were available. In our patient cohort, 271 of the 281 patients had replied to all five questions on the EQ-5D-3L and had indicated their present smoking status. Only these patients were included in the comparison (Fig. 1). The control group of the same size (271) was selected using propensity matched scoring [17] with the SPSS propensity score matching algorithm by using age, sex, and present smoking status (smoking/no smoking) as matching variables. Thus, a propensity matched control with the same age, sex, and smoking status was selected for each patient (Table 2).

Table 1
Baseline information about the patient cohort (n=281) and surgeries

		n	%
Total		281	100%
Gender	Male	158	56%
	Female	123	44%
Age in years at the time of the operation,	Years, median (min-max)	37 (23–40)	
	Under 30	27	10%
	Over 30	254	90%
Primary diagnosis*	Herniated disc	203	72%
	Spondylotic nerve root compression	77	27%
	Not recorded	1	0.4%
Symptoms before the operation	Radicular pain	259	92%
	Neck pain	155	55%
	Sensory symptoms	224	80%
	Motor symptoms	149	53%
Duration of symptoms before surgery [†]	≤2 weeks	18	6%
	2 weeks–2 months	51	18%
	2–6 months	90	32%
	6–12 months	47	17%
	>12 months	65	23%
Surgery in acute setting	Unclear	10	4%
	Spinal cord compression	23	8%
Radiological central stenosis [‡]	Radiological central stenosis [‡]	32	11%
	Clinical myelopathy [§]	33	12%
Number of levels operated	1	237	84%
	2	44	16%
Operated level	C3–C4	5	2%
	C4–C5	26	9%
	C5–C6	131	47%
	C6–C7	156	56%
	C7–T1	8	3%
Implant type	Synthetic interbody cage	200	71%
	Bone autograft	45	16%
	No implant, discectomy only	36	13%
Further cervical surgeries	No	224	80%
	Yes (one or more)	57	20%
NDI at the end of the follow-up, median (min-max)		12% (0%–84%)	
Satisfaction to the surgery now at the end of follow-up (5=very satisfied, 1=very unsatisfied)	Satisfied (grades 4–5)	258	92%
	Unsatisfied or can't say (grades 1–3)	22	8%

* The primary cause of symptoms leading to surgical treatment; it is possible that some patients had both disc herniation and various degrees of spondylotic nerve root compression.

[†] For example, the duration of two months is classified to the group “2 weeks–2 months.”

[‡] Radiological central spinal canal stenosis with or without myelomalacia assessed and reported by a radiologist as a part of routine radiological evaluation independently of this study.

[§] Clinical signs or symptoms of myelopathy observed in preoperative clinical examination.

^{||} Higher scores associated with more severe symptoms; cut-off value to clinically significant NDI 15%.

There were five subjects with previous cervical surgery done in the control group. Our purpose was to compare patients to a general population cohort in which the prevalence of degenerative cervical diseases (and also cervical diseases requiring surgical treatment) corresponds to that in general Finnish population, and for that reason previous cervical surgery was not an exclusion criteria for the control group.

EuroQol questionnaire

The EuroQol questionnaire consists of two parts: the 5D-3L questionnaire (Table 3) and the EQ-VAS scale [18]. On the 5D-3L questionnaire (Table 3), quality of life is estimated on five dimensions, each with a score of 1 to 3 (higher scores are associated with a lower quality of life). On the EQ-VAS scale, respondents are asked to estimate their overall health state through a visual analog scale (with 0% being the worst and 100% being the best health the patient can imagine). The official translated version of the questionnaire [14] was provided to the patients in Finnish or Swedish depending on the native language of the patient. Only the 5D-3L answers were available for the control group, as the Health 2011 survey did not include an EQ-VAS scale assessment.

An index value describing the overall quality of life (EQ-index) can be calculated from the EQ-5D-3L answers [18]. The dimensional scores are weighted with population-specific values [18–20]. The range of possible index values is 0 to 1, where 0 indicates the worst and 1 the best possible state of quality of life. The Finnish value set was used [21].

Statistical analysis

Statistical analysis was performed with IBM SPSS statistics 25 software. A chi-squared test and Student's *t* test were used when comparing the results between groups, and *p* values less than .05 were considered statistically significant. When using the Student's *t* test, the equality of variances was tested with Levene's test, and the appropriate *t* test was then used.

Results

ACDF cohort

The answers for the EQ-5D-3L questionnaire are presented in Table 4. A subgroup analysis was performed based on primary diagnosis, degree of central spinal cord compression, number of levels operated on, need for further cervical surgeries, age, gender, implant type, and whether the primary operation was done in an acute setting. The subgroups with statistically significant differences are presented in Table 4 and Fig. 2. Gender, implant type, and whether the primary operation was performed in an acute setting were not statistically significant factors. Patients with spondylotic stenosis as a primary diagnosis had more problems with usual activities than patients operated on for a disc herniation (*p*=.029), and they also higher anxiety/

Table 2

Baseline and employment status information about patients and the propensity matched general population cohort (note that only patients that had answered all EQ-5D-3L questions and indicated their present smoking status were included in this part of the study)

		Patients n (%)	Controls n (%)	p
Total		271 (100%)	271 (100%)	
Gender	Male	153 (57%)	153 (57%)	Matched
	Female	118 (44%)	118 (44%)	
Age now in years, median (min-max)		54 (36–68)	54 (36–68)	
Present smoking	No	201 (74%)	201 (74%)	
	Yes	70 (26%)	70 (26%)	
Employment status	Working	181 (67%)*	175 (65%) working full-time and 21 (7%) working part-time for other reasons than part-time disability pension)	.194
	Unemployed	17 (6%)	19 (7%)	
	Disability pension	34 (13%)	27 (10%)	
	Part-time disability pension	11 (4%)	3 (1%)	
	Other	26 (10%)	26 (10%)	
	Data not available	2 (1%)	0	

Propensity score matching was made based on sex, age, and smoking status. There were no statistically significant differences in employment status between the patient and control cohorts.

* In our questionnaire, patients had only the options mentioned in the table. The distinction between full-time or part-time work was not an available option.

depression levels (p=.015), but there were no statistically significant differences in the other three dimensions. Patients with clinical myelopathy had significantly more problems in mobility (p=.022), and patients with either radiological central canal stenosis or clinical myelopathy exhibited a trend of more pain/discomfort. Operation on more than one level was associated with higher (ie, worse) scores on mobility (p=.032). Patients with at least one further cervical surgery during the follow-up time had significantly higher scores on the mobility (p=.011), usual activities (p=.000), and pain/discomfort sections (p=.000; Table 4). In addition, older patients (>30 years at the time

of the index surgery) had higher (ie, worse) scores in mobility (p=.016), which was the expected result.

The EQ-5D-3L summary indexes calculated from the dimensional values are presented in Table 5, and the EQ-VAS values reported by patients are shown in Table 6 and Fig. 3. The median EQ-5D-3L index among the patients was 0.74 (mean: 0.74, min: 0.25, max: 1.00), and the mean EQ-VAS score among patients was 73% (min: 10%, max: 100%). Patients with spondylosis had significantly lower EQ-5D-3L indexes and EQ-VAS scores (ie, lower quality of life) than patients with disc herniation. Patients with clinical myelopathy also had significantly lower scores on both assessment types compared to patients with no central spinal cord compression at all. Patients with no further cervical surgeries had significantly higher (ie, better) scores than patients with further cervical surgeries. Also, surgery on more than one level predicted lower quality of life, though the difference was statistically significant only for the EQ-VAS scores. Patients that were not satisfied to the index surgery (Table 1) had significantly lower (ie, worse) EQ-index scores (0.64 vs. 0.75, p=.001) and also significantly higher (ie, worse) dimensional scores in Usual activities (p=.001) and Pain/Discomfort (p=.011), but not in other three dimensions.

Table 3

EQ-5D-3L questionnaire in English [15]

		Score
Mobility	I have no problems in walking about.	1
	I have some problems in walking about.	2
Self-care	I am confined to bed.	3
	I have no problems with self-care.	1
Usual activities (eg, work, study, housework, family or leisure activities)	I have some problems washing or dressing myself.	2
	I am unable to wash or dress myself.	3
Pain/discomfort	I have no problems with performing my usual activities.	1
	I have some problems with performing my usual activities.	2
Anxiety/depression	I am unable to perform my usual activities.	3
	I have no pain or discomfort.	1
	I have moderate pain or discomfort.	2
	I have extreme pain or discomfort.	3
	I am not anxious or depressed.	1
	I am moderately anxious or depressed.	2
	I am extremely anxious or depressed.	3

Comparison to a general population cohort

Baseline and employment status comparisons between the patient and control populations are presented in Table 2. There were no statistically significant differences in employment status (p=.194 when comparing overall working status). Patients were on disability pension or part-time disability pension more often than the controls, but this difference was not statistically significant (p=.062).

Table 4
EQ-5D-3L questionnaire profiles in terms of patients, subgroups, and controls, the distribution of EQ-5D-3L scores in different groups (all patients, controls, and patient subgroups), and p values (patients vs. controls and subgroups)

EQ-5D-3L score	Mobility, n(%)			Self-care, n(%)			Usual activities, n(%)			Pain/discomfort, n(%)			Anxiety/depression, n(%)			p value	
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
All patients	185 (68%)	86 (32%)	0	247 (91%)	24 (9%)	0	178 (66%)	80 (30%)	13 (5%)	90 (33%)	154 (57%)	27 (10%)	0	227 (84%)	42 (16%)	2 (1%)	.116
Controls	222 (82%)	49 (18%)	0	258 (95%)	13 (5%)	0	236 (87%)	34 (13%)	1 (0.4%)	137 (48%)	130 (48%)	4 (2%)	0	243 (90%)	26 (10%)	2 (1%)	
Primary diagnosis	142 (70%)	60 (30%)	0	185 (92%)	17 (8%)	0	140 (69%)	56 (28%)	6 (3%)	70 (35%)	114 (56%)	18 (9%)	0	175 (87%)	24 (12%)	3 (2%)	.015*
spondylosis	47 (63%)	28 (37%)	0	68 (91%)	7 (9%)	0	42 (56%)	26 (35%)	7 (9%)	21 (28%)	45 (60%)	9 (12%)	0	56 (75%)	19 (25%)	0	
no	146 (72%)	56 (28%)	0	186 (92%)	16 (8%)	0	139 (69%)	55 (27%)	8 (4%)	77 (38%)	109 (54%)	16 (8%)	0	170 (84%)	31 (15%)	1 (1%)	.566
Central spinal cord compression	23 (72%)	9 (28%)	0	29 (91%)	3 (9%)	0	19 (59%)	10 (31%)	3 (9%)	7 (22%)	21 (66%)	4 (13%)	0	27 (84%)	5 (16%)	0	
Only radiological	16 (49%)	17 (52%)	0	30 (91%)	3 (9%)	0	20 (61%)	11 (33%)	2 (6%)	7 (21%)	20 (61%)	6 (18%)	0	26 (79%)	6 (18%)	1 (3%)	
Clinical myelopathy	166 (71%)	68 (29%)	0	214 (92%)	20 (9%)	0	160 (68%)	64 (27%)	10 (4%)	83 (36%)	127 (54%)	24 (10%)	0	194 (83%)	38 (16%)	2 (1%)	.519
Number of levels operated	24 (55%)	20 (46%)	0	40 (91%)	4 (9%)	0	23 (52%)	18 (41%)	3 (7%)	9 (21%)	32 (73%)	3 (7%)	0	38 (86%)	5 (11%)	1 (2%)	
Further cervical surgeries during follow up	159 (72%)	62 (28%)	0	205 (93%)	16 (7%)	0	156 (71%)	59 (27%)	6 (3%)	87 (39%)	118 (53%)	16 (7%)	0	189 (86%)	29 (13%)	3 (1%)	.076
1 or more	31 (54%)	26 (46%)	0	49 (86%)	8 (14%)	0	27 (47%)	23 (40%)	7 (12%)	5 (9%)	41 (72%)	11 (19%)	0	43 (75%)	14 (25%)	0	

Patients had significantly higher dimensional scores (ie, lower quality of life) than controls in mobility, usual activities, and pain/discomfort. Spondylosis as a primary diagnosis, clinical myelopathy, more than one level operated on, and further cervical surgeries during the follow-up predicted significantly higher scores in at least one dimension. When comparing patient subgroups, only patients with answers to all five dimensions were included (n=278). In patients vs. controls, the answer to smoking status was also required (n=271).

* p values <.05 were considered statistically significant.

The dimensional EQ-5D-3L scores among the patient and control populations are presented in Fig. 4, and the distribution of the EQ-index values is shown in Fig. 5. Patients had significantly higher dimensional EQ-5D-3L scores (ie, lower quality of life in that dimension) than controls in mobility (p=.000), usual activities (p=.000) and pain/discomfort (p=.000). The mean EQ-5D-3L index was 0.74 among patients and 0.83 among the controls (p=.00), signifying better health-related quality of life in the control population.

In the ACDF cohort analysis (previous chapter), herniated IV disc as primary diagnosis, no central compression, one-level operation, and no further cervical surgeries were associated with better life quality. The data for patients who presented with all of these factors (n=112 patients) indicating a better prognosis were collected and compared with that of the other patients (n=159), who all had at least one risk factor for a worse prognosis. There was a statistically significant difference in the pain/discomfort dimension (p=.001) as well as the overall EQ-index (mean EQ-indexes: 0.79 and 0.71, respectively, p=.001) and EQ-VAS scores (mean EQ-VAS scores: 78% and 70%, respectively, p=.000) in favor of the selected patients. Furthermore, the data for this group of selected patients with favorable profiles were compared to that of the general population control group. In this comparison, there were no statistically significant differences between the selected patients and the control group in terms of the dimensional scores, but the mean EQ-index in the selected patient group with favorable prognostic factors was still lower than that of the controls (EQ-indexes: 0.79 and 0.84, respectively, p=.032).

Discussion

In this study, we investigated the health-related quality of life of young adult ACDF patients and a representative general population cohort in the long-term follow-up. For the ACDF patients, spondylosis as a primary diagnosis, clinical myelopathy, and further cervical surgeries during follow-up were associated with lower quality of life in the subgroup analyses. Similarly, in the overall EQ-index assessment, patient subgroups with spondylosis as primary diagnosis, at least one reoperation, and clinical myelopathy had lower scores, ie, lower quality of life. Further, the same factors also lowered the EQ-VAS scores for the patient subgroups, but patients with index surgery entailing more than one cervical level also had lower EQ-VAS scores.

The patients who had undergone ACDF surgery reported significantly more problems than the general population cohort in three out of five dimensions that were assessed on the EQ-5D questionnaire: mobility, usual activities, and pain/discomfort. The EQ-5D-3L index calculated from the dimensional values was also lower for these patients, depicting a generally decreased health-related quality of life. The mean EQ-VAS score among patients was 73%. As the Health 2011 survey did not include the EQ-VAS (but only

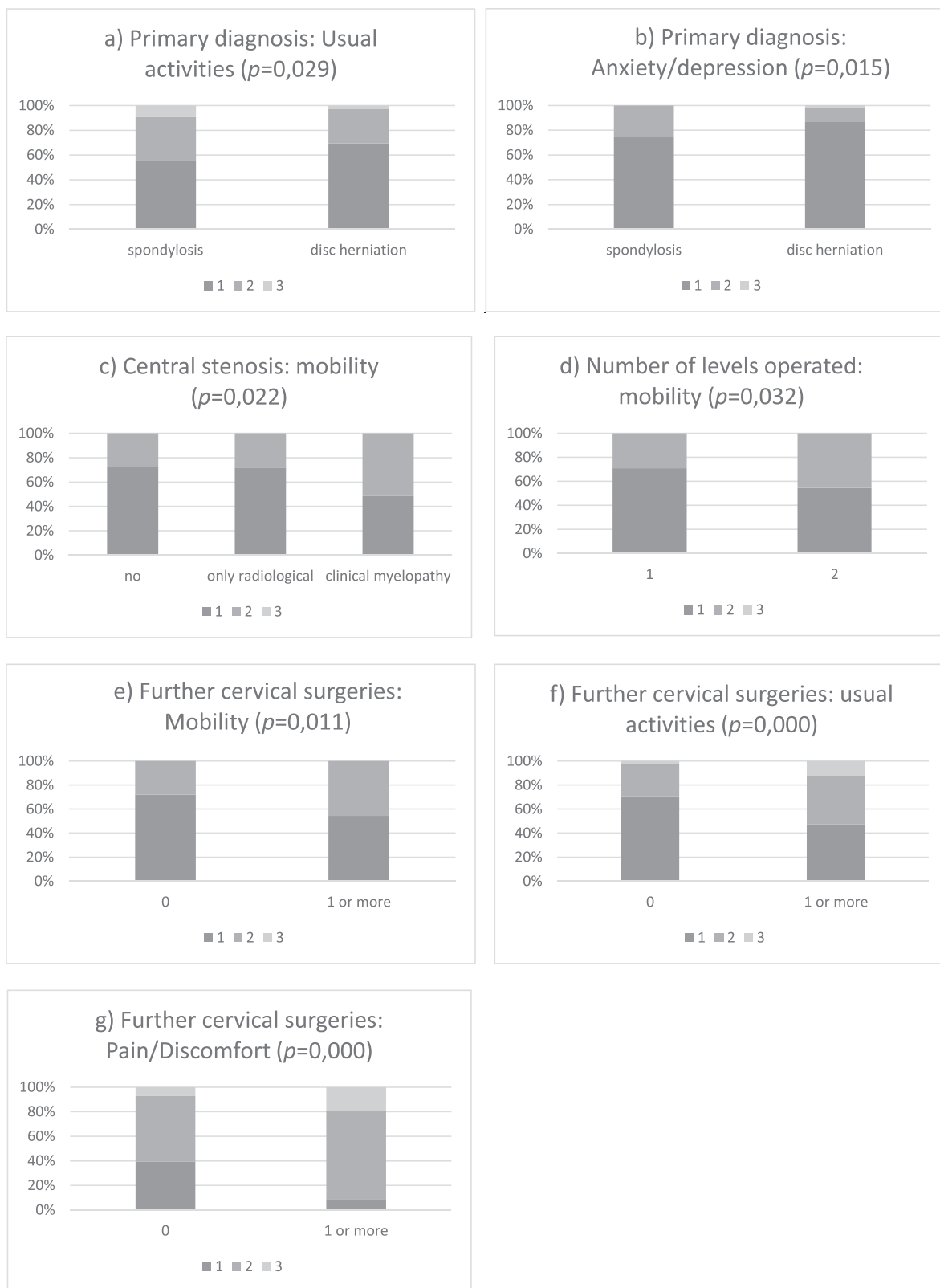


Fig. 2. Statistically significant differences in the EQ-5D-3L dimensions between patient subgroups. Shades of gray represent dimensional scores (1–3, with 1 signifying good or normal functional level and 3 signifying severe morbidity in that dimension), and the height of the column indicates the percentage of patients with each score.

Table 5
EQ-5D-3L index results

	n	Mean EQ-5D-3L index	Min-max (standard deviation)	p value	
All patients	271	0.74	0.25–1.00 (0.20)	.000	
Controls	271	0.83	0.25–1.00 (0.18)		
Primary diagnosis					
	Herniated disc	202	0.76	0.25–1.00 (0.19)	.049
	Spondylosis	75	0.70	0.31–1.00 (0.21)	
Age					
	<30	251	0.74	0.28–1.00 (0.20)	.585
	>30	27	0.76	0.25–1.00 (0.20)	
Sex					
	Female	120	0.73	0.28–1.00 (0.19)	.305
	Male	158	0.75	0.25–1.00 (0.20)	
Operated levels					
	1	234	0.75	0.25–1.00 (0.20)	.100
	2 or more	44	0.70	0.35–1.00 (0.18)	
Implant type					
	Synthetic interbody cage	199	0.74	0.25–1.00 (0.20)	Synthetic vs autograft: .904
	Bone autograft	43	0.74	0.39–1.00 (0.18)	synthetic vs. no implant: .440
	No implant, discectomy only	36	0.77	0.34–1.00 (0.19)	Autograft vs. no implant: .564
Spinal cord compression					
	No	202	0.76	0.25–1.00 (0.20)	No vs. clinical myelopathy: .033
	Only radiological findings	32	0.71	0.31–1.00 (0.19)	No vs. only radiological: .174
	clinical myelopathy	33	0.68	0.28–1.00 (0.18)	Only radiological vs. clinical: .541
Number of late reoperations					
	0	221	0.77	0.25–1.00 (0.20)	.000
	1 or more	57	0.64	0.31–1.00 (0.17)	

the EQ-5D-3L questionnaire), an exact comparison with the matched general population sample was not possible for the EQ-VAS assessment. However, an overall estimate of the EQ-VAS score for the general Finnish population in 1992 was 76.8%, including all age groups [20].

In our previous study concerning the same patient population, the main result was that satisfaction with surgery was very high in the long-term follow-up of 12 to 28 years, but a significant number of patients experienced mild but persistent neck symptoms in the long term. The present study showed that the quality of life measured by standardized EQ-5D-3L scale was also lower than that of the general population, and a statistically significant difference in the

EQ-index (but not in separate the EQ dimensions) remained when only patients with the best prognosis (ie, herniated IV disc as primary diagnosis, no central compression, one-level operation, and no further cervical surgeries) were included. However, there was no significant difference in the employment proportions of the patient and control cohorts. Thus, even with a slightly reduced health-related quality of life and some degree of neck symptoms, these patients are able to function productively in society. Further, it is not known what the prognosis would have been without operation. The lack of a conservatively treated patient group is a major limitation of our study. It would be important to establish what would the quality of life be if

Table 6
EQ-VAS results

	n	Mean EQ-VAS	Standard deviation	p value	
All patients	278	73%	19%		
Primary diagnosis					
	herniated disc	200	75%	18%	.002
	spondylosis	77	66%	21%	
Age					
	<30	27	78%	18%	.115
	>30	251	72%	20%	
sex					
	female	121	72%	21%	.471
	male	157	73%	19%	
Operated levels					
	1	236	74%	19%	.025
	2 or more	42	67%	20%	
Implant type					
	Synthetic interbody cage	198	72%	20%	Synthetic vs autograft: .369
	bone autograft	44	75%	18%	Synthetic vs. no implant: .519
	no implant, discectomy only	36	74%	17%	Autograft vs. no implant: .869
Spinal cord compression					
	no	202	75%	19%	No vs. clinical myelopathy: .030
	only radiological findings	32	69%	19%	No vs. only radiological: .131
	clinical myelopathy	32	66%	20%	only radiological vs. clinical: 0.615
Number of late reoperations					
	0	222	75%	18%	0.000
	1 or more	56	64%	21%	

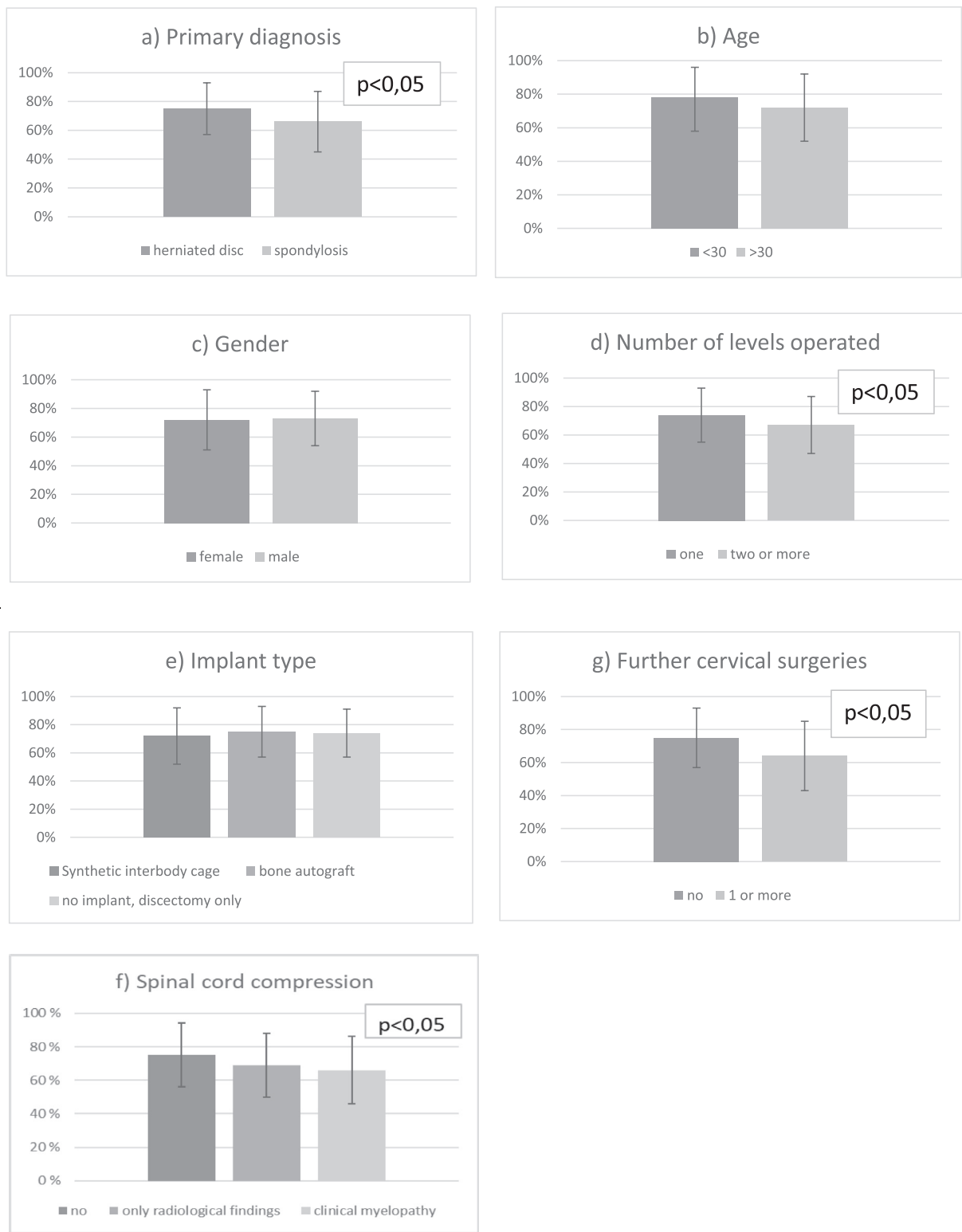


Fig. 3. Mean EQ-VAS values and standard deviations in the subgroup analysis, with patients grouped by (A) primary diagnosis, (B) age, (C) gender, (D) number of levels operated on, (E) implant type, (F) number of further cervical surgeries, and (G) spinal cord compression. Vertical lines represent the standard deviation. Primary diagnosis, number of levels operated on, number of further cervical surgeries, and degree of spinal cord compression were statistically significant factors. High percentages represent better perceived overall health-related quality of life.

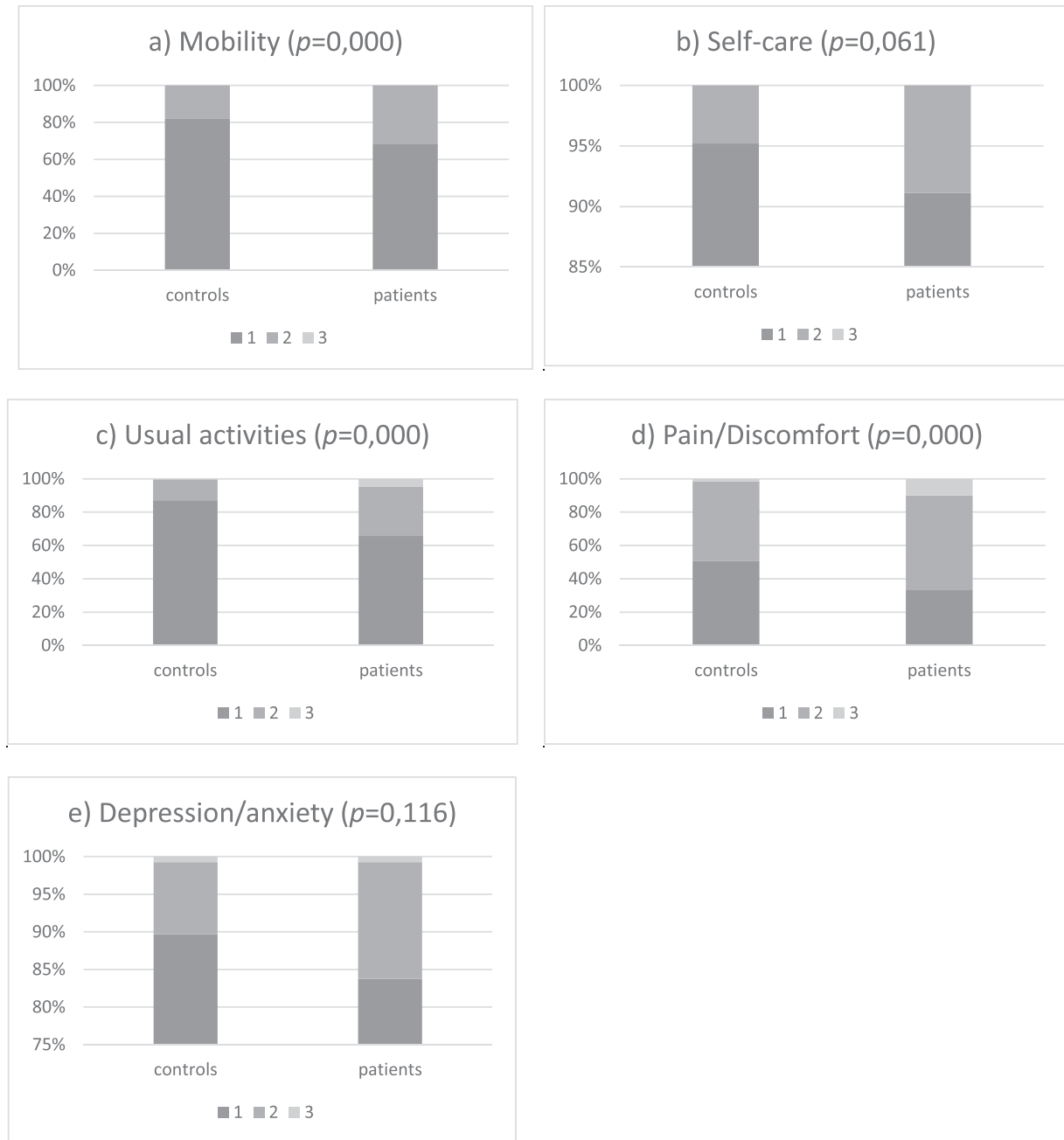


Fig. 4. Dimensional EQ-5D-3L scores among patients and controls: (A) mobility, (B) self-care, (C) usual activities, (D) pain/discomfort, and (E) depression/anxiety. Shades of gray represent dimensional scores (1–3), and the height of the column indicates the percentage of patients with each score.

no surgical intervention would be performed. This aspect definitely calls for prospective randomized studies with long-term follow-up and quality of life measures.

As there was a significant difference between the subgroups of patients with disc herniation and spondylosis as the primary diagnosis, this could be an indication that the lower quality of life seen in the ACDF patients overall could more likely be attributed to the degenerative cervical disease itself than the residual postsurgical symptoms. It is possible that patients who have needed surgical treatment for degenerative cervical disease at a young age may have a

tendency to develop degenerative cervical changes. In [22], Saarni et al investigated the impact of chronic health conditions on quality of life measured by the 15D and EQ-5D. In that study, Parkinson's disease had the largest negative impact on health-related quality of life at the individual level (mean EQ-5D index: 0.440) followed by anxiety disorders (0.682), depressive disorders (0.730), and arthrosis of the hip and knee (0.675). The mean EQ-5D index among patients with neck problems was 0.756 (mean age: 53 years), which was quite close to our result of 0.74 (mean age: 54 years). Overall, the majority of neck symptoms are

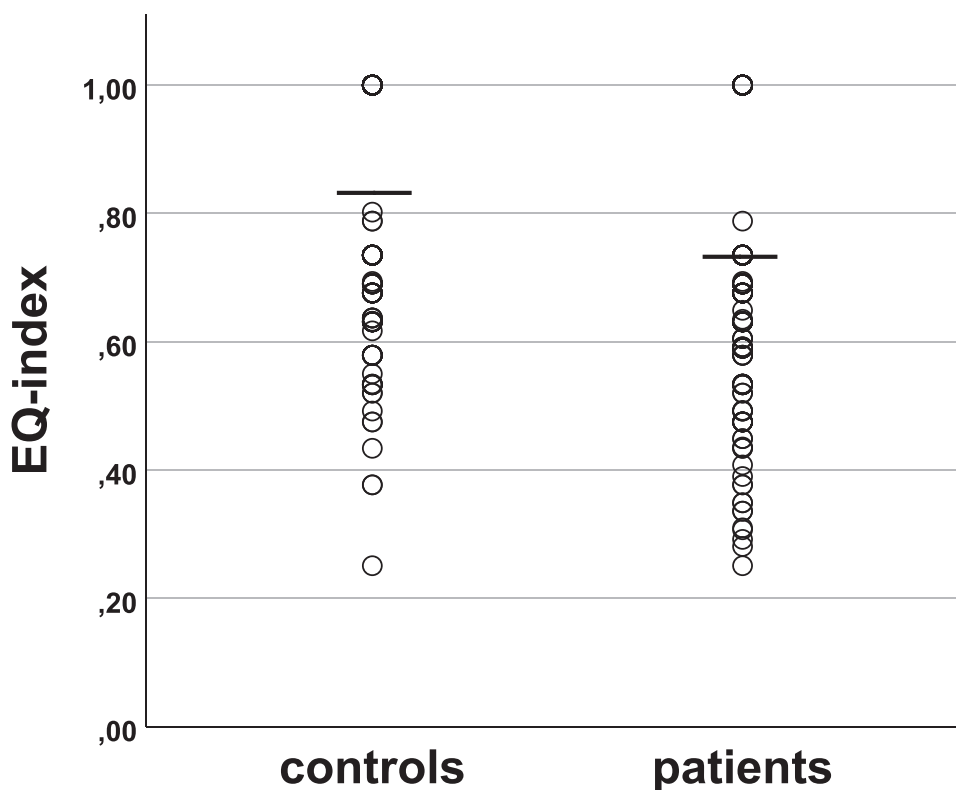


Fig. 5. Distribution of EQ-index results among patients and controls. The horizontal line represents the mean of the group. Higher index scores signify better health-related quality of life.

treated conservatively, and only patients with intense and persistent symptoms undergo surgical treatments. Thus, it is likely that most of the neck patients in Saarni et al.'s study were treated conservatively, whereas in our study, all patients underwent surgery. Interestingly, the mean EQ-indexes (of the neck patients in Saarni et al.'s study and the patients in this study) were very similar (0.756 vs. 0.74, respectively), which may indicate that the reduction in quality of life was caused by the degenerative cervical disorder itself. Engquist et al [23] compared the quality of life of patients with cervical radiculopathy treated either with surgery and physiotherapy or physiotherapy alone with a follow-up of 5 to 8 years using both the EQ-5D index and the EQ-VAS scale. The mean EQ-5D-indexes were 0.80 in the surgical and 0.67 in the conservatively treated group, and the mean EQ-VAS scores were 83% in surgical and 71% in the conservatively treated group after the follow-up, implying a benefit to quality of life of surgical treatment. However, the differences were not statistically significant. To the best of our knowledge, the study by Engquist et al is the only in which the quality of life of cervical radiculopathy patients treated with surgical and conservative treatment was compared in a long-term follow-up. However, the follow-up time was considerably shorter than that in our study. In addition, patients who have more symptoms and a lower quality of life may answer more actively. Thus, the quality of life of the patient group can

seem to be lower than it really is. The participation rate is another major limitation of our study: ca 37% of the patients did not return the questionnaires.

It has been shown that there are significant differences in mean EQ-5D scores between different populations (eg, different nationalities [19]), which makes the choice of the comparison cohort important. In general Finnish population norms [19], the percentages of people reporting some problems (ie, scores of 2 or 3) on the EQ-5D-3L dimensions were 26% in mobility, 9% in self-care, 21% in usual activities, 48% in pain/discomfort, and 14% in anxiety/depression. Further, the mean EQ-5D index decreased with age (0.891 in the 35–44 year age group, 0.853 in the 45–54 group, 0.805 in the 55–64 group, and 0.762 in the 64–74 group). In our control group cohort, the percentages of those reporting some problems were 18% in mobility, 5% in self-care, 13% in usual activities, 49% in pain/discomfort, and 10% in anxiety/depression. Thus, these percentages were lower than those indicative of population norms [19], especially in mobility, self-care, and usual activities. However, all age groups are included in the population norms [19], and the scores are higher in older age groups, which accounts for these differences. The mean EQ-5D index in our control group was 0.83, and the mean age was 54 years. Thus, the EQ-5D index values for the control cohort here are well in line with the findings from earlier reports for different Finnish population age groups [19].

Burkhardt et al have published several articles on the long-term results of ACDF with a follow-up of 17 to 45 years [9,11,12]. In their studies, all age groups were included, and they also measured the quality of life with the EQ-5D index. The percentages of patients having no problems (ie, score of 1) were 86% to 90% in mobility, 92% to 95% in self-care, 76% to 85% in usual activities, 82% to 93% in pain/discomfort, and 94% to 96% in anxiety/depression [9,11,12]. Thus, the dimensional scores reported were lower than those in our study. However, the 5Q-3L dimensional scores are higher in Finland than in Germany also in the general population [19], highlighting the aforementioned importance of comparing quality of life results to those of an appropriate control group and the difficulty of comparing results between patient groups consisting of different nationalities or otherwise among different base populations. For example, in the general population, 47.8% of Finns report some degree or significant pain (ie, score of 1 or 2), whereas only 27.6% of the German population report any complaints. It should be noted Burkhardt et al did not compare their EQ-5D-3L to any general population, leaving the context of the studies ambiguous. Thus, comparisons of EQ-5D results should be made with extreme care in patient cohorts coming from different general populations. In our study, all patients were operated without anterior plating according to the clinical practice in Finland. In [11] Burkhardt et al compared the long-term outcomes of anterior cervical surgery with and without Caspar plating, and there was no statistically significant differences in EQ-5D scores between groups. As we know, there are no long-term studies about patients with posterior cervical surgery with comparison of quality of life to general population. In their pilot study of 50 patients [24], Ghogawala et al compared effectiveness of dorsal and ventral surgery for cervical spondylotic myelopathy. Greater improvement in health-related quality of life (measured by SF-36) was observed after ventral surgery. However, the follow-up time was only 1 year and the study focused only on myelopathy patients. In [25], Silverplats et al investigated the quality of life of surgically treated lumbar disc herniation patients with follow-up time of 7 years. EQ-index among their patients was 0.74 at follow-up of 7 years and it was lower compared to age-correlated normal population. Thus, this result with lumbar patients resembles our results with cervical patients.

In another study, Kienapfel et al [13] had a follow-up period of 3 to 12 years (median 7 years), and they used the Profile of Quality of Life in the Chronically Ill (PLC) for assessment. In their study, radiological signs of myelocompression in the postoperative MRI taken at the end of the follow-up were associated with lower quality of life. Similarly, in our study, clinical preoperative myelocompression was associated with a lower quality of life. Kienapfel et al also compared the quality of life of ACDF patients with that of the general population, and the scores of the patients were significantly lower in the dimension of “everyday capabilities” of the PLC, whereas in other

dimensions, there were no statistically significant differences. However, when the scores of patients with myelocompression were compared to those of the general population, there was a statistically significant difference in most of the dimensions.

Conclusions

In the present study, we investigated the quality of life of ACDF patients who underwent surgery under 40 years of age in a long-term follow-up of 12 to 25 years. The life quality measured by the EQ-5D-3L was lower in the patient population when compared to the general population, though satisfaction with the surgery was very high, and there was no significant difference in employment status between the patients and the control population. Spondylosis as a primary diagnosis, clinical myelopathy, and further cervical surgeries were associated with lower quality of life in the subgroup analyses of the patients. However, the prognosis of the patients without surgery remains unknown. Thus, more studies where ACDF patients are compared to both the general population and conservatively treated patients are needed to better understand the effects of degenerative cervical diseases and surgical treatment on life quality in the longer term.

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