

Differences in Patient-Reported Outcomes between Anterior and Posterior Approaches for Treatment of Cervical Spondylotic Myelopathy: A Quality Outcomes Database Analysis

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Key Words: anterior approaches; cervical myelopathy; cervical spine; cervical spondylotic myelopathy; EQ-5D; modified Japanese Orthopaedic Association score; minimal clinically important difference; Neck Disability Index; patient-reported outcome; posterior approaches; Quality Outcomes Database; spine

Running Title: Anterior vs. posterior approaches for CSM

Abstract

Objective: Surgery for cervical spondylotic myelopathy (CSM) may use anterior or posterior approaches. Our objective was to compare baseline differences and validated postoperative patient-reported outcome measures between anterior and posterior approaches.

Methods: The NeuroPoint Quality Outcomes Database was queried retrospectively to identify patients with symptomatic CSM treated at 14 high-volume sites. Demographic, comorbidity, socioeconomic, and outcome measures were compared between treatment groups at baseline and 3 and 12 months postoperatively.

Results: Of the 1151 patients with CSM in the cervical registry, 791 (68.7%) underwent anterior surgery and 360 (31.3%) underwent posterior surgery. Significant baseline differences were observed in age, comorbidities, myelopathy severity, unemployment, and length of hospital stay. After adjusting for these differences, anterior surgery patients had significantly lower Neck Disability Index (NDI) and a higher proportion reaching a minimal clinically important difference (MCID) in NDI ($p=0.005$ at 3 months; $p=0.003$ at 12 months). Although modified Japanese Orthopaedic Association scores were lower in anterior surgery patients at 3 and 12 months ($p<0.001$ and $p=0.022$, respectively), no differences were seen in MCID or change from baseline. Greater EQ-5D improvement at 3 months after anterior vs. posterior surgery ($p=0.024$) was not sustained at 12 months and was insignificant on multivariate analysis.

Conclusions: In the largest analysis to date of CSM surgery data, significant baseline differences existed for patients undergoing anterior versus posterior surgery for CSM. After adjusting for these differences, patients undergoing anterior surgery were more likely to achieve clinically significant improvement in NDI at short- and long-term follow-up.

Key Words: anterior approaches; cervical myelopathy; cervical spine; cervical spondylotic myelopathy; EQ-5D; modified Japanese Orthopaedic Association score; minimal clinically important difference; Neck Disability Index; patient-reported outcome; posterior approaches; Quality Outcomes Database; spine

Introduction

Cervical spondylotic myelopathy (CSM) is the most common cause of adult spinal cord disease.¹ CSM is the result of chronic osteoarthritic degenerative changes of the bony and ligamentous anatomy of the cervical spine as well as the cervical disc spaces.² If left untreated, CSM can lead to significant patient disability.² In symptomatic patients, surgical correction of underlying pathology contributing to CSM is indicated and may involve either a posterior approach or an anterior approach.³

Previous studies have compared outcomes after anterior or posterior approaches for surgical treatment of CSM. Posterior approaches, particularly posterior laminectomy and instrumented fusion, have been associated with longer length of stay,⁴ greater hospital charges,^{4,5} implant-related complications,⁴ cerebrospinal fluid (CSF) leak rate,⁴ and infections^{6,7} relative to anterior approaches. However, anterior approaches have been associated with higher risk of dysphagia,^{4,6,8} dysarthria,⁴ or hematoma⁴ and longer operative duration⁸ relative to posterior approaches. Patient-reported outcome (PRO) measures validate patient perception of surgery and important neurologic deficits. Importantly, previous studies have demonstrated similar outcomes in terms of myelopathy improvement between anterior and posterior approaches.^{6,7,9} Patient selection and optimal surgical approach are chosen based on patient factors in addition to imaging alone. In some instances, anterior and posterior approaches may be equivalent by these considerations, and the approach decision largely depends on surgeon preference.

Prior multicenter studies have used large government databases to analyze anterior and posterior approaches.^{4,5} These databases have limitations given that the databases are reliant on diagnosis

codes and are not maintained or audited by neurosurgery- or orthopedic-specific personnel. Furthermore, these studies typically lack long-term follow-up beyond a 30- or 90-day complication capture window. The prospective multicenter study by Fehlings et al.⁹ compared anterior and posterior approaches for CSM and showed largely equivocal outcomes, but the sample size was still relatively small for a multicenter study, with 264 total patients (169 anterior, 95 posterior). The only randomized trial comparing anterior and posterior approaches was a single-center study in which only 68 patients were randomized,⁸ which may limit broader generalization of findings.

The object of this study was to describe baseline differences and postoperative outcome differences in patients undergoing anterior versus posterior surgery for degenerative cervical myelopathy using a prospectively collected, multi-institutional, neurosurgery-specific dataset.

Methods

Data Source

The Neuropoint Quality Outcomes Database (QOD) is a deidentified, multi-institutional, prospectively collected clinical registry maintained by Neuropoint. Previous articles have described the cervical QOD methodology and data collection process in detail.¹⁰⁻¹² Briefly, patients undergoing anterior or posterior cervical spine surgery for the diagnosis of disc herniation, stenosis (foraminal or central), instability, or adjacent segment disease are eligible for inclusion. Exclusion criteria include spinal infection, trauma, tumor, deformity, pre-existing spinal cord injury, pediatric patients, and incarcerated patients. Each participating site has Institutional Review Board approval for patient enrollment.

Patient Cohort

The authors queried the cervical QOD module for patient data from January 2016 to December 2018. Patients with myelopathy were included in the study; the three variables used to define myelopathy were (1) indication for surgery was myelopathy (also radiculopathy and instability if myelopathy was also present); (2) predominant symptoms for surgery was myelopathy; and (3) baseline modified Japanese Orthopaedic Association (mJOA) score was <17. Data from 14 high-volume sites from across the US were included.

Variables of Interest

Demographic variables including age, sex, race, employment status, and education status were included for analysis. Clinical and comorbidity variables were collected including body mass index (BMI), length of stay, diabetes, coronary artery disease, chronic obstructive pulmonary disease, smoking status, and American Society of Anesthesiologists (ASA) class.

Baseline (preoperative) and postoperative (3 and 12 months) variables relevant to myelopathy included the following PROs: mJOA score (a previously described and validated myelopathy patient self-assessment¹³), Neck Disability Index (NDI), a described and validated patient assessment on a scale from 0-100 of neck-related disability¹⁴, and EQ-5D (EuroQol-5D, a validated questionnaire to assess quality of life¹⁵). Minimal clinically important difference (MCID) values were determined for mJOA using the following mJOA point change cutoffs: 1 for mild cervical myelopathy (mJOA 15–17), 2 for moderate myelopathy (mJOA 12–14), and 3

for severe myelopathy (mJOA <12).¹⁶ An MCID of 17.3 was used for NDI¹⁷ and an MCID of 0.0485 was used for EQ-5D¹⁸ based on prior literature in the cervical population.

Statistical Analysis

Descriptive statistics were generated for patient demographics, operative variables, and postoperative outcomes. Analysis of variance (ANOVA) was used to compare continuous variable outcomes. Chi-square test with Pearson's correlation was used to compare categorical variable outcomes. Multivariate analyses were performed to determine whether baseline patient characteristics measures in conjunction with surgical approach and comorbidities affected MCIDs of the 3 PROs at 3 and 12 months via binary logistic regression. A two-tailed p value of <0.05 ($\alpha=0.05$) was considered significant. All statistical analyses were performed using SPSS v. 25 (SPSS Statistics for Windows, Version 25.0. IBM, Armonk, NY).

Results

Of the 1150 patients who met the inclusion criteria, 791 patients (68.7%) underwent anterior surgery (AS) and 360 patients (31.3%) underwent posterior surgery (PS). Patient demographic and comorbidity variables are shown in Table 1. Patients undergoing AS were significantly younger (mean age 58.6 ± 11.8 vs. 64.8 ± 10.6 years, $p < 0.001$) and had lower comorbidity burden (ASA grade ≥ 3 47.2% vs. 59.6%, $p < 0.001$), lower rate of diabetes (19.8% vs. 25.0%, $p = 0.048$), lower unemployment (55.8% vs. 74.4%, $p < 0.001$), and shorter length of stay (1.4 ± 1.6 vs. 3.6 ± 2.9 days, $p < 0.001$). No differences were observed for sex, race, BMI, coronary artery disease, depression, chronic obstructive pulmonary disease, smoking status, or education level.

Results of baseline and postoperative PRO measures are shown in Table 2. The displayed values are raw scores. Patients who underwent AS had less severe myelopathy at baseline (mean mJOA score 12.3 ± 2.7 vs. 11.5 ± 3.1 , $p < 0.001$) but had no significant differences in baseline disability or quality of life (NDI or EQ-5D). At 3 months postoperatively, patients who underwent AS had less severe myelopathy (mJOA score 14.2 ± 2.5 vs. 13.5 ± 2.7 , $p < 0.001$) and higher quality of life (EQ-5D scores 0.740 ± 0.205 vs. 0.698 ± 0.213 , $p = 0.004$). No differences were seen for 3-month NDI. At 12 months postoperatively, patients who underwent AS had less severe myelopathy (mJOA score 13.9 ± 2.7 vs. 13.5 ± 2.9 , $p = 0.022$) but no other differences were observed.

To account for differences in myelopathy, disability, quality of life, and pain before and after surgical intervention, we calculated changes from baseline for each measure (Table 3). At 3 months postoperatively, disability improved more from baseline in the AS group (mean NDI change from baseline -16.7 ± 19.1 vs. -12.2 ± 19.3 , $p < 0.001$) as had the quality of life (EQ-5D $+0.179 \pm 0.227$ vs. $+0.143 \pm 0.226$, $p = 0.024$). Improvements in mJOA were not significantly different between approaches at 3 months from baseline. At 12 months postoperatively, patients who underwent AS maintained a greater improvement in disability (NDI -18.8 ± 20.0 vs. -13.1 ± 19.9 , $p < 0.001$).

In addition to change scores, we evaluated achievement of previously reported MCID cutoff values (Table 4). At 3 months postoperatively, the percent of patients achieving MCID for disability was significantly different (NDI: 47.9% anterior vs 37.4% posterior, $p = 0.002$). This difference remained at 12 months postoperatively (NDI: 51.5% vs. 40.1%, $p = 0.002$). No differences were seen for MCID in mJOA or EQ-5D.

A total of 6 separate multivariate analyses were performed to determine whether baseline patient characteristics and comorbidities in conjunction with surgical approach affected achievement of MCID for the outcome measures (see Online Supplement for multivariate tables). At both 3 and 12 months postoperatively, patients in the AS group were more likely to achieve clinically meaningful improvement in NDI ($p=0.005$, $OR=1.54$, 95% CI 1.14–2.09 at 3 months; $p=0.003$, $OR=1.64$, 95% CI 1.19–2.25 at 12 months).

Discussion

The question of whether to use anterior or posterior approaches to surgically correct CSM can be challenging to answer. Before this study, differences in baseline patient characteristics between anterior and posterior approaches were not clearly identified using multi-institutional, large-sample, neurosurgery-specific data. In the largest analysis to date of prospective “real-world” CSM surgery data, we identified significant differences between patients undergoing anterior and posterior surgery for CSM. Multivariate analysis of 3- and 12-month follow-up data indicated that—for clinically important difference—disability (measured by change in NDI from baseline) was the only significantly different outcome between approaches. Although the purpose of this study is not necessarily to guide surgeon decision-making regarding the initial approach decision, the results may provide data regarding expectations for patient recovery after surgery relative to their baseline levels of myelopathy, disability, and quality of life.

Patient demographics and comorbidities

We found that patients in the AS group were typically younger, which is in agreement with results published by previous studies comparing anterior and posterior approaches for CSM.⁹ This finding is intuitive given that advanced degenerative changes (e.g., more advanced multilevel stenosis) occur more often in older patients, which may necessitate a posterior approach to adequately decompress the neural elements.

Regarding comorbidities, patients in the AS group had lower overall comorbidity burden (as captured by ASA classification) and lower rates of coronary artery disease compared with patients in the PS group. Prior studies have also shown that patients undergoing posterior CSM have higher rates of preoperative comorbidities and postoperative myocardial infarction.⁴ Apart from age and employment, other differences in demographic factors, such as race or education level, were not seen.

Patient myelopathy, disability, and quality-of-life PROs

Previous studies have reported mixed results in regards to baseline and postoperative measurements of myelopathy and disability for anterior versus posterior CSM surgery. Fehlings et al.⁹ reported that there were no baseline differences in NDI between anterior and posterior groups and that there was more postoperative improvement in the mJOA within the posterior group (2.47 vs. 3.62, $p < 0.01$), although there were different baseline mJOA scores. Kato et al.⁶ showed no differences in postoperative mJOA or NDI between anterior and posterior approaches in a prospective study of 757 CSM patients. In a randomized trial of 68 patients, El-Ghandour et al.⁸ found significantly better outcome in the NDI in the anterior group at 1 year ($p < 0.05$), but no significant difference in myelopathy improvement. In a systemic review, Lawrence et al.⁷ set out

to compare the effectiveness and safety profiles of anterior versus posterior decompression procedures for multilevel CSM. They concluded that there was no clear advantage to either an anterior surgical approach or a posterior surgical approach when treating patients with multilevel CSM.

Study Limitations

This study is limited by the retrospective nature of the analysis; however, the data were collected prospectively for the QOD registry. We were also limited by the lack of radiographic data.

Although we used 3 different variables to define myelopathy as stringently as possible, these are all by patient and surgeon report of patient symptoms, and there is no information on radiographic extent of disease, alignment, stenosis, or the presence of hyperintense cord signal change on magnetic resonance imaging. The mJOA as a measure of myelopathy severity only captures clinically relevant myelopathic findings rather than the aforementioned imaging findings that are critical to consider when determining surgical approach. Still, prior studies have shown that preoperative radiographic deformity parameters may not contribute to postoperative outcomes. Lau et al.¹² analyzed radiographic parameters in patients undergoing anterior cervical discectomy and fusion and found that cervical sagittal vertical axis, cervical lordosis, and T1 slope were not associated with any clinical outcome measured. One limitation of the NDI as an outcome measure for comparing anterior versus posterior surgical intervention is that the NDI is likely higher in posterior patients because of greater pain from posterior paraspinal muscle dissection and the fact that a greater number of segments is typically fused on average with a resultant lack of motion. Another limitation is that this study included patients from 14 high-volume sites. Although this collaboration includes both academic and private practice groups, the

bias towards high-volume neurosurgical practice is likely also biased towards more complex patients and may not be reflective of more common and simpler CSM disease. Finally, anterior or posterior approaches may be selected because of anatomical considerations that are irrespective of, and not captured in, the data presented herein.

Conclusions

We present data comparing differences in patients undergoing anterior versus posterior surgery for CSM using a large multicenter dataset including data from specific procedures and multivariate analysis of clinically relevant patient outcomes. Significant differences existed in baseline characteristics of patients undergoing anterior versus posterior surgery for CSM, particularly patient age, baseline myelopathy scores, comorbidity burden, and employment status. There were notable differences in baseline and postoperative quality-of-life metrics between patients undergoing these approaches, yet the approaches were clearly equivalent by many measures. Our findings provide data that may help set realistic expectations for patient recovery after CSM surgery relative to baseline levels of myelopathy, disability, and quality of life.

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Conflicts of Interest: No conflicts of interest relevant to the paper.

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Previous Presentations: This work was presented as a poster presentation at the CSRS 2020 Meeting and as an oral presentation at the 2021 AANS/CNS Section on the Disorders of the Spine and Peripheral Nerves Meeting.

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Table 1. Patient demographics and comorbidities

Variable	Anterior (N=791)	Posterior (N=360)	P
Age in years (mean \pm SD)	58.6 \pm 11.8	64.8 \pm 10.6	<0.001
BMI (mean \pm SD)	30.3 \pm 6.5	29.8 \pm 6.3	0.212
Length of stay in days (mean \pm SD)	1.4 \pm 1.6	3.6 \pm 2.9	<0.001
Sex			0.264
Male	407 (51.5)	198 (55.0)	
Female	384 (48.5)	162 (45.0)	
Race			0.585
White	595 (75.3)	283 (78.6)	
Black	114 (14.4)	62 (17.2)	
Asian	9 (1.1)	3 (0.8)	
Pacific Islander	3 (0.4)	2 (0.6)	
Native American	4 (0.5)	1 (0.3)	
Diabetes	157 (19.8)	90 (25.0)	0.048
CAD	68 (8.6)	42 (11.7)	0.101
COPD	54 (6.8)	28 (7.8)	0.561
Current smoker	128 (16.2)	58 (16.2)	0.906
Depression	165 (20.9)	86 (23.9)	0.249
ASA Grade			<0.001
I	21 (2.8)	2 (0.6)	
II	373 (50.0)	129 (39.8)	
III	341 (45.7)	184 (56.8)	

IV	11 (1.5)	9 (2.8)	
Current employed and working	349 (44.2)	92 (25.6)	<0.001
Level of education			0.681
Less than high school	44 (5.6)	21 (5.9)	
GED/high school diploma	301 (38.3)	125 (34.9)	
2-year degree	131 (16.7)	70 (19.6)	
4-year degree	175 (22.3)	77 (21.5)	
Post college	107 (13.6)	48 (13.4)	

Data reported as n (%) unless indicated.

Statistical analyses were performed using Student's t-test for continuous variables and Chi-square test for categorical variables.

BMI = body mass index; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; ASA = American Society of Anesthesiologists; GED = general education development; SD = standard deviation of the mean

Table 2. Patient-reported outcome measures for anterior and posterior surgery

Variable	Missing values (%)	Anterior (N=791)	Posterior (N=360)	P
Baseline				
mJOA	0 (0)	12.3±2.7	11.5±3.1	<0.001
NDI	4 (0.3)	39.3±20.6	36.7±21.0	0.057
EQ-5D	94 (8.2)	0.563±0.223	0.551±0.225	0.431
3-month follow-up				
mJOA	207 (18.0)	14.2±2.5	13.5±2.7	<0.001
NDI	180 (15.6)	22.5±17.5	24.1±18.7	0.190
EQ-5D	223 (19.4)	0.740±0.205	0.698±0.213	0.004
12-month follow-up				
mJOA	324 (28.1)	13.9±2.7	13.5±2.9	0.022
NDI	318 (27.6)	9.9±9.6	11.0±9.7	0.124
EQ-5D	364 (31.6)	0.736±0.212	0.712±0.203	0.121

Data reported as mean±SD unless indicated.

mJOA = modified Japanese Orthopaedic Association; NDI = Neck Disability Index

Table 3. Patient-reported outcome measures reported as change from baseline

Variable	Missing values (%)	Anterior (N=791)	Posterior (N=360)	P
3-month follow-up				
Δ mJOA	207 (18.0)	+1.9±2.6	+2.0±3.0	0.452
Δ NDI	183 (15.9)	-16.7±19.1	-12.2±19.3	<0.001
Δ EQ-5D	274 (23.8)	+0.179±0.227	+0.143±0.226	0.024
12-month follow-up				
Δ mJOA	324 (28.1)	+1.6±2.7	+1.9±3.2	0.178
Δ NDI	321 (27.9)	-18.8±20.0	-13.1±19.9	<0.001
Δ EQ-5D	398 (34.6)	+0.168±0.240	+0.152±0.226	0.380

Data reported as mean±SD unless indicated.

mJOA = modified Japanese Orthopaedic Association; NDI = Neck Disability Index; Δ = change from baseline

Table 4. Patients achieving minimal clinically important difference (MCID) in patient-reported outcome measures

Variable	Missing values	Anterior (N=791)	Posterior (N=360)	P
3-month follow-up				
MCID mJOA	207 (18.0)	363 (56.6)	170 (56.1)	0.879
MCID NDI	183 (15.9)	314 (47.9)	117 (37.4)	0.002
MCID EQ-5D	274 (23.8)	411 (69.4)	184 (64.6)	0.149
12-month follow-up				
MCID mJOA	324 (28.1)	299 (54.9)	150 (53.2)	0.647
MCID NDI	321 (27.9)	281 (51.5)	114 (40.1)	0.002
MCID EQ-5D	398 (34.6)	334 (68.0)	176 (67.2)	0.812

Data reported as n (%) unless indicated.

mJOA = modified Japanese Orthopaedic Association; NDI = Neck Disability Index

Abbreviations

ANOVA, analysis of variance

AS, anterior surgery

ASA, American Society of Anesthesiologists

BMI, body mass index

CSF, cerebrospinal fluid

CSM, cervical spondylotic myelopathy

EQ-5D, EuroQol 5D

MCID, minimal clinically important difference

mJOA, modified Japanese Orthopaedic Association

NDI, Neck Disability Index

PRO, patient-reported outcome

PS, posterior surgery

QOD, Quality Outcomes Database