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Anterior vs Posterior Approach in Multilevel Cervical Spondylotic Myelopathy: A Nationwide Propensity-Matched Analysis of Complications, Outcomes, and Narcotic Use

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ABSTRACT

Background: There is unclear evidence regarding the optimal surgical approach for multilevel cervical spondylotic myelopathy (CSM). The objective of this study was to compare complications, outcomes, and narcotic use in anterior discectomy and fusion (ACDF) vs posterior decompression and fusion (PCDF) in CSM patients.

Study Design: Registry-based retrospective cohort analysis.

Methods: Patients undergoing 3-level ACDF or PCDF for CSM between 2007 and 2017 were identified from the Humana Claims Database using relevant procedure codes. Propensity score-matched groups were compared in regards to complications, outcomes, and narcotic use.

Results: Propensity score matching generated equal cohorts of 6124 patients. The posterior fusion group had a higher rate of urinary tract infection (OR 2.47, $P < 0.0001$), deep vein thrombosis (OR 1.90, $P < 0.0001$), and pulmonary embolism (OR 1.75, $P < 0.0001$). In regards to 30-day outcomes, the posterior approach demonstrated higher rates of stroke (OR 1.68, $P < 0.0001$), wound dehiscence (OR 5.59, $P < 0.0001$), Surgical site infection (SSI) (OR 4.76, $P < 0.0001$), wound revision surgery (OR 3.02, $P < 0.0001$), and all-cause readmission (OR 2.01, $P < 0.0001$). One-year outcomes revealed higher rates of pseudarthrosis (4.7% vs 2.0%, OR 2.43, $P < 0.0001$) and revision or extension surgery (OR 2.33, $P < 0.0001$) in the posterior fusion cohort. These patients also demonstrated significantly higher mean morphine milligram equivalent used at 30 days (OR 1.19, $P < 0.0001$), as well as 60 (OR 1.20, $P < 0.0001$), 90 (OR 1.21, $P < 0.0001$), and 120 (OR 1.21, $P < 0.0001$) days.

Conclusions: This nationwide propensity-matched analysis of multilevel CSM patients found the posterior approach to be associated with increased rates of inpatient complications, wound complications, 30-day readmission, 1-year pseudarthrosis, and 1-year revision or extension surgery. These patients also demonstrated higher levels of narcotic use up to 120 days after surgery.

Clinical Relevance: The posterior approach for treatment of CSM may be associated with increased rates of short- and long-term complications in addition to increased narcotic consumption in comparison to the anterior approach.

Level of Evidence: 3.

Cervical Spine

Keywords: Cervical, spondylotic, myelopathy, anterior, posterior, ACDF, PCDF, CSM, degenerative, spondylosis

INTRODUCTION

Cervical spondylotic myelopathy (CSM) is one of the leading causes of atraumatic spinal cord dysfunction in the United States in the adult population.[1,2] Traditional guidelines recommend surgery with significant symptoms to arrest disease progression and preserve quality of life; however, there has been a recent trend toward early detection and treatment of even mild disease prior to the onset of spinal cord damage.[3,4]

When surgical intervention is pursued for CSM, the primary goal of surgery is to decompress the spinal cord. Decompression can be achieved through anterior, posterior, and combined anterior-posterior approaches. Anterior approaches may be favored for anterior pathology (eg, discs, osteophytes, and posterior longitudinal ligament), addressing cervical kyphosis, and/or 1- to 2-level pathologies.[5] Posterior approaches may be preferred for wider decompressions, pathologies of greater than 3 levels, and ossified posterior longitudinal ligament. Despite these nuanced differences, the anatomy in many cases poses a clinical equipoise between anterior and posterior approaches and the choice is left to surgeon preference.

However, there is unclear evidence regarding comparative outcomes in this population with equipoise. A meta-analysis of randomized-controlled trials comparing these options failed to draw definitive conclusions on which surgical approach was more effective.[6] Isolating cases demonstrating clinical equipoise, we sought to compare complications and outcomes in anterior discectomy and fusion (ACDF) vs posterior decompression and fusion (PCDF) through the use of a large health-care database.

MATERIALS AND METHODS

Data for this study were derived from the Humana Claims Database from 2007 to 2016. During this period, the database contained over 22 million patients with approximately 2 million patients entering the database on an annual basis. The database contains detailed information pertaining to patient, hospital, admission, and outcome characteristics in addition to medication usage.

The Humana Database was specifically analyzed from the first quarter (Q1) of 2007 to third quarter (Q3) of 2016. Medical diagnoses were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) in addition to the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). Relevant procedures were identified using Current Procedural Terminology (CPT) codes.

Patients were first identified with diagnosis codes indicating CSM, querying for 721.1 (cervical spondylosis with myelopathy, ICD-9) and M47.12 (other spondylosis with myelopathy, cervical region, and ICD-10). As a mean to control for pathologies that would inherently influence surgical decision-making in regards to approach, several potentially present diagnosis codes were excluded. Ossification of the posterior longitudinal ligament (OPLL) is frequently treated with a posterior approach given increased surgical risk for anterior approaches; consequently, diagnosis codes 723.7 (OPLL in cervical region, ICD-9) and M48.8 × 2 (OPLL, ICD-10) were excluded. Similarly, ankylosing spondylitis (AS) and diffuse idiopathic skeletal hyperostosis (DISH) may influence both fusion length and approach; consequently, 720.0 (AS, ICD-9), M45.9 (AS, ICD-10), 721.6 (ankylosing hyperostosis of cervical spine, ICD-9), M48.12 (ankylosing hyperostosis [Forestier], cervical region, ICD-10), and M48.10 (DISH, ICD-10) were excluded.

This patient population was then stratified into anterior fusion and posterior fusion groups. In order to facilitate investigation of patients deemed to have clinical equipoise in approach decision-making, CPT codes were employed to identify patients undergoing fusion lengths of exactly 3 levels. In the anterior fusion group, procedure codes 22551 (along with 2 additional codes for 22552) and 22554 (along with 2 additional codes for 22585) were used to identify patients undergoing 3-level ACDF. The procedure codes 63081 (along with the possibility of additional codes for 63082) were allowed to include for possible single- and multilevel corpectomies. In the posterior fusion group, procedure codes 22600 (along with 2 additional codes for 22614) were used to identify patients undergoing 3-level PCDF.

Baseline patient demographics queried included age, sex, race, and medical comorbidities. Outcomes evaluated included inpatient complications, mortality, and readmission. One-year outcomes evaluated included rates of pseudarthrosis and revision surgery. In addition, rates of narcotic usage at 30, 60, 90, and 120 days with corresponding mean morphine milligram equivalent (MME) per patient were evaluated.

Statistical analysis was performed using R version 3.4.4 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were calculated by count and percentage for categorical variables. Baseline characteristics were compared between patients in anterior fusion vs posterior fusion groups by Student *t* test for continuous variables and the χ^2 test for categorical variables. Propensity score matching was then performed to compare outcomes in these groups. The propensity score was constructed with independent variable covariates that included age, sex, comorbidities, region, and race that differed between the dependent variable of ACDF or PCDF group. The goal of matching was to mitigate bias associated with covariates. Notably, regionality has been suggested to significantly affect rates of cervical spine surgery.[7] Matching was performed in a one-to-one ratio using the exact matching technique. Outcomes were compared between these groups by Student *t* test for continuous variables and the χ^2 test for categorical variables. Standard and weighted mean differences (SMDs and WMDs) for continuous outcomes and ORs for categorical outcomes and their corresponding 95% CIs were calculated. 95% CIs were calculated for all risk ratios by using an alpha level of $P \leq 0.05$.

Institutional Review Board approval was not required for this study as data were drawn from a de-identified health-care database.

Table 1. Baseline characteristics of propensity score–matched cohorts by treatment group (*N* = 12,248).

Characteristics	Total (*N* = 12,248)	PCDF (*N* = 6124)	ACDF (*N* = 6124)	*P*
Age, y				1.0
≤64	4650 (38.0)	2351 (38.4)	2299 (37.5)	
65–69	2826 (23.1)	1424 (23.3)	1402 (22.9)	
70–74	2552 (20.8)	1294 (21.1)	1258 (20.5)	
75–79	1628 (13.3)	829 (13.5)	799 (13.0)	
80–84	744 (6.1)	378 (6.2)	366 (6.0)	
≥85	187 (1.5)	94 (1.5)	93 (1.5)	
Sex				1.0
Men,	6962 (56.8)	3481 (56.8)	3481(56.8)	
Women	5466 (44.6)	2733 (44.6)	2733 (44.6)	
Race				1.0
White	8500 (69.4)	4250 (69.4)	4250 (69.4)	
Black	1508 (12.3)	754 (12.3)	754 (12.3)	
Hispanic	62 (0.5)	31 (0.5)	31 (0.5)	
Other	68 (0.6)	34 (0.6)	34 (0.6)	
Unknown	2266 (18.5)	1133 (18.5)	1133 (18.5)	
Comorbidities				
Smoking status	2805 (22.9)	1458 (23.8)	1347 (22.0)	0.02
Depression	4217 (34.4)	2085 (34.0)	2132 (34.8)	0.37
Anxiety	3665 (29.9)	1837 (30.0)	1828 (29.9)	0.86
Chronic kidney disease	3280 (26.8)	1694 (27.7)	1586 (25.9)	0.03
Chronic lung disease	1403 (11.5)	679 (11.1)	724 (11.8)	0.20
Congestive heart failure	1785 (14.6)	960 (15.7)	825 (13.5)	<0.01
Coagulopathy	929 (7.6)	502 (8.2)	427 (7.0)	0.01
Diabetes mellitus	4906 (40.1)	2374 (38.8)	2532 (41.3)	<0.01
Alcohol abuse	684 (5.6)	395 (6.5)	289 (4.7)	<0.01
Hypertension	9846 (80.4)	4900 (80.0)	4946 (80.8)	0.30
Obesity	3226 (26.3)	1546 (25.2)	1680 (27.4)	0.01
Hyperlipidemia	8909 (72.7)	4342 (70.9)	4567 (74.6)	<0.01
Hospital region				
Midwest	2815 (23.0)	1572 (25.7)	1243 (20.3)	<0.01
Northeast	241 (2.0)	141 (2.3)	100 (1.6)	<0.01
South	8208 (67.0)	3870 (63.2)	4332 (70.7)	<0.01
West	1175 (9.6)	636 (10.4)	539 (8.8)	<0.01

Abbreviations: ACDF, anterior discectomy and fusion; PCDF, posterior decompression and fusion.
Data presented as *n* (%).

RESULTS

A total of 74,316 patients with CSM and without the noted exclusion criteria were identified. Of this population, 22,325 patients underwent ACDF and 6622 underwent PCDF. Propensity score matching was employed with the covariates of age, sex, comorbidities, region, and race in a one-to-one ratio using the exact matching technique to produce 2 equal cohorts with adjustments for confounding variables. This resulted in a total cohort of 12,248 patients with 6124 patients undergoing ACDF and 6124 patients undergoing PCDF (Table 1). There was no statistically significant difference between the 2 matched cohorts in regards to age, sex, and race. The majority of patients underwent surgery in the South (67%), followed by the Midwest (23%) and West (9.6%). The most common comorbidity was hypertension (80%), followed by hyperlipidemia (73%), diabetes mellitus (40%), depression (34%), anxiety (30%), chronic kidney disease (27%), and obesity (26%). A minority of patients (23%) in the total cohort were noted to be active smokers. The slight differences between the ACDF and PCDF cohorts in rates of smoking status (22% vs 24%), chronic kidney disease (26% vs 28%), congestive heart failure (14% vs 16%), coagulopathy (7% vs 8%), diabetes mellitus (41% vs 39%), alcohol abuse (5% vs 7%), obesity (27% vs 25%), and hyperlipidemia (75% vs 71%) were not felt to be clinically significant.

Outcomes of propensity score–matched cohorts by treatment group are presented in Table 2. In terms of inpatient complications, the posterior fusion group had a

Table 2. Outcomes of propensity score–matched cohorts by treatment group (*N* = 12,248).

	PCDF (*N* = 6124)	ACDF (*N* = 6124)	OR (95% CI)	*P*
Inpatient complications				
Coma, *n* (%)	34 (0.6)	27 (0.4)	1.26 (0.75–1.77)	0.37
Death	0 (0)	0 (0)	NA	1.00
Hematoma formation	94 (1.5)	84 (1.4)	1.12 (0.83–1.51)	0.45
Dysphagia	100 (1.6)	163 (2.7)	0.61 (0.36–0.86)	0.0001
UTI	701 (11.4)	304 (5.0)	2.47 (2.34–2.61)	<0.0001
DVT	261 (4.3)	140 (2.3)	1.90 (1.69–2.11)	<0.0001
PE	113 (1.8)	65 (1.1)	1.75 (1.45–2.06)	0.0003
30-Day complications				
Stroke	255 (4.2)	154 (2.5)	1.68 (1.48–1.89)	<0.0001
Wound dehiscence	164 (2.7)	30 (0.5)	5.59 (5.20–5.98)	<0.0001
Surgical site infection	289 (4.7)	63 (1.0)	4.76 (4.49–5.04)	<0.0001
Wound revision surgery	72 (1.2)	24 (0.4)	3.02 (2.56–3.49)	<0.0001
All-cause readmission	1253 (20.5)	694 (11.3)	2.01 (1.91–2.11)	<0.0001
1-Year outcomes				
Pseudarthrosis	288 (4.7)	122 (2.0)	2.43 (1.96–3.01)	<0.0001
Revision or extension of index surgery	485 (7.9)	218 (3.6)	2.33 (2.17–2.49)	<0.0001
Additional anterior or posterior fusion	265 (4.3)a	429 (7.0)b	0.60 (0.44–0.76)	<0.0001

Abbreviations: ACDF, anterior discectomy and fusion; DVT, deep vein thrombosis; NA, not applicable.; PCDF, posterior decompression and fusion; PE, pulmonary embolism; UTI, urinary tract infection.
Data presented as *n* (%) unless otherwise indicated.
[a]Additional ACDF surgery.
[b]Additional PCDF surgery.

Table 3. Narcotic use of propensity score-matched cohorts by treatment group (*N* = 12,248).

	PCDF (*N* = 6124)	ACDF (*N* = 6124)	OR (95% CI)	*P*
Frequency of narcotic use				
30-day narcotic use, *n* (%)	4208 (68.7)	4338 (70.8)	0.90 (0.83–0.98)	0.01
60-day narcotic use, *n* (%)	3990 (65.2)	4185 (68.3)	0.79 (0.79–0.94)	0.0002
90-day narcotic use, *n* (%)	3818 (62.3)	4055 (66.2)	0.84 (0.77–0.92)	<0.0001
120-day narcotic use, *n* (%)	3674 (60.0)	3943 (64.4)	0.83 (0.76–0.90)	<0.0001
Level of narcotic use				
30-day mean MME, mg	1584.25	1384.64	1.19 (1.11–1.28)	<0.0001
60-day mean MME, mg	1601.76	1395.59	1.20 (1.12–1.28)	<0.0001
90-day mean MME, mg	1614.86	1402.07	1.21 (1.12–1.29)	<0.0001
120-day mean MME, mg	1624.52	1408.09	1.21 (1.13–1.29)	<0.0001

Abbreviations: ACDF, anterior discectomy and fusion; CSM, cervical spondylotic myelopathy; MME, morphine milligram equivalent; PCDF, posterior decompression and fusion.
Data presented as n (%) unless otherwise indicated.

higher rate of urinary tract infection (UTI) (OR 2.47, *P* < 0.0001), deep vein thrombosis (DVT) (OR 1.90, *P* < 0.0001), and pulmonary embolism (PE) (OR 1.75, *P* < 0.0001). However, the rate of dysphagia (OR 0.61, *P* = 0.0001) was significantly lower in the posterior fusion group. There were no cases of inpatient mortality in either fusion cohort. In regards to 30-day outcomes, the posterior fusion group demonstrated higher rates of stroke (OR 1.68, *P* < 0.0001), wound dehiscence (OR 5.59, *P* < 0.0001), surgical site infection (OR 4.76, *P* < 0.0001), wound revision surgery (OR 3.02, *P* < 0.0001), and all-cause readmission (OR 2.01, *P* < 0.0001). Finally, 1-year outcomes revealed higher rates of pseudarthrosis (OR 2.43, *P* < 0.0001) and revision or extension surgery (OR 2.33, *P* < 0.0001) in the posterior fusion cohort. However, the PCDF cohort demonstrated a lower rate of additional ACDF surgery (OR 0.60, *P* < 0.0001) in comparison to the rates of additional PCDF surgery performed for the ACDF cohort.

Narcotic use of propensity score-matched cohorts by treatment group is presented in Table 3. Mean MME remained largely stable at 30, 60, 90, and 120 days for both cohorts. However, the posterior fusion group demonstrated a statistically significant higher mean MME in comparison to the posterior fusion group at 30 days (OR 1.19, *P* < 0.0001), as well as 60 (OR 1.20, *P* < 0.0001), 90 (OR 1.21, *P* < 0.0001), and 120 (OR 1.21, *P* < 0.0001) days. In contrast to lower mean MME, the frequency of narcotic use at 30 days (OR 0.90, *P* < 0.0001) was significantly lower in the posterior fusion group. Similarly, this difference persisted at 60, 90, and 120 days.

DISCUSSION

The results of the current study suggest that in cases of multilevel CSM, an anterior surgical approach to decompression and fusion is generally superior to a posterior approach in terms of perioperative complication rates, outcomes, and narcotic use. These findings are a significant addition to the current literature, in which a number of prior investigations have demonstrated unclear evidence in regards to both outcomes and complications in comparing CSM patients undergoing ACDF vs PCDF. Frequently reported outcomes and complication data among these studies include 30-day readmission rates, complication rates, and reoperation rates, all of which were assessed in our analysis. However, the billing data utilized in the current study did not enable the assessment of other often-reported endpoints, such as blood loss, operative time, or patient-reported outcomes.

Complications and Outcomes

The complication data presented in this study are in agreement with most previously reported data, finding posterior fusion to be associated with higher rates of inpatient complications and 30-day readmission. The elevated risks of UTI and DVT/PE may be partially explained by the increased length of stay (LOS) demonstrated by posterior fusion patients. Furthermore, prone positioning during surgical intervention may specifically predispose patients to thromboembolic complications such as DVT/PE secondary to reduced venous return. The significantly increased odds of dysphagia in ACDF patients found in this study and throughout the literature are generally accepted to stem from the increased esophageal manipulation inherent to the procedure.[8]

A detailed investigation of 30-day complications in the current study also found increased rates of wound dehiscence, surgical site infection, and wound revision surgery associated with PCDF. Elevated rates of wound complications have been well documented in the literature.[9,10] A number of factors may contribute to these findings, including the increased LOS associated with posterior fusions in addition to patients spending significant time in bed with pressure on the wound. Furthermore, the posterior approach necessitates a more elaborate multilayer closure with greater tension on the surgical wound, also potentially increasing the risk of wound breakdown or infection.

The current study also expands on previously reported data with follow-up captured by the Humana Database, finding that the posterior fusion cohort demonstrated a significantly higher rate of pseudarthrosis or nonunion (4.7% vs 2.0%, OR 2.43, $P < 0.0001$). In addition, also demonstrated was a significantly higher rate of revision or extension surgery in the same cohort. Contrary to this finding, however, the anterior fusion group had a higher rate of necessitating additional nonrevision surgery, in this case PCDF. This preference by spine surgeons to perform a posterior fusion after nonunion of an ACDF may be explained by a reluctance to reopen an anterior approach secondary to scar formation and the difficulty in revising these grafts. This preference may also reflect the higher fusion rates and lower incidence of repeat revision surgery demonstrated for PCDF following initial ACDF pseudoarthrosis.[11]

Opioid Utilization

The rising concerns of an opioid epidemic in the United States has resulted in greater awareness of opioid usage across specialties. In regards to spine surgery, preoperative narcotic use has been shown to have a potentially significant impact on outcomes following ACDF.[12] In a prospective cohort analysis of 583 patients, Lee et al reported that 56% of patients reported some degree of opioid use prior to cervical or thoracolumbar surgery.[13] Overall, there is unclear evidence regarding rates of postoperative narcotic utilization in cervical spine surgery and no data comparing anterior and posterior fusion groups. In a database study of 17,391 patients, Pugely et al demonstrated significantly higher narcotic prescription fill rates in opioid users compared to opioid-naive patients at 30 days (82% vs 48%) and at 1 year (45% vs 6%).[14] The results of our study suggest a greater incidence of narcotic use after anterior fusion, but that patients undergoing posterior fusion may require larger doses of narcotics for pain management. This significant difference in mean MME may be explained by the greater degree of muscle and fascial dissection necessary in the posterior approach and the resulting pain. In contrast, while anterior fusions may be performed with less dissection and subsequent pain, a greater portion of these patients may have a history of preoperative opioid use. Of note, Pugely et al did in fact note a significantly higher rate of preoperative opioid use in anterior fusions compared to posterior fusions (53.4% vs 44.9%, $P < 0.001$).[14]

Review of the Literature

A recent systematic review and meta-analysis by Zhang et al (2019), which amalgamated 959 ACDF and 1072 PCDF patients treated for multilevel CSM from 24 prospective and retrospective comparative studies, concluded that in comparison to the posterior approach, the anterior approach was associated with significant increases in Japanese Orthopedic Association (JOA) score (SMD: 0.36, 95% CI 0.10–0.62) and neurological recovery rate (WMD: 10.55, 95% CI 3.99–17.11), yet was correlated with greater operative time (WMD: 49.87, 95% CI 17.67–82.08).[6] Similarly, a systematic review and meta-analysis by Luo et al (2015) of randomized-controlled or nonrandomized-controlled trials published up to November 2014 comparing the effectiveness of anterior and posterior surgical approaches for the treatment of multilevel CSM found a significantly higher JOA score in the anterior surgery group in 5 studies involving 420 patients (WMD 0.79, 95% CI 0.16–1.42), a significantly higher operative time in the anterior surgery group in 4 studies involving 252 patients (WMD 61.3, 95% CI 52.33–70.28), and a significantly higher postoperative complication rate in the anterior surgery group in 9 studies involving 804 patients (OR 1.65, 95% CI 1.13–2.39).[15] However, in contrast with the analysis conducted by Zhang et al, which accounted for many more recent retrospective and prospective studies, Luo et al found no statistically significant difference in neurological recovery rate between the anterior and posterior surgery groups. Since the time period covered by these 2 analyses, Audat et al (2018) noted no radiographic or clinical differences between anterior and posterior decompression groups, with the exception of a significantly greater improvement in Neck Disability Index in the anterior approach, which was deemed by the authors not to be a clinically significant difference.[16]

The studies included in either of the 2 previously mentioned reviews comprised largely retrospective analyses, and these were virtually always from a single institution, which may hamper the generalizability of each to a more general population. Of the 7 prospective studies in either of the aforementioned meta-analyses, the vast majority were nonrandomized observational studies, and of those randomized trials, only 2 were multicenter: US-based Fehlings et al (2013) and international study Kato et al (2017), which also stood as the largest study to date by sample size ($N = 435$).[17,18] In light of this, the current study stands as the largest retrospective or prospective analysis on the topic conducted to date, as well as its first nationwide analysis.

Several recent and worthwhile studies comparing ACDF and PCDF were not mentioned in the aforementioned meta-analyses. First, an analysis of prospectively collected quality outcomes data from 245 patients (163 anterior and 82 posterior) comparing the 2 approaches for 3- to 5-level Degenerative cervical myelopathy (DCM) conducted by Asher et al (2019) demonstrated shorter hospital LOS for anterior approaches ($P < 0.001$, OR 0.16, 95% CI 0.08–0.30), but similar 12-month Neck Disability Index, EuroQol instrument (EQ5D), numeric rating scale of neck pain and arm pain, modified Japanese Orthopedic Association score for myelopathy, North American Spine Society satisfaction questionnaire score as well as 90-day readmission and return to work.[19] An analysis of 3057 surgical CSM cases from the American College of Surgeons National Surgical Quality Improvement Program by Passias et al (2018) similarly found the posterior surgical approach to be associated with an LOS greater than 4 days ($P < 0.001$, OR 2.695, 95% CI 3.676–1.976), in addition to a higher frequency of readmission when compared to anterior fusion (55.7% vs 44.3%; $P = 0.005$).[20]

The uncertainty regarding the relative prevalence of surgical complications between anterior and posterior approaches was exemplified in a survey study of 916 AOSpine International members conducted by Tetreault et al (2015), in which 40.48% of respondents reported higher complication rates in posterior surgery compared with anterior surgery, 29.48% reported higher complication rates in anterior surgery compared with posterior, and 30.14% reported no difference.[21] However, the aforementioned meta-analysis by Zhang et al reported pooled results of 15 studies with 667 patients in the posterior approach group and 683 patients in the anterior approach group showing significantly higher rates of complications in the anterior approach group (relative risk = 1.53, 95% CI 1.24–1.89).[6] Veeravagu et al (2016) used MarketScan data from 2006 to 2010 to identify 35,962 CSM patients, ultimately finding an overall complication rate of 15.6% among the 30,600 CSM patients who underwent ACDF compared to an overall complication rate of 29.2 % in the 3540 CSM patients who underwent posterior fusion, a statistically significant difference.[22]

Limitations

There exist a number of limitations that govern our study, especially as it pertains to the use of a large health-care database. These limitations are well known in the medical literature. Given that our study relied on ICD-9-CM and ICD-10-CM codes for identification of patient demographics and outcomes, there exists a distinct possibility of underreporting, missed codes, and/or inaccurate codes secondary to input errors. Additionally, the majority of our dataset is based on ICD-9-CM coding; in comparison to ICD-10-CM, ICD-9-CM codes are generally less granular and use broad-based definitions for disease processes. These limitations may limit the utility of the matching process employed as, for example, comorbidities reported may be inaccurate. Moreover, this limitation underlies an inherent obstacle in the use of large health-care databases regardless of ICD variant in that these datasets have limited, albeit improving, granularity in general. Similarly, we are unable to assess exactly how the presence of pseudarthrosis was determined by providers, and if pseudarthrosis was the causative factor in subsequent revision surgery. In general, the indication for reoperation is not recorded in the claims database. We lament that reoperation reasons cannot be more fully explored. Instead, we have reported all-cause revision rates, which inherently lack specificity. While the Humana Claims Database allows for an immense amount of data collection, it is not designed for usage specifically for surgical spine patients. Consequently, validated patient-reported outcome measures such as the Neck Disability Index, visual analog scale, or Oswestry Disability Index are unable to be assessed for these patients. These indices are critical for assessing outcomes in regards to quality of life and functional status. Finally, the use of propensity matching for generating equal and similar cohorts, while useful in large datasets, is in no way a substitute for prospective randomization.

CONCLUSIONS

This nationwide analysis of multilevel CSM patients found the posterior approach for decompression and fusion to be associated with increased rates of inpatient complications, wound complications, 30-day readmission, 1-year pseudarthrosis, and 1-year revision or extension surgery. In addition, patients undergoing posterior fusion demonstrated higher levels of narcotic use up to 120 days after surgery.

REFERENCES

1. Gibson J, Nouri A, Krueger B, et al. Degenerative cervical myelopathy: a clinical review. *Yale J Biol Med*. 2018;91(1):43–48.

2. Nouri A, Tetreault L, Singh A, Karadimas SK, Fehlings MG. Degenerative cervical myelopathy: epidemiology, genetics, and pathogenesis. *Spine (Phila Pa 1976)*. 2015;40(12):E675-93. doi:10.1097/BRS.0000000000000913

3. Badhiwala JH, Witiw CD, Nassiri F, et al. Efficacy and safety of surgery for mild degenerative cervical myelopathy: results of the AOSpine North America and international prospective multicenter studies. *Neurosurgery*. 2019;84(4):890–897. doi:10.1093/neuros/nyy133

4. Bakhsheshian J, Mehta VA, Liu JC. Current diagnosis and management of cervical spondylotic myelopathy. *Global Spine J*. 2017;7(6):572–586. doi:10.1177/2192568217699208

5. Klineberg E. Cervical spondylotic myelopathy: a review of the evidence. *Orthop Clin North Am*. 2010;41(2):193–202. doi:10.1016/j.ocl.2009.12.010

6. Zhang L, Chen J, Cao C, et al. Anterior versus posterior approach for the therapy of multilevel cervical spondylotic myelopathy: a meta-analysis and systematic review. *Arch Orthop Trauma Surg*. 2019;139(6):735–742. doi:10.1007/s00402-018-03102-6

7. Liu CY, Zygourakis CC, Yoon S, et al. Trends in utilization and cost of cervical spine surgery using the national inpatient sample database, 2001 to 2013. *Spine (Phila Pa 1976)*. 2017;42(15):E906–E913. doi:10.1097/BRS.0000000000001999

8. Cheung JPY, Luk KD-K. Complications of anterior and posterior cervical spine surgery. *Asian Spine J*. 2016;10(2):385–400. doi:10.4184/asj.2016.10.2.385

9. Sebastian A, Huddleston P, Kakar S, Habermann E, Wagie A, Nassr A. Risk factors for surgical site infection after posterior cervical spine surgery: an analysis of 5,441 patients from the ACS NSQIP 2005-2012. *Spine J*. 2016;16(4):504–509. doi:10.1016/j.spinee.2015.12.009

10. Kwon BK, Fisher CG, Boyd MC, et al. A prospective randomized controlled trial of anterior compared with posterior stabilization for unilateral facet injuries of the cervical spine. *J Neurosurg Spine*. 2007;7(1):1–12. doi:10.3171/SPI-07/07/001

11. Carreon L, Glassman SD, Campbell MJ. Treatment of anterior cervical pseudoarthrosis: posterior fusion versus anterior revision. *Spine J*. 2006;6(2):154–156. doi:10.1016/j.spinee.2005.07.003

12. Lawrence JTR, London N, Bohlman HH, Chin KR. Preoperative narcotic use as a predictor of clinical outcome: results following anterior cervical arthrodesis. *Spine (Phila Pa 1976)*. 2008;33(19):2074–2078. doi:10.1097/BRS.0b013e3181809f07

13. Lee D, Armaghani S, Archer KR, et al. Preoperative opioid use as a predictor of adverse postoperative self-reported outcomes in patients undergoing spine surgery. *J Bone Joint Surg Am*. 2014;96(11):e89):11:. doi:10.2106/JBJS.M.00865

14. Pugely AJ, Bedard NA, Kalakoti P, et al. Opioid use following cervical spine surgery: trends and factors associated with long-term use. *Spine J*. 2018;18(11):1974–1981. doi:10.1016/j.spinee.2018.03.018

15. Luo J, Cao K, Huang S, et al. Comparison of anterior approach versus posterior approach for the treatment of multilevel cervical spondylotic myelopathy. *Eur Spine J*. 2015;24(8):1621–1630. doi:10.1007/s00586-015-3911-4

16. Audat ZA, Fawareh MD, Radydeh AM, et al. Anterior versus posterior approach to treat cervical spondylotic myelopathy, clinical and radiological results with long period of follow-up. *SAGE Open Med*. 2018;6:2050312118766199. doi:10.1177/2050312118766199

17. Fehlings MG, Barry S, Kopjar B, et al. Anterior versus posterior surgical approaches to treat cervical spondylotic myelopathy: outcomes of the prospective multicenter AOSpine North America CSM study in 264 patients. *Spine (Phila Pa 1976)*. 2013;38(26):2247–2252. doi:10.1097/BRS.0000000000000047

18. Kato S, Nouri A, Wu D, Nori S, Tetreault L, Fehlings MG. Comparison of anterior and posterior surgery for degenerative cervical myelopathy: an MRI-based propensity-score-matched analysis using data from the prospective multicenter AOSpine CSM North America and international studies. *J Bone Joint Surg Am*. 2017;99(12):1013–1021. doi:10.2106/JBJS.16.00882

19. Asher AL, Devin CJ, Kerezoudis P, et al. Comparison of outcomes following anterior vs posterior fusion surgery for patients with degenerative cervical myelopathy: an analysis from quality outcomes database. *Neurosurgery*. 2019;84(4):919–926. doi:10.1093/neuros/nyy144

20. Passias PG, Jalai CM, Worley N, et al. Predictors of hospital length of stay and 30-day readmission in cervical spondylotic myelopathy patients: an analysis of 3057 patients using the ACS-NSQIP database. *World Neurosurg*. 2018;110:e450–e458. doi:10.1016/j.wneu.2017.11.009

21. Tetreault L, Nouri A, Singh A, Fawcett M, Nater A, Fehlings MG. An assessment of the key predictors of perioperative complications in patients with cervical spondylotic myelopathy undergoing surgical treatment: results from a survey of 916 AOSpine international members. *World Neurosurg*. 2015;83(5):679–690. doi:10.1016/j.wneu.2015.01.021

22. Veeravagu A, Connolly ID, Lamsam L, et al. Surgical outcomes of cervical spondylotic myelopathy: an analysis of a national, administrative, longitudinal database. *Neurosurg Focus*. 2016;40(6):E11. doi:10.3171/2016.3.FOCUS1669

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