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Postoperative C5 Palsy after Anterior or Posterior Decompression for Degenerative Cervical Myelopathy

A Subgroup Analysis of the Multicenter, Prospective, Randomized, Phase III, CSM-Protect Clinical Trial

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Study Design. Retrospective cohort study of prospectively accrued data.

Objective. To evaluate a large, prospective, multicentre dataset of surgically treated degenerative cervical myelopathy (DCM) cases on the contemporary risk of C5 palsy with surgical approach.

Summary of Background Data. The influence of surgical technique on postoperative C5 palsy after decompression for DCM is intensely debated. Comprehensive, covariate-adjusted analyses are needed using contemporary data.

Methods. Patients with moderate to severe DCM were prospectively enrolled in the multicenter, randomized, Phase III CSM-Protect clinical trial and underwent either anterior or posterior decompression between Jan 31, 2012 and May 16, 2017. The primary outcome was the incidence of postoperative C5 palsy, defined as the onset of muscle weakness by at least one grade in manual muscle test at the C5 myotome with slight or absent sensory disruption after cervical surgery. Two comparative cohorts were made based on the anterior or posterior surgical approach. Multivariate hierarchical mixed-effects logistic regression was used to estimate odds ratios (OR) with 95% confidence intervals (CI) for C5 palsy.

Results. A total of 283 patients were included, and 53.4% underwent posterior decompression. The total incidence of postoperative C5 palsy was 7.4% and was significantly higher in patients who underwent posterior decompression compared with anterior decompression (11.26% vs. 3.03%, $P = 0.008$). After multivariable regression, the posterior approach was independently associated with greater than four times the likelihood of postoperative C5 palsy ($P = 0.017$). Rates of C5 palsy recovery were comparable between the two surgical approaches.

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A.B.B. and M.G.F. designed the study. A.B.B., A.M., and M.A. were involved with data collection and analysis. A.B.B., M.A., and M.G.F. were involved with the drafting of the work. All authors were involved with critical revisions of the manuscript and approved the publication of the study.

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Conclusion. The odds of postoperative C5 palsy are significantly higher after posterior decompression compared to anterior decompression for DCM. This may influence surgical decision-making when there is equipoise in deciding between anterior and posterior treatment options for DCM.

Level of Evidence. Therapeutic Level—II

Key words: degenerative cervical myelopathy, C5 palsy, surgical approach, randomized clinical trial, prospective, outcomes, complications, decompression, cervical spondylotic myelopathy, multicenter

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The onset of motor weakness of the C5 myotome with slight or absent sensory deficits is a well-documented complication after cervical spinal decompression. This complication, termed postoperative C5 palsy, has a recorded incidence on average between 4.6% and 6%, with individual studies reporting up to 30%.[1,2] C5 palsy can lead to extended disability and often worsens quality of life, especially in the elderly.[3] Its incidence after decompression for varying forms of degenerative cervical myelopathy (DCM) is well described in the literature, particularly in cases that are secondary to ossification of the posterior longitudinal ligament (OPLL).[4–6] The etiology and risk factors for the pathogenesis of C5 palsy are highly debated. Previously, it was assumed that the causes were directly linked to surgical techniques, such as evident trauma to the spinal cord or a nerve root during surgery and compression of the nerve roots by a dislocated transplanted strut bone following surgery.[7–9] However, reports have increasingly emerged that there are numerous C5 palsy forms with unknown origins unrelated to surgical intervention. With regards to the late presentation of C5 palsy, the pathogenesis may involve the altered alignment of the cervical spine after decompression surgery, which may cause the spinal cord and/or nerve root to be distracted and/or compressed by nearby anatomical structures such as the facet joint and the vertebral body, especially when patients begin rehabilitation after regaining their standing ability within a week of surgery. According to multiple anatomical analyses by Hirabayashi *et al*, the compression and stretching of the C5 nerve root close to the foramen exit is the most likely cause of C5 palsy. The C5 nerve root has the least range of motion among the cervical nerve roots that make up the brachial plexus because it has the shortest distance between the dura mater's division and the foramen's egress. The posterior rootlets are caudal to the anterior rootlets of the cervical nerve, which means that the anterior rootlets are mechanically stretched and compressed from the caudal side towards the tip of the superior facet joint in the foramen, which is the narrowest portion of the foramen.[9,10]

Hence, an increasing number of studies have emerged attempting to assess the factors associated with C5 palsy and various surgical techniques such as cervical laminoplasties and laminectomies, anterior cervical decompression and fusion (ACDF), and posterior fusion.[11–14] In an effort to compare anterior and posterior surgical approaches, in 2014, Bydon *et al* reviewed the literature on cervical surgeries and found an C5 palsy incidence of 4.6% in anterior surgeries and 8.6% in posterior surgeries.[15] However, a limited number of studies have used a prospective, multicenter study to report the incidence or assess the risk factors for C5 palsy after cervical spine surgery for a purely myelopathic cohort. In this paper, we present a comprehensive study examining the association between surgical approach and the incidence of C5 palsy using one of the largest, contemporary, prospective cohorts of patients with DCM.

MATERIALS AND METHODS

Data Sources

Individual participant data from the CSM-Protect trial were used for this study (ClinicalTrials.gov Identifier: NCT01257828).[16] CSM-Protect was a multicentre, double-blind, placebo-controlled, randomized, phase 3 trial assessing the safety and efficacy of the anticonvulsant medication, riluzole, in patients after surgical decompression for DCM. The trial enrolled 300 patients across 16 university-affiliated centers in Canada and the United States between Jan 31, 2012 and May 16, 2017, following a rigorous assessment of symptoms and patient history. Ultimately, 290 patients underwent decompressive surgery. Detailed information on each patient's demographics, health history, surgery, and complications was recorded. The large sample size and granular data within the trial dataset allowed for a rigorous study of postoperative C5 palsy in patients who underwent decompressive surgery for DCM. Written informed consent was obtained from all patients before study enrolment and 15 or more days before surgery.[16] Ethical approval was obtained from the Institutional Review Board from each of the participating 16 university-affiliated hospitals across Canada and the USA, with Toronto Western Hospital serving as the lead site (University Health Network Research Ethics Board Approval# 11-0548).[16]

Participants and Eligibility Criteria

Adult patients (18-80 years) with symptomatic DCM were included in the CSM-Protect trial. The presence of symptoms was determined following criteria of at least one objective physical examination sign and one clinical symptom related to DCM. All patients received surgical decompression of the cervical spine using an anterior or posterior approach, which was left to the surgeon's discretion. Anterior surgical approaches included corpectomy and ACDF. Posterior surgical approaches included laminectomy with fusion, laminoplasty, and combined laminectomy and laminoplasty. The combined posterior approach included all cases wherein laminectomy and laminoplasty were performed within the same operation. Patients who underwent both anterior and posterior approaches were excluded (n = 7). Patients

were excluded if they had a history of prior surgery for their DCM, cervical spine trauma, neoplastic disease, active infection, or had concomitant symptomatic lumbar stenosis. The study cohort was divided into two comparative groups by surgical approach: anterior surgery and posterior surgery.

Data Extraction

Data relevant to participants' demographics, comorbidities, and surgery were extracted from the CSM-Protect dataset. Demographic variables included age, sex, and race. Measured comorbidities included myocardial infarction, congestive heart failure, hypertension, deep vein thrombosis/pulmonary embolism, chronic obstructive pulmonary disease (COPD), diabetes, anxiety/depression, stroke, and smoking. Baseline surgical variables included procedure type, individual surgical levels as well as multilevel surgery, and operative length. Other variables included baseline modified Japanese Orthopedic Association score (mJOA), Nurick score, Neck Disability Index (NDI), and OPLL.

Outcomes

The primary outcome of the study was the incidence of postoperative C5 palsy. C5 palsy was defined as the onset of muscle weakness by at least one grade in a manual muscle test at the C5 myotome with slight or absent sensory disruption after cervical surgery. Incidence was calculated by dividing the occurrence of postoperative C5 palsy in patients at risk of developing the disease, which encompassed all included study participants. Secondary outcomes were recovery status of C5 palsy, severity of C5 palsy as measured with deltoid strength from 0-5 odds ratio of C5 palsy, and incidence of C5 palsy across surgical procedures.

Statistical Analysis

Descriptive statistics were performed on baseline variables using mean (SD) for continuous variables and frequency (%) for categorical variables. The surgical approach was used to identify comparison cohorts of patients. Baseline variables for the anterior surgical decompression cohort were compared with a patient cohort that underwent posterior surgical decompression using the Student *t*-test for continuous variables, X^2 test for categorical variables, and Fisher exact test for categorical variables with a count of less than five in either cohort. The incidence of C5 palsy was presented as a rate (%). Baseline variables that were significantly different in between-group comparisons were included as covariates in a mixed-effects, multivariable logistic regression approach with hospital site as a random effect, which was used to estimate odds ratios (ORs) with 95% confidence intervals (CIs) for the association between C5 palsy and surgical approach. The rate of complete C5 palsy recovery was compared between study groups with a X^2 test. Between-group comparisons of baseline variables were made between patients with postoperative C5 palsy and those without. Descriptive statistics were performed on a subset of patients who underwent C4-C5 surgery to compare the rate of postoperative C5 palsy between anterior and posterior surgeries. Significance was set at $P < 0.05$ (two-tailed). All analyses were conducted using R, version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Study Population

We identified a total of 290 adult subjects from the CSM-Protect dataset who met our inclusion criteria. After seven individuals were removed according to the exclusion criteria, 283 subjects were included in the analysis. Subjects were 58.6 ± 10.2 yr old and 56.9% male. Subjects had a mean mJOA score of 11.8 ± 1.5, Nurick score of 3.3 ± 0.8, and NDI score of 19.6 ± 9.1. Seventeen percent of patients had OPLL. Most patients received surgery for > 2 cervical levels (91.2%), most commonly with laminectomy with fusion (39.9%), ACDF (35.0%), corpectomy (11.7%), laminoplasty (9.9%), and combined laminectomy and laminoplasty (3.5%). For comparative analysis, the cohort was divided into an anterior surgery group (n = 132, 46.6%) and a posterior surgery group (n = 151, 53.4%). Compared with patients that underwent posterior surgery, the anterior surgery group was younger (56.4 ± 10.0 yr *vs.* 60.6 ± 9.9, $P = 0.001$), had a lower proportion of male patients (47.0% *vs.* 65.6%, $P = 0.002$), and a higher proportion of smokers (68.2% *vs.* 53.6%, $P = 0.018$). The posterior cohort had a greater proportion of patients that underwent decompression of > 2 levels (98.7% *vs.* 82.6%, $P < 0.001$) (Table 1).

Incidence of C5 Palsy

The total incidence of postoperative C5 palsy in the study cohort was 7.4% (n = 21). The incidence of postoperative C5 palsy was significantly greater in the posterior surgery group compared with the anterior surgery group (11.3% *vs.* 3.0%, $P = 0.016$) (Table 2). Rates of recovery were not significantly different between surgical approaches (Table 2). In patients with C5 palsy, deltoid strength was not significantly different between surgical approaches (anterior: 3.5 ± 1.0 *vs.* posterior: 3.5 ± 0.9, $P = 0.956$). When stratifying across procedure types, combined laminectomy and laminoplasty had the highest incidence of 20.0% (n = 2) followed by laminoplasty (n = 4, 14.3%), laminectomy with fusion (n = 11, 9.7%), and ACDF and corpectomy that had the same rate of 3.1% (Table 3) (Supplement 1, Supplemental Digital Content 1, http://links.lww.com/BRS/C445). We performed an additional subgroup analysis of only those procedures that involved the C4-C5 level (n = 152, 53.7%) (Supplement 2, Supplemental Digital Content 2, http://links.lww.com/BRS/C446). In this subgroup, 23 patients (15.1%) underwent anterior surgery, of which 5 were corpectomies (21.7%). All surgeries involving the C4-C5 level were greater than two levels, with 15.8% at three levels, 47.4% at four levels, 35.5% at five levels, and 1.3% undergoing six-level surgery. Anterior surgeries involving the C4-C5 level were either three-level (n = 11, 47.8%) or four-level approaches (n = 12, 52.2%). In this C4-5 subset, there was

TABLE 1. Descriptive Statistics and Comparison of Baseline Variables between Anterior and Posterior Surgery Cohorts and those with and without Postoperative C5 palsy

Baseline variables	Overall (*N* = 283)	Anterior (*N* = 132)	Posterior (*N* = 151)	*P*	No C5 palsy (*N* = 262)	C5 palsy (*N* = 21)	*P*
Age in mean years (SD)	58.60 (10.15)	56.37 (9.99)	60.55 (9.93)	0.001	58.51 (10.05)	59.74 (11.63)	0.594
Male gender (%)	161 (56.9)	62 (47.0)	99 (65.6)	0.002	144 (55.0)	17 (81.0)	0.037
Race (%)				0.205			0.118
White	228 (82.0)	111 (85.4)	117 (79.1)		210 (81.7)	18 (85.7)	
Black or African American	27 (9.7)	8 (6.2)	19 (12.8)		26 (10.1)	1 (4.8)	
Asian	2 (0.7)	1 (0.8)	1 (0.7)		1 (0.4)	1 (4.8)	
American Indian or Alaska Native	14 (5.0)	5 (3.8)	9 (6.1)		14 (5.4)	0 (0.0)	
Unknown	7 (2.5)	5 (3.8)	2 (1.4)		6 (2.3)	1 (4.8)	
Patient comorbidities							
Myocardial infarction (%)	4 (1.4)	0 (0.0)	4 (2.6)	0.126	3 (1.1)	1 (4.8)	0.267
Congestive heart failure (%)	6 (2.1)	3 (2.3)	3 (2.0)	1.000	6 (2.3)	0 (0.0)	1.000
Hypertension (%)	78 (27.6)	35 (26.5)	43 (28.5)	0.814	70 (26.7)	8 (38.1)	0.385
DVT/PE (%)	5 (1.8)	2 (1.5)	3 (2.0)	1.000	5 (1.9)	0 (0.0)	1.000
COPD (%)	40 (14.1)	17 (12.9)	23 (15.2)	0.692	38 (14.5)	2 (9.5)	0.761
Diabetes (%)	32 (11.3)	11 (8.3)	21 (13.9)	0.197	30 (11.5)	2 (9.5)	1.000
Anxiety/Depression (%)	47 (16.6)	22 (16.7)	25 (16.6)	1.000	43 (16.4)	4 (19.0)	0.994
Stroke (%)	5 (1.8)	3 (2.3)	2 (1.3)	0.879	5 (1.9)	0 (0.0)	1.000
Former or current smoker (%)	171 (60.4)	90 (68.2)	81 (53.6)	0.018	158 (60.3)	13 (61.9)	1.000
Surgical level							
> 2 surgical levels (%)	258 (91.2)	109 (82.6)	149 (98.7)	< 0.001	238 (90.8)	20 (95.2)	0.777
C1 (%)	5 (1.8)	0 (0.0)	5 (3.3)	0.097	5 (1.9)	0 (0.0)	1.000
C2 (%)	267 (94.3)	119 (90.2)	148 (98.0)	0.009	247 (94.3)	20 (95.2)	1.000
C3 (%)	70 (24.7)	2 (1.5)	68 (45.0)	< 0.001	62 (23.7)	8 (38.1)	0.226
C4 (%)	248 (87.6)	107 (81.1)	141 (93.4)	0.003	229 (87.4)	19 (90.5)	0.947
C5 (%)	184 (65.0)	46 (34.8)	138 (91.4)	< 0.001	167 (63.7)	17 (81.0)	0.176
C6 (%)	189 (66.8)	69 (52.3)	120 (79.5)	< 0.001	171 (65.3)	18 (85.7)	0.094
C7 (%)	236 (83.4)	88 (66.7)	148 (98.0)	< 0.001	215 (82.1)	21 (100.0)	0.069
Baseline mean mJOA score (SD)	11.77 (1.52)	11.91 (1.47)	11.65 (1.56)	0.160	11.75 (1.52)	12.00 (1.55)	0.479
Baseline mean Nurick score (SD)	3.32 (0.82)	3.24 (0.75)	3.39 (0.87)	0.139	3.31 (0.83)	3.48 (0.60)	0.360
Baseline mean NDI score (SD)	19.61 (9.06)	20.70 (9.21)	18.63 (8.84)	0.060	19.47 (9.10)	21.37 (8.47)	0.380
OPLL (%)	48 (17.0)	19 (14.4)	29 (19.2)	0.359	44 (16.8)	4 (19.0)	1.000
Riluzole (%)	138 (48.8)	61 (46.2)	77 (51.0)	0.494	127 (48.5)	11 (52.4)	0.906
Operative length in mean hours (SD)	3.11 (1.44)	3.02 (1.55)	3.18 (1.35)	0.342	3.09 (1.43)	3.39 (1.64)	0.348
Procedure type (%)							0.066
ACDF	99 (35.0)	99 (75.0)	0 (0.0)		96 (36.6)	3 (14.3)	
Corpectomy	33 (11.7)	33 (25.0)	0 (0.0)		32 (12.2)	1 (4.8)	
Combined laminectomy and laminoplasty	10 (3.5)	0 (0.0)	10 (6.6)		8 (3.1)	2 (9.5)	
Laminectomy with fusion	113 (39.9)	0 (0.0)	113 (74.8)		102 (38.9)	11 (52.4)	
Laminoplasty	28 (9.9)	0 (0.0)	28 (18.5)		24 (9.2)	4 (19.0)	

ACDF indicates anterior cervical discectomy and fusion; COPD, chronic obstructive pulmonary disease; DVT/PE, deep vein thrombosis/pulmonary embolism; mJOA, modified Japanese Orthopedic Association; NDI, Neck Disability Index; OPLL, ossification of the posterior longitudinal ligament; SD, standard deviation.

no incidence of C5 palsy in any of the anterior procedures (ACDF or corpectomy), while in the posterior group, the incidence was found to be 12.5% (n = 3/24) for laminoplasty, 10.3% for laminectomy and fusion (n = 10/97), and 25% for combined laminectomy and laminoplasty (n = 2/8).

Baseline Variables and C5 Palsy

In between-group comparisons of baseline factors between patients with postoperative C5 palsy and without, the C5 palsy group had a greater proportion of male patients (81.0% *vs.* 55.0%, $P = 0.037$) (Table 1). There were no other statistically significant differences in baseline

TABLE 2. Rates of C5 Palsy after Anterior Cervical Decompression Compared to Posterior Cervical Decompression

	Overall (N = 283)	Anterior (N = 132)	Posterior (N = 151)	*P*
C5 palsy (%)	21 (7.4)	4 (3.0)	17 (11.3)	0.016
Rates of C5 palsy recovery (%)				0.533
Complete Recovery	13 (68.4)	2 (66.7)	11 (68.8)	
Incomplete Recovery	3 (15.8)	0 (0.0)	3 (18.8)	
No recovery	3 (15.8)	1 (33.3)	2 (12.5)	

TABLE 3. Rates of Postoperative C5 Palsy by Type of Procedure

Procedure type	Overall (N = 283)	No C5 palsy	C5 palsy
ACDF (%)	99 (35.0)	96 (96.9)	3 (3.1)
Corpectomy (%)	33 (11.7)	32 (96.9)	1 (3.1)
Combined laminectomy and laminoplasty (%)	10 (3.5)	8 (80.0)	2 (20.0)
Laminectomy with fusion (%)	113 (39.9)	102 (90.3)	11 (9.7)
Laminoplasty (%)	28 (9.9)	24 (85.7)	4 (14.3)

ACDF indicates anterior cervical discectomy and fusion.

variables, including preoperative disease and symptom severity, as measured by mJOA, NDI, and Nurick scores.

Multivariable Analysis

After mixed-effects regression including age, gender, smoking status, ≤ 2 surgical levels versus >2 levels, and hospital site as a random effect, only the surgical approach was independently associated with C5 palsy. Patients receiving posterior surgical decompression had a greater than four-fold odds of C5 palsy as compared to the anterior surgery group (OR: 4.61 95% CI [1.32–16.12], $P = 0.017$) (Fig. 1).

DISCUSSION

We describe a comprehensive analysis using a contemporary, prospective dataset on C5 palsy in DCM. We found that a posterior surgical approach for DCM was associated with a nearly 5-fold increase in the risk of C5 palsy. With regards to the rate of C5 palsy for individual posterior procedures, the highest rate of C5 palsy was found to be among patients undergoing combined laminoplasty and laminectomy with instrumentation (2/10, 20%), followed by laminoplasty (4/28, 14.3%) and laminectomy with instrumentation (11/113, 9.7%). For anterior approaches, the rate of C5 palsy was found to be 3.1% each for ACDF and corpectomy.

Our contemporary analyses are generally consistent with those reported in prior literature. According to a systematic review of 11,481 patients,[17] the rate of C5 palsy among all cervical surgery was found to be 6.3%, and among patients undergoing surgery for OPLL, significantly higher (8.1%) compared with patients with CSM (4.8%). Although OPLL is now covered under the umbrella term of DCM,[18] we analyzed the rate of C5 palsy for patients undergoing surgery for OPLL and found that the rate was 8.3%, which was only marginally higher than the rate for all other cases of DCM (7.2%). This lack of a significant difference in the rate of C5 palsy between OPLL and non-OPLL is interesting because OPLL has historically been reported as a significant risk factor for developing C5 palsy. According to a systematic review in 5195 patients undergoing posterior cervical surgery, OPLL was found to be associated with a greater than 2-fold increase in the risk of C5 palsy (OR 2.188; 95% CI, 1.307-3.665).[19] Although several studies have shown a higher rate of C5 palsy among patients with OPLL, the exact mechanism or rationale behind this increased risk is poorly understood. Some experts have suggested that the C5 nerve root may be more affected by the spinal cord displacement and tethering caused by the ossified hypertrophic posterior longitudinal ligament.[20] Our results may also be attributed to the evolution of a preferred surgical approach for OPLL. Historically, either a laminoplasty or laminectomy with or without instrumentation was preferred for OPLL; however, recent studies have shown that anterior approaches may also be effective. Moghaddamjou and Fehlings *et al* opined that an anterior approach should, in theory, result in better neurological outcomes because it directly accomplishes decompression and, that compared to posterior techniques, anterior surgery results in better postoperative spinal alignment, albeit with a higher rate of other complications.[21] Hence, given

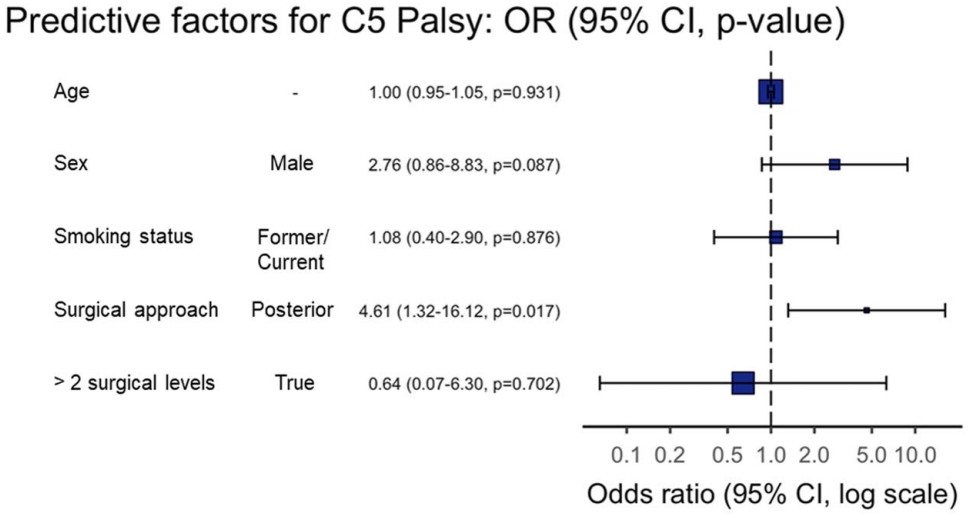

Figure 1. Forest plot of predictive factors for postoperative C5 palsy after multivariate regression. CI indicates confidence interval; OR, odds ratios.

that 40% of OPLL patients in our cohort underwent an anterior approach and that an anterior approach is itself associated with a lower rate of C5 palsy, this may have resulted in the lower rate of C5 palsy among OPLL patients, which is in contrast to previous studies.

The association between surgical approach and incidence of C5 palsy has previously been reported. In a systematic review analyzing risk factors associated with C5 palsy, the authors reported a pooled average incidence of 4.3% for anterior approaches and 8.5% for posterior approaches.[2] However, it is important to note that no study has previously identified a posterior approach to be associated with higher odds among patients undergoing surgery for myelopathy using multivariable analysis. Ours is the first to establish the independent risk of posterior surgery with an incidence of C5 palsy while adjusting for potential confounders. Several theories have been put forth to explain this higher incidence of C5 palsy among patients undergoing posterior cervical surgery, including direct nerve root injury (mechanical, electrical, or thermal trauma at the time of surgery), nerve root ischemia, reperfusion injury post-decompression, segmental spinal cord injury or dysfunction, preoperative and subsequent postoperative axial spinal cord rotation, and nerve root tethering with subsequent post-decompression traction injury, which has been shown to occur with dorsal spinal cord migration following a posterior decompression.[1,22–25]

With regard to the rate of C5 palsy for each individual surgical procedure, we found that the highest rate was among those undergoing combined posterior laminoplasty and laminectomy. The authors acknowledge that there were only 10 patients who underwent this procedure, and 2 of them developed C5 palsy. Hence, there may be some selection bias due to low sample size. Thus, although our cohort had a distinctly higher incidence of postoperative C5 palsy, due to the limited sample size, there is likely not enough information to suggest that this approach should be avoided in practice. However, our finding highlights the need for scrutiny when considering this procedure and the importance of further study with granular details on individual procedural techniques. The literature is mixed with regard to the rate of C5 palsy for this procedure. In a retrospective single-institutional study,[26] comparing the incidence of C5 palsy between patients undergoing laminoplasty alone and those undergoing laminoplasty and posterior fusion over a period of 10 years, the authors reported a C5 palsy incidence of 50% for the combined laminoplasty and posterior fusion, compared to 8% among patients undergoing laminoplasty alone. This may be explained by the fact that when laminoplasty is combined with posterior instrumented fusion, additional risk factors may exist attributable to the iatrogenic foraminal stenosis that may develop as a result of an anterolisthetic vertebra being pulled posteriorly by the instrumentation's "lag correction effect".[27,28]

Our finding that corpectomy and ACDF had the same rate of C5 palsy (3.1%) is also an interesting finding that warrants further discussion. This finding contrasts with what has previously been reported. In a systematic review and meta-analysis consisting of 3098 patients undergoing anterior cervical surgery,[29] the authors found that ACDF was associated with significantly decreased odds of developing C5 palsy (OR 0.42, 95% CI 0.22-0.82) among cases with greater than 2 level surgery. Interestingly, the authors found no difference in the incidence of C5 palsy between ACDF and corpectomy for 1-2 level surgery. Thus, the conventional wisdom has been that even in anterior cases, larger decompressions could theoretically result in C5 palsy due to larger spinal cord shifts.

Limitations

There are several limitations to the study. The bilateral or unilateral nature of C5 palsy was not included in the analysis and reporting due to its inconsistent documentation. Our reasoning to conduct a cohort study that was not matched was due to the ambiguity in risk factors for C5 palsy in the literature, likely owed to the potential multifactorial pathophysiology of the disease. Furthermore, the choice of surgical approach was left to the discretion of the attending surgeon. This may introduce selection bias that may impact the primary outcome, particularly in the absence of quasi-experimental methods like propensity score matching. Moreover, given the multi-institutional nature of the study, procedural nuances were not standardized, and hence, there may have been some variability in the surgical techniques performed, including laminoplasty (French-door *vs.* open-door) or laminectomy (trough width, acquired lordosis with intraoperative extension, etc) as well as additional foraminotomies. Furthermore, given the nonstandardized nature of approaches, the combined laminectomy and laminoplasty group may have included an inconsistent and heterogeneous combination of the two approaches that may have impacted the outcome. Moreover, when stratified by individual procedure type, the subset sample sizes were insufficient to detect any meaningful differences. Furthermore, in our multivariable analysis, we dichotomized the number of surgical levels to ≤ 2 levels versus more than 2 levels, and hence, we did not individually investigate further distinct levels. Thus, it is possible that the number of levels may have been a significant contributor if the analysis included granular surgical levels. Therefore, our findings are restricted to no differences between ≤ 2 levels versus more than 2 levels. With regard to lordosis, the degree of preoperative and postoperative lordosis was not accounted for in our multivariable analysis and may be an avenue for further study. We also acknowledge that fewer cases in the anterior group compared with the posterior group involved the C4-C5 level, which may reflect a selection bias of anterior surgery for decompressions involving fewer levels, and another factor explaining the lower rate of C5 palsy. Future studies may be strengthened by prospectively collecting data on the timing of the onset of C5 palsy (immediate *vs.* delayed), timing of recovery, and localization of the palsy (eg, hinge *vs.* open side in laminoplasty) as well as possible confounders such as foraminal diameter and cord rotation and a focused patient enrollment of C4-C5 surgical decompression.

CONCLUSION

The odds of postoperative C5 palsy are significantly higher in patients who received posterior decompression compared with anterior decompression for moderate and severe DCM. This may influence surgical decision-making when discussing the risks and benefits between anterior and posterior treatment options for DCM.

➢ Key Points

- ❑ The posterior surgical approach for degenerative cervical myelopathy is associated with greater than four-fold odds of postoperative C5 palsy than anterior approaches.
- ❑ Combined laminectomy and laminoplasty had the highest incidence of C5 palsy, followed by laminoplasty, then laminectomy with fusion.
- ❑ Corpectomy and ACDF had similar rates of postoperative C5 palsy.

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