Comparing ACDF Outcomes by Cervical Spine Level: A Single Center Retrospective Study

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INTRODUCTION: Anterior cervical discectomy and fusion (ACDF) is one of the most common procedures utilized for treatment of cervical radiculopathy and myelopathy. Minimal data is available analyzing the effects of C3-C4 involvement in ACDF. Given higher level of cord involvement and greater complexity of anatomy at this level of the cervical spine, we hypothesize that the patients undergoing ACDF with involvement of the C3-C4 level have higher rates of postoperative dysphagia and greater lengths of hospital stay.

METHODS: A retrospective chart review was conducted on all patients diagnosed with cervical myelopathy or radiculopathy due to degenerative disc disease and treated with an anterior cervical discectomy and fusion (ACDF) from January 2012 to September 2022 at a single academic center. Trauma patients were excluded. Patients undergoing revision surgery, having undergone previous undocumented ACDF surgery, and those involving levels outside of C3-C7 were excluded. Patients were grouped based on C3-4 level inclusion within the ACDF construct versus those without C3-4 level involvement. Patients' demographics, clinical characteristics, and surgical outcomes including procedure time, length of hospital stay (LOS), improvement in neurological symptoms, major and minor complications, and discharge disposition were collected from medical records. Major and minor complications were defined according to *Campbell et* al[1]. Data were analyzed using SAS version 9.4. Baseline patient characteristics and outcomes were compared between groups using the chi-square test for categorical variables and the Student's t-test for continuous normally distributed variables.

RESULTS: Eight-hundred and sixty patients were included in the study. Patients with C3-C4 involvement were found to be older (58.4 vs. 53.6, p=<0.0001), with increased likelihood of being African American (56.7% vs. 36%, p=<0.0001) and/or male (70.1% vs. 46.9%, p=<0.0001). In addition, both the C3-C4 inclusion group and the group without C3-C4 involvement had a high percentage of Medicaid (18.9% and 27.4%, respectively) and Medicare patients (43.6% and 32.4%, respectively). In the C3-C4 inclusion group, 15.5% of cases involved the maximum of four fusions between C3 and C7 (C3-C4, C4-C5, C5-C6, C6-C7) while the group without C3-C4 involvement had 14.1% of cases involving the maximum of three cervical fusions between C4 and C7 (C4-C5, C5-C6, C6-C7). There was no significant difference in median follow up time between the two groups and was 207 days (min – max: 0 – 3,347) for ACDFs with C3-C4 involvement and 202 days (0 – 3,820) for ACDFs without C3-C4 involvement (p=0.764). Median surgery time was 3 hrs and 4 min (44 min – 7 hrs and 39 min) for ACDFs with C3-C4 involvement and 2 hrs and 44 min (43 min – 8 hrs and 22 min) for ACDFs without C3-C4 involvement (p=0.0003). In multivariable analysis, after adjusting the outcomes in Table 1 for the variables reported in the results stated above, ACDFs with C3-C4 involvement was associated with a 79% increase in the odds of being discharged to a rehabilitation facility instead of home (adjusted odds ratio=aOR: 1.79, 95% CI: 1.07-3.00), and higher adjusted odds of having at least one minor complication (aOR: 1.82, 95% CI: 1.24-2.67). Specifically, the odds of dysphagia were 66% higher in the C3-C4 inclusion group (aOR: 1.66, 95% CI 1.09-2.53). In addition, individuals in the C3-C4 inclusion group were less likely to report an improvement or resolution in their neurological symptoms after surgery (aOR: 0.44, 95% CI: 0.29-0.67). Furthermore, on average patients with ACDFs without C3-C4 involvement stayed nearly one more day in the hospital vs. patients with C3-C4 involvement (1.8 vs. 2.6 days; P<0.0001).

DISCUSSION: C3-C4 fusion involvement has previously been reported as a risk factor for post-ACDF dysphagia. Our results support this. Furthermore, there are additional adverse outcomes associated with C3-C4 involvement such as length of stay and need for rehabilitation. ACDFs with higher numbers of fusion levels involved are reported to be associated with poorer outcomes. After controlling for this confounding variable, our results demonstrate a significant difference in the need for rehabilitation, neurological symptom progression, and prevalence of minor complications in patients undergoing ACDF with C3-C4 involvement versus those without (Table 2).

SIGNIFICANCE/CLINICAL REVELANCE: There is concern with the outcomes associated with ACDF at higher cervical levels. This data set may merit more consideration when surgical intervention would involve an anterior C3-C4 fusion.

Table 1: Outcomes of patients diagnosed with cervical myelopathy who underwent ACDF either without or with C3-C4 involvement (N = 860).

Characteristics	ACDF without C3-C4 (n = 569)	ACDF with C3-C4 (n = 291)	p-value
LOS, mean (95%CI)	1.5 (1.3 – 1.8)	3.0 (2.6 – 3.6)	**<0.0001**
Discharge location, % (n)			**<0.0001**
Home	92.8 (528)	83.5 (243)	
In-patient/out-patient rehabilitation	7.2 (41)	16.5 (48)	
Follow-up PCF needed, % (n)	0.7 (4)	1.7 (10)	0.175
NS post-surgery not available, % (n)	25.9 (147)	23.7 (69)	0.479
NS post-surgery (n=642), % (n)			**0.0001**
Resolved/Improved	75.5 (317)	60.8 (135)	
No change/Worsen	24.5 (103)	39.2 (87)	
Complications			
At least 1 major complication, % (n)	12.8 (73)	15.1 (44)	0.354
New neurologic deficit, % (n)	5.1 (29)	5.2 (15)	0.971
Revision surgery, % (n)	3.2 (18)	4.5 (13)	0.332
At least 1 minor complication, % (n)	18.8 (107)	29.6 (86)	**0.0004**
Dysphagia, % (n)	15.0 (85)	22.0 (64)	**0.01**

Characteristics	aOR (95% CI)
In-patient/out-patient rehabilitation discharge	**1.79 (1.07 , 3.00)**
Post-surgery NS resolved/improved (n=619)	**0.44 (0.29 , 0.67)**
Complications	
At least 1 major complication	1.35 (0.84 , 2.18)
New neurologic deficit	1.61 (0.74 , 3.47)
Revision surgery	1.29 (0.54 , 3.08)
At least 1 minor complication	**1.82 (1.24 , 2.67)**
Dysphagia	**1.66 (1.09 , 2.53)**

Table 2: Adjusted Odds Ratio (aOR) of event for patients diagnosed with cervical myelopathy who underwent ACDF with C3-C4 involvement vs. no C3-C4 involvement (N = 829). Table 2 only includes African American and Caucasian patients due to small cell count when including all recorded demographics.

ACDF = Anterior cervical discectomy and fusion; CI= Confidence interval; NS=Neurological symptoms; LOS= Length of hospital stay; PCF= Posterior cervical fusion.