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Dysphagia May Attenuate Improvements in Postoperative Outcomes Following Anterior Cervical Discectomy and Fusion

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ABSTRACT

Background: Past studies outline potential risk factors for dysphagia following anterior cervical discectomy and fusion (ACDF). Few studies explored the impact of dysphagia, as measured by the swallowing quality of life (SWAL-QOL), on postoperative patient-reported outcome measure (PROM) improvement. This study aimed to determine the relationship between dysphagia and improvement in pain, disability, physical function, and mental health following ACDF.

Methods: A retrospective review of patients undergoing primary 1- or 2-level ACDF was performed. Individuals without a completed preoperative SWAL-QOL were excluded. Outcomes were collected for visual analog scale (VAS) neck and arm pain, Neck Disability Index (NDI), Patient-Reported Outcome Measurement Information System Physical Function (PROMIS-PF), 12-Item Short Form Physical Component Score (SF-12 PCS), 9-Item Patient Health Questionnaire (PHQ-9), and SWAL-QOL. Postoperative improvement from preoperative values was evaluated using a paired *t* test. The impact of SWAL-QOL on each PROM was assessed using linear regression.

Results: A total of 91 patients were included. Mean preoperative SWAL-QoL was 90.4, which worsened at 6 weeks and resolved by 6 months ($P \leq 0.007$, both). VAS neck and arm scores significantly improved postoperatively ($P < 0.001$), as did the NDI score ($P < 0.001$). Physical function significantly improved at 12 weeks and 6 months ($P \leq 0.021$, both). Depressive symptoms improved at 6 weeks and 12 weeks ($P \leq 0.007$, both). Preoperatively, SWAL-QOL demonstrated significant relationships with all PROMs ($P \leq 0.005$, all). At 6 weeks, 12 weeks, and 6 months ($P \leq 0.048$, all), SWAL-QoL again demonstrated a similar significant association with all PROMs. Multiple regression did not demonstrate common demographic or operative variables that were significant predictors of PROMs.

Conclusion: Following ACDF, patients experienced a worsening of dysphagia but resolved by 12 weeks. All PROMs demonstrated significant improvements by the 6-month timepoint, except for PHQ-9. SWAL-QoL demonstrated a significant effect on all postoperative outcomes, which may suggest that this questionnaire could effectively evaluate dysphagia and predict positive or negative outcomes following ACDF.

Level of Evidence: 3

Clinical Relevance: The severity of dysphagia has a significant association with pain, disability, mental health, and physical function patient-reported outcome measures in patients undergoing ACDF.

Cervical Spine

Keywords: dysphagia, cervical fusion, quality of life

INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) is an efficacious treatment option for patients with degenerative cervical spine pathology.[1] While ACDF patients may experience improved pain, disability, and physical function,[2] patients are still at risk for postoperative complications.[3] Of these complications, dysphagia is among the most common.[3–5]

Oropharyngeal dysphagia is a disorder associated with dysfunction of the swallowing mechanism, resulting in difficulty or pain with swallowing.[6] The incidence of postoperative dysphagia was 4% for patients undergoing a single-level procedure in a recent meta-analysis.[7] Although postoperative dysphagia is often transient,[8] the debilitating symptoms may significantly affect a patient's recovery in the acute postoperative period.[9] The swallowing quality of life questionnaire (SWAL-QOL) is a patient-reported outcome measure (PROM) that captures dysphagia-specific outcomes from the patient's perspective.[10] While previous studies in the cervical spine have implemented outcome measures such as the Dysphagia Disability Index (DDI) or the Bazaz dysphagia scale,[11,12] SWAL-QOL's confirmed

validation and reliability for oropharyngeal dysphagia makes it a desired metric to use within the spine population.[13]

While the prevalence of dysphagia following ACDF and other cervical spine procedures is well established, few studies have examined its impact on a patient's postoperative recovery and overall satisfaction. In the spine literature, Paziuk et al demonstrated no relationship between a patient's overall satisfaction level and the presence of postoperative dysphagia following ACDF.[14]

Vaishnav et al studied the association of SWAL-QOL and PROMs, which included visual analog scale (VAS) and the Neck Disability Index (NDI), in an effort to identify predictive factors of postoperative dysphagia.[15] However, little is known about the impact that dysphagia, as recorded by SWAL-QOL, may have on other PROMs in the postoperative period. Dysphagia has been associated with increased rates of anxiety, depression, and overall poor general health within the general population.[16] As such, it may be intuitive that the quantification of postoperative dysphagia may be associated with the overall postoperative outcome following an ACDF.

The purpose of the current study is to demonstrate any relationship between dysphagia and changes in postoperative pain, disability, physical function, and mental health following ACDF procedures. The authors hypothesized that SWAL-QOL results may predict pain, disability, physical function, and mental health among patients who undergo an ACDF procedure.

METHODS

Study Cohort Identification

Patients eligible for this study were identified through a retrospective review of a prospective single-surgeon surgical database for anterior cervical spine procedures performed at the same academic medical institution from November 2014 to December 2019. Inclusion criteria were set to primary, elective, single-level ACDF without posterior instrumentation. Exclusion criteria were set as multilevel procedures or procedures indicated for infectious, malignant, or traumatic etiologies. Additionally, patients who underwent procedures above the C5 level were excluded from analysis, as well as individuals with an incomplete preoperative SWAL-QOL questionnaire. Prior to initiating the study, both Institutional Review Board approval (ORA 14051301) and written informed consent were obtained.

Collection of Data

Patient health information related to demographics, comorbidity burden, physical fitness for surgery, spinal pathology, neuropathy, perioperative characteristics, and postoperative complications were collected. Demographics were restricted to age, self-identified gender, body mass index (BMI), diabetic and active smoker status, and insurance collected. Comorbidity burden was evaluated using the Charlson Comorbidity Index and physical appropriateness for surgery was classified using the American Society of Anesthesiologists physical classification. Other perioperative information included number of operative levels, stratification of level(s) operated on, operative duration (from skin incision to skin closure), estimated intraoperative blood loss (EBL), postoperative length of stay (LOS), and day of discharge.

The primary outcome of interest was symptoms of dysphagia that were evaluated using SWAL-QOL. This survey is a questionnaire that is divided into 11 separate domains that pose a variable number of questions detailing the negative effects of dysphagia on a patient's quality of life. Scores from each domain are equally weighed to generate an overall SWAL-QOL score, with a lower value indicating a worse impact of dysphagia. Secondary outcomes of interest included PROMs that detailed a patient's pain, disability, physical function, and mental health. Pain was evaluated using the VAS while disability utilized the NDI. Physical function was evaluated using 2 separate metrics: the 12-Item Short Form Physical Component Score (SF-12 PCS) and the Patient-Reported Outcome Measurement Information System Physical Function (PROMIS-PF). Mental health was evaluated using the 9-Item Patient Health Questionnaire, which helps capture the frequency of symptoms associated with major depressive disorder as described in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV/V). All surveys were administered and completed through a private portal using the Outcomes Based Electronic Research Database (OBERD, Columbia, MO) at the preoperative, 6-week, 12-week, and 6-month timepoints. All instances of survey completion were performed prior to meeting with the clinician.

Statistical Analysis

Summary statistics were performed for demographic and perioperative characteristics. To evaluate the improvement of each PROM from preoperative baseline values, a paired Student *t* test was performed at each timepoint. SWAL-QOL scores as a predictor for other PROMs were evaluated using a simple linear

Table 1. Patient demographics.

Characteristic	Total ($N = 91$)
Age, y, mean ± SD	48.1 ± 10.1
Body mass index, mean ± SD	29.5 ± 5.7
Gender	
Female	35.2% (32)
Male	64.8% (59)
Diabetic status	
Nondiabetic	85.7% (78)
Diabetic	14.3% (13)
Smoking status	
Nonsmoker	84.6% (77)
Smoker	15.4% (14)
American Society of Anesthesiologists score	
<2	25.0% (18)
≥2	75.0% (54)
Charlson Comorbidity Index score	
<1	38.2% (34)
≥1	61.8% (55)
Insurance	
Medicare/Medicaid	1.1% (1)
Workers' compensation	27.5% (25)
Private	71.4% (65)

Note. Data presented as % (*n*) unless otherwise indicated.

Table 2. Perioperative characteristics.

Characteristic	Total ($N = 91$)
Spinal pathology	
Herniated nucleus pulposus	86.8% (79)
Central spinal stenosis[a]	6.6% (6)
Degenerative disk disease[a]	6.6% (6)
Neuropathy	
Radiculopathy	15.5% (15)
Myelopathy	1.1% (1)
Myeloradiculopathy	83.3% (75)
Number of operative levels	
1 level	62.6% (57)
2 levels	37.4% (34)
Operative level	
C5-C6	29.7% (27)
C6-C7	30.8% (28)
C7-T1	2.2% (2)
C5-C7	35.2% (32)
C6-T1	2.2% (2)
Cervical plating	
Standalone cage	36.3% (33)
Anterior plate	63.7% (58)
Operative time, min, mean ± SD	55.3 ± 15.3
Estimated blood loss, mL mean ± SD	28.3 ± 11.3
Length of stay, h, mean ± SD	9.9 ± 7.5
Day of discharge	
POD 0	83.1% (74)
POD 1	16.9% (15)
In-hospital complications	
Urinary retention[b]	1.0% (1)
Tracheoesophageal hematoma[c]	1.0% (1)

Abbreviation: POD, postoperative day.
Note: Data presented as % (*n*) unless otherwise indicated.
[a]Stenosis not attributed to a herniated nucleus pulposus
[b]One patient demonstrated a postvoid residual volume of 300 mL on POD 0. The patient required straight catheterization and was placed on Flomax. The patient was able to void spontaneously on POD 2.
[c]One patient had an expanding superficial hematoma while in the postoperative recovery area. An emergent evacuation of a pretracheal hematoma was performed. The patient was discharged safely home on POD 1.

regression. All statistical tests were performed using StataIC 16.1 (StataCorp, College Station, TX) and had the alpha value set to 0.05 to reject the null hypothesis.

RESULTS

Patient Cohort

A retrospective review initially identified 192 patients who underwent an ACDF procedure for degenerative spinal pathologies. After applying inclusion and exclusion criteria, a final study cohort of 91 patients was included. Patients had a mean age of 48.1 years with a mean BMI of 29.5 kg/m2 and the majority being male (64.8%). The majority of patients had a comorbidity burden of ≥1 (61.8%) and an American Society of Anesthesiology score ≥2 (75.0%) (Table 1). Preoperative spinal pathology had a higher prevalence of herniated nucleus pulposus (86.8%) in the study cohort, and the majority had symptoms of a myeloradiculopathy (83.3%). ACDF procedures typically took place at a single level (62.6%) with the use of an anterior cervical plate (63.7%). C5-C6, C6-C7, and C7-T1 single-level fusions represented 29.7%, 30.8%, and 2.2 % of all cases, respectively. C5-C7 and C6-T1 double-level fusions represented 35.2% and 2.2% of all cases, respectively. The mean operative duration was 55.3 minutes and was associated with an EBL and LOS of 28.3 mL and 9.9 hours, respectively. A total of 2 postoperative complications were reported, with 1 patient experiencing urinary retention and another patient having a tracheoesophageal hematoma, which required emergent evacuation (Table 2). All patients were safely discharged home.

A summary of all mean PROM scores is found in Table 3. The primary outcome of interest was dysphagia, as measured by the SWAL-QOL survey. Patients reported a in SWAL-QOL scores at the 6-week timepoint ($P = 0.007$), which was resolved by the 12-week timepoint ($P = 0.557$) and demonstrated a significant improvement at the 6-month timepoint ($P = 0.002$). Secondary outcomes of interest demonstrated significant improvements from the respective preoperative value at all postoperative timepoints for VAS neck, VAS arm, and NDI ($P < 0.001$). Additionally, SF-12 PCS and PROMIS-PF demonstrated similar significant improvement only at the 12-week and 6-month timepoints ($P \leq 0.021$, all). Last, PHQ-9 only demonstrated significant

Table 3. Postoperative outcome measures (N = 91).

Outcome Measures	Mean ± SD (n)	P Value[a]
Swallowing quality of life		
Preoperative	90.4 ± 6.8 (91)	-
6 wk	88.3 ± 10.2 (74)	**0.007**
12 wk	91.0 ± 8.1 (57)	0.557
6 mo	93.7 ± 6.1 (42)	**0.002**
VAS neck		
Preoperative	5.7 ± 2.5 (89)	-
6 wk	3.2 ± 2.4 (82)	**<0.001**
12 wk	2.6 ± 2.3 (78)	**<0.001**
6 mo	2.4 ± 2.2 (63)	**<0.001**
VAS arm		
Preoperative	5.8 ± 2.4 (89)	-
6 wk	2.6 ± 2.4 (81)	**<0.001**
12 wk	3.1 ± 3.1 (73)	**<0.001**
6 mo	2.5 ± 2.6 (61)	**<0.001**
Neck Disability Index		
Preoperative	36.4 ± 19.2 (88)	-
6 wk	29.4 ± 18.4 (80)	**0.009**
12 wk	24.9 ± 18.9 (73)	**<0.001**
6 mo	18.2 ± 17.5 (60)	**<0.001**
12-Item Short Form Physical Component Score		
Preoperative	35.9 ± 8.6 (84)	-
6 wk	35.0 ± 9.1 (71)	0.984
12 wk	38.7 ± 10.1 (56)	**0.021**
6 mo	41.3 ± 10.7 (55)	**<0.001**
PROMIS-PF		
Preoperative	40.3 ± 6.7 (77)	-
6 wk	41.6 ± 6.7 (62)	0.299
12 wk	44.7 ± 9.7 (50)	**<0.001**
6 mo	48.0 ± 8.9 (44)	**<0.001**
9-Item Patient Health Questionnaire		
Preoperative	7.3 ± 6.4 (56)	-
6 wk	5.3 ± 5.7 (51)	**0.007**
12 wk	4.8 ± 6.7 (40)	**0.004**
6 mo	5.4 ± 5.8 (34)	0.153

Abbreviations: PROMIS-PF, Patient-Reported Outcome Measurement Information System Physical Function; VAS, visual analog score.
Note: **Boldface** indicates statistical significance
[a]P values calculated using paired t test

improvements at the 6-week and 12-week timepoints ($P \leq 0.007$, all).

Regression analysis revealed that SWAL-QOL was significantly associated with VAS neck, VAS arm, NDI, SF-12 PCS, PROMIS-PF, and PHQ-9 at the preoperative timepoint ($P \leq 0.005$). The questionnaire had the largest effect on NDI ($\beta = -1.14$; $R^2 = 0.171$; $P < 0.001$) and the smallest effect on VAS arm ($\beta = -0.101$; $R^2 = 0.086$; $P = 0.005$). Postoperatively, SWAL-QOL demonstrated a significant association with all PROMs at 6 weeks ($P \leq 0.011$), 12 weeks ($P \leq 0.002$), and 6 months ($P \leq 0.048$) (Table 4). At the 6-week timepoint, dysphagia scores demonstrated the strongest effect on NDI values ($\beta = -1.06$; $R^2 = 0.368$; $P < 0.001$) while again having the smallest effect on VAS Arm scores ($\beta = -0.068$; $R^2 = 0.087$; $P = 0.011$). A similar relationship was again seen at 12 weeks for NDI ($\beta = -1.41$; $R^2 = 0.378$; $P < 0.001$) and VAS Arm ($\beta = -0.144$; $R^2 = 0.168$; $P = 0.002$) as well as at 6 months ($\beta = -1.84$; $R^2 = 0.481$; $P < 0.001$) ($\beta = -0.142$; $R^2 = 0.098$; $P = 0.048$).

DISCUSSION

The efficacy of an ACDF for the treatment of intractable pain and disability resulting from degenerative cervical spine pathologies has been well demonstrated in the literature.[1,17] Typically, patients experience an improved level of pain, disability, and quality of life following this procedure.[18,19] However, a number of postoperative complications may occur of which dysphagia is the most common.[3–5] Past studies have described baseline characteristics as potential risk factors for postoperative dysphagia;[20] however, the association of dysphagia with improvements in pain, disability, and quality of life is not well understood. The purpose of the current study was to demonstrate any association between dysphagia and postoperative outcomes as measured by the SWAL-QOL questionnaire and various PROMs, respectively.

Dysphagia is largely a clinical diagnosis.[21] However, several outcome metrics have been established to quantify the impact of swallowing difficulty in a patient's quality of life: (1) Bazaz dysphagia score,[12] (2) HSS dysphagia, (3) dysphonia inventory,[22] (4) M.D. Anderson dysphagia inventory,[23] and the (5) SWAL-QOL tool.[10,13,24] The SWAL-QOL tool is of particular interest as it has been internally validated—demonstrating convergent, discriminant, and clinical validity.[13] Additionally, all aspects of the metric exhibit internal consistency, reliability, and short-term reproducibility. McHorney et al further demonstrated that the questionnaire was able to differentiate between normal swallowing and oropharyngeal dysphagia. The dysphagic patients reported worse scores for food selection, fear, eating desire, communication, sleep, and fatigue.[13] Moreover, the same authors also established that the SWAL-QOL instrument had high sensitivity to the severity of pharyngeal symptoms. Investigators were able to demonstrate a significant difference ($P < 0.001$) between quartiles of symptom scales and quality of life scores, with the largest difference observed for fear, food selection, burden, and mental health domains.[13] The questionnaire is among the few dysphagia evaluation tools which has demonstrated correlation with severity of swallowing difficulty in patients with cervical spine deformity or degenerative pathology.[20,25–27] While this tool effectively evaluates and quantifies dysphagia, its relationship with other PROMs is less established. In addition, the clinical implications of

Table 4. SWAL-QOL as a predictor of PROMs.

Outcome Measures	Effect Size (β)	SE	R^2	Adjusted R^2	*P* Value[a]
Preoperative					
VAS neck	-0.127	0.036	0.124	0.114	**0.001**
VAS arm	-0.101	0.035	0.086	0.076	**0.005**
NDI	-1.14	0.272	0.171	0.161	**<0.001**
SF-12 PCS	0.488	0.126	0.154	0.144	**<0.001**
PROMIS-PF	0.404	0.098	0.182	0.171	**<0.001**
PHQ-9	-0.440	0.098	0.271	0.257	**<0.001**
6 wk					
VAS Neck	-0.111	0.024	0.225	0.215	**<0.001**
VAS Arm	-0.068	0.026	0.087	0.074	**0.011**
NDI	-1.06	0.164	0.368	0.359	**<0.001**
SF-12 PCS	0.423	0.083	0.283	0.273	**<0.001**
PROMIS-PF	0.256	0.077	0.156	0.142	**0.001**
PHQ-9	-0.288	0.065	0.305	0.289	**<0.001**
12 wk					
VAS Neck	-0.159	0.034	0.282	0.279	**<0.001**
VAS Arm	-0.144	0.045	0.168	0.152	**0.002**
NDI	-1.41	0.252	0.378	0.366	**<0.001**
SF-12 PCS	0.543	0.156	0.197	0.181	**0.001**
PROMIS-PF	0.615	0.157	0.248	0.232	**<0.001**
PHQ-9	-0.616	0.098	0.552	0.538	**<0.001**
6 mo					
VAS Neck	-0.185	0.049	0.273	0.254	**0.001**
VAS Arm	-0.142	0.069	0.098	0.075	**0.048**
NDI	-1.84	0.309	0.481	0.467	**<0.001**
SF-12 PCS	0.931	0.192	0.381	0.365	**<0.001**
PROMIS-PF	0.853	0.163	0.459	0.442	**<0.001**
PHQ-9	-0.598	0.050	0.820	0.814	**<0.001**

Abbreviations: NDI, Neck Diability Index; PHQ-9, 9-Item Patient Health Questionnaire; PROMIS-PF, Patient-Reported Outcome Measurement Information System Physical Function; SF-12 PCS, 12-Item Short Form Physical Component Score; VAS, visual analog scale.

Note: **Boldface** indicates statistical significance

[a]*P* values calculated using simple linear regression to determine effect of SWAL-QOL on outcomes.

swallowing difficulty with respect to its effect on other areas of a patient's postoperative recovery have largely remained underreported in the spine surgery literature.

The current study was able to demonstrate that following ACDF procedures, patients only experienced a significant worsening of swallowing difficulty at 6 weeks, which was typically resolved by the 12-week follow-up appointment and with further improvement at 6 months. Several past studies have reported similar results. Iyer et al observed that among 88 patients undergoing cervical deformity surgery, 45.5 % of the patients reported significant dysphagia at the 3-month follow-up as compared to their baseline values. However, no significant difference was demonstrated when comparing baseline and postoperative values at the final follow-up visit.[27] Similarly, both Qizhi et al and Siska et al reported that patients undergoing ACDF for degenerative pathology demonstrated a significant worsening in SWAL-QOL at the immediate postoperative timepoint with symptoms peaking near the 2–3-week postoperative timepoint.[28,29] The variability in the resolution of swallowing problems may be partially explained by operative characteristics. It has been suggested that increased operative time and prolonged retraction of soft tissue and nerves (recurrent laryngeal) may be related to the incidence of dysphagia.[30] However, depending on the magnitude of intracompartmental pressure and the resulting ischemia to the soft tissue, the subsequent inflammation and/or damage may prolong the duration of dysphagia.[31,32] Despite the seemingly transient nature of dysphagia following anterior cervical procedures, the short-term clinical implications may have lingering effects on the postoperative quality of life.

Prior studies regarding the association of dysphagia with quality of life have largely been restricted to patient populations undergoing treatment for oropharyngeal malignancies or sequelae of strokes.[33,34] An epidemiological study by Eslick et al demonstrated that among the general population, the presence of dysphagia had a negative impact on an individual's quality of life, as measured by the SF-36.[16] Also, Lovell et al established an association between dysphagia and poorer quality of life in patients with nasopharyngeal carcinoma.[33]

Within the spine literature, the validity and utility of SWAL-QOL have been studied for its ability to quantify postoperative swallowing disorders and its sequelae.[29,35] The current study demonstrated a significant relationship between the SWAL-QOL measure and other commonly reported PROMs for pain, disability, physical health, and mental health.[36] The utilization of the (1)

Bazaz dysphagia scores and (2) the EAT-10 survey by Rosenthal et al suggests that the resolution of swallowing difficulty coincided with significant improvements in NDI, Euro-Qol 5-dimensions (EQ-5D), and EQ-VAS at 6-month and 1-year follow-up.[37] However, in that particular study, the PROMs were not evaluated during the early postoperative period, which may represent the peak of dysphagia symptoms. As such, any short-term relationship could only be speculated. A different study by Iyer et al utilized the SWAL-QOL survey to demonstrate that swallowing scores were significantly correlated with postoperative NDI and EQ-5D.[27]

The current study expands upon the associations previously demonstrated in the literature. Specifically, SWAL-QOL scores are significantly associated with postoperative VAS, NDI, SF-12 PCS, PROMIS-PF, and PHQ-9. This relationship may be seemingly obvious as specific domains of the survey directly evaluate certain components of patient outcomes (eg, mental or physical health) that may overlap between the above PROMs. Nonetheless, the results suggest that the assessment of dysphagia severity via the SWAL-QOL questionnaire may extend beyond swallowing difficulty and may be indicative of the patients' overall health and outcome. This relationship also may help surgeons instill confidence in patients that in the event of dysphagia, they should expect a relatively progressive improvement in swallowing-related symptoms in conjunction with improvement in other symptoms.

Limitations

There are several limitations associated with this study. Much of the results were predicated on use of patient-reported questionnaires, which are prone to recall and participation bias.[38] Additionally, the SWAL-QOL questionnaire may not be the most efficient survey to administer to patients. Due to its high number of total questions (44-items), coupled with the task of completing other vital questionnaires (eg, NDI, SF-12 PCS, and PROMIS-PF) the application of SWAL-QOL can increase a patient's questionnaire burden and result in attrition of patient compliance. Use of an abridged SWAL-QOL may prove beneficial without sacrificing the ability to capture the severity of dysphagia, as previous studies demonstrated that a reduction from 44 to 16 questions retained the ability to detect clinically significant postoperative changes from preoperative values.[25] Importantly, patients willing to take the time to complete the survey may be more willing to participate in research and introduce selection bias. Moreover, the administration of the questionnaire was restricted to standard of care postoperative follow-up appointments. Given that dysphagia can present more acutely, we were unable to capture scores during those timepoints prior to or immediately following the 6-week follow-up appointment. As such, the results may reflect a dysphagia score during the improvement or worsening phase rather than capturing the severity at the peak of symptoms. Furthermore, patients received their treatment from a single surgeon, which may limit our ability to generalize the results. Lastly, only patients undergoing surgery at C5-C6 or below were included in the present study. Prior literature has reported that upper cervical surgery may pose a higher risk of dysphagia, while other studies including Rihn et al demonstrated no such effect in dysphagia by cervical location, substratified as C4-C5 and above vs C5-C6 and below.[30,39,40] The authors of the latter study however reported that lack of difference in dysphagia scores may have been a consequence of limited sample size.[30] As the majority of ACDF procedures performed by the single surgeon were performed at C5-C6 or below, we selected for lower cervical segment procedures only to avoid potential confounding effects in inclusion of upper cervical procedures. Nevertheless, this restricts the generalizability of our findings and is an important limitation to recognize. Ultimately, future studies incorporating multiple surgeons among multiple institutions are necessary to further strengthen surgeons' understanding and confidence on the relationship between SWAL-QOL and other outcome measures.

CONCLUSION

Following ACDF procedures, patients demonstrated peak dysphagia at 6 weeks postoperatively, but a majority of the symptoms were resolved by 3 months. In conjunction, patients were also able to demonstrate significant improvements in pain, disability, physical function, and mental health. The severity of dysphagia had a significant association with all other patient-reported outcome measures. These results demonstrate the utility of the SWAL-QOL as an adjunct assessment tool for postoperative outcomes following ACDF procedures.

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