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A commentary by Christoph J. Siepe, MD, is linked to the online version of this article at jbjs.org.

The Effect of Local Versus Intravenous Corticosteroids on the Likelihood of Dysphagia and Dysphonia Following Anterior Cervical Discectomy and Fusion

A Single-Blinded, Prospective, Randomized Controlled Trial

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Background: Dysphagia and dysphonia are the most common postoperative complications following anterior cervical discectomy and fusion (ACDF). Although most postoperative dysphagia is mild and transient, severe dysphagia can have profound effects on overall patient health and on surgical outcomes. The purpose of this study was to compare the efficacy of local to intravenous (IV) steroid administration during ACDF on postoperative dysphagia and dysphonia.

Methods: This was a single-blinded, prospective, randomized clinical trial. Seventy-five patients undergoing ACDF with cervical plating were randomized into 3 groups: control (no steroid), IV steroid (10 mg of IV dexamethasone at the time of closure), or local steroid (40 mg of local triamcinolone). Patient-reported outcome measures (PROMs) were collected for dysphagia, dysphonia, and neck pain postoperatively for 1 year.

Results: Patient demographics were similar. Postoperative day 1 PROMs showed significantly lower scores for dysphonia ($p = 0.015$) and neck pain ($p = 0.034$) in the local steroid group. At 2 weeks postoperatively, the local steroid cohort showed significantly decreased prevalence of severe dysphagia (Eating Assessment Tool-10 [EAT-10], severe dysphagia, $p = 0.027$) compared with the control and IV steroid groups. Both steroid groups had significantly less severe dysphagia when compared with the control group at the 6-week and 3-month time points. At 1 year postoperatively, both steroid groups had significantly reduced dysphagia rates ($p = 0.014$) compared with the control group.

Conclusions: Both local and IV steroid administration after cervical plating in ACDF yielded better PROMs for dysphagia compared with a control group. This finding is particularly evident in the reduced number of patients who reported severe dysphagia symptoms following ACDF with local steroid application within the first 2 postoperative weeks. Future studies should attempt to stratify dysphagia severity when reporting outcomes related to anterior cervical spine surgery.

Level of Evidence: Therapeutic Level I. See Instructions for Authors for a complete description of levels of evidence.

Dysphagia and dysphonia are the most common postoperative complications following anterior cervical discectomy and fusion (ACDF)[1,2]. While most postoperative dysphagia is mild and transient, severe dysphagia can have profound effects on the overall health of the patient and on surgical outcomes. Severe dysphagia places the patient at

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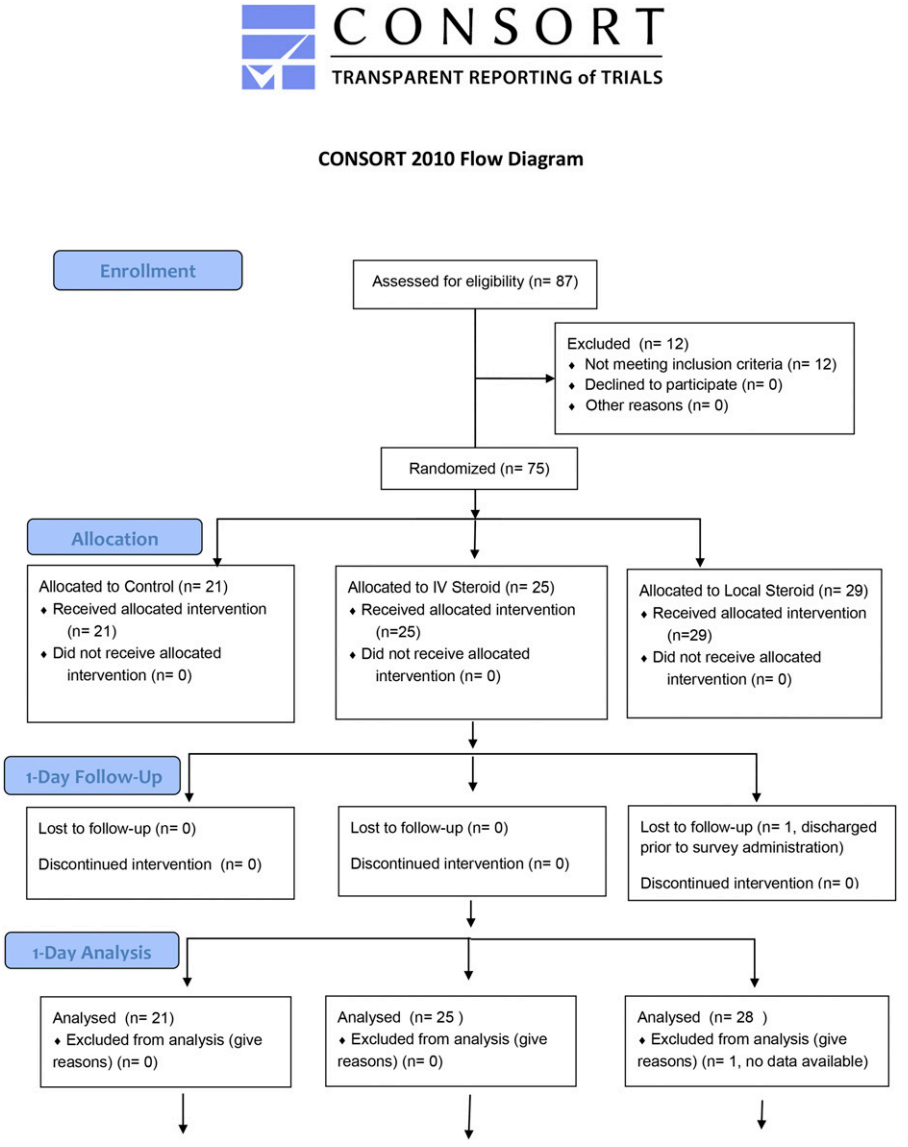

Fig. 1-A

Figs. 1-A, 1-B, and 1-C CONSORT (Consolidated Standards of Reporting Trials) flow diagram showing exclusions, treatment group randomization, and follow-up inclusion.

higher risk for malnutrition, aspiration, pneumonia, and death[3,4]. Although mild, transient dysphagia may be considered an acceptable side effect of anterior cervical surgery in light of the long-term pain relief provided by the procedure, severe and persistent dysphagia should be considered a complication that hinders optimal surgical outcomes. Similarly, dysphonia is often transient, but severe cases are associated with postoperative airway obstruction, aspiration, or persistent cough.

The reported prevalence of dysphagia after ACDF is variable, ranging from 3% to 67%[1,5,6]. This variability reflects the different ways in which dysphagia is measured and defined. Although many dysphagia classification systems exist, the Eating Assessment Tool-10 (EAT-10) has proven to be reliable, valid, treatment-responsive, and multiculturally versatile[6]. In that system, scores of >3 qualify as clinically relevant dysphagia and scores of >15 qualify as severe dysphagia, which is associated with a 2.2 times greater risk of aspiration[3]. Recent research suggests that this system may be most appropriately used in the spine surgical population[7,8]. Likewise, postoperative dysphonia has wide variation in its method of measurement, and as such has a wide variation of reported prevalences (1% to 51%)[6,9]. One system for evaluating dysphonia, the Voice Handicap Index-10 (VHI-10), has proven to be reliable, valid, and able to be expediently administered[6].

Surgeons often underreport the prevalence and severity of the symptoms that patients experience. In a study that used patient surveys to assess the accuracy of surgeon records following anterior cervical arthrodesis, Edwards et al. showed that dysphagia was underreported by 80% and dysphonia by 84%[10]. Research into dysphagia and dysphonia has lagged because

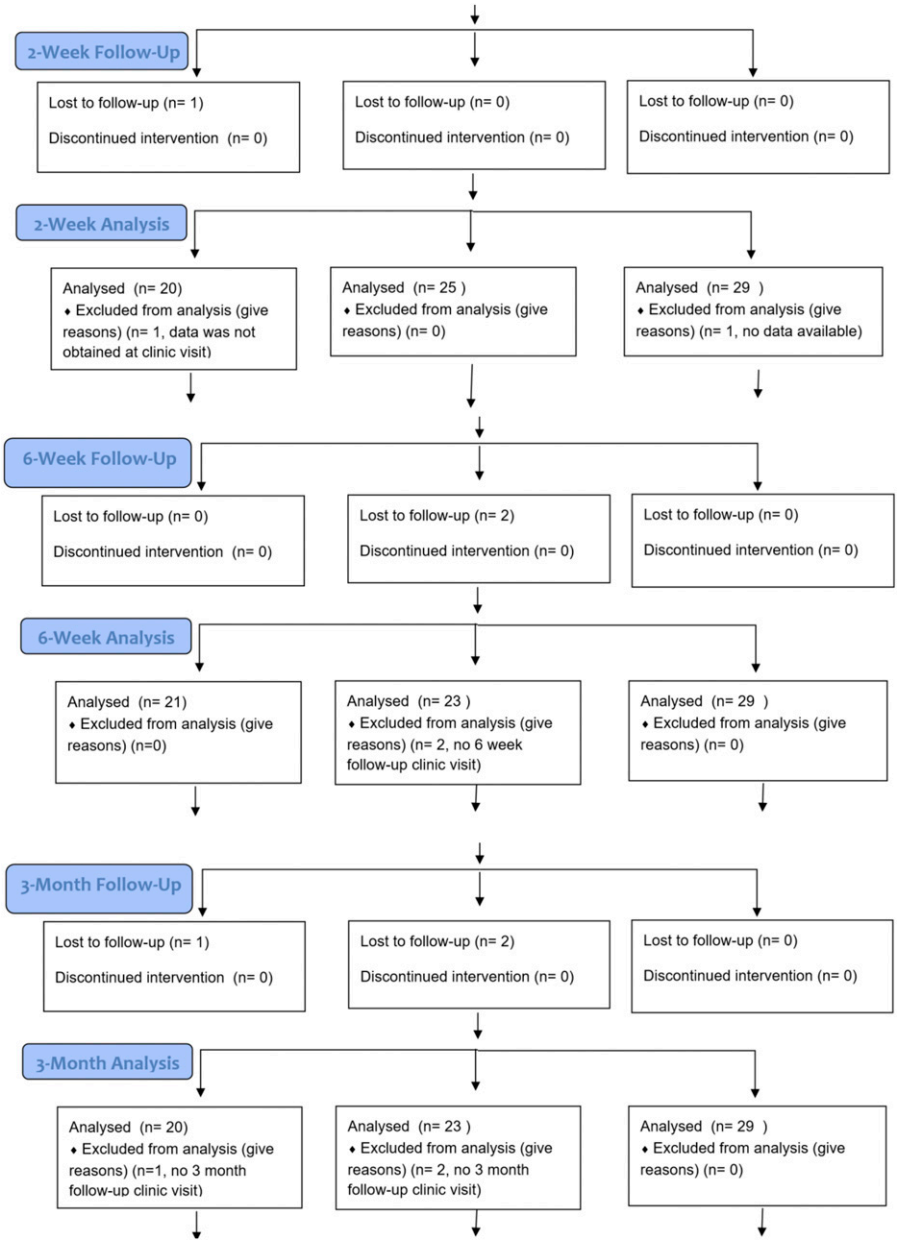

Fig. 1-B

these complications are underreported and inconsistently measured.

Postoperative dysphagia has been attributed to superior or recurrent laryngeal nerve injury and to soft-tissue swelling[11]. For many other medical treatments, steroid administration has been used to decrease nerve irritation and soft-tissue swelling. The use of intravenous (IV) methylprednisolone perioperatively has been shown to decrease abnormal findings on laryngoscopy, decrease airway edema, reduce dysphagia, and lead to shorter hospital stays after ACDF[12-16]. In a prospective, randomized study on the efficacy of local retropharyngeal steroid application, Lee et al. found that local steroid application reduced post-ACDF odynophagia and prevertebral soft-tissue swelling compared with a control group[15]. However, steroid administration has not been widely accepted because concern still exists over possible catastrophic complications (e.g., esophageal rupture and infection) and pseudarthrosis.

The present study is a prospective, single-blinded, randomized clinical trial. The purpose of the study was to assess the efficacy of intraoperative steroid administration (IV or local) on dysphagia and dysphonia after ACDF.

Materials and Methods

After institutional review board approval was obtained, 75 patients were recruited for a prospective, randomized, single-blinded study. Patients were included if they were ≥18

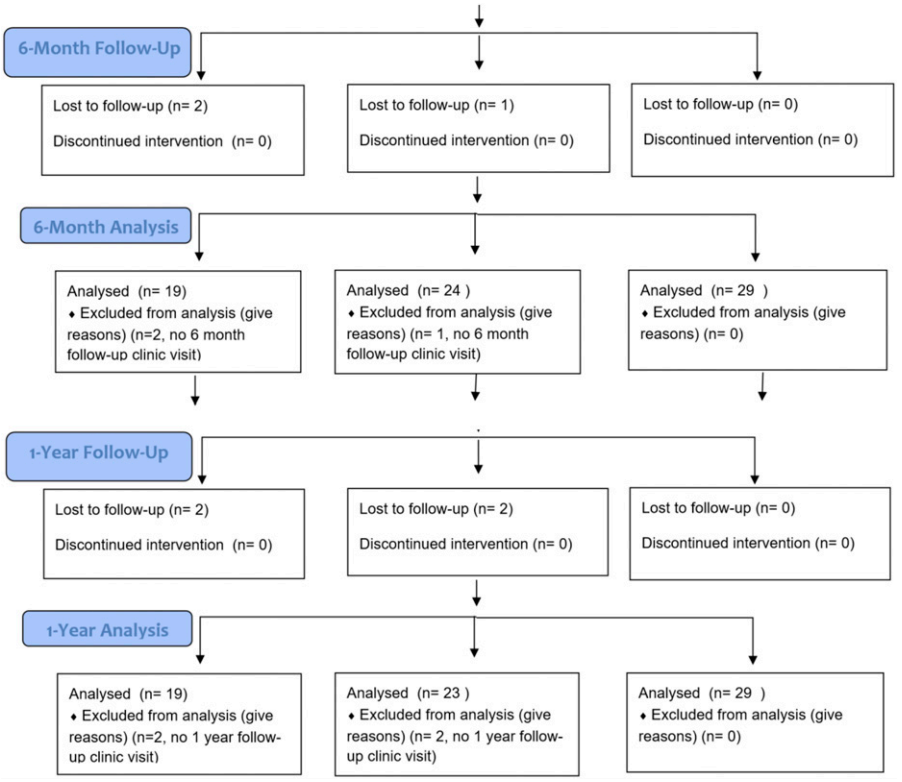

Fig. 1-C

years of age and undergoing ACDF for the treatment of radiculopathy or myelopathy. Patients were excluded if they were undergoing operations for trauma, infection, or tumor, if the ACDF was a revision procedure, or if the patient had any general metabolic diseases. The number of cervical levels fused was not a consideration for exclusion.

After informed consent was obtained, ACDF was performed with use of the standard Smith-Robinson technique by 1 of 3 surgeons (A.A.P., W.K.H., J.W.S.). The side of the surgical approach was guided by both the location of the abnormality and the surgeon preference. The platysma was split with use of electrocauterization and the deep cervical fascia was separated with use of Metzenbaum scissors. The infrahyoid muscles and the trachea were gently retracted medially. The prevertebral fascia was incised at the midline with use of a protected-tip electrocautery device. The longus colli muscle flaps were developed laterally to the uncinate, and self-retaining retractors were used to hold the flaps in place. Following the initial placement of a self-retaining retractor, the endotracheal cuff was deflated and subsequently reinflated to decrease endotracheal cuff pressure during the case. Discectomies were performed out to the uncinate processes bilaterally. The posterior longitudinal ligament was released in all cases, and when present, posterior osteophytes were completely removed. When performing multilevel discectomies, the retractor was released and replaced to decrease the amount of static retraction time. An interbody spacer and a cervical plate were used in all cases. When the fusion site was augmented, local autograft bone was used. No recombinant bone morphogenetic protein was utilized in any subject.

Patients were then randomized into 3 cohorts: control (no steroid), IV steroid (1-time IV dose of 10 mg of IV dexamethasone at the time of closure), and local steroid (40 mg of triamcinolone placed in the retropharyngeal space directly on the cervical plate) (Fig. 1). Patients were blinded with regard to which treatment they received until at least 1 year after

TABLE I Bazaz Classification for Dysphagia*

Severity of Dysphagia	Symptoms	
	Trouble Swallowing Liquids	Trouble Swallowing Solids
None	None	None
Mild	None	Rarely
Moderate	None or rarely	Occasionally (some foods)
Severe	None or rarely	Frequently (majority of foods)

*Reproduced, with modification, from: Bazaz R, Lee MJ, Yoo JU. Incidence of dysphagia after anterior cervical spine surgery: a prospective study. Spine (Phila Pa 1976). 2002 Nov 15;27(22): 2453-8.. With permission from Wolters Kluwer.

Eating Assessment Tool (EAT-10) Survey

	0 = No Problem				4 = Severe Problem
To what extent are the following scenarios problematic for you?	0	1	2	3	4
1. My swallowing problem has caused me to lose weight	0	1	2	3	4
2. My swallowing problem interferes with my ability to go out for meals	0	1	2	3	4
3. Swallowing liquids takes extra effort	0	1	2	3	4
4. Swallowing solids takes extra effort	0	1	2	3	4
5. Swallowing pills takes extra effort	0	1	2	3	4
6. Swallowing is painful	0	1	2	3	4
7. The pleasure of eating is affected by my swallowing	0	1	2	3	4
8. When I swallow food sticks in my throat	0	1	2	3	4
9. I cough when I eat	0	1	2	3	4
10. Swallowing is stressful	0	1	2	3	4

Fig. 2

Eating Assessment Tool (EAT-10) survey. (Reproduced from: Belafsky PC, Mouadeb DA, Rees CJ, Pryor JC, Postma GN, Allen J, Leonard RJ. Validity and reliability of the Eating Assessment Tool (EAT-10). Ann Otol Rhinol Laryngol. 2008 Dec;117(12):919-24. With permission from SAGE Publications.)

surgery. Patients were enrolled in a parallel fashion with no designated allocation ratio. Allocation was determined by a random number generator, with the numbers 1 through 3 each corresponding to a specific treatment group. Random number allocation was performed by a research coordinator and then relayed to the treating surgeon.

For dysphagia. primary outcomes were measured with use of the Bazaz[17] classification (dichotomous scoring) and the EAT-10 (severe classification) (Table I and Fig. 2). For dysphonia, primary outcomes were measured with use of the VHI-10 (Fig. 3). These patient-reported outcome surveys have been widely used and validated[6,18-20]. Secondary outcomes were measured with use of the Bazaz classification (mild, moderate, or severe scoring), EAT-10 (dysphagia), Neck Disability Index (NDI) and Visual Analog Scale (VAS) for neck pain, presence of surgical site infection, reoperation, and pseudarthrosis. Patient outcomes were collected preoperatively and at 1 day, 2 weeks, 6 weeks, 3 months, 6 months, and 1 year postoperatively (Fig. 1).

An a priori power analysis was performed with use of previous studies that utilized the EAT-10 scale[18]. The present study had 92% power to demonstrate noninferiority with a sample size of 75 patients. At each time point, the Pearson chi-square test was utilized to assess associations between treatment groups and categorical measures. The Fisher exact test was utilized when the expected cell counts were <5 for a given cross-tabulation. Continuous variables were compared across groups with use of 1-way analysis of variance (ANOVA) for normally distributed data and with Kruskal-Wallis tests when statistical assumptions (such as normality) were questionable. Post-hoc comparisons were made with use of Benjamini-Hochberg corrections for measures that differed significantly between treatment groups. Mixed effect models were also performed, with

Voice Handicap Index (VHI-10)

	0 = Never, 1 = Almost Never, 2 = Sometimes, 3 = Almost Always, 4 = Always				
To what extent are the following true for you?	0	1	2	3	4
1. My voice makes it difficult for people to hear me	0	1	2	3	4
2. I run out of air when I talk	0	1	2	3	4
3. People have difficulty understanding me in a noisy room	0	1	2	3	4
4. The sound of my voice varies throughout the day	0	1	2	3	4
5. My family has difficulty hearing me when I call them throughout the house	0	1	2	3	4
6. I use the phone less often than I would like to	0	1	2	3	4
7. I'm tense when talking to others because of my voice	0	1	2	3	4
8. I tend to avoid groups of people because of my voice	0	1	2	3	4
9. People seem irritated with my voice	0	1	2	3	4
10. People ask, "What's wrong with your voice?"	0	1	2	3	4

Fig. 3

Voice Handicap Index-10: scores greater than 11 are indicative of clinically significant dysphonia. (Reproduced from: Rosen CA, Lee AS, Osborne J, Zullo T, Murry T. Development and validation of the Voice Handicap Index-10. Laryngoscope. 2004 Sep;114(9):1549-56. With permission from John Wiley & Sons.)

TABLE II Dysphonia, Dysphagia, and Neck Pain Patient-Reported Outcomes Following ACDF, by Treatment Group

	Control Group	IV Steroid Group	Local Steroid Group	P Value
Sex				
Male	11	14	15	
Female	10	11	14	
Mean age *(yr)*	54.0	51.6	55.6	0.522
No. of levels fused				0.351
1	12 (57%)	12 (48%)	14 (48%)	
2	8 (38%)	13 (52%)	12 (41%)	
3	1 (5%)	0 (0%)	3 (10%)	
Preop.*				
No. of patients	21	25	29	
Bazaz: mild, moderate, or severe	5%	0%	7%	0.495
Bazaz: moderate or severe	0%	0%	0%	—
EAT-10: dysphagia	10%	16%	10%	0.820
EAT-10: severe dysphagia	0%	0%	0%	NA
Abnormal VHI-10	5%	4%	3%	1.000
VAS: neck pain†	8.0 (6.0, 9.0)	8.0 (6.0, 9.0)	7.0 (4.0, 9.0)	0.328
NDI‡	40 (19)	34 (18)	35 (19)	0.597
Postop. day 1*				
No. of patients with data	21	25	28	
Bazaz: mild, moderate, or severe	62%	44%	50%	0.494
Bazaz: moderate or severe	33%	24%	7%	0.053
EAT-10: dysphagia	76%	68%	61%	0.552
EAT-10: severe dysphagia	38%	32%	18%	0.273
Abnormal VHI-10	10%	20%	0%	0.015§
VAS: neck pain†	7.0 (6.50, 9.00)	6.0 (3.00, 9.00)	6.00 (3.00, 7.00)	0.034§
NDI‡	27 (14)	28 (16)	27 (18)	0.955
2 wk postop.*				
No. of patients with data	20	25	29	
Bazaz: mild, moderate, or severe	30%	16%	14%	0.392
Bazaz: moderate or severe	15%	16%	0%	0.050†
EAT-10: dysphagia	50%	48%	28%	0.188
EAT-10: severe dysphagia	20%	16%	0%	0.027§
Abnormal VHI-10	15%	16%	3%	0.225
VAS: neck pain†	6.0 (5.00, 8.00)	4.0 (3.00, 6.00)	4.0 (3.00, 6.00)	0.037§
NDI‡	31 (20)	24 (15)	20 (16)	0.152
6 wk postop.*				
No. of patients with data	21	23	29	
Bazaz: mild, moderate, or severe	29%	17%	7%	0.116
Bazaz: moderate or severe	24%	9%	0%	0.009§
EAT-10: dysphagia	38%	35%	17%	0.226
EAT-10: severe dysphagia	29%	0%	0%	<0.001§
Abnormal VHI-10	10%	9%	3%	0.608
VAS: neck pain†	5.0 (3.00, 8.00)	4.0 (2.00, 5.50)	5.0 (3.00, 7.00)	0.270
NDI‡	23 (19)	21 (15)	24 (19)	0.844
3 mo postop.*				
No. of patients with data	20	23	29	
Bazaz: mild, moderate, or severe	15%	13%	14%	1.000
Bazaz: moderate or severe	15%	0%	0%	0.019§
EAT-10: dysphagia	20%	9%	7%	0.318

continued

TABLE II (*continued*)

	Control Group	IV Steroid Group	Local Steroid Group	P Value
EAT10: severe dysphagia	10%	0%	0%	0.074
Abnormal VHI-10	10%	4%	0%	0.183
VAS: neck pain†	4.5 (1.75, 7.00)	3.0 (1.00, 4.00)	3.0 (2.00, 5.00)	0.238
NDI‡	14.6 (40)	11.1 (23.3)	10 (23.5)	0.703
6 mo postop.*				
No. of patients with data	19	24	29	
Bazaz: mild, moderate, or severe	16%	8%	14%	0.741
Bazaz: moderate or severe	5%	0%	0%	0.264
EAT-10: dysphagia	21%	8%	14%	0.526
EAT-10: severe dysphagia	0%	0%	0%	NA
Abnormal VHI-10	10%	9%	3%	0.608
VAS: neck pain†	5.0 (3.00, 8.00)	4.0 (2.00, 5.50)	5.0 (3.00, 7.00)	0.270
NDI‡	23 (19)	21 (15)	24 (19)	0.844
1 yr postop.*				
No. of patients with data	19	23	29	
Bazaz: mild, moderate, or severe	14%	0%	3%	0.094
Bazaz: moderate or severe	5%	0%	3%	0.739
EAT-10: dysphagia	24%	0%	7%	0.014§
EAT-10: severe dysphagia	10%	0%	0%	0.076
Abnormal VHI-10	10%	4%	0%	0.186
VAS: neck pain†	4.0 (1.00, 6.00)	2.0 (1.00, 4.00)	1.0 (1.00, 5.00)	0.653
NDI‡	22.2 (33.6)	4.0 (18)	6.0 (26)	0.263

*Data are presented as the percentage of patients in the given cohort with abnormal patient-reported outcomes (EAT-10 dysphagia: score >3; EAT-10 severe dysphagia: score >15; abnormal VHI-10: score >11; Bazaz: mild, moderate, or severe indicates that a Bazaz classification of mild, moderate, or severe dysphagia was considered abnormal; Bazaz: moderate or severe indicates that a Bazaz classification of moderate or severe dysphagia was considered abnormal). †Data are presented as the median VAS neck pain score, with the interquartile range in parentheses. ‡Data are presented as the mean NDI percentage, with the standard deviation in parentheses. §Significant; p values shown are related to a 1-way analysis.

time, treatment group, and time × treatment group interaction terms as fixed effects and with a random intercept term to account for repeated measures. All analyses assumed a 5% level of significance and were performed with use of R (version 3.3.2; R Foundation for Statistical Computing). The ClinicalTrials.gov trial registration number was NCT02577991.

Results

Seventy-five patients were included in the study, with 21 randomized to the control group; 25, the IV steroid group; and 29, the local steroid group. The demographic variables and the number of cervical levels operated on were not significantly different between the groups (Table II; p values are results of 1-way ANOVA analysis). Although there was no significant difference between groups in the number of levels fused, it is worth noting that 10% of the local steroid cohort underwent 3-level ACDFs, compared with only 5% and 0% of the control group and IV steroid group, respectively. The baseline patient-reported outcomes for dysphagia (Bazaz and EAT-10), dysphonia (VHI-10), and neck pain (NDI and VAS) were not significantly different between the groups.

At postoperative day 1, patient-reported outcomes showed significantly lower scores for the VHI-10 ($p = 0.015$) and VAS neck pain ($p = 0.034$) in the local steroid group compared with the control and IV steroid groups (Table II, Fig. 4). There were also fewer patients with moderate and severe dysphagia, according to the Bazaz classification, at postoperative day 1 in the local steroid group ($p = 0.053$) compared with the control and IV steroid groups. At 2 weeks postoperatively, the local steroid cohort showed significantly decreased prevalence of severe dysphagia (Bazaz, moderate or severe, $p = 0.050$; EAT-10, severe dysphagia, $p = 0.027$) compared with the control and IV steroid groups. VAS neck pain was significantly lower in both steroid groups compared with the control group ($p = 0.037$).

At 6 weeks postoperatively, the local steroid group had outperformed the IV steroid group in terms of severe dysphagia, according to the Bazaz classification (Fig. 4). Both steroid groups had significantly less moderate and severe dysphagia compared with the control group (Bazaz, moderate or severe, $p = 0.009$; EAT-10, severe dysphagia, $p < 0.001$). At 3 months postoperatively, both the local and IV steroid groups had significantly lower rates of moderate and severe dysphagia, as classified by the Bazaz score, compared with the control group (Bazaz, moderate or severe, $p = 0.019$). A similar trend was seen with the number of patients with severe dysphagia,

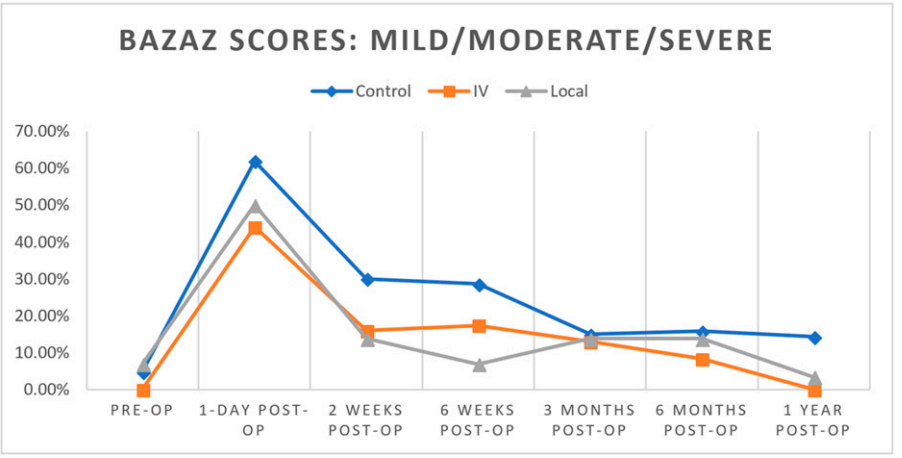

Fig. 4-A

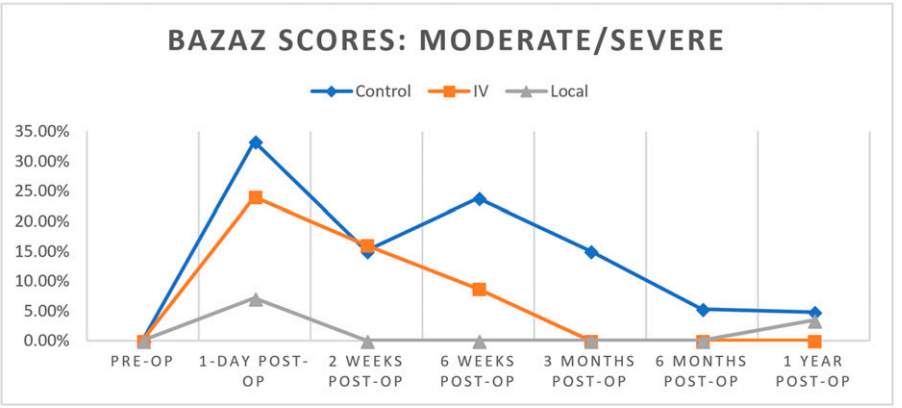

Fig. 4-B

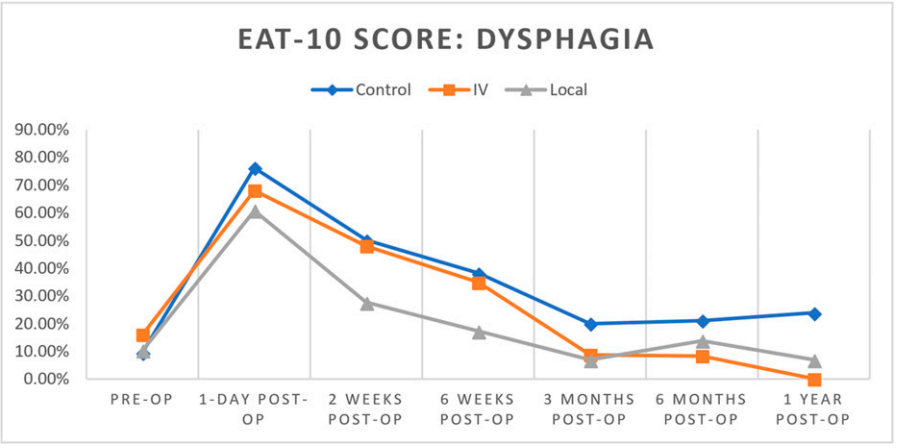

Fig. 4-C

Fig. 4-A through 4-E Patient-reported outcomes at various time points. Graph showing the percentage of patients with Bazaz (mild, moderate, or severe) scores for each group at each time point. **Fig. 4-B** Graph showing the percentage of patients with Bazaz (moderate or severe) scores for each group at each time point. **Fig. 4-C** Graph showing the percentage of patients with EAT-10 (dysphagia) scores for each group at each time point.

according to the EAT-10 scale, although this difference did not reach significance (EAT-10, severe dysphagia, $p = 0.074$).

At 6 months postoperatively, there were no significant differences among any of the groups for any of the outcome measures. At 1 year postoperatively, both steroid groups had significantly reduced dysphagia rates when compared with the control group (EAT-10, dysphagia, $p = 0.014$). Again, a similar trend was seen with severe dysphagia, although this

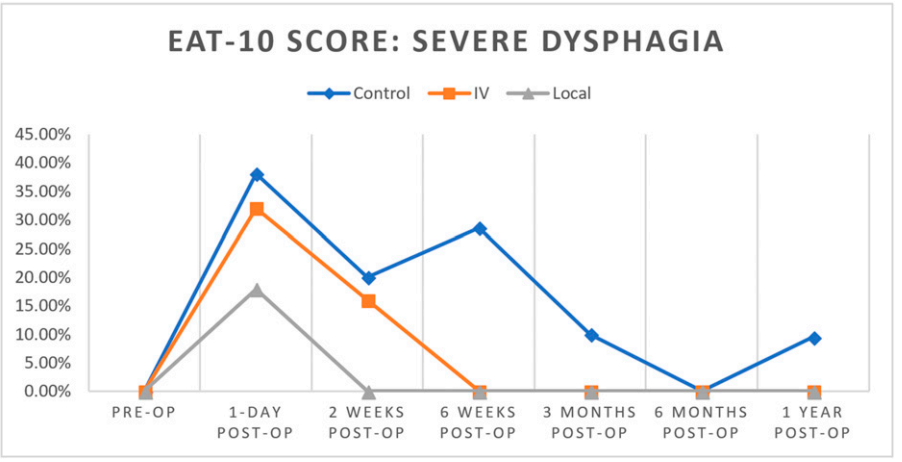

Fig. 4-D

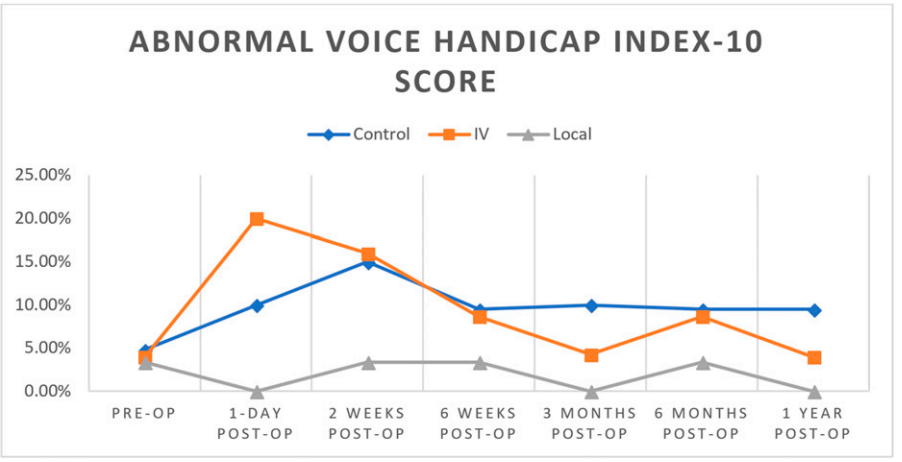

Fig. 4-E

Fig. 4-D Graph showing the percentage of patients with EAT-10 (severe dysphagia) scores for each group at each time point. **Fig. 4-E** Graph showing the percentage of patients with abnormal VHI-10 scores for each group at each time point.

difference did not reach significance (EAT-10, severe dysphagia, $p = 0.076$).

Notably, when minor dysphagia was included in the analysis, there were no significant differences among the groups prior to the 1-year evaluation (Bazaz, mild, moderate, or severe, and EAT-10, dysphagia, p values all >0.05).

Analysis utilizing a generalized linear mixed-effect model showed that dysphagia outcomes (EAT-10, abnormal) were significantly different between time points throughout the study (preoperatively to 1 year postoperatively; $p < 0.001$) (Tables III and IV). Post-hoc analysis revealed that treatment with either local or IV corticosteroids resulted in significantly less dysphagia over time compared with the control group ($p = 0.0259$). In addition, there was a significant time × treatment group interaction effect for EAT-10, abnormal outcome. Particularly, the change in the rate of dysphagia was lower in the IV steroid group compared with the control group overtime.

A common concern with steroid administration during ACDF is the effect on wound complications and fusion rates. A chart review of our study patients showed that there were no wound complications. Likewise, no esophageal injuries or complications were noted. One patient who underwent a 2-level ACDF required revision surgery for a symptomatic nonunion during the study period. The nonunion was discovered 1 year postoperatively based on symptoms of

TABLE III EAT-10 Dysphagia Mixed Effect Model Analysis, Solutions for Fixed Effects

Effect	Estimate	DF*	T Value	P Value
Time × IV steroid	0.00932	437	2.71	0.0071†
Time × local steroid*	−0.00283	437	−1.06	0.2891
IV steroid	0.1017	437	0.21	0.8372
Local steroid	−0.5318	437	−1.09	0.2776

*DF = degrees of freedom. †Significant.

TABLE IV EAT-10 Dysphagia Mixed Effect Model Analysis, Type III Test of Fixed Effects*

Effect	Num DF	Den DF	F Value	P Value
Time	1	437	26.78	<0.001†
Time × treatment group	2	437	3.69	0.0259†
Treatment group	2	437	1.03	0.3562

*Num DF = numerator degrees of freedom; Den DF = denominator degrees of freedom. †Significant.

radiculopathy that returned after a prior 10-month resolution. The nonunion was confirmed with use of computed tomography imaging, and the procedure was revised with a posterior spinal fusion at 1.5 years after the primary surgery. Another patient who underwent a 1-level ACDF was noted to have an asymptomatic nonunion that was discovered outside the study period (2.5 years postoperatively), and the patient is being managed nonoperatively as of the time of the present study. Both patients who experienced nonunion were in the local steroid treatment group.

Discussion

ACDF is an effective treatment for cervical spine degenerative conditions when nonoperative treatment has failed[21,22]. Despite the proven clinical success of ACDF, postoperative issues can arise, with the most common being dysphagia and dysphonia[1,2]. This study demonstrates that local steroid application significantly reduces severe dysphagia and improves postoperative neck pain after ACDF surgery.

The reported prevalence of dysphagia and dysphonia after anterior cervical spine surgery has varied widely[9,23,24]. The large variance in reported prevalence is likely because of differences in study designs, definitions, and outcome measures. Transient, mild dysphagia has a larger variation than severe dysphagia in reported prevalence, possibly because it may be considered by some surgeons to be an acceptable side effect of ACDF[4,23], whereas severe dysphagia is more likely to be reported and is linked to poor surgical outcomes and increased medical costs[3,13]. There have been limited attempts in the literature to distinguish between mild and severe cases of post-ACDF dysphagia as it pertains to reports of complications[6]. It is our opinion that focusing on reducing the burden of severe dysphagia will provide meaningful clinical improvement to anterior spine surgery.

Many studies have attempted to delineate the risk factors associated with dysphagia following ACDF, which include older age (≥60 years), preoperative dysphagia, increased operative time, female sex, and number of levels fused[4,5,9,23]. In response to the reported rates of dysphagia following ACDF, specific techniques have been developed that include reducing retraction, manipulating endotracheal cuff pressures, utilizing low-profile implants, reducing operative time, and utilizing preoperative traction exercises; the application of these techniques has led to varying degrees of success[25].

More recent studies have analyzed the use of perioperative corticosteroids to reduce the likelihood of dysphagia following ACDF. The use of IV methylprednisolone perioperatively has been shown to decrease abnormal ear, nose, and throat findings on laryngoscopy, decrease airway edema, reduce dysphagia, and lead to shorter hospital stays after ACDF[12-14]. A prospective, randomized study of the effect of local retropharyngeal steroid on prevertebral soft-tissue swelling after ACDF found that local steroid application reduced odynophagia and swelling compared with a control group[15]. However, the correlation between prevertebral soft-tissue swelling and dysphagia is still unclear[26,27]. To our knowledge, no study has compared the effects of locally applied retropharyngeal steroid to IV steroid administration on the likelihood of postoperative dysphagia and dysphonia.

In the present study, which is a single-blinded, prospective, randomized clinical trial, we were able to demonstrate that steroid administration improved outcomes for dysphagia, dysphonia, and neck pain following ACDF compared with a control group. Local steroid administration outperformed IV steroid administration in terms of severe dysphagia at 2 weeks postoperatively. Baseline demographics and accepted risk factors for dysphagia (including age, female sex, and number of levels fused) were not significantly different among any of the treatment groups. This allowed for an accurate comparison among groups and limited confounding variables. In fact, the only difference in baseline demographics (3-level fusion) may have potentially introduced bias toward worse dysphagia outcomes in the local steroid cohort.

As previously described, dysphagia outcomes are notoriously difficult to report. We utilized the best available outcome measures for dysphagia (EAT-10 and Bazaz) that have been validated in the literature, and separately analyzed the prevalence of mild and severe cases of dysphagia. This distinction may impact future reporting because mild, transient cases of dysphagia do not increase hospital cost and medical comorbidity. Conversely, severe cases of dysphagia are disabling. Severe dysphagia has been linked to malnutrition, delayed recovery, and even increased mortality risk[28-30]. In addition to the serious medical implications, severe dysphagia can impair quality of life, resulting in social isolation and depression[31,32]. The present study shows that future studies should differentiate severe and mild cases of dysphagia because of the vast differences associated with their outcomes.

Odynophagia can sometimes manifest as neck pain following ACDF. The present study shows that steroid administration significantly improved patient-reported VAS neck pain for the first 2 weeks after surgery ($p < 0.05$). This effect on neck pain could be related to the reduction in short-term odynophagia with steroid administration after cervical plating. Dysphonia is another frequent postoperative issue following anterior cervical spine surgery. The VHI-10 is a strong, validated assessment tool for dysphonia[20,33]. The results of this study show that local steroid application significantly reduced

the likelihood of dysphonia at postoperative day 1, though the clinical relevance of this finding may be small, as no difference in significance was seen at other time points.

A concern with local steroid application after ACDF is the potential for wound, esophageal, or pseudarthrosis complications. Other studies that researched steroid administration during ACDF have not seen an effect on long-term fusion rates or wound complications[13,16]. The patients in our study had no wound complications, surgical site infections, or esophageal complications. However, 2 patients were diagnosed with pseudarthrosis, with both cases belonging to the local steroid group; 1 of these patients required reoperation and the other was asymptomatic. This rate of pseudarthrosis and reoperation is consistent with other reported results after ACDF[34]. Although the study is not powered to reach conclusions regarding the influence of local steroid administration on pseudarthrosis, this observation in our trial shows that further research on this topic is needed.

Although our study is a single-blinded, prospective, randomized clinical trial, there are inherent limitations. Surgeons and surveyors were not blinded to the treatment that the patient received. We attempted to reduce inherent bias by allowing patients to complete outcome surveys without the assistance of the research team. Also, although an a priori power analysis was performed, the study might have shown more differences among study groups with a larger cohort, especially considering that the rates of dysphagia were particularly low in the steroid groups.

In conclusion, these results suggest that steroid administration after cervical plating in ACDF yields better patient-reported outcomes for dysphagia, dysphonia, and neck pain compared with controls. This benefit on outcomes is particularly evident in the reduction of patients reporting severe dysphagia symptoms following ACDF with local steroid application during the first 2 weeks postoperatively. Medium to long-term effects of steroid administration on fusion rates will need to be established in future studies. In addition, subsequent clinical research on ACDF should attempt to stratify dysphagia when reporting outcomes related to anterior cervical surgery. ■

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