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# Effect of perioperative steroids on dysphagia after anterior cervical spine surgery: A systematic review

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## Abstract

### Background

Dysphagia following anterior cervical spine surgery is common. Steroids potentially reduce post-operative inflammation that leads to dysphagia; however, the efficacy, optimal dose and route of steroid administration have not been fully elucidated.

### Objective

The purpose of this systematic review is to evaluate the effect of peri-operative steroids on the incidence and severity of dysphagia following anterior cervical spine surgery.

### Methods

A PubMed search adherent to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines was performed to include clinical studies reporting use of steroids in adult patients following anterior cervical spine surgery. Data regarding steroid dose, route and timing of administration were abstracted. Incidence and severity of post-operative dysphagia were pooled across studies.

### Results

Seven of 72 screened articles met inclusion criteria for a total of 246,298 patients that received steroids. Patients that received systemic and local steroids had significant reductions in rate and severity of dysphagia post-operatively. Reduction of dysphagia severity was more pronounced in patients undergoing multilevel procedures in both groups. There was no difference in infectious complications among patients that received steroids compared with controls. There was no difference in fusion rates at long-term follow-up.

### Conclusions and Clinical Relevance

Steroids may reduce dysphagia after anterior cervical spinal procedures in the early post-operative period without increasing complications. This may be especially beneficial in patients undergoing multilevel procedures. Future studies should further define the optimal dose and route of steroid administration, and the specific contraindications for use.

CERVICAL SPINE

KEYWORDS: ANTERIOR CERVICAL SPINE, DYSPHAGIA, STEROIDS

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## Introduction

### Rationale

The anterior approach is commonly utilized in surgical management of cervical spine pathology. Though it is generally considered safe, there have been reports of various complications.<sup>1,2</sup> One such complication is postoperative dysphagia. Dysphagia following anterior cervical spine surgery is a significant postoperative complaint, with a reported incidence of up to

79%.<sup>3-5</sup> Symptoms primarily occur during the early postoperative period, decreasing significantly by 6 months post-op and ultimately plateauing at 1 year in most patients.<sup>3,4</sup> Dysphagia persisting past 1 year has a prevalence of 15.2%.<sup>5</sup> The etiology of postoperative dysphagia is multifactorial. Contributing factors include prevertebral soft tissue swelling, vocal cord paresis,<sup>4,6,7</sup> scar tissue formation, hardware complication and cervical graft material.<sup>1,4,8</sup> Risk factors that have been identified include multilevel fusion and fe-

male gender,<sup>3,4,9,10</sup> revision surgery,<sup>5</sup> and plate prominence.<sup>2,11</sup>

Given that dysphagia is a common complication of anterior cervical spine surgery, numerous techniques have been investigated to decrease its incidence, decreased plate prominence and cuff pressure are just a few.<sup>2,4,10,11</sup> One therapeutic intervention that shows promise is the use of perioperative steroids.<sup>12-18</sup> By reducing the inflammatory response, steroids should decrease dysphagia as well as pain in the post-operative period.<sup>16</sup> The use of steroids has resulted in decreased dysphagia incidence and severity as well as airway edema, in some studies<sup>12,15-18</sup>; however, in other studies the effect of steroids has been equivocal.<sup>13</sup> In addition to these inconsistent results with dysphagia, there is concern about the adverse effects of steroids, such as delayed time to fusion and increased infection rates.<sup>15,19</sup> The use of both systemic and local steroids has been reported in previous studies.<sup>12-18</sup> The main justification of local steroids over systemic has been the presumed lower rate of systemic complications with local use.<sup>16</sup> Efficacy between the two methods has not yet been compared.

Though the use of perioperative steroids in preventing dysphagia after anterior cervical spine surgery has been examined in various studies, a consensus regarding efficacy has yet to be reached.

## Objectives

The purpose of this review was to evaluate the efficacy of perioperative steroids in reducing dysphagia incidence and severity after anterior cervical spine procedures by performing a systematic review of the literature.

## Methods

### Study Selection

A literature review of PubMed was performed according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>20</sup> The following search terms were screened for inclusion: ["steroids"] AND ["anterior cervical fusion" OR "ACDF"] AND ["dysphagia" OR "odynophagia"]. Clinical articles written in the English language and published between 1990 and 2016 were

screened for inclusion. Inclusion criteria were as follows (1) articles describing anterior cervical spine surgery in adult humans; (2) use of pre-, intra-, or post-operative steroids; (3) assessment of post-operative dysphagia or odynophagia. Duplicate articles, reviews, letters to the editors, and commentaries were excluded. The literature searches were independently performed by two authors (AA and SH); disagreements were resolved by consensus. A thorough bibliographic search of screened articles was also performed for additional qualifying articles. The last search was performed on January 31, 2016.

### Data Extraction & Quality Assessment

Where available, the following data were extracted from each included study: sample size; basic demographics; type and dose of steroid used; frequency of single versus multilevel procedures; length of hospital stay; time to follow-up; incidence and severity of post-operative dysphagia; radiographic measures of prevertebral soft tissue swelling; postoperative complications; and time to fusion. Calculations for steroid dose equivalents were completed using standard conversions as described in the literature (20mg dexamethasone: 106.67mg methylprednisolone, 106.67mg triamcinolone).<sup>21-23</sup> For non-randomized cohort and case-control studies, the Newcastle-Ottawa Scale was used to assess quality and risk of bias. This is a 9-point scale assessing cohort selection, comparability, and outcome or exposure, with a higher score indicating higher quality.<sup>24</sup>

### Primary & Secondary Outcomes

The primary study outcomes were incidence and severity of post-operative dysphagia and/or odynophagia after anterior cervical spine procedures. Studies investigating the severity of dysphagia used various standardized scoring systems, which are summarized in Table 1. Secondary outcomes included severity of prevertebral soft tissue swelling, time to fusion, length of hospital stay, post-operative pain, and other complication rates.

### Statistical Analysis

It is noted that not all studies provided data or information on each subset of patients; therefore comparative analysis is limited by to the nature of the source data. Data for all patients was reported when avail-

able in the literature. Statistical analysis was not conducted for this review because comparative analyses could not be performed.

## Results

### Study Selection

Seventy-two articles were identified from the initial literature search. Fifty-one non-duplicates underwent abstract and title review for applicability and in-

clusion. Nine underwent full-text review. Two articles were excluded due to lack of sufficient outcome data for post-operative dysphagia/odynophagia. The remaining 7 articles met inclusion criteria. Five articles were prospective randomized controlled trials<sup>12-16</sup>; and two were retrospective case-control studies.<sup>17,18</sup>

The results of the literature search are summarized in the PRISMA flow diagram (Figure 1).

### Study Characteristics

The randomized controlled trials (n=5) are graded as

**Table 1. Summary of assessments used to measure dysphagia and highlights of individual study outcomes.**

Study, year	Dysphagia Severity Assessment	Assessment Description	Results	Conclusion
<b>SYSTEMIC STEROIDS</b>				
<i>Pedram, 2003</i>	N/a	Patient subjectively described swallowing difficulty without standardized scale	Dysphagia or odynophagia reported 24-36h post-operatively in 56 (71.79%) steroid-treated patients compared to 130 (82.28%) control patients.	Perioperative systemic steroids reduce incidence of post-operative swallowing impairment in the early post-operative period.
<i>Nam, 2013</i>	Visual analogue scale (VAS) for dysphagia	10-point scale based on patient self-report of swallowing difficulty (0 = no difficulty swallowing, 10 = worst difficulty swallowing).	No statistically significant differences in mean VAS scores between high dose steroids, low dose steroids, and control groups noted during the first 5 post-op days.	Perioperative systemic steroids do not affect severity of post-operative swallowing impairment in the early post-operative period.
<i>Song, 2014</i>	Bazaz Dysphagia Score	Dysphagia described as absent, mild, moderate, severe based on patient report.	Steroid group had lower Bazaz ratings compared to control group during POD 2-5 (p<0.05 each day).	Perioperative systemic steroids improve post-operative severity in the early post-operative period.
<i>Jeyamohan, 2015</i>	Functional Outcome Swallowing Scale (FOSS)	Score 0-5 based on patient report of swallowing function, frequency of associated symptoms, and need for non-oral feeding	Steroid group lower mean FOSS score at 1-month follow-up compared to control group (0.064 vs. 0.66, p=0.027); this difference disappeared after 1 month.	Perioperative systemic steroids improve post-operative dysphagia severity in the early post-operative period, which subsides in the long-term.
<b>LOCAL STEROIDS</b>				
<i>Lee, 2011</i>	Visual analogue scale (VAS) for odynophagia	10-point scale based on patient self-report of pain with swallowing (0 = no pain; 10 = worst pain).	Steroid group exhibited statistically significant lower mean VAS odynophagia scores immediately and at 2-weeks post-operation.	Perioperative local steroids reduce post-operative dysphagia in the early post-operative period.
<i>Cancienne, 2015</i>	N/a	Patient subjectively described swallowing difficulty without normalized scale	9% of steroid group vs. 14.6% of control group experienced dysphagia within 90 days of fusions with 3 or more levels (p=0.005).	Perioperative local steroids reduce incidence of post-operative dysphagia in patients undergoing anterior cervical spinal fusion of 3 or more levels.
<i>Koreckij, 2016</i>	Bazaz Dysphagia Scale	Dysphagia described as absent, mild, moderate, severe based on patient report.	Steroid group had fewer patients with severe dysphagia at 6 weeks post-op (14.3% vs. 40.9%, p=0.008) and 3 month (0% vs. 23.9%, p=0.022) compared to controls.	Perioperative local steroids improve post-operative dysphagia severity beyond the early post-operative period.
	EAT-10: A swallowing screening tool	10 item questionnaire evaluating swallowing and associated psychosocial issues. Each item scored 0-4 (0=no problem, 4=severe problem). Total score ranges from 0-40. Total score of 3 or higher is abnormal (indicative of dysphagia).	Steroid group had fewer patients with abnormal EAT-10 scores at 3 months post-op in comparison to control group (18.2% vs. 57.1%; p=0.012).	Perioperative local steroids reduce incidence of dysphagia in the late post-operative period.

POD: post-operative day.

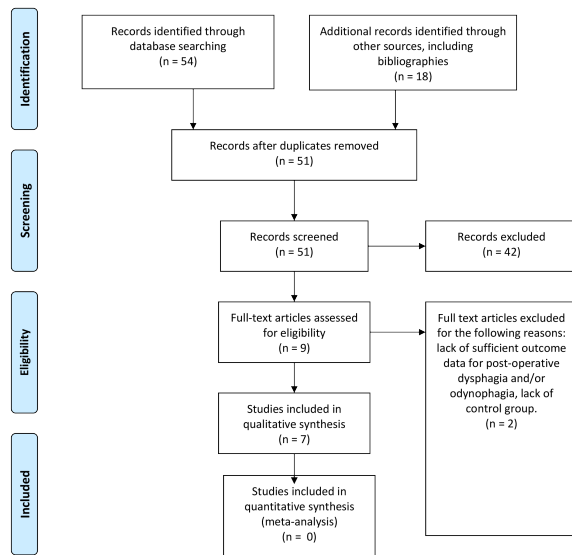


Fig. 1. PRISMA flow diagram for systematic reviews.

level of evidence 1<sup>12-16</sup>; the retrospective studies (n=2) are graded as level of evidence 3.<sup>17,18,25</sup> Dysphagia was measured using a number of different modalities, which are summarized in Table 1.

### Patient Demographics

A total of 246,298 patients were included across all studies; 194 patients received systemic steroids while 2,139 received local steroids; 243,965 subjects served as controls and received no intervention. Indication for initial anterior cervical spine surgery included: cervical radiculopathy, myelopathy, spondylosis, canal stenosis, disc herniation, and trauma. Dysphagia was measured post-operatively from immediately post-op to 24 months post-op. 52.94 percent (130,390 out of 246,298) of patients were female. Patient and outcomes data are reported in Table 1 & Table 2.

**Table 2. Summary of patient and study demographics of patients receiving steroids after anterior cervical spine surgery.**

Author, Year	Design	Total number of patients included	Number of operative levels	Number of multilevel surgeries included, n (%)	Major indications for initial anterior cervical spinal surgery	Follow-up intervals	Demographics of Control Patients				Demographics of Intervention Patients				Steroid Dose Frequency	Steroid Dose Equivalent*
							Total Patients	Mean Age (in years) +/- SD	% Male	Control administered	Total patients	Mean Age +/- SD	% Male	Intervention administered		
SYSTEMIC STEROIDS																
Pedram, 2003	RCT	236	1-5	66 (28)	Cervical canal stenosis, herniated disc, trauma	24-36h PO	158	47+/-15.3 (range: 15-88)	n/a	N/A	78	47+/-12.3 (range: 17-83)	n/a	IV Methylprednisolone	0h, 12h, 24h	0.19 mg/kg
Nam, 2013	RCT	62	1	0 (0)	Cervical radiculopathy	Daily POD 0-5	22	48.8	80	NS	High dose: 20 Low dose: 20	High dose: 46.9 +/- 8.6 Low dose: 45.6+/-7.3	High dose: 55 Low dose: 70	IV Dexamethasone	0h, 24h, 48h	High dose: 20/10/10mg Low dose: 10/5/5mg
Song, 2014	RCT	40	>3	40 (100)	Cervical radiculopathy, myelopathy	Daily POD 1-discharge	20	57.3+/-11 (range: 29-77)	80	N/A	20	59.9+/-10.3 (range: 42-47)	70	IV Methylprednisolone	0h, 6h, 12h, 18h, 24h	46.88mg
Jeyamohan, 2015	RCT	112	≥2	112 (100)	Cervical spondylosis	1mo, 3mo, 6mo, 12mo, 24mo	56	55	48.22	NS	56	54	58.93	IV dexamethasone	IO, 6h, 12h, 18h, 24h	0.20mg/kg IO, 0.06mg/kg PO
LOCAL STEROIDS																
Lee, 2011	RCT	50	1-2	21 (42)	Cervical radiculopathy, myelopathy	POD 0, 2, 4, 2wk	25	50.9	56	N/A	25	54.3	72	RP triamcinolone	IO	7.50mg
Cancienne, 2015	Retrospective case control	245754	Short surgery: 1-2 Long surgery: ≥3	n/a	n/a	Within POD 0-90	243,662	n/a	Short surgery: 47 Long surgery: 47.5	N/A	2092	n/a	Short surgery: 40.3 Long surgery: 42.1	RP Triamcinolone or methylprednisolone	IO	0.19mg, 1.88mg, 3.75mg, 7.5mg, 15mg
Koreckij, 2016	Retrospective case control	44	2-4	44 (100)	Cervical radiculopathy, myelopathy	POD 1, 6wk, 3mo	22	57.6+/-9.9	50	IV dexamethasone 10mg	22	55.1 +/-7.9	54.5	IV dexamethasone 10mg + RP methylprednisolone	IO	15mg

0h: immediately post-operatively; NS: Normal saline; IO: intraoperative; IV: intravenous; Long surgery: operated on 3 or more spinal levels; Mo: month; PO: post-operative; POD: post-operative day ; RP: retropharyngeal; Short surgery: operated on <3 spinal levels ; Wk: week. \*Dose equivalents relative to dexamethasone.

### Study quality and risk of bias

The risk of bias for the two retrospective case-control studies was assessed using the Newcastle-Ottawa scale.<sup>24</sup> One study received 4 out of 9 stars<sup>18</sup>; with 2 stars for study selection, 0 stars for group comparability, and 2 stars for exposure. The other study received 6 out of 9 stars<sup>17</sup>; with 2 stars for study selection, 2 stars for group comparability, and 2 stars for exposure.

### Systemic Steroids and Dysphagia/Odynophagia Incidence

Of the systemic steroid studies, only one study evaluated the incidence of dysphagia in 236 patients who underwent single and multilevel anterior cervical spine procedures.<sup>14</sup> Patients were given 3 doses of IV methylprednisolone immediately post-op, at 12h, and at 24h. Incidence of dysphagia or odynophagia was assessed via patient report at 24-36h post-op. 56 out of 78 patients (71.79%) who were given steroids experienced dysphagia/odynophagia, compared to 130 patients out of 158 (82.28%) in the control group.

### Severity

Severity of dysphagia and/or odynophagia was assessed in 3 studies using standardized scoring systems (Table 1) across 214 patients; 116 patients receiving steroids and the remaining 98 receiving normal saline.<sup>12,13,15</sup> Dysphagia severity was assessed using three different scoring systems: 1) A 10-point visual analogue scale (VAS), in which patients ranked their swallowing difficulty from 0 (no difficulty swallowing) to 10 (worst difficulty swallowing); 2) The Bazaz scale (Table 3); and 3) functional outcome swallowing scale (FOSS) (Table 4). Two studies assessed severity in the acute post-operative setting (i.e. within 1 month post-op) in 102 patients, with 42 control subjects.<sup>12,13</sup> Nam et al assessed dysphagia severity in 62 consecutive patients undergoing single level ACDF using the VAS.<sup>13</sup> The patients were randomly assigned into 3 groups (high dose IV dexamethasone (n=20), low dose IV dexamethasone (n=20), normal saline (n=22)). Doses of steroid or saline were given immediately post-op, at 24h and 48h post-op. Patients were monitored post-op days 0-5. The mean VAS scores among the 3 groups peaked post-op day 1 and decreased through day 5; there was no statistical significance between the groups at any point in the

follow-up period. Song et al assessed dysphagia severity in 40 patients undergoing multilevel ACDF with the Bazaz scale.<sup>12</sup> Twenty patients were given IV methylprednisolone immediately post-op and every 6h for the first 24h post-op, and the remaining 20 were not given anything. Patients were evaluated daily until discharge. Dysphagia was most severe POD1, with 95% and 100% scoring dysphagia as “severe” for steroids and control groups respectively. As dysphagia severity decreased in the two groups, a statistically significant difference was noted through post-op days 2 and 5. On post-op day 2, 0% patients in the steroid group ranked their dysphagia as severe compared to 70% in the control group ( $p = .027$ ). On post-op day 5, 0% patients receiving steroids ranked their dysphagia as severe, 15% as moderate, and 70% as mild, compared to 70% moderate and 30% mild in the control group ( $p = .005$ ).

Long-term severity of dysphagia was assessed in one study<sup>15</sup> in 112 patients after multilevel anterior cervical spine surgery. Patients were randomly assigned into 2 groups, with 56 patients receiving IV dexamethasone and 56 patients receiving saline intra-operatively, and every 6h post-op for the first 24h

**Table 3. Bazaz score for dysphagia severity.**

Severity	Problems swallowing liquids	Problems swallowing solids
None	None	None
Mild	None	Rare
Moderate	None/rare	Occasionally (only with specific foods)
Severe	None/rare	Frequent (majority of food)

**Table 4. Functional Outcome Swallowing Scale (FOSS) for dysphagia severity.**

Score	Symptoms
0	Normal function; asymptomatic
1	Normal function; episodic or daily symptoms of dysphagia
2	Compensated abnormal function manifested by significant dietary modifications or prolonged mealtimes w/o weight loss or aspiration
3	Decompensated abnormal function; daily coughing, gagging, aspiration during meals
4	Severely decompensated abnormal function; severe aspiration & bronchopulmonary complications; non-oral feeding for most nutrition
5	Non-oral feeding for all nutrition



post-op. Dysphagia severity was determined using the functional outcome swallowing scale (FOSS, Table 4) at 1mo, 3mo, 6mo, 12mo, and 24mo post-op. Decreased dysphagia severity, as represented by lower FOSS scores, were reported in the steroid group at 1 month post-op (steroid: .064, control: .66,  $p = .027$ ); however this difference subsided thereafter.

#### Prevertebral Soft Tissue Swelling

Prevertebral soft tissue swelling (PSTS) was evaluated in 2 studies and used as a surrogate for dysphagia.<sup>12,13</sup> Nam et al assessed PSTS by measuring the area (cm<sup>2</sup>) from the lower border of C1 to the upper end plate of C7 for patients receiving high dose dexamethasone, low dose dexamethasone and placebo respectively.<sup>13</sup> PSTS peaked post-op day 3 and continued to decrease through day 5 but no statistical significance was noted between the groups.

Song et al found similar trends by measuring PSTS length (mm) at each level from C2 to C7 using lateral radiographs.<sup>12</sup> During post-operative days 2-6, PSTS increased significantly more in the control group than in those receiving steroids ( $p < .001$ ).

#### Time to Fusion

Fusion status was evaluated using cervical CT scans in one study, with fusion reported when bridging osseous trabeculae were seen spanning each operative level without intervening radiographic lucencies.<sup>15</sup> At 6 months post-op 39.5% of patients in the steroid group demonstrated fusion, compared to 60% in the control group ( $p = .048$ ). This difference was not detected at 12 months and 24 months (Fusion rate at 12 months for steroid: 75%, control: 80%,  $p = .57$ ; 24 months steroid: 92.69%, control: 95.2%,  $p = .57$ ).

#### Length of Hospital Stay

The average hospital stay was shorter in the systemic steroid-receiving group compared to the control group across two separate studies (Song et al:  $5.1 \pm .7$  days for the steroid group vs.  $6.0 \pm 1.02$  for the control group,  $p = .003$ ).<sup>12,15</sup>

#### Neck Disability

Neck disability after anterior cervical spine surgery was evaluated in one study using the Oswestry Dis-

ability Index (ODI).<sup>15</sup> There was no statistically significant difference in neck disability between the two groups at any point post-operatively.

#### Complications

Complications across the studies included in this cohort were: vocal cord motility disorders ( $n=8$ ); and tonsillar laceration secondary to intubation ( $n=1$ ). There were no reports of intraoperative esophageal perforation, vascular compromise, or CSF leak. The complication rate was 2% (9 out of 450 patients).

#### Local Steroids and Dysphagia/Odynophagia

##### Incidence

Of the local steroid studies, incidence was reported in two studies.<sup>17,18</sup> In the first, a large retrospective study, cumulative incidence of dysphagia/odynophagia was 9.5% (23,446 out of 245,754 patients). The incidence in the steroid cohort was 7.88% (162 out of 2,092) compared to 9.52% (23,284 out of 243,662) in the control group. There was statistically significant reduction in incidence of dysphagia in the steroid group (29 out of 322, 9%) in comparison to the control group (6,633 out of 45,432, 14.6%) in patients who received multilevel (3 or more levels) ACDF ( $p = .005$ ).<sup>18</sup> The second study evaluated dysphagia using the EAT-10 scale (Table 1) in 44 patients.<sup>17</sup> Their investigation found no statistically significant difference at 6 weeks post-op; however, by 3 months there was a significant decrease in the dysphagia incidence in the steroid group compared to the control group (18.2% vs. 57.1% respectively;  $p = .012$ ).<sup>17</sup>

##### Severity

Severity of dysphagia and/or odynophagia was assessed in 2 studies using standardized scoring systems (Table 1) across 94 patients; 47 patients receiving steroids and the remaining 47 serving as controls.<sup>17,26</sup> Lee et al. measured the resolution of odynophagia in the acute post-operative period using the VAS score and found that immediate post-operative mean VAS scores in the steroid and control groups were 2.5 and 5.3 respectively ( $p < .001$ ).<sup>26</sup> This difference persisted through 2-week evaluation (mean VAS scores 1.2 and 3.5 for the steroid and control groups, respectively ( $p < .001$ )). Koreckij et al utilized the Bazaz scale to evaluate dysphagia in the prolonged post-operative phase, demonstrating that



14.3% of patients receiving steroids had severe dysphagia at 6 weeks compared to 40.9% in the control group ( $p = .022$ ).<sup>17</sup>

### Prevertebral Soft Tissue Swelling

Two studies measured prevertebral soft tissue swelling (PSTS) at C3-5 using lateral radiographs.<sup>16,17</sup> Both studies demonstrated decreased PSTS in the patients receiving local steroids immediately post-operatively, however only one study was statistically significant.<sup>16</sup> In the latter study,<sup>16</sup> the PSTS difference was maintained at two weeks post-operatively ( $p = .0036$ ).

### Time to Fusion

Time to fusion was reported in one study and defined by “the presence of bony extension into the space between the graft in addition to the absence of segmental motion.”<sup>16</sup> The mean follow-up was 21.4 months in the steroid group and 22.3 months in the control group. The steroid group demonstrated union in all patients (25 of 25), while the control group revealed 96% fusion (24 of 25).

### Length of Hospital Stay

Two studies assessed the length of hospital stay.<sup>17,18</sup> Patients receiving steroids had shorter length of hospital stays compared to the control groups and reached statistical significance ( $1 \pm 1.1$  days, vs.  $2 \pm 2.2$  days respectively,  $p < .001$  and  $1.27 \pm .6$  vs.  $2.2 \pm 1.9$ , respectively,  $p = .03$ ).

### Neck Disability

Neck disability after anterior cervical spine surgery was evaluated in two studies.<sup>16,17</sup> Neither studies demonstrated statistical significance between the two groups at any point during the follow-up periods (Koreckij et al evaluated at 6 weeks and 3 months in and Lee et al at the last follow up, with mean duration of follow-up of 21.4 months and 22.3 months for the steroid and control groups respectively).<sup>17,26</sup>

### Esophageal rupture & other complications

Across the studies included in this cohort there was one complication reported: wound infection leading to pseudoarthrosis ( $n=1$ ). There were no reports of intraoperative esophageal perforation, vascular compromise, or CSF leak. The complication rate for this

cohort (when reported) was 1.1% (1 out of 94 patients).

## Discussion

### Dysphagia/Odynophagia & Prevertebral Soft Tissue Swelling

The purpose of this review was to evaluate the efficacy of perioperative steroids in reducing post-operative dysphagia after anterior cervical spinal surgery by performing a systematic review of the literature.

Dysphagia incidence was uniformly lower with steroids, however statistical significance was inconsistent. It appears that the effect on lowering dysphagia incidence is more pronounced as time passes. This was demonstrated by the statistically significant reduced incidence at 3 months compared to 6 weeks in the Koreckij et al study.<sup>17</sup> Of note, the effect of intraoperative steroids on the reduction of dysphagia incidence seemed to be more pronounced in procedures involving 3 or more levels.<sup>18</sup>

With the exception of Nam et al, all of the studies demonstrated statistically significant reduced dysphagia severity in the steroid group in comparison to the control group at some point during the follow-up period.<sup>12,15-17</sup> These results were mirrored by prevertebral soft tissue swelling, suggesting that perioperative steroids also decrease severity of prevertebral soft tissue swelling and associated complications. The effect of steroids on reduction of both dysphagia severity and prevertebral soft tissue swelling was more pronounced in the early post-operative period ( $\leq 2$  weeks) with the effects on dysphagia severity persisting up to 3 months post-op. Despite the apparent association, the role of prevertebral soft tissue swelling in causing dysphagia remains unclear.<sup>27-29</sup> It should be noted that Nam et al was the only study that consisted of all single level cervical procedures, suggesting that there is more benefit of steroid intervention with multilevel procedures.<sup>13</sup>

Taken together these results provide evidence that perioperative steroids effectively reduce dysphagia and/or odynophagia in the early post-operative period, the benefit being more pronounced in multilevel

procedures. Perioperative steroids should probably be used in conjunction with other methods for multi-level procedures, such as limiting retraction time<sup>30,31</sup> and cuff pressure,<sup>10</sup> with the hope of achieving even greater reduction in post-operative dysphagia.

### Systemic vs. Local Steroids

There were no apparent differences between local and systemic steroids in regards to infections, other complications, and hospital readmission. Intraoperative dose of local steroids can only be administered once, whereas multiple doses of systemic steroids were administered up to 48h post-op. The studies that utilized local steroids consistently reported statistically significant differences in dysphagia incidence and severity through 3 months post-op, however the results were more inconsistent in the systemic steroid studies. Taken together these results suggest that local steroids are more cost-effective, and possibly more efficacious in dysphagia/odynophagia prevention.

### Delayed fusion/infection/other complications

Though delayed fusion has been expressed as a concern for the use of intraoperative steroids,<sup>15,30</sup> the studies in this review demonstrate that steroids do not significantly hinder fusion rates. Use of perioperative steroids decreased the early fusion rate in the study by Jeyamohan et al, however this drawback did not persist past at 6 months.<sup>15</sup> This finding was further supported by Lee et al (2011), in which 100% of patients in the steroid group achieved fusion by the last follow-up.<sup>26</sup> Despite the reported increased infection rate associated with steroid use in general,<sup>19</sup> infection rates did not significantly vary among the steroid and control groups in any of the studies. Moreover, a higher number of non-dysphagia/odynophagia complications were reported in the groups that did not receive steroids. Lee et al (2015) describes esophageal perforation as a potential complication of local perioperative steroids in the late post-operative period,<sup>32</sup> however this complication was not reported in any of the studies of this review. Given that the study only reports two patient cases, it is difficult to ascertain whether the esophageal perforation was directly related to steroid use. Therefore, it can be concluded that there is no current evidence of an increased complication rate associated

with perioperative steroids in anterior cervical spine surgery. Despite this conclusion, the use of steroids is still considered off-label, effective doses are still unknown, and given the theoretical concerns particularly with local administration, caution should be exercised when selecting patients for this intervention.

### Limitations & Future Directions

This review is limited by the different methods used to report dysphagia and/or odynophagia. These methods included the Bazaz scale,<sup>12,17</sup> FOSS score,<sup>15</sup> and VAS.<sup>13,16</sup> The same limitation was encountered with pre-vertebral soft tissue swelling. Effective comparison cannot be achieved without a standardized measure of these outcomes. Also, because various steroid types and doses were used in the included studies, exact dose and type of steroid for desired effect on dysphagia remains unclear. Additionally, given that certain complications such as esophageal perforation or infection are relatively uncommon after ACDF, the studies included in this review were likely not adequately powered concerning them; making it difficult to appropriately compare complication rates between the systemic and local steroid groups. Lastly, there was only one randomized control trial that utilized local steroids; therefore more studies were used with lower levels of evidence than with systemic steroids.

This review highlights the need for a standardized tool to evaluate post-operative dysphagia, in order to better understand the incidence, severity, as well as the effect of steroids. Additionally, despite the comparison done in this review, a prospective study comparing local and systemic steroids would provide more sufficient analysis and better indicate which, if either, is more efficacious in preventing post-operative dysphagia following anterior cervical spine surgery.

## Conclusion

The purpose of this systematic review is to evaluate the effect of peri-operative steroids on the incidence and severity of dysphagia following anterior cervical spine surgery by conducting a systematic review of the literature. Peri-operative steroids reduce dyspha-

gia after anterior cervical spinal procedures in the early post-operative period, without increasing complications or adversely affecting long-term fusion; and are especially beneficial in patients undergoing multilevel procedures.

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## Disclosures & COI

None of the authors have any disclosures or conflicts-of-interests to report with respect to this manuscript.

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