**Does Local Intraoperative Corticosteroids Delivered in a Gel-Matrix Minimize Dysphagia following Anterior Discectomy and Fusion (ACDF)? A preliminary analysis of a Double Blind Randomized Controlled Trial (RCT)**

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# Summary

The aim of this double blind RCT was to determine if the application of local intraoperative corticosteroids (LIC), during ACDF surgery impacts the post-op dysphagia severity. This interim analysis revealed that patients treated with LIC showed smaller pre to post op worsening in several dysphagia specific PRO domain scores, compared to a control group.

# Abstract

## Null-Hypothesis:

Local intraoperative corticosteroids (LIC) application has no effect on the early post-operative dysphagia severity.

## Design:

Double Blind Randomized Clinical Trial – preliminary results, ongoing enrollment

## Introduction:

Dysphagia is a common complication in the setting of ACDF surgery. There is a controversy in the literature regarding the effectiveness of local intraoperative corticosteroids in reducing post-operative dysphagia. This study aims to evaluate the effectiveness of LIC in decreasing the severity of swallowing difficulty following ACDF.

## Methods:

Adult patients undergoing primary multi-level ACDF (2-4 levels) were enrolled at a single institution, and randomized (double-blinded) to two arms. Steroid Arm (S) received 1ml (40mg) of methylprednisolone delivered with an absorbable gel matrix (vehicle) to the retro-esophageal space prior to closure. The Control Arm (C) only received the vehicle prior to closure. Dysphagia specific PROs (Swal-QOL, Eat-10, Bazaz) were collected pre-operatively, and at day-1 (POD1), day-2 (POD2), and 1 month (M1) post-operatively. A Mann-Whitney U test was performed to compare the median change in the PRO scores (S vs C) from baseline to each post-op time point.

## Results:

A total of 59 patients were enrolled: 30 patients in the Steroid Arm (37% with >2 level fusion; 57% male), and 29 patients in the Control Arm (52% with >2 levels ACDF; 2 Corpectomy; 66% male). The Control arm had a higher BMI (31.7±6 vs 28.4±5.6, p=.03), longer OR time (158±42 vs 132.6±40, p=.02), and rated their baseline neck (5.9±2.5 vs 3.77±2.8, p<0.01) and right arm (3.82±3.2 vs 1.48±2.2, p=.002) pain higher on the visual pain scales. At baseline, patients in the Steroid and Control arm had similar dysphagia outcome scores. Pre to post-operative comparison of the SWAL-QOL domains revealed that patients in group C had a worsening of Burden sub-score at POD2, Fear at POD1 & 2 and M1, Mental Health at POD1, Food selection at POD2, Eating Duration at M1; they also had a larger increase in the modified inpatient Eat-10 score at POD1, and the total Eat-10 score at M1. There was no difference between the groups on the Bazaz -Dysphagia score at any time point.

## Conclusion:

Our study shows a promising potential for the application of LIC with this delivery method to prophylactically reduce dysphagia following ACDFs.

# Manuscript

**Introduction**

Anterior Cervical Discectomy and Fusion (ACDF) is a highly successful and often favored approach for treating Cervical Spine Pathologies[1–5]. One of the more common complications of this surgical approach is the development of post-operative dysphagia, more commonly known as swallowing problems[1,2,4,6,7].

Swallowing is the result of a complex coordination of the connective, muscular, and neuronal structures of the oral cavity, pharynx, and esophagus; impairment, interruption, or disruption of this intricate bio-mechanism leads to swallowing dysfunction following ADCF. The specific surgical factors that cause post-operative dysphagia and demographic factors that place patients at an elevated risk of developing more severe post-operative dysphagia have been widely debated in the literature.

The literature addressing dysphagia after ACDF includes a broad range of reported incidence, severity, and duration (i.e. time to resolution of the complication). The occurrence of post-operative dysphagia has been reported as ranging from 1% to 79% [4,8–11]. The severity of dysphagia experienced by patients following ACDFs can range anywhere from a mild and subjective discomfort (i.e. fullness of the throat and soreness) to serious medical issues such as malnutrition, social isolation, aspiration pneumonia, airway obstruction, and even death [6,12–14]. Most studies report that the majority of dysphagia related symptoms occur in the early phase of the recovery period, and gradually dissipate over time. Permeant dysphagia following ACDFs has been reported to occur but is far less common.[[9,10,15–17]. The divergence in literature is likely due to the method in which dysphagia and swallowing problems were assessed (prospective vs retrospective), assessment type (subjective vs. objective), type of questionnaires used (validated vs. non-validated, simple vs. in- depth), time period at which dysphagia was assessed (early vs. late in post-operative period), as well as the aforementioned surgical and patient factors.[1,6,7,9,10,18]

Corticosteroids have been utilized as an intervention to reduce soft tissue swelling in the anterior aspect of the neck in the critical care, ENT, and anesthesiology literature.[5] In recent years, several studies have investigated the efficacy of local and systemic steroids in preventing post-operative dysphagia.[5,9,11,14,19–21,16] The majority of studies investigating the use of **systemic steroids** in the perioperative period have found that they were effective in reducing the incidence and severity of post-operative swallowing problems[5,19,20]. While these results are encouraging, systemic corticosteroid utilization is associated with potential systematic side effects and fusion complications, which are a deterrent for its use [5,9,11]. In this context, a few investigators have started to investigate the impact of **local corticosteroids** applied to the retropharyngeal space. These studies also reported on the effectiveness of corticosteroids in reducing post-operative swallowing problems, but had several limitations ranging from a retrospective design[9], use of questionnaires not specific to dysphagia [11], exclusion of long ACDF (i.e. > 2 levels) [11], or use of administrative database/CPT codes to assess dysphagia[22].

Our study aims to elucidate the role of local intraoperative corticosteroids (LIC) in dysphagia after multi-level ACDF by utilizing validated questionnaires in a prospectively randomized double-blinded fashion. To further reduce any bias associated with the study, our hypothesis was that there would be no difference in swallowing difficulty between the patients who do and the patients who do not receive intraoperative topical steroids in their wound at the end of the surgical case.

## Methods

### Study design

This IRB approved study is a single center, prospective, randomized, double-blind control trial. Study inclusion criteria were patients over 18 years old undergoing 2, 3, or 4 levels of ACDF. Exclusion criteria were revision surgery, ongoing infection, cases of trauma with esophageal damage or vertebral fracture, patients with diagnosis related to swallowing issues (i.e. Esophagitis, Barrett’s Esophagus, Sjogren’s Syndrome, Multiple Sclerosis, Laryngitis), patients with a medical history that puts them at an extremely elevated risk of extended length of stay/ infection, and all those who do not wish to be randomized/ blinded.

### Randomization Assignment / Treatments

Patients in this study were randomized in a double blinded fashion to either the Steroid (S), or the Control (C) arm. Subjects randomized to the Steroid Arm received 1ml (40mg) of methylprednisolone, delivered with an absorbable gel matrix (vehicle) to the retro-esophageal space prior to closure. Subjects randomized to the Control Arm received only the gel matrix prior to closure.

Prior to initiation of the study, the Biostatistics Department created a computer generated randomization table of subjects’ IDs vs. randomized arm. The subject ID and randomization arm were assigned to a subject after the informed consent form was signed. On the day of the surgery, the research coordinator paired the randomization number with the pre-generated randomization key to obtain the randomization assignment. While the OR was being set up, the randomization was shared with the surgical team, and specific instructions were given to ensure that the Surgeon and First Assist remained blinded throughout the operation.

As per the institutional standard of care, all patients received 8 to 10ml of IV dexamethasone regardless of the randomization arm. This intra-operative administration of steroid aims to protect the spinal cord and nerve root injury during the procedure and is recommended by the institution’s Anesthesiology Service for its anti-anemic effects.

### Time period of analysis

While the study design included following-up the patients up to 1-year post-op, this interim analysis solely focused on the early outcomes of patients with a minimum one month follow-up.

### Data Collection

Data collection included **baseline** **demographic variables** (age, sex, BMI, Charlson Comorbidity Index [CCI], smoking history, and diagnosis), **surgical information** (operative time, number of levels fused, surgical level distribution [i.e. C4-7]), and **inpatient data** (length of stay [LOS], , additional post-operative steroid administration)

All primary patient reported outcomes (PROs) were dysphagia specific and included the following instruments: SWAL-QOL, Eat-10, and Bazaz. These questionnaires were administered pre-operatively, on post-op Day 1 (POD1), post-op Day 2 (POD2), and 1 month post-operatively. Secondary PROs included NDI (collected pre-operatively, and at 1 month post-operatively), as well as VAS for Neck and Arm pain (collected pre-operatively, at POD1, POD2, and at 1 month post-operatively)

### Statistics

Steroid and Control arms were compared in terms of demographics and surgical information using a student’s independentt-test and chi square/fisher exact test for normally distributed data, and a Mann-Whitney U test otherwise. In terms of PROs, a Mann-Whitney U test was performed to compare the group medians for dysphagia scores at Baseline, Post-op Day 1, Post-op Day 2, and 1 month postoperatively. In addition, a pre-post op comparison was conducted by calculating the change in PRO from baseline to each post-operative time point for each patient. Statistical significance was determined for all results with p<0.05.

## Results

### *Patient Population (Table 1)*

At the time of this interim analysis, a total of 65 patients have been formally enrolled in the study. Due to 5 screen failures, and 1 patient requesting to be withdrawn, 59 of the initial 65 patients were included in the analysis. This cohort of 59 patients included 36 males and 23 females, with a mean age of 55yo. A total of 30 patients were randomized to the steroid arm, and 29 to the control arm. The comparison of the demographic information across the 2 randomized branches revealed no significant difference in gender distribution, history of GERD, Charlson Comorbidity Index (CCI) score, smoking status, or average age. The Steroid arm had a significantly lower BMI than the Control arm (28.4 ± 5.6 kg/m2 vs. 31.7 ± 5.96 kg/m2, p=0.032). Three broad primary diagnosis categories were identified with no significant difference across the randomization arms: radiculopathy (27), myeloradiculopathy (17), myelopathy (18)

**Table 1: Comparison of demographic data between the Steroid and the Control arm.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Control | Steroid | p |
| Sex (% male) | 66% | 57% | .334 |
| Age | 55.5 ±11.1 | 55.6 ± 9.9 | .992 |
| History of GERD | 8 | 11 | .580 |
| Smokers (Current) | 9 (3) | 12 (2) | .589 |
| BMI (kg/m2) | 31.7 ± 5.96 | 28.4 ± 5.6 | .032 |
| Diagnosis (n) |  |  |  |
| Radiculopathy | 11 | 16 | .486 |
| Myelo-radiculopathy | 11 | 6 |
| Myelopathy | 7 | 11 |

### Surgical Data and Length of Stay (Table 2)

The average number of levels fused for the steroid and control arm was 2.47 ± .68 and 2.59 ±.63 respectively (p=0.486). The distribution of number of levels fused revealed that 52% of the control arm underwent a >2 level surgery and 33% of the steroid arm underwent a >2 level surgery. The Steroid and control group each had one patient that underwent an anterior/posterior fusion, and the control group had 2 patients that underwent corpectomies.

The average operative time for the entire cohort, steroid and control arm was 144±42, 132±39, and 157±42 minutes, respectively. The independent t-test revealed that the Control arm operative time was significantly longer than the Steroid arm (+25 minutes). However, no significant differences were found when the individual average operative times for 2-, 3-, and 4- level fusions were compared between the groups.

There was a trend (p=0.058) for the Steroid arm to have a shorter length of stay, LOS (1.99±0.9 days vs. 2.96±2.5 days) than the Control arm. The independent t-test was repeated after the patients with unrelated extended LOS were removed (1 patient for a psychiatric issue, 1 for an issue related to clotting medication), and no significant difference for the average LOS was found (Control arm=2.4±1.1 days vs. Steroid Arm=1.99±0.9, p=0.114)

**Table 2: Comparison of surgical data between the Steroid and the Control arms.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Control | Steroid | P |
| # of ACDF levels | 2.59 ±.63 | 2.47 ± .68 | .486 |
| 2-levels (# pts) | 14 | 19 | 0.299 |
| 3-levels (# pts) | 13 | 8 | 0.18 |
| 4-levels (# pts) | 2 | 3 | 1 |
| Op Time (Overall) | 157±4 | 132±4 | **0.02** |
| Op Time for 2 Level | 139±29 | 120±4 | 0.11 |
| Op Time for 3 Level | 163±39 | 149±3 | 0.44 |
| Op Time for 4 Level | 236±30 | 165±28 | 0.07 |
| Length of Stay (LOS) | 1.99±0.9 | 2.96±2.5 | 0.058 |

### Post-Op IV Steroids

10 patients in the control arm and 9 patients in the Steroid arm were given IV dexamethasone post-operatively. Within the Control Arm, all these 10 patients received IV steroids for dysphagia-related complaints; while, within the Steroid Arm, 5 patients received IV steroids for dysphagia-related complaints and 4 for radicular pain/numbness.

### SWAL-QOL:

A comparison of the median scores of the SWAL-QOL domains found that patients in the Control arm had worse scores for Burden at POD2, Fear at POD1 and POD2, Mental Health at POD1, Food selection at POD2, and Eating Duration at M1 (**Table 3**). These findings were confirmed with a pre to post comparison (larger decline in domain scores for the Control arm). In addition, the Control arm patients also exhibited a worsening of the fear domain at M1 (**Table 4**).

### Eat-10 and modified Eat-10:

The pre to post op comparison of the Eat-10 measure found that the Control arm patients had a larger increase in total Eat-10 score at M1 (**Table 5**). A comparison of the group medians mirrored this result (**Table 6)**. Due to the irrelevancy of the first two questions of the Eat-10 in first 48 hours post-op, a modified EAT-10 total score was calculated for the inpatient stay (sum of remaining 8 questions). The pre to post op comparison of the Modified Eat-10 found that the Control arm patients had a larger increase in a modified inpatient Eat-10 score at POD1 (**Table 5**), but the comparison of the group medians only found that the difference was trending towards significance at this time point (**Table 6**).

### Bazaz:

The comparison of the Bazaz scores at different time-points revealed no significant difference between the randomized arms (p>0.2 at all time-points).

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| **Table 3: Comparison of the median SWAL-QOL scores for different time-points** | | | | | | | | | | | | | |
|  | | Pre-Op ( C N=29, S N=30) | | | **POD1** ( C N=28, S N=28) | | | **POD2** (C N=25, S N=24) | | | **M1** (C N=27, S N=28) | | |
| Median | IQR | P | Median | IQR | P | Median | IQR | P | Median | IQR | P |
| **Burden** | **C** | 100 | (100‒100) | 0.309 | 62.5 | (25‒87.5) | 0.117 | **62.5** | **(25‒87.5)** | **0.049** | 87.5 | (62.5‒100) | 0.106 |
| **S** | 100 | (100‒100) | 81.25 | (50‒100) | **81.25** | **(53.1‒100)** | 100 | (78.1‒100) |
| **Fear** | **C** | 100 | (100‒100) | 0.313 | **87.5** | **(68.8‒100)** | **0.049** | **87.5** | **(50‒96.8)** | **0.032** | 93.8 | (87.5‒100) | 0.062 |
| **S** | 100 | (100‒100) | **100** | **(82.8‒100)** | **100** | **(76.6‒100)** | 100 | (90.6‒100) |
| **Mental Health** | **C** | 100 | (100‒100) | 0.309 | **70** | **(50‒100)** | **0.026** | 70 | (37.5‒97.5) | 0.054 | 100 | (75‒100) | 0.337 |
| **S** | 100 | (100‒100) | **100** | **(81.3‒100)** | 95 | (77.5‒100) | 100 | (82.5‒100) |
| **Food Section** | **C** | 100 | (100‒100) | 0.583 | 75 | (28.1‒87.5) | 0.06 | **50** | **(25‒100)** | **0.034** | 100 | (75‒100) | 0.298 |
| **S** | 100 | (100‒100) | 93.8 | (50‒100) | **100** | **(53.1‒100)** | 100 | (100‒100) |
| **Eating Duration** | **C** | 100 | (100‒100) | 0.273 | 75 | (25‒100) | 0.842 | 50 | (18.8‒87.5) | 0.435 | **87.5** | **(50‒100)** | **0.012** |
| **S** | 100 | (100‒100) | 75 | (37.5‒100) | 75 | (28.8‒100) | **100** | **(87.5‒100)** |
| *IQR: Interquartile range (Q1-Q3) C:Control arm S:Steroid arm* | | | | | | | | | | | | | |

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| **Table 4: Comparison of the change in SWAL-QOL scores from the baseline (i.e. pre-op)** | | | | | | | | | | | | | | | | | | | | |
|  |  | | **POD1** ( C N=28, S N=28) | | | | | | **POD2** (C N=25, S N=24) | | | | | | **M1** (C N=27, S N=28) | | | | | |
| Median | | IQR | | P | | Median | | IQR | | P | | Median | | IQR | | P | |
| **Burden** | **C** | | -31.3 | | (-75‒-12.5) | | 0.128 | | **-37.5** | | **(-75‒-12.5)** | | **0.049** | | -12.5 | | (-37.5‒0) | | 0.147 | |
| **S** | | -18.8 | | (-50‒0) | | **-18.8** | | **(-46.9‒0)** | | 0 | | (-21.9‒0) | |
| **Fear** | **C** | | **-9.4** | | **(-29.7‒0)** | | **0.05** | | **-12.5** | | **(-43.8‒-3.1)** | | **0.032** | | **-6.3** | | **(-12.5‒0)** | | **0.046** | |
| **S** | | **0** | | **(-17.2‒0)** | | **0** | | **(-18.8‒0)** | | **0** | | **(0‒0)** | |
| **Mental Health** | **C** | | **-30** | | **(-50‒0)** | | **0.027** | | -30 | | (-60‒-2.5) | |  | | 0 | | (-25‒0) | | 0.435 | |
| **S** | | **0** | | **(-18.8‒0)** | | -5 | | (-22.5‒0) | | 0 | | (-17.5‒0) | |
| **Food Section** | **C** | | -25 | | (-59.4‒-3.1) | | 0.098 | | **-50** | | **(-75‒0)** | | **0.034** | | 0 | | (-25‒0) | | 0.056 | |
| **S** | | -6.3 | | (-50‒0) | | **0** | | **(-46.9‒0)** | | 0 | | (0‒0) | |
| **Eating Duration** | **C** | | -25 | | (-71.9‒0) | | 0.967 | | -50 | | (-75‒-12.5) | | 0.435 | | **-12.5** | | **(-25‒0)** | | **0.001** | |
| **S** | | -25 | | (-62.5‒0) | | -25 | | (-71.9‒0) | | **0** | | **(-12.5‒0)** | |
| *IQR: Interquartile range (Q1-Q3) C:Control arm S:Steroid arm* | | | | | | | | | | | | | | | | | | | | |
| **Table 5: Comparison of the change in EAST-10 scores from the baseline (i.e. pre-op)** | | | | | | | | | | | | | | | | | | | | | |
|  | |  | | **POD1** ( C N=28, S N=28) | | | | | | **POD2** (C N=25, S N=24) | | | | | | **M1** (C N=27, S N=28) | | | | | |
| Median | | IQR | | P | | Median | | IQR | | P | | Median | | IQR | | P | |
| **Standard** | | **C** | | 18 | | (7.25‒20.5) | | 0.052 | | 17 | | (7.5‒25.5) | | 0.19 | | **5** | | **(0‒10)** | | **0.021** | |
| **S** | | 8 | | (3.25‒19) | | 8 | | (4.25‒19.75) | | **0** | | **(0‒4.25)** | |
| **Modified for Inpatient Stay** | | **C** | | **15.5** | | **(7.25‒20)** | | **0.043** | | 15 | | (7.3‒20) | | 0.074 | | N/A | | | | | |
| **S** | | **7.5** | | **(3.25‒15)** | | 7 | | (3.5‒16) | |
| *Eat-10: 0= best score, SWAL-QOL: 100= best score* | | | | | | | | | | | | | | | | | | | | | |
| *Modified for Inpatient Stay Eat-10: Sum of questions (8 out of 10) determined to be relevant for inpatient stay* | | | | | | | | | | | | | | | | | | | | | |
| *IQR: Interquartile range (Q1-Q3) C:Control arm S:Steroid arm* | | | | | | | | | | | | | | | | | | | | | |

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| **Table 6: Comparison of the median EAST-10 scores for different time-points** | | | | | | | | | | | | | |
|  | | Pre-Op ( C N=29, S N=30) | | | **POD1** ( C N=28, S N=28) | | | **POD2** (C N=25, S N=24) | | | **M1** (C N=27, S N=28) | | |
| Median | IQR | P | Median | IQR | P | Median | IQR | P | Median | IQR | P |
| **Standard** | **C** | 0 | (0‒0) | 0.415 | 18 | (7.25‒24.5) | 0.067 | 17 | (7.5‒25.5) | 0.214 | **5** | **(0‒10)** | **0.03** |
| **S** | 0 | (0‒.25) | 8 | (4‒20.75) | 15 | (8‒25) | **0** | **(0‒4.5)** |
| **Modified for Inpatient Stay** | **C** | N/A | | | 15.5 | (7.25‒24) | 0.055 | 15.5 | (7.3‒25) | 0.099 | N/A | | |
| **S** | 7.5 | (4‒17.5) | 15 | (8‒20) |
| *Eat-10: 0= best score, SWAL-QOL: 100= best score* | | | | | | | | | | | | | |
| *Modified for Inpatient Stay Eat-10: Sum of questions (8 out of 10) determined to be relevant for inpatient stay* | | | | | | | | | | | | | |
| *IQR: Interquartile range (Q1-Q3) C:Control arm S:Steroid arm* | | | | | | | | | | | | | |

### NDI and VAS

Patients in the Control arm presented a significantly greater VAS Neck at baseline (**Table 7**) than the Steroid arm; there was no difference in the subsequent follow-up time points. The control arm also exhibited greater VAS Arm on the right side (baseline and M1), and left side (POD1 only). There was no significant difference in terms of NDI.

**Table 7: Comparison of the NDI and VAS for different time-points**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Pre-Op** | | **POD1** | | **POD2** | | **M1** | |
| Mean | P | Mean | P | Mean | P | Mean | P |
| **NDI** | **C** | 39.9 | 0.74 | Not collected | | Not collected | | 34 | 0.6 |
| **S** | 30.5 | 31 |
| **VAS Neck** | **C** | **5.9** | **0.003** | 5.5 | 0.13 | 5.2 | 0.13 | 2.3 | 0.6 |
| **S** | **3.8** | 4.2 | 3.8 | 2.0 |
| **VAS Right Arm** | **C** | **3.8** | **0.002** | 1.1 | 0.9 | 1.7 | 0.5 | **1.8** | **0.04** |
| **S** | **1.5** | 1.0 | 1.3 | **0.6** |
| **VAS Left Arm** | **C** | 3.4 | 0.2 | **2.8** | **0.08** | 2.1 | 0.2 | 2.3 | 0.2 |
| **S** | 2.4 | **0.9** | 1.3 | 1.3 |

### Steroid Related Post-operative complications

A Fisher exact test was conducted to compare the occurrence of documented complications in the post-operative period for both groups. No significant difference was found for leukocytosis, hyperglycemia, blood loss or anemia in the early post-operative period.

**Table 8: Comparison of Steroid-Related Complications between the Steroid and the Control arms.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Control | Steroid | P |
| ABLA | 9 | 8 | 0.7779 |
| Leukocytosis (reported in chart notes) | 8 | 7 | 0.771 |
| Leukocytosis (based on retrospective review of lab results) | 20 | 21 | 1 |
| Untreated EBG (reported in chart notes) | 4 | 4 | 1 |
| Untreated EBG (based on retrospective review of lab results) | 27 | 21 | 0.254 |

## Discussion

Anterior cervical discectomy and fusion (ACDF) is a popular, effective, and relatively low-risk surgical option for the treatment of multilevel cervical pathologies. Despite its well documented success rate, one of the major drawbacks of this procedure is the possible development of post-operative dysphagia.

While the reported incidence of dysphagia widely varies in the literature, it is clear that a therapeutic or preventative solution is needed to reduce the severity or even prevent the development of dysphagia. As such, over the past several years, multiple investigators have looked into the effects of both systemic and local steroid application.

Studies investigating the effects of **systemic steroid** **use** have mixed results in terms of its effectiveness in reducing post-operative dysphagia. Jeyamohan et al. [23] developed a RCT with 112 ACDF patients randomized to either intravenous saline or dexamethasone. They reported the latter to be comparatively effective in reducing dysphagia, as measured by the functional outcome swallowing scale (FOSS) 1 month following the surgery. Song et al. [19] in a prospective study of multi-level ACDF compared 20 patients who received 250mg of IV methylprednisolone 4-times a day during 24h to 20 control patients; they reported significantly reduced rates of dysphagia as measured by the Bazaz score, and reduced length of stay. On the other hand, Pedram et al. [20] demonstrated that high doses of IV methylprednisolone given immediatelyafter the operation, 12hrs post-op, and 24hrs post-op reduced damage to the pharyngeal wall, arytenoids, and vocal cords, but did not reduce dysphagia.

Since the use of systemic steroids does not come without concerns (delayed fusion, peptic ulcer disease, post-operative infection, etc.) a few authors have investigated the effect of **local steroid** on dysphagia and/or Prevertebral Soft Tissue Swelling (PSTS) following ACDF. Lee et al. [11] in a prospective randomized study of 50 patients, reported that local steroids on the retropharyngeal sponge were effective in reducing post-operative odynophagia and PSTS; this study was limited to 1 and 2-levels ACDF and did not include any dysphagia specific questionnaires. Using an administrative database, Cancienne et al. [22] reported a lower incidence of dysphagia (9% vs. 14.6%) with use of local steroid in the setting of long ACDF (i.e. 3 level or more); no difference was found for short ACDF. Finally, in a retrospective review of 44 patients who underwent 2-4 ACDF levels, Koreckjii et al. [9] reported better Bazaz-Yoo scores for the steroid group (80mg of methylprednisolone delivered on a collagen sponge) than for the control one; no significant difference was found in terms of EAT-10 or PSTS.

The aim of the current study is to investigate the effectiveness of intraoperative topical steroids in decreasing the severity of swallowing difficulty following anterior cervical fusion surgery. More specifically, our study was designed to address some of the limitations observed in existing studies. As such, we designed a prospective double blind randomized trial of multi-level ACDF surgery, and quantified the post-operative dysphagia using two validated questionnaires, SWAL-QOL [24] and EAT-10 [7,25,26],and the Bazaz dysphagia measure.

The outcomes included in this manuscript are the results from an early and interim analysis of our prospective double blinded RCT. Pre-operatively the steroid and control arms differed significantly in terms of average neck & right arm VAS pain, and BMI, but no significant differences were identified in terms of pre-operative swallowing function and baseline demographic characteristics. The only surgical factor found to be significantly different between the two arms was the OR time for the entire cohort. However OR time of the 2, 3, and 4 level procedures were found to be similar. Finally with the exception of the intermittent axial pain in the control group, no significant differences in secondary outcomes were observed.

### Dysphagia:

As demonstrated by the significant differences in two of the three dysphagia specific outcomes, patients who received local intraoperative steroids experienced dysphagia to a lesser degree during the immediate peri-operative and early post-operative time period.

### SWAL-QOL

As illustrated by the significant differences in SWAL-QOL domains, patients randomized to the Control arm do not perform as well as the Steroid Arm in the early perioperative time period. This subjective assessment and experience of swallowing added to the overall burden of the post-operative recovery during their hospital stay. Compared to baseline, at 1 Month, the control arm also exhibited a deficit in the SWAL-QOL Fear domain, meaning that these patients are worried about choking on food/liquids to somewhat of a greater extent than the Steroid arm. Furthermore, as demonstrated by the differences in the SWAL-QOL Eating duration, their impeded ability to swallow/ impairment of their swallowing function has caused them to eat at a slightly slower rate.

### Eat-10:

The observed difference in Eat-10 and Modified Eat-10 questionnaire on POD1 indicates that the swallowing function of patients in the control group is significantly impaired compared to the steroid group.

At 1 Month the total Eat-10 score in the control group is significantly higher than that of the steroid group. The median score of 5, which is over the threshold set for problematic swallowing (3)[7,25,26] indicates that a majority of the group population is still having issues at this point. The Steroid group median score of 0 indicates that patients given the steroid had a faster return to their baseline swallowing function after surgery.

### Limitations

The results of our study are not without limitations. First and foremost, this is early interim analysis of a study that has a larger target enrollment and a follow up period of one year. The aforementioned status of our study has led to a slight imbalance in patient factors such as BMI, and operative factors. Due to the discrepancy in the literature, it is hard to anticipate to what extent these factors play in the development of post-operative dysphagia. As enrollment continues, we are expecting these differences to level-off.

\*Not all patients included In the analysis were able to fill out questionnaires at all time points. Finally, due to the standard of care protocols at our institution, all patients undergoing ACDFs are given 8-10ml of IV dexamethasone by the anesthesiologist during the surgery. Since patients are given the IV steroid uniformly, it is hard to determine if or how much its application affects the ordinary course of post-operative dysphagia

Further investigation is needed to delineate the impact of steroid on dysphagia, fusion rates, and pre-vertebral soft tissue swelling following ACDFs.

## Conclusion:

Our study shows a promising potential for the application of LIC with this delivery method to prophylactically reduce dysphagia following ACDFs.

Our early results support those findings of Lee [11], Koreckjii [9], and Cancienne [22] and contribute to literature by provided evidence that administering local intraoperative steroids to the retro-esophageal space,in a randomized and double blinded fashion; results in a reduction of validated dysphagia specific questionnaire scores without increasing the rate of early complications. .

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