5-2018

A new surgical approach for O-C2 fusion, solving the problem of dysphagia.

M. Kathryn McClure
University of Louisville

A NEW SURGICAL APPROACH FOR O-C2 FUSION, SOLVING THE PROBLEM OF DYSPHAGIA

By

M. Kathryn McClure

B.S.- Brescia University,
Owensboro, Kentucky,
May 2015

A Thesis
Submitted to the Faculty of the
School of Medicine of the University of Louisville
in Partial Fulfillment of the Requirements
for the Degree of

Master of Science
in Communicative Disorders

Department of Otolaryngology – Head/Neck Surgery and Communicative Disorders
University of Louisville
Louisville, Kentucky

May 2018

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A Thesis Approved on
April 18, 2018
by the following Thesis Committee:

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Teresa Pitts, Ph.D., Thesis Advisor

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Rhonda Mattingly, Ed.D.

_____
Alan Smith, Ed.D.

DEDICATION

To my parents, Ann and Patrick, and my siblings, Philip, Conor and Beth

ACKNOWLEDGMENTS

I thank my friends, Andrea, Lauren, Austin, Beth, Kaitlyn, Renee, Elizabeth, LuTisha, Emily, Helen, Sarah and Caleb for their unwavering faith and support. I thank Alan Smith, Ed.D, Rhonda Mattingly, Ed.D, Gay Masters, Ph.D and Teresa Pitts, Ph.D for encouraging and supporting my goals and efforts during my academic career at the University of Louisville.

ABSTRACT

A NEW SURGICAL APPROACH FOR O-C2 FUSION, SOLVING THE PROBLEM OF DYSPHAGIA

M. Kathryn McClure

April 18, 2018

The fusion of the second cervical vertebrae to the occipital bone (O-C2 fusion) for head stabilization can result in postoperative dysphagia and dyspnea, negatively impacting the patient's quality of life. Currently, the O-C2 angle is used for head placement, which may not place the head neutrally. We hypothesize that aligning the external auditory meatus with midline of the C2 will reduce oropharyngeal stenosis, reducing dysphagia. One male patient with poor swallow quality of life who required a revision of a previous O-C2 surgery was evaluated via videofluoroscopy and completed the standard swallow quality of life questionnaire (SWAL-QOL) before and after revision. The diameter and area of the oropharyngeal space were measured. Data shows increased oropharyngeal area and diameter after surgery, and an improved SWAL-QOL score. This is early evidence of an improved surgical approach for O-C2 fusion which could eliminate the complication of dysphagia.

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INTRODUCTION

Surgeries for cervical fusion

The fusion of cervical spine vertebrae [the second cervical vertebra (C2) to the occipital bone (O)] for head stabilization is performed due to spinal trauma, weakness from tumors, or a congenital or acquired condition and termed occipitocervical fusion (O-C2) (Bekelis, Gottfried, Wolinsky, Gokaslan, & Omeis, 2010; Cappuccio, De Iure, Amendola, Paderni, & Bosco, 2013; Huang et al., 2015; Menezes, 2008; Yoshida, Neo, Fujibayashi, & Nakamura, 2007). The vertebrae-head position, during surgery, is currently chosen by measurements of the O-C2 angle which is from McGregor's line to the inferior endplate of the C2 vertebra (Ota et al., 2011). McGregor's line is a theoretical line which originates at the occipital bone's most caudal aspect, runs through the odontoid process of C1, and terminates at the most posterior portion of the hard palate (McGregor, 1948). This angle is used determine the placement of the head on the neck after it is fused together.

However, due to the surgical complexity, the patient's head may be fixed in the neutral, flexion, extension, protrusion, or retraction positions with the same or similar O-C2 angle measurement (Ota et al., 2011). Common surgical complications are dysphagia (disorder of swallow), and dyspnea (difficulty breathing) (Huang et al., 2015). Tien et al (2013) claim that the incidence of post-operative dyspnea and dysphagia to range from 4% to 71% (Tian & Yu, 2013). Additionally, the prevalence of dysphagia in their data is

12.79% in anterior cervical fusion, and 9.35% in posterior cervical fusion (Tian & Yu, 2013). They hypothesized the link between dysphagia, dyspnea and the occipitocervical fusion is due to an oropharyngeal stenosis secondary to a misalignment of the cervical spine after surgery (Izeki et al., 2014; Miyata et al., 2009; Tian & Yu, 2013; Yoshida et al., 2007). In two case reports done by Huang et al (2015), one patient presented with a severe case of obstructive sleep apnea that was not present before the O-C2 fusion surgery, however, this patient did not display any signs of dysphagia. The other patient, who had a history of central sleep apnea, displayed signs of dysphagia and increased dyspnea secondary to the O-C2 fusion (Huang et al., 2015).

An acute O-C2 angle results in a narrowed oropharyngeal space and/or upper airway obstruction, and this change in the oropharyngeal anatomy causes the dysphagia and/or dyspnea (Izeki et al., 2014; Ota et al., 2011; Yoshida et al., 2007). In a normal swallow, the bolus is propelled into the oropharyngeal space, bypassing the retroflexed epiglottis, and squeezed down to the upper esophageal sphincter by the pharyngeal stripping wave (Shaw & Martino, 2013). In a disordered swallow with oropharyngeal stenosis, the epiglottis may not be able to fully retroflex, leaving the laryngeal vestibule unprotected, which often leads to aspiration (Logemann, 1998). In normal breathing, the patient inhales and exhales due to changes in balance of pressure in the body with no obstructions from the mouth to the lungs (Seikel, Drumright, & King, 2016). In disordered breathing, the patient may have an obstruction, an inability to regulate the necessary pressures or damaged anatomy that inhibits successful inhalation or exhalation, leading to anoxia or suffocation (Sapienza & Hoffman Ruddy, 2013).

Swallow

There are four stages of the normal swallow: oral preparation stage, oral stage, pharyngeal stage, and esophageal stage (Logemann, 1998). The oral prep stage is where mastication of solids or the holding of liquids in the oral cavity takes place. The bolus is formed and prepared to be transported to the back of the mouth to be swallowed (Logemann, 1998). The oral stage consists of the activation of the swallow reflex, propulsion of the bolus to the anterior faucal pillars, thus beginning the pharyngeal stage (Logemann, 1998). The oral prep stage and oral stage together make up the oral phase of the swallow. The pharyngeal stage, or the pharyngeal phase, occurs when the soft palate elevates, closing the velopharyngeal port, with closure of the airway by the superior and anterior elevation of the hyoid bone and larynx (Logemann, 1998). The epiglottis retroflexes for further airway protection. The bolus moves down through the pharynx with a pharyngeal peristaltic wave until it approaches the opened upper esophageal sphincter and enters the esophageal stage (Logemann, 1998). The bolus moves down through the esophagus with an esophageal peristaltic movement and gravity until it passes the lower esophageal sphincter and enters the stomach in the esophageal phase (Logemann, 1998). The hyoid bone and all laryngeal structures return to rest during the esophageal phase. Pommerenke (1928) found that the most common site that activates the swallow reflex in humans is the faucal pillars by using blunt mechanical stimulation on various structures in the oral cavity and pharynx.

The central nervous system is responsible for the innervation and regulation of the swallow (Lang, 2009). Despite being the result of "central pattern-generating circuitry of the brain stem and peripheral reflexes," each phase of the swallow (oral, pharyngeal,

and esophageal) is independent (Lang, 2009, p. 333). Although the phases are coordinated, each reflex has its own innervation. The oropharynx is innervated by the pharyngeal branches of both the vagus and glossopharyngeal cranial nerves (Pitts, 2014). The inferior branch of the superior laryngeal nerve of the vagus nerve innervates the hypopharynx (Pitts, 2014). The facial nerve innervates the muscles of the face and the muscles of mastication are innervated by the vagus nerve (Shaw & Martino, 2013). The afferent fibers important for initiating the voluntary swallow are found in the internal branch of the superior laryngeal nerve (Ludlow, 2005). The oral phase of the swallow is voluntarily initiated with the presence of hunger and food placed in the mouth to be masticated (Lang, 2009). Afferent signals are sent to the reticular formation, where the center for swallowing lies in the brain stem (Logemann, 1983). Then the swallow center sends out efferent signals that begins "a variety of neuromotor behaviors" for the initiation and duration of the pharyngeal phase (Logemann, 1983, p. 40). Lang (2009) found the pharyngeal and esophageal phases are not initiated by the end of the phase before it, but rather, they are initiated by interphase reflexes. The sensory feedback assists in the coordination and timing of deglutition but is not responsible for regulation of the motor aspect of the swallow (Lang, 2009). The afferent and efferent controls rely upon each other to produce a coordinated, normal swallow.

Complimentary upper airway functions

The oropharyngeal space is used for more than just respiration and nutritional purposes. Some common behaviors that utilize the upper airway are coughing, and phonation (Sapienza & Hoffman Ruddy, 2013; Seikel et al., 2016). Coughing is important in swallowing as it is responsible for clearing out food or drink that can

penetrate beyond the pyriform sinuses into the airway (Pitts, 2014). Phonation relies upon the respiratory system as a foundation. With no changes in subglottic air pressure, the vocal folds cannot be blown apart to produce vocalization that travels through the oropharyngeal space to be shaped by the articulators for communication (Sapienza & Hoffman Ruddy, 2013; Seikel et al., 2016). The success of these reflexive or voluntary behaviors depend upon the maintained integrity of the upper airway space (Sapienza & Hoffman Ruddy, 2013).

The importance of the oropharyngeal airway diameter can be seen in other upper airway disorders such as sleep apnea. Some studies claim that patients with obstructive sleep apnea (OSA) have a significantly smaller pharyngeal cross-sectional area than healthy patients, measured using the acoustic-reflection technique (Bradley et al., 1986). While a normal patient's pharyngeal area measured at 4.5 ± 0.4 cm², a patient with OSA's pharyngeal area measured at 3.4 ± 0.2 cm² which was statistically significant with a $p < 0.05$ (Bradley et al., 1986). Using cephalometry and computed tomography (commonly called CT) scans of the upper airway, Mayer et al. (1996) found that OSA patients have an oropharyngeal area of 85 ± 57 mm² while snorers have an area of 95 ± 55 mm². Conversely, they found that snorers have a smaller hypopharyngeal area at 207 ± 136 mm² while patients' with OSA hypopharyngeal area measures 245 ± 142 mm² (Mayer et al., 1996). However, other studies have found that a larger airway is found in patients with OSA than in patients that only snore and normal subjects. These authors found, using magnetic resonance imaging (commonly called MRI) to measure the pharyngeal anatomy, that the posterior airway space measured 1.3 ± 0.5 cm for OSA patients as opposed to the 0.9 ± 0.5 cm measured for the posterior airway space for

snorers (Rodenstein et al., 1990) Normal subjects had the smallest posterior airway space with a measurement of 0.8 ± 0.3 cm (Rodenstein et al., 1990).

Quality of Life

A patient's quality of life can be subject to multiple variables, such as participating in common societal mores like gatherings for holidays, birthdays, or important dates. Being unable to join in familial social situations due to a difficulty with eating or an inability to eat by mouth can have a deleterious effect on a patient's quality of life (Nguyen et al., 2005). Not only are there physical impacts like dehydration, malnutrition, and weight loss, there are psychological impacts as well (Shaw & Martino, 2013). Social isolation can be associated with both dysphagia and depression. One study suggests that a patient that is depressed may not be motivated to better their swallow and return to a regular or oral diet, decreasing their chances of improved outcomes (Gillespie, Brodsky, Day, Lee, & Martin-Harris, 2004). Anxiety is most commonly linked with intermittent dysphagia while depression is most often seen with progressive dysphagia (Eslick & Talley, 2008). Strategies like selecting foods that they can manage and will enjoy as well as having to take additional time to eat a meal can reduce the patient's overall desire to eat when they experience difficulty or embarrassment with using these compensations to safely swallow (Arslan, Demir, Kilinc, & Karaduman, 2017).

Clinical tests exist to test severity of dysphagia and the patient's quality of life, such as the Eating Assessment Tool – 10 commonly known as the EAT-10 and the Swallowing Quality of Life (SWAL-QOL). Having tests that can quickly, reliably, and validly screen patients for dysphagia, including the severity, allows for treatments to begin sooner, making it possible to prevent some of the more dangerous complications

like dehydration and malnutrition (Arslan et al., 2017). Nguyen et al (2005) found the level of dysphagia severity to be statistically significant in respect to its effect on patient quality of life (Nguyen et al., 2005). Self-reporting can be a valuable resource to clinicians. A patient may not have a clinical diagnosis of dysphagia but may be so uncomfortable due to a misalignment of the head, that their desire to eat and enjoyment of eating may be significantly lowered, negatively impacting their quality of life. Using clinical quality of life tests allows for clinicians to address postoperative psychological complications like depression and anxiety. Regular repetitions of these tests also allow clinicians to reliably track a patient's progress before, after and during treatments (Kaspar & Ekberg, 2012).

A common and reliable assessment of the symptoms and the psychological difficulties due to the patient's dysphagia is the Swallowing Quality of Life, or SWAL-QOL. The SWAL-QOL was created by an interdisciplinary team of speech-language pathologists, physicians, and researchers. These experts wanted to create an assessment tool that was from the perspective of the patient on their dysphagia symptoms and their quality of life, most importantly the effect dysphagia can have on the psychosocial aspect of their quality of life (Leow, Huckabee, Anderson, & Beckert, 2010; McHorney, Bricker, Kramer, et al., 2000). To achieve this, the authors made the decision to split the creation process into three phases (McHorney, Bricker, Kramer, et al., 2000; McHorney et al., 2002).

Phase One consisted of gathering qualitative data from patients with dysphagia and their caregivers through focus groups in different parts of the country to create questions and create a standardized list of questions, the SWAL-QOL (McHorney,

Bricker, Kramer, et al., 2000; McHorney et al., 2002). The focus groups were separated by sex to avoid the skewed interaction dynamic that most often occurs in mixed sex focus groups. Family members were split up to avoid the uneven familial dynamic that can occur in groups as well (McHorney, Bricker, Kramer, et al., 2000). After the meetings, the authors narrowed the information down to the 19 most important aspects or scales: burden, food selection, symptoms, eating duration, eating desire, eating loss, fear, sleep, fatigue, communication, self-image, psychological distress, social functioning, role functioning, clinical information, options information, self-care advise, technical quality, and patient-centered quality (McHorney, Bricker, Kramer, et al., 2000). These scales were then ordered by what was considered most clinically sensitive and relevant, resulting in a total of 185 items on the original SWAL-QOL at the end of Phase One.

Phase Two consists of pretesting the initial SWAL-QOL in a sample group of patients with dysphagia, with the initial results being psychometrically analyzed. After the analysis, the SWAL-QOL was revised and refined, reducing the length of the assessment (McHorney, Bricker, Kramer, et al., 2000; McHorney et al., 2002). The 199 item test included 185 SWAL-QOL questions, four questions to measure quality of life and quality of care for validity reasons, four questions to assess general health, and six demographic questions (McHorney, Bricker, Robbins, et al., 2000). Data were collected and analyzed for six areas of concern: the burden on the respondent, the quality off the data, the variability of the items, the convergent validity of the items, internal consistency reliability, and the scale scores' range and skewness following aggregation (McHorney, Bricker, Robbins, et al., 2000). A start and end time were taken to assess the amount of time the participants required to complete the entire assessment. The scales were made

using Likert's method with the scores being 0-100 with zero being the most undesirable and 100 being the most desirable and 1-99 being the percentage of a total possible score meaning that a high score implied a better quality of life (McHorney, Bricker, Robbins, et al., 2000). Item reduction and validation was achieved using various statistical methods, including varimax rotation and Cronbach's alpha coefficient (McHorney, Bricker, Robbins, et al., 2000). The results of Phase Two reduced the original 185 SWAL-QOL questions to 93 questions. The authors state the aim of Phase Three is to further reduce the number of questions and to run more psychometric tests for further validation of the scales and items (McHorney, Bricker, Robbins, et al., 2000).

Phase Three consists of a field testing of the revised and reduced length SWAL-QOL with extensive psychometric testing (McHorney, Bricker, Kramer, et al., 2000; McHorney et al., 2002). The 123-item assessment (93 SWAL-QOL questions and 30 questions for demographic differences and validity criteria) was mailed to a control group of 40 healthy adults with no history of dysphagia and to 400 participants who fit the criteria needed for the previous two phases (McHorney et al., 2002). The authors tested the quality-of-life questions with the quality-of-care questions and removed any that did not have a statistically significant correlation (McHorney et al., 2002). Other items considered for removal by the authors included those with low discrimination parameters, those with missing data rates of 10% or higher, and items that had greater than 15% of responses at the floor, ceiling or both (McHorney et al., 2002). At the end of Phase three, the SWAL-QOL was split into two separate self-reporting tests, the SWAL-QOL, for swallowing quality of life, and the SWAL-CARE, for quality of swallowing clinician, information and advice given and overall satisfaction with the care they have received

(McHorney et al., 2002). The SWAL-QOL consists of 44 questions while the SWAL-CARE has 15. According toMcHorney et al. (2002), they split the items into two tests as the SWAL-QOL can be completed at the initial visit, but it could take multiple visits to accurately complete the SWAL-CARE. The assessments were found to discriminate between healthy participants and those with swallowing disorders as well as being able to discriminate between the varying levels of severity of dysphagia (McHorney et al., 2002). However, it should be noted the authors cautioned that the data have a disproportionate representation of Caucasians and men and should not be used as a national norm (McHorney et al., 2002).

The SWAL-QOL is a longer, more in-depth assessment for patient reported dysphagia symptoms and their own quality of life than the EAT-10. The scaling in the SWAL-QOL also differs significantly from the EAT-10 where score for the best QOL is the lowest. With the SWAL-QOL, the higher the score, the better the patient feels their quality of life to be, so a higher score is indicative of a good quality of life, per the patient's report. Originally written in English, the SWAL-QOL has been proven valid and reliable in Italian, Greek, Dutch, Portuguese, Chinese, Swedish, Persian, German, French, and Korean (Antunes, Vieira, & Dinis-Ribeiro, 2015; Bogaardt, Speyer, Baijens, & Fokkens, 2009; Finizia, Rudberg, Bergqvist, & Rydén, 2012; Georgopoulos et al., 2018; Ginocchio et al., 2016; Khaldoun, Woisard, & Verin, 2009; Kim & Cha, 2014; Kraus et al., 2018; Lam & Lai, 2010; Tarameshlu, Azimi, Jalaie, Ghelichi, & Ansari, 2017). When comparing psychometric measures of multiple health care quality of life assessments, Timmerman, Speyer, Heijnen, and Klijn-Zwijnenburg (2014) found that the SWAL-QOL was one of two assessments that had the most accurate psychometric ratings

for interpretability and validity (Timmerman, Speyer, Heijnen, & Klijn-Zwijnenberg, 2014).

Purpose

The purpose of this study is to determine whether aligning the medial portion of the C2 vertebra with the external auditory meatus will reduce stenosis of the pharynx, thus reducing dysphagia and dyspnea in patients who undergo O-C2 fusion surgery.

Hypothesis

We hypothesize that by placing the head most neutrally on the neck using the EAM to C2 alignment, the incidence of stenosis of the oropharynx with post-operative dysphagia and dyspnea will decrease, thus improving patient's quality of life.

CHAPTER 2

METHODS

Participant(s)

One participant, a 50-year-old male, was recruited from the University of Louisville Hospital. Criteria for inclusion in the study consisted of the patient requiring an occipitocervical fusion surgery, or history of O-C2 fusion surgery that required a revision. The patient received both his initial surgery using the original alignment method and his revision surgery using our method of alignment at the University of Louisville.

Measurements

Videofluoroscopy

Videofluoroscopy was performed to assess the function of the swallow after the initial O-C2 fusion surgery and after the revision surgery to realign the fusion placement. The participant was seated in an upright position and all views were done in the lateral viewpoint. The videofluoroscopy evaluations used in this study were done at the University of Louisville Hospital Radiology Department in Louisville, KY by a certified speech language pathologist. The patient was given 10cc of thin liquid twice from a cup, and 30cc of thin liquid as a sequential swallow from a cup for the videofluoroscopy done after both the initial fusion surgery and the revision surgery. The speech-language-pathologist recorded the thin consistencies, both single and sequential, and quiet breathing.

Measurements of the Oropharyngeal Space

Measurements of the oropharyngeal space, both pre- and post-revision, were taken frame by frame from recordings using MicroDicom (© 2007-2017, MicroDicom Viewer)**.** Diameter and area of the base of the tongue, the level of the vallecula and the maximal distension of the upper esophageal sphincter were measured. These measurements were taken during single swallows of thin liquid, sequential swallow of thin liquid and short periods of quiet breathing. The patient did not follow protocol in the post-revision videofluoroscopy, emptying the 30cc thin liquid for the sequential swallow into the oral cavity and swallowing the entire bolus at once. Measurements were taken for an increased thin bolus size instead of the sequential swallow from the post-revision videofluoroscopy. Stills of the videofluoroscopy were taken using MicroDicom (© 2007-2017, MicroDicom Viewer).

Quality of Life

The participant completed the Swallowing Quality of Life (SWAL-QOL) scale to self-report symptoms of dysphagia before and after the revision surgery. Data were entered into an Excel spreadsheet using the differing identifiers.

CHAPTER 3

RESULTS

Videofluoroscopy

There was an overall increase in oropharyngeal area and diameter following the revision surgery; with the exception of maximal distension of the upper esophageal sphincter which decreased in size. Measurements of area were taken at the base of tongue, vallecula and upper esophageal sphincter during the tasks of breathing, single swallow and sequential swallow. These measurements can be seen in Table 1 and Figures 1-4. When measuring area at the base of tongue, we found the pre-revision area to be 8.73 mm^2 during breathing, 8.22 mm^2 for single swallow, and 12.14 mm^2 for sequential swallow. Pre-revision area of the vallecula measured 11.16 mm^2 for breathing, 6.54 mm^2 measured for single swallow and 6.30 mm^2 measured for sequential swallow. Pre-revision area measured for the upper esophageal sphincter is 6.98 mm^2 during breathing, 10.92 mm^2 during single swallow and 12.14 mm^2 for sequential swallow. Post-revision area for base of tongue was measured at 9.44 mm^2, 11.65 mm^2 for single swallow, and 14.47 mm^2 for sequential swallow. Post-revision measurements of the vallecula were 14.25 mm^2 for breathing, 10.10 mm^2 for single swallow, and 26.19 mm^2 for sequential swallow. Upper esophageal sphincter post-revision area was measured at 5.58 mm^2 during breathing, 10.16 mm^2 for single swallow and 7.88 mm^2 during sequential swallow.

Diameter measurements were taken at the base of tongue, vallecula and upper esophageal sphincter during breathing, and swallowing, both single and sequential. Pre-

revision diameter at the base of tongue measured at 3.85 mm during breathing, 5.38 mm during single swallow and 6.15 mm during sequential swallow. Vallecula pre-revision diameter was measured at 6.66 mm when breathing, 4.86 mm with single swallow, and 3.85 mm with sequential swallow. Pre-revision upper esophageal sphincter diameter was measured at 4.42 for breathing, 5.18 mm for single swallow and 6.15 mm for sequential swallow. Post-revision diameter was also measured. Base of tongue was measured at 5.32 mm with breathing, 4.63 mm with single swallow and 7.44 mm with sequential swallow. Post-revision diameter of the vallecula was measured at 6.87 mm for breathing, 5.94 mm for single swallow, and 12.14 mm for sequential swallow. Post-revision measurements of the upper esophageal sphincter is measured at 4.12 mm when breathing, 5.2 mm with single swallow and 5.46 mm with sequential swallow.

Quality of Life

Figure 5 display the quality of life assessments the participant completed after his initial surgery and following his revision surgery. The SWAL-QOL domains with increased scores following the revision surgery are eating burden, eating desire, eating selection, fear, mental health, social functioning, sleep, and dysphagia symptoms.

Some of the most important domain increases were in burden (the “work of swallow”), eating desire, mental health, and social functioning. The score for burden increased from 20 to 70, while eating desire increased from 26.7 to 100, both substantial improvements. Burden and eating desire can often be linked together or considered inversely proportional; as the amount of effort increases, the desire to eat decreases.

The results of the overall scores showed a 32-point increase in summary scores between the pre- and post-revision surgeries.

Table 1.

Alterations in the diameter of upper airway measurements before and after a C2-O revision surgery using alignment of the EAM to the C2 vertebrae.

	Task	Base of Tongue		Valleculae		Upper Esophageal Sphincter	
		Diameter (mm)	Area (mm²)	Diameter (mm)	Area (mm²)	Diameter (mm)	Area (mm²)
PRE	Breathing	3.85	8.73	6.66	11.16	4.42	6.98
	Single Swallow	5.38	8.22	4.86	6.54	5.18	10.92
	Sequential Swallow	6.15	12.14	3.85	6.3	6.15	12.14
POST	Breathing	5.32	9.44	6.87	14.25	4.12	5.85
	Single Swallow	4.63	11.65	5.94	10.1	5.2	10.16
	Sequential Swallow	7.44	14.47	12.14	26.19	5.46	7.88

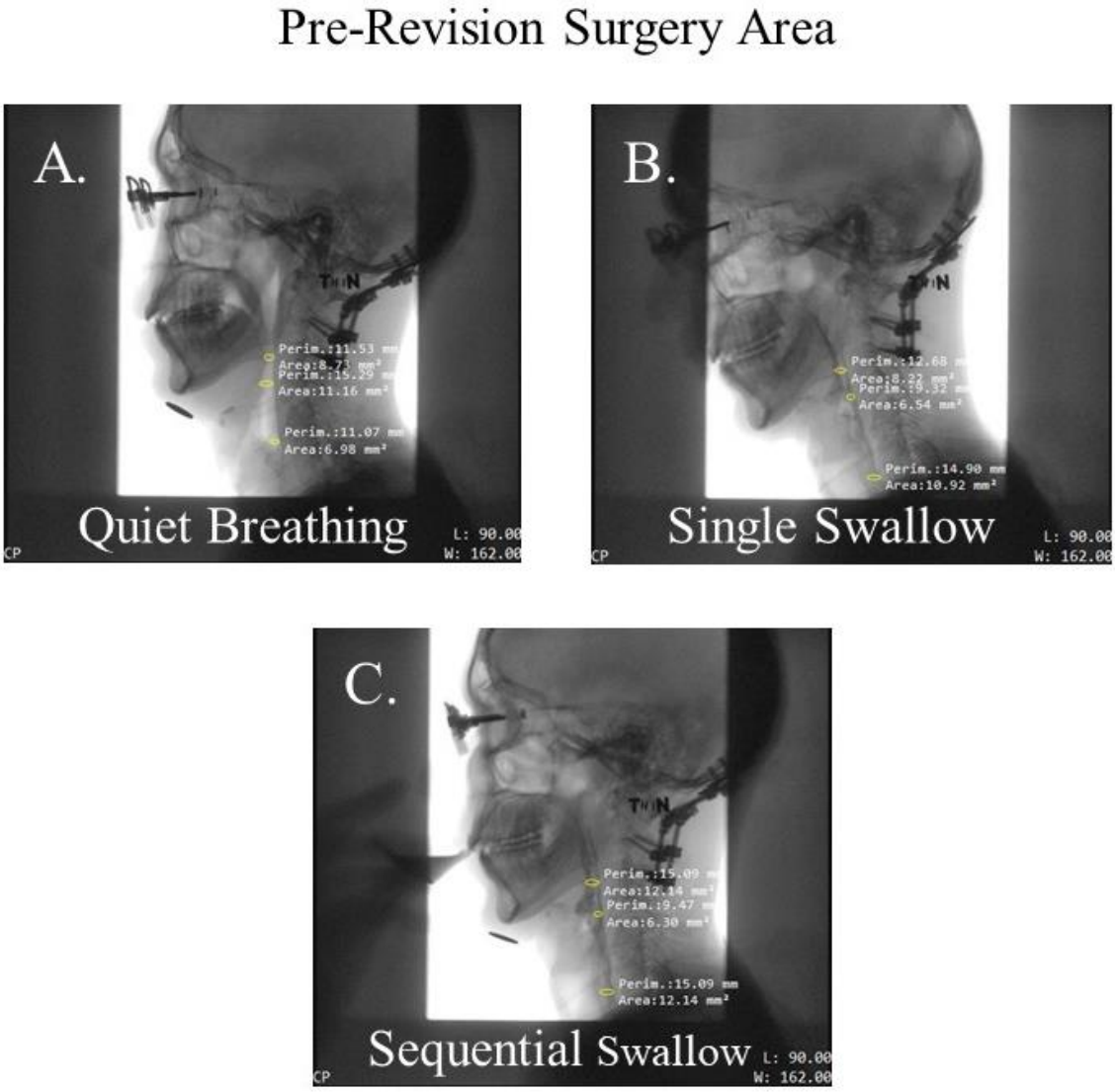

Figure 1. Videofluoroscopy stills of pre-revision base of tongue, vallecula, and upper esophageal sphincter area measurements.

*The small round disc on the chin is the penny.

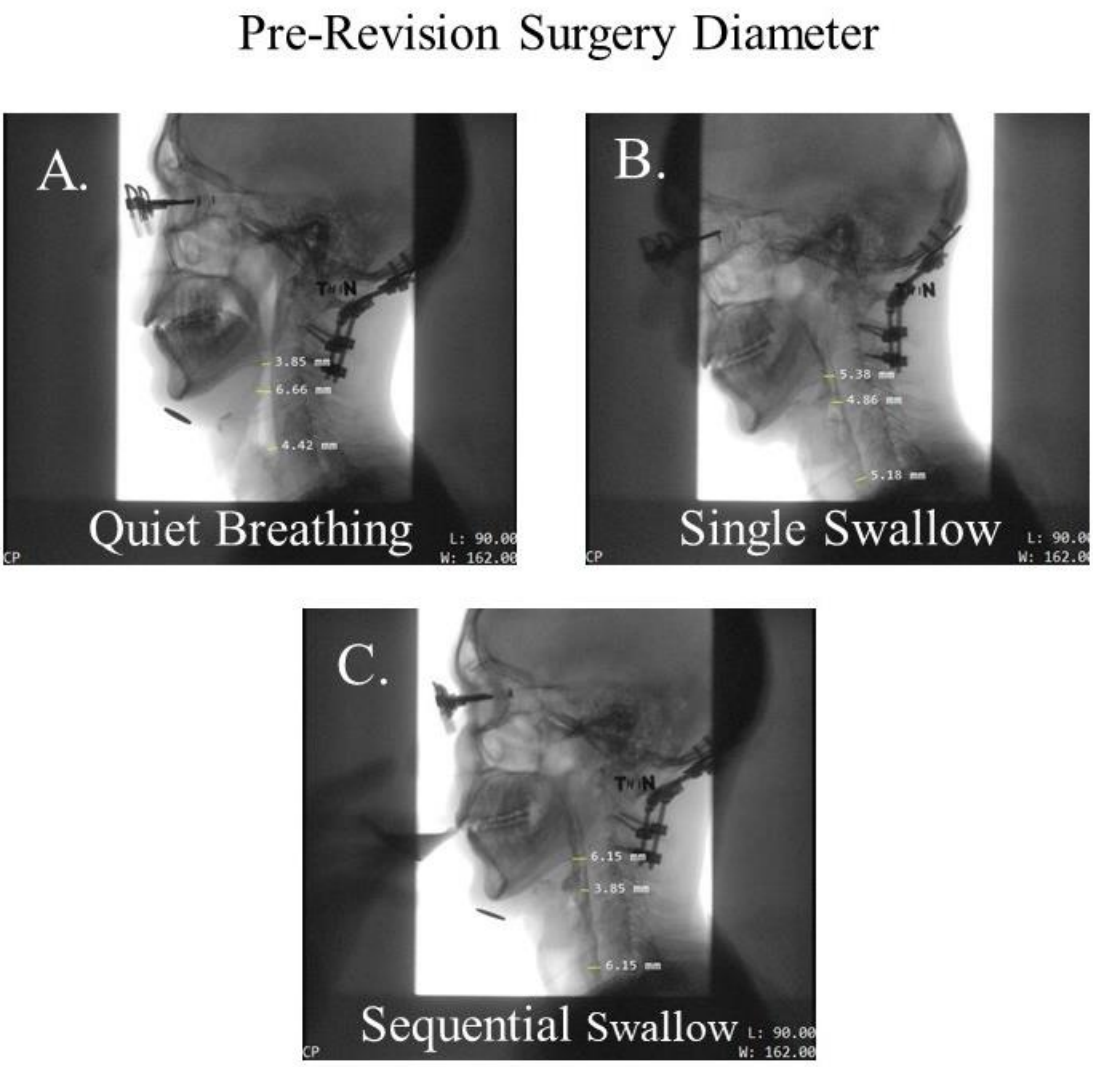

Figure 2. Videofluoroscopy stills of base of tongue, vallecula, and upper esophageal sphincter diameter measurements.

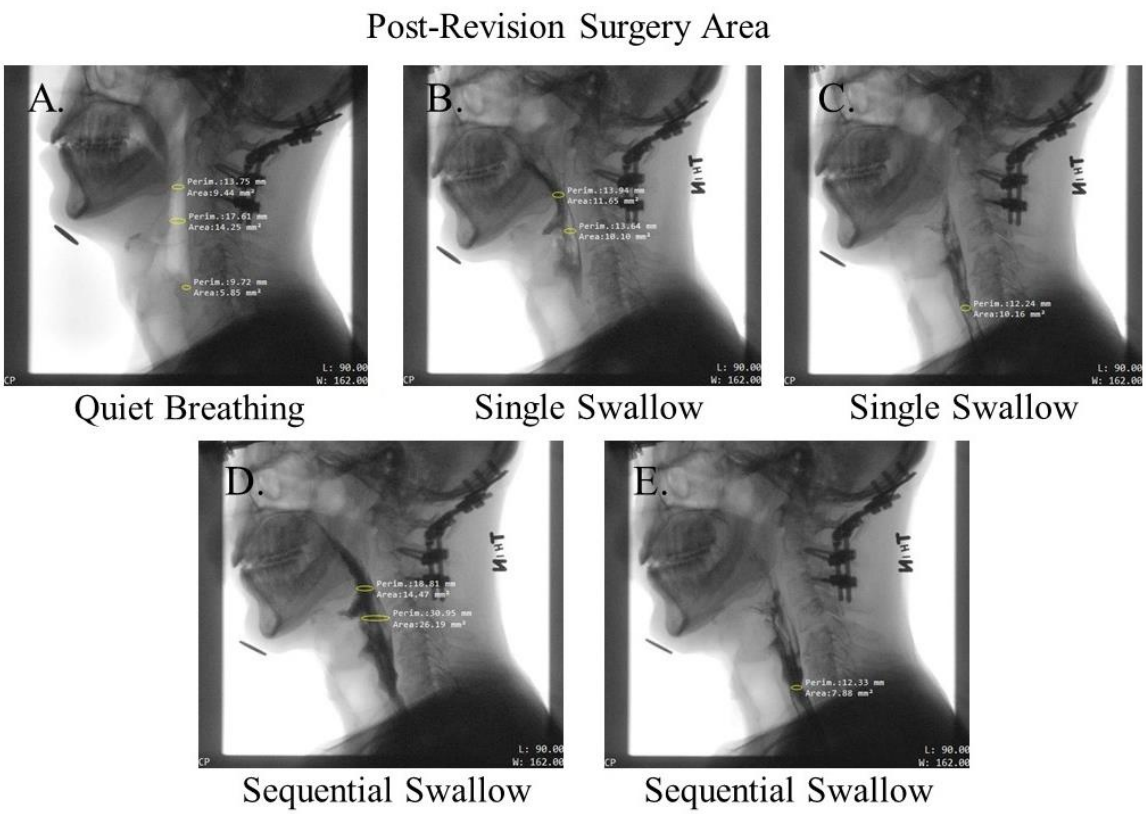

Figure 3. Videofluoroscopy stills of post-revision base of tongue, vallecula, and upper esophageal sphincter area measurements.

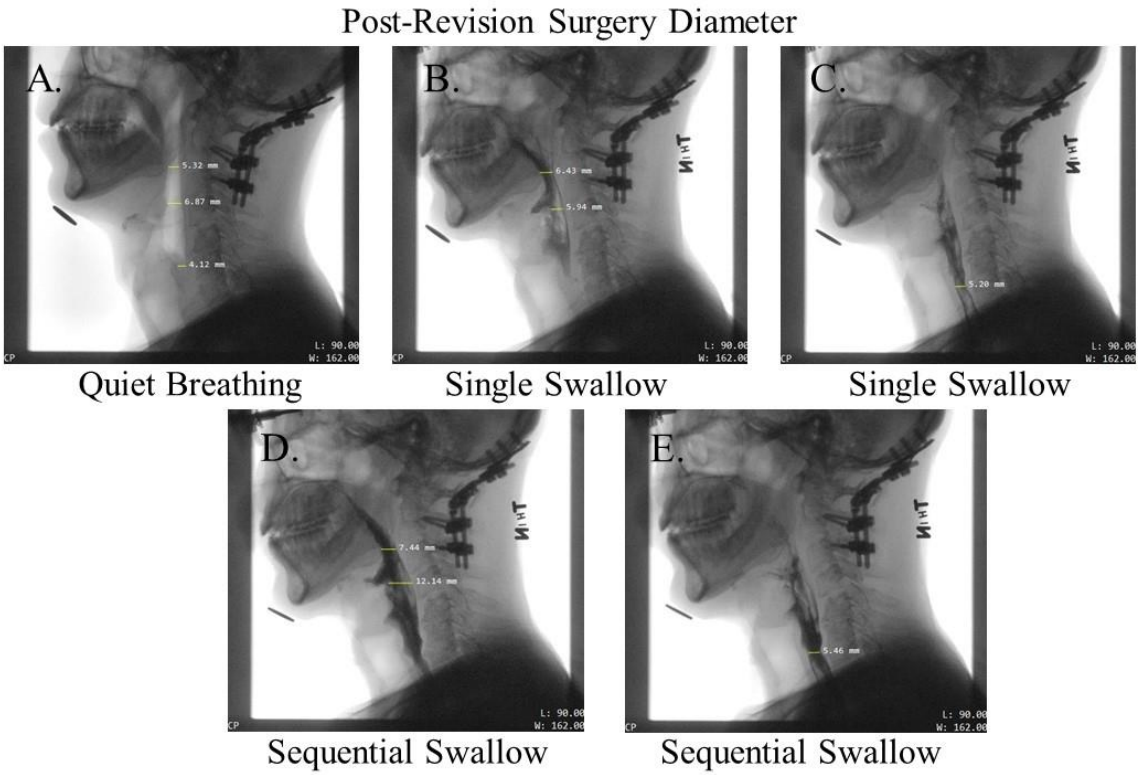

Figure 4. Videofluoroscopy stills of post-revision base of tongue, vallecula, and upper esophageal sphincter diameter measurements.

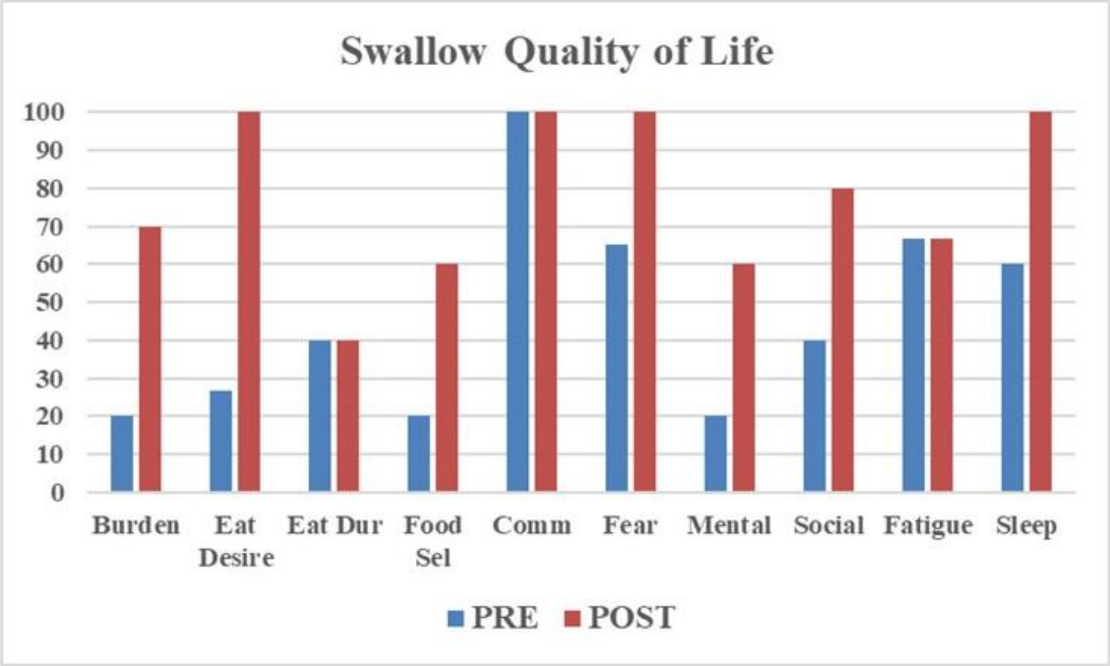

Figure 5. Comparison of pre- and post-revision SWAL-QOL scores. Higher scores represent increases in quality of life.

CHAPTER 4

DISCUSSION

The most important findings of our study is the importance of proper head placement and the effect it has on the patient's eating-related quality of life. Data show a measurable difference in the area and diameter of the oropharyngeal space after being realigned when the external auditory meatus is aligned with midline of C2. This change directly impacted the symptoms of dysphagia the patient reported. Despite the patient presenting with a mild oropharyngeal dysphagia as determined by videofluoroscopy following both surgeries, with a more neutrally aligned head and an increase in oropharyngeal space, the patient's swallowing quality of life greatly improved, as reported by the patient's scores on the SWAL-QOL. The interprofessional relationship between neurosurgery and speech language pathology resulted in a revised surgical technique that appears to resolve the post-operative issues that plagued multiple patients.

Interprofessional collaboration, when defined by World Health Organizations in the WHO Framework for Action on Interprofessional Education & Collaborative Practice (2010), is practice that occurs when professionals from multiple fields work together alongside the patient, their family, caregivers, and communities to provide the best care possible. Research has shown that an increase in collaboration between medical fields is linked with improved patient care, especially those with complex medical conditions (Pullon, Morgan, Macdonald, McKinlay, & Gray, 2016). In a study across primary care

providers in New Zealand, aspects of interprofessional collaboration as simple as sharing a common space and having short interactions with co-workers provided increased positive relationships and care within the practice (Pullon et al., 2016). This research showed that relationships between healthcare workers as a team and between the team or business and the community at large are contributing factors to improved care for patients with complicated social or health concerns (Pullon et al., 2016). Another study stresses the importance of communication and compassion for effective interprofessional collaboration (Rider et al., 2014). Collaboration between health-care professionals is paramount to furthering relevant and productive research (Rider et al., 2014). Each field brings different viewpoints and expertise to analyzing and solving problems. For example, while a surgeon may be interested with making sure the spine is fused correctly and safely with as few complications as possible; the speech language pathologist is most concerned with the after effects the surgery has on the patient's ability to eat/drink and communicate. Both set of priorities and concerns are equally valid, therefore a method that can satisfy both is the desired goal. The continued integrated efforts of multiple medical fields will further create more dialogue which, in turn, creates more ideas and solutions to problems that have hitherto been unexplored (Rider et al., 2014).

If a patient is misaligned, there are physical and social consequences (Ekberg, Hamdy, Woisard, Wuttge-Hannig, & Ortega, 2002; Izeki et al., 2014; Miyata et al., 2009; Tian & Yu, 2013). We have shown that there is the physical consequence of a narrowing of the oropharynx which can impact breathing and swallowing, two of the most basic requirements for life (Huang et al., 2015). These circumstances can inhibit the person from engaging in the activities they once enjoyed, which often includes eating, a

prominent social activity that people of all cultures engage in with friends and family (Ekberg et al., 2002). Dysphagia can be the result of misalignment of the head from an incorrect O-C2 angle during O-C2 fusion and is a potentially socially isolating disorder, often associated with depression and anxiety (Eslick & Talley, 2008; Izeki et al., 2014; Tian & Yu, 2013). If eating is something they can no longer do or enjoy, that entire aspect of their social life is no longer available to them. It has been seen that social isolation is severely detrimental to the mental health and quality of life of those involved, especially in populations like those people with degenerative diseases (Leow et al., 2010). Proper methodology for head placement for occipitocervical fusion surgeries is imperative to preventing a negative impact on patient quality of life, including swallowing and socialization (Izeki et al., 2014)

Limitations

Although a small sample of subjects was available for this study, the effects of this study will affect far more people. Patients who have a misalignment from the original O-C2 fusion surgery are being invited to the University of Louisville Hospital to receive the necessary revision using our improved surgical technique. It is important to mention that all neurosurgeons at the University of Louisville Hospital are currently utilizing this method, and as the writing of this thesis, there has been no evidence of any revisions needed or cases of post-operative dysphagia. A larger and more in-depth study should be done to confirm and expand upon the results found in our limited study.

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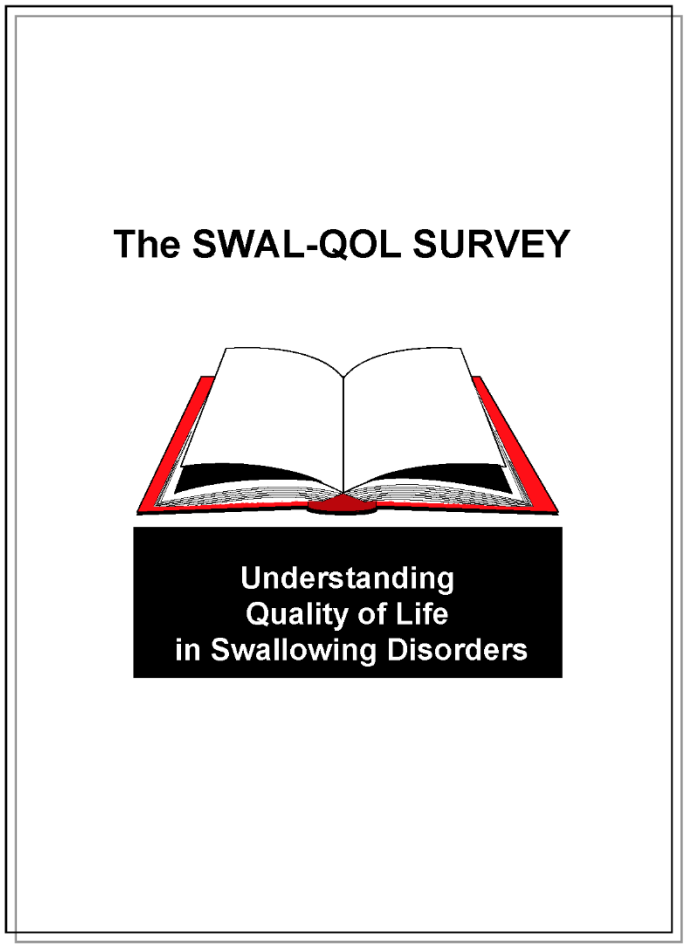
APPENDIX A: ABBREVIATIONS

C2	Second cervical vertebra
C2-O Fusion	Fusion of the occipital bone to the second cervical vertebra
O	Occipital
OSA	Obstructive Sleep Apnea
SWAL-CARE	Swallow related care quality of life questionnaire
SWAL-QOL	Swallow quality of life questionnaire

APPENDIX B: SWAL-QOL



Instructions for Completing the SWAL-QOL Survey

This questionnaire is designed to find out how your swallowing problem has been affecting your day-to-day quality of life.

Please take the time to carefully read and answer each question. Some questions may look like others, but each one is different.

Here's an example of how the questions in the survey will look.

1. In the last month how often have you experiences each of the symptoms below.

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
Feel weak	1	2	3	4	5

Thank you for your help in taking part in this survey!

IMPORTANT NOTE: We understand that you may have a number of physical problems. Sometimes it is hard to separate these from swallowing difficulties, but we hope that you can do your best to concentrate ***only*** on your ***swallowing problem.*** Thank you for your efforts in completing this questionnaire.

1. Below are some general statements that people with ***swallowing problems*** might mention. In the last month, **how true** have the following statements been for you.

(circle one number on each line)

	Very much true	**Quite a bit true**	**Somewhat true**	**A little true**	**Not at all true**
Dealing with my swallowing problem is very difficult.	1	2	3	4	5
My swallowing problem is a major distraction in my life.	1	2	3	4	5

2. Below are aspects of day-to-day eating that people with ***swallowing problems*** sometimes talk about. In the last month, **how true** have the following statements been for you?

(circle one number on each line)

	Very much true	**Quite a bit true**	**Somewhat true**	**A little true**	**Not at all true**
Most days, I don't care if I eat or not.	1	2	3	4	5
It takes me longer to eat than other people.	1	2	3	4	5
I'm rarely hungry anymore.	1	2	3	4	5
It takes me forever to eat a meal.	1	2	3	4	5
I don't enjoy eating anymore.	1	2	3	4	5

3. Below are some physical problems that people with ***swallowing problems*** sometimes experience. In the last month, **how often** you have experienced each problem as a result of your swallowing problem?

(circle one number on each line)

	Almost always	**Often**	**Sometimes**	**Hardly ever**	**Never**
Coughing	1	2	3	4	5
Choking when you eat food	1	2	3	4	5
Choking when you take liquids	1	2	3	4	5
Having thick saliva or phlegm	1	2	3	4	5
Gagging	1	2	3	4	5
Drooling	1	2	3	4	5
Problems chewing	1	2	3	4	5
Having excess saliva or phlegm	1	2	3	4	5
Having to clear your throat	1	2	3	4	5
Food sticking in your throat	1	2	3	4	5
Food sticking in your mouth	1	2	3	4	5
Food or liquid dribbling out of your mouth	1	2	3	4	5
Food or liquid coming out your nose	1	2	3	4	5
Coughing food or liquid out of your mouth when it gets stuck	1	2	3	4	5

4. Next, please answer a few questions about how your ***swallowing problem*** has affected your diet and eating in the last month.

(circle one number on each line)

	Strongly agree	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**
Figuring out what I can and can't eat is a problem for me.	1	2	3	4	5
It is difficult to find foods that I both like and can eat.	1	2	3	4	5

5. In the last month, **how often** have the following statements about communication applied to you because of your ***swallowing problem***?

(circle one number on each line)

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
People have a hard time understanding me.	1	2	3	4	5
It's been difficult for me to speak clearly.	1	2	3	4	5

6. Below are some concerns that people with ***swallowing problems*** sometimes mention. In the last month, **how often** have you experienced each feeling?

(circle one number on each line)

	Almost always	Often	Sometimes	Hardly ever	Never
I fear I may start choking when I eat food.	1	2	3	4	5
I worry about getting pneumonia.	1	2	3	4	5
I am afraid of choking when I drink liquids.	1	2	3	4	5
I never know when I am going to choke.	1	2	3	4	5

7. In the last month, how often have the following statements **been true** for you because of your ***swallowing problem***?

(circle one number on each line)

	Always true	Often true	Sometimes true	Hardly ever true	Never true
My swallowing problem depresses me.	1	2	3	4	5
Having to be so careful when I eat or drink annoys me.	1	2	3	4	5
I've been discouraged by my swallowing problem.	1	2	3	4	5
My swallowing problem frustrates me.	1	2	3	4	5
I get impatient dealing with my swallowing problem.	1	2	3	4	5

8. Think about your social life in the last month. How strongly would you agree or disagree with the following statements?

(circle one number on each line)

	Strongly agree	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**
I do not go out to eat because of my swallowing problem.	1	2	3	4	5
My swallowing problem makes it hard to have a social life.	1	2	3	4	5
My usual work or leisure activities have changed because of my swallowing problem.	1	2	3	4	5
Social gatherings (like holidays or get-togethers) are not enjoyable because of my swallowing problem.	1	2	3	4	5
My role with family and friends has changed because of my swallowing problem.	1	2	3	4	5

9. In the last month, **how often** have you experienced each of the following physical symptoms?

(circle one number on each line)

	All of the time	**Most of the time**	**Some of the time**	**A little of the time**	**None of the time**
Feel weak?	1	2	3	4	5
Have trouble falling asleep?	1	2	3	4	5
Feel tired?	1	2	3	4	5
Have trouble staying asleep?	1	2	3	4	5
Feel exhausted?	1	2	3	4	5

10. Do you now take any food or liquid through a feeding tube?

(circle one)

No 1

Yes..... 2

11. Please circle the letter of the one description below that best describes the consistency or texture of the food you have been eating most often in the last week.

Circle one:

A. Circle this one if you are eating a full normal diet, which would include a wide variety of foods, including hard to chew items like steak, carrots, bread, salad, and popcorn.

B. Circle this one if you are eating soft, easy to chew foods like casseroles, canned fruits, soft cooked vegetables, ground meat, or cream soups.

C. Circle this one if you are eating food that is put through a blender or food processor or anything that is like pudding or pureed foods.

D. Circle this one if you take most of your nutrition by tube, but sometimes eat ice cream, pudding, apple sauce, or other pleasure foods.

E. Circle this one if you take all of your nourishment through a tube.

12. **Please circle the letter** of the one description below that best describes the consistency of liquids you have been drinking most often in the last week.

Circle one:

A. Circle this if you drink liquids such as water, milk, tea, fruit juice, and coffee.

B. Circle this if the majority of liquids you drink are thick, like tomato juice or apricot nectar. Such thick liquids drip off your spoon in a slow steady stream when you turn it upside down.

C. Circle this if your liquids are moderately thick, like a thick milkshake or smoothie. Such moderately thick liquids are difficult to suck through a straw, like a very thick milkshake, or drip off your spoon slowly drop by drop when you turn it upside down, such as honey.

D. Circle this if your liquids are very thick, like pudding. Such very thick liquids will stick to a spoon when you turn it upside down, such as pudding.

E. Circle this if you did not take any liquids by mouth or if you have been limited to ice chips.

13. In general, would you say your health is:

(circle one)

Poor 1

Fair 2

Good 3

Very Good 4

Excellent 5

General Questions About You

What is the date of your birth?

Please write in your date of birth here: ____/____/____
month day year

What is your age today? _____

Are you –

(circle one)

Male 1

Female 2

What is your <u>main</u> racial or ethnic group?

(circle one)

White or Caucasian, but not Hispanic or Latino 1

Black or African-American, but not Hispanic or Latino 2

Hispanic or Latino 3

Asian 4

Other 5

What is the highest year of school or college you have ever completed?

(circle one number)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	16+
Grade School								High School				College				Post Graduate

What is your current marital status?

(circle one)

Never married 1

Married 2

Divorced 3

Separated 4

Widowed 5

Did anybody help you complete this questionnaire?

(circle one)

No, I did it myself 1

Yes, someone helped me fill it out 2

IF SOMEONE HELPED YOU FILL OUT THIS QUESTIONNAIRE, how did that person help you?

(circle one)

Read you the questions and/or wrote down the answers you gave 1

Answered the questions for you 2

Helped in some other way 3

Please write today's date here: _____ / _____ / _____
month day year

Last Page

COMMENTS:

Do you have any comments about this questionnaire? We welcome your comments about the questionnaire in general or about specific questions, especially any that were unclear or confusing to you.

Thank you for completing this questionnaire!

CURRICULUM VITAE

NAME:	Mary Kathryn McClure
ADDRESS:	Department of Otolaryngology – Head/Neck Surgery & Communicative Disorders 627 South Preston Street, Suite 220 University of Louisville Louisville, KY 40202
DOB	Louisville, Kentucky – December 27, 1992
EDUCATION & TRAINING	B.S, Speech Pathology & Audiology Brescia University 2011-15
	(Anticipated) M.S, Communicative Disorders University of Louisville 2016-18
PROFESSIONAL SOCIETIES	American Speech Language and Hearing Association Kentucky Speech Language and Hearing Association National Student Speech Language and Hearing Association
PRESENTATIONS	McClure MK, Altstadt T, Pitts T. New O-C2 fusion surgery approach solving the dysphagia problem. University of Louisville Graduate Student Regional Research Conference, Louisville, KY: March 2018.
	McClure MK, Altstadt T, Pitts T. New O-C2 fusion surgery approach solving the dysphagia problem. Kentucky Speech and Hearing Association Conference, Lexington, KY: February 2018.