

EXAMINING THE EFFECTS OF ANKYLOGLOSSIA ON SWALLOWING FUNCTION

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ABSTRACT

Oropharyngeal dysphagia (OPD) involves difficulty during one or more of the stages of swallowing, resulting in difficulty moving the bolus from the mouth to the stomach. A deficit in tongue mobility, such as that found with ankyloglossia, may affect the oropharyngeal transit time of the bolus and predispose a person to OPD. This study was conducted to examine the possible relationship between tongue tie and oropharyngeal dysphagia. Data were gathered on 8 participants (5 females, 3 males) between the ages of 12-43 years. The *Lingual Frenulum Protocol* (Marchesan, 2012) was used to determine tongue tie. An Iowa Oral Performance Instrument (IOPI) measured tongue tip, tongue dorsum, and lip strength, and a combination of electromyography, and the five-finger palpation method measured laryngeal timing. Measurements were compared with normative data from Holzer (2011). Results revealed that participants with ankyloglossia had signs of oral stage dysphagia, including reduced articulator strength (tongue tip and dorsum, and lips) and reduced masseter activity. Oropharyngeal transit times were not significantly different from the norms.

Key Words: tongue tie, ankyloglossia, oropharyngeal dysphagia

INTRODUCTION

The processes of mastication and deglutition are normally executed without any conscious effort, even though over 55 pairs of muscles are involved in the processes (Seikel, Drumright, & King, 2016). Because these processes are governed largely by neural circuitry that orchestrates the precise timing of bolus movement, a deficit at any stage in the swallow can result in discoordination and life-threatening consequences should the bolus

enter the airway. This study examined the effects associated with tethering of the tongue secondary to ankyloglossia. Although ankyloglossia is typically viewed as affecting swallowing function during the post-natal nursing period, the potential for the disorder to interfere with the timing and processes associated with swallowing implies that it could lead to swallowing difficulties later in life.

Oropharyngeal dysphagia (OPD) refers to a deficit in any of the stages of swallowing that results in reduction of swallowing function. Swallowing is typically viewed as including four stages: Oral preparatory, oral transit, pharyngeal, and esophageal. The oral preparatory stage involves reception and manipulation of the bolus as it is prepared for swallowing. During this stage the food bolus is repeatedly moved from the tongue to the molars and back, providing the trituration process that serves to mix the bolus with the mucoid saliva of the sublingual and submandibular glands, in preparation for the next stage. The typical oral transit stage involves elevation of the tongue tip to the alveolar ridge, forming an anterior and lateral seal that facilitates the posterior movement of the tongue as it moves the bolus toward the oropharynx. The pharyngeal stage of swallowing is initiated when the bolus reaches the faucial pillars, posterior tongue, valleculae, or variously, the posterior pharyngeal wall. Physical contact triggers a cascade of responses that can be characterized under three global functions: Protection, pressure generation, and bolus transit timing (Seikel et al., 2016).

Protection of the airway is of vital importance and is accomplished by elevation of the hyoid-larynx complex (hyolaryngeal elevation), adduction of the true vocal folds and false folds, and by lowering of the epiglottis to cover

the laryngeal aditus. Hyolaryngeal elevation begins with anterior movement of the tongue base and tip during the oral transit stage. The epiglottis is mechanically linked to the tongue and hyoid, such that retraction of the tongue during the oral transit stage, coupled with the elevated larynx, causes dropping of the epiglottis to cover the laryngeal aditus. This mechanical linkage is supported by the action of the thyroepiglotticus muscle. These safeguards allow the bolus to pass over the epiglottis, split into roughly equal halves, move into the pyriform sinuses, and ultimately pass through the upper esophageal sphincter to the esophagus. The laryngeal elevation function is protective in a second way, in that it facilitates inhibition of the cricopharyngeus muscle, opening the upper esophageal sphincter. In addition to compromising pharyngeal peristalsis, failure to sufficiently elevate the larynx can result in pharyngeal residue above the level of the cricopharyngeus, leaving the individual vulnerable to aspiration of the contents should he or she become supine. Pharyngeal peristalsis, the product of sequential contraction of the pharyngeal constrictors, supports clearing residue from the pharyngeal walls, reducing collateral aspiration of residual bolus material.

The second category of action, pressure generation, involves pressurizing the pharynx by elevation of the velum, retraction of the tongue in a piston-like fashion into the

oropharynx, and elevation of the larynx to open the upper esophageal sphincter. A lingual seal is essential to pressurization, providing separation of the oral and pharyngeal spaces. The relatively higher pressure of the pharynx moves the bolus into the lower-pressure esophagus.

The third category of action, oropharyngeal timing, is the complex and highly orchestrated product of an intact nervous system. Bolus manipulation and transit timing are governed by central pattern generators (CPGs) that capitalize upon the presence of reflexes, such as the sucking reflex, chewing reflex, and palatal reflex (e.g., Jean, 1984). The chewing center of the posterior brainstem is responsible for the mastication responses resulting in the rotary chew necessary for grinding the bolus on the molars. The respiratory center of the brainstem has CPGs responsible for rhythmic breathing as well as respiration in response to gas chemical changes in the blood.

There are two CPGs for swallowing, both housed within the dorsal medulla. The dorsal swallowing group (DSG), located near the nucleus ambiguus, generates the patterns associated with swallowing, while the ventral swallowing group (VSG) is responsible for the muscle activation. The DSG entrains the reflexive responses associated with the pharyngeal swallow (i.e., adduction of the vocal folds, elevation of the velum, elevation of the

larynx) and organizes them into a sequential response that moves the bolus seamlessly to the waiting esophagus. The VSG is responsible for activation of these muscles in the highly orchestrated fashion that accomplishes the task. The result is oral transit of the bolus requiring up to one second and pharyngeal transit that is accomplished in less than a second (see Dodds, Stewart, & Logemann, 1990 and Seikel et al., 2016). The DSG and VSG ensure that the sequence is accomplished with appropriate timing, assuming normal physical and neuroanatomical structures. Alterations in the physical parameters of swallowing change the timing equation, such that, for example, increasing bolus viscosity or volume alters timing of both initiation and transit of the bolus (e.g., Kendall, Leonard & McKenzie, 2001). Similarly, as an individual ages, sensory and motor systems associated with swallowing change, modifying the swallow timing (e.g., Selley, Flack, Ellis & Brooks, 1989). At issue in the present study is whether the tethering of the tongue found in ankyloglossia is sufficient to interrupt the timing inherent in the system.

It is important to distinguish between signs of a swallowing problem, and the actual deficit in the swallow. A sign is the physical manifestation that indicates that there is a deficit, whereas the deficit is the abnormality in a structure, if any, that affects the function of the structure. Some common signs of

dysphagia are pocketing food in the lateral or anterior sulci, increased oropharyngeal transit time of the bolus, and nasal regurgitation. For these signs, the respective deficits may be weak buccal musculature, weakened tongue muscles, and slowed velar elevation (Seikel et al., 2016).

This study examined the relationship between a structural variation in humans, ankyloglossia, and swallow function. Ankyloglossia is a genetic oral condition characterized by an abnormally short lingual frenulum (Messner, Lalakea, Aby, Macmahon, & Bair, 2000; Yoon et al., 2017). The wide variety of characteristics, signs, range of severity, and effects of ankyloglossia contribute to the difficulty in diagnosing it and in determining prevalence (Ballard, Auer, & Khoury, 2002; Bai and Vaz, 2014; Buryk, Bloom, & Shope, 2011; Hogan, Westcott, and Griffith, 2005; Kotlow, 1999; Lalakea & Messner, 2003; Williams & Waldron, 1985; Yoon et al., 2017). Degrees of impact from ankyloglossia have been reported on feeding, speech, social issues, and sleep (Buryk et al., 2011; Huang, Quo, Berkowski, & Guilleminault, 2015; Messner & Lalakea, 2000; Yoon et al., 2017).

Oropharyngeal dysphagia indicates difficulty during one or more of the stages of swallowing that causes difficulty preparing the bolus for swallowing or moving the bolus from the mouth to the stomach (Logemann, 1998). There are

many causes for oropharyngeal dysphagia, including structural changes that affect the oropharyngeal swallow. Ferres-Amat, Pastor-Vera, Ferres-Amat, Mareque-Bueno, Prats-Armengol, and Ferres-Padro (2016) state that ankyloglossia causes atypical deglutition due to insufficient palatal support to produce a mature adult swallow. As discussed, the mature swallow requires adequate oral seal and posterior movement of the tongue, processes that are restricted in the infant and developing child with hypertrophic lingual frenulum.

The tongue is the propelling structure that pushes and squeezes the bolus to the faucial pillars during the oral stage of the swallow, and a deficit in its mobility may affect the oropharyngeal transit time of the bolus. Francis, Krishnaswami, and McPheeters (2015) state, "Not all patients identified with ankyloglossia may have difficulties breastfeeding and/or need surgery. However, no data exists to differentiate how patients may fare later in life" (p. 1463). There is suggestion of a relationship between ankyloglossia and swallowing. Olive (2016) conducted a study of 8 participants with ankyloglossia comparing them to norms for the measurements of oropharyngeal transit time, masseter contraction, laryngeal timing, and measure of force based on IOPI of tongue tip, dorsum, and lips. Results reported all participants having a noticeable delay in oropharyngeal transit time

for all bolus consistencies, a noticeable difference in masseter contraction, a marked delay in laryngeal timing, and reduced tongue tip, dorsum, or lip strength (Olive, 2016). As this was the first study linking ankyloglossia and oropharyngeal dysphagia more studies in this area are needed. The question of the present study is: Do individuals with tongue-tie differ from the norms of individuals without tongue-tie in measures associated with oropharyngeal dysphagia?

METHODOLOGY

The purpose of this study was to increase the evidence regarding whether or not individuals with ankyloglossia vary from the norm in measures of oral pharyngeal dysphagia. The study (IRB-FY2017053) was approved by the Human Subjects Committee, Office for Research at Idaho State University.

Participants

Participants included 5 females (mean age 25 yrs.) and 3 males (mean age 13.3 years), between 12 and 43 years of age.

Instruments and Materials

The following parameters were recorded: presence and degree of ankyloglossia, tongue dorsum and tip strength, lip strength, degree of masseter activity, and oropharyngeal transit time.

The *Lingual Frenulum Protocol* (LFP) (Marchesan, 2012) was used to confirm the presence of ankyloglossia in all participants, as well as to obtain case history. All subjects completed a demographic survey to obtain information on participants' birth date, gender, history of serious medical conditions or disorders, and preference of food types. Results lead to the exclusion of participants with a history of cleft palate or cleft lip, intellectual or motor limitations, neurogenic structural impairments to the head or neck, neurogenic disorders, or traumatic brain injury with coma. Participants with a history of a concussion resulting in a period of unconsciousness lasting no more than 5 minutes, and who had no reduction in motor or cognitive function, were not excluded from the study.

Clinical observation and professional judgment were used to measure subjective variables, which consisted of presence of open or closed mouth posture at rest, presence of tongue protrusion during swallow, rated cohesion of bolus, and residue on the tongue after the swallow. Superior tongue and lip strength were measured using the Iowa Oral Performance Instrument (IOPI) (Breakthrough model 1.5). Degrees of masseter contraction and oral pharyngeal transit time were measured using a two channel Infiniti EMG (Thought Technology) by means of surface electrodes. Food and liquids that were administered to the

participants included Snack Pack chocolate pudding, water, and Triscuit crackers.

A syringe calibrated for volume, measured in cubic centimeters, was used to measure pudding amounts and water.

Procedures

A counterbalanced order of presentation of measurement was used by developing three protocols (available upon request). Participants were assigned to one of the three groups (refer to Table 1). The counterbalanced order helped to control for measurement presentation effect

such as fatigue or familiarity. The *Lingual Frenulum Protocol* was administered first for all three groups as it was critical for diagnosing an individual with tongue tie. Participants were evaluated in the Idaho State University Speech, Language, and Hearing Clinic or in their homes. All participants were tested in a quiet environment, free of distractions. Participants were seated in an upright, comfortable position, and were allowed to drink water after completion of each bolus trial.

Table 1. Presentation Order of Measurement Tasks.

Group A	Group B	Group C
Lingual Frenulum Protocol	Lingual Frenulum Protocol	Lingual Frenulum Protocol
IOPI force	EMG masseter contraction	EMG laryngeal timing
EMG masseter contraction	EMG laryngeal timing	IOPI force
EMG laryngeal timing	IOPI force	EMG masseter contraction

Tongue, Lip, and Masseter Strength.

IOPI measurements for tongue tip strength, tongue dorsum strength, and lip strength were each done three times, recording the force exerted in micropascals. Masseter activity was recorded using EMG surface electrodes placed superficially on the belly of the masseter. Electrodes were first placed to obtain a masseter baseline and to measure masseter contraction. To identify the masseter belly, participants were asked to clench their back teeth while the researcher palpated the

masseter. The EMG electrodes were placed bilaterally on the masseter belly in a vertical plane, with the right and left masseters assigned Channel A and Channel B, respectively. The ground electrodes were placed on the participants' clavicle. A masseter activity baseline was recorded while participants clenched their molars, as an indication of maximum masseter function. This provided a comparison for masseter activity during swallow trials. Participants were asked to bite down with their back teeth as hard as

possible and then to relax, repeated for a total of three trials. Subsequently, groups were presented each bolus in three trials ($\frac{1}{2}$ teaspoon of pudding, 1 $\frac{1}{2}$ teaspoon of pudding, 10 cc of water, and a Triscuit cracker). Each subject was to hold the bolus until told to swallow. The researcher palpated the lateral neck and submental region during the swallow, using the five-finger method (Logemann, 1998). At the initiation and termination of the swallow, the researcher pushed the spacebar of the laptop computer, which placed a mark on the EMG recording. The Triscuit cracker was an exception to this; in this case, participants chewed until they were prepared to swallow, and then swallowed with their own timing. This was determined to be minimally disruptive to the swallow timing itself. EMG was recorded for all boluses. Again, the researcher marked timing initiation and termination of the swallow using the spacebar. Each stimulus was presented three times.

EMG and Behavioral Laryngeal Timing

Instrumental and behavioral measurements of oropharyngeal transit timing were used with the goal of identifying the initiation and termination of the swallow. Initiation was defined as movement of the tongue and was instrumentally measured by recording the EMG of the submental region. Termination was defined as the depression of the larynx following swallow. As the myogenic response of depression is variable, this was also

measured behaviorally using the 5-finger palpation method.

Channel A of the EMG was placed on the submental region, approximating the mylohyoid muscle. The first electrode was placed approximately two centimeters posterior from the chin point, and the second electrode placed two centimeters posterior to the first. Channel B had one electrode placed to the left of the thyroid notch with the second electrode placed two centimeters posterior to the first.

Participants were presented with $\frac{1}{2}$ teaspoon of pudding and instructed to clean the spoon and then to swallow when ready, repeated three times. The five-finger palpation method of Logemann (1998) was used as a behavioral measurement of laryngeal timing. The researcher also depressed the spacebar of the laptop computer at initiation of the swallow and at depression of the larynx, placing a marker on the EMG recording.

The researcher pulled down the subject's lower lip during a swallow to observe lingual function. The participant was presented with 1 $\frac{1}{2}$ teaspoons of pudding and instructed to clean the entire spoon and swallow when ready. The researcher observed any tongue protrusion during the bolus preparation, the swallow, and for completion of the task. Presence or absence of tongue protrusion was indicated on the protocol. The remaining boluses were also

sampled, each presented three consecutive times.

Reliability

Ten percent of laryngeal timing recordings of participants were re-measured by a second judge. The paired responses were compared using Pearson Product Moment Correlation Coefficients, revealing a .5748 positive correlation for interjudge reliability. The EMG of 10% of each participant's laryngeal timing measurements were re-measured by the researcher and cast into a Pearson Product Moment Correlation, resulting in a high correlation of 0.96 for intra-judge reliability.

RESULTS

The purpose of the study was to investigate the relationship between tongue tie and oral pharyngeal dysphagia. Eight participants with

tongue tie, diagnosed using the *Lingual Frenulum Protocol* (LFP), were assessed using EMG and IOPI instrumentation to determine tongue and lip strength, masseter strength, and swallowing time. Measurements were examined to determine differences between tongue-tie individuals and normative data of individuals without tongue-tie.

Demographic Survey

Eight subjects (3 males and 5 females) between the ages of 12-43 years (mean of 13.3 years for males and 25 for females) participated. Results of the demographic survey are summarized in Table 2. No other areas listed on the demographic survey were reported by participants.

Table 2. Demographic Survey Results.

	Males	Females	Total
European American	2	4	6
White Hispanic	1		1
Other/Multi-racial		1	1
Neuromedical conditions: head injury, stroke, brain masses, multiple sclerosis (1), cerebral palsy, dementia, brain surgery	0	1	1
Mouth Breather	1		1
Enlarged Tonsils/Adenoids	2	2	4
Tonsils/Adenoids Removed	1	2	3
Opened Space During Mixed Dentition		2	2
Current Open Spaces in Dentition		1	1
TMJ Syndrome		1	1
Allergies	2	1	3
Oral Surgery: wisdom teeth (3)		3	3
History of Finger Sucking	1		1
Other Surgery: ear tubes (2), gall bladder (1)	1	1	2

Group Trends

Group data for IOPI tip, dorsum, and lip measurements are compared to normative data in Figures 1, 2, and 3 respectively, as arrayed by tongue tie coefficient (note that larger coefficients denote more severe tongue tie). With some exceptions, as tongue tie severity increased, the ability to generate tongue force decreased when compared to individuals of the same age, without tongue tie. Group comparison of oropharyngeal transit times for ½ tsp pudding, 1 ½ tsp pudding, 10 cc water, and Triscuit crackers to normative data are shown in Figures 4, 5, 6, and 7, respectively, arrayed by tongue tie coefficient. For ½ tsp of pudding, all but one participant exhibited increased (but non-significant) oropharyngeal transit time. For 1 ½ tsp of pudding and 10 cc of water, five out of eight

participants demonstrated increased oropharyngeal transit time. In the Triscuit cracker trials, five out of seven participants had increased oropharyngeal transit time (one participant's results did not save correctly on the computer).

Group trends gained from behavioral observations of the tongue indicated that 7/8 participants had oblong or square shaped tongue tips and 2/8 had heart shaped tips. Additionally, 6/8 had the mouth floor visible from the inferior alveolar crest, 6/8 had sublingual attachment between the middle and apex of the tongue, and 1/8 had sublingual attachment at the apex of the tongue. In addition, 6/8 had their tongue protrude during swallowing trials, indicative of a tongue thrust.

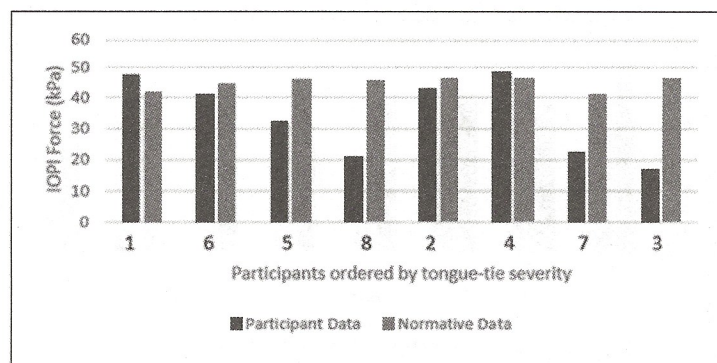


Figure 1. IOPI Tongue Tip Comparison by Severity of Tongue Tie to Normative Data.

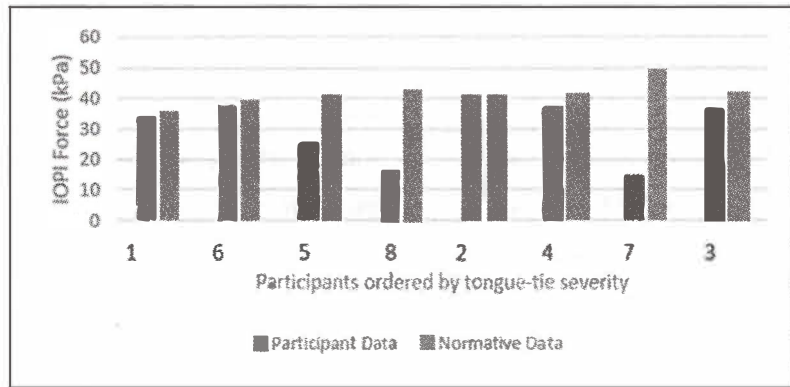


Figure 2. IOPI Tongue Dorsum Comparison by Severity of Tongue Tie to Normative Data.

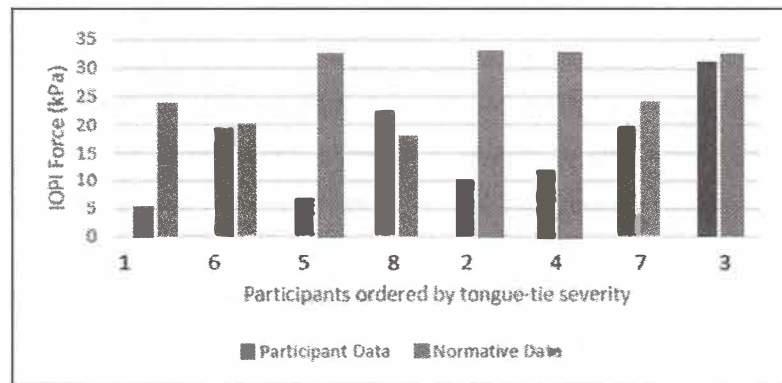


Figure 3. IOPI Lips Comparison by Severity of Tongue Tie to Normative Data.

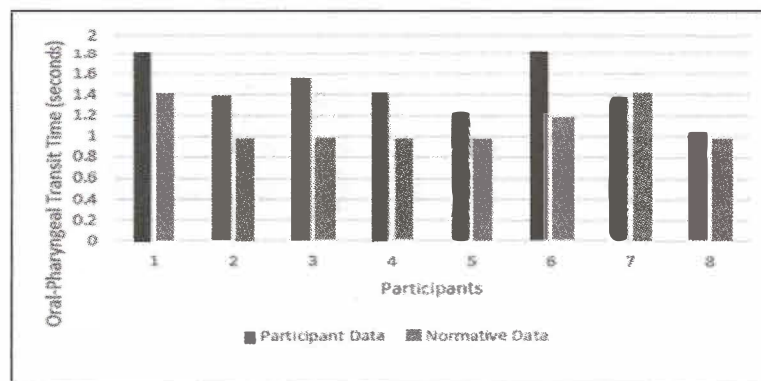


Figure 4. Group Oropharyngeal Transit Time for 1/2 tsp Pudding.

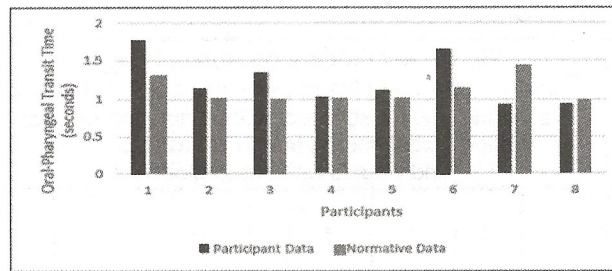


Figure 5. Group Oropharyngeal Transit Time for 1 ½ tsp Pudding.

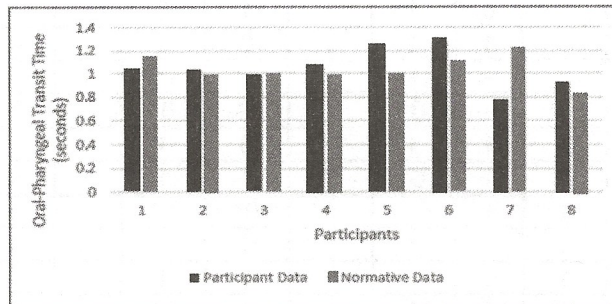


Figure 6. Group Oropharyngeal Transit Time for 10 cc water.

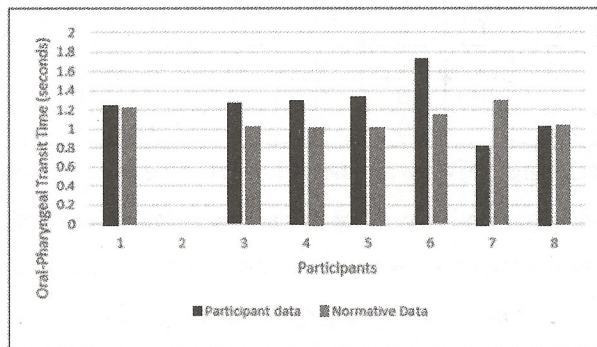


Figure 7. Group Oropharyngeal Transit Time for Triscuit Crackers.

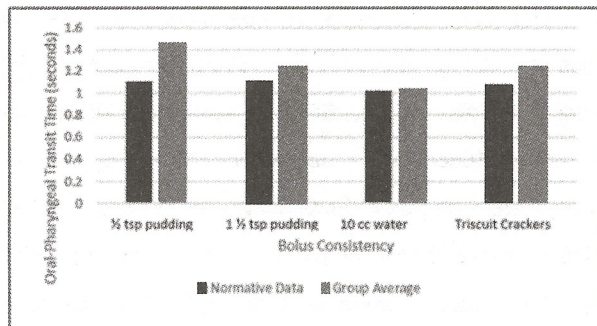


Figure 8. Average Group Oropharyngeal Transit Times.

Table 3. Tally of significant findings by subject.

Measurement	Significant Finding by Subject (α .05) Arbitrary criterion of 50% of participants (i.e. 4) displaying a finding was established as threshold for variable demonstrating strong trend toward presence in individuals with ankyloglossia									Meet or Exceed .5 criterion
	1	2	3	4	5	6	7	8	T	
lopitipavg	0*	0	1	0	1	0	1	1	4	X
lopidorsavg	0	0	1	1	1	0	1	1	5	X
lophilipavg	1	1	0	1	0	0	1	0*	4	X
mcbARMSavg	1	-	1	1	0*	0*	1	1	5	X
mcbBRMSavg	1	-	0*	0*	0*	0*	1	1	3	
mcpud1ARMS	0*	1	1	0*	0	1	1	1	5	X
mcpud1BRMS	0*	1	0*	1	1	1	1	1	6	X
mcpud2ARMS	1	1	1	1	0*	0*	1	1	6	X
mcpud2BRMS	1	1	1	1	1	1	1	1	8	X
mc10ccARMS	1	1	1	1	1	1	1	1	8	X
mc10ccBRMS	1	1	1	1	1	0*	1	1	7	X
mccrackARMS	1	1	1	1	1	1	1	1	8	X
mccrackBRMS	1	1	1	0	1	0	1	1	6	X
stcpud1avg	0	0	1	0	0	1	0	0	2	
stcpud2avg	0	0	0	0	0	1	0	0	1	
stc10ccavg	0	0	0	0	0	0	0	0	0	
Stccrackavg	0	-	0	0	0	1	0	0	1	

Note that tallies indicated with asterisk (*) were significant but not in the direction predicted through one-tail test, and therefore do not contribute to the tally. Note that scores indicated with dash (-) were not calculated due to anomalies in data. Note the following definitions of abbreviations: lopitipavg = average tongue tip force using IOPI; lopidorsavg = average dorsum force using IOPI; lophilipavg = average lip force using IOPI; mcbARMSavg = degree of EMG activity for left side masseter contraction during swallow; mcbBRMSavg = degree of EMG activity for right side masseter contraction during swallow; mcpud1ARMS = degree of EMG activity for masseter during the ½ tsp bolus of pudding, left side; mcpud1BRMS = degree of EMG activity for masseter during the ½ tsp bolus of pudding, right side; mcpud2ARMS = degree of EMG activity for masseter during the 1½ tsp bolus of pudding, left side; mcpud2BRMS = degree of EMG activity for masseter during the 1½ tsp bolus of pudding, right side; mc10ccARMS = degree of EMG activity for masseter during the 10 cc tsp bolus of water, left side; mc10ccBRMS = degree of EMG activity for masseter during the 10 cc tsp bolus of water, right side; mccrackARMS = degree of EMG activity for masseter during the Triscuit cracker swallow, left side; mccrackBRMS = degree of EMG activity for masseter during the Triscuit cracker swallow, left side; stcpud1avg = swallow timing for ½ tsp pudding bolus; stcpud2avg = swallow timing for the 1-1/2 tsp pudding bolus; stc10ccavg = swallow timing for the 10 cc water bolus; stccrackavg = swallow timing for the cracker bolus.

Significant Findings as a Group

Inferential statistical analysis was completed for each individual for all of the measures by calculating a z score for the measure and comparing it to the normative data prepared by Holzer (2011), with the significance level set at .05. Presence of significant findings by variable for each participant is presented in Table 3. For the purposes of identifying the strength of the significant findings in terms of grouped responses, a threshold tally of 4 or greater (50% of participants showing significance on a variable) was taken as an indication of a trend in individuals with ankyloglossia. All IOPI measurements exceeded the criterion, as did all masseter contraction measures, with the exception of the right channel average activity. Notably, none of the oropharyngeal timing variables met the criterion. By this metric, individuals with ankyloglossia show consistent reductions in articulator force (tongue tip and dorsum, and lip), as well as masseter activity for all boluses. In contrast, oropharyngeal transit time does not appear to be a consistent indicator related to tongue tie.

DISCUSSION

The purpose of this study was to obtain data about the possible relationship between tongue tie and oropharyngeal dysphagia (OPD). The measurements of strength and masseter contraction were obtained in order to investigate relationships between tongue tie

and risk factors for OPD. Laryngeal timing was collected as a primary risk factor for OPD. All collected data were compared to the normative data of Holzer (2011) and compared through z scores to determine significant differences. This study sought to identify presence of signs of oropharyngeal dysphagia in individuals diagnosed with ankyloglossia.

In this study, the primary indicator of ankyloglossia was severity determined by tongue tie coefficient, the ratio between MO_{ts} and MO_{max} (i.e. maximal mouth opening with tongue to "spot" at the incisive papilla versus maximal mouth opening). While Evers (2013) noted that delayed oropharyngeal transit time is a primary indicator of oropharyngeal dysphagia, other indicators such as reduced oral musculature strength are also indicative of OPD. Lazarus, et al. (2000) provided evidence that tongue strength plays a role in oropharyngeal swallowing, and several studies (Dworkin & Hartman, 1979; Yeates, Molfenter & Steele, 2008; Yoshida et al., 2006) have found lingual weakness to be present in OPD. Although the laryngeal timing data of the present study did not differ significantly from the norms, there was nonetheless a clear trend toward longer oropharyngeal transit times for individuals with increased tongue tie severity. The data of the present study confirm that individuals with ankyloglossia show signs of oropharyngeal dysphagia, based upon the decreased tongue tip, dorsum, and lip strength

(Table 3). Further, the present study found consistently reduced masseter activity for all bolus types in the ankyloglossia group. While not reaching statistical significance, oropharyngeal transit times were generally longer than the norms (Figure 8). Individuals with ankyloglossia demonstrate a trend of reduction in articulator force (tongue tip and dorsum, and lips) and reduced masseter activity for all bolus types.

Masseter activity varied for both bolus size and type for individuals with tongue-tie, as revealed in the group summary in Table 3. Reduced masseter activity for individuals with tongue tie could be due to the tongue not contacting the roof of the mouth during the swallow to supply counter pressure. In a typical swallow, the tongue tip contacts the roof of the mouth during the propulsion stage, which generates counterforce at the tongue base. This activates the masseter stabilization of the tongue base (Olive, 2016). Limited tongue mobility would be expected for individuals with a point of attachment at the inferior alveolar crest, which 6/8 participants exhibited. Also, limited mobility may be seen with individuals with a sublingual attachment between the middle and the apex of the tongue, which 7/8 participants possessed. Both of these conditions would lead to reduced masseter activity. Thus, the presence of an oromyofunctional disorder arising from ankyloglossia would be directly linked to oral stage dysphagia.

The study revealed that all force measures differed from the norms for this group. Table 3 indicates consistent significant difference in force for all locations (tongue tip and dorsum, and lips) for individuals with tongue tie compared to the normative data. The lower IOPI tongue tip measurements clearly relate to the LFP, in that 7/8 participants had an attachment of the frenulum at the apex or between the middle and the apex of the tongue and 6/8 revealed an anterior connection of the frenulum at the inferior alveolar crest. These points of attachment may limit the mobility of the tongue tip, which would reduce the use of the tongue tip, causing reduced tongue tip force. The overall trend indicates that tongue tie reduces tongue tip, dorsum, and lips strength. Again, as with the masseter activity differences and the trend toward longer oropharyngeal transit times, there is strong evidence for risk of oropharyngeal dysphagia in individuals with tongue tie.

Clinical Implications

This study presents implications that individuals with ankyloglossia are at risk for life-threatening oropharyngeal dysphagia. The clear presence of tongue weakness and reduced counterforce by masseter activity speak directly to oral stage dysphagia, including issues related to oral preparation and oral transit. A young individual may be able to compensate for such limitations in oral function. Nicosia, et al. (2000) found that older

individuals may be at a greater risk for dysphagia due to age related decreased lingual strength and difficulty generating swallowing pressure. It is entirely possible that individuals with tongue tie who begin with decreased lingual strength may continue to experience further muscular weakness associated with aging that will result in poor bolus containment and prolonged propulsion which, when coupled with reduced sensory awareness, may result in premature spillage of the bolus into the airway, or other signs of dysphagia.

Limitations of Current Study

Limitations of this study consist of a small sample size, the need for a comparison group to allow grouped statistical analysis, and issues with diagnosis of tongue tie. All participants were identified with tongue tie using the *Lingual Frenulum Protocol* (LFP), exhibiting a score of 3 or greater. However, Yoon, et al. (2017), recommended using the Tongue Range of Motion Ratio (TRMR) via the Quick Tongue Tie Assessment tool (QTT) to assess the degree of mobility restriction relative to functionality. Four participants qualified as tongue-tied on the LFP scoring overall but had MOMotts and MOMax ratio scores of 60% and 70% via the QTT, equating to a grade 2 functional restriction (Yoon et al., 2017). Continuing efforts to standardize assessment processes in ankyloglossia will ultimately ameliorate these problems.

Implications for Future Research

Future studies concerning the impact of tongue tie and oropharyngeal dysphagia should include a larger sample size. Additionally, the investigation of the impact of oral exercises on tongue strength would be valuable to the clinical community attempting to alleviate the effects of tongue thrust and tongue tie.

CONCLUSION

This study recorded and analyzed the data of 8 individuals with tongue tie aged 12-43 years compared to age matched norms from Holzer (2011). Individuals with ankyloglossia showed significant reductions in masseter activity, lingual strength and lip strength. While not significant, there was a trend for prolonged oropharyngeal transit time for individuals with tongue tie. Based on the results of this study, indicators of oropharyngeal dysphagia are present in individuals with ankyloglossia.

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