LARYNGEAL FUNCTION OUTCOMES IN CHILDREN POST-AIRWAY RECONSTRUCTION FOLLOWING INJECTION LARYNGOPLASTY

By

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ABSTRACT

LARYNGEAL FUNCTION OUTCOMES IN CHILDREN POST-AIRWAY RECONSTRUCTION FOLLOWING INJECTION LARYNGOPLASTY

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Laryngotracheal stenosis is defined as congenital or acquired narrowing of the airway that may affect the glottis, subglottis, and/or trachea. Subglottic stenosis (SGS) is narrowing of the upper airway extending from just below the vocal folds to the lower border of the cricoid cartilage. Perceptually, a child with SGS may present with stridor and/or respiratory distress, due to decreased vocal fold medialization, resulting in need for airway reconstruction to provide an adequate airway and restore proper respiratory function. A common outcome of airway reconstruction procedures is unilateral vocal fold paralysis or paresis resulting in glottal insufficiency. Glottal insufficiency is one of the most common contributing factors in patients who present with dysphonia. Approximately half of children who undergo airway reconstruction are known to have dysphonia, or hoarse voice, which is said to have a negative influence on well-being. Voice therapy may provide improvement in vocal function in some cases; however, surgical intervention is required to improve vocal fold medialization by means of injection laryngoplasty. Currently, there is a lack of research for vocal fold medialization in the pediatric population as well as no research, to date, that assesses which injections are most effective in restoring vocal function. This study was a retrospective case series and medical record review which sought to determine efficacy of injection laryngoplasty and the parameters by which it is impacted. It was found that gender was the closest in correlation with glottal efficiency. Further research is warranted to determine a formal algorithm to assess vocal outcomes post-injection laryngoplasty.

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KEY TO ABBREVIATIONS

SGS	Subglottic Stenosis
pVHI	Pediatric Voice Handicap Index
GE	Glottal Efficiency
CAPE-V	Consensus Auditory-Perceptual Evaluation of Voice
PAS	Phonatory Aerodynamic System
CSL	Computerized Speech Lab

1. INTRODUCTION

The congenital or acquired narrowing of the airway, laryngotracheal stenosis, is commonly found at the level of the glottis, subglottic, and/or trachea (Lesperance & Zalzal, 1998). SGS is characterized by a narrowing of the upper airway extending from just below the vocal folds to the lower border of the cricoid cartilage. Acquired SGS typically results from prolonged endotracheal intubation or direct laryngotracheal injury (e.g. trauma, burn, and/or traumatic intubation); in cases such as these, prolonged intubation refers to a time period greater than 14 days. In the pediatric population, such airway injuries are noted with premature or critically ill babies whose pulmonary condition necessitates ongoing airway management. Congenital subglottic stenosis, on the other hand, occurs as a rare birth defect or results from a genetic syndrome where the airway remains narrow. Often, a child with SGS may present with stridor and/or respiratory distress for which airway reconstruction is warranted.

1.1 Airway Reconstruction

The level of airway obstruction in individuals with SGS is rated using the Myer-Cotton staging system: Grade I lesions have less than 50% obstruction, Grade II lesions have 51% to 70% obstruction, Grade III lesions have 71% to 99% obstruction, and Grade IV lesions have no detectable lumen or complete stenosis (Myer, O'Connor, & Cotton, 1994). Once the level of obstruction has been determined, a surgical technique is selected to establish an adequate airway; this is done so by ways of airway reconstruction including laryngotracheoplasty, laryngotracheal reconstruction, cricotracheal resection, or laryngofissure. A child with Grade I or II SGS is typically treated with endoscopic surgery or tracheal balloon dilation; however, concomitant airway lesions have been significantly associated with failure of balloon dilation treatment (Whigham et al., 2012), potentially resulting in another surgery or other airway issues. Children

with Grade III and IV SGS are treated with laryngotracheal reconstruction, single- or double-staged. Laryngotracheal reconstruction is used to increase the airway lumen by splitting the narrowed segment of the cartilaginous rings and then suturing harvested cartilage grafts to increase the lumen's diameter of the trachea. Crichotracheal resection is where the narrowed part of the airway, just below the larynx, is removed and the larynx and trachea are sewn back together. Cricotracheal resection can also be single- or double-staged depending on where the narrowing occurs. A laryngofissure is performed by vertically splitting the thyroid cartilage exactly in the midline and widely opening up the immediate subglottic larynx. Wright (2008) found, however, that laryngofissures do tend to increase the chances of significant vocal fold edema.

1.2 Pediatric Voice Disorders

Airway reconstruction is the recommended method to restore respiratory function by providing an adequate airway; however, this often results in poor glottal closure and allows for air to escape through the glottis during phonation (Ojha, Setlur, Bunting & Hartnick, 2015). This incomplete glottal closure results in dysphonia. Dysphonia is defined as a disorder characterized by altered vocal quality that impairs communication or reduces voice-related quality of life (Schwartz et al., 2009) and review of literature has shown that 69% of children present with dysphonia following laryngotracheal reconstruction (Sell & McCurtain, 1988). Additionally, a study by Baker et al. (2006) found that approximately half of children who undergo airway reconstruction are known to have dysphonia as a result of altered laryngeal anatomy. Vocal folds are the most common phonation source for individuals; during phonation the folds are brought together (adducted), airflow from the lungs is temporarily blocked, subglottal pressure then increases and the vocal folds are pushed back open (abducted). This continuous adduction-abduction pattern results in phonation (voice). Disruption of this adduction-abduction pattern

results in dysphonic speech. In order to prevent air from escaping and regulate the vocal fold pattern, compensatory strategies (i.e. use of the ventricular folds, arytenoids against the petiole of the epiglottis, or arytenoids against the ventricular folds) are used therefore resulting in supraglottic phonation. Voice therapy can minimize supraglottic compression and reduce compensatory strategies (Ojha, Setlur, Bunting & Hartnick, 2015) by teaching individuals to increase breath support, decrease excess muscle tension, improve vocal fold closure, and decrease vocal effort and fatigue. The most common techniques used in voice therapy for individuals with dysphonia are diaphragmatic breathing, lip trills, stretching, and neck and laryngeal massage (Verdolini, 1998). What happens, however, when a patient is not completely satisfied or when maximum vocal function is not achieved? Ojha, Setlur, Bunting and Hartnick (2015) report that although some information is available, more efforts need to be made to address the issue of dysphonia in children with laryngotracheal reconstruction; more specifically, further research is required to determine how injectables may or may not correct any residual dysphonia.

1.3 Perceptual Outcomes

Children with dysphonia often experience social withdrawal and depression, which may result in a negative influence on functional, emotional, educational and social outcomes (Baker et al., 2006). Literature in voice has an abundance of studies related to and studying the effects of voice disorders in adults, but limited research has been done with the pediatric population. A study by Zur et al. (2007) both developed and found the Pediatric Voice Handicap Index (pVHI), a modified version of the Voice Handicap Index, to be highly reliable in evaluating the effects of dysphonia on functional, physical and emotional well-being. The 30-item survey reflects the parents' responses about his or her child with statements such as: "my child's voice makes it difficult for people to hear him/hear", "my child runs out of air when talking", "people seem

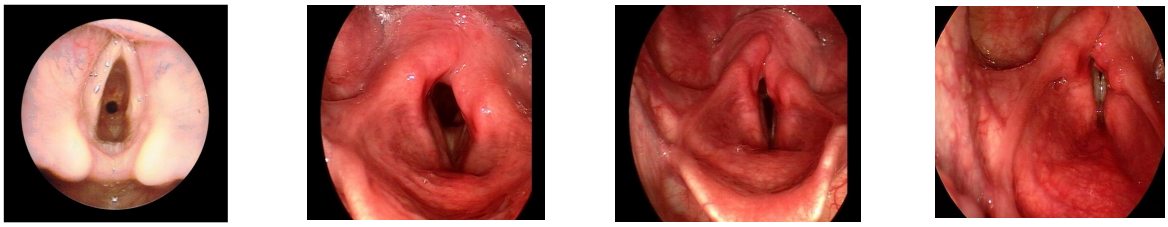
irritated with my child's voice" (Appendix B). It is strongly recommended that patients receive an early postoperative evaluation, following airway reconstruction, by a speech-language pathologist in order to prevent or treat potential development of poor-quality, supraglottic voice, and other poor vocal habits that may occur following airway reconstruction surgery (White et al., 2009). Speech-language pathologists work with these individuals on relaxation and voice exercises to help eliminate these compensatory strategies and restore the voice to its normal function.

1.4 Injection Laryngoplasty

In some cases, voice therapy is highly successful in treating voice disorders; however, some individuals wish for further improvement once therapy has been maximized as glottal insufficiency may persist. Glottal insufficiency is a condition where individuals are unable to achieve complete glottic closure resulting in a weak and breathy voice due to air escaping during phonation. According to Zaretsky and Rice (1996), incomplete glottic closure can lead to aspiration, inability to produce an effective cough, and breathy hypophonia. For individuals with incomplete glottic closure as a result of airway reconstruction, injection laryngoplasty is offered as a means to improve medialization. Injection laryngoplasty is a procedure involving injection of viscous material into the vocal folds with the purpose of "bulking up" the folds to allow for medialization (Figure 1). This surgical procedure has gained popularity in recent years due to its low procedural cost, technical feasibility, and clinical efficacy (Phua et al., 2013). Indications for injection laryngoplasty include any of the following: vocal fold paresis or paralysis, vocal fold atrophy, vocal fold bowing, and vocal fold scarring. For an injection to be successful, the ideal injection material should be biocompatible and not cause local tissue reaction or fibrosis, be easy to prepare and use, and durable and resistant to reabsorption or migration (Phua et al., 2013). It should also

have low cost and should maintain the viscoelasticity of the vocal fold post-injection (Phua et al., 2013).

There are currently three substances that are most commonly used for injection laryngoplasty (Restylane, Radiesse Voice Gel, and lipoinjections) (Mallur & Rosen, 2010); however, neither of the three meet all the aforementioned criteria. Restylane (Hyaluronic Acid) is made up of a synthetic material and is used for temporary augmentation. Individuals with Restylane injections have effects lasting 3-6 months before the body reabsorbs the material. Radiesse Voie Gel (Calcium Hydroxylapatite) is a firmer and longer lasting material than Restylane. Lastly, fat injections, also known as Lipoinjections, provide a more permanent correction of mild vocal fold weakness or paresis, which often results in incomplete vocal fold closure during voice production. In cases where lipoinjections are used, the material is injected to overmedialize the vocal fold past the midline as absorption is expected (Zaretsky & Rice, 1997). The aforementioned materials can be injected onto the vocal folds (unilaterally or bilaterally) or in the supraglottic region depending on the level of function determined through stroboscopic assessment. Currently, there is no research that provides information on which injection comes the closest to restoring vocal function and provides the best post-surgical laryngeal function. Injection laryngoplasty is a surgical treatment alternative to laryngeal framework surgery and though each injection material has its advantages and drawbacks, there is no formal algorithm that exists in comparing the vocal outcomes following each (Mallur & Rosen, 2010).



Subglottic Stenosis Abduction (pre injection) Adduction (pre injection) Adduction (post injection)

Figure 1. Injection Laryngoplasty (Zacharias, S.)

1.5 Glottal Efficiency

Phonatory control and consistency depends upon the dynamic management of the respiratory, laryngeal and resonator subsystems (Carroll et al., 1996). It is the respiratory system that provides the driving force behind phonation. Any alteration to the respiratory framework (i.e. the larynx, vocal cords, etc.) would undoubtedly result in changes in phonatory function. But how does one measure this change? Glottal efficiency (GE) has been identified as the quantitative measure of the ability of the larynx to convert the aerodynamic power generated by the pulmonary system into acoustic power transmitted through the vocal tract and measured at the lips (Titze, 1995). Kirsh and colleagues (2017) described GE as the ratio between acoustic power and aerodynamic power, where acoustic power is the intensity of sound that radiates from the mouth and aerodynamic power is the product of subglottic air pressure and flow rate. In other words, GE is the amount of work put into producing voice. Researchers (Zur et al., 2007) have analyzed GE in singers and their findings suggest that increasing subglottal pressure has a positive correlation with acoustic intensity. This correlation, however, is reliant on glottal adduction remaining unaltered. Given that airway reconstruction often results in disruption of the convergent-divergent motion of the vocal folds, this study aims to assess how injection laryngoplasty, with its goal to allow for improved vocal fold medialization, impacts GE.

1.6 Current study

This study is motivated by the question of whether vocal fold outcomes of children with airway reconstruction differ post-injection laryngoplasty and how. In this study, laryngeal function outcomes (as measured by glottal efficiency) and perceptual characteristics (as measured by the pVHI) in children pre- and post- airway reconstruction following injection laryngoplasty were compared. It was expected that improvement in laryngeal function will be evident post-injection. The following questions were investigated in order to determine whether these changes are positive or negative and the extent of which contributing factors were influencing these changes: (1) it was hypothesized that vocal function would improve following injection laryngoplasty (per changes in GE), (2) it was also hypothesized that the parents' perceptual characteristics of their child's voice (functional, physical, and emotional scores) would improve post-injection laryngoplasty, (3) how, if at all, are GE and perceptual characteristics impacted by sex, type of injection material used, injection site, and type of airway reconstruction.

2. RESEARCH DESIGN AND METHODS

2.1 Participants

This study was a retrospective case series and medical record review of 16 pediatric patients (7 females, 9 males) at the Pediatric Center for Voice Disorders at Cincinnati Children's Hospital. Participants were identified for this study based on the following criteria from the medical record database: (1) history of airway surgery, (2) history of injection laryngoplasty, (3) pre- and post- injection acoustic and aerodynamic measurements, and (4) pre- and post-injection parent surveys (i.e. pVHI and Initial Intake History Form). Case history was acquired via the Initial Intake History Form (Appendix A).

2.2 Data Collection

2.2.1 Pediatric Voice Handicap Index

The (pVHI) was given to parents to rate their child's voice in the following categories: functional, physical and emotional well-being (Appendix B). Given the nature of the questions and the description of the negative effects of voices on their lives (e.g. my child's voice is worse in the evening, my child tends to avoid communicating because of his/her voice, etc.), lower scores on the pVHI were indicative of good and/or improved vocal function. Overall scores could be as low as 0 and as high as 92.

2.2.2 Acoustic Data

Upon completion of the Initial Intake History Form and pVHI, patients were taken to a soundproof booth where acoustic data were recorded using the Kay Elemetrics Computerized Speech Lab (CSL) (Kay Elemetrics Corp., Pinebrook, NJ) with the CSL Real-time Pitch. Subjects

were asked to perform various vocal tasks (as outlined in Figure 2 below) while being recorded with a microphone set 5 inches away from the mouth and placed in an off-axis position.

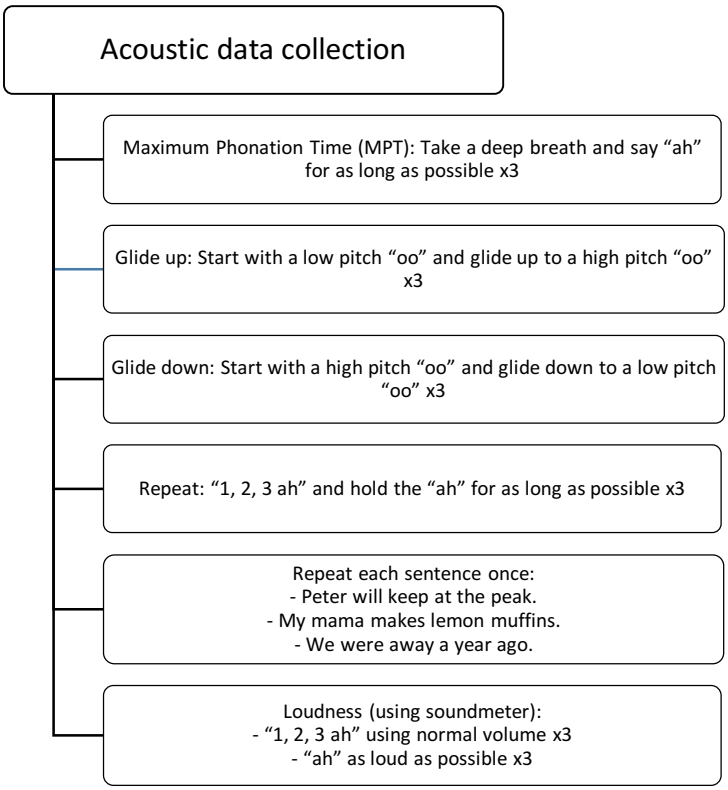


Figure 2. Acoustic data collection.

2.2.3 Aerodynamic Data

Aerodynamic data were collected using the KayPENTAX *Phonatory Aerodynamic System (*PAS) Model 6600 (KayPENTAX Corp., Lincoln Park, NJ) designed to measure airflow and pressure related to speech and voice production. During airflow assessment, subjects were fitted with PAS airflow masks and were asked to place them firmly on their faces while producing a prolonged vowel /a/. For the pressure measurements, subjects were trained to allow their lips to close firmly on the plastic tube within the mask while repeating the syllable /pa/ (Figure 2).

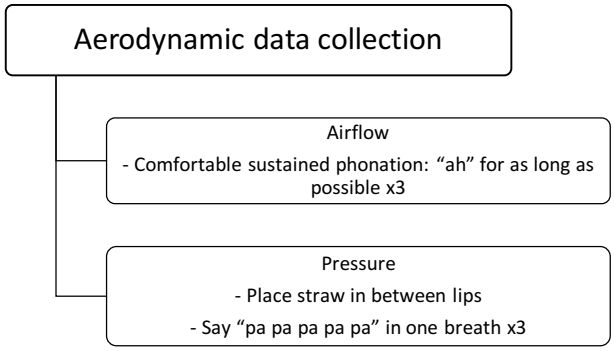


Figure 3. Aerodynamic data collection.

2.2.4 Stroboscopy

Upon completion of acoustic and aerodynamic data collection, subjects underwent a videolaryngostroboscopy evaluation using either a flexible distal chip transnasal endoscopy or a rigid endoscopy. During evaluation, subjects were asked to perform varying vocal tasks (i.e. say “ee”, vary pitch while saying “ee”, and repeat sentences used during the acoustic data collection) as researcher recorded findings on Stroboscopy evaluation form (Appendix C) and the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) (Appendix D). Patients for whom injection laryngoplasty was suggested were seen again post-injection at the clinic.

2.2.5 Glottal Efficiency

Acoustic and aerodynamic data from each participant were pulled in order to calculate both pre- and post- injection GE values. As previously mentioned, Kirsh et al. (2017) defined GE as the ratio between acoustic and aerodynamic power. For purposes of this study, their equation for this definition (GE ≈ Sound Pressure Level (SPL) / Psg x Q) was utilized.

2.3 Data Analysis

Data from the Pediatric Voice Clinic at Cincinnati Children's Hospital Medical Center were obtained via Redcap. Participants were chosen based on the criteria outlined for this study. Given that pVHI data for all 16 participants were not available, descriptive analyses were conducted to answer the first research question: it was hypothesized that the parents' perceptual characteristics of their child's voice (functional, physical, and emotional scores) would improve post-injection laryngoplasty. Aerodynamic and acoustic measurements were collected for calculation of GE with the goal to answer the first research question: it was hypothesized that vocal function would improve following injection laryngoplasty (per changes in GE). Once GE had been calculated both prior to and post injection, a value for percent change was derived.

Given the different ordinal variables and abnormal distribution of data in this study, a Wilcoxon Rank Sum test was conducted for each parameter (i.e. sex, injection type, and injection material) by GE percent change to determine a rank correlation. This test allowed for investigation into the third research question: how, if at all, are GE impacted by sex, type of injection material used and site of injection.

3. RESULTS

3.1 *Perceptual Outcomes*

Of the 16 participants in this study, complete pVHI data was only available for 10. Total pVHI scores could be as low as 0 and as high as 92, with lower scores correlating with an improvement in perceived vocal outcomes. Given the small sample size of this study, statistical analyses could not be conducted on this given data. On average, post-injection laryngoplasty, parents reported lower scores on the pVHI indicating an overall improvement in vocal outcomes (Table 1).

Table 1.
pVHI outcomes

	Min	*Max*	*Mean*	*SD*
Pre-injection	14	96	50.3	24.92
Post-injection	4	72	38.1	20.97

3.2 Glottal Efficiency

GE percent change was calculated to provide a quantifiable value to improvement post-injection laryngoplasty. Majority (9) of the participants demonstrated improvement in GE, as demonstrated by calculating percent change (Table 2, Figure 4). Additionally, a larger amount of female participants (N=5) had a positive percent change vs male participants (N=3). Paired sample t-test indicated a non-significant increase ($t(15)=.898$, $p=.383$) in GE pre ($M=9.51$, $SD=7.41$) and post-injection laryngoplasty ($M=11.98$, $SD=15.70$).

Table 2.

Participant demographics, age at airway reconstruction and injection and GE percent change

Participant	*Sex*	*Age at Airway Reconstruction*	*Age at Injection*	*% change*
1	F	18	18	11.85
2	F	2	7	3.29
3	F	17	18	-11.66
4	M	3	12	-37.43
5	F	1	17	1.79
6	M	15	17	-72.17
7	F	8	11	300.41
8	M	18	20	31.71
9	M	1	13	-55.81
10	M	14	14	35.01
11	M	9	9	-13.67
12	M	21	20	263.53
13	F	2	9	102.74
14	F	5	13	116.14
15	M	1	10	-65.98
16	F	8	8	-5.22

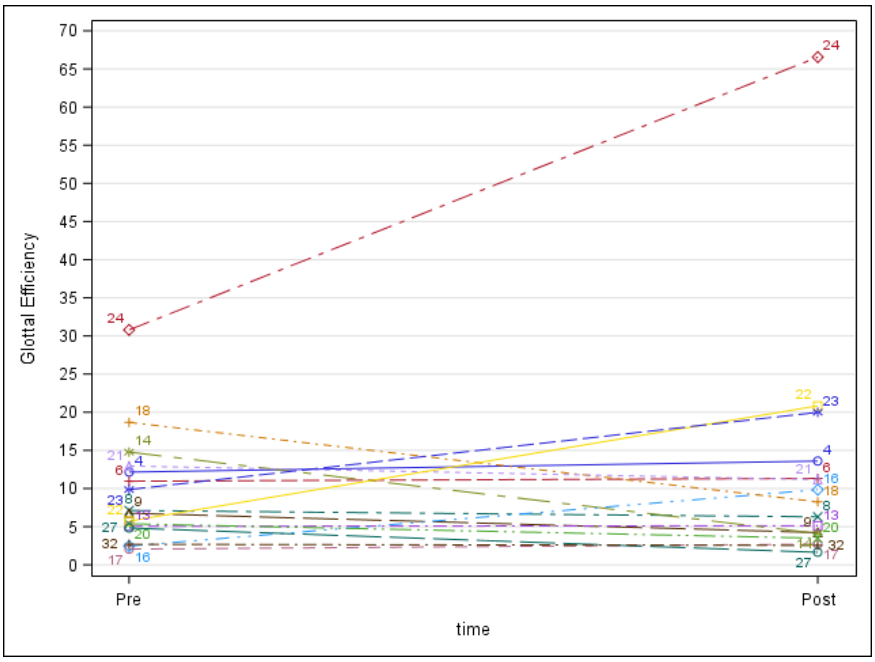


Figure 4. GE pre- and post-injection laryngoplasty.

The Wilcoxon Sum Rank test was administered to determine whether there was a significant interaction between GE percent change and sex, injection material and site of injection. Calculated median and interquartile ranges are outlined in Table 3.

Table 3.

Wilcoxon Sum Rank test median and interquartile range (IQR, 25th-75th percentile) of three parameters by GE

Parameters	*Median*	*IQR*
Sex		
Male	-36.2	-60.9, 9.0
Female	7.57	-1.72, 109.44
Injection material		
Radiesse VoiceGel	-5.22	-55.81, 31.71
Restylane	3.28	-11.66, 102.74
Site of injection		
Bilateral vocal fold	-1.72	-35.01, 3.28
Unilateral vocal fold	0.10	-51.70, 183.13
Supraglottic	-13.67	-13.67, -13.67

Correlation values (Table 4) depict that although sex was the closest in interaction (p=.06), neither of the parameters including injection material (p=.43) or site of injection (p=.85) were found to be positively correlated with GE percent change.

Table 4.

Difference in glottal efficiency by sex, injection material and site of injection (*p* values)

Parameters	*P value*
Sex	.06
Injection material	.43
Site of injection	.85

Figures 5, 6 and 7 present the distribution of GE percent change by sex, injection material and site of injection, respectively.

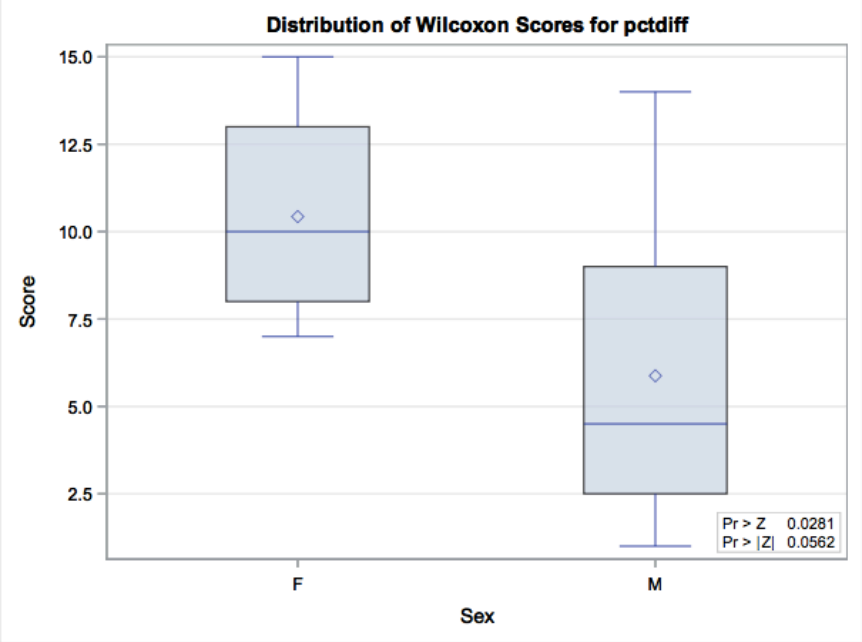


Figure 5. GE by Sex

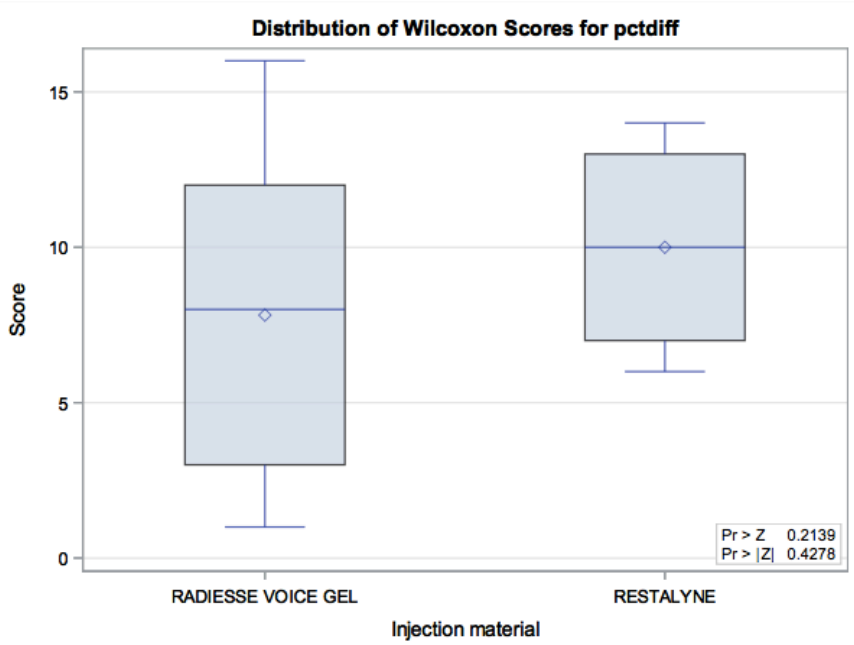


Figure 6. GE by Injection Material

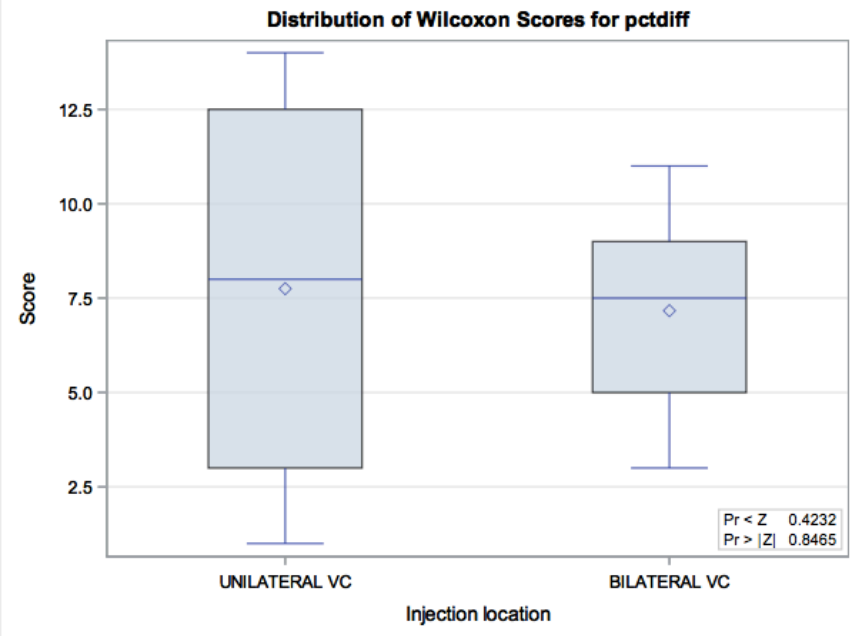


Figure 7. GE by Site of Injection

4. DISCUSSION

Although pediatric voice disorders are becoming more common, there is still a lack of information available regarding their evaluation and treatment (Theis, 2010). Children who undergo airway reconstruction are often left with dysphonic voices and as a result are negatively impacted in several aspects of their well-being. Research has been conducted in the previous years to study voice outcomes post-airway reconstruction; however, there is little in the literature that looks into vocal function following injection laryngoplasty. Upon initial assessment following laryngotracheal reconstruction, a physician will determine whether or not treatment for a voice disorder is warranted. Should this be the case, speech therapy is often the first recommendation. With speech therapy, the child has an opportunity to learn techniques to produce a more functional voice before more invasive procedures are discussed. Following completion of therapy, if a child or his/her parents feel as though further improvement is needed, injection laryngoplasty is introduced.

Research has gone as far as to discuss when injection laryngoplasty is deemed appropriate as well as described the different materials used. Currently, there is no research that analyzes which injections are most effective in restoring vocal function. This study was created in hopes to fill the gaps in pediatric voice disorders research and to allow for more information to assist both medical and therapeutic intervention planning. Focus on GE as an outcome measure appears appropriate given that it portrays vocal function in numerical terms and creates the foundation for creation of an algorithm to be universally used in assessing voice. It is important to note that this equation used for calculating GE is relatively new to research in voice disorders. Although no statistically significant correlations were found between GE and injection material or site of injection, there appears to be potential for a correlation with gender (given a larger sample size).

It was also hypothesized that the parents' perceptual characteristics of their child's voice (functional, physical and emotional scores) would improve post-injection laryngoplasty. Given pre- and post- pVHI scores, this hypothesis was supported. Due to the small sample size available for this study, statistical analysis could not be completed however it appears as though parents are reporting increased vocal function with injection laryngoplasty. This study adds to the pediatric voice disorders and airway reconstruction literature in that it provides a foundation for further studies to follow in assessing vocal function outcomes following airway reconstruction and post-injection laryngoplasty. Research in this area can provide crucial information regarding maximizing functional vocal outcomes in the pediatric population.

Given the nature of a pilot study, limitations are inevitable. One highly influential limitation of this study was the small sample size. Unfortunately, there are very few medical facilities for which pediatric voice disorders are evaluated and treated; Cincinnati Children's Hospital Medical Center is one of these facilities. Although there was a large dataset from which the participants in this study were examined, only 17 participants met the aforementioned research criteria. Additionally, aerodynamic and acoustic measures can be challenging in the pediatric population (Theis, 2010) given noncompliance, lack of participation and inaccurate completion of tasks; therefore, limited data were available for analysis. An assigned numerical value for GE is relatively new to the world of voice. Unfortunately, no comparisons can be made with other studies to facilitate in the validity of this variable.

5. CONCLUSION

In summary, overall, per parents' report, participants (perceptually) did achieve improved vocal function following injection laryngoplasty. No correlations were found with GE and sex, injection material and site of injection, which may be due to the small sample size of this study. Additionally, although there was no significant difference in GE scores pre and post injection laryngoplasty, researchers suspect a larger sample size may result in significant findings. GE does provide a mathematical and quantifiable value to vocal function which could benefit assessment and treatment of voice disorders. As mentioned in Table 2, a positive increase in GE percent change was noted with female participants. A larger amount of male participants (N=5) demonstrated a decrease in GE than females (N=2). Further studies could assess whether these changes are correlated with age both at the time of surgery and injection laryngoplasty and how the impact of puberty may play a roll (i.e. differences in larynx size, vocal fold size/mass, etc.).

This study was formed with the intention for other facilities to also conduct the same research so a formal algorithm can be formed to improve the assessment and treatment of children with airway reconstruction history. However, until this algorithm is formed and for treatment thereafter, the role of speech-language pathologists in treatment of pediatric dysphonia is vital. Speech language pathology, more specifically voice therapy, focuses on the restoration of proper vocal function to allow for adequate phonation. Results from this study could very well be attributed to several factors in this field, including: gender and anatomy (changes in the vocal tract and differences between males and females), sources of phonation and compensatory strategies (supraglottic phonation) and overall vocal fatigue. As demonstrated by the Wilcoxon Rank Sum Test, gender was the closest in correlation with GE. It is important to note that a larger amount of females demonstrated a positive percent change in GE post-injection laryngoplasty. Given puberty

and its effects on laryngeal function, it would be interesting for further studies to assess whether vocal tract differences and age of injection are correlated with this percent change. Additionally, the use of other laryngeal structures for phonation other than the vocal folds (i.e. supraglottic phonation) serves as a sufficient source of phonation for some individuals; however, others experience vocal fatigue and inability to produce a functional voice. Voice therapy teaches exercises that allow for more functional phonation and help reduce the use of compensatory strategies that are often acquired by children with SGS. It is necessary that the input of speech language pathologists be utilized in both the assessment and treatment of children with dysphonia.

APPENDICES

APPENDIX A

Initial Intake History Form.

Patient ID _____ **Today's Date _____/_____/_____**

Birth Date _____/_____/_____

Why was your child referred to the Voice Clinic? Please circle all that apply.

- My child is hoarse
- My child has a quiet voice
- My child's physician referred us to this clinic
- Other: _____

Who referred your child? _____

MEDICAL HISTORY

Was your child full-term? Yes[1] No[2] If no, how many weeks gestation _____ weeks

Does your child have any of the following medical conditions?

Down's Syndrome	Yes[1]	No[2]	Don't know[3]
Eosinophilic Esphagitis (EE)	Yes[1]	No[2]	Don't know[3]
Head Trauma	Yes[1]	No[2]	Don't know[3]
Mental Retardation	Yes[1]	No[2]	Don't know[3]
Cerebral Palsy	Yes[1]	No[2]	Don't know[3]

	Currently			In the past		
Gastrointestinal Reflux	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]
Cancer	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]
Asthma	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]
Swallowing Disorder	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]
Heart Condition	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]

BPD	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]
Other Pulmonary Disease	Yes[1]	No[2]	Don't know[3]	Yes[1]	No[2]	Don't know[3]

Other (Please describe)_____

My child is exposed to cigarette smoke. Daily Occasionally Never

How much of the following beverages does your child drink per day?

Water _____ cups (approximately 8 oz)

Juice _____ cups (approximately 8 oz)

Milk _____ cups (approximately 8 oz)

Soda/Pop _____ cups (approximately 8 oz)

AIRWAY HISTORY

Was your child ever intubated (breathing tube through mouth)? Yes[1] No[2] Don't know[3]

Did your child require multiple intubations? Yes[1] No[2] Don't know[3]

Did your child require a tracheostomy tube? Yes[1] No[2] Don't know[3]

If yes, for how long? _____weeks OR _____ months _____ years

Does your child currently have a tracheostomy tube? Yes[1] No[2]

If yes, does your child use a Passy Muir Valve? Yes[1] No[2]

How many hours is the valve worn during the day? Yes[1] No[2]

Does your child have any of the following symptoms?

Stridor (noise when breathing)	Always[4]	Sometimes[5]	Never[6]
Shortness of breath during exercise	Always[4]	Sometimes[5]	Never[6]
Shortness of breath during speech	Always[4]	Sometimes[5]	Never[6]
Snoring	Always[4]	Sometimes[5]	Never[6]

VOICE HISTORY

Does your child have the following symptoms related to his or her voice?

Frequent hoarseness	Always[4]	Sometimes[5]	Never[6]
The volume of the voice is too soft	Always[4]	Sometimes[5]	Never[6]
The volume of the voice is too loud	Always[4]	Sometimes[5]	Never[6]
The voice sounds breathy or airy	Always[4]	Sometimes[5]	Never[6]
The pitch of the voice is too high	Always[4]	Sometimes[5]	Never[6]
The pitch of the voice is too low	Always[4]	Sometimes[5]	Never[6]
Pain associated with voice use	Always[4]	Sometimes[5]	Never[6]
Increased effort to use the voice	Always[4]	Sometimes[5]	Never[6]
Fatigue during/after voice use	Always[4]	Sometimes[5]	Never[6]

Does your child's voice vary in quality throughout the day (e.g., worse in the morning or worse in the evening)? Yes[1] No[2]

If yes, please describe _____

Do you, your family, or others have a hard time understanding what your child says?

Yes[1] No[2]

If yes, please describe _____

Describe your child's typical amount of talking during the day (circle one).

Excessive

Normal

Minimal

Does your child overuse his/her voice during the day (screaming, shouting, crying, cheering)? Yes[1] No[2]

If yes, please describe _____

Is your child a singer? Yes[1] No[2]

If yes, does your child take singing lessons? Yes[1] No[2]

SWALLOWING:

Has your child ever had difficulty with feeding and/or swallowing?

Yes[1] No[2] Don't know[3]

If yes, has your child ever:

Been NPO (not allowed to eat/drink by mouth)?	Yes[1]	No[2]	Don't know[3]
Required a G Tube for nutrition?	Yes[1]	No[2]	Don't know[3]
Had a restricted diet for the type of liquid or food consumed?	Yes[1]	No[2]	Don't know[3]
Coughed/choked during or after drinking/eating?	Yes[1]	No[2]	Don't know[3]
Had a voice change after drinking/eating?	Yes[1]	No[2]	Don't know[3]
Refused to drink or eat by mouth?	Yes[1]	No[2]	Don't know[3]
Had multiple lung infections due to swallowing difficulty?	Yes[1]	No[2]	Don't know[3]

DEVELOPMENTAL HISTORY:

Were development milestones for:

Motor skills (walking)	Normal	Delayed
Communication (talking)	Normal	Delayed

What is your child's current grade in school? _____

Is your child making appropriate progress in school (academically and socially)?

Yes[1] No[2] Don't know[3]

Has your child ever received speech therapy?	Yes[1]	No[2]	Don't know[3]
Is your child currently receiving speech therapy?	Yes[1]	No[2]	Don't know[3]

If your child has or is currently receiving speech therapy, what has been or is the focus of this therapy?

(You may need to circle more than one area)

In the past	*Currently*
Swallowing	Swallowing

Articulation development	Articulation development
Language development	Language development
Voice quality	Voice quality

Other information that you feel is useful for the voice team:

APPENDIX B

Pediatric Voice Parent Questionnaire and Pediatric Voice Handicap Index.

The following is a list of questions regarding the impact of your child's voice quality on his/her overall communication, development, education, social and family life. Any input or insight you have will be a great help to the CCHMC voice team:

1. Please describe your child's voice:
2. Please describe how your child's voice effects his/her overall ability to communicate within the home:
3. Please describe how your child's voice effects his/her ability to communicate in social situations (play, recess, with friends):
4. Please describe how your child's voice effects his/her ability to communicate in educational settings:
5. Are you satisfied with the support your child receives from his/her school regarding voice and communication?
6. If your child has a tracheotomy tube, are you satisfied with the level of support and care you receive from the schools?
7. Please describe the physical effort (e.g. gets tired, strains) your child experiences when using his/her voice:
8. Do you feel like your child's voice has an impact on his/her general well-being and development? If yes, how?
9. Please describe any concerns your child has about his/her voice (e.g. sometimes embarrassed, sometimes avoids communication, never has a concern):
10. Other comments?

Thank you

Subject Number: _____ Date: _____

I would rate my/my child's talkativeness as the following (circle response)

1	2	3	4	5	6	7
Quiet Listener			Average Talker			Extremely Talkative

To be filled out by Staff:

F= _____
P= _____
E= _____
Total= _____

Talkativeness: _____

Instructions: These are statements that many people have used to describe their voices and the effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

0=Never 1=Almost Never 2=Sometimes 3=Almost always 4=Always

Part I - F

1)	My child's voice makes it difficult for people to hear him/her	0 1 2 3 4
2)	People have difficulty understanding my child in a noisy room	0 1 2 3 4
3)	At home, we have difficulty hearing my child when he/she calls through the house.	0 1 2 3 4
4)	My child tends to avoid communicating because of his/her voice.	0 1 2 3 4
5)	My child speaks with friends, neighbors, or relatives less often because of his/her voice.	0 1 2 3 4
6)	People ask my child to repeat him/herself when speaking face-to-face.	0 1 2 3 4
7)	My child's voice difficulties restrict personal, educational and social activities.	0 1 2 3 4

Part II – P

1)	My child runs out of air when talking	0 1 2 3 4
2)	The sound of my child's voice changes throughout the day	0 1 2 3 4
3)	People ask, 'What's wrong with your child's voice?"	0 1 2 3 4
4)	My child's voice sounds dry, raspy, and/or hoarse	0 1 2 3 4
5)	The quality of my child's voice is unpredictable	0 1 2 3 4
6)	My child uses a great deal of effort to speak (e.g., straining)	0 1 2 3 4
7)	My child's voice is worse in the evening	0 1 2 3 4

0=Never 1=Almost Never 2=Sometimes 3=Almost always 4=Always

8)	My child's voice "gives out" when speaking	0 1 2 3 4
9)	My child has to yell in order for others to hear him/her.	0 1 2 3 4

Part III – E

1)	My child appears tense when talking to others because of his or her voice.	0 1 2 3 4
2)	People seem irritated with my child's voice	0 1 2 3 4
3)	I find other people don't understand my child's voice problem	0 1 2 3 4
4)	My child is frustrated with his/her voice problem	0 1 2 3 4
5)	My child is less outgoing because of his/her voice problem	0 1 2 3 4
6)	My child is annoyed when people ask him/her to repeat	0 1 2 3 4
7)	My child is embarrassed when people ask him/her to repeat	0 1 2 3 4

Overall Severity Rating of Voice
(Please place "X" mark anywhere along this line to indicate the severity of your child's voice; the verbal descriptions serve as a guide)

_____

Normal Severe

APPENDIX C

Stroboscopy Evaluation Form.

Type Rigid Flexible High speed
Lesion UL VC Paralysis BL VC paralysis Scarring of VC Large Glottic Gap Vertical level of VC asymmetric
Interartytenoid space Edema No edema
Appearance of Vocal Folds Edema Erythema n/a
Glottic closure Cannot rate Complete Incomplete Irregular Hourglass Spindle Ant gap Post gap n/a
Laryngeal closure Cannot rate Complete Partial None
Supraglottic compression Cannot rate None Lateral Anterior-post Mixed n/a

Supraglottic degree Cannot rate None Mild Moderate Severe n/a
Vertical level Cannot rate Level Off level n/a
Lt Vocal Fold Edge Cannot rate Straight Irregular Lesion Scarring n/a
Rt Vocal Fold Edge Cannot rate Straight Irregular Lesion Scarring n/a
Lt Artytenoid mobility Cannot rate Normal Restricted Fixed n/a
Rt Artytenoid mobility Cannot rate Normal Restricted Fixed n/a
Vibration source

Cannot rate	True VF	Ventricular folds	Mixed	Ary/Epi/Pet	n/a	
Any simulated slow motion vibratory characteristics visible?						
		Yes	No			
Could the parameters be rated?						
		Yes	No			
Lt Mucosal Wave						
Cannot rate	Normal	Mild	Moderate	Severe	Present/NR	n/a
Rt Mucosal Wave						
Cannot rate	Normal	Mild	Moderate	Severe	Present/NR	n/a
Lt Amplitude						
Cannot rate	Normal	Mild	Moderate	Severe	n/a	
Rt Amplitude						
Cannot rate	Normal	Mild	Moderate	Severe	n/a	
Phase symmetry						
Cannot rate	Symmetric	Mild assym	Mod assym	Sev assym	n/a	

Phase closure Cannot rate Normal/equal Mild open Mod open Sev open Mild closed Mod closed Sev closed n/a
Lt Non-Vibratory segment Cannot rate None 20-40% 40-60% 60-80% >80% n/a
Rt Non-Vibratory segment Cannot rate None 20-40% 40-60% 60-80% >80% n/a

APPENDIX D

Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)

Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)

Name:_____ **Date:**_____

The following parameters of voice quality will be rated upon completion of the following tasks:
1. Sustained vowels, /a/ and /i/ for 3-5 seconds duration each.
2. Sentence production:
   a. The blue spot is on the key again.
   b. How hard did he hit him?
   c. We were away a year ago.
   d. We eat eggs every Easter.
   e. My mama makes lemon muffins.
   f. Peter will keep at the peak.
3. Spontaneous speech in response to: "Tell me about your voice problem." or "Tell me how your voice is functioning."

Legend: C = Consistent I = Intermittent
MI = Mildly Deviant
MO =Moderately Deviant
SE = Severely Deviant

					SCORE
Overall Severity	_____ MI MO SE		C	I	/100
Roughness	_____ MI MO SE		C	I	/100
Breathiness	_____ MI MO SE		C	I	/100
Strain	_____ MI MO SE		C	I	/100
Pitch	(Indicate the nature of the abnormality): _____ _____ MI MO SE		C	I	/100
Loudness	(Indicate the nature of the abnormality): _____ _____ MI MO SE		C	I	/100
_____	_____ MI MO SE		C	I	/100
_____	_____ MI MO SE		C	I	/100

COMMENTS ABOUT RESONANCE: NORMAL OTHER (Provide description):_____
_____

ADDITIONAL FEATURES (for example, diplophonia, fry, falsetto, asthenia, aphonia, pitch instability, tremor, wet/gurgly, or other relevant terms):

Clinician:_____

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