ABSTRACT

Ashley Sanders. Subjective and Objective Measures of Dysphonia Pre-Thyroidectomy (Under the direction of Kathleen T. Cox, Ph.D.). Department of Communication Sciences and Disorders, May 2013.

There has been a link established between post-surgical dysphonia and thyroidectomy procedures and various studies identify that a large percentage of these patients have dysphonia after surgery. Most of these incidences of dysphonia resolve six months after the procedure, but there are reported cases of dysphonia that persists longer than six months and which are unrelated to any potential complications that could cause dysphonia. There may be a percentage of patients who present with dysphonia before surgery, which would indicate that the resilient dysphonia is related not to the surgery, but rather to their baseline vocal quality. The purpose of this study is to determine if there is a percentage of patients who are scheduled for thyroidectomies that have dysphonia and if there are any screening methods (subjective or objective) that surgeons may use to refer these potential cases of dysphonia for a full voice evaluation before the surgery. Eleven patients were included in this study. Each patient was a candidate for thyroidectomy and elected to have the procedure performed by Dr. Walter E. Pofahl, the cooperative surgeon for this study. For each patient, the following protocol was administered: background questions targeting factors that may indicate an increased risk of dysphonia, Voice Handicap Index, Consensus Auditory-Perceptual Evaluation of Voice, and Voice Evaluation Suite. This protocol was designed to measure present dysphonia subjectively, by gaining the patients' and the investigator's opinion of dysphonia, and objectively, through acoustic measurements. Graphical comparisons of the data revealed several "risk factors" surgeons could keep in mind and the CAPE-V may be a useful tool for pre-surgical referral.

SUBJECTIVE AND OBJECTIVE SCREENING MEASURES OF DYSPHONIA PRE-THYROIDECTOMY

A Thesis

Presented to

the Faculty of the Department of Communication Sciences and Disorders

East Carolina University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Communication Sciences and Disorders

By

Ashley K. Sanders

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DEDICATION

To my mother and father:

Thank you for the enormous amount of encouragement and the steadfast faith in my abilities. You two have provided for me a chance to follow my dreams, and I could not be more thankful for the two of you.

Love,

Ashley

To Matthew:

Thank you for the patience, the encouragement, and the miles. I couldn't have done it without you.

Always,

Ashley

ACKNOWLEDGEMENTS

I would like to thank Dr. Cox for her never-ending support and for sharing her knowledge with me throughout this project.

I would like to thank the members of my committee, Dr. Walter Pofahl, Dr. Suzanne Hudson and Dr. Jamie Perry, for their guidance and help with this project.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Introduction

Thyroidectomy is a surgical procedure utilized to treat a multitude of thyroid diseases such as goiter, cancers of the thyroid, and hyperthyroidism (Sosa et al., 1998). Thyroid cancer is the most endocrine-related form of cancer and makes up 1% of all cancers (Hayat et al., 2007). Thyroid diseases, as a whole, affect 3-5% of the population (Tunbridge et al., 1977) and there are around 80,000 thyroidectomies each year (Harness & Thompson, 1986).

There have been many studies on the relationship between dysphonia and thyroidectomies. Dysphonia is an impairment of the voice in which there may be changes in pitch, loudness, or quality of the voice (Sapienza & Hoffman Ruddy, 2009). It typically presents post-thyroidectomy as a roughness or change in pitch and the voice may feel weaker and fatigue more quickly than before surgery (Kark, Kissin, Auerback, & Meikle, 1984; Pagedar & Freeman, 2009). There tends to be, however, a wide range of symptoms which can greatly vary from patient to patient (Lombardi et al., 2009). After surgery, if the patient complains of having vocal symptoms, he or she will be followed by the surgeon and then referred to a speech-language pathologist (SLP) for treatment if the symptoms do not improve. Evaluation by an otolaryngologist (ENT) will also typically occur if the primary surgeon was not an ENT.

Dysphonia is an important consideration for many patients because it can have a profound impact on their daily lives, their work and/or leisure activities, especially if the patient is a professional or recreational voice user. Current literature has documented the prevalence of dysphonia in relation to thyroidectomy. Henry et al. (2008) discuss previous studies which have found patients report dysphonia within the first 4 weeks after surgery approximately 25-90% of the time. Of this group, 11-15% report dysphonia after 6 months. Other studies reported similar

results (McIvor, Flint, Gillibrand, Morton 2000; Meek, Carding, Howard, & Lennard, 2008; Lombardi et al., 2009; Stojadinovic et al., 2002; Solomon, Helou, & Stojadinovic, 2009).

Causes of Post-Thyroidectomy Dysphonia

The most concerning etiology of postsurgical dysphonia is damage to the recurrent laryngeal nerve (RLN) (Akyildiz, Ogut, Akyildiz, & Engin, 2008; Crumley, 1990; Meek et al., 2007; McIvor et al., 2000; Musholt, Musholt, Garm, Napiontek, & Keilmann, 2006; Lombardi et al., 2006; Satterfield, 2002). This can result in vocal cord paralysis and occurs in 0.3-13% of cases (McIvor et al., 2000). The RLN is an important consideration for surgeons, however, and many surgical techniques have been implemented to prevent damage. In some cases, it has been reported the proximity to or the compression of the RLN and postoperative hematomas near the nerve may affect voice qualities (Musholt et al., 2006). There is also potential for damage to the external branch of the superior laryngeal nerve (SLN) in 3-58% of cases. This tends to have nonspecific side effects but is especially detrimental to those who use their voice professionally (Musholt et al., 2006; Kark et al., 1984; Pagedar & Freeman, 2009; Page, Zaatar, Biet, & Strunski, 2007). Damage to the external branch of the SLN can be difficult to determine and the reported number of incidences in the literature were established using different methods of identification. There are cases of postsurgical dysphonia which present without any damage to the laryngeal nerves; most of the literature on post-thyroidectomy dysphonia provides examples of dysphonia without damage to these nerves (Akyildiz et al., 2008; Lombardi et al., 2009; Stojadnovic et al. 2002).

There are many other potential causes of postsurgical dysphonia: complications and bruising from endotracheal intubation, division of the prethyroid strap muscle, edema of the laryngeal complex, trauma resulting from the surgery itself, localized neck pain, dysfunction of

the cricothyroid muscle, psychogenic dysfunctions, endocrine changes, and many more (Meek et al., 2007; Lombardi et al., 2009; Riddell, 1956; Sataloff, 1997; Holt, McMurry, & Joseph, 1977; Mathieson, 2001). Patients sometimes continue to report long-term dysphonia when there is no evidence of any complications from the surgery (Stojadinovic et al, 2002).

The most current research focuses primarily on levels of postsurgical dysphonia or on the impacts of different measureable surgical complications on the voice (Akyildiz et al., 2008; Awan, Helou, Stojadinovic, & Solomon, 2011; Henry et al., 2008; Henry et al., 2010; Lombardi et al., 2006, Lombardi et al., 2009; McIvor et al., 2000; Meek et al., 2007; Satterfield, 2002). It should be noted, however, findings regarding some of these are varied. In one study by Henry et al. (2008), no significant changes were found in subjective reports and objective measurements of voice quality between patients who did have the muscle divided and those who did not. Many professionals still cite this as a potential cause of postsurgical dysphonia (Akyildiz et al. 2008; Lombardi et al. 2006; Meek et al. 2007, Satterfield, 2002; McIvor et al., 2000).

Levels of Pre-surgical Dysphonia

Since dysphonia can present in patients who do not have any objectively measureable postsurgical complications, it is important to establish pre-surgical levels of dysphonia in patients who are undergoing this procedure. Most literature discussing the relationship between thyroidectomies and dysphonia either excludes patients who have any voice conditions before surgery or is vague in their descriptions of the voice disorders. They also vary in assessments, whether objective or subjective, and whether or not they used a multidimensional measurement (Lombardi et al., 2006; Akyildiz et al., 2008; Page et al., 2007; Meek et al., 2007; McIvor et al., 2000).

Meek et al. (2007) cited implications about voice quality cannot be made concerning solely postsurgical outcomes, though their project only focused on these postsurgical changes. They also recognized the importance of a multidimensional assessment of voice conditions before and after surgery. Using a variety of methods to assess the vocal condition of patients allows for a more complete picture of the characteristics of a patient's voice. They concluded thyroidectomies do not have a detrimental effect of voice quality and six of the patients in this study even showed improvement in their vocal characteristics. The methods they listed and used in their study, however, were subjective measurements. They utilized a Vocal Performance Questionnaire (a patient-rated assessment of the impact of their voice changes on their daily life), the GRBAS auditory-perceptual scale, and videolaryngostroboscopy. The current study will utilize both objective and subjective measurements before the thyroidectomy procedure to determine if the patient has existing levels of dysphonia.

Page et al. (2007) performed a patient study of 395 patients which utilized pre-surgical data. Their study focused on subjectively reported dysphonia after the surgery and how it related to recovery time and persistence. The patients and their families were presented with a questionnaire which asked for a perceptual assessment of the voice, whether it was normal or classified based on hoarseness, low in pitch, or prone to fatigue. The patient was also examined via indirect laryngoscopy. After the assessment, the voice was classified as being either improved, the same, or worsened using the same questionnaire and laryngeal endoscopy. Before surgery, 20% of patients reported voice abnormalities and 91% of these cases resolved after surgery. This suggests a link between the pre-operative dysphonia to thyroid disease. How are we to account for the other 9%? Page et al. (2007) point out a limitation of their study as the lack of objective data, which would provide a clearer picture on the presence of pre-surgical

dysphonia. This study will employ objective acoustic analysis as one of its measures of dysphonia pre-thyroidectomy.

In a study by Akyildiz et al. (2008), the voice of patients was examined before and after surgery as well. Laryngostroboscopy was used to visualize the vocal cords, the voices were recorded and the Multi-Dimensional Voice Program (Kay Pentax) was used for assessment. They assessed the voice one week after surgery, but their objective analysis yielded results which showed no significant voice deterioration and the multivariate assessment showed no effect of the surgery on voice parameters. They did find preoperative voice abnormalities in female patients. This study used objective measurements in their data collection but did not assess the patients' or clinicians' opinions on the voices. The current study will utilize subjective as well as objective data measurements to include the patient and clinician assessments of the pre-surgical voice.

McIvor et al. (2000) had a study which also examined patients before and after thyroidectomy surgery. Pre- and postoperatively, they used Visipitch (KayPentax, Lincoln Park, NJ) to measure levels of dysphonia. They also used a subjective questionnaire after surgery to determine the patient's view on their voice. One-third of their patients presented with dysphonia before surgery and 22% reported voice abnormalities after. According to their findings, patient-reported dysphonia matched the dysphonia recorded with Visipitch with only 64% accuracy. They also used a subjective questionnaire after surgery to determine the patient's perception of their voice. The current study will build off of the study by McIvor et al. (2000) by adding subjective measures to determine patient and clinician opinion on pre-existing vocal abnormalities.

Van Lierde et al.'s (2009) study looked at vocal characteristics before and after surgery. For this study, they used subjective measures (GRBAS scale and laryengostroboscopy) and objective measures (maximum phonation time, the Vocal Range Profile, the Multi-Dimensional Voice Program, and the Dysphonia Severity Index) to determine levels of dysphonia. No significant differences were found between the subjective strobostrobic evaluation, the psychosocial impact, and the objective voice characteristics. There was a total recovery of voice and visually perceived improvements in the larynx by 3 months after the procedure. The current study will be similar to this, but will not focus on the Dysphonia Severity Index. Instead, the current study will look at all measures equally in determining the dysphonic characteristic of patients' voice before thyroidectomy.

Critical pre-existing conditions There are many premorbid conditions which can affect the voice but are often disregarded in the context of dysphonia before a thyroidectomy procedure. Henry et al. (2010) performed a study which looked at different conditions that affected voice quality using the Dysphonia Severity Index (DSI). They found smoking had an effect on the DSI of patients. Their studies showed patients who had smoked had worse DSI scores and this remained true 6 months postoperatively. Their study also illustrated scores on the DSI tended to be predictive of voice abnormalities after surgery for the first 6 months. Patients who had smoked could potentially have a more resilient voice abnormality because they showed a worse score initially and a decreased score after surgery. Smoking and other forms of poor vocal hygiene can contribute to dysphonia.

There are also preexisting physiologic determinates of vocal quality. Disorders of the thyroid can have an effect on voice quality before surgery. One study (Gupta, Bhatia, Agarwal, Mehrotra, & Mishr, 1977) reports an incidence of 77% of patients who have hypothyroidism also

have resulting vocal impairments such as hoarseness, lowered pitch, vocal fatigue, and limited range (Kark et al., 1984). In a study by Birkent, Karacalioglu, Merati, Akcam, & Gerek (2008), thyroid hormone replacement post-thyroidectomy which was used to treat the hypothryoidsim showed an improvement in fundamental frequency of women, though there was no measureable improvement in other voice parameters or in male patients. Goiter can also have an effect on the voice as well. Watt-Boolsen, Blichert-Toft, & Boberg (1979) found a decrease of vocal impairments in patients with non-toxic goiter after thyroidectomy due to improved mobility of the laryngeal structure and a reduction of compression on the laryngeal nerves.

Variables which affect dysphonia levels. There have also been studies which illustrate the effect of different variables on dysphonia levels. In Henry et al.'s (2010) DSI study, it was found that DSI tends to worsen as age increases. They also found women typically had better DSI scores preoperatively, but there was no significant change after surgery for either sex.

Tools and Rationale

This study will examine the levels of dysphonia present in individuals scheduled to undergo a thyroidectomy procedure. Objective and subjective measures will be utilized, providing an illustration of the acoustic characteristics of the voice, auditory-perceptual ratings of the examiners, and the patient's perception of their voice.

In the current literature, most studies chose to use the Multi-Dimensional Voice Program (MDVP) to assess acoustic characteristic of voice. The MDVP bases its measurements of the acoustic characteristics of the voice on the patient's production of the sustained vowel /a/. According to Awan et al. (2010), the sustained vowel measurement, though illustrative of many vocal characteristics, is not entirely representative of the voice a patient uses the majority of the time. The typical speaking voice measurements will include more attributes of the voice which

are typically used—rapid voice onset, rapid termination, and intonational patterns—and these are important for the determination of the existence of dysphonia (Awan et al., 2010). They thusly propose assessment of the speaking voice should include measurements of both sustained vowels and conversational speech. For this study, acoustic measurements will be made using the Voice Evaluation Suite (KayPentax, Lincoln Park, NJ), which takes measurements of both sustained vowels and conversational speech.

There are two tools which are typically used to determine clinician auditory-perception of voice qualities—the GRBAS scale and the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V). The GRBAS scale measures grade (G), roughness (R), breathiness (B), asthenia (A), and strain (S) and relies on a 4-point Likert scale. There are, however, no protocols or guidelines for administration and evaluation, among other issues (Zraick et al., 2011; Gorodetsky et al., 1992; Kreiman et al., 1996). Because of this, the GRBAS scale may not be the best tool for clinical auditory-perceptual evaluations of voice. The CAPE-V was developed by a group of professionals within American Speech-Language and Hearing Association. Instead of a Likert scale, it utilizes a Visual Analog Scale (VAS) which provides a scale of 0-100, based on the millimeter measurement. It measures overall severity, roughness, breathiness, strain, pitch, loudness, resonance and also includes space for the clinician to add in other vocal characteristics, such as vocal fry, based on the individual patient's presentation. In a study by Zriack et al. (2011), the CAPE-V was found to have a higher inter- and intra-rater reliability and suggests it may be more sensitive to smaller differences in the voice. Another study showed there is no significant difference between experienced and inexperienced intra-rater reliability (Helou et al., 2010). There are also moderately strong correlations between the clinical application and the

laboratory setting (Solomon et al., 2009). Because of these results, the CAPE-V will be used in the current study to determine auditory-perceptual ratings of voice.

The Voice Handicap Index (VHI) is a questionnaire used to determine a patient's view of their voice. It provides a functional, physical, and emotional measurement of the patient's impression of their voice. In a study by Stojadinovic et al. (2007), the VHI was highly predictive of vocal effects after thyroidectomies. Patients reported significant vocal changes 1-2 weeks after the surgery and the VHI correlated with predictive values 88% of the time for positive changes and 97% of the time for negative changes.

Using these methods, the present study aims to answer the following research questions:

1. What is the incidence of pre-thyroidectomy dysphonia?
2. Does the presence of dysphonia, as determined by perceptual assessment, relate to the patient's perception of voice disorder as measured by the VHI?
3. Which subjective measures are most indicative of pre-surgical levels of dysphonia?
4. Which acoustic measures demonstrate abnormal values in patients with pre-thyroidectomy dysphonia?

Methodology

This section will describe participant selection and participation, as well as the methods used to collect and analyze acoustic data on the participants' voices.

Participants

Eleven participants were enrolled in this study, ages 33-70. Each of these participants was previously diagnosed with the need for a thyroidectomy and was referred to Dr. Walter E Pofahl, ECU Department of Surgery, for surgical consultation. Every participant in this study was a surgical candidate for a thyroidectomy and elected to have the surgery with Dr. Pofahl as the surgeon. Eligibility requirements for participation were the following: participants had to be at least 18 years old, have no history of previous diagnosis of a voice disorder, no neurological or pulmonary disorders, and were not pregnant. Children and prisoners were also not allowed to participate.

Dr. Pofahl met with the patients in his clinic and determined their eligibility for a thyroidectomy. Once identified, the medical assistants in Dr. Pofahl's office or Donna Eggers (doctoral student graduate assistant) informed the patients of the opportunity to serve as a study participant. Patients were provided with a packet of information about the study including a blank informed consent form. The examiner was in the clinic at the time the patient was identified by the medical team and could speak directly to the patient about the opportunity to participate in the study. Potential patients were educated on the principles and procedures of the study and asked for their willingness to participate. If the patients agreed to participate, they were scheduled for acoustic analysis the same day.

The assessment took place in the Department of Surgery Clinic. The analysis was performed by the doctoral student (Eggers). Before the analysis, the investigator followed

informed consent procedures and had the participant sign an informed consent document. The investigators then performed an acoustic assessment as well as a perceptual assessment, which are all described below.

Procedures

Once the participant agreed to participation, he or she was escorted to the testing area, and the study was re-explained and the participant was shown the equipment which would be used. The informed consent process was completed: the study was explained verbally, the informed consent form was presented and explained thoroughly, the participant was offered time to read the informed consent form completely, and the participant was asked if any questions were present. The participant was given a copy of the informed consent form to take home. The testing procedures then began.

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

The CAPE-V is a subjective auditory-perceptual tool used for voice assessment by SLPs (see Appendix A). The protocol required participants to perform several vocal tasks. The investigators then recorded perceptions of severity ratings on a visual analog scale of 100mm in length—the areas which are rated by the CAPE-V include overall severity, roughness, breathiness, strain, pitch, loudness, and resonance. In addition, there are spaces for the investigators to note other vocal qualities, such as tremor or diplophonia.

The investigator followed the recommended protocol for the CAPE-V, which is as follows:

1) The participant was asked to sustain the vowel /a/ for 3-5 seconds,

2) The participant was asked to say the following sentences:

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 park.

3) The participant was asked a question ("Tell me about your voice problem" or "Tell me how your voice is functioning") to gain a spontaneous sample of speech.

The Visual Analog Scale is a 100mm line where 0mm is "normal" and 100mm is "severe." There are guiding labels under the line designating level of severity—"MI" for mild, "MO" for moderate, and "SE" for severe. During the protocol, the investigator marked the line in correspondence to her judgment of the different voice parameters. After all tasks were completed, the investigator measured the distance to the mark from the left end of the line in millimeters and wrote the measurement in the score column. The investigator also made note of and marked "C" for consistent or "I" for inconsistent for each voice parameter. .

Voice Handicap Index (VHI)

The VHI is a tool used by SLPs to gain a subjective measurement of the patient's perception of their vocal handicap (see Appendix B). The VHI is a series of 30 statements which are commonly reported complaints of people with voice issues. These statements are given to the participant to read and judge along a Likert scale of "Never", "Almost Never", "Sometimes", "Almost Always", and "Always." The following are a few examples of such statements and the complete VHI can be found in Appendix B:

1) I run out of air when I talk.

2) I'm tense when talking to others because of my voice.

3) My voice makes it difficult for people to hear me.

Each of the answer choices available to the participant corresponds to a number ranging from 0 for "Never" to 4 for "Always." The investigator scored the VHI after the administration, giving each statement a number which corresponds to the participants' answers. The VHI measures three domains of voice perception—the physical, emotional, and functional effect of the voice on daily life. The numbers are then added to determine a "Grand Total" which can be from 0-120. A score of 0-30 is low, with most likely a minimal impact of voice on the participant's life. 31-60 is a moderate score and impact and 61-120 is a severe score and impact.

Acoustic analysis via Voice Evaluation Suite (VES)

The VES (Vocal Innovations, Pittsburg, PA) is a tool which measures the acoustic qualities of the participants' voice. The program provides a protocol which was followed by the investigator. The participants are asked to vocalize in a variety of different tasks. A head-mounted microphone was used in this procedure and placed 3cm away from the participants' mouth. Each participant was trained before each of the tasks. The following are the tasks asked by each participant to complete:

1) Sustaining the vowel /a/ for 4 seconds.

2) Sustaining the vowel /a/ for as long as possible.

3) Sustaining the vowel /a/ at a high pitch.

4) Sustaining the vowel /a/ at a low pitch.

5) Sustaining a vowel of the participant's choice at a loud volume.

6) Sustaining a vowel of the participant's choice at a soft volume.

7) Rapid repetition of /a/ for four seconds.

8) Gliding /a/ from a low pitch to a high pitch.

9) Connected speech task (The Rainbow Passage was used in this study).

An example of the VES data sheet is found in Appendix C.

For each task described above, dependent variables were recorded. Table 1 illustrates the dependent variables obtained from each assessment method.

Table 1
Dependent Variables Measured in VES Protocol

CAPE-V	VHI	VES	
		Task	Measurement
Overall severity Roughness Breathiness Strain Pitch Loudness Resonance Additional features (diplophonia, fry, falsetto, asthenia, etc.)	Physical Emotional Functional Score: 0-30 minimal handicap 31-60 moderate handicap 61-120 severe handicap	Sustain vowel Continuous speech Maximum performance	Average fundamental frequency (F0), jitter, average sound pressure level (SPL), shimmer, single to noise ratio, signal type Average F0, minimum F0, maximum F0, average SPL, minimum SPL, maximum SPL Phonation time, /s/ time, /z/ time, s/z ratio, minimum SPL, maximum SPL, SPL range, minimum F0, maximum F0, F0 range, diadochokinetic (DDK) range, DDK weakness, DDK inconsistency

Statistical Analysis

Graphical comparisons were made of the properties of the patients who were referred and not referred and the relationship between objective measures and subjective patient measures. The data obtained was compared to normal values to provide a description of the prevalence of dysphonia in this particular population. Variables such as age, gender, thyroid disease, smoking status, and the amount of phonotruamatic behaviors of the individual patients were included in the data and analysis. The goal of this data collection was to develop information to provide surgeons with knowledge which will assist them in recognizing patients with potential dysphonia or vocal issues and who may benefit from a voice screening prior to the thyroidectomy.

Results

Participants

There were 11 patients who agreed to participate in this study. 10 of these participants were female and one was male. Ages ranged from 33-70 years. Four patients were receiving a thyroidectomy for thyroid nodules, four for goiter, one for a thyroid cyst, and two patients who had previously had partial thyroidectomy and now presented with a thyroid cyst. Tables 2-6 provide the breakdown of the rate of occurrence for each of the different variables which may have an effect on rates of dysphonia.

Table 2
Patient Report of Voice Quality

	Frequency	Percent
None	5	45.5
Fatigue	1	9.1
Hoarseness	2	18.2
Both	3	27.3
Total	11	100

Table 3
Patient History of Smoking

	Frequency	Percent
None	4	36.4
Yes, not currently	5	45.5
Yes, currently	2	18.2
Total	11	100

Table 4
Patient History of Reflux

	Frequency	Percent
None	6	54.4
Yes, treating	2	18.2
Yes, no treating	3	27.3
Total	11	100

Table 5
Patient History of Dysphagia

	Frequency	Percent
None	8	72.7
Intermittent	1	91.1
Yes	2	18.2
Total	11	100

Table 6
Patient Report of Voice Use

	Frequency	Percent
None	4	36.4
Hobby use	3	27.3
Job use	4	36.4
Total	11	100

Background Variables

This study aimed to parse out subjective indications of dysphonia which surgeons can use to screen patients before scheduling thyroidectomies. Several of the demographic variables are loosely related to the referrals. When examining patient age, the range of referral is 47-64. Figure one illustrates the referral patterns based on patient age.

Another potential indicator is patient diagnosis. All of the patients referred in this study were diagnosed with goiter. Of all of the patients with goiter in this study, 75% (3/4) were referred for suspected dysphonia. None of the patients with nodules, cysts, or who had previously undergone a partial thyroidectomy were referred for their subjective vocal quality. Figure two illustrates referral patterns based on patient diagnosis.

All patients who were referred reported either hoarseness or both hoarseness and fatigue. Patients with no reported issues with their voice or those with only fatigue avoided referral. Figure three illustrates referral based on patient report of their voice quality.

The final demographic variable which could be used to indicate potential dysphonia was patient report of voice use. All of the patients referred either used their voice extensively for their employment or for hobbies. The patients who reported no heavy requirements for their voice were not referred for a further voice evaluation by an SLP. Figure four illustrates referral based on patient report of their voice use.

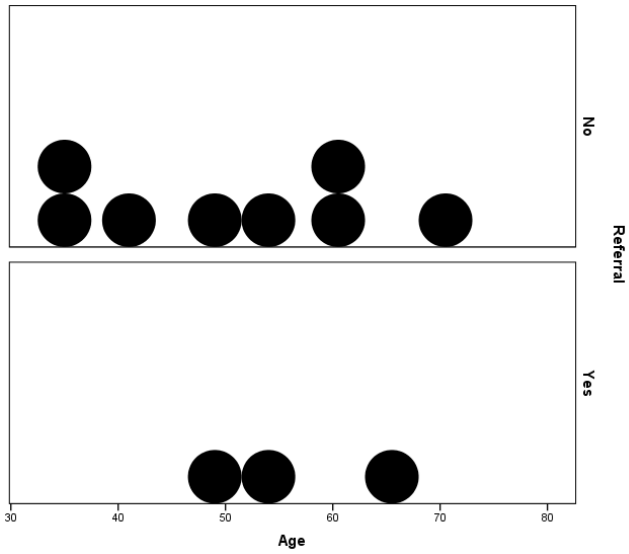

Figure 1. Referral based on patient age.

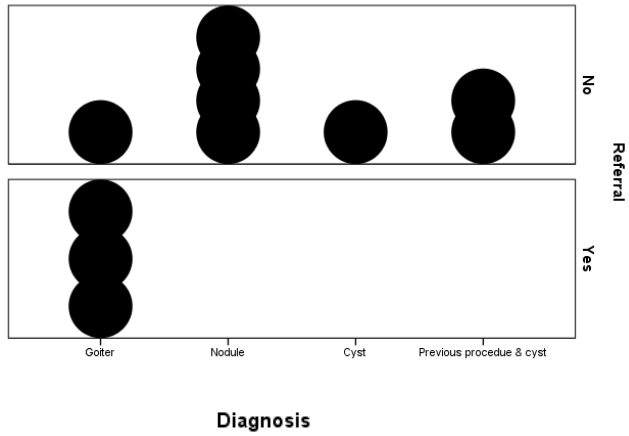

Figure 2. Referral based on diagnosis.

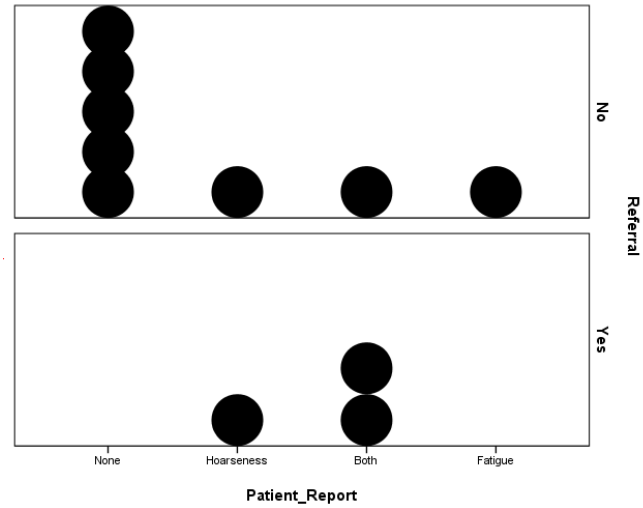

Figure 3. Referral based on patient report of voice quality.

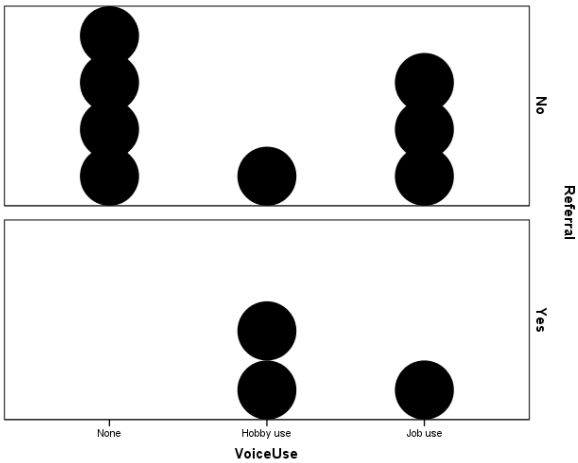

Figure 4. Referral based on patient report of voice use and/or requirements.

VHI Scores

The subjective measures provided by the VHI and CAPE-V also provided indications to consider for referral. Only one of the VHI measures designated patterns for referral—the physical impact of the voice on the patient. For those referred, they scored between nine and 12 for this particular measure. It should be noted, however, two other patients who were not referred scored higher on this measure. A score of nine or higher for physical impact may be

indicative of a dysphonia which should be evaluated before a thyroidectomy. Figure 5 illustrates occurrence of VHI physical referrals.

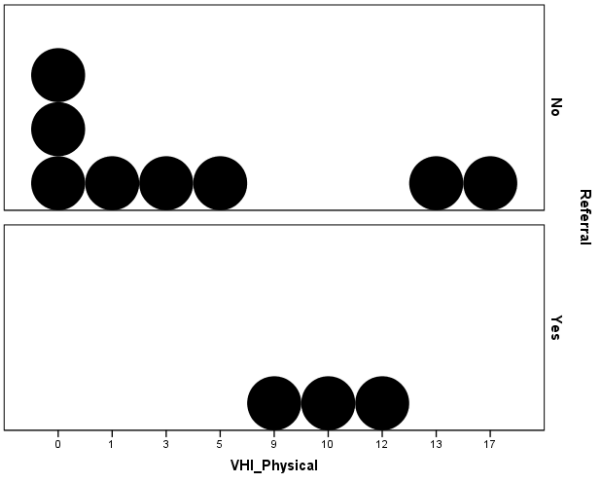

Figure 5. Referrals based on VHI Physical scores.

CAPE-V Scores

The CAPE-V provided several measures to consider. For all CAPE-V measures discussed, only two of the three referrals scored in a significant manner. One patient who was referred scored only very mildly on all CAPE-V measures according to the investigator and was referred due to suspected laryngopharyngeal reflux, though she reported no reflux issues. All CAPE-V measures discussed as relevant will be based on the scores for the other two patients who were referred for further voice evaluation by SLPs. Important measures specified by the CAPE-V during this investigation are Overall Severity, Roughness, Breathiness, and Strain. The following is a list of cut-off scores for each of these important measures: Overall Severity, 45; Roughness, 30; Breathiness, 40; and Strain, 30. Each of these cutoff scores is the lowest score which received a referral. The important component to consider when examining the referral scores for these CAPE-V measures is that patients who were not referred for further evaluation

did not receive a higher CAPE-V than the cut-off scores. Figures six-nine illustrate incidence of the CAPE-V referrals.

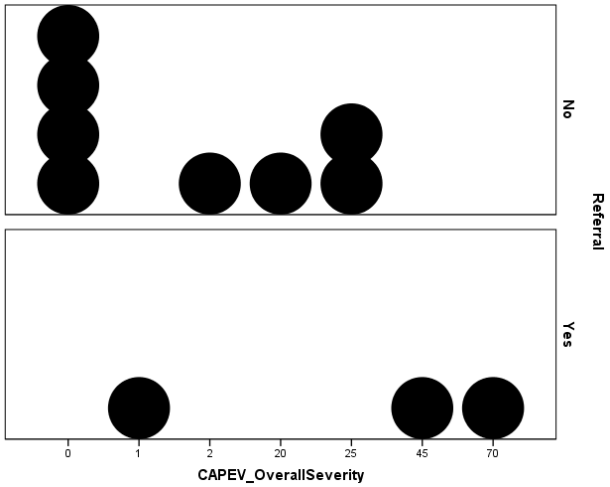

Figure 6. Referral based on CAPE-V Overall Severity scores.

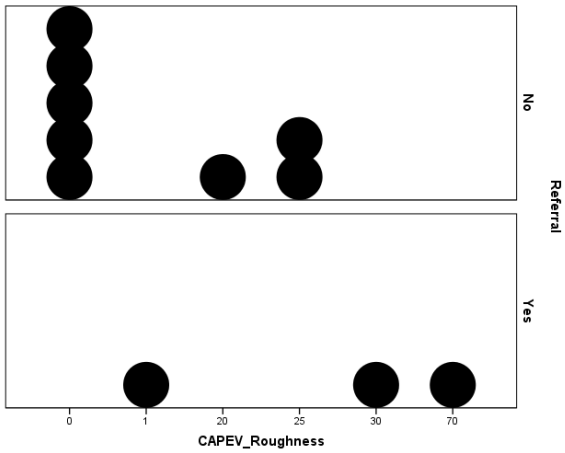

Figure 7. Referral based on CAPE-V Roughness scores.

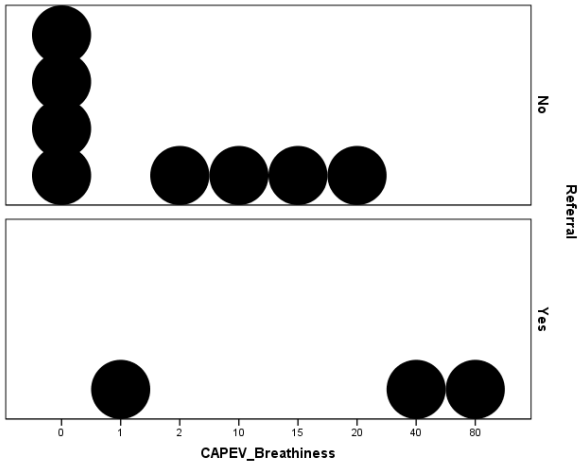

Figure 8. Referral based on CAPE-V Breathiness scores.

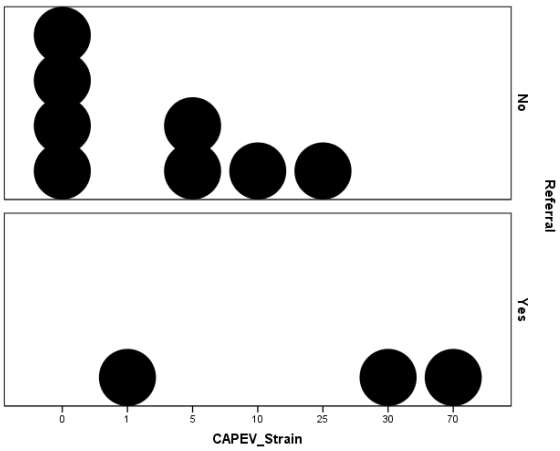

Figure 9. Referral based on CAPE-V Strain scores.

Acoustic Variables

The acoustic data was unremarkable when comparing specific scores of each of the patients between the referred and non-referred groups. When looking at the averages of each measure, there was a difference between the groups for shimmer, average fundamental

frequencies in connected speech, phonation time, s-time, z-time, minimum fundamental frequency, and maximum fundamental frequency. Those referred had, on average, higher shimmer values, lower fundamental frequencies in connected speech, shorter phonation times, shorter s- and z-times, lower minimum fundamental frequencies during maximum performance, and lower maximum fundamental frequency during maximum performance. It is also important to note that for all measures, many of the patients, whether they were referred for suspected dysphonia or not, were not near the reference values for many of the variables for average voice provided by VES. Refer to Table 7 for a comparison of the averages for each measure between the referral and non-referral group.

Table 7
Acoustic Measurements of Participants Using VES

Referral		Average F0	Jitter	Average SPL	Shimmer	H/N Ratio	Average F0 in Connected Speech
No	Mean	195.125	6.74	82.71	4.86	6.96	182.46
	Standard Deviation	62.25	2.42	3.10	5.48	3.19	44.44
Yes	Mean	191.01	6.10	84.03	7.67	5.17	166.90
	Standard Deviation	42.79	2.43	3.10	5.48	3.19	16.45
Referral		MinF0	MaxF0	Average SPL in Connected Speech	MinSPL	MaxSPL	Phonation Time
No	Mean	127.79	297.20	83.18	70.89	92.31	14.44
	Standard Deviation	32.62	84.67	2.39	4.12	4.92	4.43
Yes	Mean	128.67	287.20	85.93	76.83	93.70	11.50
	Standard Deviation	10.70	69.11	4.76	6.33	4.37	1.51

Referral		S-Time	Z-Time	S/Z Ratio	Min SPL Max Performance	Max SPL Max Performance	SPL Range
No	Mean	13.95	14.26	1.01	76.58	93.48	16.9
	Standard Deviation	5.13	5.28	.30	5.96	11.52	10.91
Yes	Mean	11.07	9.77	1.21	73.23	94.80	20.40
	Standard Deviation	2.89	2.20	0.50	1.11	4.38	4.61

Referral		F0 Range	DDK Rate	Min F0 Max Performance	Max F0 Max Performance
No	Mean	16.50	3.56	175.40	459.21
	Standard Deviation	4.18	1.04	41.21	113.06
Yes	Mean	13.00	3.37	164.83	359.53
	Standard Deviation	8.72	1.33	20.77	122.96

Discussion

The main purpose of this study was to determine the incidence of dysphonia in patients who were scheduled to undergo a thyroidectomy, if the presence of dysphonia as perceptually judged by a professional relate to VHI scores, if a subjective measure was sensitive to the presence of dysphonia, and if any acoustic measurements realte to those judged to be dysphonic. All assessment procedures in this study were performed by the same investigator under the same clinical conditions.

To address the first question, the incidence of dysphonia in this sample population is considered those patients who were referred for a further voice evaluation—3/11 or approximately 27%. Remember, 3-5% of the population has some sort of thyroid disease, so it is possible that 1.35% of those who have thyroid disease also have dysphonia. Also, if 80,000 thyroidectomies are performed on an annual basis, 21,600 of these are performed on patients with a baseline dysphonia which may persist after the procedure.

Only one of the VHI measures was related to those who were referred during this study—the physical domain. The physical component of the VHI refers to "self-perceptions of laryngeal discomfort and the voice output characteristics," (Jacobson et al, 1997). Elements of the VHI which patients may relate to include items such as running out of air when speaking, variation in voice throughout the day, a creaky/dry sounding voice, a worse voice in the evening, and voice giving out in the middle of speaking. Functional and emotional scores did not relate to referral for dysphonia.

The CAPE-V was largely sensitive to the referrals in the study population. Overall Severity, Roughness, Breathiness, and Strain were loosely related to refferals for dysphonic speech before thyroidectomies. The CAPE-V is a tool which can be employed by surgeons as

the study by Helou et al. in 2010 revealed inexperienced raters were just a reliable as experienced raters.

There were several background factors which could be considered an indicator for issues with a patient's voice after undergoing a thyroidectomy. No patients below the age of 45 were referred for further voice evaluation. While there are patients older than 45 who were not referred, patients 45 and older may be at greater risk for dysphonia and issues after thyroidectomy than younger patients and thus could be considered "at risk". Also, only those patients with goiter were referred, while a cysts, nodules, and even previous thyroidectomies did not warrant voices which were considered dysphonic. The study by Watt-Boolsen, Blichert-Toft, & Boberg (1979) found a decrease of dysphonia in patients with non-toxic goiters after thyroidectomy due to improved mobility of the laryngeal structure and a reduction of compression on the laryngeal nerves illustrated an improvement of voice quality after the removal of goiter. Patient report of voice quality revealed considerations for referral as well. Those with hoarseness alone or in combination with fatigue warranted referral over those with just fatigue issues or no issues at all. Lastly, those who were referred at least used their voice extensively for their job or a hobby. It is important to note none of these variables for referral for mutually exclusive—there are no absolutely definitive measures which indicate referral. They do, however, suggest risk factors surgeons should consider when scheduling a patient for a thyroidectomy.

There were no singular acoustic variables which indicated the need for referral. In actuality, many of the measured variables on this sample of patients were not within the reference range as established by the VES. When looking at the averages between the referred and non-referred groups, several of the variables showed significant difference—shimmer,

average fundamental frequencies in connected speech, phonation time, s-time, z-time, minimum fundamental frequency, and maximum fundamental frequency. McIvor et al. in a 2000 study found that dysphonia indicated by acoustic data did not correlate with patient report of vocal impairment, which is similar to the results found in this study. Page et al. in 2007 reported that 91% of pre-surgical dysphonia resolved after surgery, suggesting that thyroid disease may, in fact, cause dysphonia and it only resolves through thyroidectomies. The study population in the current study had largely dysphonic acoustic data which may be related to their thyroid disease but was not indicated in the subjective assessment by both the investigator and the patient. Since no acoustic variable was largely indicative of a specific dysphonia, these variables may not be useful as a screening measure.

Study Limitations

The largest drawback of the present study was the small sample size. To truly determine if there is a subjective screening measure which can be employed by surgeons on patients who are scheduled for a thyroidectomy, a larger study population would be more significant. Patients were also only taken from one surgeon in the present study. A more complete picture would be gained by sampling patients scheduled for thyroidectomies from multiple surgeons' offices.

Conclusion and Future Directions

There continues to be a percentage of patients who undergo thyroidectomies and develop post-surgical vocal disturbances without any obvious causes. One consideration to explain these post-surgical rates of dysphonia is to determine if pre-surgical levels of dysphonia exist in these patients. If surgeons can screen for pre-surgical dysphonia, the rate of indeterminate post-surgical dysphonia may be reduced, or at least explained and prepared for. While this study was limited in scope, it did reveal a 27% pre-surgical rate of dysphonia, which indicates further

pursuit of investigation of pre-surgical rates of dysphonia and subjective screening measures to be used by surgeons. As all of the patients who were referred in this study were diagnosed with goiter, it is important consider further studies which exclude those diagnosed with goiter. This is important to determine if a population outside of goiter has dysphonia since goiter inherently causes dysphonia. It is also important to further explore the relationship between patient opinion of impairment versus acoustic measurements indicating referral. It is unclear, but important to consider, if a post-operative dysphonia would be more resilient if a patient had a severe opinion of their vocal impairment or if the acoustic measurement indicated a dysphonia. Finally, since the CAPE-V may be a useful tool for surgeons to pre-screen patients, it would be important to determine a cut-off score for pre-surgical referral for further voice evaluation.

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Appendix A

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:_____

Appendix B

Name_____ Date_____Follow-up #_____

Voice Handicap Index (VHI)
(Jacobson, Johnson, Grywalski, *et al.*)

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

(Never = 0 points; Almost Never = 1 point; Sometimes = 2 points; Almost Always = 3 points; Always = 4 points)

	Never	Almost Never	Sometimes	Almost Always	Always
F1. My voice makes it difficult for people to hear me.					
P2. I run out of air when I talk					
F3. People have difficulty understanding me in a noisy room					
P4. The sound of my voice varies throughout the day.					
F5. My family has difficulty hearing me when I call them throughout the house.					
F6. I use the phone less often than I would like.					
E7. I'm tense when talking with others because of my voice.					
F8. I tend to avoid groups of people because of my voice.					
E9. People seem irritated with my voice.					
P10. People ask, "What's wrong with your voice?"					
F11. I speak with friends, neighbors, or relatives less often because of my voice.					
F12. People ask me to repeat myself when speaking face-to-face.					
P13. My voice sounds creaky and dry.					

	Never	Almost Never	Sometimes	Almost Always	Always
P 14. I feel as though I have to strain to produce voice					
E15. I find other people don't understand my voice problem.					
F16. My voice difficulties restrict my personal and social life.					
P17. The clarity of my voice is unpredictable.					
P18. I try to change my voice to sound different.					
F19. I feel left out of conversations because of my voice.					
P20. I use a great deal of effort to speak.					
P21. My voice is worse in the evening.					
F22. My voice problem causes me to lose income.					
E23. My voice problem upsets me.					
E24. I am less out-going because of my voice problem.					
E25. My voice makes me feel handicapped.					
P26. My voice "gives out" on me in the middle of speaking.					
E27. I feel annoyed when people ask me to repeat.					
E28. I feel embarrassed when people ask me to repeat.					
E29. My voice makes me feel incompetent.					
E30. I'm ashamed of my voice problem.					

Please circle the word that matches your voice today.

Normal Mild Moderate Severe

P_____F_____E_____ Total_____

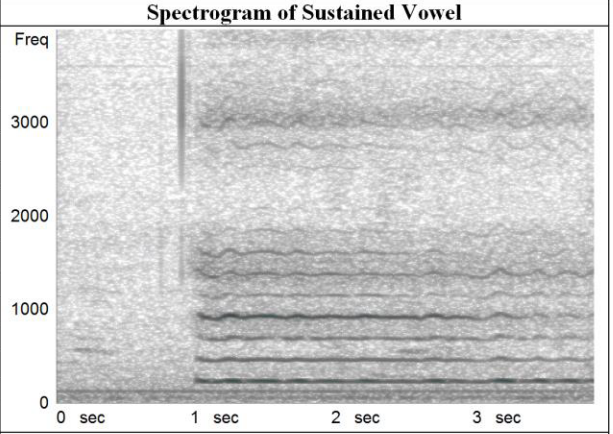
Appendix C

Voice Evaluation Record

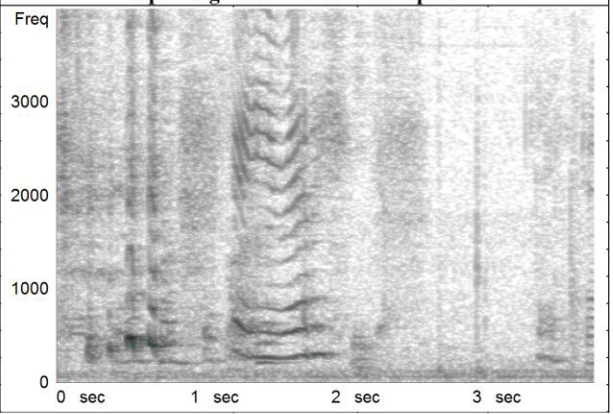
Patient Information	
Patient Name: [redacted]	Date: 5/23/2012 Initial Evaluation
DOB: [redacted] Gender: F Occupation:	Record Number: [redacted]

Sustained Vowel			
Measure	5/23/2012	Date	Reference
Average F0 (Hz)	230.5*		209.0
Jitter (%)	10.2*		0.7
Ave SPL (dB)	80.9		87.0
Shimmer (%)	4.1*		2.7
H/N Ratio (dB)	4.3*		11.8
Signal Type (1 to 3)			1
Continuous Speech			
Average F0 (Hz)	238.5*		210.0
Min F0 (Hz)	148.7*		127.0
Max F0 (Hz)	475.2*		391.0
Ave SPL (dB)	85.4		85.0
Min SPL (dB)	71.5		55.0
Max SPL (dB)	104.0		95.0
Maximum Performance			
Phonation Time (sec)	15.8		21.0
S Time (sec)	16.2		22.0
Z Time (sec)	10.5		24.0
S/Z Ratio	1.54		0.9
Min SPL (dB)	72.5		75.0
Max SPL (dB)	68.8		111.0
SPL Range (dB)	-3.6		36.0
Min F0 (Hz)	143.4*		183.0
Max F0 (Hz)	292.2*		750.0
F0 Range (semitone)	12*		24
DDK Rate (per sec)	2.8		4.7
DDK Weakness			
DDK Inconsistency			

Spectrogram of Sustained Vowel



Spectrogram of Continuous Speech



Reference values are for adult patients. Normal limits are +/- 2.0 std deviation.
SPL is measured at 3 cm mouth to microphone distance.
* Voice is non-periodic Type 2 or Type 3. Measurements of F0, shimmer, jitter, and H/N ratio may not be reliable.

Examiner Name: _____ Examiner Title: _____

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **www.ecu.edu/irb**

Notification of Initial Approval: Expedited

From: Biomedical IRB
To: Ashley Sanders
CC:
Kathleen Cox
Date: 5/16/2012
Re: UMCIRB 11-001498
Dysphonia Pre-Thyroidectomy

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 5/15/2012 to 5/14/2013. The research study is eligible for review under expedited category #4 and 6. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

The approval includes the following items:

Name	Description
Campus Map | History	Recruitment Documents/Scripts
CAPE-V | History	Surveys and Questionnaires
Demographic questionnaire | History	Interview/Focus Group Scripts/Questions
Equipment 1 | History	Other Medical Procedures/Considerations
Equipment 2 | History	Other Medical Procedures/Considerations
Informed-Consent-Template-No-More-Than-Minimal-Risk.doc | History	Consent Forms
Prospectus, Ch.1 and Ch.2 | History	Study Protocol or Grant Application
Recruitment flyer | History	Recruitment Documents/Scripts
VHI | History	Surveys and Questionnaires
Voice Handicap Index | History	Interview/Focus Group Scripts/Questions

The Chairperson (or designee) does not have a potential for conflict of interest on this study.