

LARYNGEAL STRUCTURE AND FUNCTION IN MALE-TO-FEMALE
TRANSSEXUAL PERSONS: ENDOSCOPIC AND STROBOSCOPIC
PRESENTATION

BY

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B.A., University of Kansas, 2004

Submitted to the Intercampus Program in Communicative Disorders and the faculty
of the Graduate School of the University of Kansas in partial fulfillment of the
requirements for the degree of Master of Arts in Speech-Language Pathology.

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Abstract

Data are lacking regarding the physical correlates that accompany the methods used by male-to-female transsexual (MFT) persons to feminize their voices. Visual study of these alterations is needed to better understand the methods used by MFT individuals to feminize their voices and to observe any potentially harmful vocal behaviors in which they may be engaging.

Nine MFT individuals who reported having a “passing” female voice were observed endo-/stroboscopically performing several vocal tasks. These examinations were rated for several physical parameters. Audio recordings were simultaneously captured and used in a listening experiment.

The results indicated that MFT speakers attempting a more feminine voice often utilized incomplete glottal closure and a more open phase closure ratio. Signs of vocal hyperfunction were observed in all participants. The results of this study provide preliminary evidence of the physical adjustments seen in MFT speakers. Clinical implications and directions for future research are discussed.

Acknowledgements

I would like to thank Dr. Jeff Searl, without whom this project would not have even been possible. From its inception, you have provided me with your support, guidance, expertise, and patience on this project, which has made this experience both enjoyable and truly educational. I appreciate your willingness to take on a project that lay somewhat outside your area of expertise, but still give it the same enthusiasm and dedication that you obviously put forth in all of your projects. You have truly been a mentor to me throughout my graduate career and I am thankful for all that you have done.

I would also like to thank Dr. Debby Daniels and Karen Haring for agreeing to sit on my thesis committee. I appreciate the help you gave me in getting my research off the ground and the guidance you gave in shaping my writing. Thank you for being great instructors and showing me that being a good speech-language pathologist does not mean that you cannot also be having fun.

Thank you to Angela Dietsch for your countless hours of assistance creating the listening experiment. I know all the frustration you experienced and realize that it could have been me, had you not been there to offer your time and dedication. Thank you also for lending an ear during my moments of frustration and reassuring me that everything would work out. Turns out you were right.

Thank you to the Otolaryngology–Head & Neck Surgery Department at KUMC for the generous use of their equipment and space for this project. Thank you

also to the speech-language pathologists in that department for providing their valuable time and expertise, which helped make this project possible.

My deepest gratitude goes to my parents who I can never thank enough. The endless support and encouragement that I have received throughout the years has allowed me to not only pursue my ambitions but find success in them, as well.

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Transsexualism is a condition in which a person believes that his or her psychological gender is incongruent with his or her anatomical gender (Oates & Dacakis, 1983). According to the American Psychological Association, transsexuals are a subgroup of transgender people (Schneider et al., 2006). Although definitions vary across sources, other subgroups of transgender people include cross dressers, transvestites, androgynes, and bigender individuals, among others. Definitions, terminology, and associated criteria for categorizing transgender individuals (referred to as, gender variant, by some sources) have shifted over time and have generated controversy among interested parties (medical professionals, psychologists, gender variant individuals, etc.).

The term transsexualism was used in the Diagnostic and Statistical Manual of Mental Disorders-III (DSM) in 1980. It was replaced by the term gender identity disorder (GID) in the DSM-IV (1994) because the former was often criticized as focusing on the condition as a sexual disorder as opposed to an issue with self-identity. However, in other widely used reference materials, such as the International Classification of Disease-10 (ICD-10; World Health Organization, 1994), the term transsexualism persists. For the current document, GID is used whenever possible. However, much of the prior literature has used “transsexual” (or variants thereof), and it is common among medical professionals, as well as many gender variant individuals, to continue to use transsexual at least for specific designations, such as “male-to-female transsexual” (MFT). Therefore, “transsexual” is also used in places

within this manuscript for purposes of readability and clarity when citing the literature.

People with GID represent a relatively small percent of the general population; however, recent calculations done by Olyslager and Conway (2007) suggested that the incidence of transsexualism is much higher than previously thought. Data from Western Europe and Australia suggested that prevalence of MFT persons was anywhere from 1:12,700 to 1:100,000 (De Cuypere, et al., 2007). Olyslager and Conway (2007) reanalyzed many of these previous studies and combined them with more recent data from Thailand, the United Kingdom, and the United States and determined a lower bound of 1:500 (.2%) prevalence of male-to-female transsexuality. It is generally accepted that GID affects biologic males more frequently than biologic females, in a ratio of 3:1 (Cohen-Kettenis & Gooren, 1999; Sohn & Bosinski, 2007).

The process of diagnosing GID is outlined in the standards of care published by The World Professional Association of Transgender Health (WPATH; formerly known as the Harry Benjamin International Gender Dysphoria Association; Meyer et al., 2001). These widely accepted standards of care, now in their sixth edition, reflect a professional consensus about the psychiatric, psychological, medical, and surgical management of GID (Sohn & Bosinski, 2007).

According to the ICD-10, there are three criteria that a person must meet for a medical diagnosis of transsexualism. First, the individual must have the desire to live and be accepted as a member of the opposite sex, usually accompanied by the wish to

make his or her body congruent with the preferred sex through surgery and hormone treatment. Second, the transsexual identity must have been present for at least 2 years. Third, the disorder must not be a symptom of another mental disorder or chromosomal abnormality (World Health Organization, 1994).

Mental health professionals use the criteria in the DSM-IV to diagnose mental disorders. To be diagnosed with GID under this criteria, a person must have: 1) a strong and persistent cross-gender identity, 2) persistent discomfort with his or her sex or discomfort in the gender role of that sex, 3) a disturbance that is not concurrent with a physical intersex condition, and 4) a disturbance that causes clinically significant distress or impairment in social, occupational, or other important areas of functioning (American Psychiatric Association, 1994). While the criteria for diagnosing GID are similar to those for diagnosing transsexualism found in the ICD-10, it is important to note that desire for hormone treatment and/or surgery is not required for a diagnosis of GID.

Diagnosis of GID is typically made by a mental health professional who conducts a thorough investigation of the client's mental and emotional health, as well as social and developmental history. Psychological evaluation is a necessary part of assessment for the diagnosis of GID (Christenson, 2006). Multiple standardized measures, such as the Minnesota Multiphasic Personality Inventory, Version 2 (MMPI-2) and the Millon Clinical Multiaxial Inventory-III (MCMI-III), are used to gain a psychometric perspective of the client's mental and emotional functioning and personality structure. Client interviews to obtain pertinent history are crucial in

making a diagnosis. Often, the mental health professional is confirming what the client already “knows;” however, other disorders that might cause gender dysphoria must be ruled out (e.g., thought disorders, transvestic fetishism; Christenson, 2006). A complete mental health evaluation is also important because GID often co-occurs with depression, anxiety disorders, personality disorders, and substance abuse (Pauly, 1993; Clements-Nolle, Marx, Guzman, & Katz, 2001; Feldman & Bockting, 2003).

Treatment for individuals with GID varies with the severity of the symptoms that a person exhibits. Treatment for individuals who present with irreversible transsexualism involves a series of steps related to the person’s psychological wellbeing and physical appearance with the overall goal of matching the person’s outward gender presentation with his or her internal gender. Psychological evaluation is the first step required by WPATH (Meyer et al., 2001). The extent to which a person alters his or her body as part of the gender transition is an individual choice that can begin after a minimum of three months of productive psychotherapy. The sequence and types of physical changes pursued will obviously vary for a person transitioning from male to female as opposed to female to male. This investigation focuses exclusively on MFT persons, therefore; only literature relevant to this group is described.

After 3 months of psychotherapy or real-life experience, an MFT individual can begin taking hormones (estrogens) that will promote the development of secondary female characteristics (e.g., breast development and redistribution of body fat). Electrolysis to remove unwanted facial and body hair may also be initiated at this

time. When the MFT individual feels ready, she can begin the “real-life experience” that requires her to carry out everyday activities in her preferred gender role. In order to be eligible for genital reconstructive surgery (GRS), an MFT person must live as a woman full time in everyday life for 12 months. GRS is not a required step in the transition process and many transsexuals opt not to continue with this step for health, financial, or personal reasons (Gelfer, 1999). A variety of elective plastic surgeries are available to feminize facial features, alter/augment breasts and reduce the size of the thyroid cartilage, among other possibilities. The intent of the elective surgeries is to make the MFT person’s physiological makeup consistent with his or her presenting gender (Freidenberg, 2002).

As part of the gender transition process, most MFT persons make some attempt to feminize their voices. This attempt can take the form of self-study programs, working with other MFT persons, and working with voice coaches. Some MFT persons will seek out the help of speech-language pathologists (SLPs). In the United States, there are various clinics and speech-language pathology training programs that have established programs to address the needs of MFT persons (e.g., University of Washington, Seattle, University of North Carolina, Greensboro, College of Saint Rose). Despite their relatively low prevalence in the general population, MFT persons represent an increasing percentage of SLPs’ caseloads (Freidenberg, 2002). Freidenberg estimated that in her private practice as an SLP who specializes in voice and voice disorders, MFT clients constituted 5-10% of her caseload. The American Speech-Language-Hearing Association (ASHA) has no official standards or

statements regarding communication therapy for transsexual persons. ASHA's website (<http://www.asha.org>) provides a brief overview of the various aspects of voice and communication that SLPs should target in therapy with an MFT person and recommends adhering to the standards of care established by WPATH (The American Speech-Language-Hearing Association, n.d.).

An MFT person seeking intervention from an SLP is typically concerned with raising the pitch of her voice (King, Lindstedt, Jensen, & Law, 1999). Administration of testosterone has shown to successfully lower the vocal pitch of female-to-male transsexual (FMT) individuals; however, administration of estrogen has shown little or no effect on the MFT client's voice (Söderpalm, Larsson, & Almquist, 2004; Mézáros et al., 2005). In addition to raising the habitual pitch, voice therapy with MFT clients can also include minimizing chest resonance, adopting a more feminine intonation pattern, altering articulation, speaking with a slightly faster rate, using less assertive vocabulary, and inserting more traditional feminine pragmatic features, such as tag questions, into everyday speech (de Bruin, Coerts, & Greven, 2000). The combination of increasing the pitch and feminizing speech and communication can help MFT individuals achieve their outcome of being perceived as women. A number of studies have reported that SLP intervention can increase the perception of femininity in MFT persons (Bralley, Bull, Gore, & Edgerton, 1978; Mount & Salmon, 1988; Spencer, 1988; Dacakis, 2000; Söderpalm et al., 2004; Mézáros et al., 2005; Carew, Dacakis, & Oates, 2007).

Achieving a feminine voice can be an important component to the overall gender transition process. Change in physical appearance to the body and face is possible through hormone therapy, plastic surgery, and GRS. However, if the voice and physical appearance are incongruent, it may prevent an MFT person from being viewed as a member of her preferred gender in society (i.e. “passing;” Van Borsel, De Cuypere, & Van den Berghe, 2001; Carew et al., 2007). A masculine voice can betray an MFT person’s biologic sex and can be a major source of incongruity of gender and behavior (Oates & Dacakis, 1997). Interpersonal communication is an important factor in the social acceptance and self-image of the MFT person, and obtaining female communicative behaviors is critical to fulfilling the desired gender role (Bralley et al., 1978; Pasricha, Dacakis, & Oates, 2008). If the voice persists as a mismatch with an MFT person’s desired gender presentation, the consequences can be serious. MFT persons may be the victims of violent assault and may experience breakdown in interpersonal relationships if they are not accepted by society in their preferred gender role (Beemer, 1996).

Despite the importance of voice feminization for MFT clients, limited research attention has been devoted to the topic. There is currently no standard practice for SLPs to follow when working with MFT clients. Most of the available literature is descriptive in nature and focuses on acoustic measures of fundamental frequency (F_0) and the perceptual correlate pitch associated with behavioral or surgical intervention for the voice (e.g., Bralley et al., 1978; Spencer, 1988, Wolfe, Ratusanik, Smith, & Northrop, 1990). In order to advance the care that SLPs can

provide for MFT clients, significantly more information is needed that can explain how an individual with biologically male vocal structures can generate a feminine-sounding voice. Acoustic and perceptual studies are useful, but more detailed understanding of laryngeal adjustments that either occur or can be induced are needed to refine SLP interventions, and perhaps allow identification of laryngeal physiological targets to include in behavioral voice treatment. Visual examination of the larynx of MFT participants has been done in a small number of studies, but the purposes and design of these studies does not permit drawing strong conclusions that can be used to understand how laryngeal function must change or to guide the SLP intervention itself.

The literature review that follows first addresses the various approaches that have been tried to help feminize the voice in MFT individuals (self-help, surgery, SLP intervention). Specific parameters of speech and voice that might be considered in the SLP intervention are then reviewed. Limitations in this body of literature, with a particular emphasis on the lack of studies that help explain how a person could alter laryngeal activity to produce a feminine voice, is presented followed by a statement of purpose for the current investigation.

Literature Review

Approaches to Feminizing the Voice in MFT Persons

There is no single standard of care that has been agreed upon as the method for successfully feminizing the voice in MFT persons. It seems likely that various approaches might be successful for any given individual. In general, MFT persons have three options available to them for trying to modify their voice and communication: self-directed programs, surgery, and behavioral intervention with an SLP.

Self-Directed Programs. A number of websites are available containing tips, suggestions, and activities for MFT persons who would like to obtain a more feminine voice on their own. Although the source of this information is not always clear, much of this advice appears to be from MFT persons who have already achieved a feminine-sounding voice who are sharing techniques that were successful for them. Many of the techniques recommended are similar to those suggested in the peer-reviewed literature (e.g., increasing pitch range, use of head resonance, prosodic manipulation, etc.). It is not clear how many MFT persons utilize the information on such websites and how successful any particular approach, tip, or set of activities is in helping to feminize the voice.

In addition to websites that offer suggestions, there are also “packaged,” at-home programs that can be accessed for a fee. Based on a web search, the most widely promoted of these is titled, “Finding Your Female Voice” (James & Addams, 2007). The program includes video instructions, structured exercises accompanied by

models on CD, and exercises using a spectrogram program to analyze speech. Other at-home programs include “Fundamentals of Your Feminine Voice,” “Develop a Female Voice,” and “Transsexual Voice for the Tone Deaf.” As with the website information, the authors of these packaged voice feminization programs are MFT persons who have successfully feminized their voices, at least based on their own assessment.

While there are testimonials that speak to the effectiveness of these programs, there is little empirical data addressing voice outcomes when MFT persons attempt to modify their voices without help from professionals. Mézáros et al. (2005) found that MFT persons who sought professional intervention from an SLP demonstrated a greater rise in habitual F_0 , a decrease in vocal range (with the elimination of the lower pitch range), and fewer pathologic results as measured by the Friedrich dysphonia index when compared to MFT persons who attempted to feminize their voices without professional intervention. Mézáros et al. (2005) recommended conservative voice treatment for all MFT persons during their transition from male to female, and surgery only when necessary. This recommendation is consistent with previous opinions (Gross, 1999; Yang, Palmer, Murray, Meltzer, & Cohen, 2002) indicating that voluntary raising of speaking pitch is more likely to result in dysphonia when attempted without therapeutic support from an SLP. Self-study may be an effective means of feminizing the voice for some MFT persons as suggested by testimonials and by the proliferation of home programs and sharing of “successful” tips and information on the internet. Lack of professional resources prepared to deal with

voice feminization approaches in MFT persons, financial constraints, and limited empirical data on best therapeutic approaches in this area are all likely contributors to the ongoing use of self-directed voice feminization approaches.

Surgery. Surgical interventions have been attempted to assist with voice feminization in MFT persons although empirical data on outcomes are limited. The surgeries that have been attempted include cricothyroid approximation (CTA; Isshiki, Morita, Odamura, & Hiramoto, 1974; Brown, Perry, Cheesman, & Pring, 2000; Yang et al., 2002; Neumann & Welzel, 2004; Kanagalingam et al., 2005), laser assisted voice adjustment (LAVA; Orloff, Mann, Damrose, & Goldman, 2006), and various approaches to adjust the length and tension of the vibrating portion of the vocal folds (e.g., Donald, 1982; Gross, 1999; Kunachak, Prakunhungsit, & Sujjalak, 2000; Anderson, 2007; Thomas, 2007). The surgical approaches are intended to alter the vibrating characteristics of the vocal folds by altering vocal fold tension, length, or mass, thus potentially altering the F_0 (and subsequently the pitch).

Neumann and Welzel (2004) described a process of modified CTA surgery in which miniplates were used to shorten the space between the anterior portion of the cricoid and thyroid cartilages. The procedure resulted in an F_0 increase in 91% of participants, however it caused a decrease in dynamic range (i.e. restriction when speaking loudly) in 77% of participants. Van Borsel, Van Eynde, De Cuypere and Bonte (2008) found that CTA was effective in raising habitual F_0 , however, it was not sufficient in producing a female-sounding voice. Orloff et al. (2006) showed that LAVA increased F_0 in 78% of patients (average F_0 increase of 34 Hz). The remaining

22% of patients showed either no change or a decrease in F_0 , and patients reported decreases in the level of clarity, loudness, and vocal range of their voices after LAVA.

The number of reports in the literature regarding particular surgical outcomes is small and the total number of individuals on whom any particular surgery has been performed is limited. Despite the lack of empirical evidence, the general consensus among laryngologists and SLPs is that voice feminization surgeries should be reserved for individuals for whom behavioral therapy has not been adequately effective in raising vocal F_0 (e.g., Moerman, Vermeersch, Van Borsel, & Wallaert, 2000; Wagner, Fugain, Monneron-Girard, Cordier, & Chabolle, 2003; Mézáros et al., 2005). The primary limitation of the surgical approaches attempted to date is that F_0 was the primary, and perhaps sole, parameter that was addressed by the surgery. Other aspects of voice and speech in addition to pitch are known to contribute to a more feminine sounding voice, so altering pitch alone via surgery may not result in an acceptable degree of feminization. It is for this reason that even when voice feminization surgery is pursued, speech therapy is generally recommended to complete the process (e.g., Oates & Dacakis, 1997; Yang et al., 2002; Neumann & Welzel, 2004).

Speech Therapy. There are no data available allowing an estimate of the percentage of MFT persons that seek the help of an SLP for feminizing the voice. Data are also lacking regarding the sequence of steps that MFT persons usually pursue related to their voice (e.g., self-study first, followed by SLP, followed by

surgery, or some other sequence). SLPs receive training in approaches to modify vocal behaviors and, as such, are one of a small group of professionals that MFT persons might seek (others might be voice coaches or singing instructors).

Speech, voice, and language differences between males and females have been of interest to speech scientists and SLPs for many years. As such, there exists a body of literature describing communication differences based on gender. This literature is not specific to transsexual individuals, who present with a unique set of circumstances and issues, but it has, at a minimum, served to identify potential communication parameters to consider when assisting MFT persons acquire speech and communication that can pass as female in their day-to-day interactions. Oates and Dacakis (1983) cited differences in male and female voice in the areas of pitch, resonance, intonation, vocal quality, and loudness. They also noted documented gender differences in speech, such as articulatory precision, and various aspects of language, such as syntactical form, vocabulary usage, and pragmatics (e.g., assertiveness, interrupting). The general consensus from the literature is that aspects of voice, speech and language should be addressed in the SLP therapy provided for MFT persons (Oates & Dacakis, 1997; de Bruin et al., 2000). The current study focuses on laryngeal aspects of voice production that are more directly related to nonsegmental features. For that reason, only aspects of voice that have been identified

as potentially import in behavioral intervention with MFT persons are considered in the following section.¹

Voice Parameters Suggested as Targets in Behavioral Voice Feminization Therapy

Pitch. The pitch of the voice is the primary cue utilized by listeners to identify the gender of non-transsexual male and female speakers (Coleman, 1976, Whiteside, 1998). Pitch is the perceptual correlate of frequency; as frequency increases, pitch increases, and as frequency decreases, pitch decreases (Seikel, King, & Drumright, 2005). The frequency of the voice (and therefore, the pitch) is determined principally by the mass per unit length and stiffness (tension) of the vocal folds. Rate of glottal flow and configuration of the glottis also play a role. Less massive folds (as in most females compared to males) vibrate faster than more massive folds; more tense vocal folds vibrate faster than less tense vocal folds.

As MFT persons are biologically male, they are likely to have relatively massive vocal folds, and therefore, slower vocal fold vibration, a lower F_0 , and ultimately a perception by listeners of a low-pitched voice that is characteristic of a male. The mass of the vocal folds in a MFT person is unaffected by the administration of female hormones that is part of the gender transition process (Söderpalm et al., 2004; Mézáros et al., 2005).² Therefore, unless MFT persons

¹ For information on articulation differences in male and female speech, see Simpson (2000). Methods for achieving more feminine articulation for the MFT client are described in Boonin (2006a). For a review of gender language differences and adapting them for MFT clients see Oates & Dacakis (1983) and Andrews (1999).

² In contrast, the F_0 of FMT persons has been shown to decrease with administration of testosterone. Damrose (2009) noted a drop in F_0 of 116 Hz (from 229 Hz to 113 Hz) in a FMT patient receiving androgen hormones as part of the gender transition process. This drop in pitch is typically enough for most FMT persons to be satisfied with their voices (Van Borsel, De Cuypere, Ruvens, & Destaeke,

modify how they use their larynges, the habitual pitch that they generate will remain low, causing listeners to perceive them as males rather than as females. As with non-transsexual individuals, listeners have been shown to utilize F_0 as the most salient aspect of voice to determine gender in MFT persons (Gelfer & Mikos, 2005). Not surprisingly, many MFT persons consider raising the F_0 of their voice to be their primary goal when seeking communication intervention (Gelfer, 1999).

Pitch modification has been the focus of voice intervention with the MFT population for many years (Kalra, 1977; Bralley et al., 1978; Mount & Salmon, 1988; Kaye, Bortz, & Tuomi, 1993). Most of this early work involved single-participant case studies that focused primarily on raising F_0 , and in general, this has been demonstrated to be feasible with most individuals. For example, Bralley et al. (1978) described intervention with an MFT participant who practiced increasing F_0 in tasks ranging from single monosyllabic words to conversational speech. Their participant achieved a median F_0 of 165 Hz during conversation after treatment compared to a pre-treatment median F_0 of 145 Hz. Mount and Salmon (1988) described a therapy program involving the use of a Visi-pitch display to study and match the pitch contours of a female clinician's speech. The participant in this study achieved an increase in F_0 of the vowels /i, a, u/ from pretreatment levels of 110 Hz to 195-210 Hz at termination of treatment and 200-235 Hz 5 years post treatment.

More recently, Söderpalm et al. (2004) followed 22 MFT patients referred for voice intervention over a period of 11 years. They reported statistically significant

2000). If they are not satisfied with their voices, it is usually a result of difficulty with a persisting female resonance and not with pitch (de Bruin et al., 2000).

increases in F_0 , with the greatest increases in patients who received more than 14 months of intervention. Mézáros et al. (2005) compared the habitual F_0 change of three MFT persons receiving voice intervention to two MFT persons not receiving intervention. They found that the MFT persons who received intervention achieved a habitual F_0 in the female range (185-202 Hz) and those who did not achieved a habitual F_0 in the “gender neutral” range (147-165 Hz).

The extent of the increase in F_0 needed to pass as female, however, cannot be stated definitively from the literature. The mean F_0 for biological adult females ranges from ~190-224 Hz; for biological adult males, the mean F_0 is typically ~100-130 Hz (Oates & Dacakis, 1997). The MFT literature has often cited ~160 Hz as a reasonable mean F_0 goal for MFT clients in SLP intervention. Spencer (1988) presented recordings of MFT participants reading a passage to a group of listeners and asked them to identify the speaker as male or female. Speakers with an F_0 below 160 Hz were perceived to be male, while those using an F_0 greater than 160 Hz were perceived as female by the vast majority of listeners. Similarly, Wolfe et al. (1990) reported an F_0 of 155 Hz as the lower threshold for the perception of MFT participants in their study as female.

Günzburger (1995) played recordings of two MFT speakers to 31 listeners. Twenty-five utterances of each MFT participant speaking in both her male voice and her female voice were presented. One of the MFT speakers had acoustically-confirmed differential voice characteristics of higher F_0 and lower intensity values in the female voice and the other participant showed insignificant F_0 differences and a

typical intensity values. The listeners identified the intended gender with almost 99% accuracy in the first speaker and with slightly below 75% accuracy in the second speaker. These results showed a statistically significant difference in the perception of gender based on variables of pitch and loudness. The generalization possible from these results is low, however, as only two speakers were analyzed and other features of the voice signal, such as resonance and intonation, which could have affected perception were not reported.

In contrast, Gelfer and Schofield (2000) and Gorham-Rowan and Morris (2006) found that achieving an F_0 of 160 Hz was not sufficient for all MFT persons to be perceived as female. An F_0 of 160 Hz or higher is neither sufficient on its own, nor is it necessarily required to be perceived as female. That is, some MFT persons may achieve an elevated F_0 , but listeners may still perceive them as male if other aspects of speech, voice, and language remain consistent with those of a male speaker. Conversely, some MFT persons may not achieve the 160 Hz F_0 , but may modify other speech, voice, and language in other ways that successfully convey femininity to a listener.

McNeill, Wilson, Clark, and Deakin (2008) examined the correlation between 12 MFT persons' satisfaction with their own voice and listener perceptions of femininity. They found that a strong correlation existed between self-satisfaction and the perception of femininity by lay listeners. Interestingly, a significant correlation was not found between F_0 and self-satisfaction. This suggested that client satisfaction

and listener perception of femininity were not based solely on achieving the desired level of F_0 increase.

Loudness. Biological males generally speak louder than biological females (Yanagihara, Koike, & Von Leden, 1966; Pavlovic, 1987; Awan 1993). Loudness is the perceptual correlate of vocal intensity, which is determined by a number of factors. Subglottal air pressure is considered a primary and direct determinant of vocal intensity. The magnitude of subglottal air pressure build-up is dependent on medial compression of the vocal folds (in turn, related to vocal fold mass and tissue compliance), glottal configuration (e.g. degree of arytenoid approximation and completeness of glottal closure), and respiratory forces (e.g. expiratory pressures). In general, male vocal folds are 20-30% thicker (i.e. more massive) than female vocal folds (Titze, 1989) and males produce more complete glottal closure (Södersten & Lindestad, 1990; Södersten, Hertegård, & Hammarberg, 1995) than females, which may help explain the increased intensity (and loudness) reported for males. Mean vocal intensity has been shown to be 3-5 dB greater in biological males than females (Yanagihara et al., 1966; Pavlovic, 1987; Awan, 1993).

Unlike pitch, loudness has received very limited attention in the data-based research on the voice of MFT persons. A louder voice for MFT persons might be predicted based on the fact that their laryngeal anatomy, and perhaps their habitual voice use prior to beginning the gender transition process, may predispose them to increased vocal intensity compared to females. However, both males and females should be capable of manipulating vocal loudness and intensity as evidenced by the

fact that individuals without vocal or respiratory abnormalities have a loudness range that usually includes very soft voice.

Günzburger (1995) provided the only empirically based description of the effect of loudness on the perception of gender in MFT persons. She found that when speaking in their feminized voices, as opposed to their habitual male voices, five of her six MFT participants spoke with lower intensity level. She also reported that when speaking in their male voices, the MFT participants spoke with a greater intensity range. These differences showed a positive correlation with perceptual ratings by listeners (i.e. lower vocal intensity was rated as being more female sounding, and greater vocal intensity was rated as being more male sounding). These results should be interpreted with caution, however, because the description of this parameter is not isolated from other parameters such as F_0 .

Boonin (2006b) suggests that speaking in a louder voice over an extended period of time (e.g. in public speaking) can cause F_0 to drop in some MFT persons. Despite the lack of empirical data, descriptions from SLPs involved in voice intervention with MFT persons frequently include comments suggesting that decreasing loudness and maintaining a feminine-sounding voice in instances that require a louder speaking voice may need to be addressed in therapy.

Voice Quality. Women are more likely to be perceived as having a breathy voice compared to men (Sulter & Peters, 1996; Klatt & Klatt, 1990). Acoustically, breathiness is the outcome of increased aspiration noise at the level of the glottis (Klatt & Klatt, 1990; Hanson & Chuang, 1999). The cause of the aspiration noise is

most often attributed to the presence of incomplete vocal fold closure and the presence of a posterior glottic gap, which are more common in biologic females (Södersten & Lindestad, 1990; Södersten et al., 1995). Van Borsel, Janssens, and De Bodt (2009) presented a normal /a/ and a breathy /a/ from seven biological female speakers to a group of student judges. The breathy /a/ was consistently perceived as more feminine by all judges when presented both randomly and paired by speaker. Andrews and Schmidt (1997) found that listeners consistently used breathy voice as a discriminating factor when asked to determine the gender of male cross dressers speaking in masculine and feminine voices.

Acquiring a breathier voice has been identified in the SLP literature as a potential target in voice feminization therapy for MFT clients (Freidenberg, 2002; Dacakis, 2002). Individuals presumably have the ability to alter laryngeal behavior to produce a breathier voice if given proper instructions and/or opportunity to practice and explore voicing behavior. This is evidenced in traditional voice therapy with individuals who are taught to use a breathier, less strident voice using techniques such as the Confidential Voice (e.g. Verdolini-Marston, Burke, Lessac, Glaze, & Cladwell, 1995). There is no reason to suspect that MFT persons have any less ability to alter vocal quality. However, despite descriptions of needing to produce a breathier voice, systematic investigation of vocal quality alterations and adjustments of laryngeal configuration in MFT persons has not been reported. The extent to which the quality should be altered, best methods to accomplish this, and description of the changes in

laryngeal behaviors that are invoked by MFT persons with passing feminine voices are poorly described.

Resonance. Acoustically, resonance is the reinforcing or prolongation of sound by reflection of sound waves (Stemple, Glaze, & Gerdeman, 1995). The term resonance is often utilized when describing and defining vowels, and in such instances, formant frequencies are measured as a way of quantifying resonance (Wiltshire, 1995). Vocal tract resonance (acoustic and perceptual) differs as a result of varying the size, shape, length, compliance and port openings of the vocal tract (Ladefoged, 2005). In general, biologic males and females differ in terms of their vocal tract resonances because of the differences in the volume and length of the vocal tract. The male vocal tract is about 15% longer than the female vocal tract, which causes the formant frequencies of male speakers to be lower than those of female speakers (Gelfer & Mikos, 2005; Oates & Dacakis, 1997).

Resonance is also used as a perceptual term in discussions of vocal quality as related to vocal registers (e.g. Case, 2002). Perceptually, resonance is defined as the auditory impression of ringing or tonal quality in the voiced components of speech, primarily vowels, (Peterson, Barkmeier, Verdolini-Marston, & Hoffman, 1994). The “ringing” is often associated with a speaker perception of oral/facial vibratory sensations on or near the alveolar ridge and other bony facial plates (Peterson et al., 1994). The tonal quality differences are associated with changes in laryngeal configuration and vocal fold vibration and have been described as vocal registers (Titze, 1994). A number of different terms have been used to describe vocal

registers, although Titze's (1994) use of pulse, modal, and falsetto are widely accepted; corresponding terminology from the voice singing literature are chest, head and falsetto.

Voice therapy for an MFT person could conceivably address resonance issues from the perspective of vowel formant frequencies or vocal registers (or both). Approximating female resonance features is a necessary step if the voice of an MFT person is to be perceived as female (Mount & Salmon, 1988; Carew et al., 2007). In terms of vocal registers, the goal of voice intervention for MFT clients is typically to minimize the use of chest resonance, which is typically associated with male voice, and increase head resonance, which is typically associated with female voice (de Bruin et al., 2000). Chest, or pulse, register is considered a low-frequency register in which the pattern of vocal fold vibration is slow enough that individual glottal vibrations can be heard (Sataloff, 1998). Head, or modal, register involves vibration of the entire membranous glottis and is considered to be the most efficient functioning of the larynx. While it has been suggested that therapy with MFT persons requires a shift in the percentage of time used in chest as opposed to head register, there have been no reports in the literature describing the laryngeal adjustments that are expected to occur to make such a shift.

There has been some limited presentation of data on vowel formant frequency changes in therapy with MFT persons. Carew et al. (2007) completed an oral resonance therapy program that taught lip spreading and anterior tongue carriage with 10 MFT persons. The authors reported an increase in vowel formant frequencies (F_1 ,

F_2 , F_3) and F_0 (30 Hz). Although not analyzed statistically, a majority of participants (70%) were perceived as having a more feminine voice following treatment. The authors speculated that the perception of increased femininity resulted from the increases in formant frequencies and F_0 . Mount and Salmon (1988) found that only when the second formant frequencies (F_2) of the vowels /i, a, u/ were consistent with typical female F_2 values was their MFT client consistently perceived as female. Gelfer and Schofield (2000) investigated vowel formant frequencies for /i/ and /a/ produced by 15 MFT participants. Vowel formants were consistently higher for the group of MFT participants perceived by listeners to be female compared to MFT participants perceived as male, although the differences did not reach statistical significance.

Presumably, when resonance features and F_0 fall within ranges typical for a female, listeners are likely to perceive the listener as female; the same might be presumed for male ranges. When mismatches occur between two parameters (e.g. female pitch but male resonance features) or when a given parameter falls within an ambiguous region, listeners may be less sure about the speaker's gender. However, the literature is not definitive on the issue of how resonance features and F_0 interact to influence listeners' perceptions of a speaker's gender.

For example, Coleman (1976) presented 5-second clips of 10 speakers (5 male, 5 female) with matched (i.e. male resonance with male pitch and female resonance with female pitch) and mismatched features (i.e. male resonance features but female pitch and vice versa) to a group of 25 listeners. An electrolarynx was used

to produce the mismatched pitch. The majority of mismatched tokens (68%) were identified as male. The authors were unable to make strong statements regarding resonance and F_0 interactions relative to perceived gender as half of the mismatched tokens identified as male had male resonance and female F_0 and the remaining had female resonance and male F_0 (i.e., either combination of mismatch was nearly equally likely to result in a perception of a male speaker).

Whiteside (1998) conducted a similar experiment with three male and three female participants, but used synthesized vowels rather than an electrolarynx to create the mismatched tokens. Unlike the Coleman experiment, Whiteside found that when a mismatch occurred, pitch was the more salient cue in determining a participant's gender. More recently, Gelfer & Mikos (2005) conducted a similar study with MFT participants. Like the Whiteside study, F_0 was found to be the stronger influence on listeners' identification of the MFT speaker's gender even when a mismatch with resonance characteristics was present.

Intonation. Intonation refers to the patterns of pitch rising and falling and to the use of emphasis through pitch alteration (Mourdaunt, 2006). There appear to be differences in intonation between males and females in general, although exceptions exist on an individual basis. Non-transsexual females have been found to use a wider pitch range and greater pitch variability than males (Pellowe & Jones, 1978; McConnell-Ginet, 1983). Females more frequently utilize a rising pitch at the end of sentences compared to males, who tend to use falling tones (Pellowe & Jones, 1978).

Brend (1975) found that males tended to avoid upward pitch movement, while female speakers avoided level tones in their speech.

Günzburger (1989) referred to various studies that have shown that F_0 standard deviation is greater for females compared to males (non-MFT individuals). She also described steeper slopes for pitch change in women than men. Benjamin (1981) and Henton (1995), as cited in Oates & Dacakis (1997), however, found that gender differences were not significant when intonation patterns such as upward and downward inflections and rate of change in F_0 were measured.

Despite the inconsistencies in the literature, a need to focus on altering intonation patterns in MFT persons has been suggested by some investigators. Spencer (1988) asked a group of listeners to identify recordings of eight MFT persons as being either male or female, and asked listeners to rate each speaker on two seven-point scales, one of maleness and one of femaleness. The MFT persons whose voices were rated as having more adequate speech patterns (i.e., female, more feminine) reported mimicking what they felt to be characteristic female intonation patterns. This suggests that, at least from the MFT person's perspective, intonation pattern was an important characteristic of their female speech. Wolfe et al. (1990) reported that MFT persons who had a higher percentage of upward intonations and downward shifts in their speech were rated as being female and those with fewer intonations and shifts were rated as being male. They did, however, note that F_0 was the more salient aspect of speech that listeners used to determine the gender of the MFT speakers.

Laryngeal Alterations used by MFT Persons During Voice Production

Anatomical Presentation. Söderpalm et al. (2004) provided the only report of which the author is aware that contained endoscopic information on the larynges of MFT persons who had not undergone laryngeal surgery.³ They included 22 MFT participants in a study on the evaluation, intervention, follow-up procedures and outcome of voice therapy. As part of the initial evaluation of participants in this study, a phoniatric assessment was conducted that included laryngeal visualization (endoscopy and stroboscopy) to rule out structural abnormalities. The authors reported that there were no structural differences in the vocal tract of an MFT person compared to that of a non-transsexual male. However, they did not attempt to describe differences in an MFT person's larynx as they produced the feminine voice compared to the masculine voice. Mézáros et al. (2005) also conducted endoscopic examinations of MFT vocal tracts, however, they made no comments on their findings. The literature regarding the impact of hormone therapy in MFT persons has not included laryngeal visualization. However, as stated above, the general consensus is that administration of female hormones during the transition process does not induce changes in laryngeal structure.

In addition to better defining laryngeal modifications that are beneficial in voice feminization therapy for MFT clients, endoscopic studies would also be of importance in delineating whether individuals are engaging in potentially harmful

³ Studies describing CTA, LAVA, and other laryngeal surgeries typically have included endoscopy or stroboscopy as a means of documenting surgical outcomes (e.g., Yang et al., 2002; Orloff et al., 2006; Anderson, 2007). However, these studies have not described the behavioral alterations that an MFT person might utilize to produce a feminine voice.

laryngeal behaviors when using their female voice. Oates and Dacakis (1983) and Söderpalm et al. (2004), among others, have advocated voice therapy for MFT clients who are seeking to feminize their voices in order to prevent use of potentially abusive vocal behaviors. However, there is very little description in the literature of the types of vocal abuse and/or pathologies that occur in this population. Gross (1999) reported that many of the 10 MFT patients in his study presented with hyperfunctional voice disorders prior to CTA surgery and that voice therapy was able to alleviate these problems, although no details of the type of intervention or specific outcomes were provided. Söderpalm et al. (2004) noted supraglottal constriction during phonation in over half of their MFT participants; the authors speculated that the supraglottal constriction was associated with vocal fatigue. They also suggested that the constriction was a warning sign for possible damage to the laryngeal structure because it was indicative of excess phonatory effort.

Mézáros et al. (2005) calculated the Friedrich dysphonia index for five MFT participants, three who were receiving voice treatment and two who were not. The index was calculated by averaging a speaker's scores on measures of hoarseness, pitch range, intensity range, phonation time, and communicative impairment. The three MFT participants who received voice treatment showed movement from hypertonic to normotonic voice functions, while the two untreated controls maintained a consistent level of hypertonic voice functions, considered to be pathologic. Dacakis (2002) suggested that the manipulation of the phonatory mechanism in a nonhabitual manner could cause increased laryngeal tension and

result in vocal fold damage. Vocal pathologies associated with vocal abuse are vocal fold swelling, contact ulcers, vocal nodules, vocal polyps, hypertrophy of the laryngeal epithelium, and thickening of the vocal folds (Andrews, 1999).

Physiologic Alterations. Investigators interested in voice feminization for MFT persons frequently make inferences about how an individual alters laryngeal function to produce a female voice. However, direct investigations of laryngeal movements, configurations and aerodynamics in MFT persons during voice production are limited. Clearly, MFT persons make adjustments in laryngeal behavior when they successfully increase their pitch or alter vocal quality; however, descriptions of the actual adjustments have not been reported. Gorham-Rowan and Morris (2006) identified the need for more detailed understanding of laryngeal behaviors in MFT persons in order to have a better understanding of how this population manipulates the vocal folds to produce a feminized voice (e.g. increased tension of the vocal folds or presence of a glottal opening during feminine production). Söderpalm et al. (2004) reported no functional differences in laryngeal movements in their study of 22 MFT patients; however, this was a retrospective study that was not designed specifically to evaluate laryngeal movements in detail.

Vocal pitch adjustment can be accomplished in a variety of ways that involve a potentially complex interplay of respiratory, laryngeal, and supralaryngeal structures (Lam Tang, Boliek, & Rieger, 2008). Within the larynx itself, pitch alteration can entail different manipulations across individuals or phonatory tasks. For example, vocal fold elongation via contraction of the cricothyroid muscles is a well-

recognized method for pitch change (Lam Tang et al., 2008; Seikel et al., 2005). Internal tension of the vocal folds can be manipulated to adjust vocal pitch (Jiang, Lin, & Hanson, 2000; Sulter, Schutte, & Miller, 1996) and this tension can be manipulated independent of vocal fold length in some individuals (Hoppe et al., 2003).

The ability to explain voice quality manipulation in MFT persons at the level of the larynx is also limited. Establishing a breathier quality is frequently identified as a therapeutic target. To date, however, there is no endo-/stroboscopic information related to laryngeal adjustments in MFT persons who have successfully altered their speech to be breathier. Some may allow a posterior glottal gap; others might adjust laryngeal activity so that there is a longitudinal gap in the membranous glottis; still others may do a combination of these or other reconfigurations. It is possible that still others may not alter arytenoid position or degree of vocal fold adduction when moving from the masculine to the feminine voice, yet still achieve a feminine sounding voice through other means.

Gorham-Rowan and Morris (2006) reported aerodynamic data suggesting less complete glottal closure in MFT persons producing their female voice. Minimum flow rates during the closed portion of the glottal cycle were higher than those for biologic females and for MFT persons using their biologic male voice. Whether this glottal flow during the closed portion of the glottal cycle occurs because of a posterior glottal gap or some other laryngeal configuration (e.g., longitudinal gap, vertical movement of the folds or larynx) cannot be determined from aerodynamic data.

A related matter is the concern that some MFT persons may unduly increase laryngeal effort, perhaps leading to strained vocal quality, as they attempt to increase pitch. Again, laryngeal visualization data are lacking in this regard. Söderpalm et al. (2004) offered a potentially relevant observation in this regard, although their observation was related to supralaryngeal rather than laryngeal structures. They noted that more than half of their 22 MFT participants showed evidence of constriction of supralaryngeal structures suggesting increased muscular tension during phonation; they also commented on a reduction in vocal fatigue following voice intervention, implying that fatigue (possibly related to phonatory effort) was an issue prior to the SLP intervention.

Aerodynamic data have also suggested the possibility of increased tension with phonation in the preferred female voice of MFT persons. Gorham-Rowan and Morris (2006) investigated laryngeal aerodynamics in 13 MFT participants producing sustained vowels in their habitual male voice and in their female voice. The MFT participants had a significantly higher maximum flow declination rate (MFDR) in both their male and female voices compared to non-transsexual males and females. A higher MFDR was interpreted as an indication of quicker glottal closure and abrupt termination of glottal airflow, as has been reported for individuals with vocal nodules and spasmodic dysphonia (populations associated with laryngeal hyperadduction). In this study, MFT participants produced higher alternating glottal airflow when compared to biologic males. Increased alternating glottal airflow may result from

increased tracheal pressure, a product of increased respiratory drive and/or elevated laryngeal tension.

Statement of Purpose

Currently, no visual descriptions of the laryngeal manipulations made by MFT persons to feminize their voices exist in the literature. Achieving an authentic-sounding female voice is an important objective for this population. Much of the current literature on MFT individuals has focused on determining the effect that various aspects of voice (e.g., pitch, resonance, loudness) have on the perception of speaker gender. While many factors contribute to the perception of a person's gender based on a voice sample, pitch, or F_0 , has been repeatedly shown to be the most salient factor used to determine the gender of the speaker. Vocal tract resonance has also been shown to have a significant effect on gender discrimination in some studies.

Anecdotal reports and studies of aerodynamic data of MFT voice suggest that MFT persons are manipulating the phonatory mechanism in order to alter the pitch, voice quality and resonance features of their voices (e.g., creating increased vocal fold tension, creating a posterior glottal gap, raising the larynx to create a shorter vocal tract). Observations of these changes could be made by endoscopic and stroboscopic examination of these structures during production of both the feminized and habitual male voice. If the underlying physiology of the feminized MFT voice is better understood, a more focused and appropriate set of therapeutic goals and instructions should be possible with an ultimate goal of improving voice feminization outcomes.

The overall purpose of the proposed study was to add significantly to the understanding of laryngeal presentation of MFT persons who have a feminine voice

that passes in their daily life. Clinician descriptions and ratings from endoscopy and stroboscopy served as the primary data source. Steady-state phonation on sustained vowels was the main phonatory behavior observed. The two primary specific aims of this investigation were as follows:

1. Describe the laryngeal and vocal fold configurations and movements during phonation by MFT persons using a feminine voice. A number of parameters were judged from the endoscopic and stroboscopic images of sustained phonation including:
 - a. amplitude of excursion of the vocal fold edge from midline (degree and symmetry)
 - b. mucosal wave excursion (degree and symmetry)
 - c. non-vibrating portions of the vocal folds
 - d. supraglottic activity (i.e. supralaryngeal constriction (degree and symmetry))
 - e. vocal fold edge smoothness and straightness (irregularities and symmetry)
 - f. vertical level of the vocal folds (symmetry)
 - g. phase closure
 - h. phase symmetry
 - i. regularity of vocal fold vibration
 - j. glottal closure formation
 - k. tissue color

- l. presence/absence of edema, vascularity, indicators of adequate hydration
- m. laryngeal height adjustments (during pitch glides)
- n. pharyngeal tension (during modal pitch and pitch glides)

Descriptions of the above parameters were obtained as participants produced vowels in the feminine voice produced at their typical pitch and loudness; some parameters also required sampling at the high and low ends of their pitch range when using the female voice.

2. Identify any potential abusive vocal behaviors that the MFT participants may be using while speaking in their female voice.

The endo-/stroboscopic data obtained in this study allowed description of the incidence and types of laryngeal abnormalities present, if any, in a group of MFT persons. History gathering was also done to allow more detailed description of the timeline and process by which each participant arrived at her current feminized voice.

Some limited acoustic analysis is presented in this study to provide descriptions of the speech samples utilized and assess impacts of the scoping procedure on voice production. Perceptual judgments of speaker gender were also obtained to confirm the extent to which listeners heard the MFT participants as female and to provide context to the interpretation of the endo-/stroboscopic data.⁴

⁴ Listeners provided ratings of masculinity/femininity in addition to the decision about speaker gender. These masculinity/femininity ratings were not analyzed as part of this study but will be archived for later analysis.

Method

Participants

Nine adults volunteered to participate in the current study. Specific inclusion criteria were as follows:

1. Self-identification as an MFT person who has been living in the female role at least 75% of the time for the past 6 months. These criteria were selected to ensure that participants had been living in a female role for a sufficient amount of time to allow the use of the female voice to be habitual.
2. 18-75 years of age. This large age range is reflective of the varying age at which MFT persons choose to transition genders.
3. Normal male voice prior to transitioning genders and acquiring a female voice per self-report.
4. Absence of current, self-reported voice problems.
5. “Passing” female voice (i.e. the MFT participants reported that their voice sounds feminine and was routinely perceived by others as a woman’s voice). McNeill et al. (2008) reported that MFT persons who reported high levels of satisfaction/ability to “pass” with their voices were perceived to be female by listeners. The participants provided this information via self-reports on a history questionnaire.
6. No surgery to any portion of the vocal tract (larynx, pharynx, palate, tongue, lips) that would alter speech and voice production. The purpose

of this study was to observe anatomical and physiological differences in MFT persons who had not had surgical alterations to the vocal tract that would affect phonation.

7. Negative history for medical conditions that are associated with speech and voice abnormalities. Participants were asked to identify any medical conditions that they had been diagnosed with from a list of disorders on a history questionnaire (Appendix A).
8. No known allergy to topical anesthetics. A topical anesthetic was used during endo-/stroboscopy. To avoid allergic reactions during the study, participants were asked of any known allergy to topical anesthetics on the history questionnaire.

Inclusion criteria were assessed via a written questionnaire (Appendix A), as described above. The questionnaire also solicited information regarding the participant's male-to-female transition, method for establishing a "passing" female voice, perception of what makes a voice sound feminine, current voice use, and current behaviors that may affect the voice (e.g. smoking, alcohol consumption, etc.).

Participants were recruited via word of mouth and internet listservs that serve the transgender community in the Kansas City and Topeka areas.

Procedures

The consent process and data collection were done in one meeting that took place in the Otolaryngology-Head & Neck Surgery Department at the University of Kansas Medical Center (KUMC). Prior to data collection, each participant was given

time to read the consent form, ask questions, and be informed by the investigator as needed. Each participant signed a consent form with a photocopy given to her for her records. The following steps were then completed.

1. Completion and review of the history questionnaire. The participants were emailed a copy of the history questionnaire that they completed prior to arriving for participation in the study. The history questionnaire asked for information about their gender transition, speech, language, hearing, and medical histories, as well as other information (Appendix A). Most participants had completed the questionnaire prior to arrival for the first visit. Those who had not, completed the form on site.
2. Endoscopic and stroboscopic examination of the larynx. All participants were examined using a flexible endoscope in the Otolaryngology Department at KUMC. One of two state-licensed SLPs completed the scoping procedures for each participant. Each SLP had at least 4 years of experience in dealing with voice disorders, including doing flexible nasopharyngolaryngoscopy. An otolaryngologist with substantial experience in visual examinations of the larynx was onsite if needed.

The participant was seated in an examination chair in the endo-/stroboscopy suite. The following steps were completed:

1. The scopist explained the procedure and showed the scope to the participant.
2. The scopist administered an aerosolized vasoconstrictor into the participant's most patent nasal passage. Aerosolized lidocaine was also administered to

reduce sensation in the nasal cavity and increase the participant's tolerance of the scope.

3. A flexible nasoendoscope (Pentax VNL-1170K) was advanced in the nasal cavity. A KayPentax Digital Strobe (Version 6.2.1) was used to supply light to the scope (constant and stroboscopic, as needed) and to capture, display, record and playback the examination. The scope was coupled to a digital camera (Pentax EPK-700) that was connected to the CPU for recording; a computer monitor was used to display the examination in real-time during the exam. A throat microphone was positioned on the neck to trigger the stroboscopic light.
4. The position of the scope was adjusted as needed to allow a view of the larynx that included the true vocal folds (anterior commissure to the arytenoids), ventricular folds, arytenoids, aryepiglottic folds and posterior and lateral hypopharyngeal walls. During the initial portion of the exam, the scopist adjusted the scope to allow inspection of the tongue base, vallecular space, epiglottis, posterior and lateral pharyngeal walls, and pyriform sinuses.

With the scope in position to view the larynx, each participant completed the protocol outlined below using her female voice:

1. Quiet breathing for 10-20 seconds. (Continuous light)

2. Sustained vowel production (/i/) at a comfortable pitch and loudness for 5-10 seconds. Approximately three trials of the sustained vowel were recorded. (Stroboscopic light)
3. Pitch glide from the participant's lowest to highest pitch, then highest to lowest, on a sustained vowel (/i/). The intent was to solicit the participant's maximum pitch range (in the pitch glide task) while using the preferred female voice. Multiple trials with coaching and encouragement from the scopist and investigator were allowed until a minimum of three trials gliding up and gliding down were recorded. (Stroboscopic light)
4. Loudness range during sustained vowel production (/i/) in the female voice was recorded using an incremental doubling or halving technique. The participant was asked to say /i/ at a comfortable pitch and loudness. She was then asked to "double" the loudness and say /i/ for approximately 5 seconds, then double that loudness. In order to avoid the possibility of inducing fatigue or poor voicing behaviors, participants were only asked to double the loudness twice. This allowed an assessment of laryngeal configuration and movements at elevated loudness levels, but was unlikely that it truly represented the participant's maximum loudness. The two-step doubling procedure was recorded three times. Participants were then asked to produce /i/ again at a comfortable pitch and loudness, then asked to produce the

quietest female voice possible, without whispering. This was recorded three times. (Stroboscopic light) The loudness recordings were archived for future analysis, but were not a focus in the current study.

5. Reading a portion of the Rainbow Passage (Appendix B; Fairbanks, 1960) at a typical pitch, loudness, and rate. (Stroboscopic light)

Throughout the scoping procedure, an acoustic voice recording was simultaneously obtained using an AKG C410 Headset microphone and Marantz PMD300 Portable CD-Recorder. The headset microphone was positioned approximately 10 cm away from the corner of the mouth in order to not interfere with the nasal scoping procedure. The acoustic recordings of the participant's voice were used for subsequent perceptual listening experiments (described below).

The vocal tasks described above were also performed without the nasopharyngoscope in place and recorded acoustically in the exam room using the same microphone, recorder, microphone positioning, and input gain on the recorder. Participants repeated the speech protocol used for the scoping with the exception of the quiet breathing. Participants were recorded using their female voice. This acoustic recording was compared to the acoustic recording made during the scoping procedure to determine whether the scoping procedure might have altered the voice sample produced. Additionally, the acoustic recording of the Rainbow Passage was used as part of the perceptual experiment to determine the degree to which listeners accurately identify the speaker gender. The order in which the two recordings were

collected (endo-/stroboscopic with simultaneous acoustic recording vs. acoustic recording only) was alternated between subjects.

Measurement

Endo-/Stroboscopic Image Analysis. To prepare the exams for analysis, Microsoft Movie Maker was used to extract clips of each subject breathing quietly, producing extended vowels at a comfortable pitch and loudness, and producing pitch glides (ascending and descending). A total of 3-5 productions of each task from each subject were extracted for the final movie that was viewed for image analysis.

Two state-licensed SLPs with a minimum of 4 years of clinical experience in the area of clinical voice disorders, including evaluation of endo-/stroboscopic recordings provided independent ratings of each recording using a standard rating form that was a modification of the Stroboscopy Evaluation Rating Form (SERF; Poburka, 1999) (Appendix C). The raters then reviewed their scores and the video together and arrived at a consensus rating for each parameter. The parameters that were rated, and the portion of the speech sample used to rate each parameter are detailed below (Table 1). The SLP raters were not involved in the scoping procedures and had not met any of the MFT participants. Space was provided at the end of the form for the raters to make note of any other impressions or observations that were not specifically included in the rating protocol.

Acoustic Analysis. The digital audio recordings from the endo-/stroboscopic and audio only portions of the examination were analyzed using PRAAT v.5.1.02. A 2-second segment was extracted from the middle of a participant's second trial of

Table 1.

Parameters to be Rated During the Review of the Endo-/Stroboscopic Examinations

Parameter	Continuous Light		
	Quiet Breathing	Comfortable Pitch and Loudness	Pitch Glide
Symmetry of major laryngeal structures at rest (epiglottis, aryepiglottic folds, ventricular folds, arytenoids, true vocal folds)	X		
Amplitude of excursion of the vocal fold edge from midline (degree and symmetry)		X	
Mucosal wave excursion (degree and symmetry)		X	
Non-vibrating portions of the vocal folds		X	
Supraglottic activity (i.e. supralaryngeal constriction (degree and symmetry))		X	X
Vocal fold edge smoothness and straightness (irregularities and symmetry)	X	X	
Vertical level of the vocal		X	

folds (symmetry)			
Phase closure		X	
Phase symmetry		X	
Regularity of vocal fold vibration		X	
Glottal closure formation		X	
Tissue color	X		
Presence/absence of edema, vascularity, indicators of adequate hydration	X	X	
Laryngeal height adjustments			X
Pharyngeal tension		X	X

sustained /i/ at comfortable pitch and loudness. This 2-second vowel sample was analyzed acoustically and extracted for use in the perceptual listening experiment described below. The acoustic analysis included the following measures: mean F_0 , standard deviation of F_0 , jitter, shimmer, harmonic-to-noise ratio (HNR), mean dB,⁵ and formant frequencies 1 through 4 (F_1 - F_4). PRAAT software was also used to extract the second sentence of the Rainbow Passage for use in the perceptual listening experiment. The second sentence was analyzed acoustically to derive the mean F_0 , standard deviation of F_0 , F_0 minimum, F_0 maximum, HNR, mean dB, and syllables per second.

Perceptual Ratings of Voice. A perceptual rating experiment was conducted to determine how unfamiliar listeners perceived the MFT participants (i.e. whether the MFT participants were perceived as female). Ten young adults (nine females, one male) with little to no exposure to MFT persons served as listeners. All listeners were graduate students in audiology or speech-language pathology enrolled in the Intercampus Program in Communicative Disorders at the University of Kansas. The listeners ranged in age from 23 to 28 years old (mean age 25.1 years). Hearing status was collected via self-report. Seven listeners reported hearing within normal limits; the remaining three reported mild hearing loss but functional hearing that did not require amplification.

⁵ The mean dB measure was a relative measure rather than a calibrated one. The equipment, microphone position, gain settings, and recording room were constant across all recordings so that relative dB measures could be used to evaluate increases or decreases in loudness in one condition versus others.

The 2-second sustained /i/ sample that was extracted and analyzed for the acoustic measures was used in this perceptual experiment. Digital recordings of biological male and female age-matched control participants producing a sustained /i/ were also included in the listening experiment (i.e., 2-second segment of sustained /i/). Age matching to the MFT participants was within +/-2 years. For each MFT participant, a recording of a biological male and female of the same age (+/- 2 years) was included to verify the listeners' ability to correctly identify biological male and female speakers. Alvin2 software (beta version) was used to design a listening experiment. The 2-second voice samples were randomized across the full set of MFT and control participants. All recordings of MFT participants and ~25% (4 of 13) of the control subjects (two male controls, and two female controls) were played twice to allow listener reliability in making the perceptual judgment to be evaluated.

Playback was done in a quiet laboratory room using Alvin2 software, a laptop computer and high quality computer speakers. The software randomly selected a voice sample, played it over the computer speaker when the listener clicked a button on screen, and provided an on-screen environment for the listener to record their perceptions. For each voice sample that was played, the listener completed two tasks before moving on to the next voice sample. Listeners were first asked to identify the gender of the speaker by using the computer mouse to click a box labeled "Male" or "Female." They then rated the relative femininity/masculinity of the voice within the gender they selected by clicking on a slider bar on the computer screen. The slider bar was anchored on the left with the label "Masculine" and on the right with

“Feminine.” The listeners were instructed that they should rate the relative femininity/masculinity within the gender they selected (i.e. if they selected the voice as being “Female,” they would then rate it as a very masculine-sounding female, a very feminine-sounding female, or somewhere in between). Recall that only the male/female decision task is analyzed in this study primarily to confirm the extent to which listeners perceive the MFT participants as female. The masculinity/femininity ratings were archived for later analysis. Listeners were not told at any time that some of the voices they were listening to were MFT persons.

The listeners also participated in an identical experiment (identification of speaker gender and rating of femininity/masculinity) that used the second sentence of the Rainbow Passage as stimuli instead of a sustained /i/. Using the same listening experiment generator, the samples of the female and male voices from each MFT and control participant were randomized and played back for listeners. The order of completing the two listening tasks (rating of vowel productions and reading samples) was counter-balanced across the set of ten listeners.

Analysis

Reliability and Agreement.

Stroboscopic Data. The two SLP raters first independently rated each video sample using the standard form (Appendix C). They then conferred to offer one consensus rating that was used in the primary descriptive analysis. It was of interest to determine the extent to which this was a truly collaborative process as opposed to one in which a single rater might have dominated the decision making. To address

this issue, the individual ratings and the consensus ratings were reviewed for all endo-/stroboscopic parameters for all participants (n=144 decisions). The consensus decision recorded on the form and used for the primary analysis was coded as a “0” if the independent ratings from the two SLPs were identical, i.e., exact agreement. If the two independent ratings were not in agreement, the consensus rating was coded as a “1” if the consensus decision matched SLP #1’s decision, “2” if it matched SLP #2, and “5” if it matched neither SLP #1 nor #2’s ratings. These re-coded consensus ratings are displayed in Table 2.

Overall, there was exact agreement for 95 of 144 decisions (66%). For the remaining 49 decisions, 25 reflected SLP #1’s rating (17%), 22 reflected SLP #2’s rating (15%), and 3 were a rating that was neither SLP #1’s or #2’s original rating (2%). The exact agreement rate indicated that the two SLPs agreed the majority of the time, and when they did disagree on the independent ratings, the final consensus ratings were roughly split between SLP #1 (17%) and SLP #2 (15%). This suggested that both contributed equally to the final decisions that were recorded.

Listener Perception Data. The first listening task involved deciding if a speaker was male or female. Recall that the listening task had all of the MFT samples, and four control participant samples included twice. Exact agreement for the male/female decision based on the sustained vowel samples by the control participants was 97.5% (39 of 40; Table 3) and for the Rainbow Passage 100% (40 of 40; Table 4). For the MFT participants, exact agreement for the male/female decision based on the sustained vowels was 86.5% (78 of 90; Table 5) and for the Rainbow

Table 2.

Agreement Between SLP Endo-/Stroboscopic Exam Raters¹

Parameter	MFT Participants									Sum	Percent
	1	2	3	4	5	6	7	8	9		
Amplitude R	0	0	0	1	0	0	2	0	1		
Amplitude L	0	0	0	1	5	0	2	0	0		
Mucosal Wave R	0	1	1	0	0	0	1	0	1		
Mucosal Wave L	2	0	1	0	0	0	0	0	2		
Supraglottic R	2	1	1	0	1	2	0	2	0		
Supraglottic L	2	1	1	0	1	0	2	2	0		
Supraglottic A	0	2	0	0	2	0	0	0	1		
Supraglottic Pr	2	1	1	1	1	1	2	0	0		
Vertical Level	0	0	0	0	0	0	0	2	0		
Phase Closure	0	0	0	1	0	1	0	0	0		
Phase Sym.	0	0	0	0	0	0	5	0	0		
Regularity	0	0	0	0	0	0	0	0	0		
Glottal Closure	0	0	0	0	2	0	0	1	0		
Laryngeal Height	5	0	0	0	2	1	1	0	2		
Phar. Tension G	0	0	0	0	0	2	0	2	0		
Phar. Tension M	0	0	0	0	0	0	2	0	0		
										95	66%
Exact Agreement	11	11	11	12	9	11	8	11	11	95	66%
Rater 1 Choice	0	4	5	4	3	3	2	1	3	25	17%
Rater 2 Choice	4	1	0	0	3	2	5	4	2	21	15%
Compromise	1	0	0	0	1	0	1	0	0	3	2%

¹ A "0" indicated exact agreement between the two SLPs; "1" was a consensus rating that equaled SLP #1's rating; "2" equaled SLP #2's rating; and "5" equaled neither SLP #1 nor SLP #2's ratings.

Table 3.

Listener Agreement for Male/Female Decision of Control Participants within Group for the Sustained Modal Vowel²

Control Participant					
Listener	3	6	9	12	% of Participants with Exact Agreement
1	1	1	1	1	100
2	1	1	1	1	100
3	1	1	1	1	100
4	1	1	1	1	100
5	1	1	1	1	100
6	1	1	1	1	100
7	1	1	1	1	100
8	1	1	1	1	100
9	1	1	1	1	100
10	1	0	1	1	75
<hr/> % of Listeners with Exact Agreement for this Participant					
	100	90	100	100	

² 1=ratings agreed; 0=ratings disagreed

Table 4.

Listener Agreement for Male/Female Decision of Control Participants within Group for the Rainbow Passage³

Control Participant					
Listener	3	6	9	12	% of Participants For Whom Listener had Exact Agreement
1	1	1	1	1	100
2	1	1	1	1	100
3	1	1	1	1	100
4	1	1	1	1	100
5	1	1	1	1	100
6	1	1	1	1	100
7	1	1	1	1	100
8	1	1	1	1	100
9	1	1	1	1	100
10	1	1	1	1	100
<hr/> % of Listeners who had Exact Agreement for this Participants					
	100	100	100	100	

³ 1=ratings agreed; 0=ratings disagreed

Table 5.

Listener Agreement for Male/Female Decision of MFT Participants within Group for the Sustained Modal Vowel⁴

MFT Participant										
Listener	1	2	3	4	5	6	7	8	9	% of Participants with Exact Agreement
1	0	1	1	1	1	1	1	1	1	89
2	1	1	1	1	1	1	1	1	1	100
3	0	1	1	1	1	1	1	1	1	89
4	0	1	0	1	0	1	1	1	1	67
5	1	1	1	0	1	1	1	1	0	78
6	1	1	1	1	1	0	1	1	1	89
7	1	1	0	1	1	1	1	1	1	89
8	0	1	1	0	1	1	1	1	1	78
9	1	1	1	1	1	1	1	1	0	89
10	1	1	1	1	1	1	1	1	1	100
<hr/> % of Listeners with Exact Agreement for this Participant <hr/>										
	60	100	80	80	90	90	100	100	80	

⁴ 1=ratings agreed; 0=ratings disagreed

Table 6.

Listener Agreement for Male/Female Decision of MFT Participants within Group for the Rainbow Passage⁵

MFT Participant										
Listener										% of Participants
	1	2	3	4	5	6	7	8	9	For Whom Listener had Exact Agreement
1	1	1	1	1	1	1	1	1	1	100
2	1	1	1	1	1	1	1	1	1	100
3	1	1	1	1	1	1	1	1	1	100
4	0	1	1	1	1	1	1	1	1	90
5	1	1	1	1	1	1	1	1	1	100
6	1	1	1	1	1	1	1	1	1	100
7	1	1	1	1	1	1	1	1	1	100
8	0	1	1	1	1	1	1	1	1	90
9	1	1	1	1	1	1	1	1	1	100
10	1	1	1	1	1	1	1	1	1	100
<hr/> % of Listeners who had Exact Agreement for this Participant										
	80	100	100	100	100	100	100	100	100	100

⁵ 1=ratings agreed; 0=ratings disagreed

Passage 97.8% (88 of 90; Table 6). Overall, the exact agreement data indicate that listeners were consistent in their male/female decision for both groups of speakers and for both speech samples.

Endo-/Stroboscopic Analysis. The primary data analysis was descriptive in nature with the intention of informing about the laryngeal presentation of MFT persons producing their female voice. Depending on whether a parameter was judged categorically or scaled in some fashion, frequency distributions, means, medians, ranges and standard deviations were computed.

Acoustic Analysis. The acoustic analyses were completed to allow for more informed interpretation of the visual-perceptual ratings of the stroboscopic data. *Spearman's rho correlation coefficients* between various rating data from the stroboscopic exams and acoustic parameters were computed using SPSS v.16.0. One concern was that the scoping procedure might cause an MFT person to alter her voice production, and in doing so would compromise the ability to confidently describe the laryngeal adjustments that the MFT individual was doing to produce the female voice. To evaluate the influence of the scope presence on voice production, a set of ten acoustic parameters were compared for the samples recorded with and without the scope in place. These were taken from the audio recording made with the headset microphone and portable CD-recorder (as opposed to the microphone positioned on the neck as part of the stroboscopy set-up). A series of *t*-tests for paired data were calculated for each acoustic parameter. Correlations between acoustic parameters from the sustained vowel and the Rainbow Passage were also calculated

to determine the relationship between the steady state vowel-production and the reading sample that would be considered closer to spontaneous speech.

Perceptual Ratings Analysis. For the perceptual experiment data, the primary intent was to determine the extent to which listeners accurately identified the intended gender of the speaker from the sustained vowel production. The sustained vowels, as opposed to the Rainbow Passage, served as the primary data set because the endo-/stroboscopic data were derived from the vowel production. However, the analysis of the perceptual data for the sustained vowels that is described below was also completed for the perceptual ratings of the Rainbow Passage. The Rainbow Passage might be considered a closer approximation to spontaneous speech than the sustained vowel. To help confirm the extent to which the MFT participants pass as female, the Rainbow Passage provided a more ecologically valid sample than the vowel.

Each identification response by a listener was coded as “accurate” if it matched the intended gender of the speaker (i.e., accurate for an MFT speaker was identified as “female” by the listener). The response was coded as “inaccurate” if the listener identified the speaker gender as being opposite of what the participant was intending. For each participant sample, a percent accurate identification was calculated based on responses from the group of ten listeners. The mean percent accurate identification was calculated for the MFT and the control groups.

Additionally, a 2x2 contingency table was constructed with the columns representing the two speaker groups (MFT and Control) and the two rows representing “accurate” and “inaccurate” identification. For the contingency table, a listener was considered

accurately identified if eight or more listeners ($\geq 80\%$) accurately identified the intended gender. A *Fisher exact probability test* was calculated to evaluate the distribution of responses in the contingency table for the vowel and for the Rainbow Passage, respectively.

Results

Description of the MFT Sample

Biographical information was collected via a history questionnaire (Appendix A). All nine participants were MFT persons who lived in a female gender role 100% of the time in their daily lives and were taking part in hormone replacement therapy at the time of their participation. Means and standard deviations were calculated for participant age (mean 50.1 years) and length of time spent living in a female gender role 100% of the time (mean 5.2 years). Five participants (56%) had undergone genital reconstructive surgery, and three (33%) had undergone other surgeries or medical procedures that may have had some effect on the voice (but were not done with the intention of altering the voice). These data are detailed in Table 7.

Information about the participants' voice use was also collected in the history questionnaire. The participants were asked if they ever experienced pain, fatigue, strain or loss with regard to their voice. Sixty-seven percent of participants reported some type of voice symptom(s). Additionally, 67% of participants reported that they frequently used their voice in activities such as singing or excessive talking at work. One participant had a history of smoking, but had quit three years prior to participation in the current investigation. These data are summarized in Table 8.

Participants were asked their own perceptions of their feminized voice. They were asked how often they believed others perceived their voice as female, how feminine they would rate their own voice, how satisfied they were with their voice, and the method(s) that they used to feminize their voice. The participants believed

Table 7.

Biographical Data of MFT Participants (SD = standard deviation)

Participant	Age in years	Years spent in female role 100% of the time	Genital reconstructive surgery	Other Surgeries/ Procedures that may affect the voice
1	38	1 year	no	none
2	71	8 years	no	Septoplasty
3	33	6 years	yes	Intubated
4	49	4 years	yes	Tracheal Shave, Upper Lip Reduction
5	51	8 years	yes	none
6	51	2 years	yes	none
7	61	3 years	no	none
8	54	12 years	yes	none
9	43	2 years	no	none
Summary	Mean = 50.1 SD = 10.9	Mean = 5.2 years SD = 3.4 years	yes = 5 (56%) no = 4 (44%)	

Table 8.

Voice Use Information of MFT Participants

Participant	Pain	Fatigue	Strain	Loss	Substantial Voice Use?	Smoking History
1					Occupation	never
2			X		no	never
3					Occupation	never
4	X	X	X		Singing	never
5	X	X	X		Occupation	never
6	X	X	X		Occupation	never
7	X	X	X		no	42 yrs; quit 3 yrs prior to study participation
8		X		X	Karaoke	never
9					no	never
Summary	44%	56%	56%	11%	67%	11%
Frequency	(4/9)	(5/9)	(5/9)	(1/9)	(6/9)	(1/9)

that others perceived their voices as female an average of 85% of the time. Self-ratings of vocal femininity and satisfaction were done on a scale of 1 to 10 (1=male/masculine/not satisfied, 10=female/feminine/satisfied). Mean vocal femininity rating was 7.55 and voice satisfaction was 7.33. Two participants reported having seen an SLP or other voice professional; however, this was on a consultative basis only. None of the 9 participants received regular intervention from a SLP or other voice professional. Individual responses are reported in Table 9.

Endo-/Stroboscopic Image Analysis

Statistical means and standard deviations were calculated for various parameters judged from the endo-/stroboscopic examinations. Ratings for individual participants on each parameter are given in Tables 10-12. The right and left vocal fold edges traveled an average of 36% and 33% of the total width of each vocal fold, respectively⁶. The mucosal wave of the right and left vocal folds traveled a distance that was on average 41% and 34% of the width of each vocal fold, respectively. Extent of supraglottic activity during voice production was rated for the right ventricular fold and left ventricular fold separately. Additionally, the SLP raters rated the extent of supraglottic constriction in the anterior-posterior dimension with separate ratings for anterior constriction and posterior constriction. The extent of supraglottic constriction was scaled from 0=no constriction noted to 5=substantial constriction (see Appendix C). All of the MFT participants were noted to have some

⁶ For this rating, the SLPs chose a distance representing 0-20% (scale value=2), 21%-40% (4), 41-60% (6), 61-80% (8) or 81-100% (10) of the width of the vocal fold. For the mean calculation here, the scale values were converted to 20%, 40%, 60%, 80% and 100%. This same scaling was utilized for the mucosal wave parameter.

Table 9.

Perceptions of Feminized Voice by MFT Participants and Methods Used to Feminize the Voice

Participant	Self Report of frequency that voice is perceived as female by others	Self rating of voice femininity ¹	Satisfaction with voice ²	Method used to feminize voice ³
1	100%	10	10	c
2	90%	7	9	b
3	90%	9	9	c
4	100%	9	9	b, c
5	95%	8	9	a, c
6	80%	6	4	a
7	50%	5	4	a
8	90%	7	8	a
9	70%	7	4	none
Summary	Mean = 85% SD = 3.5	Mean = 7.55 SD = 2.19	Mean = 7.33 SD = 1.49	a = 44% (4/9) b = 22% (2/9) c = 44% (4/9) none = 11% (1/9)

¹1=male, 10=female

²1=Not satisfied, 10=satisfied

³ Reported methods were: “at home program” (a), “consultation with SLP/voice professional” (b), and “self-directed practice” (c)

degree of supraglottic constriction of both the left and right ventricular folds during sustained /i/ production. Constriction of the right ventricular fold toward midline had a mean rating of 1.9, and the left ventricular fold had a mean rating of 2.0. Eight of nine participants had some degree of anterior supraglottic constriction (i.e., epiglottis or pedicle of the epiglottis moving posteriorly). This supraglottic anterior constriction had a mean rating of 1.4. The raters only supplied ratings of posterior supraglottic constriction for four of the nine MFT participants. Upon examination, it was unclear why the raters did not provide ratings for the remaining five participants, and as such, these data have not been included in this investigation. Individual ratings of each MFT participant are included in Table 10. One participant (Participant 4) had a non-vibrating portion of the right and left vocal folds. The non-vibrating portion was located on the posterior portion of both vocal folds and represented 20% of the superior, posterior surface of each vocal fold.

Eight of nine participants (89%) had vocal folds that vibrated on the same vertical plane (i.e., on-plane which is considered normal). Phase closure of the vocal folds was variable among the participants. Four participants (44%) were rated as having a phase closure relationship of 66%/33% open-to-closed ratio which is considered to be normal (Table 11). Four other participants (44%) presented with a 90%/10% open-to-closed ratio; this reflects an open-closed relationship that is skewed toward “open” and is consistent with a phase closure relationship during breathy voice production. One participant (11%) presented with a 33%/66% open-to-closed ratio; this is an open-closed relationship skewed toward “closed” and is

Table 10.

Numeric Measurements of Glottal and Supraglottal Movement

Participant	Amp	Amp	MW	MW	SGC	SGC	SGC
	(R VF)	(L VF)	(R VF)	(L VF)	(R)	(L)	(A)
1	40%	40%	40%	60%	2	2	1
2	20%	20%	40%	20%	3	3	1
3	40%	40%	50%	50%	1	1	0
4	20%	20%	20%	20%	3	3	2
5	40%	40%	40%	40%	2	2	2
6	40%	40%	40%	40%	1	1	1
7	20%	20%	40%	20%	2	1	2
8	40%	40%	40%	40%	1	1	2
9	60%	40%	60%	20%	2	4	2
Mean	36%	33%	41%	34%	1.9	2.0	1.4
SD	13	10	11	15	0.8	1.1	0.7

Key:

Amp=Amplitude
VF=Vocal Fold

MW=Mucosal Wave
R=Right L=Left

SGC=Supraglottic Contraction
A=Anterior

Table 11.

Features of Vocal Fold Position and Movement During Sustained /i/ at Modal

Pitch

Participant	Vertical Level	Phase Closure	Phase Symmetry	Regularity
1	on-plane	66%/33%	100%	100%
2	on-plane	33%/66%	100%	80%
3	on-plane	66%/33%	100%	100%
4	on-plane	90%/10%	100%	100%
5	on-plane	66%/33%	100%	80%
6	on-plane	90%/10%	100%	100%
7	on-plane	90%/10%	60%	100%
8	off-plane	66%/33%	80%	100%
9	on-plane	90%-10%	100%	100%

consistent with pressed voice production.

Seven participants (78%) had vocal folds that vibrated symmetrically 100% of the time; one (11%) had vocal folds that vibrated symmetrically 80% of the time and another (11%) 60% of the time. A greater time spent in symmetrical vibration is considered optimal for producing a clear voice quality. Seven participants (78%) had vocal folds that vibrated regularly 100% of the time; two participants (22%) had vocal folds that vibrated regularly 80% of the time. A higher percentage of time spent in regular vibration is desired.

Participants presented with a variety of glottal closure patterns (Table 12). Two participants (22%) had complete glottal closure during a sustained /i/. An hourglass formation, anterior gap, and longitudinal gap, respectively, were seen in one participant each (11% each). Four participants (44%) had a posterior gap during phonation. Five participants showed signs of dehydration, four with thick mucous (44%) and one with mild mucous (11%). Laryngeal height adjustments (upward) during phonation at a modal pitch were observed in eight participants (89%). Three participants (33%) made minimal adjustments and five participants (56%) made moderate laryngeal height adjustments during pitch elevation. During pitch glides, all participants were rated as having increased tension in the pharyngeal walls. Five participants (56%) demonstrated “significant” tension and four participants (44%) had “some” tension. During modal pitch phonation, two participants (22%) demonstrated pharyngeal tension, while the remaining seven participants (78%) had none.

Table 12.

Other Notable Features of the Larynx and Pharynx from the Endo-/Stroboscopic Examination

Participant	Glottal Closure	Signs of Dehydration	Laryngeal Height Adjustment	Pharyngeal Tension Pitch Glides	Pharyngeal Tension Modal
1	Posterior Gap	None	Moderate	Significant	None
2	Complete	Thick Mucous	Moderate	Some	None
3	Posterior Gap	Thick Mucous	Moderate	Some	None
4	Posterior Gap	None	Minimum	Significant	None
5	Posterior Gap	None	Minimum	Significant	Some
6	Anterior Gap	Thick Mucous	Moderate	Some	None
7	Incomplete	Mild Mucous	Minimum	Significant	Some
8	Complete	Thick Mucous	None	Some	None
9	Hourglass	None	Moderate	Some	None

Acoustic Analysis

Preliminary analysis of acoustic signals was completed in order to determine whether the presence of the nasopharyngoscope altered the voice production. Audio recordings of the MFT participants from the endo-/stroboscopic and from the audio only portions of the experiment were compared across ten acoustic parameters. Means, standard deviations, t values and probabilities for the ten parameters are presented in Table 13. Values for the ten parameters for each MFT participant are shown in Tables 14 and 15. There were no statistical differences in acoustic parameters for vowels produced with versus without the scope in place, indicating that the scope presence did not significantly alter the voice sample.

A second set of preliminary analyses of the acoustic data was completed to compare acoustic features of the sustained /i/ to that of the Rainbow Passage. This was done to provide some information regarding the extent to which the voice and laryngeal activity of MFT participants during a steady-state production (/i/) were comparable to activity during a speech sample that might more closely approximate spontaneous speech (sentence reading). Using audio recordings of sustained /i/ and the second sentence of the Rainbow Passage when the scope was in position, two separate paired t -tests were computed to evaluate within speaker differences in mean F_0 and mean dB, respectively (Table 16). Neither of the two t -tests reached statistical significance with an alpha level of .05. However, the t -test for the mean F_0 approached statistical significance ($p=.053$). The mean F_0 for the

Table 13.

Means, Standard Deviations (SD) and t-Test Results for the Acoustic Parameters of the Modal Vowel (/i/) of MFT Participants

Parameter	Scope Presence	Mean	SD	t-value	Significance
F ₀	Scope	188.94	30.13	-0.405	0.696
	No Scope	196.21	42.72		
F0 SD	Scope	2.44	2.3	-1.062	0.319
	No Scope	7.19	13.23		
Jitter	Scope	0.25	0.13	-0.716	0.494
	No Scope	0.29	0.13		
Shimmer	Scope	5.82	2.38	0.688	0.511
	No Scope	5.3	2.25		
HNR	Scope	22.77	3.71	-0.488	0.639
	No Scope	23.3	4.63		
Mean dB	Scope	80.88	3.83	0.05	0.961
	No Scope	80.82	3.61		
F ₁	Scope	310.64	34.82	-0.17	0.869
	No Scope	312.88	40.97		
F ₂	Scope	2465.2	253.85	1.17	0.276
	No Scope	2387.7	326.63		
F ₃	Scope	3000.26	292.14	-1.017	0.339
	No Scope	3102.18	277.91		
F ₄	Scope	4369.22	488.8	1.246	0.248
	No Scope	4159.31	391.42		

Table 14.

Acoustic Parameters of the Modal Vowel /i/ of MFT Participants with the Nasopharyngoscope in Place

Participant	Mean	F ₀	Mean							
	F ₀	SD	Jitter	Shimmer	HNR	dB	F ₁	F ₂	F ₃	F ₄
1	214.38	2.20	0.26	9.00	18.26	75.38	346.29	2296.48	3196.84	4745.22
2	175.22	2.53	0.13	4.56	22.59	83.19	336.96	2282.09	2633.19	4137.90
3	190.63	1.16	0.30	7.33	20.46	79.46	284.00	2835.54	3401.49	4662.14
4	189.21	1.48	0.23	3.70	25.46	84.67	334.20	2645.83	3274.89	4697.22
5	216.37	8.40	0.52	5.85	21.12	81.27	353.42	2774.45	3109.63	5061.29
6	164.96	0.96	0.17	9.68	18.5	74.76	296.67	2267.95	2681.89	3982.26
7	238.69	2.32	0.22	2.87	29.66	85.38	253.57	2084.96	2666.43	3435.21
8	141.63	1.31	0.11	5.26	23.16	80.23	314.33	2466.52	2864.85	4221.21
9	169.37	1.59	0.35	4.14	25.75	83.57	276.34	2533.01	3173.17	4380.50
Mean	188.94	2.44	0.25	5.82	22.77	80.88	310.64	2465.20	3000.26	4369.22
SD	28.41	2.17	0.12	2.24	3.5	3.61	32.83	227.05	261.30	437.19

Table 15.

Acoustic Parameters of the Second Sentence of the Rainbow Passage of MFT

Participants without the Nasopharyngoscope in Place

Participant	Mean F ₀	F ₀ SD	Min F ₀	Max F ₀	HNR	Mean dB	Duration (sec.)
1	198.36	22.86	96.40	293.15	14.38	76.93	3.36
2	156.48	51.66	69.10	255.81	13.50	79.18	3.78
3	187.05	64.13	79.55	483.34	13.77	76.70	3.68
4	194.68	48.39	75.53	279.88	16.29	83.90	3.63
5	165.06	26.37	67.34	244.96	14.53	78.57	3.77
6	169.64	26.60	75.28	238.04	15.82	77.46	4.55
7	177.55	34.61	67.70	493.69	17.47	79.84	5.17
8	146.71	37.91	94.73	457.79	15.75	83.10	5.03
9	132.30	16.82	76.60	188.78	16.41	82.83	3.61
Mean	169.75	36.59	78.02	326.16	15.44	79.83	4.06
SD	20.90	14.58	10.19	111.31	1.26	2.63	0.63

sustained vowel was ~188 Hz compared to ~170 Hz for the reading passage. Overall, however, the interpretation of this preliminary analysis is that the mean F_0 and dB do not statistically differ for the sustained vowel and the reading passage.

Perceptual Ratings of Voice

In the perceptual rating portion of the study, four of the MFT participants (44%) were consistently rated as having a female voice during the reading of the second sentence of the Rainbow Passage while the remaining five were judged to be male (consistently = $\geq 80\%$ of listeners identifying as a particular gender; Table 17). For the sustained vowel samples, gender identification accuracy dropped to 22% for the MFT participants (two of nine participants). In contrast, listeners accurately identified speaker gender for 100% of the control participants (male and female) based on acoustic recordings of the Rainbow Passage (Table 18). Accuracy of gender identification remained high when listeners judged the sustained /i/ from the control speakers (89% for females; 100% for males). The perceptual raters consistently rated all control participants as belonging to correct gender during both parts of the experiment.

To evaluate whether there was a statistical difference in the proportion of participants in the MFT and control groups who were accurately identified in terms of gender, 2x2 contingency tables were constructed for the vowel and the Rainbow Passage data (Tables 17 and 18). In each contingency table, columns represented speaker group (MFT Participants, Controls) and rows represented

Table 16.

t-Test Results from Comparison of Acoustic Measures of Vowel and the Rainbow Passage with the Nasopharyngoscope in Place.

Parameter	Stimulus	Mean	SD	t	Significance
Mean F0	Vowel	188.94	30.13	2.27	0.053
	Rainbow	169.76	22.17		
Mean dB	Vowel	80.88	3.83	1.05	0.323
	Rainbow	79.83	2.79		

Table 17.

Male/Female Identification Rates by Group and Speech Sample (accurate ID = $\geq 80\%$) for MFT Participants

Group	Participant	Rainbow Passage			Sustained Vowel		
		Female	Male	Accurate	Female	Male	Accurate
MFT	1	100	0	yes	30	70	no
	2	10	90	no	0	100	no
	3	100	0	yes	60	40	no
	4	100	0	yes	90	10	yes
	5	100	0	yes	90	10	yes
	6	0	100	no	0	100	no
	7	0	100	no	0	100	no
	8	0	100	no	0	100	no
	9	0	100	no	20	80	no
<hr/>							
% Accurately							
Identified				44%	22%		

Table 18.

Male/Female Identification Rates by Group and Speech Sample (accurate ID = $\geq 80\%$) for Control Participants

Group	Participant	Rainbow Passage			Sustained Vowel		
		Female	Male	Accurate	Female	Male	Accurate
Control - Female	1	100	0	yes	100	0	yes
	2	100	0	yes	70	30	no
	3	100	0	yes	90	10	yes
	4	100	0	yes	100	0	yes
	5	100	0	yes	90	10	yes
	6	100	0	yes	100	0	yes
	7	100	0	yes	100	0	yes
<hr/>							
% Accurately							
Identified				100%	89%		
Control - Male	8	0	100	yes	0	100	yes
	9	0	100	yes	0	100	yes
	10	0	100	yes	0	100	yes
	11	0	100	yes	0	100	yes
	12	0	100	yes	0	100	yes
	13	0	100	yes	0	100	yes
	14	0	100	yes	0	100	yes
<hr/>							
% Accurately							
Identified				100%	100%		

accuracy of gender identification. A *Fisher exact probability test* for a 2x2 table was computed for each table (vowel and the Rainbow Passage, respectively) to determine the probability of obtaining a frequency distribution as extreme or even more extreme than the frequency distribution observed in this study (Siegel & Castellan, 1988).

For each *Fisher exact probability test*, the null hypothesis (H_0) was that accuracy of gender identification does not vary as a function of participant group; the alternative hypothesis (H_1) was that accuracy of gender identification does vary significantly depending on which participant group a person belongs. Using the *Fisher exact probability test* for the vowel samples, the probability of obtaining cell frequencies as extreme or even more extreme than those actually observed in Table 19 was 0.001⁷. For the samples from the Rainbow Passage, the computed probability of obtaining cell frequencies as extreme or even more extreme than those actually observed in Table 20 was 0.004. These probability values are small; leading to the rejection of H_0 and the conclusion that accuracy of gender identification varies depending on participant group membership. In this case, gender identification accuracy is higher for the controls regardless of the speech sample being judged.

⁷ The formula for computing the *Fisher exact probability* from Siegel and Castellan (1988) is as follows:

$$p = \frac{(A+B)!(C+D)!(A+C)!(B+D)!}{N!A!B!C!D!}$$

Table 19.

2x2 Contingency Table for Gender Identification Accuracy Based on the Vowel Samples

Group			
	MFT	Control	
Gender Identification	Participants	Participants	Combined
Accurate	2	13	15
Inaccurate	7	1	8
Total	9	14	23

Table 20.

2x2 Contingency Table for Gender Identification Accuracy Based on the Second Sentence of the Rainbow Passage

Gender Identification	Group		Combined
	MFT Participants	Control Participants	
Accurate	4	14	18
Inaccurate	5	0	5
Total	9	14	23

Discussion

The primary purpose of the current study was to describe the laryngeal presentation of MFT speakers as they produced their female voice. In order to do this, nine MFT participants underwent endo-/stroboscopy while they produced a sustained vowel at their habitual pitch and during pitch glides. These examinations were viewed by two SLPs who made observations of the vocal folds, larynx, and pharynx. In addition to describing the configuration and movement of the vocal folds and surrounding structures in MFT speakers, this study also sought to identify any potentially abusive vocal behaviors or signs of vocal abuse. The intent was to describe the laryngeal presentation for MFT speakers whose communication passed as female the majority of the time. As described below, all participants self-reported that their voice passed a high percentage of the time in daily interactions, although the listening experiment completed in this study was not consistent with the self-reports.

Laryngeal Presentation of MFT Speakers

The nine MFT speakers in this study demonstrated a variety of laryngeal presentations when speaking in their female voice. However, there were some trends noted across the parameters that were rated by the SLPs that provide insight into how the MFT participants may be utilizing the larynx. Seven of the nine MFT speakers presented with incomplete glottal closure during the habitual pitch, sustained vowel production. The incomplete glottal closure presented in different ways across these seven speakers with four presenting with a posterior gap and one each presenting with an anterior gap, longitudinal gap, and hourglass formation, respectively.

Most biological male speakers are expected to have complete glottal closure when speaking. Kendall (2009) found that 71% of males were consistently rated as speaking with complete glottal closure when observed with videostroboscopy and high-speed laryngeal imaging. Södersten and Lindestad (1990) found similar results, with 67% of males demonstrating complete glottal closure when phonating at habitual pitch with normal loudness. When they did present with incomplete glottal closure, it was typically an anterior gap (Sulter et al., 1996). Conversely, typical biological women often present with a posterior glottal chink, ranging in incidence from ~35% (when using a soft and loud voice) to ~95% (at habitual pitch with normal loudness) in various studies (Schneider & Bigenzahn, 2003; Södersten et al., 1995; Stemple, Stanley, & Lee, 1995; Södersten & Lindestad, 1990). This glottal configuration is associated with breathiness that is often perceived in female speech (Södersten & Lindestad, 1990).

The four MFT speakers who presented with a posterior glottal gap in this investigation were consistently perceived as female during the Rainbow Passage portion of the perceptual experiment. The remaining three speakers who phonated with incomplete glottal closure (anterior gap, hourglass, and longitudinal) and the two speakers who had complete glottal closure were consistently perceived as male by listeners. It is possible that those speakers who had an incomplete glottal configuration were doing so in an attempt to achieve a breathier voice. The fact that the only four MFT speakers who phonated with a posterior gap also were the only four of the nine MFT speakers perceived as female is intriguing and may suggest that

a certain type of glottal gap is more likely to generate aero-acoustic features that result in a female sounding voice. However, the small sample size in the current investigation and the absence of previous reports of glottal configuration of MFT speakers in the existing literature argue for a cautious interpretation and a call for further investigation of the issue in MFT speakers.

An anterior glottal gap has been identified as a result of vocal fatigue in biological males and females who did not initially present with an anterior gap (Eustace, Stemple, & Lee, 1996; Stemple, Stanley, & Lee, 1995). In videostroboscopic examinations of biological males who had a history of laryngeal fatigue, an anterior gap was observed in 28% of speakers (Eustace et al., 1996). The MFT speaker in the current investigation who presented with an anterior gap (Participant 6) reported a history of vocal fatigue when speaking, which has been cited as possible source of an anterior gap (Stemple Stanley, & Lee, 1995).

One might argue that the increased vocal fold tension created by increasing the F_0 of the voice by MFT speakers might decrease the amount of glottal closure they are able to achieve. Previous studies of biological males, however, do not support this contention. Sulter and Albers (1996) found a negative relationship between pitch and glottal closure in biological women (i.e. as pitch increased, glottal closure decreased), but not in biological men. Södersten and Lindestad (1990) also found that pitch had no effect on the degree of glottal closure in biological male speakers speaking at normal loudness. It seems unlikely then that the pitch elevation that the MFT participants in this study were attempting as part of their female vocal

presentation was responsible solely for the presence of glottal gaps in the majority of the participant pool.

The open/closed phase closure of the vocal folds during phonation was also notable for the MFT speakers in this study. A 66% to 33% ratio of vocal fold phase closure (i.e. 66% open and 33% closed) is expected of normal, non-breathy speakers, as indicated on the SERF (Pobruka, 1999). Kendall (2009) supports this ratio as normal, citing an open phase of 62.3%. This pattern was seen in four of the nine speakers in this study. Interestingly three of these speakers were consistently perceived as female and spoke with a posterior gap. It is possible that by speaking with a posterior gap, that an extended open phase of the vocal folds was not necessary to presumably achieve a breathier voice that might be perceived as more feminine.

Four speakers demonstrated a 90%/10% phase closure ratio. This indicates that the SLP raters perceived that the vocal folds were open for nearly all of the glottal cycle in these individuals. One might expect that a phase closure that is predominantly “open” would result in a breathier voice that might be more consistent with a female voice. However, three of four speakers with 90%/10% phase closure ratios were consistently perceived as male during the listening experiment. There are likely to be several features of the acoustic signal that contribute to a listener’s perception of the speaker’s gender. It may very well be that characteristics of the glottal flow itself are important. Flow through a posterior glottal gap may generate particular air turbulence that is different from that through vocal folds that are vibrating but with limited midline closure. Likewise, increased airflow through the

glottis might be more often associated with breathy voice, but in the absence of other laryngeal/voice adjustments (e.g. fundamental frequency), listeners may not consistently identify a speaker as female. The type of aero-acoustic outcome (and subsequently the perceptual qualities of the voice) associated with specific types of glottal configurations was not the focus of this study, but may deserve attention in the future. If it is the case that a posterior gap is associated with better female voice in MFT individuals than other types of glottal gaps, such a physiologic target could be the focus of therapeutic intervention by using endo-/stroboscopic biofeedback.

A laryngeal height adjustment upward during pitch glides was seen in 89% of participants. Prior studies have suggested that this type of upward movement of the larynx is common when biological males and females increase their pitch (Shipp 1975, Iwarsson & Sundberg, 1998). Shipp (1975) found that during a pitch glide, male speakers typically begin with an initial drop in laryngeal position and often raise it at least to a height at which it becomes obscured by the submandibular tissue when viewed laterally under fluoroscopy.

Although not formally analyzed in this study, informal inspection of mean F_0 data suggested that there was not a strong relationship between the degree of upward laryngeal height adjustment and F_0 . Likewise, degree of laryngeal adjustment on the glide did not appear to be related to more reliable perception as female. Interestingly, the one participant who did not have an upward laryngeal height adjustment actually demonstrated a downward height adjustment during sustained vowel production. She reported that this was a conscious strategy she used to feminize her voice; however,

she had one of the lowest mean F_0 s of all participants (141.63 Hz vowel, 146.71 Hz Rainbow Passage) and was not perceived as female during the listening experiment.

Amplitude of vibration had a group mean of 33% and 36% for the left and right vocal folds respectively. This falls within the low end of the range considered normal in the study by Kendall (2009) for biological males and females. In that study the investigators considered normal vibration amplitude to be approximately one-third to one-half of the visible width of the true vocal folds, citing Woo (1996), with a distance of 42% past midline considered to be normal. There were three participants who presented with amplitude ratings of 20% for both vocal folds (participants 2, 4, and 7). It is possible that these participants were creating excess tension during phonation in an attempt to achieve a higher pitch; increased vocal fold tension could cause the vocal folds to vibrate with decreased amplitude.

Extent of mucosal wave for the MFT speakers was, on average, 41% and 34% of the width of the vocal fold on the right and the left. Again, this is in good agreement with mucosal wave findings from Kendall (2009). The majority of participants had ratings that were 40% or greater. In the current study, three of the remaining four speakers who had at least one vocal fold with a mucosal wave rating <20% were the same three that had reduced amplitude ratings. Together, the reduced amplitude and wave excursion for these speakers may be consistent with vocal folds that are vibratory, but stiffer than most others. It is possible that this might be a reflection of increased vocal fold tension as an outcome of attempts to increase F_0 . Correlation analysis to evaluate relationships between acoustic features and

stroboscopic ratings was not a focus of this study. However, a secondary set of analysis calculating *Spearman rho rank order correlations* between the F_0 of the sustained vowel and the ratings of amplitude and mucosal wave resulted in weak correlations that were not statistically significant. It may simply be that these participants have mucosal wave excursions that fall toward the low end of the normal range.

Phase symmetry was normal for all but one MFT participant ($\geq 80\%$ was considered normal). Mild asymmetry in phase closure has been observed in patients with complaints of laryngeal fatigue (Eustace et al., 1996). Kendall (2009) observed asymmetry in vocal fold vibration in 26%-38% of participants without vocal pathologies. Participant 7 in the current study was judged to have 60% phase symmetry. This particular individual also had ratings for amplitude and mucosal wave that were lower than normal, had incomplete glottal closure, and a phase closure of 90%/10% (i.e., open). This woman stood out from her peers in many ways on the stroboscopy rating parameters and deviated more from the norm. She also happened to produce the sustained vowel at the highest F_0 in the group (mean of 238.69 Hz vs. group mean of 188.94 Hz) while being identified as male 100% of the time based on the sustained vowel and reading passage listening experiments. Overall, the picture for this participant is one in which she is attempting an elevated pitch but may be doing so by stiffening the vocal folds (resulting in reduced amplitude and mucosal wave) and positioning them in an open glottis configuration wherein the medial edges of the vocal folds are principally vibrating. Participant 7 also had a history of

smoking, which cannot be fully discounted as a possible contributor to asymmetries seen in her larynx.

In general, regularity, vertical plane position of the vocal folds, and presence of non-vibratory portions of the membranous vocal folds were rated as normal for all or nearly all of the MFT participants (i.e. no trend for abnormality for any of these three parameters). Regularity of the vocal folds was judged to be normal for all nine participants. Eight of nine participants had vocal folds judged to be in the same vertical plane (i.e. normal). One participant had a non-vibrating portion of the vocal folds in the posterior 20% of both vocal folds. This individual had a history of reflux, which might have caused some minor tissue change in the posterior glottis although indications of active reflux impacting the larynx were not readily apparent.

In summary, stroboscopic findings of the nine MFT speakers were as follows:

1. Incomplete glottal closure was common during sustained vowel production at habitual pitch. A posterior glottal gap was most common although three other types of gaps were also noted.
2. Posterior glottal gaps were present in the four speakers consistently rated as female in the listening experiment and those with other types of gaps or with complete closure were not perceived as females.
3. Phase closure ratios in the normal range (66%/33%) occurred most often in those speakers who presented with a female-sounding voice. A phase closure relationship that was more “open” (90%/10%) occurred in nearly half the group but these speakers tended not to be perceived as female.

4. The majority of participants in this study presented with normal upward laryngeal height adjustments during ascending pitch glides, vocal folds that vibrated with an amplitude and mucosal wave that fell within normal limits, and phase symmetry, regularity, vertical plane symmetry, and non-vibratory portions of the vocal folds that were considered normal. Parameters that were seen in the participants that are typically characteristic of a hyperfunctional larynx are presented in the following section.

Endo-/Stroboscopic Indications of Vocal Hyperfunction

Supraglottic contraction of the left and right ventricular folds during phonation was seen to varying degrees in all participants during the endo-/stroboscopic examinations. Clinically, this is usually interpreted as an indicator of increased tension and effort (Morrison & Rammage, 1993; Woo, Colton, Casper, & Brewer, 1994), and for that reason is considered a possible marker for hyperfunctional voice use. The fact that all of the MFT participants had activity of the right and left ventricular folds suggests that this is a strong tendency in the group. Besides contraction of the ventricular folds toward midline, voice clinicians often look for approximation of the pedicle of the epiglottis anteriorly with the arytenoids posteriorly (i.e. anterior-posterior (AP) supraglottic constriction). Eight of the nine MFT speakers were rated as having AP constriction (ranging from minimal to mild on the 5-point scale) in addition to left-right constriction suggesting that there was a general increase in laryngeal muscle tension during voicing. Stager, Neubert, Miller, Regnell, and Bielamowicz (2003) found that static left-right supraglottic constriction

and AP constriction (considered to always be static) are indicative of voice use patterns with excessive muscle tension. In the current study, the left-right and AP supraglottic activity might be an outcome of the MFT participants' attempt to increase speaking F_0 . That is, they may engage in a general increase in laryngeal muscle activity when trying to increase the length and tension of the vocal folds to elevate F_0 as part of their attempt to sound feminine. It might also be that in order to position the arytenoids and vocal folds to create a glottal gap, as was seen in all but two speakers, some individuals might engage in maladaptive increases in supraglottic muscle activity.

Ideally, to better understand the relationship between F_0 and supraglottic constriction, the MFT speakers would have also produced their former, presumably lower pitch, male voice during the stroboscopic exam for comparison. This was requested from all participants in the study. However, only three of the MFT speakers could easily shift back to producing what they felt was truly their "old" male voice. Several indicated that they no longer had much of a sense of how to produce their former voice. Others stated that even though they could attempt their male voice, they were unsure if that was truly what it used to be. Still others felt that they were producing a character voice when trying to sound like a man. An alternative would be to have stroboscopic ratings made of the MFT speakers producing the vowel at varying F_0 using their female voices. Recordings of the current participants doing pitch glides were obtained during this study. These archived recordings will be available for such analysis in future studies.

Presence of thick, whitish mucous either pooling or stranding within the larynx was seen in five (56%) of the participants. Clinically, presence of this type of mucous is often interpreted as a possible sign of less than optimal hydration. High viscosity mucous on the vocal folds has been shown to change the mechanical properties of the vocal fold cover and hamper mucosal vibration (Nakagawa, Fukuda, Kawaida, Shiotani, & Kanzaki, 1998). Hsiao, Liu, and Lin (2002) showed that this rough, thick mucous creates surface irregularities on the vocal folds resulting in greater glottal air turbulence and altered voice production. They also postulated that the mucous may have reduced the amplitude and frequency of the vocal fold vibration and exacerbated the symptoms of dysphonia. The mucous aggregation on the vocal folds that was present in half of the group, along with the elevated ratings of supraglottic activity during phonation for all of the group, lend preliminary support to the conclusion that the MFT speakers evaluated in this study may be engaging in maladaptive behaviors with a larynx that is not optimal in terms of hydration when producing their female voice. It is important to note that no edema, atypical color, or unusual vocal fold vascularity was appreciated in any of the participants' larynges. That is, there were no obvious tissue changes to the vocal folds such as nodules or edema. However, in the non-MFT literature it is clear that individuals with functional voice disorders (i.e., misuse, abuse, over-use of the voice) often do not show evidence of changes in the larynx (Morrison & Rammage, 1993; Koufman & Blalock, 1991; Hillman, Holmberg, Perkell, Walsh, & Vaughan, 1989).

Further support for the notion that several of the MFT speakers in the current study may be demonstrating a functional dysphonia is derived from their self-report of voice related complaints. Recall that participants were asked if they experienced voice-related pain, fatigue, strain, or loss. Six participants (67% of the group) reported that they experienced at least one of these phenomena. These types of symptoms are not expected to be present with healthy voice use. Boone, McFarlane, and Von Berg (2005) estimate that only about 3% of adults age 18 and over experience continuing voice symptoms, and this group primarily consists of groups of heavy voice users such as teachers.

Note Regarding Male/Female Identification by Listeners

The intended purpose of this study was to describe the laryngeal presentation of MFT persons whose voices successfully “passed” as female in their daily lives. However, there are conflicting indications about whether or not all the participants in the study had a passing female voice. The mean percent of the time that the MFT participants’ voices passed was 85% via self-report and six of nine reported $\geq 90\%$. All but one reported passing at least 70% of the time. As a group, this suggests a high self-reported pass-rate with perhaps one exception (Participant 7 discussed below). The perceptual listening experiment outcomes stand in contrast to these high self-reported passing rates.

The perceptual study was conducted to verify the participants’ claimed ability to pass solely on their voice. When hearing the second sentence of the Rainbow Passage, only four of the nine participants passed (speakers 1, 3, 4 and 5). These four

MFT participants were identified as female by 100% of listeners, while the remaining five participants were perceived as male by 90%-100% of listeners. Identification rates for the four MFT speakers identified as female from the sentence dropped when listeners were presented with the sustained vowel sample with only two individuals identified as female by at least 90% of the listeners. It is not surprising that the gender identification rates dropped when using the sustained vowel given the reduction in other possible gender cues in the acoustic signal compared to sentence reading (intonation, rate, articulatory modifications, etc.). However, the low identification rate from the reading stands in stark contrast to the self-reported passing rate.

It may be that higher passing rates reported by the MFT participants are accurate for more natural communication exchanges where there is more extensive verbal output as well as visual cues that might help signal the preferred female gender (e.g., clothing, facial/body/hair presentation, body language). Regardless, even without visual cues, listeners are able to accurately identify speakers as either male or female from an audio-only sample for non-MFT individuals (sustained vowel as well as reading). In previous studies requiring listeners to determine gender of male and female control speakers and MFT speakers, listeners correctly identified the gender of 100% or nearly 100% of male and female controls (Spencer, 1988; Gelfer & Schofield, 2000). That was not the case for the group of MFT participants in this study.

It was clear that a distinct divide existed in the participant pool between participants whose voices were perceived by the listeners as female and those whose

voices were perceived as male. As such, caution in the interpretation and generalization of the stroboscopic ratings is warranted. The descriptions of the laryngeal presentation are reflective of the convenience sample of MFT individuals that were available in the geographic area, not of MFT individuals for whom there is clear evidence of success at passing as female based on voice alone.

Consideration of Individual Participants and Subgroups

Given the heterogeneity in terms of passing and in terms of laryngeal presentation stroboscopically, preliminary consideration of data for individuals and small subgroups of the nine MFT persons is justified. The four MFT participants who were consistently perceived as female in the listening experiment also reported higher levels of femininity and satisfaction with their voice compared to the five who were consistently perceived as male in the listening experiment. There were not enough participants in this study to statistically compare those who were perceived as female and those who were not. However, it is intriguing that the mean self-rating of voice femininity for those consistently perceived as female by listeners was 9 (out of 10) compared to a mean of 6.4 for those perceived as male. Self-satisfaction with the voice for the four who were perceived as female was also notably higher compared to the five perceived as male (9.25 compared to 5.8 out of 10). The MFT participant self-report data and the listening experiment results seem to indicate that there is some correspondence between the two. That is, those MFT speakers who report high satisfaction with the voice and high voice femininity also tend to be perceived by others as female. This is consistent with the results of McNeill et al. (2008). Future

study utilizing larger samples and study designs specific to this issue is needed to further explore this issue.

The fact that four participants stood out perceptually to listeners and by self-report regarding their voice begs the question: Are there indications that they present differently than the remaining five participants in terms of the stroboscopic ratings, biographical data, or voice use and symptom report? Clearly the following observations must be considered preliminary given the small number of individuals being described. However, they may provide some direction for future studies.

Stroboscopically what stands out most is that these four individuals who were perceived as female all had a posterior glottic gap; none of the five perceived as male did. As noted previously, posterior glottal gaps are more prevalent in biological females than males. It may be that this particular glottal configuration is important for generating a voice that is more likely to be perceived as female. By speaking with a posterior glottal gap, MFT speakers may be creating similar-sounding aspiration noise that most speakers would associate with a female speaker.

The only other observations from the endo-/stroboscopic exam that shows a trend within the group of four who were consistently perceived as female were the ratings of mucous. Three of the four were judged to have no signs of dehydration; in contrast, four of the five perceived as male had indications of dehydration. This could be interpreted as a reflection of greater vocal care and hygiene for the four participants who were consistently perceived as female. The data gathered in this study do not allow for further investigation of this possibility, although there is some

intuitive sense to the conclusion (i.e. greater attention paid to the voice and its use might result in a better vocal outcome). Interestingly, these four women did not differentiate themselves from the group on the ratings of supraglottic activity. Ideally, the MFT women would be able to generate a feminine voice without excess effort or tension. However, these four women seemed as likely as those perceived as males to have increased supraglottic constriction.

The four MFT participants perceived as female in the listening experiment had an average age that was nearly 13 years less than the five perceived as male (43 years vs. 56 years). Ranked by age, the four perceived as female were the 1st, 2nd, 4th, and 5th (tied) youngest of the nine. Future studies exploring the relationship between age and feminization of the voice in MFT persons are needed to determine whether the current study results can be generalized or if they are idiosyncratic to the nine MFT participants in the current study. There are known age-related changes to the larynx that impact features of the voice, but it is not known how the biological aging of the larynx influences the MFT participants production of a female voice.

One other potential trend to make note of is the self-report of substantial voice use. Under the category for “substantial voice use”, three of the four women consistently perceived as female indicated significant occupational voice use and the fourth reported “singing” under this same category. Only two of the five speakers who were consistently perceived as male reported substantial voice use (one for occupational, one for karaoke). As a group the four perceived as female may have had more opportunity to practice and perfect their communication because of the heavy

voice use demanded in their lives. Presumably extended attempts to use the female voice as part of their job would result not only in “practice time” with the voice, but would also provide these women with natural feedback from coworkers or others that could help shape what they do with the voice. Future research will be needed to establish the amount and type of practice that yields the best voice feminization outcome.

There was no clear trend within the self-report of voice symptoms of pain, fatigue, strain and voice loss. Two of the four women who were perceived as female reported no negative voice symptoms; the other two both reported pain, fatigue and strain. Participants who reported only having used an at-home program or a one-time consultation with a voice professional were actually less successful than those who had devised their own method for feminizing their voice (“self-directed practice”) based on the listening experiment outcomes. All four of the women perceived as female reported “self-directed practice” as the method that they used to feminize the voice (with or without other methods). None of the five participants who were perceived as male reported “self-directed practice.” Again, this may simply be reflective of greater amount of time and attention spent on voice feminization by the four who had a passing female voice.

Acoustic analysis was not a primary focus in this study, but rather was used to help verify whether the scoping procedure altered voice production. As reported in the results, there were not statistical differences between the sustained vowels or the second sentence of the reading passage from acoustic recordings made with and

without the flexible endoscope in position. Although not a focus of the analysis, the acoustic recordings were available, allowing for a brief check on possible differences in acoustic features of the productions from the four perceived as female compared to the five perceived as male. Again, statistical comparisons are avoided given the small participant numbers and the lack of *a priori* study design considerations for such acoustic comparisons. However, it is interesting to note that the four perceived as female had a notably higher F_0 for the sustained vowel (202 Hz vs. 177 Hz) and reading passage (186 Hz vs. 156 Hz).

The available literature about acoustic features of MFT voice are clear that increasing F_0 alone is generally not sufficient to result in a passing female voice (Kaye, et al., 1993; Gelfer & Schofield, 2000; Gorham-Rowan & Morris, 2006). However, increasing F_0 is part of the adjustment that seems necessary and a gender ambiguous F_0 of 150-160 Hz is often targeted (Spencer, 1988; Wolfe et al., 1990). In the current investigation, the MFT participants who were consistently perceived as female had mean F_0 well above the gender ambiguous range in both the vowel and Rainbow Passage productions. The five speakers who were consistently perceived as male had mean F_0 that tended to be lower than those who were consistently perceived as females, although they were still generally within the gender ambiguous range.

Summary and Clinical Implications

Overall, this convenience sample of nine MFT participants showed a variety of laryngeal presentations endo-/stroboscopically but a few trends were observed. The results of this study indicated that attaining a posterior gap occurred consistently for

MFT speakers who were perceived as female. This suggests that a posterior gap may be important to for generating the aero-acoustic features of voice that listeners ultimately hear as a woman's voice. Those perceived as female also presented with a phase closure ratio that is seen in non-MFT participants; a more open phase closure ratio was seen for the majority of the group of individuals perceived as male. All participants presented with left-right supraglottic constriction and most demonstrated AP supraglottic constriction. Over half of the participants had some amount of mucous on the vocal folds during the endo-/stroboscopic exam. Two-thirds of participants experienced pain, fatigue, strain, and/or loss via self-report. These observations all are consistent with reports of voice overuse or misuse that suggests maladaptive voicing behaviors when attempting to produce the female voice.

Nasopharyngoendoscopy and stroboscopy may be a valuable biofeedback tool that could be used in voice therapy and is readily available to many SLPs who regularly work with individuals who have voice disorders. The results of this study suggest that other glottal formations may be insufficient in achieving a passing female voice, although replication of the study is certainly needed before generalizing broadly. The current study also highlights the possible need to address vocal hyperfunction during voice feminization therapy. This is particularly the case for clients who may have acquired hyperfunctional behaviors when trying to feminize their voices on their own.

None of the participants in this study received or sought out therapy from a professional to help in the voice feminization process. While some in the MFT

community may be able to attain an acceptable female-sounding voice as demonstrated by four of the participants in this study, it is clear that some may not be able to do so on their own. Even among the four who would be considered successful with voice feminization based on their self-report and the listener perceptual study, two had indications from stroboscopy (excess supraglottic activity) and self-report (voice pain, fatigue and strain) that most clinicians consider reflective of unhealthy voice use consistent with excess phonatory effort.

Overall, two-thirds of the participants in this study reported signs reflective of voice misuse or abuse, and only 22% of participants were perceived as female without co-occurring vocal symptoms. This was not a treatment outcome study, so it is not possible to say that professional intervention could have avoided the apparent increase in phonatory effort seen in these women. However, it is reasonable to assume that an SLP who is trained to diagnose, treat, and prevent vocal pathologies could teach an MFT person to use her voice in such a way that will help achieve her desired voice outcome without causing harm to her larynx and without inducing voice complaints of pain, fatigue, strain and loss (Mészáros et al., 2005). The findings also suggest that at-home voice feminization programs that are readily available for MFT women are not sufficient for all people; none of the women in this study who solely used the programs to feminize their voices were perceived as female in the perceptual experiment.

The results of this study reinforce the argument made by others that achieving a mean F_0 of 150-160 Hz is necessary, but not necessarily sufficient, to be perceived

as female (Spencer, 1988; Wolfe et al., 1990). The four participants perceived as female had a mean F_0 that ranged between 165.06 Hz and 198.36 Hz. The five participants not perceived as female had a mean F_0 that ranged between 132.30 Hz and 177.55 Hz. While three of these participants had mean F_0 that fell within or above the accepted target range, they were still not perceived as female. It is clear that other factors were affecting how listeners perceived them. Other authors have suggested that resonance and intonation patterns have a major influence on gender perception and, as such, should also be addressed in MFT voice intervention (Oates & Dacakis, 1997; Wiltshire, 1995; Dacakis, 2002; Carew, Oates, & Dacakis, 2007). Identification of these other factors was not the focus of this study. Future work that incorporates a multiparameter acoustic analysis (along with perhaps aerodynamic and endoscopic) and a more appropriate methodology is needed to address this issue.

Limitations and Future Directions

The primary limitation in this study was the small number of MFT participants, which limits the extent to which the findings can be generalized. The small group was also fairly heterogeneous in terms of age, time since beginning the transition process and other biographical factors. More stringent study inclusion criteria would perhaps allow for more informed interpretation of potentially relevant factors. However, the MFT population is relatively small in most geographic areas and is often difficult to identify and recruit into studies by medical and health care professionals for various reasons, which likely will necessitate cooperation among

investigators to complete collaborative research projects with sufficient participant numbers.

A second major limitation to this study was that the participants' ability to pass as female based on the voice alone was not confirmed by the listening experiment despite the participants' relatively high self-reported pass rate. In order to more accurately describe trends in the laryngeal presentation of MFT speakers who have successfully feminized their voices, a larger sample of the population should be examined and more careful confirmation of the extent to which listeners perceive participants as female is needed. Regardless, this study set out to describe the laryngeal presentation of MFT individuals who self-reported passing as female and that is what was done.

The speech sample collected from the MFT participants may not have been an accurate representation of their natural speaking voices. During the endo-/stroboscopic and audio only portions of the study, participants were asked to use their "normal female voice." It is possible, however, that they could have been speaking in such a manner that they believed would make them sound more feminine and was not truly representative of the voice that they used in their daily lives.

A third primary limitation was the speech sample that served as the focus of the investigation. Sustained vowels were chosen as the focus for the stroboscopic ratings and the perceptual listening experiment utilized the sustained vowel and a one-sentence portion of a reading passage. Laryngeal behaviors, and other speech behaviors, are obviously more complex when an individual is communicating in more

natural communication environments. The sustained vowel was chosen as the focus for the stroboscopic ratings because it allowed for an extended view of the larynx during phonation that could be used to rate the vocal folds and surrounding structure on the desired parameters. Clearly, however, this relatively steady-state and brief voice task is devoid of a wide range of other cues that might help an MFT woman convey that she is female. The sentence reading passage might more closely resemble connected speech than a sustained vowel; however, other factors that might influence gender perception are restricted such as word choice, grammatical structure choice and intonation. For both speech samples, visual cues to gender such as body language, appearance and use of communicative gestures are absent. Had the listener's been able to see the MFT speakers as they were talking, it may have influenced their decision, either positively or negatively.

A number of research needs have been identified throughout this manuscript. Some of the more prominent needs include:

1. More careful consideration of biographical factors that might impact the voice feminization process or outcomes.
2. Increased participant pool size to allow broader generalization of results.
3. A focus on communication treatment outcome studies for MFT persons that compares SLP intervention to other non-SLP directed attempts at voice feminization. Such studies should also consider the varying foci of SLP intervention (e.g., resonance, articulation, general communication style, etc.).

4. Within-participant comparisons of laryngeal adjustments when using the female and the male voice are needed to more carefully describe how MFT persons change laryngeal presentation or use when shifting between female and male voice modes. Aerodynamic and acoustic measures of the voice, along with stroboscopic would allow for a more complete description of how the voice is altered and could potentially help identify therapeutic targets.
5. Between participant comparison of the endoscopic, aerodynamic, acoustic and perceptual differences for those MFT persons who are identified as female by listeners to those who are not could help identify potentially relevant differences that could help guide SLPs in selecting therapeutic targets and approaches.
6. Correlations of perceptual characteristics (e.g. breathiness, pitch) with visual endo-/stroboscopic ratings in MFT persons that will enhance our understanding of what an MFT person may have to do physically to achieve a certain quality to her voice.

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Appendix A

Today's Date _____

Questionnaire

Name _____

Age _____

E-mail Address _____

Phone Number (____)____ - _____

Male to Female Transition

Do you identify as a male-to-female transsexual/transgendered person?

- Yes
- No

If not, please explain.

How long ago did you begin transitioning from male-to-female? (indicate in years or months)

Are you currently or have you ever taken hormones as a part of your transition?

- Yes
- No

If YES,

- how long have you been taking them?
- which ones are you taking?

If NO, do you plan to take hormones in the future?

Have you undergone any gender reassignment surgery?

- Yes
- No



If YES,

- When was it performed?
- Please describe the type of surgery(ies) you've had.
- Do you plan to undergo additional surgeries? Please describe.

If you have already undergone gender reassignment surgery, do you plan on undergoing more? If so, when?

If you have not undergone gender reassignment surgery, do you plan to in the future? If so, when? What type(s) of surgeries are planned?

What percentage of your life do you currently spend in your preferred gender?

For how long (in years or months) have you been living in your preferred gender with this frequency?

If you are not currently living in your preferred gender 100% of the time, do you plan on doing so in the future? If so, when?

Male to Female Voice

What percent of the time would you say that your voice passes as female?

How feminine would describe your female voice on a scale of 1 to 10 (1 being very male, 10 being very female)?

How satisfied are you with your female voice on a scale of 1 to 10 (1 being completely dissatisfied, 10 being completely satisfied)?

How often are you perceived as a woman on the telephone on a scale of 1 to 10 (1 being always perceived as a man, 10 being always perceived as a woman)?

How feminine do you believe that friends, family and significant others in your life would rate your voice (1 being not at all feminine, 10 being absolutely feminine)?

Have you used any at-home (audio, video, or from a book) or self-directed programs to help you feminize your voice? If so, please describe the program and what you did?

In the past, have you received services from a speech-language pathologist or any other type of voice professional to assist you with the feminization of your voice? If so, when did you have this service, what was the focus/specific techniques, how long did it go on, if you stopped - why did you stop how long and how frequently (how many times a week/month) did you receive intervention? Please describe any techniques that you learned that you still use.

Are you currently receiving services from a speech-language pathologist or other voice professional for voice feminization therapy? If so, how long and how frequently have you been receiving intervention? Please describe any techniques that you have learned that you are using and/or describe the focus of the therapy.

Have you had any surgery to alter the pitch of your voice? If so, describe the procedures you have had? When did you have the surgery(ies)? In your opinion, was the surgery successful?

What other steps, not listed above, have you taken to feminize your voice?

In your opinion, what makes one person sound more feminine than another?

Speech/Voice History

Before you began transitioning from male to female,

- Did you have any articulation or other speech problems (stuttering for example)? (This includes any problems you may have had as a young child.) If yes, explain. Did you see a speech therapist or other professional to help with this speech issue?
- Were you ever diagnosed with a voice problem? If yes, explain. Did you see a voice professional to help with this issue?

Since starting your transition

- Have you experienced any
 - Pain or discomfort in your larynx/voice box when you talk
 - Tiredness or fatigue in your voice
 - Strain or effort in your voice
 - Loss of your voice (unrelated to colds or other illness)
- If yes to any of the above – did you see a speech therapist or throat doctor (ENT)?

Are you currently experiencing any problems with your speech or voice? If so, please explain?

Do you use your voice in your occupation or in performance?

General Medical History

Have you been diagnosed with or experience any of the following? If yes, please describe when you were diagnosed, length of time you've experienced symptoms

- | | |
|--|---|
| <input type="checkbox"/> AIDS | <input type="checkbox"/> Heart Disease |
| <input type="checkbox"/> Allergies | <input type="checkbox"/> Hiatal Hernia |
| <input type="checkbox"/> Anxiety Disorder | <input type="checkbox"/> Hoarseness |
| <input type="checkbox"/> Arthritis | <input type="checkbox"/> Lump in Throat Sensation |
| <input type="checkbox"/> Asthma | <input type="checkbox"/> Lung Disease |
| <input type="checkbox"/> Bad Bruising | <input type="checkbox"/> Muscle Weakness |
| <input type="checkbox"/> Breathing Problem | <input type="checkbox"/> Nasal Discharge |
| <input type="checkbox"/> Chronic Fatigue | <input type="checkbox"/> Neck or Back Injury |
| <input type="checkbox"/> Chronic Cough/Choke | <input type="checkbox"/> Neurological Disease |
| <input type="checkbox"/> Depression | <input type="checkbox"/> Post-Nasal Drip |
| <input type="checkbox"/> Diabetes | <input type="checkbox"/> Psychiatric Disorder |
| <input type="checkbox"/> Difficult Nasal Breathing | <input type="checkbox"/> Seizures |
| <input type="checkbox"/> Dizziness | <input type="checkbox"/> Sinus Problems |
| <input type="checkbox"/> Dramatic Weight Gain/Loss | <input type="checkbox"/> Sleep Disorder |
| <input type="checkbox"/> Ear Infections | <input type="checkbox"/> Swallowing Problems |
| <input type="checkbox"/> Ear Pain | <input type="checkbox"/> Throat Pain |
| <input type="checkbox"/> Headaches (Chronic) | <input type="checkbox"/> Thyroid Problems |
| <input type="checkbox"/> Head Injury | <input type="checkbox"/> TMJ Disorder |
| <input type="checkbox"/> Head or Ear Noise | <input type="checkbox"/> Tremor |
| <input type="checkbox"/> Hearing Loss | <input type="checkbox"/> Total Voice Loss |
| <input type="checkbox"/> Heartburn | <input type="checkbox"/> Ulcers |

Have you ever been diagnosed with a hearing loss? If yes, when were you diagnosed and to what degree?

Please list any medications you take and the reason you take the medication.

Daily quantity of: _____ Coffee, tea, soda, chocolate _____ Alcoholic beverages

_____ Water, and other non-caffeinated, non-alcoholic drinks

_____ Cigarettes, Cigars, Other

How long have you been smoking? _____

Have you quit? Yes No

If yes, when did you quit and for how long had you smoked?

Surgical History: Please list any surgeries (including the year) you have had in the following areas:

- lungs
- heart
- gastrointestinal tract (esophagus, stomach, intestines)
- larynx (if not already described above)
- throat
- mouth (including dental surgery)
- nose
- face

Are you currently experiencing any illness or condition that may affect your voice (chest cold, stuffy nose, etc)?

Appendix B

The Rainbow Passage

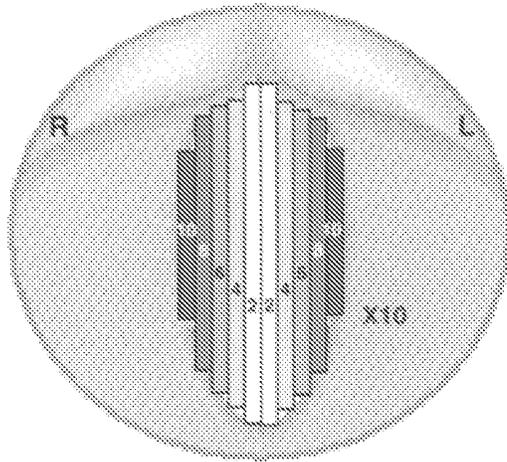
When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow. Throughout the centuries people have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there would be no more universal floods. The Greeks used to imagine that it was a sign from the gods to foretell war or heavy rain. The Norsemen considered the rainbow as a bridge over which the gods passed from earth to their home in the sky. Others have tried to explain the phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the rain. Since then physicists have found that it is not reflection, but refraction by the raindrops, which causes the rainbows. Many complicated ideas about the rainbow have been formed. The difference in the rainbow depends considerably upon the size of the drops, and the width of the colored band increases as the size of the drops increases. The actual primary rainbow observed is said to be the effect of super-imposition of a number of bows. If the red of the second bow falls upon the green of the first, the result is to give a bow with an abnormally wide yellow band, since red and green light when mixed form yellow. This is a very common type of bow, one showing mainly red and yellow, with little or no green or blue.

From Fairbanks, G. (1960). Voice and articulation drillbook, 2nd ed. New York: Harper & Row. pp. 124-13

Appendix C Stroboscopy Rating Form

Rater: _____
Subject: _____

Amplitude
(Rate @ normal pitch & loudness)

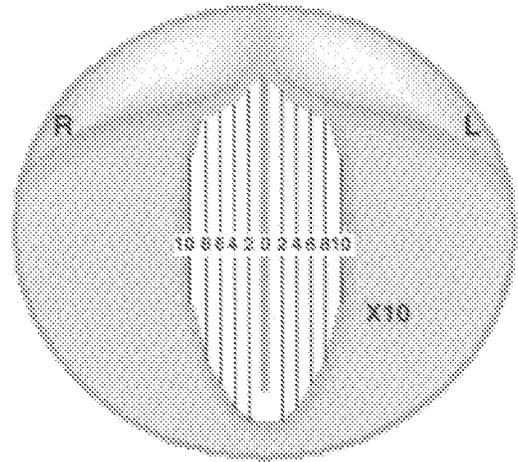


Right: _____%

Left: _____%

Fo: _____

Mucosal Wave
(Rate @ normal pitch & loudness)

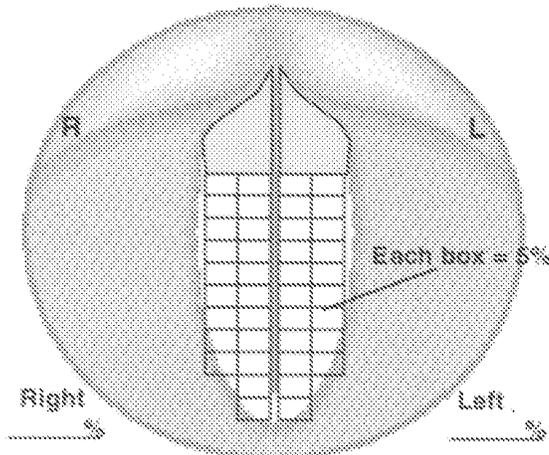


Right: _____%

Left: _____%

Fo: _____

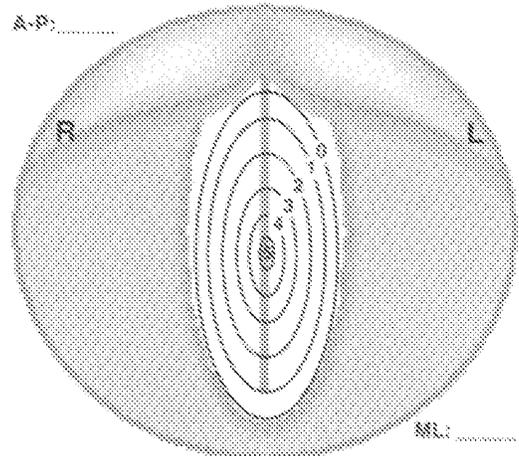
Non-vibrating Portion
(shade in affected areas)



Right

Left

Supraglottic Activity
(Ignore voice onsets)



ML: _____

ML: _____

Adapted from Poburka, B.J. (1999). A new stroboscopy rating form. *Journal of Voice*, 13, 403-413.

Vocal Fold Edge Smoothness

Right Fold 0 1 2 3 4 5 smooth rough	circle on	Left Fold 0 1 2 3 4 5 smooth rough
--	-----------	---

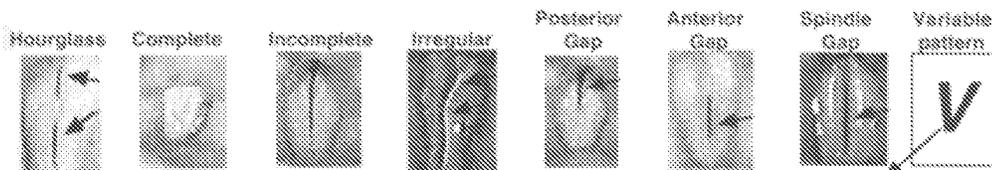
Vocal Fold Edge Straightness

Right Fold 0 1 2 3 4 5 straight irregular	circle on	Left Fold 0 1 2 3 4 5 straight irregular
--	-----------	---

Rate @normal pitch & loudness

<u>Vertical Level</u>	<u>Phase Closure</u>	<u>Phase Symmetry</u>	<u>Regularity</u>
circle one cross section view of glottal area  on-plane  off-plane	Rate @ point of contact % of time open closed Breathy +90% <10% circle one 66% 33% Norma 33% 66% <10% +90% Pressed / Fr Frame count: open phase: _____ Closed phase: _____	Rate @ point of contact % of time symmetrical Always assymetrical circle one 0% 20% 40% 60% 80% 100% Always symmetrical	% of time regular Always irregular circle one 0% 20% 40% 60% 80% 100% Always regular Method(s) used: stop phase _____ running phase _____

Glottal Closure



If closure pattern is variable, indicate the predominant closure pattern: _____

Color: Atypical in the larynx and surrounding structures? Yes No

Location of discoloration _____

Additional Notes _____

Adapted from Poburka, B.J. (1999). A new stroboscopy rating form. *Journal of Voice*, 13, 403-413

Edema: Present in the vocal folds? Yes No

Location of edema _____

Additional Notes _____

Vascularity: Atypical in the larynx and surrounding structures? Yes No

Anything unusual or exceptional about the vascularity _____

Additional Notes _____

Hydration: Signs of poor hydration? Yes No

Anything unusual or exceptional about hydration _____

Additional Notes _____

Laryngeal Height Adjustment: During Pitch Glides? Yes No

Degree: Minimum

Moderate

Significant

Pharyngeal Tension:

Present during pitch glides? Yes No

Degree: None

Some

Significant

Present during typical pitch? Yes No

Degree: None

Some

Significant

Additional Notes _____

Adapted from Poburka, B.J. (1999). A new stroboscopy rating form. *Journal of Voice*, 13, 403-413.