Relative Fundamental Frequency in Individuals with Globus Syndrome and Muscle Tension Dysphagia

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Summary: Objective. Relative fundamental frequency (RFF) has been investigated as an acoustic measure to assess for changes in laryngeal tension. This study aimed to assess RFF in individuals with globus syndrome, individuals with muscle tension dysphagia (MTDg), and individuals with typical voices.

Methods. RFF values were calculated from the speech acoustics of individuals with globus syndrome (n = 12), individuals with MTDg (n = 12), and age- and sex-matched controls with typical voices (n = 24). An analysis of variance was performed on RFF values to assess the effect of group.

Results. There was no statistically significant effect of group on RFF values, with similar values for individuals with globus syndrome, individuals with MTDg, and control participants.

Conclusions. These results suggest that individuals with these disorders do not appear to possess paralaryngeal muscle tension in a locus and/or manner that directly impacts voice production.

Keywords: Muscle tension dysphagia–Globus syndrome–Globus pharyngeus–Voice assessment–Voice disorders.

INTRODUCTION

Recent work has sought to better characterize the presumed etiologies and disorder-specific characteristics of globus pharyngeus and idiopathic functional dysphagia. Idiopathic functional dysphagia, or the more recently coined “muscle tension dysphagia” (MTDg),[1] exists in a spectrum of disorders commonly seen in otolaryngology clinics. Those with MTDg report swallowing difficulties in the absence of any organic clinical findings. Similarly, those with globus pharyngeus (commonly referred to as “globus syndrome”) report various sensations in peri-pharyngeal areas despite a lack of observed organic findings. Thus, MTDg and globus syndrome are both diagnoses of exclusion: symptoms without physical findings on examination. Both disorders, to an extent, involve the sensation of something being stuck in the throat.[1,2] However, individuals with globus syndrome report symptoms in moments outside of and distinct from the act of swallowing.[2] Conversely, individuals with MTDg may report a range of symptoms; however, those symptoms are specifically focused on the act of swallowing. Both disorders manifest as a perceived sensory disturbance without an objective clinical finding (i.e., a mass, lesion, etc.), which is experienced as either related to or unrelated to the act of swallowing. Patients with both disorders are often treated at some point in their care by speech-language pathologists (SLPs), with a therapeutic focus on unloading presumed muscle tension as it relates to the patient’s symptoms and after the exclusion of other overt etiologies.[1,3,4] Because of this interventional focus on underlying muscle tension, recent research has attempted to further classify the disorders, proposing they may be linked via a spectrum of disorders that originate from vocal hyperfunction,[1] or “excessive peri-laryngeal musculoskeletal activity”.[5] Thus, increased paralaryngeal muscle tension may be a common underlying factor in both disorders.

Globus syndrome is described as the sensation of something stuck in the throat.[2] A wide range of suggested etiologies include gastroesophageal reflux disease (GERD), esophageal dysmotility, dysfunction of the upper esophageal sphincter (UES), thyroid disease, psychological disturbance, laryngeal muscle tension, and a multitude of other upper-aerodigestive etiologies.[6] For instance, some have suggested that GERD is present in as many as 23%-68% of individuals with globus syndrome.[7,8] Despite this range of potential contributors to the disorder, no single etiology has been described for individuals with globus syndrome. Some work has described the term “irritable larynx syndrome,”[9] which suggests in its framework that globus syndrome may be related to underlying muscle tension.[7,8] Similarly, recent work using high-resolution manometry found that individuals without laryngopharyngeal reflux but with globus syndrome had higher resting pressures of the UES muscle compared to individuals without globus syndrome.[10] Clinically, when patients do not find relief from a trial of management for other suspected etiologies (e.g., GERD management, thyroid treatment), they are often referred to SLPs for treatment of underlying paralaryngeal muscle tension.[11] For these individuals, the use of behavioral voice therapy has demonstrated symptomatic improvement using various techniques aimed at unloading muscle tension,[3] including laryngeal massage.[12] Thus, increased laryngeal tension may, in theory, be a contributing mechanism in some individuals with globus syndrome.

Multiple research studies have described a group of patients with “functional dysphagia,”[13-18] which refers to patient-reported dysphagia in the absence of any known physical cause, observed physiological impairment, abnormal

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Accepted for publication October 5, 2021.

Acknowledgements: This research was supported by grant R01 DC015570 (C.E.S) from the National Institute on Deafness and Other Communication Disorders.

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Journal of Voice, Vol. ■■, No. ■■, pp. ■■-■■

0892-1997

https://doi.org/10.1016/j.jvoice.2021.10.013

residue, or impaired swallowing function.[19] Use of the name "MTDg" to specifically describe individuals with functional dysphagia was introduced by Kang et al.[1]. In their study, the authors retrospectively analyzed patients who presented with the following: a report of primary dysphagia symptoms, a normal modified barium swallow study (MBS), and the subjective impression of laryngeal muscle tension upon laryngoscopic evaluation. Patients who presented with these criteria were assigned the designation of MTDg. During the laryngoscopic evaluations of these patients, the authors reported the subjective impression of "laryngeal muscle tension" appearing as supraglottic compression or plica ventricularis (false fold/ventricular phonation). Based on their observations, the authors proposed a theoretical framework of a spectrum of muscle tension-based disorders—including muscle tension dysphonia, chronic cough/paradoxical vocal fold motion, MTDg, and globus syndrome—which is similar to the proposed irritable larynx syndrome by Morrison et al.[9] with the addition of MTDg. Of the group of 67 individuals classified with MTDg, Kang et al.[1] reported the most common patient-reported symptoms as difficulty swallowing solids, throat discomfort with swallowing, and the sensation of food sticking in the throat. Further, they reported that 55% of individuals with MTDg reported secondary symptoms of dysphonia. Another study observed patients with "functional dysphagia" (i.e., MBS within normal limits and the absence of any vocal fold pathology), and found that clinicians reported the impression of laryngeal muscle tension, as viewed by supraglottic constriction on laryngoscopy, in 75% of patients.[18] Using electromyography (EMG) and palpatory/visual inspection measures of the swallowing and oral mechanisms, Krasnodebska et al.[20] found that patients with MTDg and observed abnormalities (in a palpatory and oral examination by an SLP) had significantly higher infrahyoid muscle activity during swallowing than those without these abnormalities, as well as an overall increased duration of their swallowing phases. In regard to MTDg treatment, recent research has described successful outcomes using similar behavioral interventions used for globus syndrome, including circumlaryngeal massage and other techniques aimed at unloading tension from the paralaryngeal area.[1,4,21] Thus, underlying paralaryngeal muscle tension appears plausible as a contributor in some individuals with MTDg.

In order to better understand the relationship between muscle tension dysphagia, globus syndrome, and dysphonia, finding a measure that relates to the potential underlying feature of muscle tension is warranted. Multiple studies use the subjective impression of supraglottic constriction during phonation via laryngoscopy as a means of reporting the presence or absence of laryngeal tension or vocal hyperfunction.[1,4,22-24] Although benign at first glance, this methodology may be problematic when used as the sole criterion for diagnosing vocal hyperfunction. When examining healthy individuals without a voice disorder, Stager and Bielamowicz [25] observed that 74% demonstrated supraglottic constriction in the antero-posterior (AP) direction and 45% demonstrated medial compression of the false vocal folds during phonation (compared to 92% for AP compression and 80% for medial compression in individuals with muscle tension dysphonia). Other research has found that the degree of supraglottic constriction in the AP direction is higher in individuals with dysphonia than without, but that the degree of medial compression is not.[22,26] A recent study found that, using a grading system of 1 to 3, the overall grade of AP compression was positively correlated with subglottal pressure, but medial compression did not demonstrate a correlation.[26] These results suggest that the presence of supraglottic constriction is likely not a reliable indicator of vocal hyperfunction, but rather the degree and manner of constriction may be more important to consider. However, it is important to note that the authors did not report during which speaking conditions subglottal pressure was measured (nor the sound pressure level of the speakers during the phonatory tasks). As such, these results should be interpreted with caution. For their inclusionary criteria for a diagnosis of MTDg, Kang et al.[1,4] reported individuals having "significant laryngeal muscle tension" via transnasal laryngoscopy, but no specific mention of the manner was reported. Considering the findings that the mere presence of general supraglottic constriction appears not to correlate with vocal hyperfunction, an objective measure that is sensitive to vocal hyperfunction may be useful to assess its presence in individuals with globus syndrome and MTDg.

Recent research has examined the acoustic measure relative fundamental frequency (RFF) as a method of assessing laryngeal tension and vocal effort during voice production.[27,28] RFF involves measuring the fundamental frequency (f_o) of the ten cycles before and after a voiceless consonant in a vowel-consonant-vowel production (e.g., /ifi/), and comparing them to the cycles corresponding to the steady-state f_o of their corresponding vowels.[29] RFF values are lower in individuals with hyperfunctional voice disorders,[29-31] Parkinson's disease,[32,33] and adductor laryngeal dystonia[34,35] when compared to individuals with typical voices. Upon successful completion of voice therapy meant to reduce vocal hyperfunction during voicing, RFF has also been shown to normalize in individuals with hyperfunctional voice disorders.[36] Thus, RFF appears to relate to laryngeal muscle tension during voicing and may be an objective acoustic measure sensitive to changes in laryngeal tension. Although individuals with MTDg and globus syndrome do not always report or experience dysphonia, the underlying element of general laryngeal muscle tension may be present in these groups, and RFF patterns in patients with MTDg and globus syndrome have yet to be observed.

Objective measures relating to laryngeal muscle tension may help to further elucidate the underlying physiological mechanisms of both globus syndrome and MTDg. In turn, this improved understanding could assist in both diagnosis and measurement of treatment response. In this study, we measured the acoustic, voice-based measure RFF in individuals with MTDg and globus syndrome with the goal of better understanding the presence of paralaryngeal muscle tension. Since RFF is thought to relate to increased laryngeal tension, we hypothesized that offset and onset RFF values would be lower in individuals with both MTDg and globus syndrome compared to individuals without voice, swallowing, or globus complaints.

METHODS

Participants

Participants were recruited from a pool of adults who had received diagnoses of globus syndrome or MTDg after comprehensive evaluation by a referring physician and speech-language pathologist in the Department of Otolaryngology at Boston Medical Center (Boston, MA, USA). Individuals with a primary voice or cough complaint were excluded. To rule out a potential organic cause for the patient-reported symptoms, the absence of any masses, lesions, or laryngeal pathology was confirmed via a transnasal laryngoscopy at the initial evaluation for all participants. Individuals were confirmed to have a primary diagnosis of globus syndrome if their reported symptoms were unrelated to swallowing. Those who reported symptoms primarily related to swallowing and had physician-documented supraglottic constriction during their laryngoscopy received an MBS to confirm the absence of any oropharyngeal dysphagia. These individuals thus received an exclusionary diagnosis of MTDg. Patient-reported symptoms for individuals diagnosed with globus syndrome varied from feeling something stuck in the throat to a lump sensation in the throat. Symptoms for individuals with MTDg consisted of a lump sensation while swallowing; the sensation of food, liquid, or pills sticking in the throat; or increased effort to swallow. A total of 12 individuals met the criteria for globus syndrome (3 cisgender males, 9 cisgender females, age range = 27−81 years, mean = 45 years, SD = 14.8 years) and 12 individuals met the criteria for MTDg (1 cisgender male, 11 cisgender females, age range = 28−68 years, mean = 53 years, SD = 14.4 years). Approval was obtained from the Boston Medical Center Institutional Review Board for retrospective analysis of acoustic data from these participants.

For comparison to individuals in the globus syndrome and MTDg groups, 24 age- and sex-matched individuals (4 cisgender males, 20 cisgender females, age range = 27−81 years, mean = 50 years, SD = 15 years) were selected from an existing database of voice recordings at Boston University. Ages were matched within ±5 years. All individuals in this control group were native speakers of American English and reported no prior history of smoking or any neurological, swallowing, speech, language, or hearing disorders. These participants provided written, informed consent in compliance with the Boston University Institutional Review Board.

Data collection

Speech acoustics were retrospectively selected from an existing database of clinical evaluation data and research databases at Boston Medical Center Department of Otolaryngology (globus syndrome and MTDg data) and the Stepp Lab for Sensorimotor Rehabilitation Engineering at Boston University (control data). Acoustic recordings of individuals with globus syndrome or MTDg from Boston Medical Center were obtained at the time of their speech-language pathology evaluation in a quiet clinic room with a handheld condenser microphone (model H4n Pro; Zoom, Hauppauge, NY). Acoustic recordings of control participants were recorded at Boston Medical Center in a quiet clinic room with a dynamic headset microphone (model WH20XLR; Shure, Niles, IL) or at BU in a sound-treated booth with a dynamic headset microphone (model SM35XLR; Shure, Niles, IL). In both locations, the microphone was placed at a 90-degree angle from the lips at a distance of 6 cm from the corner of the mouth. Audio files were recorded at a sampling rate of 44.1 kHz with 16-bit resolution in .wav format. A set of nine productions of the vowel-voiceless consonant-vowel (VCV) tokens /ɑfɑ/, /ifi/, and /ufu/ were recorded for all participants to enable the calculation of RFF.[37]

Acoustic data analysis

RFF tokens for all participants were separated into sets of /ɑfɑ/, /ifi/, and /ufu/ productions and analyzed using an automated MATLAB (MathWorks, Natick, MA) script designed to calculate RFF values.[38] The automated algorithm calculates RFF through capturing the instantaneous fundamental frequency (f_o) of the 10 voicing cycles before and after the voiceless fricative (i.e., /f/) in the VCV utterance. The cycles preceding the voiceless fricative are labeled as the offset cycles, since the vocal folds are beginning to cease vibration for the voiceless fricative. The cycles following the /f/ are labeled as the onset cycles, since the vocal folds re-initiate vibration after their cessation during the voiceless fricative. The f_o values of these 20 cycles (10 offset and 10 onset cycles) were calculated using automated methods, as described in previous literature.[38] The instantaneous frequencies of the offset cycles (i.e., offset cycles 1-10) and onset cycles (i.e., onset cycles 1-10) were converted via the algorithm into semitones (ST) using offset cycle 1 and onset cycle 10 as reference frequencies, respectively. Offset cycle 1 and onset cycle 10 were used to normalize f_o values as these cycles are closest to the steady state of the vowels surrounding the voiceless fricative; thus, they are most likely to be representative of the steady-state f_o of the vowel and thus least affected by voicing onset or offset.

This process was completed for all elicited RFF tokens from all groups for a potential total of 432 total VCV utterances. This yielded a total of 8640 potential RFF values across the 20 cycles. Since various voicing patterns and conditions can reduce the usability of some acoustic signals for RFF, the automated algorithm rejects instances in which there are less than 10 onset or offset cycles identified, there is no stable identified f_o, or there are other patterns suggestive of the inability to reliably calculate RFF. Thus, a total of 2610 offset cycle values and 2560 onset cycle values were able to be analyzed. For participants with globus syndrome, there were an average (± the standard deviation) of 5.8±1.9 (range = 3-9) usable offset RFF values and 6.5±2.1 (range = 4-9) usable onset RFF values. For participants with MTDg, there were an average of 5.7±1.9 (range = 3-8) usable offset RFF values and 5.2±2.1 (range = 3-9) usable onset RFF values. For control participants, there were an average of 5.12±1.9 (range = 3-9) usable offset RFF values and 4.83±1.2 (range = 3-8) usable onset RFF values.

Statistical analysis

All statistical analysis was completed using Minitab Statistical Software (Version 17; Minitab, Inc.). Statistical significance was set *a priori* to an alpha level of .05. A two-way mixed-effects analysis of variance (ANOVA) was performed to assess the effects of cycle (within-participant; offset cycles 1-10 and onset cycles 1-10), group (between-participants; globus syndrome, MTDg, and control), and their interaction. Partial eta squared (η_p^2) was used as a measure of effect size for significant main effects.[39] Descriptive statistics were computed for offset cycle 10 and onset cycle 1 for each group due to their sensitivity to change in laryngeal tension observed in prior RFF research.[28,29,36]

RESULTS

Average RFF contours for the globus syndrome, MTDg, and control groups are shown in Figure 1. For the globus syndrome group, the average RFF values were -1.21 ST (SD = 0.84 ST) for offset cycle 10 and 2.08 ST (SD = 1.31 ST) for onset cycle 1. For the MTDg group, the average RFF values were -0.57 ST (SD = 1.07 ST) for offset cycle 10 and 2.39 ST (SD = 1.13 ST) for onset cycle 1. For the control group, the average RFF values were -1.19 ST (SD = 0.69 ST) for offset cycle 10 and 2.04 ST (SD = 1.31 ST) for onset cycle 1. The ANOVA revealed a statistically significant effect of cycle ($F = 127.39$, $P < 0.001$, $\eta_p^2 = .74$), but no statistically significant effect of group ($F = 1.83$, $P = 0.173$, $\eta_p^2 = .02$) or the interaction between cycle and group ($F = 0.640$, $P = 0.958$, $\eta_p^2 = .03$).

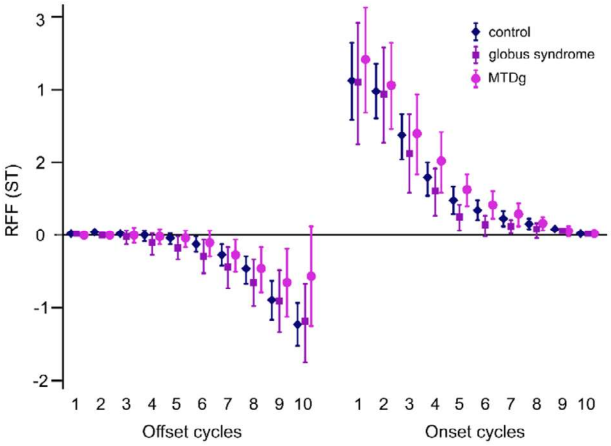

FIGURE 1. Average relative fundamental frequency (RFF) values shown in semitones (ST) for the 10 offset and 10 onset cycles of the control (diamonds), globus syndrome (squares), and muscle tension dysphagia (MTDg; circles) groups. Error bars indicate 95% confidence intervals.

DISCUSSION

Since RFF values have been demonstrated to be lower in individuals with hyperfunctional voice disorders relative to speakers with typical voices, our hypothesis was that RFF values would be lower in the MTDg and globus syndrome groups relative to control speakers. Our rationale was that RFF would be sensitive to the proposed common underlying etiology of paralaryngeal muscle tension in individuals with these disorders. However, group was not a statistically significant factor, nor was there a statistically significant interaction between group and cycle on RFF values. Our findings do indicate a trend for higher average RFF values for individuals in the MTDg group (Figure 1), but in a direction opposite to our hypothesis. This trend was not statistically significant, as might be expected given the substantial within-group variability, as evidenced by the overlapping error bars in Figure 1. Although our findings did not reveal differences between groups, we believe that they are of interest to the paucity of available data about the relationships between these groups and may offer potential insight into their underlying pathophysiology.

Although the acoustic measure RFF has been shown to be affected in individuals with vocal hyperfunction—in which underlying laryngeal tension is thought to be increased—we did not find any differences in RFF between individuals with MTDg or globus syndrome. Despite this finding, individuals with these disorders may still have underlying muscle tension that contributes to their symptoms. There are a multitude of paralaryngeal muscles (i.e., muscles that interact with and/or exist in close proximity to the larynx) with overlapping roles in the acts of voice production and of swallowing. Certain muscles may contribute more (or solely) to voice production; this includes the intrinsic laryngeal muscles, which are directly responsible for the complex process of phonation. In individuals with typical voices, these muscles provide finely tuned control over variables such as pitch, loudness, and voice quality. During swallowing, some of the intrinsic laryngeal muscles assist to adduct the vocal folds for airway protection. However, these actions likely do not require the same degree of fine motor control due to the lower target complexity of the motor task required of the intrinsic laryngeal muscles during a single act of swallowing than during voice use (i.e., the closing and then opening of the glottis during swallowing). Thus, it is plausible that a smaller disruption to the performance of these muscles (i.e., muscle tension) may have a more noticeable effect on voice production than in swallowing.

The extrinsic laryngeal muscles are another potential source of laryngeal tension, although the timing of their activation during phonation differs from the intrinsic laryngeal muscles. For instance, the suprahyoid muscles largely assist with laryngeal height changes and in stabilizing the position of the larynx.[40] While prolonged contractions (i.e., increased muscle tension) may have a net effect of a raised laryngeal position during voicing, the suprahyoid muscles are not considered to be a primary muscle group that regulates phonation. The suprahyoid muscles do, however, play a primary role in the motor act of swallowing, affording the hyolaryngeal elevation necessary for proper bolus clearance.[41] Specifically, the suprahyoid muscle group acts to raise the hyoid and thus the larynx during swallowing, which is crucial for proper swallowing function.

Swallowing is also controlled by the intrinsic and extrinsic lingual muscles (assisting with base of tongue retraction and oral transit of the bolus),[42] the pharyngeal constrictors (responsible for assisting to propel the bolus through the UES),[43] and the UES (responsible for relaxing to allow for proper entryway of the bolus into the esophagus).[41] Although these muscles are not considered primary phonatory muscles and their direct contribution to typical voice production appears limited, these muscles maintain a significant and important role in swallowing function.[41] Overall, it is plausible that individuals with MTDg may have paralaryngeal muscle tension, but that perhaps this tension is created by different muscles than those that result in the muscle tension related to vocal hyperfunction. If so, the term “paralaryngeal tension” may not capture the nuance of potential various loci of the tension nor its physiological impact on the individual acts of swallowing or voice production.

Individuals with globus syndrome and MTDg may possess excessive and/or imbalanced tension in paralaryngeal muscles that differ from those implicated in tension-related voice disorders, but it is largely not known how the level of tension of these muscles—versus paresis or paralysis—manifests symptomatically. In order to follow previous scant literature in MTDg, our current study had the inclusionary criteria of reported supraglottic hyperfunction during a laryngoscopy prior to referral for an MBS. However, as mentioned, this is a highly subjective report and its mere presence alone, over degree of severity, may not actually represent true physiologic vocal hyperfunction. This may explain why visual indications of supraglottic hyperfunction were documented without significant changes to the acoustic measure RFF in our study. Similarly, due to the largely subjective nature of visually rating swallowing dysfunction via MBS, there may be a small degree of impact on swallowing kinematics that is not appreciable solely through visual inspection. Kang et al.[1] reported that MTDg had no impact on swallowing function; however, the authors made this claim based on visual impression alone. If this claim remained true despite objective measurements, then it is possible that muscle tension patterns specific to MTDg manifest mostly as a sensory disturbance (such as in the sensation of an incomplete or effortful swallow) with no physiological impact. However, an individual with MTDg may not present with appreciable residue after their swallow—and would thus be classified as someone with no perceived impact on swallowing function—yet objective kinematic measures may indicate outside of typical limits swallowing kinematics (e.g., reduced laryngeal elevation or reduced hyoid excursion) potentially caused by overly tense muscles during swallowing, which the individual is sensate to (i.e. resulting in the sensation of an effortful or incomplete swallow rather than a functional impact such as residue). The disorder, in this instance, would not be entirely sensory in nature. Given the lack of objective measurements reported in the available research on MTDg, this remains a possibility and one in need of future research in order to better understand the pathophysiology and impact of MTDg on swallowing.

Although the current discussion involves the proposition that muscle tension may be present in these individuals in other paralaryngeal muscles (and in those related more to swallowing than voice production), this does not entirely encapsulate the patterns of individuals with globus syndrome who present without swallowing or voice complaints but instead, with the sensation of a foreign body in the throat outside of these acts. Similar to those with MTDg, these individuals did not present with any disruptions to RFF. It is important to note that excessive and/or imbalanced laryngeal muscle tension may still present in any of the previously mentioned muscles but may manifest symptomatically as a sensory disturbance unrelated to voicing or swallowing. The degree and locus of altered muscle tension in these individuals, if present, may explain its different symptomology from MTDg (i.e., excessive tension that is perceived at all times vs. excessive tension that is perceived only during the act of activating said muscle); however, the current study does not provide any further insight into this besides observing that altered tension in the muscles largely responsible for voicing was not found via RFF.

Overall, there were some limitations to the current study. The study consisted of a relatively small number of participants in each participant group, with 48 total participants. Although we did not see differences between the groups, if differences were to exist, they are not large enough to be detected by our number of participants; specifically, a *post hoc* statistical power analysis revealed that, with power set at .8 and $\alpha = .05$, our sample size of 48 participants was sufficient to detect only large between-participant effects ($\eta_p^2 = .14-.19$) when using this mixed-effects ANOVA design. Further, individuals who presented to the clinic were referred by multiple otolaryngologists who documented increased supraglottic involvement in their evaluation reports in the medical record system. Due to various practice habits, not all participants had laryngoscopies that were viewable retrospectively for confirmation of perceived supraglottic hyperfunction. Thus, the presence of supraglottic compression was attributed only from documentation by the referring otolaryngologist. Given the high degree of subjectivity in using supraglottic involvement alone as a criterion for diagnosis, our use of multiple otolaryngologists without a universal impression of disordered supraglottic hyperfunction may have allowed individuals with a large range of degrees of supraglottic hyperfunction to enter our participant pool. Within this vein, we did not specifically control for the presence or history of GERD in all participants. Practice patterns at the referring clinic often execute a trial of a proton pump inhibitor (PPI) in individuals with suspected globus syndrome prior to referral for an MBS or for voice therapy. This variable of reflux history or treatment was not considered. Thus, some individuals with GERD may have been included, which may have potentially contributed to their symptomology. Regardless, all individuals had a documented absence of laryngeal pathology, reported signs of the presence of supraglottic hyperfunction on laryngoscopy, and a normal MBS, when applicable.

In our study and at the time of their initial or SLP visits, our participants did not subjectively report any secondary voice symptoms. Given other research proposing an increased presence of concomitant dysphonia in individuals with MTDg,[1] it would be useful to examine RFF in individuals with MTDg and globus syndrome who also report dysphonia, as RFF may be impacted in these individuals with voice problems. Future work may address further analysis of the relationship and presence of dysphonia, which may be better represented in a larger sample size.

CONCLUSION

Results from this work suggest that RFF, an acoustic estimate of laryngeal tension, was not different between those with globus syndrome or MTDg relative to individuals with typical voices. These results suggest that individuals with these disorders do not appear to possess paralaryngeal muscle tension in a locus and/or manner that directly impacts voice production.

DISCLOSURE

Cara E. Stepp has received consulting fees from Altec, Inc./Delsys, Inc., companies focused on developing and commercializing technologies related to human movement. Stepp's interests were reviewed and are managed by Boston University in accordance with their conflict of interest policies. The other authors have declared that no other competing interests existed at the time of publication.

REFERENCES

1. Kang CH, Hentz JG, Lott DG. Muscle tension dysphagia: symptomology and theoretical framework. *Otolaryngol Head Neck Surg*. 2016;155:837–842. https://doi.org/10.1177/0194599816657013.
2. Kortequee S, Karkos PD, Atkinson H, et al. Management of globus pharyngeus. *Int J Otolaryngol*. 2013;2013: 946780. https://doi.org/10.1155/2013/946780.
3. Wareing M, Elias A, Mitchell D. Management of globus sensation by the speech therapist. *Logoped Phoniatr Vocol*. 1997;22:39–42.
4. Kang CH, Zhang N, Lott DG. Muscle tension dysphagia: contributing factors and treatment efficacy. *Ann Otol Rhinol Laryngol*. 2020 3489420966339. https://doi.org/10.1177/0003489420966339.
5. Oates J, Winkworth A. Current knowledge, controversies and future directions in hyperfunctional voice disorders. *Int J Speech Lang Pathol*. 2008;10:267–277. https://doi.org/10.1080/17549500802140153.
6. Lee BE, Kim GH. Globus pharyngeus: a review of its etiology, diagnosis and treatment. *World J Gastroenterol*. 2012;18:2462–2471. https://doi.org/10.3748/wjg.v18.i20.2462.
7. Hill J, Stuart RC, Fung HK, et al. Gastroesophageal reflux, motility disorders, and psychological profiles in the etiology of globus pharyngis. *Laryngoscope*. 1997;107:1373–1377. https://doi.org/10.1097/00005537-199710000-00015.
8. Chevalier JM, Brossard E, Monnier P. Globus sensation and gastroesophageal reflux. *Eur Arch Otorhinolaryngol*. 2003;260:273–276. https://doi.org/10.1007/s00405-002-0544-0.
9. Morrison M, Rammage L, Emami AJ. The irritable larynx syndrome. *J Voice*. 1999;13:447–455. https://doi.org/10.1016/s0892-1997(99)80049-6.
10. Ding H, Duan Z, Yang D, et al. High-resolution manometry in patients with and without globus pharyngeus and/or symptoms of laryngopharyngeal reflux. *BMC Gastroenterol*. 2017;17:109. https://doi.org/10.1186/s12876-017-0666-x.
11. Khalil HB, Hilton-Pierce, M MW, Vincent J. The use of speech therapy in the treatment of globus pharyngeus patients. A randomised controlled trial. *Revue de Laryngologie - Otologie - Rhinologie*. 2002;124:187–190.
12. Cheol MA. The efficacy of voice therapy in globus pharyngeus. *Korean J Otorhinolaryngol-Head Neck Surg*. 1998;41:246–250.
13. Drossman DA, Dumitrascu DL. Rome III: New standard for functional gastrointestinal disorders. *J Gastrointestin Liver Dis*. 2006;15:237–241.
14. Drossman DA. The functional gastrointestinal disorders and the Rome III process. *Gastroenterology*. 2006;130:1377–1390. https://doi.org/10.1053/j.gastro.2006.03.008.
15. Drossman DA. Functional gastrointestinal disorders: history, pathophysiology, clinical features and rome IV. *Gastroenterology*. 2016. https://doi.org/10.1053/j.gastro.2016.02.032.
16. Aziz Q, Fass R, Gyawali CP, et al. Functional Esophageal Disorders. *Gastroenterology*. 2016. https://doi.org/10.1053/j.gastro.2016.02.012.
17. Kuribayashi S, Kusano M, Kawamura O, et al. [Functional gastrointestinal disorders(FGID): progress in diagnosis and treatments. Topic II. Current status and future prospective of medical care of the representative disorders; 1. Functional esophageal disorders (chest pain or functional dysphagia)]. *Nihon Naika Gakkai Zasshi*. 2013;102:46–54. https://doi.org/10.2169/naika.102.46.
18. Hamdan AL, Ziade G, Khalifee E, et al. Prevalence of MTD among patients with functional dysphagia. *OTO Open*. 2018;2: 2473974X18792469. https://doi.org/10.1177/2473974X18792469.
19. Patel D, Kavitt Robert T, Vaezi Michael F. *Evaluation and Management of Dysphagia An Evidence-Based Approach*. 1st ed. Springer International Publishing; 2020.
20. Krasnodebska P, Jarzynska-Bucko A, Szkielkowska A, et al. Clinical and electromyographic assessment of swallowing in individuals with functional dysphonia associated with dysphagia due to muscle tension or atypical swallowing. *Audiol Res*. 2021;11:167–178. https://doi.org/10.3390/audiolres11020015.
21. DePietro JD, Rubin S, Stein DJ, et al. Laryngeal manipulation for dysphagia with muscle tension dysphonia. *Dysphagia*. 2018;33:468–473. https://doi.org/10.1007/s00455-018-9875-x.
22. Behrman A, Dahl LD, Abramson AL, et al. Anterior-posterior and medial compression of the supraglottis: signs of nonorganic dysphonia or normal postures? *J Voice*. 2003;17:403–410. https://doi.org/10.1067/s0892-1997(03)00018-3.
23. Garaycochea O, Navarrete JMA, del Rio B, et al. Muscle tension dysphonia: which laryngoscopic features can we rely on for diagnosis? *J Voice*. 2019;33. https://doi.org/10.1016/j.jvoice.2018.04.015.
24. Morrison MD, Rammage LA. Muscle Misuse voice disorders - description and classification. *Acta Oto-Laryngologica*. 1993;113:428–434. https://doi.org/10.3109/00016489309135839.
25. Stager SV, Bielamowicz SA, Regnell JR, et al. Supraglottic activity: evidence of vocal hyperfunction or laryngeal articulation? *J Speech Lang Hear Res*. 2000;43:229–238. https://doi.org/10.1044/jslhr.4301.229.

26. Fernandez S, Garaycochea O, Martinez-Arellano A, et al. Does more compression mean more pressure? a new classification for muscle tension dysphonia. *J Speech Lang Hear Res*. 2020;63:2177–2184. https://doi.org/10.1044/2020_JSLHR-20-00042.
27. Stepp CE, Sawin DE, Eadie TL. The relationship between perception of vocal effort and relative fundamental frequency during voicing offset and onset. *J Speech Lang Hear Res*. 2012;55:1887–1896. https://doi.org/10.1044/1092-4388(2012/11-0294).
28. Lien YA, Michener CM, Eadie TL, et al. Individual monitoring of vocal effort with relative fundamental frequency: relationships with aerodynamics and listener perception. *J Speech Lang Hear Res*. 2015;58:566–575. https://doi.org/10.1044/2015_JSLHR-S-14-0194.
29. Stepp CE, Hillman RE, Heaton JT. The impact of vocal hyperfunction on relative fundamental frequency during voicing offset and onset. *J Speech Lang Hear Res*. 2010;53:1220–1226. https://doi.org/10.1044/1092-4388(2010/09-0234).
30. Roy N, Fetrow RA, Merrill RM, et al. Exploring the clinical utility of relative fundamental frequency as an objective measure of vocal hyperfunction. *J Speech Lang Hear Res*. 2016;59:1002–1017. https://doi.org/10.1044/2016_JSLHR-S-15-0354.
31. Heller Murray ES, Lien YS, Van Stan JH, et al. Relative fundamental frequency distinguishes between phonotraumatic and non-phonotraumatic vocal hyperfunction. *J Speech Lang Hear Res*. 2017;60:1507–1515. https://doi.org/10.1044/2016_JSLHR-S-16-0262.
32. Stepp CE. Relative fundamental frequency during vocal onset and offset in older speakers with and without Parkinson's disease. *J Acoust Soc Am*. 2013;133:1637–1643. https://doi.org/10.1121/1.4776207.
33. Goberman AM, Blomgren M. Fundamental frequency change during offset and onset of voicing in individuals with Parkinson disease. *J Voice*. 2008;22:178–191. https://doi.org/10.1016/j.jvoice.2006.07.006.
34. Buckley DP, Cadiz MD, Eadie TL, et al. Acoustic model of perceived overall severity of dysphonia in adductor-type laryngeal dystonia. *J Speech Lang Hear Res*. 2020;63:2713–2722. https://doi.org/10.1044/2020_JSLHR-19-00354.
35. Eadie TL, Stepp CE. Acoustic correlate of vocal effort in spasmodic dysphonia. *Ann Otol Rhinol Laryngol*. 2013;122:169–176. https://doi.org/10.1177/000348941312200305.
36. Stepp CE, Merchant GR, Heaton JT, et al. Effects of voice therapy on relative fundamental frequency during voicing offset and onset in patients with vocal hyperfunction. *J Speech Lang Hear Res*. 2011;54:1260–1266. https://doi.org/10.1044/1092-4388(2011/10-0274).
37. Lien YA, Gattuccio CI, Stepp CE. Effects of phonetic context on relative fundamental frequency. *J Speech Lang Hear Res*. 2014;57:1259–1267. https://doi.org/10.1044/2014_JSLHR-S-13-0158.
38. Vojtech JM, Segina RK, Buckley DP, et al. Refining algorithmic estimation of relative fundamental frequency: Accounting for sample characteristics and fundamental frequency estimation method. *J Acoust Soc Am*. 2019;146:3184. https://doi.org/10.1121/1.5131025.
39. Witte RS, Witte JS. *Statistics*. Hoboken, NJ: J. Wiley & Sons; 2010.
40. Sataloff RT, Heman-Ackah YD, Hawkshaw MJ. Clinical anatomy and physiology of the voice. *Otolaryngol Clin North Am*. 2007;40:909–929. https://doi.org/10.1016/j.otc.2007.05.002. v..
41. Pearson Jr. WG, Hindson DF, Langmore SE, et al. Evaluating swallowing muscles essential for hyolaryngeal elevation by using muscle functional magnetic resonance imaging. *Int J Radiat Oncol Biol Phys*. 2013;85:735–740. https://doi.org/10.1016/j.ijrobp.2012.07.2370.
42. Scoppa F, Saccomanno S, Bianco G, et al. Tongue posture, tongue movements, swallowing, and cerebral areas activation: a functional magnetic resonance imaging study. *Applied Sciences-Basel*. 2020;10. doi:ARTN 6027 10.3390/app10176027.
43. Sasegbon A, Hamdy S. The anatomy and physiology of normal and abnormal swallowing in oropharyngeal dysphagia. *Neurogastroenterol Motil*. 2017;29. doi:10.1111/nmo.13100.