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RESEARCH ARTICLE

Laryngeal Vibrotactile Stimulation as a Non-Invasive Adjunctive Treatment for Spasmodic Dysphonia: A Preliminary Study

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Abstract

Spasmodic dysphonia (SD) is a debilitating condition characterized by involuntary closure of the vocal folds, leading to strained and choked speech. Current treatment options have limitations and require repeated interventions. However, recent studies have shown that high-frequency peripheral somatosensory stimulation is able to modulate neuronal discharge at the somatomotor cortical level and positively influence motor output and therefore SD symptoms. This study investigates the potential of laryngeal vibrotactile stimulation (VTS) as a non-invasive treatment for SD. A custom device was used to apply high-frequency vibrations to the larynx of three female patients with adductor-type SD. The patients underwent VTS treatment once a day for four weeks. Four parameters were used to assess vocal quality: Acoustic Voice Quality Index (AVQI), Cepstral Peak Prominence Smoothed (CPPS), number of voice interruptions (Voice Breaks), and perceptual evaluation using the GIRBAS scale. The results showed improvements in all parameters following VTS treatment, indicating enhanced phonatory function quality and speech stability. These findings highlight the potential of VTS to alleviate symptoms in individuals diagnosed with adductor-type SD.

INTRODUCTION

Spasmodic dysphonia (SD) is a type of focal dystonia that affects the larynx and results in disrupted, strained and/or choked speech and voice breaks caused by involuntary movements (spasms) of the laryngeal muscles during phonation (Ludlow, 2011). SD is more prevalent in women, with a 4:1 ratio, and typically develops around the age of 40 (Blitzer, 2018). There are two main forms of SD: adductor (ADSD), which is characterized by involuntary closure of the vocal folds, and abductor (ABSD), which is characterized by excessive opening of the vocal folds.

The exact etiology of the disorder, including potential genetic causes, is still unknown. However, it is widely hypothesized that the condition arises from a complex interplay of neurological, genetic, and environmental factors (Hintze, 2017). Furthermore, the pathophysiology of the disorder involves profound functional and structural alterations occurring on a broad scale within the basal ganglia-thalamo-cortical circuitry, brainstem, and cerebellum (Simonyan & Ludlow, 2010; Simonyan et al., 2021). The preferred treatment for SD is botulinum toxin injections (BoNT), which provide temporary relief of symptoms. However, this treatment is hampered by its ineffectiveness in nearly 40% of patients (Richardson et al., 2017) and intolerance by some individuals (Ludlow, 2009). Moreover, these injections impose a psychological burden on patients, and in some cases, a financial burden as well, since they necessitate repetitive administration every 3-4 months throughout the patient's lifetime.

Functional neuroimaging studies conducted on patients with SD have demonstrated an increased level of central activation in the laryngeal somatosensory cortex during phonation, indicating the presence of various types of somatosensory anomalies that may contribute to the pathogenesis of SD (Simonyan & Ludlow, 2010). Research indicates that the sensory basis for the laryngeal adductor response is reliant on the stimulation of mechanoreceptors in the laryngeal mucosa (Loucks et al., 2005). Furthermore, recent studies have demonstrated how high-frequency peripheral somatosensory vibro-tactile stimulation (VTS) applied over the larynx can modulate neuronal firing in the somatomotor cortex and positively influence motor output, mitigating the symptoms of SD (Khosravani et al., 2019). This introduces promising therapeutic possibilities and lays the foundation for a novel, non-invasive, and continuous treatment modality for SD.

The current study aimed to investigate the potential of vibrotactile stimulation (VTS) as a non-invasive treatment for adductor-type spasmodic dysphonia. Our objectives were two-fold: first, to assess the efficacy of laryngeal VTS using a novel device in a sample of SD patients, and second, to analyze the impact of VTS on vocal quality by examining

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four parameters - AVQI, CPPS, Voice Breaks, and the perceptual evaluation of voice quality using the GIRBAS scale.

MATERIALS AND METHODS

High frequency (10-200hz) vibration applied transversely through the skin is sufficient to stimulate the mechanoreceptors and muscle spindles that affect motor behavior (Cordo, 1995; Manhan, 2019). A device was specifically designed and assembled for the application of VTS at the laryngeal level (Figure 1).
This device comprises two cylindrical encapsulated vibration motors, which are capable of producing vibrations at a frequency of 100Hz (Model 307-100, PicoVibe, Precision Microdrives Ltd., London, UK; diameter: 8.8 mm, length 25 mm), connected to an on/off switch portable battery case and powered by two 1.5V rechargeable AA batteries.

Figure 1- *The device built for this study*

The vibrating motor model was selected based on its suitability for the specific application and because it had been previously used in a similar feasibility study on laryngeal vibrotactile stimulation (Khosravani, 2019).

To test the effects of VTS, a preliminary study was conducted on 3 female patients with adductor-type SD (ADSD), with a mean age of 58 years. None of the patients enrolled in the study had received any BoNT injections in the 6 months prior to the experimental study. Before starting the protocol, participants provided written informed consent. Participants performed the treatment directly at their own domicile. Prior to the treatment, each patient attended a meeting with the speech therapist to receive the necessary devices and instructions for the proper execution of the laryngeal VTS.
The protocol involved the application of laryngeal vibration once a day, for a duration of 20 minutes, for a period of 4 weeks. Patients were required to attend a weekly speech therapy visit to also receive treatment under supervision and provide pre-treatment and post-treatment voice samples for evaluation of the effects of the experimental therapy.

The vocal quality was evaluated during the weekly speech therapy visit by recording two phonetically balanced phrases from the Italian version of the CAPE-V and a sustained /a/ sound, both before and after the VTS treatment.
Four parameters were used to evaluate vocal quality: AVQI (Acoustic Voice Quality Index), CPPS (Cepstral Peak Prominence Smoothed), number of voice interruptions (Voice Breaks), and perceptual evaluation of voice using the Instability index of the GIRBAS scale.
The AVQI is a composite index that combines various acoustic markers into a single measure that correlates with the overall severity of dysphonia (Maryn & Weenink, 2015).
The CPPS parameter has been shown to be correlated with both the degree of vocal harmony in the sample and the perceived severity of dysphonic vocal symptoms (Watts et al., 2019); greater values of CPPS are indicative of a higher degree of vocal harmony and improved phonatory function quality.
The AVQI and CPPS values were derived via PRAAT software, while vocal breaks were identified by the speech-language pathologist and the GIRBAS was evaluated by speech therapist and phoniatrist in a double-blind manner.

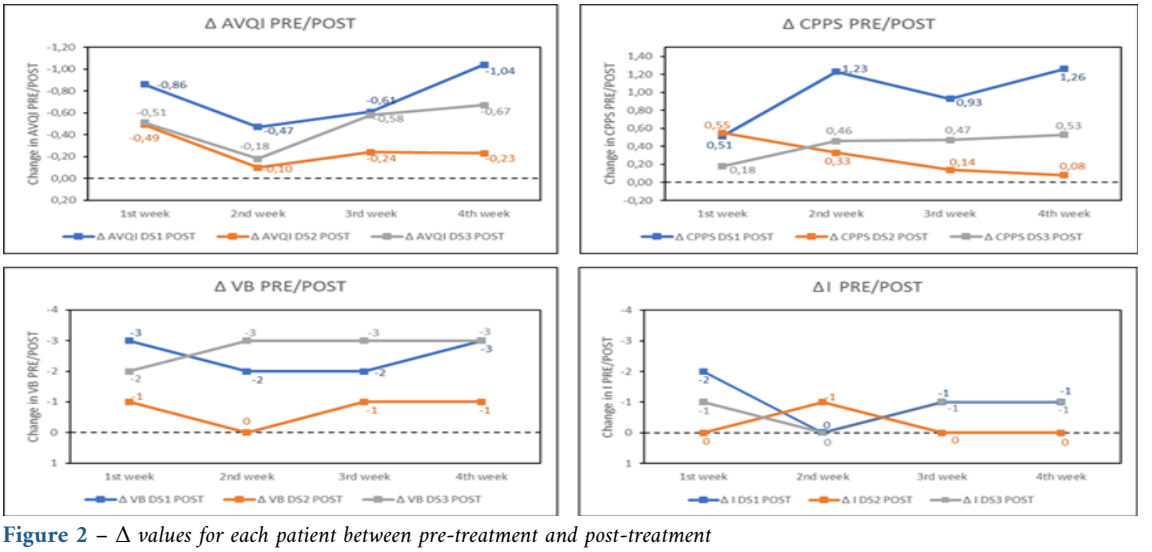

Figure 2 – Δ *values for each patient between pre-treatment and post-treatment*

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	Δ AVQI POST	Δ CPPS POST	ΔVB POST	ΔI POST
*DS*1	-0,75	0,98	-2,50	-1,00
*DS*2	-0,27	0,28	-0,75	-0,25
*DS*3	-0,49	0,41	-2,75	-0,75

Table 1 – *Mean Δ values for each patient between pre-treatment and post-treatment*

RESULTS

At the end of the 4-week protocol, the delta (Δ) variation between pre-treatment and post-treatment phonatory values was calculated for each analyzed parameter (AVQI, CPPS, VB, and I), and the average delta was determined for each patient, facilitating a more direct comparison (Table 1).
The analysis of the data revealed significant improvements in all phonatory parameters following the VTS treatment. The AVQI scores showed a mean improvement of -0.50 (ΔAVQI POST) across the three patients, indicating an enhancement in overall vocal quality. Similarly, the CPPS values increased by an average of 0.56 (ΔCPPS POST), reflecting improved phonatory function quality and vocal harmony. Furthermore, the number of voice interruptions (Voice Breaks) decreased by -1.67 (ΔVB POST) on average, indicating a reduction in disrupted speech patterns. The perceptual evaluation of voice using the GIRBAS scale also demonstrated a mean improvement of -0.67 (ΔI POST), suggesting an enhanced perceptual voice quality.

CONCLUSIONS

These preliminary findings support the effectiveness of laryngeal VTS as a potential non-invasive adjunctive treatment option for adductor-type spasmodic dysphonia. The application of high-frequency vibrations to the larynx for a duration of 20 minutes led to measurable temporary improvements across all assessed parameters (AVQI, CPPS, VB, and I), resulting in an improved phonatory function quality and speech stability, suggesting that VTS has the potential to alleviate symptoms and enhance the quality of life for individuals with adductor-type SD.
However, it is important to acknowledge that this study focused solely on the immediate post-treatment evaluation of vocal parameters. Thus, we aim to perform future assessments of the parameters considered to collect data on the persistence of treatment effects in the short and medium term, which will be critical for the advancement of future studies, in terms of outcome. Furthermore, future research will need to include larger sample sizes, control groups, and follow-up studies to determine the long-term efficacy and sustainability of laryngeal VTS as a potential treatment for adductor-type spasmodic dysphonia.

REFERENCES

1. *Blitzer, A., Brin, M.F., Simonyan, K., Ozelius, L.J., and Frucht, S.J.* (2018). *Phenomenology, genetics, and CNS network abnormalities in laryngeal dystonia: a 30-year experience. The Laryngoscope,* 128(*Suppl* 1), *S1-S9.*
2. *Cordo, P., Gurfinkel, V. S., Bevan, L. & Kerr, G. K.* (1995).*Proprioceptive consequences of tendon vibration during movement. J Neurophysiol* 74, 1675–1688,
3. *Hintze, J. M., Ludlow, C. L., Bansberg, S. F., Adler, C. H., & Lott, D. G.* (2017). *Spasmodic Dysphonia: A Review. Part* 1: *Pathogenic Factors. Otolaryngology--head and neck surgery: official journal of American Academy of Otolaryngology-Head and Neck Surgery,* 157(4), 551–557.
4. *Loucks, T. M., Poletto, C. J., Saxon, K. G., & Ludlow, C. L.* (2005). *Laryngeal muscle responses to mechanical displacement of the thyroid cartilage in humans. Journal of applied physiology,* 99(3), 922-930.
5. *Ludlow, C. L.* (2009). *Treatment for spasmodic dysphonia: limitations of current approaches. Current opinion in otolaryngology & head and neck surgery,* 17(3), 160–165.
6. *Ludlow, C.L.* (2011). *Spasmodic dysphonia: a laryngeal control disorder specific to speech. Journal of Neuroscience,* 31, 793-393.
7. *Khosravani, S., Mahnan, A., Yeh, I., Aman, J. E., Watson, P. J., Zhang, Y., ... & Konczak, J.* (2019). *Laryngeal vibration as a non-invasive neuromodulation therapy for spasmodic dysphonia. Scientific reports,* 9(1), 1-11.
8. *Mahnan, A., Konczak, J., & Faraji, S. A.* (2019). *Wearable non-invasive neuromodulation device for the symptomatic treatment of the voice disorder spasmodic dysphonia. In Frontiers in Biomedical Devices* (*Vol.* 41037, *p. V*001*T*02*A*001). *American Society of Mechanical Engineers.*
9. *Maryn, Y., & Weenink, D.* (2015). *Objective dysphonia measures in the program Praat: smoothed cepstral peak prominence and acoustic voice quality index. Journal of Voice,* 29(1), 35-43.

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10. *Nagai, T.* (1982). *Encapsulated sensory corpuscle in the mucosa of human vocal cord: An electron microscope study. Archivum histologicum japonicum*, 45(2), 145-153.

11. *Richardson, S. P., Wegele, A. R., Skipper, B., Deligtisch, A., Jinnah, H. A., & Dystonia Coalition Investigators* (2017). *Dystonia treatment: Patterns of medication use in an international cohort. Neurology*, 88(6), 543–550.

12. *Simonyan, K., Barkmeier-Kraemer, J., Blitzer, A., Hallett, M., Houde, J. F., Jacobson Kimberley, T., Ozelius, L. J., Pitman, M. J., Richardson, R. M., Sharma, N., Tanner, K., & The NIH/NIDCD Workshop on Research Priorities in Spasmodic Dysphonia/Laryngeal Dystonia* (2021). *Laryngeal Dystonia: Multidisciplinary Update on Terminology, Pathophysiology, and Research Priorities. Neurology*, 96(21), 989–1001.

13. *Simonyan, K., and Ludlow, C. L.* (2010). *Abnormal activation of the primary somatosensory cortex in spasmodic dysphonia: an fMRI study. Cerebral cortex*, 20(11), 2749-2759.

14. *Watts, C. R., Hamilton, A., Toles, L., Childs, L., & Mau, T.* (2019). *Intervention Outcomes of Two Treatments for Muscle Tension Dysphonia: A Randomized Controlled Trial. Journal of speech, language, and hearing research: JSLHR*, 62(2), 272–282.

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