Rehabilitation of Functional Dysphonia Using Semi-Occluded Vocal Tract Exercises (SVOTE)

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Abstract

This case study evaluated the efficacy of semi-occluded vocal tract (SVT) therapy as a speech intervention for functional dysphonia in a 53-year-old patient. Laryngoscopic examination revealed mild erythema and mucosal irregularity in the posterior third, edema, slight interarytenoid erythema, and phonatory hiatus in the posterior third of the posterior wall. Vocal assessments were conducted before and after rehabilitation, focusing on the perceptual, acoustic, and aerodynamic aspects. The treatment plan incorporated sustained, oscillatory, and transient occlusions over 10 sessions. The results showed enhanced voice timbre quality and normalization of the fundamental frequency appropriate for the patient's age and sex. The jitter, shimmer, and harmonic noise disturbances decreased, indicating improved wave stability and harmonic structure definition. The maximum expiratory and phonatory times, along with the s/z ratio, increased, leading to improved vocal efficiency. Additionally, the vocal risk indicator decreased, articulatory stability improved, and energy utilization became more efficient, resulting in more stable formants. The study concluded that SVT exercises produce positive vocal changes, suggesting that techniques aimed at modifying the vocal tract are effective for speech therapy rehabilitation in patients with functional dysphonia.

Keywords: Semi-occluded vocal tract; physiological tendency, functional dysphonia, speech therapy rehabilitation, and teaching.

1. Introduction

Menaldi (2002) defines dysphonia as “a symptom, an alteration of the voice that can range from simple vocal abuse to the loss of vocal efficiency, and implies the lack of control of the respiratory, resonance and projection mechanisms. Therefore, it is an alteration of the voice that disrupts communication”. This condition affects up to 47% of the general population, and is particularly common among professionals who rely heavily on their voices, such as educators, public speakers, politicians, and vocalists (Roy et al., 2005). The International Classification of Functioning (ICF) categorizes vocal disorders as conditions involving a structural deficiency in the larynx, limitations in vocal function (manifested through loss of voice modalities and symptoms of discomfort and fatigue), and restrictions in an individual's ability to participate in various roles and functions (Latorre et al., 2009). Consequently, vocal alterations can have significant social, occupational, economic, and emotional effects by limiting voice use and preventing activities that require constant vocalization. In addressing dysphonia, vocal therapy employs various techniques, programs, and philosophical approaches, some of which produce immediate changes in an individual's voice, whereas others yield long-term improvements (Inostroza-Moreno, 2021).

Various philosophical approaches to vocal therapy have emerged including hygienic, psychogenic, symptomatological, and ecliptic methods. These have long been considered the primary intervention strategies, and their effectiveness has been supported by experience. Traditionally, vocal hygiene programs, resonance therapy, vocal amplification, and respiratory training have been the cornerstones of therapeutic interventions (Atará-Paraquive and Ángel-Gordillo, 2018). However, a shift towards vocal economy training has occurred, based on the idea that reducing vibration doses and collision stress can minimize the risk of vocal injury by decreasing mechanical tissue damage. One of the most widely used techniques in this approach involves exercise with a semi-occluded vocal tract (TVSO) (Delprado et al., 2021). These exercises comprise a set of maneuvers that partially constrict or elongate the vocal tract and alter the vibration pattern of vocal folds (Story et al., 2000).

Thomas and Stemple (as cited in Guzmán and Salfate, 2018) indicated that this approach has garnered more scientific support due to the high level of evidence and numerous studies compared to other voice therapy methods. Nevertheless, Guzmán and Salfate (2018) pointed out a lack of Spanish-language theoretical reviews on semi-occluded vocal tract exercises as physiological voice therapy tools for both rehabilitation and training. Titze (2006) argued that voice therapy using semi-occluded vocal tract techniques has a long-standing history and is considered effective for both training and rehabilitation. Techniques such as lip and tongue trills, bilabial fricatives, humming, and phonation through tubes or straws have been endorsed by physicians, singing instructors, and voice coaches. Consequently, it is widely acknowledged that ETVSO exercises have a positive effect on the voice.

Additional research corroborates the immediate efficacy of vocal exercise. Frisancho et al. (2018) conducted a study to assess the instantaneous effects of the semi-occluded ventilation mask (SOVM) on individuals with functional dysphonia and those with normal voices. The study involved 64 participants, comprising 31 with functional dysphonia and 33 with normal voice. The participants were randomly assigned to either an experimental group using SOVM (33 participants) or a control group without SOVM (31 participants). All participants underwent aerodynamic, electroglottographic (EGG), acoustic, and self-perception evaluation. The findings revealed that connected-speech phonation tasks using the SOVM produced immediate positive effects in both dysphonic and normal-voiced participants, with more pronounced changes observed in dysphonic subjects. SOVMs appear to facilitate easier voice production and more efficient phonation.

Echternach et al. (2020) examined the short-term effects of water resistance therapy (WRT) on 8 participants with organic dysphonia (mass lesions in the vocal cords). During therapy and after recording, the subjects were instructed to adjust their volume to a comfortable level to vary vocal fold tension and induce stretching during the WRT. The study found significant effects during WRT intervention. However, the observed effects post-WRT could be interpreted as signs of vocal fatigue, as exceeding 10 min with the tube 5 cm underwater resulted in excessive vocal load for patients with vocal cord mass lesions. The researchers concluded that the open ratio derived from the glottic area and closure ratio increased during WRT and decreased immediately afterward.

The significance of this research stems from its aim of assessing the efficacy of semi-occluded vocal tract therapy (TVSO) in treating functional dysphonia in a 53-year-old adult through speech therapy rehabilitation. This study represents an innovative and high-priority research area, as its findings will equip speech therapists with essential theoretical and practical knowledge for planning and executing therapeutic sessions using semi-occluded vocal tract exercises (TVSO) to rehabilitate dysphonia. Given that communication is a crucial aspect of human nature, this approach seeks to enhance patients' vocal conditions through ETVSO-based voice rehabilitation, facilitating long-term learning, and the transfer of improved vocal behavior across various situations, as noted by Inostroza-Moreno (2021). Furthermore, this research will impact the broader speech and language pathology community by expanding their scope of practice in dysphonia rehabilitation through TVSO therapy. This expansion will not only improve the quality of care provided to dysphonic patients, but also serve as a foundation for future evidence-based studies. It is important to recognize that speech therapists' clinical role involves evaluating treatment outcomes and utilizing this information to guide decision-making and determine service effectiveness in line with evidence-based practice principles, as stated by Belhau (2008).

2. Materials and methods

2.1 Design

This study employed a single-case experimental approach that focused on one unit of analysis. Quantitative data collection methods are utilized by incorporating standardized instruments, such as tests, questionnaires, and scales. This research aims to be descriptive in nature, independently measuring or gathering information on various variables.

2.2 Procedure

To involve the subject in the research process, the study's characteristics were explained to the patients through a discussion. After comprehending the information, the patient voluntarily completed informed consent in line with the Colombian ethical guidelines for human research (Resolution 008430 of the Ministry of Health, 1993) and the International Declaration of Helsinki (2013).

The treatment plan began with a comprehensive voice assessment, which not only helped specify the diagnosis and various health conditions, but also facilitated the establishment of therapeutic goals and the development of a treatment approach (see Table 1).

Table 1. Determination of therapeutic objectives and treatment goals according to physiological tendency

Patient objectives	Therapeutic objectives	Proposed goals
Sustain respiratory cessation to generate vocalization "My objective is to extend the duration of breath retention without rapid depletion."	Equilibrium and regulation of laryngeal muscle exertion, respiratory effort, and supraglottic modification of the laryngeal tone.	- Functional respiratory performance and capacity. - Increased exhaled air pressure. - Stable sound and mastery of phonation. - Awareness of respiratory mechanics (phono-respiratory coordination).
Improve phonation: "The objective is to enhance vocal endurance, enabling prolonged speech without fatigue or coughing."	Enhancement of laryngeal muscle strength, tonicity, equilibrium, and stamina.	- Changes in subglottic pressure and phonation pressure threshold. - Better perception of timbre quality of voice. - More stable voice and open throat.
Enhance acoustic resonance or amplification of the vocal projection "The objective is to regain the capacity for effective instruction, ensuring that students can adequately perceive and comprehend vocal communication within the classroom environment."	Balance between subsystems of voice production.	- Healthier voice. - Increased vocal tract impedance. - Effortless voice to achieve pitch, tone, and resonance according to emotional, occupational, and social needs.

This study was conducted in three stages. Initially, baseline conditions were evaluated in the auditory-perceptual, acoustic, and aerodynamic categories. Subsequently, semi-occluded vocal tract therapy was administered over 10 sessions, each lasting 40 min, on Mondays and Wednesdays at 8am for 6 weeks. Finally, the post-therapy conditions were assessed. Case monitoring involved reviewing the patient's clinical history, including laryngoscopy and ultrasound examinations, from the onset of the vocal issues. Voice quality was quantified using the RASAT scale during timbre exploration, which is a psychoacoustic voice characteristic.

Acoustic analysis was performed using the Anagraf software (Gurlekian, 1997) in a sound-dampened environment. Voice recordings used a 16-bit, 16000 Hz sampling frequency on an HP laptop. A vocal dynamic microphone with a 60-800 Hz frequency response was positioned 10 cm from the patient's mouth. A Tascam sound card with a 24-bit/96 kHz Hi-res professional audio interface was employed. The patients were instructed to sustain the vowel // for approximately 5 s at conversational intensity following deep inhalation. This method yielded measurements of the fundamental frequency (F0), Jitter, Shimmer, harmonic-noise ratio (NHR), and cepstrum amplitude (Acep), which were used to calculate the integrated perturbation index (IPI) and vocal precision index (IPV).

Aerodynamic measurements included maximum expiratory time (TME), which represents the longest sustained /s/ consonant, and maximum phonation time (TMF), which indicates the longest sustained /a/ vowel at a comfortable volume and frequency after deep inspiration. The S/Z quotient or phono-respiratory index was also determined, representing the ratio of the maximum blowing times for the /s/ consonant.

Various semi-occluded vocal tract techniques have been used for voice therapy. These methods include vocalizing the /a/ vowel through tubes, sustaining consonant sounds through tubes, prolonged phonation of nasal consonants, and utilization of the hand-over-mouth occlusion approach. Additional techniques involved phonation into a polyethylene cup with an opening, lip buzzing, water resistance therapy (involving bubbling), lip and tongue vibrations, raspberry (simultaneous lip and tongue vibration), and phonation using voiced occlusive consonants (see Table 2).

Table 2. Summary of the therapeutic intervention applying the semi-occluded vocal tract exercises

S*	objective	Intervention actions	Assigned activities
1	Specify the reason for the consultation.	- A clinical interview was conducted (medical and vocal history). - A review of the clinical history was carried out. - Phonatory tasks (Aphonic lip vibration).	Principle of sensorimotor learning (acquisition - external focus of attention), voice sensations.
2	Assess vocal characteristics, define treatment goals, and conduct evaluations.	. A perceptual assessment of dysphonia was performed (RASAT). . An acoustic assessment of the voice was performed – Anagraf. . Vocal efficiency was measured with the assessment of aerodynamic measures (TME, TMF, S/Z ratio). -Phonatory tasks (Vibration of aphonic – phonic lips and tongue).	Sensorimotor learning principle, execution stage, recognition of sensations in the voice.
3	Apply semi-occluded vocal tract exercises for the patient with functional dysphonia.	ETVSO and phonatory tasks were applied. Sensory feedback and forward focus. . Sustained vowel-like sound. . Blowing through straw. . Straw phonation at the usual pitch. . Phonation with voiced occlusive consonants /b/. . Ascending – descending glissandos. . Costo-abdominal breathing. Inhale through the nose, exhale through the mouth. . Correct and eutonic posture in sitting and standing position.	. Acquisition-execution stage. Verbal information. (review the exercises learned). . Recognize sensations. . Record physical sensations and sounds associated with the voice (easy voice, anterior vibration, open throat sensation, softness sensation, lightness sensation).
4	Implement semi-occluded vocal tract exercises for patients with functional dysphonia.	Sustained vowel-like sound with changes in the shape of the vocal tract (from a horizontal or normal position to a vertical position). . Sustained vowel-like sound at different pitches within a comfortable range. . Sustained vowel /u/ with flexible tube . Phonation with voiced occlusive consonants /b/. . Intensity and frequency accents . Correct and eutonic posture in sitting and standing position. . Costo-abdominal breathing.	Home plan: exercises worked in the full sequence session 8-10 times a day. . Acquisition stage. Modeling. . Retention stage: (understanding and correct execution of the exercise). Record the performance of the exercise, the external focus of attention. Record the physical sensations and sounds associated with the voice (easy voice, anterior vibration, open throat sensation, softness sensation, lightness sensation).
5	Apply semi-occluded vocal tract exercises for the patient with	. Rising accents . Song melody . Prosodic melody “tell me what you did yesterday” Sensory feedback and forward focus: vibrations in the facial region.	Home plan: Exercises on demand 8 times a day, for 5 minutes. Stage of execution and retention. Perceptual learning.

	functional dysphonia.	. Correct and eutonic posture in sitting and standing position. . Lip trills with phonation. . Lip trills with variations in pitch and volume.	Record the performance of the exercise, the external focus of attention. Record the physical sensations and sounds associated with the voice.
6	Apply semi-occluded vocal tract exercises for the patient with functional dysphonia.	. Blowing through water-resistant tubes with phonation. . Straw phonation with volume variations. . Costo-abdominal breathing. Inhale through the nose, exhale through the mouth. Relaxed cheeks. . Straw phonation when reading words and sentences. . Messa di Voce exercises. . Correct and eutonic posture in sitting and standing position.	Performance stage - retention (producing new patterns of easy, resonant and vibrant voice during phonation). Record the performance of the exercise. Record the physical sensations and sounds associated with the voice.
7	Apply semi-occluded vocal tract exercises for the patient with functional dysphonia.	. Exercises to strengthen phono-respiratory coordination. . Correct and eutonic posture in sitting and standing position. . Phonation with voiced occlusive consonants /b/. . Humming. . Sustained phonation of nasal consonants /m/. . Hand-over-mouth occlusion technique. . Legato.	Home plan: Exercises on demand 8 times a day, for 5 minutes. Retention stage Perceptual learning (increase awareness of sensations). Record the performance of the exercise, the external focus of attention. Record the physical sensations and sounds associated with the voice.
8	Apply semi-occluded vocal tract exercises for the patient with functional dysphonia.	. Correct and eutonic posture in sitting and standing position. . Exercises to strengthen phono-respiratory coordination. . Ascending and descending glissandos. . Legato. . Lip buzz. . Finger Kazoo. . Intensity and tonal accents.	. Home plan: exercises worked in the full sequence session 8-10 times a day. Retention stage. Perceptual learning . Record the performance of the exercise, the focus of attention. Record the physical sensations and sounds associated with the voice.
9	Post-treatment evaluation.	. A perceptual reassessment of dysphonia was performed – RASAT. . An acoustic reassessment of the voice was performed – Anagraf. . Vocal efficiency was measured by assessing aerodynamic measures (TME, TMF, S/Z ratio).	Feedback. Comparison of the current voice with the previous voice. Constant self-monitoring of the voice.
10	Follow-up	. Explanation of the current vocal status. . Patient's evolution (initial and final conditions. . Experimentation for improvement. . The phonatory tasks learned were reviewed.	Motivation Maintaining vocal registers. Self-monitoring. The patient feels phonation is easier and is able to maintain a phonatory pattern.

S*: Sessions

2.3 Participante

A 53-year-old female educator was directed to speech therapy by an otorhinolaryngologist because of functional dysphonia resulting from gastroesophageal reflux disease (GERD). Her care is coordinated among the otorhinolaryngology, speech therapy, endocrinology, and gastroenterology departments. In addition to GERD and chronic gastritis, the patient had a 24-year history of hypertension for which she received amlodipine 20 mg daily, metoprorol 50 mg twice daily, and captupril 50 mg three times daily. She also experienced allergies (watery eyes and persistent cough), managed with desloratadine 5 mg. Additionally, she had hypothyroidism, which was controlled by levothyroxine.

Professionally, she has been a first-grade primary school instructor for 25 years. However, her voice issues necessitated occupational medicine assessment to determine work-related recommendations and monitoring. Currently, she is unable to work, as her job demands extensive daily voice use and projection, often resulting in voice loss. The patient denied any detrimental habits affecting her voice such as smoking or alcohol consumption and maintained a healthy diet to mitigate pharyngolaryngeal reflux symptoms.

2.4 Diagnosis

The Diagnostic and Statistical Manual of Mental Disorders (DSM – V) classifies dysphonia as a communication disorder that encompasses deficiencies in language, speech, and communication. Dysphonia is a voice disorder affecting the larynx, which affects vocal production and communication by altering tone, timbre, and intensity qualities. These symptoms cause significant distress, affecting an individual's work and emotional and social spheres. The manual categorizes it as an Unspecified Communication Disorder (F80.9) owing to insufficient information for a more precise diagnosis, given the multifactorial nature of dysphonia.

Speech-language diagnostic characterization identifies it as moderate to severe dysphonia with a functional etiology, stemming from gastroesophageal reflux. The voice is described as a hoarse with an elevated pitch corresponding to an increased fundamental frequency. It exhibits signs of hoarseness, breathiness, tension, and roughness, featuring few harmonics and a limited energy concentration in formants. The voice displayed spectral noise with air escape, indicating a slightly diminished vocal abduction force. This results in a minimal vocal economy and reduced aerodynamic power for voice production.

3. Results

The findings presented here focus on the clinical case, emphasizing the comparison of voice functional parameters assessed before and after the implementation of semi-occluded vocal tract exercises.

In the pre-evaluation audio-perceptual voice assessment, a voice characterized by severe breathiness and tension, moderate hoarseness, and roughness with poor timbral clarity was identified. The R2, A2, S3, A1, and T3 scores were recorded. Post-evaluation revealed persistent signs of hoarseness, roughness, and breathiness at a mild level, with significant improvement in tension. Asthenia normalized. In particular, R1, A1, S1, A0, and T0. Consequently, enhancement in the voice's timbral quality was observed (Table 3).

Table 3. Audio-perceptual evaluation of the voice pre and post-treatment

RASAT – Pre-Treatment					RASAT – Post-Treatment				
	Normal	Mild	Moderate	Severe		Normal	Mild	Moderate	Severe
Hoarseness			x		Hoarseness		x		
Roughness			x		Roughness		x		
Puffiness				x	Puffiness		x		
Asthenia		x			Asthenia	X			
Strain				x	Strain	X			

Table 4 illustrates the pre-evaluation results of the acoustic parameters, indicating that the patient exhibited a high-pitched voice with a fundamental frequency (F0) of 259 Hz. This voice is characterized by low intensity, limited range, and elevated larynx. Based on the standards established by Gurlekian and Molina (2012), the Jitter value (15.9%), Shimmer value (0.91 dB), and harmonic noise ratio (0.64) are all abnormal, suggesting signal instability. Following the intervention, a subsequent acoustic evaluation revealed an improved fundamental frequency of 197 Hz, which is appropriate for the patient's age and sex. The Jitter, Shimmer, and Harmonic Noise (NHR) parameters showed positive reductions in their respective values. Nevertheless, a minor disturbance in the acoustic signal was observed.

Table 4. Pre- and post-treatment acoustic parameters

Parameter	Pre-Treatment	Post-Treatment
F0	259HZ	197HZ
JITTER	15.9	2.03
SHIMMER	0.91	0.44
NHR	0.64	2.77
CEPSTRUM	0.28	0.38

In the initial assessment of phonatory efficiency, the patient exhibited a reduced maximum expiratory time (MET) of 13 s. Similarly, the maximum phonatory time (MFT) for sustaining the vowel /a/ averaged 10 seconds, and the S/Z index yielded a quotient of 1.3. These low support values indicated compromised respiratory support and inadequate glottal closure. Following the intervention, the post-test results showed improvement. The patient's MET increased to 18 seconds, demonstrating an enhanced expiratory duration. The MFT also improved to 17 s, indicating the patient's ability to maintain phonation for a longer and more stable period. Additionally, the patient's phono-respiratory coordination, as measured by the S/Z index, normalized to 1 (18/18), suggesting improved glottal efficiency and an increased capacity for sustained phonation (Table 5).

Table 5. Pre- and post-treatment phonatory efficiency

Parameter	Pre-Treatment	Post-Treatment
TMF	10s	17s
TME	13s	18s
S/Z QUOTIENT	13/10 = 1,3	18/18=1

The pretreatment spectrogram in Figure 1 displays an irregular fundamental frequency pattern and energy distribution, along with substantial spectral noise. This leads to unclear formants and an ill-defined harmonic component, suggesting that the voice lacks resonance. However, acoustic analysis following treatment showed significant enhancement. The waveform demonstrates increased stability and regularity, whereas the fundamental frequency becomes more uniform. The harmonic structure appeared more distinct, and there was a noticeable decrease in noise levels. Formants are now easily identifiable and steady, and their energy distribution exhibits a substantially improved consistency.

Pre-Treatment | Post - Treatment

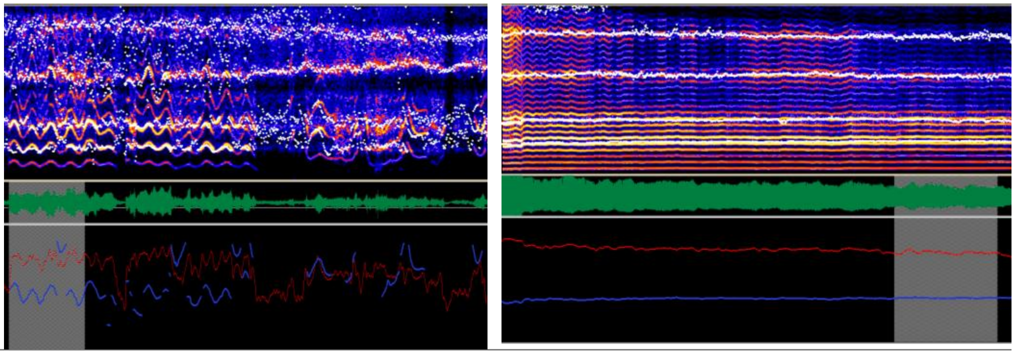

Figure 1. Pre- and post-treatment narrow band spectrogram

The pretreatment analysis in Figure 2 revealed a modified integrated disturbance index (IPI: 5.5), indicating a significantly altered voice according to the vocal risk indicator. Following treatment, IPI improved to 3.0, resulting in a lower vocal risk indicator. This suggests that while the acoustic properties of the voice are enhanced, it is still categorized as being at risk.

IPI Pre-Treatment | IPI Post – Treatment

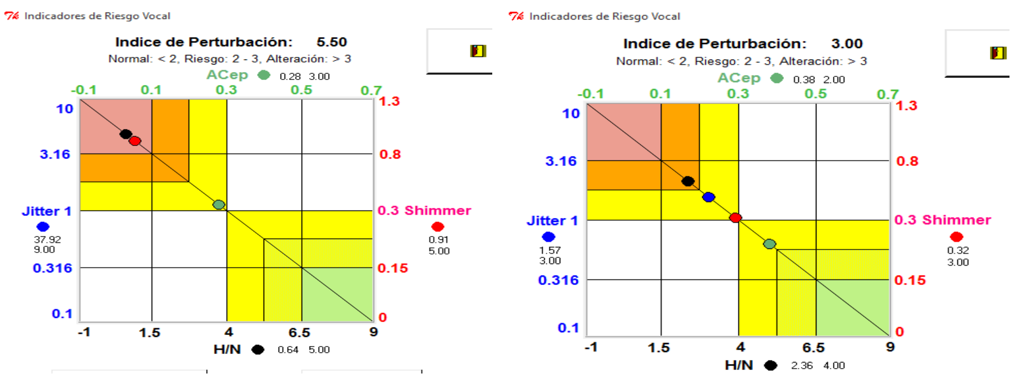

Figure 2. Integrated Disturbance Index (IPI) pre and post-treatment

The pretreatment Vocal Precision Index (VPI) results indicated a score below 82%, suggesting unstable energy utilization of the initial three formants. This instability leads to poor articulatory control, owing to insufficient vocal precision. In contrast, the post-treatment results demonstrated a high vocal precision of 98%, indicating enhanced articulatory stability, improved utilization of glottal harmonic energy, and more consistent formants (see Figure 3).

IPV PRE-TREATMENT IPV POST-TREATMENT

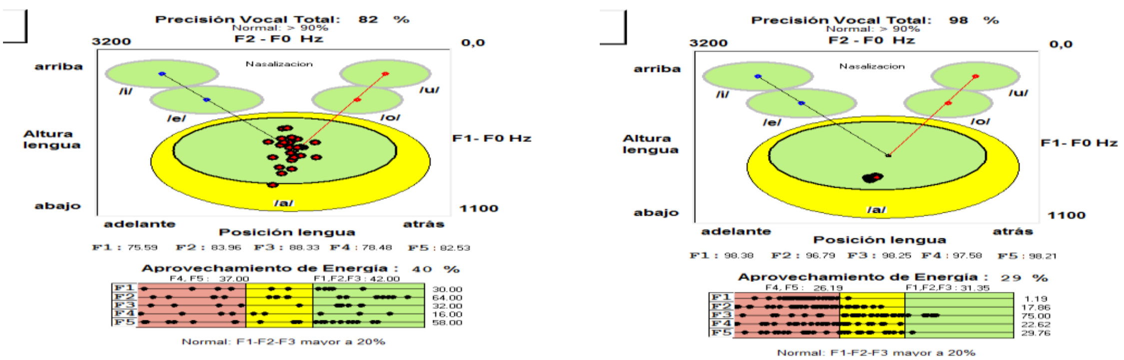

Figure 3. Vocal Accuracy Index (VAI) pre and post-treatment

4. Discussion

This study examined the efficacy of a semi-occluded vocal tract (SVT) exercise program in treating a 53-year-old woman with functional dysphonia. The study revealed enhancements in voice timbre quality, with post-treatment audio-perceptual analysis showing improvements in overall dysphonia or hoarseness severity as well as reduced tension, breathiness, and roughness. These findings align with those of Chen et al. (2007), who observed significant reductions in hoarseness severity, tension, monotonous tone, resonance, and glottal attacks among 24 female teachers with functional dysphonia after applying physiological rehabilitation techniques and resonant voice therapy. Guzmán et al. (2018) suggested that SVT exercises may effectively alleviate the discomfort caused by perceived muscle tension in the laryngeal and pharyngeal regions. This approach leads to increased muscle relaxation perception and improved resonant voice quality, resulting in easier vocalization and enhanced vibratory sensation.

An examination of voice acoustics revealed notable changes in Jitter, Shimmer, and Harmonic-Noise disturbance parameters, as well as a decrease in fundamental frequency when comparing pre- and post-treatment measurements. These findings suggest that the semi-occluded vocal tract exercises and phonatory tasks had a beneficial impact on the physiological aspects of vocal fold vibration. Although the voice still exhibited signs of dysphonia from a functional perspective after therapy, it appeared that the harmonic structure became more defined. Existing research indicates that the Jitter and Shimmer disturbance measures tend to decrease, which is thought to result from improved glottic function stability (Guzmán & Salfate, 2018).

The reduction in spectral noise results from enhanced vocal fold contact and improved source-filter interactions (Cabrera et al., 2021). In addition, the lowering and relaxation of the larynx contributed to a decrease in the fundamental frequency. Muscle tension causes the larynx to be positioned higher, resulting in a shorter vocal tract. Thus, relaxation of laryngeal muscles and reduced tension are linked to a lower laryngeal position in the neck and an elongated vocal tract (Guzmán et al., 2013). The positive changes observed after applying treatment using semi-occlusion therapeutic techniques can be attributed to the enhanced interaction between the voice source (vocal folds) and filter (vocal tract), promoting more efficient and economical phonation (Titze, 2006). Comparable outcomes were reported by Guzmán et al. (2012) in a study involving teachers with dysphonic voices perceptually classified as blown. They observed significant improvements in the cepstral analysis, jitter, and harmonic noise ratio following the use of phonatory tasks with resonance tubes.

Similarly, aerodynamic measurements showed positive changes following the implementation of semi-occluded vocal tract exercises, including increases in the maximum expiratory time, maximum phonatory time, and phono-respiratory quotient. This results in enhanced glottal efficiency and ensures sustained phonatory processing. Research has indicated that extended vocal therapy using TVSO in individuals with dysphonia can lead to decreased subglottic pressure, suggesting reduced phonatory effort, as noted by Guzmán et al. (2017). Additionally, TVSO exercises may effectively provide respiratory support, a breathing technique aimed at minimizing excessive laryngeal muscle effort during phonation, in both vocal therapy and training (Salfate and Guzmán, 2018). These findings align with those of Carrillo et al. (2019), who observed changes in the maximum phonation time, maximum blowing time, and phono-respiratory index after TVSO therapy in teachers with vocal disorders. The researchers concluded that the aerodynamic measurements demonstrated significant changes in these variables.

In addition, Guzmán et al. (2013), ETVSOs lead to modifications in the vocal tract, including an enlarged pharyngeal area, raised velum, lowered larynx position, and alterations in the acoustic and aerodynamic properties. Research in this field has shown that following ETVSO application, spectrograms indicate vocal improvement through an increase in glottal pulses, resulting in wave stabilization and a more defined harmonic structure with greater energy concentration and reduced noise. Titze (2006) explained that an inertive vocal tract produces a quicker closing phase, increased sound pressure, and enhanced high harmonics. These findings align with those of Guzmán et al. (2012), who determined that changes caused by semi-occluded vocal tract exercises enhance vocal fold adduction during sustained vowel phonation, thereby increasing the harmonic component and decreasing the noise component, which is characteristic of higher-quality voices.

Post-treatment analysis of the integrated disturbance index (IPI) and vocal precision index (IPV) revealed a reduction in vocal risk indicators, along with enhanced articulator stability and improved energy utilization, resulting in more stable formants. These physiological and acoustic modifications contribute to the production of a voice that is perceived to be more resonant and brighter (Guzmán et al. 2012). Behlau (2008) noted that partial oral occlusion promotes retroreflexive resonance and expansion throughout the vocal tract, including the mouth and the larynx. These findings align with those of Guzmán et al. (2012), who demonstrated that exercises involving a semi-occluded vocal tract lead to decreased phonatory effort. This improvement subsequently resulted in a balanced interplay between the three subsystems involved in voice production: phonation, breathing, and resonance.

5. Conclusion

The presented case demonstrates objective improvements in voice timbre quality and alterations in Jitter, Shimmer, Harmonic-Noise, and Fundamental Frequency disturbance parameters, resulting in a beneficial impact on the voice's physiological characteristics. Notable changes were also observed in aerodynamic measurements, with increases in maximum expiratory time, maximum phonatory time, and phono-respiratory quotient, indicating enhanced glottal efficiency for sustained phonation. Additionally, spectrogram analysis revealed wave stabilization characterized by a more defined harmonic structure with greater energy concentration, reduced noise, improved articulator stability, and more efficient energy utilization, as evidenced by more stable formants. In conclusion, TVSO therapy shows promise as an effective approach for speech therapy rehabilitation in functional dysphonia. The immediate signs of improvement and voice effects suggest that physiological vocal therapy incorporating semi-occluded vocal tract exercises as part of a comprehensive regimen to restore vocal function may serve as a safe and efficient intervention method for patients with functional dysphonia.

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