EFFICACY OF HALF SWALLOW BOOM AND SUPRAGLOTTIC SWALLOW IN INDIVIDUALS WITH GLOTTAL DYSFUNCTION: A COMPARATIVE STUDY

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A Dissertation Submitted in Part Fulfilment of

Degree of Master of Science (Speech Language

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July, 2024

CERTIFICATE

This is to certify that this Dissertation entitled "**Efficacy of Half Swallow Boom and Supraglottic Swallow in Individuals with Glottal Dysfunction: A Comparative Study"** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech-Language Pathology) student with Registration Number P01II22S123042. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
July, 2024

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Mysuru

July, 2024

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DECLARATION

This is to certify that this Dissertation entitled "**Efficacy of Half Swallow Boom and Supraglottic Swallow in Individuals with Glottal Dysfunction: A Comparative Study"** is a result of my study under the guidance of Dr. K. Yeshoda, Associate professor, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No.**: P01II22S123042

July, 2024

Dedicated to Amma, Appa and Dhruva

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CHAPTER 1

INTRODUCTION

Dysphonia presents a notable challenge characterized by discrepancies or inadequacies in pitch, loudness, and/or voice quality, which deviate from what is expected for an individual considering factors such as age, gender, cultural background, or location. The lifetime prevalence of voice problems was reported as 21.6% (Sheyona & Devadas, 2022). Voice disorders can be linked to a diverse array of causes or origins (Thomas et al., 2021a).

Glottal dysfunction is identified by the incomplete closure of the vocal folds during the process of phonation, this incomplete closure during phonation can lead to abnormal leakage of air further giving a breathy quality to voice. Glottal dysfunction can arise from abnormal vocal fold structure, neurophysiological impairments, and abnormal volitional production of voice because of muscle tension patterns (Stemple & Hapner, 2019).

There are three types of glottal dysfunction: Glottal Insufficiency which occurs when structural defects prevent adequate vocal fold closure, often due to loss of vocal fold tissue or lesions that restrict closure. Glottal Incompetence**,** which is caused by neuromotor or physiological disorders, this involves incomplete vocal fold movement and closure, often due to partial or complete paralysis of the recurrent laryngeal nerves. Glottal Incapability is diagnosis of exclusion, this occurs when vocal fold closure is inconsistent or incomplete without anatomical pathology or obvious neuromotor abnormalities, such as primary muscle tension dysphonia (Stemple & Hapner, 2019).

It is essential to know the laryngeal dynamics and structural status for the accurate diagnosis of voice disorders (Franco & Andrus, 2007). Employing combined acoustic measures exhibits satisfactory capability in discerning the presence or absence of laryngeal alteration and in discriminating among different laryngeal diagnoses. Specific combinations of acoustic measures proved highly accurate in distinguishing different laryngeal diagnoses. For instance, combining fundamental frequency standard deviation (F0 SD) and jitter effectively differentiated healthy larynx from cases of unilateral vocal fold paralysis. Similarly, combining F0 SD and shimmer accurately distinguished healthy larynx from those with sulcus vocalis (Lopes et al., 2017).

The precise diagnosis of the voice problem and identification of its causative factors will help the clinical decisions to plan an accurate treatment plan for the individual. The treatment for voice disorders comprises voice therapy, medication and surgical management (Ramig & Verdolini, 1998).

Evidence-based practice (EBP) is a healthcare approach where health professionals utilize the most suitable and best available evidence to make clinical decisions for individual patients. EBP respects, strengthens, and extends clinical expertise, incorporating knowledge of disease mechanisms and pathophysiology. Therefore, all clinicians must join together with the common goal of advancing EBP in their practice (Kent et al., 1999).

Speech-language pathologists (SLPs) often recommend behavioural voice therapy as the primary approach for treating voice disorders (Cohen et al., 2016). The major treatment recommendation provided for treatment seeking population with voice disorders was found to be voice therapy than other treatment option (Vijayan & Rajasudhakar, 2021). In the realm of voice therapy for glottal insufficiency, multiple approaches have demonstrated effectiveness. Therapy specifically targeting glottal incapability has consistently yielded positive responses. Moreover, individuals with glottal incompetency have shown responsiveness to improvement through the application of voice therapy techniques (Berry et al., 2001; Stemple & Hapner, 2019).

1.1 Voice Therapy for Glottal Dysfunction

Voice therapy is the primary approach to intervention for voice patients with glottal incapability and is highly effective in a majority of cases (da Cunha Pereira et al., 2018; Roy, 2008). The primary objective of therapy includes restoring a mucosal waveform on the affected side and achieving medialization and closure of the glottic gap (Damrose & Berke, 2003).

Literature suggests that numerous approaches demonstrate benefits for individuals with glottal insufficiency. For instance, programs like Vocal Function Exercises and Phonation Resistance Training Exercises are effective therapeutic interventions for individuals experiencing glottal insufficiency due to mild to moderate age-related voice changes commonly observed in presbylarynges. Along with the above-mentioned techniques, the most commonly employed voice therapy approaches for the treatment of individuals with glottal insufficiency are pushing, hard glottal attack, half-swallow boom, abdominal breathing, head and neck relaxation, lip and tongue trills, resonant voice, and accent method (Stemple & Glaze 2000).

Lombard & Steinhauer (2007) explored Twang therapy to enhance voice quality in people with hypophonic voice. They found improvements in aerodynamic, acoustic, and perceptual voice measures before and after therapy, highlighting its effectiveness alongside traditional approaches for this condition.

As mentioned earlier, there are numerous voice therapy techniques available for treating individuals with glottal dysfunction. In addition to that the Half Swallow Boom technique is frequently cited in literature for its effectiveness in improving glottal function.

1.2 Half Swallow Boom (HSB)

Boone and his colleague McFarlane (Boone, 1977; Boone & McFarlane, 1994) developed HSB as one of several voice-facilitating techniques. The HSB technique involves a swallow procedure that maximizes laryngeal closure.

McFarlane et al (1998) suggested that this technique is another means of repositioning the vocal folds to explore improved voice quality in individuals with unilateral vocal fold paralysis. The participant was asked to take a breath and go through the motions of initiating the first part of a swallow. The pharyngeal and laryngeal muscle movements that occur during the half-swallow improve glottic closure. During the zenith of the half-swallow, the patient is directed to forcefully utter “boom.” A successful execution of this technique is marked by a louder and clearer voice quality in the uttered “boom.” The muscle manipulations initiated by the half-swallow are then stabilized in the production of “boom” and subsequently extended to encompass other words and phrases.

Voice therapy and muscle-nerve reinnervation surgery were more successful than Teflon injection in improving all six vocal parameters (pitch, loudness, hoarseness, vocal roughness, breathiness, and overall quality). Techniques such as head turn, digital manipulation, and HSB reduced the severity of voice issues with an average of 9 hours of therapy. These findings suggest that voice therapy is a viable primary treatment option for individuals with unilateral vocal fold paralysis McFarlane et al. (1991).

Thiagarajan & Kothandaraman (2014) stated that the patients with puberphonia gradually learn to lower the pitch of their voice because the HSB procedure is recognized for optimizing laryngeal closure. The production of the sound "Boom" involves applying posterior pressure to the larynx, contributing to the observed lowering of pitch.

A significant improvement was noted in overall quality of life, particularly the physical subscale, among thirty-six patients with voice disorders treated over 10 weeks. The treatment included hygienic strategies, symptomatic techniques (such as chant talk, yawn-sigh technique, chewing method, elimination of hard glottal attack, HSB, pushing approach, and relaxation), and physiologic interventions (specifically, vocal functional exercise). Structural causes showed the most benefit, with notable improvements in laryngeal health, while non-structural causes saw less improvement across emotional, physical, and functional subscales (Aueworakhunanan et al., 2019).

The HSB technique, introduced by McFarlane et al. (1998), serves as a facilitator to enhance vocal fold closure and amplify vocal intensity. Facilitators like the HSB can be valuable in evaluating a patient's capacity to raise vocal intensity.

Nevertheless, clinicians need to be mindful of avoiding hyperfunction, as it may contribute to increased vocal fatigue and ineffective compensation (Asha_persp4_428, n.d.).

The above evidence proves that HSB is an effective technique for the improvement of glottal incompetence (Busto-Crespo et al., 2016; McFarlane et al., 1991a; Thiagarajan & Kothandaraman, 2014). However, there is a lack of evidence on the impact of HSB in individuals with glottal insufficiency. It needs research attention which will help in the intervention of individuals with glottal insufficiency.

The glottal closure can be established using HSB which helps in the effective voice production. Physiologically, vocal fold adduction takes place during respiration, speech, or phonation (Baki et al., 2017) and during swallowing (Kawasaki et al., 2001). Therefore, these processes can be used to improve vocal fold adduction in individuals with voice disorders due to glottal dysfunction.

During normal swallow the vocal folds closure is a part of a protective mechanism that involves swallowing apnea (Nishino, 1990). This apnea begins when the vocal folds are maximally adducted and ends when these folds begin to reopen supporting the idea that swallow apnea could be related to glottis closure (Ren et al., 1993). There are various swallow maneuvers clinically used for the effective swallow function which will reduce the risk of aspiration of bolus. The utilisation of these techniques in persons with laryngeal insufficiency may result in effective glottal closure for voice production.

1.3 Supraglottic Swallow (SGS)

There is main four swallow maneuvers for the improvement of swallowing physiology in dysphagia management: (1) the SGS, (2) the super-supraglottic swallow, (3) the effortful swallow, and (4) the Mendelsohn maneuver that are direct therapy techniques (Flood, 2017).

SGS was developed by Logemann (1983), which was designed to prevent the inhalation of food or liquid by securing the airway before swallowing. The SGS entails "taking a breath, holding your breath, keep holding your breath while you swallow and cough or take a breath, exhale a little and hold your breath while you swallow and cough" (Logemann, 1995). This manoeuvre is employed in instances of reduced or delayed vocal closure and delayed pharyngeal swallow. Its purpose is to ensure the closure of the vocal folds before and during swallowing, especially in situations involving delayed or compromised vocal closure during the swallowing process (Thomas et al., 2021b; Van Houtte et al., 2010; Vijayan & Rajasudhakar, 2021).

The SGS sequence is designed to achieve closure of the vocal folds before and during the swallow and to reduce the chances of aspiration before, during, or after the swallow (Logemann, 1986). During the SGS swallow, the vocal folds are voluntarily closed before and during the swallow, followed by a cough to clear any material from the airway (Chaudhuri et al., 2002; Martin et al., 1993; Ohmae et al., 1996).

As the literature shows SGS influences the vocal fold adduction that might help improve the vocal function in individuals with vocal insufficiency. However, there is a lack of evidence showing the effect of SGS in individuals with vocal insufficiency. The researches that show the efficacy of such techniques in vocal insufficiency may enrich the evidence-based practice in voice therapy.

1.4 Need of the study

Individuals with glottal dysfunction are treated with various techniques and approaches (Lombard & Steinhauer, 2007; Stemple & Glaze, 2000; Thiagarajan & Kothandaraman, 2014). Since the swallowing mechanism needs effective vocal fold adduction, the swallowing maneuvers may help in the improvement of vocal approximation in individuals with vocal insufficiency. HSB is mainly used in the context of glottal incompetency (Busto-Crespo et al., 2016; McFarlane et al., 1991a; Thiagarajan & kothandaraman, 2014). Evidence has shown that the SGS technique improves the vocal fold adduction (Logemann, 1991). However, there is a lack of evidence for the use of the SGS technique to improve glottal insufficiency in the purview of improvement in voice quality. Since both techniques have similar effects in terms of the achievement of a better glottal closure, there is a need to investigate and compare the efficacy of both techniques when used to improve the glottal closure in individuals with voice disorders due to glottal dysfunction.

1.5 Aim of the study

The study aimed to investigate the efficacy of the two techniques (HSB and SGS) and also compare both techniques when administered to groups of individuals with voice disorders secondary to glottal dysfunction.

1.6 Objectives of the study

1. To compare the pre-therapy and post-HSB therapy voice measures in individuals with voice disorders due to glottal dysfunction using auditory-perceptual, EGG, and acoustic parameters.
2. To compare the pre-therapy and post-SGS therapy voice measures in individuals with voice disorders due to glottal dysfunction using auditory-perceptual parameters, EGG, and acoustic parameters.
3. To compare the efficacy of HSB and SGS techniques in improving voice using auditory-perceptual parameters, EGG, and acoustic parameters.

1.7 Null hypothesis

1. H_{01}- There is no significant difference between pre-therapy and post-HSB therapy on auditory-perceptual, EGG and acoustic parameters.
2. H_{02}- There is no significant difference between pre-therapy and post-SGS therapy on auditory-perceptual, EGG and acoustic parameters.
3. H_{03}- There is no significant difference between HSB and SGS technique in improving voice using auditory-perceptual, EGG and acoustic parameters.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Dysphonia

A voice disorder occurs when voice quality, pitch, and loudness differ or are inappropriate for an individual's age, gender, cultural background, or geographic location (Aronson & Bless, 2009; Boone, 2010; Lee et al., 2004). Voice disorders may result from changes in the structure (organic disorders) and/or function (functional disorders) of the laryngeal mechanism (Van Houtte et al., 2010). The prevalence of voice disorders was reported to be varying with different populations.

2.2 Dysphonia prevalence

Roy et al. (2005), in their questionnaire-based interview study comprising 1326 participants (general population) reported that 29.6% of individuals had experienced voice problems at least once in their lifetime while 6.6% of individuals reported a currently present voice problem.

Bhattacharyya (2014) based upon their analysis of the 2012 National Health Interview Survey (NHIS) found that nearly 7.7% of adults in the USA experience voice problems every year. Bhattacharyya (2015) based upon their analysis of the 2012 NHIS pediatric voice and language module found that nearly 1.4% ± 0.1% of children in the United States of America reported voice problems in 1 year.

A systematic review and meta-analytical study done by Wang et al. (2023) in which they reviewed 13 articles (published between 2006 – 2019), suggests about 18.79% prevalence of voice problems in older adults. Their findings further suggest a higher prevalence of dysphonia in institutionalized adults (33.03%) than community-based older adults (15.2%).

In a retrospective investigation done by Van Houtte et al. (2010), the most prevalent diagnoses were functional voice disorders (30%), followed by vocal fold nodules (15%), and pharyngolaryngeal reflux (9%). The study explored the influence of age, gender, and occupation. It was found that pathologies were significantly more prevalent in females (63.8%) compared to males (36.2%). Among occupational groups, professional voice users constituted 41% of the population, with teachers being the primary subgroup. Among professional voice users, functional dysphonia was observed in 41%, vocal fold nodules in 15%, and pharyngo-laryngeal reflux in 11%.

The patients with dysphonia were diagnosed with a total of 22 different types of vocal pathologies of which the prevalence of vocal nodules is 28.1%, vocal fold paralysis/paresis is 15.5%, vocal fold edema is 13.7%, sulcus vocalis is 7.3%, and vocal polyps is 6.1% (Thomas et al., 2021a).

A study in Indian context reported that the frequency of individuals within a population who experience structural voice disorders was found to be 61%, neurogenic voice disorders was 13.5%, functional voice disorders was 13.1%, and psychogenic voice disorders were 1.7% (Vijayan & Rajasudhakar, 2021).

These studies highlight various causative factors that lead to differences in voice production. In essence, voice deviations result from glottal dysfunction caused by these factors, which affect glottal closure in different ways (Thomas et al., 2021a, Van Houtte et al., 2010).

2.3 Glottal dysfunction

There are three types of glottal dysfunction according to Stemple & Hapner (2019). The first one is the glottal insufficiency, which occurs when a structural defect precludes adequate vocal fold closure during voicing. This condition is linked to the loss of vocal fold tissue (i.e., muscle atrophy and thinning of the lamina propria). Additionally, it involves the existence of vocal fold lesions that restrict complete vocal fold closure. Second is glottal incompetence, which refers to neuromotor or physiological disorders that result in "incompetent" vocal fold movement and incomplete closure of the vocal folds during adduction. Glottal incompetence is often due to complete or partial paralysis of one or both of the recurrent laryngeal nerves that leads to limitations in lateral-medial movement of the vocal folds (i.e., incompetent vocal fold adduction). Third type of glottal dysfunction is glottal incapability which is a diagnosis of exclusion occurring when inconsistent or incomplete vocal fold closure occurs even without the presence of anatomical vocal fold pathology and in the absence obvious neuromotor abnormality (e.g., primary muscle tension dysphonia [MTD]). This dysfunction in aeromechanical valving of the vocal folds during voicing is termed glottal incapability (incoordination/inefficacy/inability) (Stemple & Hapner, 2019).

Glottic incompetence characterizes vocal fold paralysis, vocal fold atrophy, and sulcus vocalis as pathological conditions. These disorders feature impaired vocal fold mobility and disrupted glottic closure. Increased turbulent airflow and noise energy are shared characteristics among all three conditions. The perceptual sensation of breathiness in these cases stems from turbulent airflow passing through the compromised glottis (Omori et al., 1998).

Glottic insufficiency stands out as a prevalent factor in patients experiencing dysphonia, often slipping under the radar during clinical assessments. Among the leading causes of symptomatic glottic insufficiency are unilateral vocal fold paralysis, unilateral or bilateral vocal fold weakness, and vocal fold atrophy linked to the aging process (Simpson & Rosen, 2024). Rajaei et al. (2014) defined Glottal Closure Insufficiency as a "form of laryngeal hypofunction during which the closed phase of phonation, which is normally 50% of the cycle of vibration, is 45% or less". Glottal insufficiency can arise from different conditions, including neuromuscular paralysis or paresis, deformation of vocal folds due to aggressive resection of benign lesions, the loss of native tissue in vocal folds after tumor removal, and age-related changes such as presbylarynx or sulcus vocalis (Dursun et al., 2008). The voice quality of breathiness indicates that the vocal folds do not close completely during the vibratory cycle (Fritzen et al., 1986).

The primary symptoms of unilateral vocal fold paralysis can vary widely, ranging from mild vocal fatigue or well-compensated cases to severe aphonia. These variations depend on the extent of glottal insufficiency and the individual's specific compensatory phonation strategy (Wackym & Snow, 2016).

In a clinical context, individuals with glottal insufficiency may exhibit the absence of a mucosal traveling wave on the affected side, bowing of the affected fold leading to a resulting glottic gap, or a combination of both these characteristics.

Incomplete closure of the glottis results in heightened airflow during phonation, leading to the production of a breathy voice that may also exhibit reduced intensity. Hoarseness is caused by the absence of symmetrical vibration in the vocal folds (Paseman et al., 2004).

2.4 Assessment of Glottal Dysfunction

Invasive tools are ideal for assessment and early diagnosis of glottal dysfunction, factors related to affordability, easy access, time, cost may deter patients from seeking such sophisticated methods. Quantitative acoustic measures that are regularly used for the assessment of voice normalcy also find application in the early identification of glottal dysfunction. Such methods are the ready-to-reckon tools at the disposal of the SLPs with the added advantage of being non-invasive and hence affordable to almost all patients.

A prospective study was conducted by Vaca et al. (2017) on 104 healthy participants, 65 years and older where they aimed to determine the accuracy of diagnostic tools for glottal insufficiency. Laryngostroboscopy was performed on all patients, revealing a spindle-shaped glottal gap during phonation in 47 subjects. The s/z ratio had a mean value of 1.13, and the values ranged from 0.7 to 2.56. Based on the established clinical limits for this parameter, 29% of the patients presented a ratio that was suggestive of a glottal gap. According to these results, the combination of continuous light endoscopy and s/z ratio is a good screening strategy for glottal insufficiency in phonation. They allow a general otolaryngologist for early identification of subjects with presbyphonia and glottal gap without requiring a laryngostroboscopic examination at a voice clinic.

Specific combinations were found to have superior accuracy when evaluating the efficacy of combined acoustic measures in distinguishing between distinct laryngeal diagnoses. For instance, the combination of fundamental frequency standard deviation (F0 SD) and jitter displayed enhanced precision in discerning a healthy larynx from cases of unilateral vocal fold paralysis (79.64%, SD = 2.67). Likewise, the amalgamation of F0 SD and shimmer demonstrated enhanced precision in distinguishing a healthy larynx from cases with sulcus vocalis (78.39%, SD = 4.78) (Lopes et al., 2017).

Electroglottography (EGG) provides unique information about vocal fold behavior that is, for the most part, invisible to other available techniques. In particular, EGG characteristics involving the rate and symmetry of vocal fold contact changes may provide insight into vocal fold mucosal status and cover-body coupling (Orlikoff, 1991).

Electroglottography (EGG) offers a variety of parameters for analysing vocal fold vibrations. Some of the parameters include fundamental frequency, amplitude of EGG waveform, Contact Quotient (CQ), EGG contact index, EGG speed quotient, EGG contact slope. EGG is effective in detecting glottal insufficiency by analysing the consistency and completeness of vocal fold contact. Parameters such as the contact quotient and fundamental frequency estimation provide indirect evidence of vocal fold closure and can reveal irregularities indicative of glottal insufficiency (Herbst et al., 2017; Timmermans et al., 2004).

If EGG jitter reduces, it may suggest a decrease in the irregularities or perturbations in vocal fold vibration. This reduction could indicate an improvement in vocal fold function or a decrease in the severity of the laryngeal pathology affecting the voice. However, it is essential to interpret this reduction in EGG jitter in conjunction with other clinical findings and assessments to understand the overall impact on voice quality and laryngeal function (Vieira et al., 2002).

Auditory-perceptual or perceptual or qualitative measures are invaluable and prevalent measures in protocols or tools as diagnostic markers during assessment and also as outcome measures to gauge improvement or progress in voice therapy. They are termed gold-standard measures to judge voice quality owing to their intricate and innate relationship with the psycho-physical domain of voice.

In a study done by Timmermans et al., (2004), where training outcome in future professional voice users after 18 months of voice training was looked for using GRBAS as one of the auditory-perceptual outcome measure along with other components. The ‘Grade’ component showed improvement across training and no significant difference was obtained for BRAS parameter.

One of the studies done by Schindler et al. (2008) showed that utilizing techniques like hard glottal attack, pushing, and HSB in voice therapy for individuals diagnosed with unilateral vocal fold paralysis resulted in an overall improvement across all parameters of the GRBASI scale except strain. D’Alatri et al. (2008) studied the impact of HSB voice therapy in individuals with unilateral vocal fold paralysis. Other techniques included hard glottal attack, pushing, abdominal breathing; vocal function;

appropriate tone focus; accent method; and lip and tongue trill which were studied. The results indicated significant improvements in several voice quality parameters post-therapy. Specifically, there was a significant reduction in the mean values for grade, instability, breathiness, and asthenia when compared to pre-therapy assessments. Multiple studies have utilized the GRBASI scale as an outcome measure to assess the effectiveness of voice therapy in different voice disorders (Hazlett et al., 2011; Lee et al., 2023; Lu et al., 2013; Sano et al., 2020; Xu et al., 1991). Therefore, GRBASI rating scale can be used as a reliable auditory-perceptual outcome measure.

Non-linear acoustic measures are gaining recognition as diagnostic markers in the assessment of voice disorders as they are robust to detect embedded discernible signals even in the presence of aphonia. Algorithms that infer acoustic measures using mel, bark scales and cepstral measures, such as, cepstral peak prominence (CPP), smoothened Cepstral Peak Prominence (CPPS) are notable.

Evidence suggests that cepstral peak correlates well with dysphonia severity in both sustained vowel and in connected speech (Sujitha & Pebbili, 2022). Heman-Ackah et al. (2003) stated smoothed CPP for sustained vowel /a/ phonation and smoothed CPP for running speech as good indicators of dysphonia. Also, they noted that the CPPS for vowel and CPPS for speech has better sensitivity, specificity, and positive and negative predictive values than do the measures of jitter, shimmer, and NHR.

The literature suggests that the perceptual, acoustic and EGG analyses are efficient assessment techniques for the glottal dysfunction. The comprehensible and effective assessment will help in the treatment decisions, especially in case of voice therapy ASHA, (1998, 2004).

2.5 Voice therapy techniques used to improve glottal dysfunction

Voice therapy endeavours to enhance glottal closure without inducing excessive strain above the glottis, while concurrently fostering abdominal support for breathing and refining the strength and flexibility of the intrinsic muscles involved in phonation (Heuer et al., 1997; Stemple et al., 2018).

Stemple (1993) acknowledged that "there have been enormous advances in our understanding of the basic science of voice production, etiologies of voice disorders and voice evaluation techniques, but he decided that the same intervention techniques had been used by speech pathologists for decades with little attempt to scientifically evaluate their efficacy and effectiveness".

In general, voice therapy techniques are found to be superior to other surgical procedures in the treatment of patients with unilateral vocal cord paralysis (McFarlane et al., 1991b). The study employed 16 vocal cord paralysis patients and 6 normal subjects. The listeners rated the voice of the participants following voice therapy, muscle nerve reinnervation surgery, and Teflon injection. The results revealed that an average of 9 hours of voice therapy was sufficient to result in perceptual improvement in voice.

In a study done by Meerschman et al. (2019), it was shown that voice treatment with short-term intensive voice therapy has demonstrated effectiveness comparable to that of long-term traditional voice therapy for patients with dysphonia. Notably, intensive therapy achieves similar progress in only two weeks with 12 hours of treatment, contrasting with the traditional approach requiring six months and 24 hours of therapy.

2.6 Half Swallow Boom (HSB)

McFarlane et al. (1998) introduced a method for repositioning the vocal folds known as the HSB technique. In this approach, the patient is instructed to inhale and begin the initial stage of swallowing, purportedly enhancing glottal closure by engaging the muscles of the pharynx and larynx. At the apex of the half-swallow, the patient articulates 'boom' forcefully. Successful execution of this technique results in a louder and clearer 'boom' sound. The muscle adjustments induced by the half-swallow are reinforced during the 'boom' and subsequently extended to words and phrases.

The term “boom,” a single-syllable word with voiced sounds, is articulated as air is released from the constricted larynx with a minimized oral opening, creating posterior pressure on the larynx. Additionally, the head turning during the HSB technique may contribute to laryngeal closure (Pannbacker, 2001).

In a study done by McFarlane et al. (1991) involving 16 adult patients with unilateral vocal fold paralysis and 6 normal adults, voice samples were recorded and evaluated by 27 listeners, including speech-language pathologists, otolaryngologists, and lay listeners. The listeners rated voices on a 10-point scale across six vocal parameters (pitch, loudness, hoarseness, vocal roughness, breathiness, and overall quality). The patients underwent three different treatment approaches: Teflon injection

(4), voice therapy (6), and muscle-nerve reinnervation surgery (6). Voice therapy and muscle-nerve reinnervation surgery were rated more successful than Teflon injection in improving all six vocal parameters from pre-treatment to post-treatment voices. Facilitation techniques like head turn, digital manipulation, and HSB were employed in the study, reducing the severity of voice problems with an average of 9 hours of voice therapy. The findings suggest that voice therapy can be considered a primary treatment option for individuals with unilateral vocal fold paralysis.

In a comprehensive study done by Aueworakhunanan et al. (2019) encompassing patients with voice disorders, an investigation into the pre- and post-therapy quality of life was conducted. The therapeutic intervention spanned 10 weeks and incorporated a multifaceted approach, including hygienic strategies (focused on eliminating poor vocal behavior), symptomatic techniques (such as chant talk, yawn-sigh technique, chewing method, elimination of hard glottal attack, HSB, pushing approach, and relaxation), and physiologic interventions (specifically, vocal functional exercise). The study revealed a noteworthy and statistically significant enhancement in the overall quality of life for patients whose voice disorders stemmed from structural causes. This improvement was particularly pronounced in the physical subscale, indicating a positive impact on the physical well-being of patients. The mean P-VHI-TH score of 22 for this group suggested that these patients, who may have experienced discomfort due to vocal fold lesions, found direct and beneficial effects from voice therapy interventions on their laryngeal health. Conversely, patients with voice disorders originating from non-structural causes did not exhibit a significant improvement across all subscales of quality of life. Notably, functional causes showed no improvement in the emotional subscale, neurological causes did not exhibit improvement in the physical subscale, and inflammation causes demonstrated no improvement in the functional subscale.

In a systematic review of speech-language pathology management done by Walton et al. (2017) in individuals with unilateral vocal fold paralysis several studies have explored the use of the HSB technique in combination with other voice therapy approaches. This encompasses a comparative study conducted by McFarlane et al. (1991c) without controls which evaluated head-turning, HSB combined with phonation, and lateral digital manipulation. All of which involved a combination of voice therapy, surgery (thyroplasty), and Teflon injections.

The findings indicated that voice therapy alone can effectively address certain cases of unilateral vocal fold paralysis. In another study cited in the review conducted by Schindler et al. (2008), various voice therapy techniques including respiration, vocal exercises, resonant voice, hard glottal attacks, pushing, and HSB were employed. Voice therapy sessions were administered twice a week for a total of 6 to 20 sessions. The study concluded that voice therapy can notably enhance the perceptual quality and quality of life for individuals with unilateral vocal fold paralysis. In another prospective study cited in the review by D'Alatri et al. (2008), a combination of vocal hygiene, respiration techniques, vocal exercises, the HSB method, falsetto exercises, trills, speaking on inhalation, and twang therapy were utilized. These interventions were administered over 2 sessions per week, totalling 8 to 35 sessions. The study's findings indicated that voice therapy can yield notable improvements when initiated within six weeks of the onset of unilateral vocal fold paralysis (Walton et al., 2017).

Studies have shown that HSB, along with other voice therapy methods, significantly improves vocal parameters and quality of life in patients with unilateral vocal fold paralysis and other voice disorders. Voice therapy using HSB and similar techniques has been found effective, especially when started early, and can serve as a primary treatment option for improving perceptual voice quality and overall well-being.

In a study done by Kissel et al. n.d. which aimed to identify common clinical practices regarding diagnostics and treatment of UVFP. 32 certified SLPs were the respondents for the study. Among the vocal techniques used in behavioural voice therapy for Unilateral Vocal Fold Paralysis, they added various techniques in an open-ended question. One of the techniques mentioned by the respondents was HSB. A study done by Venkatraman et al., (2022) examined current trends in voice therapy practices among Speech Language Pathologists (SLPs) in India. It highlighted the educational qualifications of SLPs, their use of evidence-based practices, service delivery models, therapeutic approaches, outcome measures, and termination of therapy preferences. The findings provide insights into the evolving landscape of voice therapy in India and suggest the need for further research and development of indigenous protocols. In this e-survey done, it is noted that HSB is one of the techniques used by Speech Language Pathologists (SLPs) in India for hypofunctional voice disorders. In the study, it is reported that 1.81% of SLPs (n = 1) utilize the HSB technique as part of their therapeutic approach for voice disorders. Alongside other techniques, the HSB is one of the methods used in voice therapy for patients with mutational falsetto (Dagli et al., 2008; Prathanee, 1996).

HSB is a technique that involves inhaling, starting a swallow, and forcefully articulating "boom" to reposition the vocal folds and enhance glottal closure (McFarlane et al., 1998). This technique is utilizing swallowing as one of the physiological bases to improve voice quality. Similarly, the Supraglottic Swallow (SGS) technique involves a breath-hold manoeuvre during swallowing to protect the airway by closing the vocal folds, aiming to prevent aspiration. Both techniques engage the muscles of the pharynx and larynx to improve laryngeal elevation and vocal fold function.

2.7 Supraglottic Swallow (SGS)

The supraglottic swallow technique is employed in cases where there is suspicion of delayed pharyngeal swallow and impaired vocal fold closure (Groher & Crary, 2020; J. A. Logemann, 1995).

A study done by Shaker et al. (1990) utilized concurrent video endoscopy, video fluoroscopy, pharyngeal manometry, and submental electromyography to investigate the temporal relationship between swallow-induced glottic closure and various swallow initiation signals. Eight healthy volunteers participated in the study, and the results showed sequential events associated with laryngeal closure during swallowing, including vocal cord adduction, arytenoid cartilage approximation, laryngeal ascent, and epiglottal descent. The study also highlighted the challenges in visualizing certain events, such as the interval between vocal cord closure and opening, which were obscured by vestibular closure. The findings provide valuable insights into the coordination of glottic closure with oropharyngeal swallowing in normal subjects.

In a study involving simultaneous video-radiography and solid-state intraluminal manometry (videomanometry) in 8 patients with pharyngeal dysfunction, the patients performed supraglottic swallow, effortful swallow, and chin tuck techniques while being evaluated. The results of supraglottic swallow showed that there was an increased laryngeal elevation observed in the patient group during supraglottic swallow, when comparing supraglottic swallow with control swallows, there were tendencies towards a decreased pharyngeal peak contraction and a longer pharyngeal contraction duration, although these differences were not statistically significant. SGS technique involves a breath-hold manoeuvre to protect the airway during swallowing. This breath-hold is intended to close the vocal folds and prevent aspiration of food or liquid into the airway These findings suggest that supraglottic swallow may have some positive effects on laryngeal elevation and pharyngeal contraction duration in patients with pharyngeal dysfunction (Bülow et al., 2001; Orlikoff, 1991).

Breath-holding manoeuvres include the supraglottic manoeuvre, where breath is lightly held, and the super supraglottic manoeuvre, which requires increased effort in breath-holding. These manoeuvres aim to reduce aspiration risk by inducing voluntary airway protection before, during, and after swallowing. Some researchers have observed that voluntary breath-holding leads to varying degrees of laryngeal closure, progressing to arytenoid approximation, closure of the true vocal cords, and anterior arytenoid tilting with heightened breath-holding effort (Mendelsohn & Martin, 1993; Shaker et al., 1990).

A prospective study conducted by Donzelli & Brady (2004) aimed to evaluate the efficacy of different breath-holding techniques on vocal fold closure (VFC) for safe swallowing. The study involved 150 healthy volunteers where they compared three methods: easy breath-hold, inhale/easy breath-hold, and hard breath-hold. Using flexible nasal endoscopy, it was found that the hard breath-hold technique was the most effective, achieving true VFC in 86% of subjects and full laryngeal closure in 64%. In contrast, the inhale/easy breath-hold was the least effective. These findings suggest that the hard breath-hold method significantly enhances airway protection during swallowing by promoting optimal VFC, Consequently, it is advised that when instructing patients in the implementation of the supraglottic swallow, deep breath-holding should be omitted, and only breath-holding should be instructed.

SGS technique is used to improve vocal fold closure and protect the airway during swallowing. It involves a breath-hold manoeuvre that enhances laryngeal elevation and helps prevent aspiration. Studies have shown that SGS can positively impact vocal fold closure by increasing laryngeal elevation and extending pharyngeal contraction duration. Among various breath-holding techniques, the hard breath-hold is the most effective for achieving true vocal fold closure, ensuring better airway protection during swallowing.

The above paragraphs highlight the importance of SGS technique in achieving glottal closure. Successful glottal closure may generalize into voluntary mobility of the vocal folds which is a prerequisite for voice production. Hence, this technique could be explored as a technique to achieve glottal closure in conditions of vocal fold palsies. Techniques, such as, HSB and SGS may prove beneficial in voice restoration function. Hence, it would be of interest to investigate the utility of these two techniques, namely, HSB and SGS for facilitating vocal fold closure in conditions of vocal fold paralysis and consequent restoration of vocal fold vibrations for voice production.

CHAPTER 3
METHOD

3.1 Research design

The study employed a single-subject time series design (Table 3.1).

Table 3.1

The research design

Group 1				
O1 Pre-therapy (PT) recording of tasks for extraction of auditory-perceptual, EGG and acoustic parameters	X1 Administration of voice therapy using HSB for 5 sessions.	O2 Mid therapy (MT) (after 5 sessions of voice therapy) recording of tasks for extraction of auditory-perceptual, EGG and acoustic parameters	X1 Administration of voice therapy using HSB for the next 5 sessions	O3 Post therapy (Po-T) (after 10 sessions) recording of tasks for extraction of auditory-perceptual, EGG and acoustic parameters
Group 2				
O1 PT recording of tasks for extraction of auditory-perceptual, EGG and acoustic parameters	X2 Administration of voice therapy using SGS for 5 sessions.	O2 MT (after 5 sessions of voice therapy) recording of tasks for extraction of auditory-perceptual, EGG and acoustic parameters	X2 Administration of voice therapy using SGS for the next 5 sessions.	O3 Post therapy (after 10 sessions) recording of tasks for extraction of auditory-perceptual, EGG and acoustic parameters

Note. O1: Observation 1, X1: HSB technique, O2: Observation 2, X2: SGS technique, O3: Observation 3.

3.1.1 Sampling procedure

The present study followed a convenient sampling procedure to recruit participants and the assignment of participants to the group was random. Only participants who visited the 'Clinic for Persons with Voice Disorders' of All India Institute of Speech and Hearing, Mysore were recruited. However, the participants in each group were numbered sequentially as 1 to 4 under Group 1 (HSB) and 5 to 8 to Group 2 (SGS).

3.2 Participants

A total of eight individuals in the age range of 18-55 years who were diagnosed with Dysphonia at the 'Clinic for Persons with Voice Disorders' of All India Institute of Speech and Hearing, Mysore, and who were identified to have glottal dysfunction using laryngoscopic examination by an Otorhinolaryngologist and diagnostic assessment for voice by SLPs were recruited for the study. The demographic details of the participants are mentioned in Table 3.2. The participants were divided into two groups, randomly assigned maintaining equal number in both the groups.

Table 3.2

Demographic details of the participants

Participants	Age (in years)	Gender	ENT Diagnosis
1	51	F	Left vocal cord paralysis
2	21	M	Wide glottic chink
3	29	M	Right vocal cord palsy
4	53	M	Left vocal fold palsy
5	42	M	Left vocal fold paralysis
6	19	M	Wide glottic chink
7	55	M	Spindle-shaped glottic chink in anterior 1/3rd of the vocal folds
8	23	M	Glottic chink with mild sulcus vocalis

3.2.1 Inclusion criteria

- Age Range: 18 to 55 years.
- Individuals diagnosed with glottal dysfunction using laryngoscopic examination.
- Individuals with hypofunctional voice disorders such as vocal cord paralysis, and sulcus vocalis.

3.2.2 Exclusion criteria

- Individuals diagnosed with vocal nodule/ cyst/ polyp/ mass lesions like tumor/ Muscle Tension Dysphonia (as the practice of effort closure techniques for vocal fold contact could induce hyperfunction).
- Individuals currently undergoing hormonal therapy.

- Individuals presently under chemotherapy, radiation therapy, and antiretroviral therapy.

3.2.3 Group 1

Consisted of four participants (Participants 1, 2, 3, 4) who were provided with the HSB technique during voice therapy across two weeks (five sessions per week).

3.2.4 Group 2

Consisted of four participants (Participants 5, 6, 7, 8) who were provided with the SGS technique during voice therapy across two weeks (five sessions per week).

Participants were chosen according to the specified inclusion and exclusion criteria.

3.2.5 Participant Consent

The study's aim was communicated to the participants, and written informed consent was sought from each participant before their enrolment in the study.

3.3 Instrumentations

1. The GRBASI (Grade, Roughness, Breathiness, Asthenia, Strain and Inconsistency) scale (Dejonckere et al., 1996; Hirano, 1981) was used for the perceptual evaluation of the voice based on tasks given in 3.3.1.
2. The Electroglottograph model 6103 of the Computerized Speech Lab (CSL)-model 4500 (Kay-Elemetrics, USA) software was used to obtain EGG and its parameters. Contact Quotient and EGG jitter were measured.
3. PRAAT software version 6.3.16 was used for acoustic analysis.

4. Microphone: Boya BY- M1 Omni directional condenser microphone and recording was done using HP laptop (Microsoft Windows Version 10.0.22631.3737).
5. The perceptual analysis was carried out using GRBASI scale (Dejonckere et al., 1996; Hirano, 1981) that included the following domains:

   Grade: assesses the overall severity or grade of dysphonia, representing the listener's overall impression of the voice quality. It considered factors such as hoarseness, breathiness, and strain.

   Roughness: refers to the perception of irregularities or harshness in the voice. A higher rating on the R scale indicates a greater degree of perceived roughness in the voice quality.

   Breathiness**:** assesses the degree to which excessive air escapes during phonation, resulting in a perception of a "breathy" or airy voice quality.

   Asthenia: evaluates the weakness or lack of vocal strength in the voice. It considers factors such as vocal fatigue and the overall endurance of the voice.

   Strain: assesses the presence of excessive effort or tension during phonation. Listeners evaluate the level of strain or tension perceived in the voice.

   Instability: assesses the fluctuation of voice quality.

   The above perceptual domains were assessed using a 4-point rating scale (0 to 3), where 0 indicates normal and 3 indicates severe.

3.3.1 Tasks

The following tasks were used for the voice sample recording

a) Phonation: The participants were asked to sustain the vowel /a/ at a comfortable pitch and loudness for five seconds.

Instruction: "Please note that I will tie a neck belt with electrodes on your neck. You have to take a deep breath and prolong the vowel /a/ for 5 seconds at your comfortable pitch and loudness. A microphone positioned in front you will also audio-record your phonation".

b) Reading task: reading of a standard passage in Kannada; Bangalore reading passage (Savithri & Jayaram, 2005).

Instruction: "You will be given a reading passage in the Kannada language, read it at your comfortable pitch, rate, and loudness".

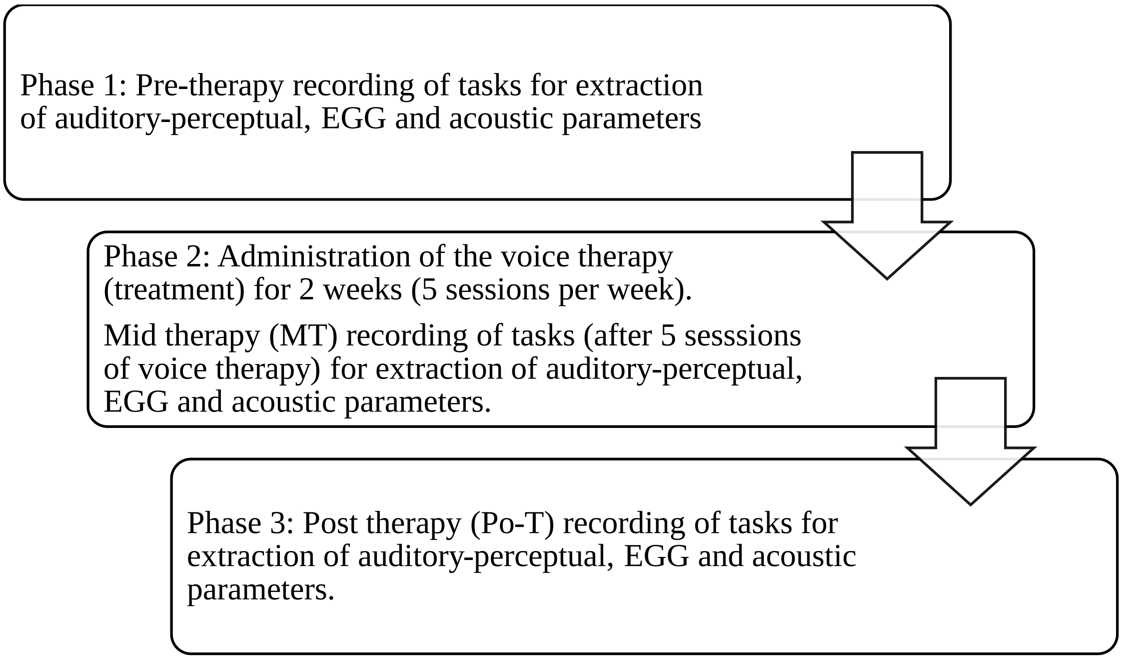
These tasks were audio-recorded thrice, that is, at PT, MT (after the completion of the 5th day of voice therapy and Po-T (after the completion of the 10th day of voice therapy). All the recordings were done in a sound-treated room.

3.4 Procedure

The study was carried out in three phases. Figure 3.1 depicts the three phases of the procedure.

Figure 3.1

Flowchart of the procedure



3.4.1 Phase One: Pre-therapy

The pre-therapy audio recordings of the voice were carried out here before the initiation of voice therapy.

3.4.2 Phase Two: Treatment Phase (Voice therapy)

The treatment phase included the administration of the voice therapy protocol to the participants.

Group I: Each participant in the first group underwent HSB therapy technique as explained by Boone, (1977); Boone & McFarlane (1994).

HSB technique: HSB voice therapy technique was provided to each participant for a total of two weeks comprising of five 30-minute sessions per week. The session was given individually to each subject by the experimenter.

The HSB technique included the following steps:

Step 1. Rapport building, educating, and counselling about the need, importance, and procedure of the voice training program, demonstration of the technique by the experimenter, and imitation and familiarization by the participant.

*Step 2***.** Practicing HSB technique

- Each participant was asked to sit upright and instructed to initiate a dry swallow and cease the swallow mid-way (participant was instructed to place one's own fingertips over their larynx to be able to feel the laryngeal elevation). Ceasing the swallow mid-way would be perceived as sustaining the larynx at an elevated position.
- After cessation of the swallow at this position, the participant was asked to say "boom".
- The same was repeated with:
  a. Head in an upright position
  b. Head turned to the right
  c. Head turned to the left
  d. Neck in a flexed position

This (a-d) constituted one cycle of HSB.

- Each session had 5 cycles of HSB.

Instruction. "Please swallow and while swallowing keep your fingers on the throat and when you feel the larynx elevated cease the swallow and say "boom", do this in an upright position, head turned to right, head turned to left and chin tucked down".

Step 3**.** Here the participant was instructed to say a number followed by the word "Boom". This was done for the count of one to ten. E.g., "Boom one", "Boom two" …. "Boom ten".

Instruction. "Please swallow and while swallowing keep your fingers on the throat and when you feel the larynx elevated cease the swallow and say "boom one", "boom two" and so on till number ten, do this in an upright position, head turned to right, head turned to left and chin tucked down"

Step 4**.** Same practice as previous sessions but here patient was instructed to replace numbers with short phrases.

*Instruction***.** "Please swallow and while swallowing keep your fingers on the throat and when you feel the larynx elevated cease the swallow and say "Boom come here", "boom go there", do this in an upright position, head turned to the right, head turned to left and chin tucked down".

For example: Phrases such as, "How are you", and "Good morning" were used.

Step 5. Gradually fade out the boom and swallow, raising the head back to the midline and raising the chin to normal position with only intermittent repetition of HSB. Phrases were given to the participants and asked to perform without swallow and boom. Between every four trials same practice as step number 4 was done.

Note: The therapy progressed in hierarchical manner and the criterion to move to the consequent step was two out of three successful attempts by the participant.

Group 2 (G2): Here each participant underwent voice therapy involving the SGS therapy technique proposed by Logemann (1983).

Step 1. Rapport building, educating, and counselling about the need, importance, and procedure of the voice training program, demonstration of the technique was carried out by the experimenter, and imitation and familiarization by the participant.

Step 2 Practicing SGS technique.

Instruction. "Breathe through your nose, then hold your breath lightly before and during swallowing. Cough immediately after you finish swallowing."

Note: The therapy progressed in hierarchical manner and the criterion to move to the consequent step was two out of three successful attempts by the participant.

3.4.3 Phase three (Post therapy- Po-T)

Post-treatment recording of tasks for extraction of auditory-perceptual, EGG, and acoustic parameters.

3.5 Analysis of Data

3.5.1 Auditory-Perceptual Evaluation

Participants: three Speech-Language Pathologists (SLP) aged between 25-40 years experienced in the assessment and management of individuals with voice disorders were the judges for the perceptual experiment.

Material: Phonation of vowel /a/ and reading of Bangalore passage. The audio-recorded samples consisting of the vowel /a/ phonation and the Bangalore passage reading samples formed the material for auditor-perceptual judgement task.

Procedure: The three judges were individually presented with the phonation and reading samples in a quiet room. The samples were randomized and presented. Judges were allowed to listen to the samples for a maximum of two times and each judge completed the task in one sitting. The GRBASI scale was used for rating the material. The results of the ratings from the three judges were compiled and tabulated for further analysis.

3.5.2 EGG Parameters

The EGG samples recorded using Computerized Speech Lab 4500 (Kay-Elemetrics, USA) were analyzed to extract the following parameters,

1. Contact Quotient- a measure of the 'relative vocal fold abduction', generally known as the 'contact quotient' or CQ (Rothenberg & Mahshie, 1988).
2. EGG Jitter- cycle-to-cycle variation in the fundamental frequency.

3.5.3 Acoustic analysis of voice

The acoustic analysis of phonation and reading samples were carried out using the PRAAT (Version 6.3.16) software. The details are explained below,

a) Fundamental frequency (F0) was extracted from phonation sample.

b) Cepstral measures were extracted using the following steps,

1. Trimming the extra portion and silence in the recorded audio signal.
2. From the tabs on the right side of the window 'Analyse Periodicity' > 'To power cepstrogram' > 'OK' were chosen.
3. A new entry named 'Power Cepstrogram' appeared within the files list in the PRAAT window.
4. Selected that file from the tabs on the right side of the praat window to select 'Query' > 'Get CPPS' > 'Ok'.

The following parameters were extracted using the cepstrum,

Cepstral Peak Prominence: is a metric that gauges the relative amplitude of the peak in the cepstrum. This peak is derived from the Fourier transform of the power spectrum of the voice signal and signifies the dominant harmonic of the acoustic voice signal (Noll, 2005). CPPS has to be measured in Cepstral Peak Prominence ($CPPS_{vowel,}$) and Cepstral Peak Prominence ($CPPS_{speech}$) (Patel et al., 2018). The parameters to obtain power cepstrogram in step 3 and CPPS in step 5 was set as per Murton et al. (2020).

3.6 Statistical analysis

The data collected was subjected to appropriate statistical analysis using IBM SPSS (Statistical Product and Service Solutions) version 21.0 software. Owing to the non-normal distribution of the data, non-parametric tests were used. Descriptive statistics of the median and interquartile range were computed. Further, the comparison of variables across PT, MT, and Po-T was done using Friedman's test. Between-group comparison was done using the Mann-Whiteny U test. Since the number of participants were limited in the study, a single-subject design analysis was carried out.

CHAPTER 4

RESULTS

The present study aimed to (a) compare pre-therapy and post Half Swallow Boom (HSB) therapy voice quality measures in individuals with voice disorders due to glottal dysfunction using auditory-perceptual, EGG, and acoustic parameters, (b) compare the pre-therapy and post Supraglottic swallow (SGS) therapy voice quality measures in individuals with voice disorders due to glottal dysfunction using auditory-perceptual parameters, EGG and acoustic parameters and (c) compare the efficacy of Half Swallow Boom and Supraglottic swallow techniques in improving voice quality using auditory-perceptual parameters, EGG and acoustic parameters.

In the current study, eight participants randomly assigned to two voice therapy groups underwent treatment for 10 sessions. The independent variables considered for the study were: *the techniques HSB and SGS* and the dependent variables considered were: *Auditory perceptual parameters (GRBASI), EGG parameters (EGG jitter and EGG Contact Quotient (CQ)), and acoustic parameters (Fundamental frequency (F0)),* $CPPS_{vowel}$, $CPPS_{speech}$*)*.

The data was obtained from each participant at Pre-therapy (PT), Mid-therapy (MT) after the 5^{th} session, and Post-therapy (Po-T) after the 10^{th} session. These values were tabulated using MS excel and subjected to statistical analysis using the IBM SPPS statistics (version 26) software. Single subject time series design was carried out to meet the objectives of the study.

The results of the current study have been stated under the following headings:

4.1 Single subject pre-post comparison

4.2 Within group comparison

4.3 Comparison between HSB and SGS

4.1. Single Subject Pre-post comparison

The single subject comparison was done using the individual values of each parameter for both the group. The comparisons were done between the three phases: PT, MT and Po-T.

4.1.1. Pre and post therapy comparison of HSB

Effect of HSB on GRBASI rating scale

The comparison was done for each domain of GRBASI scale. The single subject comparison of all four Participants undergone HSB results are explained below.

Grade: An improvement in 'Grade' was observed in Participant 1 from MT to Po-T indicating improvement in overall voice quality. For participant 2 Grade remained the same across all stages of therapy indicating no change in voice quality. Participant 3's Grade improved from PT to MT but returned to the initial level at Po-T. Participant 4's Grade improved from MT to Po-T (Table 4.1 and Figure 4.1).

Roughness: Participant 1's Roughness remained constant across all stages, indicating no change. Participant 2's Roughness increased from PT to Po-T, indicating a worsening. Participant 3's Roughness improved from PT to MT but returned to the initial level at Po-T. Participant 4's Roughness improved from PT to MT but worsened again Po-T (Table 4.1 and Figure 4.2).

Breathiness: Participant 1's Breathiness improved from PT to Po-T. Participant 2's Breathiness remained constant across all stages, indicating no change. Participant 3's Breathiness improved from PT to MT but returned to the initial level at Po-T. Participant 4's Breathiness worsened from PT to MT but improved slightly Po-T (Table 4.1 and Figure 4.3).

Asthenia: Participant 1's rating improved from PT to MT and remained stable through Po-T. Participant 2's rating remained constant from PT to MT and improved from MT to Po-T. Participant 3's rating remained constant from PT to MT and improved from MT to Po-T. Participant 4's rating remained constant across all stages, indicating no change (Table 4.1 and Figure 4.4).

Strain: Participant 1's Strain rating improved from MT to Po-T. Participant 2's Strain rating remained constant from PT to MT, then improved from MT to Po-T. Participant 3's Strain rating remained constant across all stages, indicating no change. Participant 4's Strain rating remained constant across all stages, indicating no change (Table 4.1 and Figure 4.5).

Instability: Participant 1's Instability rating improved from PT to MT and remained stable Po-T. Participant 2's Instability rating improved from PT to MT and remained stable Po-T. Participant 3's Instability rating improved from PT to MT but returned to the initial level Po-T. Participant 4's Instability rating improved from PT to MT but returned to the initial level Po-T (Table 4.1 and Figure 4.6).

Table 4.1

GRBASI values across all phases of therapy in Group 1 participants

Parameter	Participant	Pre-therapy	Mid-therapy	Post-therapy
Grade	1	2	2	1
	2	3	3	3
	3	2	1	2
	4	3	3	2
Roughness	1	2	2	2
	2	1	2	3
	3	2	1	2
	4	3	2	3
Breathiness	1	2	2	1
	2	3	3	3
	3	2	1	2
	4	1	3	2
Asthenia	1	2	1	1
	2	3	3	2
	3	2	2	1
	4	2	2	2
Strain	1	2	2	1
	2	3	3	1
	3	1	1	1
	4	2	2	2
Instability	1	2	1	1
	2	2	1	1
	3	1	0	1
	4	2	1	2

Figure 4.1

Grade values of Group 1

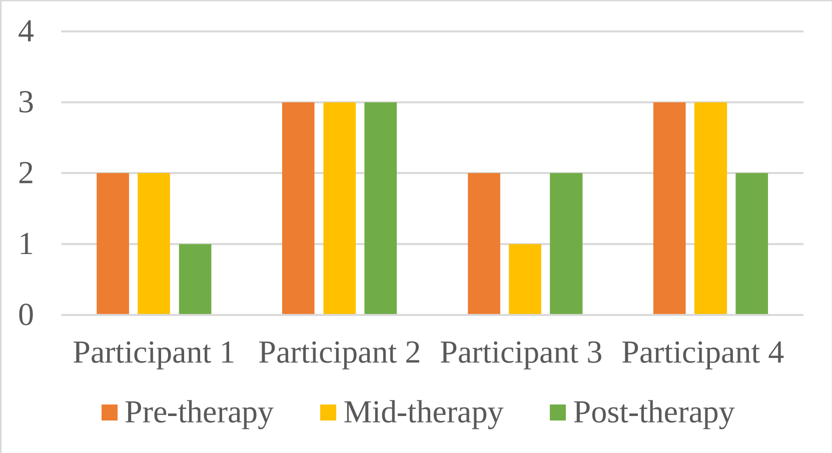


Figure 4.2

Roughness values of Group 1

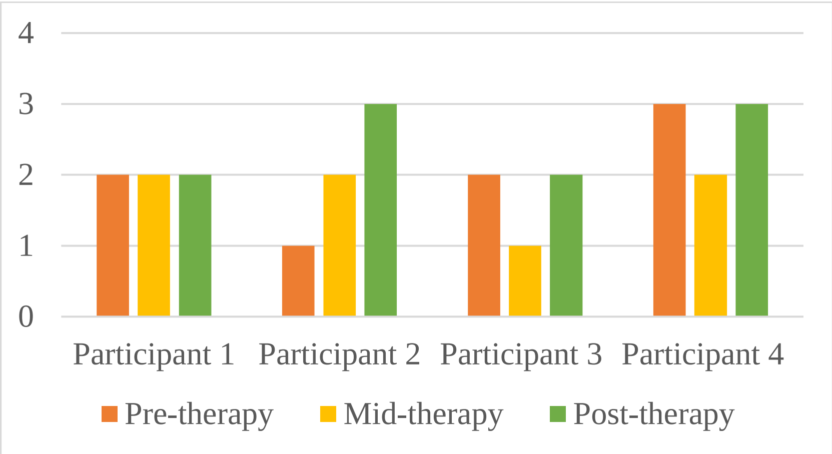


Figure 4.3

Breathiness values of Group 1

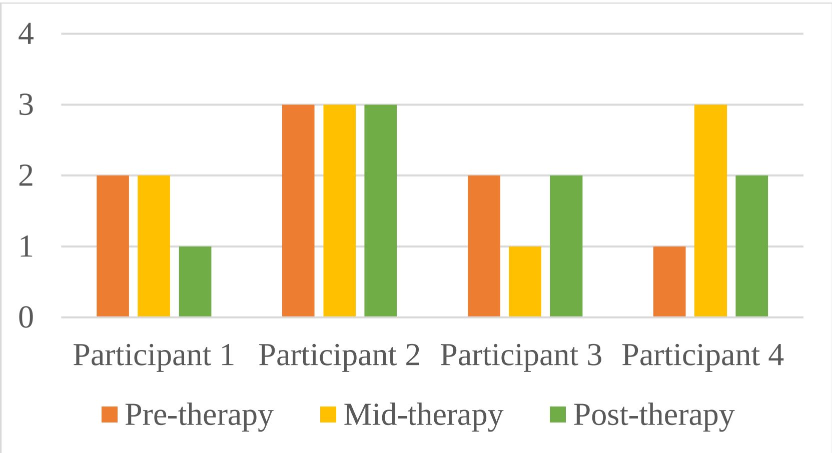


Figure 4.4

Asthenia values of Group 1

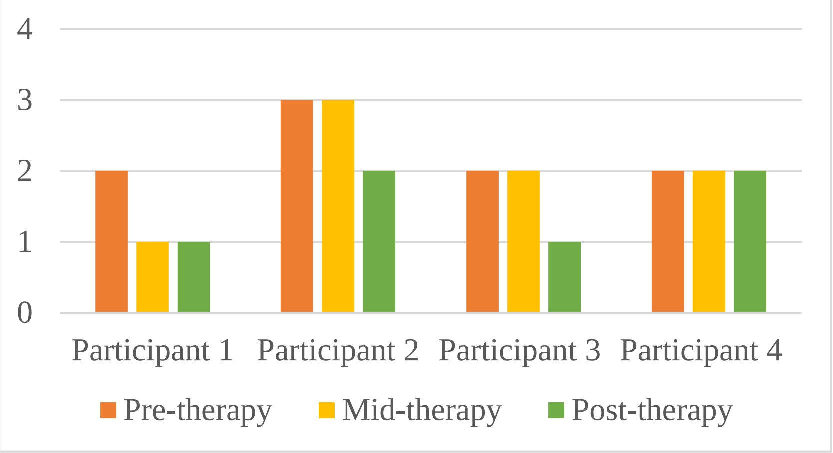


Figure 4.5

Strain values of Group 1

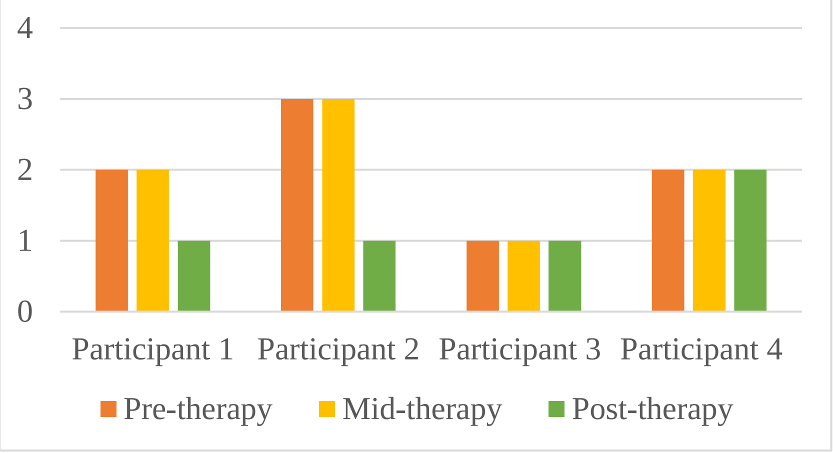
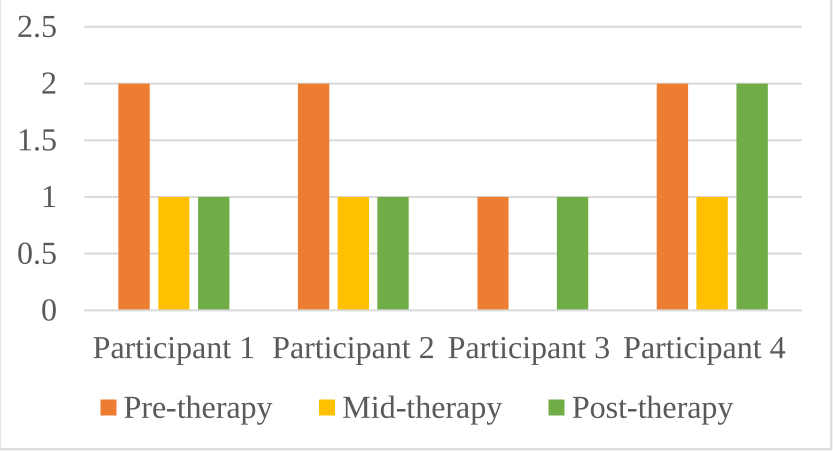


Figure 4.6

Instability values of Group 1



Effect of HSB on acoustic parameters

The comparison was done for F0, $CPPS_{vowel}$ and $CPPS_{speech}$. The single subject comparison of all 4 Participants undergone HSB results are explained below.

F0: Participant 1 showed an increase in F0 from PT to MT and a slight further increase at Po-T. Participant 2 showed an increase from PT to MT, followed by a decrease at Po-T. Participant 3 demonstrated an increase from PT to MT and another increase at Po-T. Participant 4 consistently increased in F0 across all therapy stages (Table 4.2 and Figure 4.7).

$CPPS_{vowel}$: Participant 1 showed an increase in $CPPS_{vowel}$ from PT to MT, suggesting improved voice quality, followed by a slight decrease at Po-T, but still higher than PT. Participant 2 exhibited an increase from PT to MT, indicating improvement, followed by a slight decrease at Po-T, but still higher than PT. Participant 3 demonstrated a consistent and substantial increase in $CPPS_{vowel}$ across all stages, indicating continuous improvement in voice quality. Participant 4 showed a decrease in $CPPS_{vowel}$ from PT to MT and a further decrease at Po-T, suggesting a decline in voice quality over the therapy stages (Table 4.2 and figure 4.8).

$CPPS_{speech}$: Participant 1 showed a slight increase in $CPPS_{speech}$ from PT to MT, followed by a more noticeable increase at Po-T, indicating overall improvement. Participant 2 exhibited minimal change in $CPPS_{speech}$, with a slight increase from MT to Po-T. Participant 3 demonstrated a consistent and notable increase in $CPPS_{speech}$ across all stages, indicating continuous improvement. Participant 4 showed a consistent increase in $CPPS_{speech}$ from PT to MT and further increase to Po-T, indicating an overall improvement (Table 4.2 and Figure 4.9).

Table 4.2

Details of the acoustic parameters across all phases of therapy in Group 1 participants

Parameter	Participants	Pre-therapy	Mid-therapy	Post-therapy
Fundamental	1	125.91	158.55	160.85
frequency (F0-Hz)	2	116.54	159.52	131.25
	3	123.99	129.4	143.74
	4	95.8	103.93	117.26
$CPPS_{vowel}$ (dB)	1	9.89	14.93	14.64
	2	4.31	5.7	4.96
	3	6.96	9.17	12.27
	4	8.69	7.92	6.43
$CPPS_{speech}$ (dB)	1	6.11	6.19	6.86
	2	4.35	4.34	4.44
	3	7.26	8.11	8.59
	4	4.74	5.29	5.9

Figure 4.7

F0 (in Hz) values of Group 1

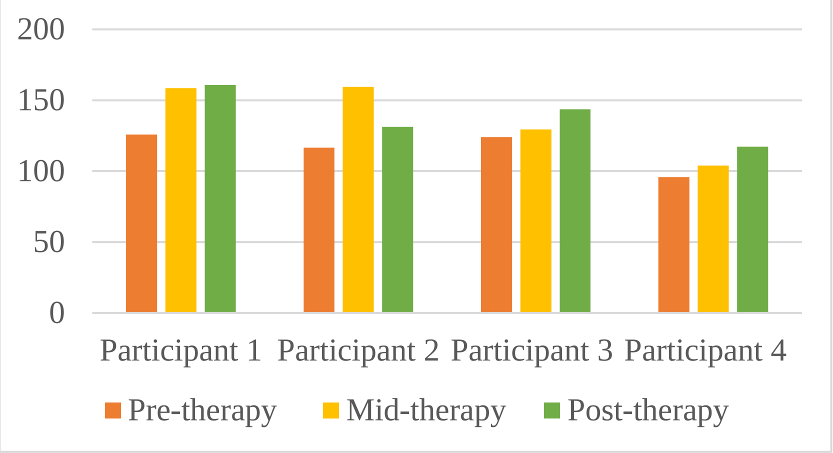


Figure 4.8

$CPPS_{vowel}$ (in dB) values of Group 1

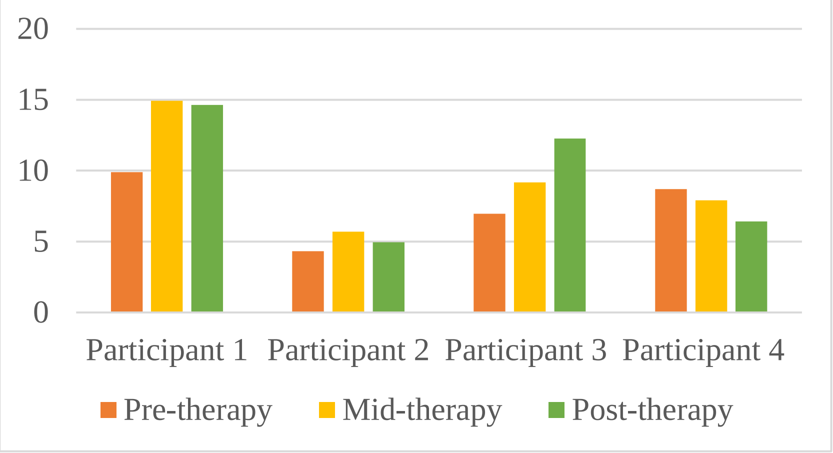
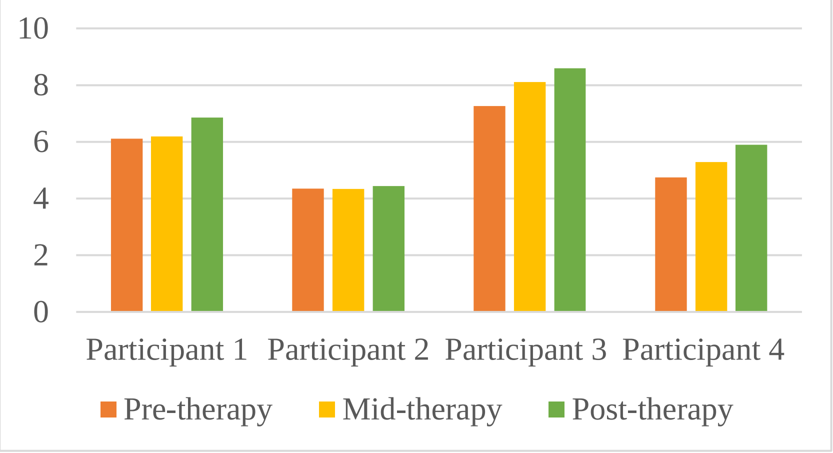


Figure 4.9

$CPPS_{speech}$ (in dB) values of Group 1



Effect of HSB on EGG parameters

The comparison was done for EGG jitter and EGG Contact Quotient (CQ) in all four Participants who underwent HSB and results are explained below.

EGG jitter: Participant 1 showed a significant decrease in EGG jitter from PT to MT, followed by a further decrease at Po-T, indicating overall improvement in voice stability. Participant 2 exhibited a significant decrease in EGG jitter from PT to MT, followed by an increase at Po-T, but still lower than PT, indicating some improvement overall. Participant 3 showed an increase in EGG jitter from PT to MT, with a slight decrease at Po-T, indicating a slight decline overall. Participant 4 showed an increase in EGG jitter from PT to MT, followed by a decrease at Po-T, indicating some improvement overall (Table 4.3 and Figure 4.10).

EGG CQ: Participant 1 showed a consistent increase in EGG CQ from PT to MT and from MT to Po-T, indicating improvement in vocal fold contact and efficiency. Participant 2 exhibited a decrease in EGG CQ from PT to MT, followed by a slight increase at Po-T, indicating some fluctuation in vocal fold contact but overall, a slight decrease compared to PT. Participant 3 showed a consistent decrease in EGG CQ from PT to MT and from MT to Po-T, indicating a reduction in vocal fold contact and efficiency. Participant 4 shows a consistent increase in EGG CQ from PT to MT and from MT to Po-T, indicating improvement in vocal fold contact and efficiency (Table 4.3 and Figure 4.11).

Table 4.3

EGG jitter and EGG Contact Quotient (CQ) values across all phases in Group 1 participants

Parameter	Participants	Pre-therapy	Mid-therapy	Post-therapy
EGG jitter (%)	1	2.82	0.76	0.48
	2	25.38	8.72	13.93
	3	1.15	3.35	3.29
	4	9.17	11.64	6.87
EGG CQ	1	29.82	36.44	42.14
	2	60.9	52.91	54.94
	3	42.08	39.51	36.18
	4	49.97	54.03	61.18

Figure 4.10

EGG jitter (in %) values of Group 1

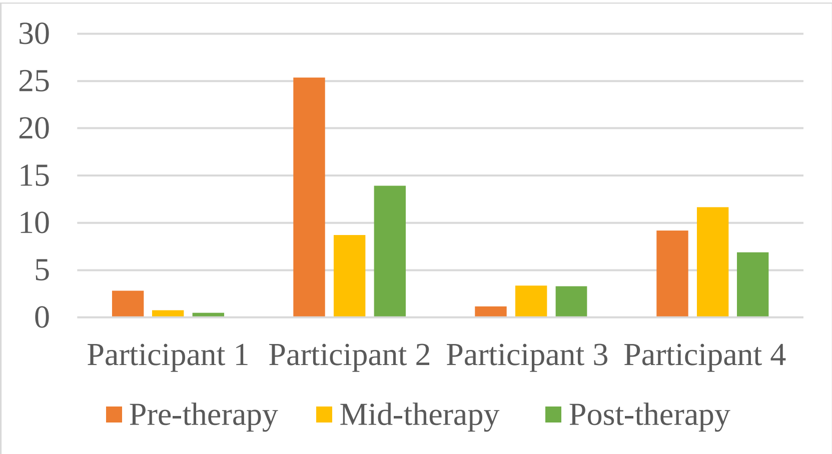
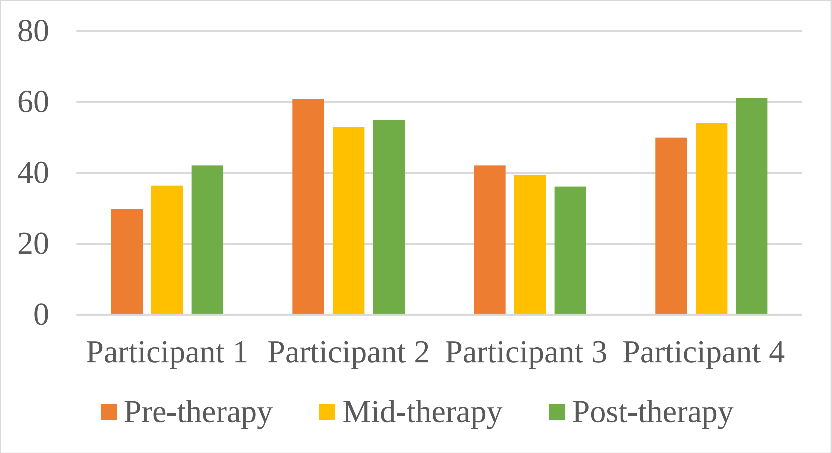


Figure 4.11

EGG CQ values of Group 1



4.1.2. ***Pre and post treatment comparison of Supraglottic Swallow***

The single subject comparison was done in Group 2 (undergone SGS) for all measured parameters. The results are explained below.

Effect of SGS on GRBASI rating scale

The comparison was done for each domain of GRBAS scales. The single subject comparison of all 4 Participants undergone SGS results are explained below.

Grade: Participant 1's Grade increased from PT to MT and remained the same Po-T, indicating a worsening in voice quality. Participant 2's Grade remained the same from PT to MT, then improved Po-T, indicating an improvement in voice quality. Participant 3's Grade remained the same from PT to MT, then worsened at Po-T. Participant 4's Grade remained consistent across all stages, indicating no change in voice quality (Table 4.4 and Figure 4.12).

Roughness: Participant 1's Roughness remained constant across all stages, indicating no change. Participant 2's Roughness improved from PT to MT and remained stable through Po-T. Participant 3's Roughness improved from PT to MT but returned to the initial level at Po-T. Participant 4's Roughness remained constant across all stages, indicating no change (Table 4.4 and Figure 4.13).

Breathiness: Participant 1's Breathiness worsened from PT to Po-T. Participant 2's Breathiness improved from PT to MT and remained stable through Po-T. Participant 3's Breathiness improved from PT to MT and remained stable through Po-T. Participant 4's Breathiness improved from PT to MT and remained stable through Po-T (Table 4.4 and Figure 4.14).

Asthenia: Participant 1's rating worsened from MT to Po-T. Participant 2's rating improved from PT to MT and continued to improve Po-T. Participant 3's rating improved from PT to MT and returned to the initial level Po-T. Participant 4's rating remained constant across all stages, indicating no change (Table 4.4 and Figure 4.15).

Strain: Participant 1's Strain rating worsened from PT to MT and improved significantly Po-T. Participant 2's Strain rating remained constant from PT to MT and improved Po-T. Participant 3's Strain rating worsened progressively from PT through Po-T. Participant 4's Strain rating worsened from PT to MT and returned to the initial level Po-T (Table 4.4 and Figure 4.16).

Instability: Participant 1's Instability rating improved from PT to MT but worsened again Po-T. Participant 2's Instability rating improved from PT to MT and remained stable Po-T. Participant 3's Instability rating worsened from PT to MT and remained stable Po-T. Participant 4's Instability rating remained constant across all stages, indicating no change (Table 4.4 and Figure 4.17).

Table 4.4

GRBASI values across therapy for all participants of Group 2

Parameter	Participant	Pre-therapy	Mid-therapy	Post-therapy
Grade	1	2	3	3
	2	2	2	1
	3	2	2	3
	4	1	1	1
Roughness	1	3	3	3
	2	2	1	1
	3	3	2	3
	4	1	1	1
Breathiness	1	1	1	2
	2	2	1	1
	3	2	1	1
	4	1	0	0
Asthenia	1	1	1	2
	2	3	2	1
	3	1	0	1
	4	0	0	0
Strain	1	2	3	1
	2	1	1	0
	3	1	2	3
	4	0	1	0
Instability	1	3	2	3
	2	2	1	1
	3	1	2	2
	4	0	0	0

Figure 4.12

Grade values of Group 2

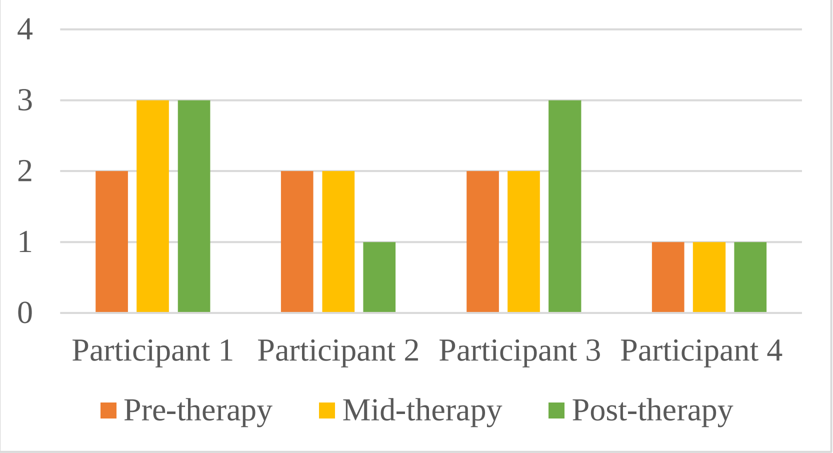


Figure 4.13

Roughness values of Group 2

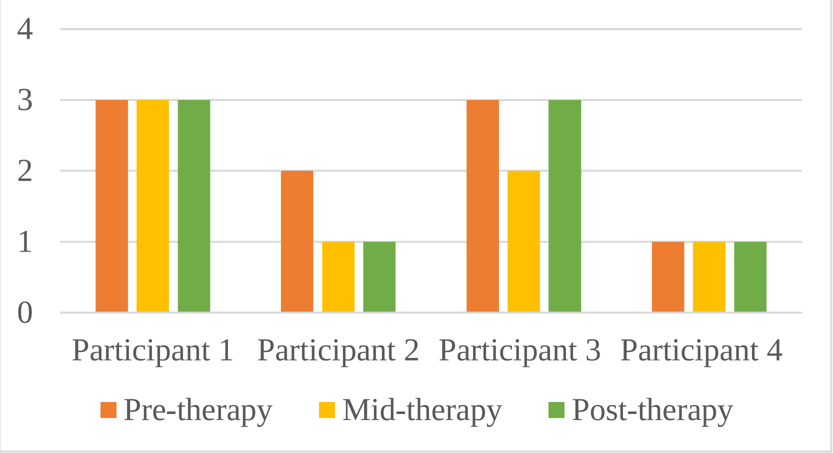


Figure 4.14

Breathiness values of Group 2

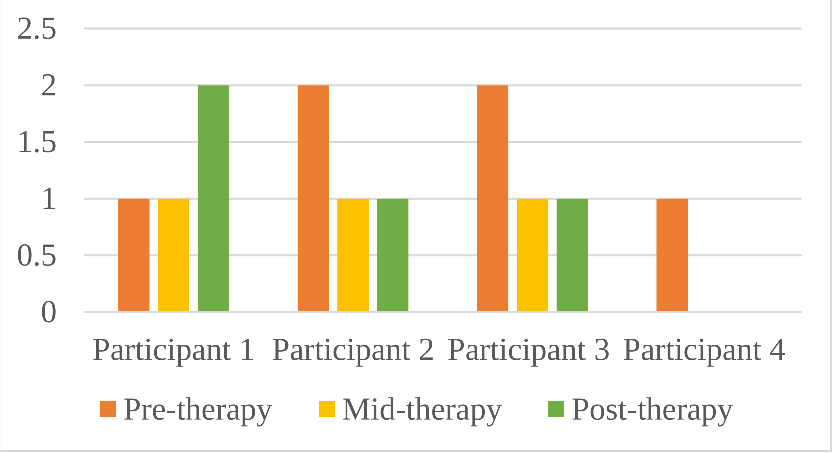


Figure 4.15

Asthenia values of Group 2

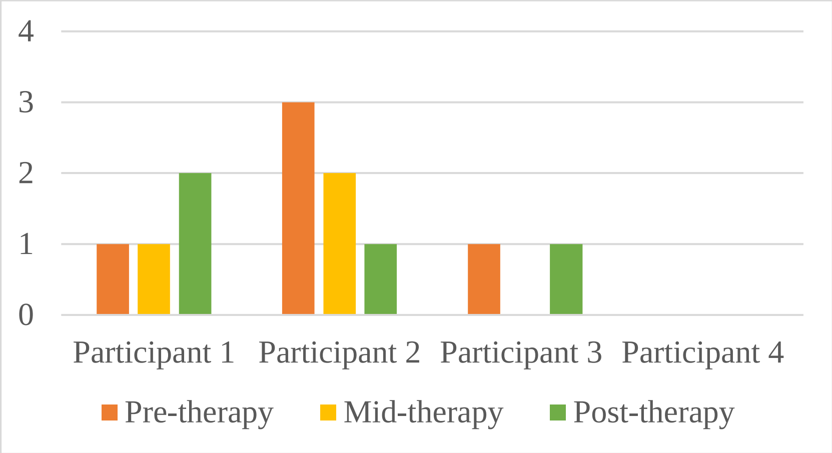


Figure 4.16

Strain values of Group 2

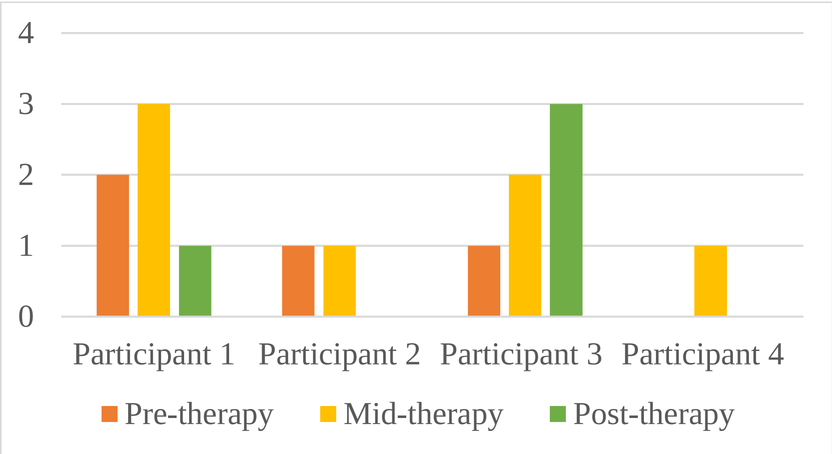
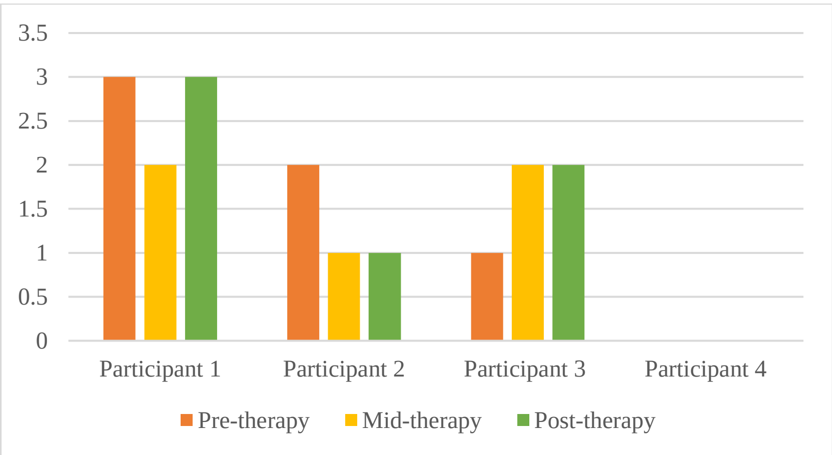


Figure 4.17

Instability values of Group 2



Effect of SGS on acoustic parameters

The comparison was done for F0, $CPPS_{vowel}$ and $CPPS_{speech}$. The single subject comparison of all 4 Participants undergone SGS results are explained below.

F0: Participant 1 showed a consistent increase in F0 from PT to MT and a slight further increase at Po-T. Participant 2 exhibited an increase from PT to MT and a further increase at Po-T. Participant 3 demonstrated a significant increase from PT to MT and remained relatively stable at Po-T. Participant 4 showed a slight increase from PT to MT, followed by a slight decrease at Po-T and returned close to the initial level (Table 4.5 and Figure 4.18).

$CPPS_{vowel}$: Participant 1 showed a decrease in $CPPS_{vowel}$ from PT to MT, followed by a significant increase at Po-T, indicating overall improvement. Participant 2 Exhibited a notable increase from PT to MT, followed by a decrease at Po-T, but still higher than PT, suggesting initial improvement. Participant 3 demonstrated a consistent increase in $CPPS_{vowel}$ across all stages, indicating continuous improvement. Participant 4 showed a slight increase from PT to MT, followed by a decrease at Po-T, indicating an overall slight decline (Table 4.5 and Figure 4.19).

$CPPS_{speech}$: Participant 1 showed a decrease in $CPPS_{speech}$ from PT to MT and a further decrease at Po-T, indicating an overall decline in voice quality. Participant 2 exhibited a significant increase in $CPPS_{speech}$ from PT to MT, followed by a slight decrease at Po-T, indicating overall improvement. Participant 3 showed minimal change from PT to MT, followed by a slight decrease at Po-T, indicating a slight overall decline. Participant 4 showed a slight decrease in $CPPS_{speech}$ from PT to MT and a further slight decrease at Po-T, indicating a small overall decline (Table 4.5 and Figure 4.20).

Table 4.5

Acoustic parameter values across therapy for all participants of Group 2

Parameter	Participants	Pre-therapy	Mid-therapy	Post-therapy
Fundamental frequency (F0-Hz)	1	147.01	166.31	167.26
	2	155.92	170.28	197.9
	3	118.4	180.71	179.52
	4	114.2	122.42	118.4
$CPPS_{vowel}$ (dB)	1	16.23	13.82	17.06
	2	8.41	11.94	9.72
	3	10.02	11.71	11.72
	4	13.02	13.62	12.2
$CPPS_{speech}$ (dB)	1	8.78	7.22	6.53
	2	6.44	8.3	8.16
	3	7.02	7.05	6.6
	4	7.63	7.19	7.12

Figure 4.18

F0 (in Hz) values of Group 2

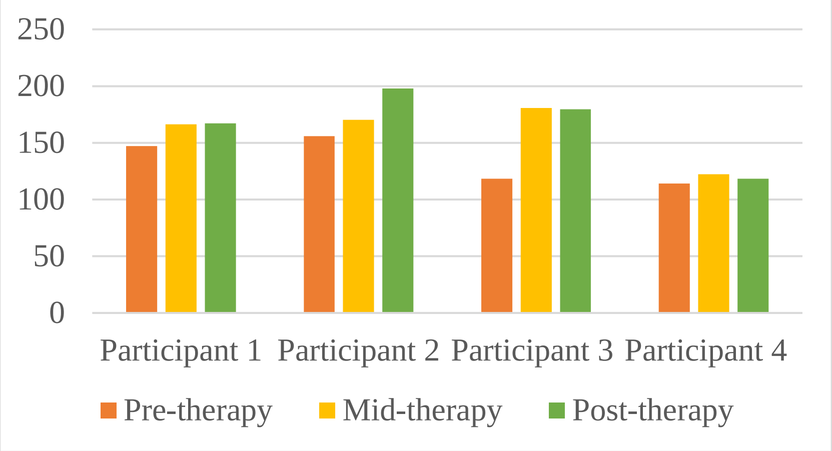


Figure 4.19

$CPPS_{vowel}$ (in dB) values of Group 2

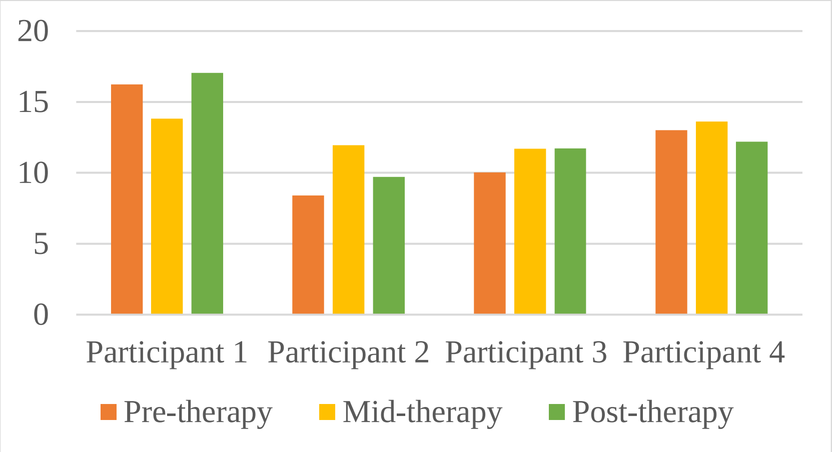
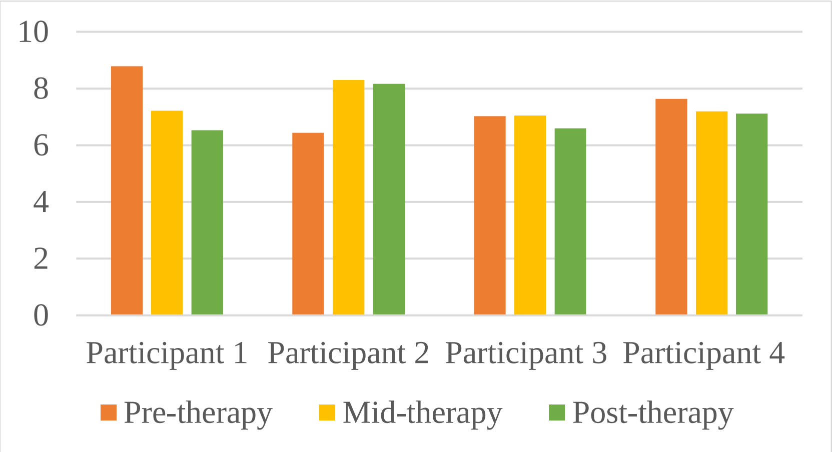


Figure 4.20

$CPPS_{speech}$ (in dB) values of Group 2



Effect of SGS on EGG parameters

The comparison was done for EGG jitter and EGG CQ. The single subject comparison of all 4 Participants undergone HSB results are explained below.

EGG jitter: Participant 1 showed a significant decrease in EGG jitter from PT to MT, followed by a very slight increase at Po-T, indicating an overall improvement in voice stability. Participant 2 exhibited a significant decrease in EGG jitter from PT to MT, followed by a further decrease at Po-T, indicating substantial improvement overall. Participant 3 showed a significant decrease in EGG jitter from PT to MT, followed by a slight further decrease at Po-T, indicating substantial improvement overall. Participant 4 showed a slight decrease in EGG jitter from PT to MT, followed by a slight increase at Po-T, indicating a minimal overall change but still low jitter levels throughout (Table 4.6 and Figure 4.21).

EGG CQ: showed that Participant 1 shows an increase in EGG CQ from PT to MT, followed by a decrease at Po-T. This indicates an initial improvement in vocal fold contact and efficiency, followed by a decline. Participant 2 exhibited a decrease in EGG CQ from PT to MT, followed by a further decrease at Po-T, indicating a decline in vocal fold contact and efficiency. Participant 3 showed a slight increase in EGG CQ from PT to MT, followed by a decrease at Po-T, indicating an initial improvement followed by a decline in vocal fold contact and efficiency. Participant 4 showed a consistent increase in EGG CQ from PT to Po-T, indicating continuous improvement in vocal fold contact and efficiency (Table 4.6 and Figure 4.22).

Table 4.6

EGG jitter and EGG Contact Quotient (CQ) values across all phases in Group 2 participants

Parameter	Participants	Pre-therapy	Mid-therapy	Post-therapy
EGG jitter (%)	1	8.48	1.82	1.83
	2	28.29	16.67	7.53
	3	8.07	0.55	0.46
	4	0.48	0.35	0.39
EGG CQ	1	48.53	53.66	46.03
	2	63.92	61.44	57.05
	3	48.12	48.47	42.36
	4	45.21	46.07	47.17

Figure 4.21

EGG jitter (in %) values of Group 2

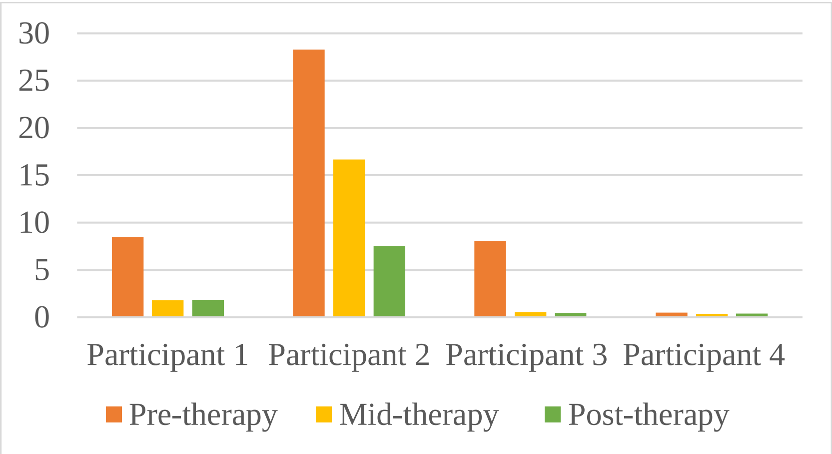
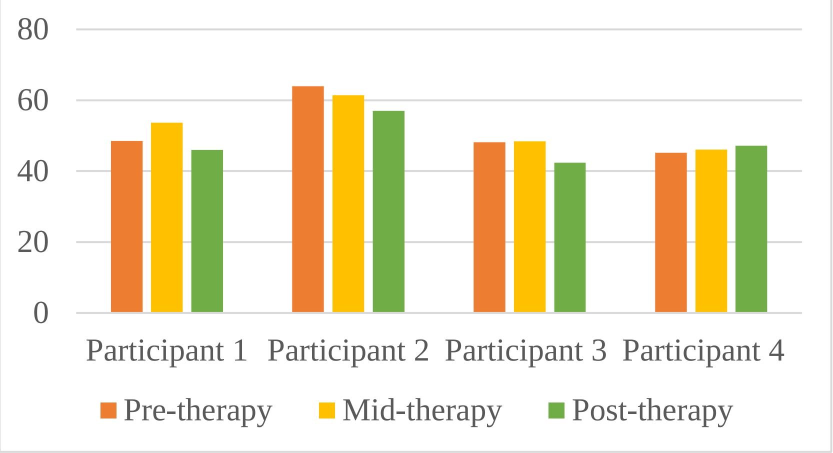


Figure 4.22

EGG CQ values of Group 2



4.2. Within Group Comparison

The within group comparison was carried out using statistical median, interquartile range (IQR) (Table 4.8, 4.9, 4.10, 4.11), and Mann-Whitney U test. The results are explained below.

4.3.1. Median and IQR comparison across therapy stages

The descriptive analyses also showed a varying pattern of change across the different measures and therapy stages for both groups. By comparing the median and IQR values of each parameter, the following observations has been made:

- Grade: Participants in Group 1 showed a reduction in median score of the 'Grade' parameter in the GRBASI scale from PT (median = 2.50) to Po-T (median = 2.00). Whereas median values for Group 2 remained unchanged (median = 2.00)
- Roughness: Group 1 showed a reduction in median from PT (median = 2.00) to Po-T (median= 2.50) and Group 2 also showed a reduction in median from PT (median = 2.50) to Po-T (median = 2.00).

- Breathiness: Group 1 showed an increase in median from PT (median = 2.00) to MT (median = 2.50) and returned to previous values in Po-T (median = 2.00). Group 2 showed reduction in values from PT (median = 1.50) to Po-T (median = 1).
- Asthenia: Group 1 showed a reduction from PT (median = 2.00) to Po-T (median = 1.50). Group 2 showed a reduction from PT (median = 1.00) to MT (median = 0.50) but returned to initial level at Po-T (median = 1.00).
- Strain: Group 1 showed a reduction from PT (median = 2.00) to Po-T (median = 1.50). Group 2 showed a reduction from PT (median = 1.00) to Po-T (median = 0.50).
- Instability: Group 1 showed a reduction from PT (median = 2.00) to Po-T (median = 1.00). Group 2 showed no change across therapy (median= 1.50).
- F0: Group 1 showed an increased in F0 values from PT (median = 120.2650) to MT (median = 143.9750) and a slight reduction Po-T (median = 138.4950) but still higher than PT. Group 2 showed a consistent increase from PT (median = 132.7050) to MT (median = 168.2950) and to Po-T (median = 173.3900).
- $CPPS_{vowel}$: Group 1 showed an increase from PT (median = 7.8250) to Po-T (9.3500). Group 2 did not exhibit change from PT (median = 11.5200) to Po-T (median = 11.9600).
- $CPPS_{speech}$: Group 1 showed an increase from PT (median = 5.4250) to Po-T (median = 6.3800). Group 2 showed a reduction from PT (median = 7.3250) to Po-T (median = 6.8600).
- EGG jitter: Group 1 showed slight reduction from PT (median = 5.9950) to Po-T (median = 5.0800). Group 2 exhibited a sharp decline in jitter from PT (median = 8.2750) to Po-T (median = 1.1450).

- EGG CQ: Group1 showed an increase in CQ from PT (median = 46.0250) to Po-T (median = 48.5400). Group 2 showed an increase from PT (median = 48.3250) to MT (median = 51.0650) and a decline at Po-T (median = 46.600) which is lesser than PT values.

The descriptive analyses suggests that while both groups have benefited from therapy, Group 2 often showed more consistency and improvements across multiple variables.

4.3.2. Within group comparison

The Friedman's test was done to compare the parameters across the 2 groups. The results revealed (table 4.7) there is a statistically significant difference between the groups for the following parameters:

- F0 for Group 1 ($p<0.05$), multiple comparisons were performed and it showed that a statistically significant difference for F0 from PT to Po-T.
- F0 for Group 2 ($p<0.05$).
- $CPPS_{speech}$ for Group 1 ($p<0.05$), multiple comparisons were performed and it showed a significant difference for $CPPS_{speech}$ from PT to Po-T.

Table 4.7

p- values of Group 1 and Group 2 for all parameters obtained from Friedman's test

S.no.	Parameter	Group	*p*-value
1	Grade- G-PT, G-MT, G-Po-T	HSB	0.368
		SGS	0.717
2	Roughness- R-PT, R-MT, R-Po-T	HSB	0.202
		SGS	0.223
3	Breathiness- B-PT, B-MT, B-Po-T	HSB	0.905
		SGS	0.174
4	Asthenia- A-PT, A-MT, A-Po-T	HSB	0.097
		SGS	0.497
5	Strain- S-PT, S-MT, S-Po-T	HSB	0.135
		SGS	0.257
6	Instability- I-PT, I-MT, I-Po-T	HSB	0.05
		SGS	0.717
7	F0- F0-PT, F0-MT, F0-Po-T	HSB	0.039
		SGS	0.050
8	$CPPS_{vowel}$- $CPPS_{vowel}$-PT, $CPPS_{vowel}$-MT, $CPPS_{vowel}$-Po-T	HSB	0.368
		SGS	0.472
9	$CPPS_{speech}$- $CPPS_{speech}$-PT, $CPPS_{speech}$-MT, $CPPS_{speech}$-Po-T	HSB	0.039
		SGS	0.174
10	EGG jitter- jitter PT, jitter MT, jitter- Po-T	HSB	0.472
		SGS	0.050
11	EGG CQ- CQ PT, CQ MT, CQ Po-T	HSB	0.779
		SGS	0.368

4.3 Comparison between HSB and SGS

The between group comparison was carried out using statistical median, interquartile range (IQR), and Mann-Whitney U test. The results are explained below.

A descriptive analysis was carried out to obtain the median and IQR for all variables. The result showed that the Group 2 had higher median values in few variables, particularly in F0 measures (PT: G1 median= 120.2650, G2 median= 132.7050, MT; G1 median= 143.9750, G2 median= 169.2950, Po-T; G1 median= 138.4950, G2 median= 173. 3900), EGG jitter (PT: G1 median= 5.9950, G2 median= 8.2750, MT; G1 median= 6.0350, G2 median= 1.850, Po-T; G1 median= 5.0800, G2 median= 1.1450), indicating better results in these areas. Additionally, the interquartile ranges suggest that the SGS technique tends to exhibit more consistency across several measures compared to the HSB technique (Tables 4.8, 4.9, 4.10, and 4.11).

Mann -Whitney test was administered to compare the effect of SGS and HSB technique. Among the variables analysed, only the **breathiness of GRBASI scale in MT** shows a statistically significant difference between Group 1 and Group 2 with a p-value of .044 ($p < .05$). This indicates that for the breathiness variable, there is a significant difference in the median values between the two groups. All other variables have p-values greater than .05, indicating no statistically significant differences between Group 1 and Group 2 for those variables.

Table 4.8

Median and Interquartile range (IQR) values for Grade, Roughness, and Breathiness across phases for Group 1 and Group 2

Group		**Grade**			**Roughness**			**Breathiness**		
		PT	MT	Po-T	PT	MT	Po-T	PT	MT	Po-T
HSB	Median	2.50	2.50	2.00	2.00	2.00	2.50	2.00	2.50	2.00
	IQR	1	2	2	2	1	1	2	2	2
SGS	Median	2.00	2.00	2.00	2.50	1.50	2.00	1.50	1.00	1.00
	IQR	1	2	2	2	2	2	1	1	2

Table 4.9

Median and Interquartile range (IQR) values for Asthenia, Strain, and Instability across phases for Group 1 and Group 2

Group		**Asthenia**			**Strain**			**Instability**		
		PT	MT	Po-T	PT	MT	Po-T	PT	MT	Po-T
HSB	Median	2.00	2.00	1.50	2.00	2.00	1.50	2.00	1.00	1.00
	IQR	1	2	1	1	2	1	1	1	1
SGS	Median	1.00	0.50	1.00	1.00	1.50	0.50	1.50	1.50	1.50
	IQR	2	2	2	2	2	3	3	2	3

Table 4.10

Median and interquartile range (IQR) values for F0, $CPPS_{vowel}$, and $CPPS_{speech}$ across phases for Group 1 and Group 2

Group		**F0 (Hz)**			**$CPPS_{vowel}$ (dB)**			**$CPPS_{speech}$ (dB)**		
		PT	MT	Po-T	PT	MT	Po-T	PT	MT	Po-T
HSB	Median	120.2650	143.9750	138.4950	7.8250	8.5450	9.3500	5.4250	5.7400	6.3800
	IQR	24.22	48.98	35.31	4.62	7.24	8.72	2.53	3.05	3.35
SGS	Median	132.7050	168.2950	173.3900	11.5200	12.7800	11.9600	7.3250	7.2050	6.8600
	IQR	38.44	44.71	62.69	6.62	2.00	5.62	1.91	0.95	1.35

Table 4.11

Median and interquartile range (IQR) values for EGG jitter and EGG CQ across phases for Group 1 and Group 2

Group		**EGG jitter (%)**			**EGG CQ**		
		PT	MT	Po-T	PT	MT	Po-T
HSB	Median	5.9950	6.0350	5.0800	46.0250	46.2100	48.5400
	IQR	19.76	9.50	10.98	25.28	16.54	21.95
SGS	Median	8.2750	1.1850	1.1450	48.3250	51.0650	46.6000
	IQR	20.96	12.56	5.70	14.14	12.82	11.30

CHAPTER 5

DISCUSSION

The primary aim of the present study was to investigate the efficacy of two therapy techniques, i.e., Half Swallow Boom and Supraglottic swallow, and draw a comparison between both of them when administered to two different groups of individuals with voice disorders secondary to glottal dysfunction.

The results revealed several points of interest and the major findings of the current study have been discussed under the following headings:

5.1. Effect of Half Swallow Boom (HSB) therapy technique on auditory-perceptual, acoustic, and EGG parameters across therapy stages.

5.2. Effect of Supraglottic Swallow (SGS) therapy technique on auditory-perceptual, acoustic, and EGG parameters across therapy stages.

5.3. Comparison of HSB and SGS therapy techniques on improving auditory-perceptual, acoustic, and EGG parameters across therapy stages.

5.1 Effect of Half Swallow Boom (HSB) therapy technique on auditory-perceptual, acoustic, and EGG parameters across therapy stages.

a) Auditory-perceptual parameters

The GRBASI scale was utilized to perceptually monitor progress, and the results indicated that two out of four participants exhibited improvement in the ‘Grade’ parameter, one out of four showed improvements in the Roughness parameter, two out of four demonstrated improvements in Breathiness, three out of four had improvements in Asthenia, two out of four showed improvements in Strain, and all four participants showed improvement in instability.

These findings support the already existing literature that HSB can perceptually enhance voice quality. One of the studies done by Schindler et al. (2008) showed that utilizing techniques like hard glottal attack, pushing, and HSB in voice therapy for individuals diagnosed with unilateral vocal fold paralysis resulted in an overall improvement across all parameters of the GRBASI except strain because Asthenia parameter was higher than the Strain values in the PT assessment, probably because the glottal insufficiency often gives the impression of Asthenicity even if a Strain is present. In another study done by D'Alatri et al. (2008), where voice therapy was given to individuals with unilateral vocal fold paralysis, one of the techniques used in voice therapy was HSB among other techniques which included hard glottal attack, pushing, abdominal breathing; vocal function; appropriate tone focus; accent method; and lip and tongue trill. The results of the study indicated significant improvements in several voice quality parameters post-therapy. Specifically, there was a significant reduction in the mean values for Grade, Instability, Breathiness, and Asthenia when compared to PT assessments.

Based on these findings, it can be concluded that the HSB technique likely shows perceptual improvement in voice parameters because it effectively engaged and coordinated the vocal folds and surrounding muscles. By practicing HSB technique, individuals may achieve better vocal fold closure and improved breath control leading to enhanced vocal quality (D'Alatri et al., 2008; Lu et al., 2020; Vieira et al., 2002). The technique's specific impact on various aspects of voice, such as roughness, breathiness, asthenia, and instability, suggests that it helps in balancing the vocal mechanism, resulting in noticeable perceptual improvements.

Additionally, the results indicated that the 'Grade' parameter of the GRBASI for two out of four participants stayed constant throughout the therapy. The Roughness worsened for two out of four participants, while for one participant remained unchanged. The Breathiness remained constant for two out of four participants. Asthenia stayed the same for one out of four patients, and the Strain remained unchanged for two out of four participants.

While using HSB since it's a vocal fold closure-based technique there is a risk of inducing hyperfunctional compensation (Schindler et al., 2008), this could explain the worsening of Roughness scores. The Strain remained unchanged for two participants because the presence of glottal insufficiency can give an impression of asthenicity even if Strain is present (Schindler et al., 2008).

b) Acoustic parameters

In acoustic parameters; F0, $CPPS_{vowel,}$ and $CPPS_{speech}$ were measured.

F0: A statistically significant difference was obtained from PT to Po-T on Friedman's test. HSB is a closure-based technique that enhances glottal closure (D'Alatri et al., 2008), increased glottal closure can lead to an increase in vocal fold vibration (Henrich et al., 2005) which in turn is responsible for the increase in F0. Also, since glottal closure is increasing in HSB it can be inferred that the tension in the vocal fold is increasing. Increased F0 is often associated with increased tension in vocal cords which is controlled by the thyroarytenoid and cricothyroid muscles (Titze, 2000).

$CPPS_{vowel}$ and $CPPS_{speech}$: three out of four participants showed an improvement in the $CPPS_{vowel}$ parameter, and a statistically significant difference was obtained from

PT to Po-T on Friedman's test for $CPPS_{speech}$ indicating enhanced voice quality. A periodic voice signal will have a high-amplitude CPPS, and a weakly periodic or an aperiodic voice signal will have low amplitude CPPS indicating that the HSB technique caused the voice signal to be more periodic. CPPS could be lowered in cases of unilateral vocal fold paralysis due to the presence of a phonatory gap (Sujitha & Pebbili, 2022). Since the results showed that there is a significant increase in F0 across therapy stages, this increase in vocal F0 may affect the CPPS because increased vocal F0 tends to result in a more stable F0 with increased motor-unit firing rates and decreased jitter, resulting in increased CPPS measure. So, in this study, it could be inferred that an increase in CPPS values could be a decrease in glottal dysfunction.

c) EGG parameters

EGG jitter: three out of four participants showed a decrease in jitter value across therapy stages. This indicates an overall improvement in stability and regularity of vocal fold movement during phonation. EGG jitter which measures the cycle-to-cycle variations in fundamental frequency reflects irregularities in vocal fold vibration patterns. A decrease in EGG jitter may suggest that the vocal folds are vibrating more regularly and smoothly during phonation. This can be a sign of improved vocal fold coordination and function (Vieira et al., 2002). Radhakrishnan (2022) showed that increase in coordination and stability in vocal fold vibration patterns can contribute to the reduction of jitter in EGG signals during phonation tasks involving the Nasal Resistance technique and reason for reduced EGG jitter is better glottal closure and improved regularity of vocal fold vibration.

EGG CQ: Participant 1 and Participant 4 showed an overall improvement in CQ where the values of Participant 1 increased from 29.82 pre-therapy to 42.14 post-therapy and the values of Participant 4 increased from 49.97 to 61.18. EGG CQ represents the vocal fold contact duration in a single period and also the phonation type. The increase in CQ shows the better vocal fold contact (Kankare et al., 2012). HSB is a technique that improves glottal closure (D'Alatri et al., 2008), implying the contact of the vocal fold increases, however, there is no literature available to support the same in this technique. From the results of the current study, it can be assumed that the HSB is effective in improving the vocal fold contact. At the same time, CQ values of Participant 2 and 3 had a decrease from PT to Po-T, suggesting the inconsistent results on same. However, there is one issue reported in calculation of EGG CQ in cases of breathy voice quality where CQ values become inflated when the SNR is below 10 dB, incorrectly suggesting a high level of vocal fold contact when actually there no contact (Herbst et al., 2017).

Overall, an improvement is observed in both EGG jitter and EGG CQ. However, inconsistencies in the results suggest that a larger sample size could help address these variations and provide more reliable conclusions.

To conclude, HSB, an established evidence-based technique used in voice therapy (D'Alatri et al., 2008; Schindler et al., 2008) and the results do show an overall increase in many parameters. In a study done by (Kissel et al., n.d.) among the vocal techniques used in behavioral voice therapy for Unilateral Vocal Fold Paralysis, respondents added various techniques in an open-ended question. One of the techniques mentioned by the respondents was "half-swallow boom". In an e-survey done by

(Venkatraman et al., 2022) it is noted that HSB technique is used by Speech Language Pathologists (SLPs) in India for hypofunctional voice disorders. It was reported that 1.81% of SLPs (n = 1) utilized the HSB technique as part of their therapeutic approach for voice disorders. Alongside other techniques, the HSB is one of the methods used in voice therapy for patients with mutational falsetto (Dagli et al., 2008; Prathanee, 1996).

5.2 Effect of Supraglottic Swallow (SGS) therapy technique on auditory-perceptual, acoustic, and EGG parameters across therapy stages.

a) Auditory-perceptual parameter

The GRBASI rating scale results

Improvement was seen in one participant for the 'Grade' parameter, in another participant for Roughness, three for Breathiness, one for Asthenia, two for Strain, and one for Instability. Improvement in breathiness can be due to the SGS technique causing an increase in vocal fold closure (Henrich et al., 2005) which could lead to better respiratory-phonatory coordination.

The remining participants showed no change and they even showed worsening perceptual scores. The worsening in the score was observed in the Asthenia and Strain parameters. The reason for this could be that effort closure induced by the SGS technique could result in strain and hyperfunction when used repeatedly. Occurrence of strain might be the result of hyper-functional compensation (Schindler et al., 2008).

The variability effect in the results could be because of factors such as small sample size, different etiologies across participants, age and other personal factors of the participants, time difference between the onset of the condition, intervention and other comorbidities. Literature support could not be evidenced due to non-availability of studies in the existing literature about the effect of SGS technique on auditory-perceptual aspects of voice as this technique is predominantly used in individuals with dysphagia.

b) Acoustic parameters

The F0, $CPPS_{vowel}$ and $CPPS_{speech}$ were utilised for the SGS group as well.

F0: There is an increase in F0 values across therapy stages as per the Friedman's test results. SGS enhances vocal fold closure wherein increased glottal closure can lead to an increase in vocal fold vibration (Henrich et al., 2005) which in turn is responsible for the increase in F0. An increase in F0 with flow phonation may lead to increased tension of the vocal fold and symmetric vocal fold vibration (Kaneko et al., 2022). Based on this an increased F0 could be suggestive of increased tension of the vocal fold leading to symmetric vibrations of the vocal folds.

$CPPS_{vowel}$ and $CPPS_{speech}$: Three out of four participants showed an improvement in $CPPS_{vowel}$ and $CPPS_{speech}$ values. A periodic voice signal will have a high-amplitude CPPS, and a weakly periodic or an aperiodic voice signal will have a low-amplitude CPPS. Indicating that the SGS technique caused the voice signal to be more periodic. CPPS could be lowered in cases of unilateral vocal fold paralysis due to the presence of a phonatory gap. From the results of this study, it could be inferred that an increase in CPPS values could be indicative of decreased glottal dysfunction.

Only one participant showed a slight improvement in $CPPS_{speech}$ value. This discrepancy between $CPPS_{vowel}$ and $CPPS_{speech}$ could be because continuous speech includes a variety of phonemes, transitions, and dynamic changes in pitch and loudness. These variations introduce more irregularities and noise into the signal, often resulting in lower CPPS values compared to sustained vowels. $CPPS_{speech}$ measurements are taken during natural speech, which includes a wider range of vocal behaviors and environmental influences, potentially affecting the signal quality and consistency.

c) EGG parameters

EGG jitter: Three out of four participants showed an improvement in jitter values across therapy stages indicating an overall improvement in stability and regularity. A decrease in EGG jitter signifies improved vocal fold regularity, stability, and function, indicating positive changes in vocal fold behaviour and voice quality (Vieira et al., 2002). A decrease in EGG jitter may suggest that the vocal folds are vibrating more regularly and smoothly during phonation.

EGG CQ: one participant showed a consistent improvement in CQ value. The increase in CQ shows the better vocal fold contact (Kankare et al., 2012) whereas two participants showed an initial improvement followed by a slight decline and one participant showed an overall decline suggesting inconsistent findings.

In conclusion, SGS is a technique designed to improve airway closure (Bodén et al., 2006), the principle of using SGS in dysphagia practice is to improve airway protection which can also lead to better phonatory functions as shown in the current study due to the following reasons:

- The technique encourages better coordination of the laryngeal muscles involved in swallowing and phonation. This improved muscle function can result in generalized and stable vocal fold vibrations.
- By closing the glottis more effectively, the technique increases subglottic pressure. Higher subglottic pressure enhances vocal fold contact and consequent vibrations, contributing to a stronger and clearer voice.
- SGS causes a forceful closure of the vocal folds, which can strengthen the adductory muscles over time. Stronger adductory muscles contribute to better vocal fold closure and improved phonatory function.

There is an abundance of research indicating that it results in an enhancement of swallow functions. The literature does not examine the secondary effect of the approach, wherein voice quality could improve. However, the current study is pointing out that SGS can be an effective technique to improve the voice production in individuals with glottal dysfunction.

5.3 Comparison of HSB and SS therapy techniques on improving auditory-perceptual, acoustic, and EGG parameters across therapy stages.

Even though some differences were observed in each parameter between both the groups, there were no statistically significant difference between the two groups. The lack of this difference implies that both the techniques are equally beneficial for individuals with glottal dysfunction. The HSB is a widely accepted voice therapy technique for glottal dysfunction, while SGS is utilised only for swallowing disorders (Mendelsohn & Martin, 1993; Shaker et al., 1990). The results of the current study suggests that the SGS is a potential therapy technique even for individuals with glottal dysfunction. However, lack of significance and non-uniform results could be due to the limited number of participants in the groups, etiological and personal factors related to the participants. So, exploring the efficiency of these techniques in a large population is required.

CHAPTER 6

SUMMARY AND CONCLUSION

Dysphonia presents a notable challenge characterized by discrepancies or inadequacies in pitch, loudness, and/or voice quality, which deviate from what is expected from an individual considering factors such as age, gender, cultural background, or location. One of the causes of voice disorders/ Dysphonia is Glottal dysfunction.

Glottal dysfunction, identified by the incomplete closure of the vocal folds during the process of phonation can lead to abnormal leakage of air further giving a breathy quality to the voice. Glottal dysfunction can arise from abnormal vocal fold structure, neurophysiological impairments, and abnormal volitional production of voice because of muscle tension patterns (Stemple & Hapner, 2019). It can be classified into three types: a) Glottal Insufficiency that occurs when a structural defect prevents adequate vocal fold closure during voicing, b) Glottal Incompetency that refers to neuromotor or physiological disorders resulting in "incompetent" vocal fold movement and incomplete closure during adduction, and c) Glottal Incapability which is a diagnosis of exclusion, occurring when inconsistent or incomplete vocal fold closure happens without anatomical pathology or obvious neuromotor abnormality.

Research indicates several effective approaches for treating glottal insufficiency. Some of the common voice therapy techniques for glottal insufficiency include pushing, hard glottal attack, HSB, abdominal breathing, head and neck relaxation, lip and tongue trills, resonant voice, and the accent method (Stemple & Glaze 2000).

HSB is one of the voice therapy techniques developed by Boone and McFarlane (Boone, 1977; Boone & McFarlane, 1994) as one of the several voice-facilitating techniques. The HSB technique involves a swallow procedure that maximizes laryngeal closure. McFarlane et al (1998) suggested that this technique is another means of repositioning the vocal folds to explore improved voice quality in individuals with unilateral vocal fold paralysis.

Supraglottic Swallow (SGS) was developed by Logemann (1983) and is designed to prevent the inhalation of food or liquid by securing the airway before swallowing. During the SGS swallow, the vocal folds are voluntarily closed before and during the swallow, followed by a cough to clear any material from the airway (Chaudhuri et al., 2002; Martin et al., 1993; Ohmae et al., 1996).

The primary aim of the present study was to investigate the efficacy of two therapy techniques, i.e., HSB and SGS, and compare the two for eliciting improved vocal fold contact/ closure and consequent voicing when administered to two different groups of individuals with voice disorders secondary to glottal dysfunction. Eight participants, one female and seven males (Mean age=36.62 years, SD=4.31) were recruited with a confirmed diagnosis of glottal dysfunction and randomly assigned to two treatment groups: those who underwent treatment with the HSB technique (Group 1; n=4) and other who underwent treatment with SGS technique (Group 2; n=4) for 10 sessions. The study was carried out in three phases; Phase one: Pre-therapy recording of outcome measures before initiation of treatment, and Phase two: The treatment (voice therapy) phase included the administration of the treatment protocol to the participants and Mid therapy (MT) recording of the outcome measures after the conclusion of day 5 therapy session. HSB voice therapy technique was provided to the Group 1 participants for a total of two weeks comprising of five 30-minute sessions per week. The SGS voice therapy technique done by breathing through nose, then holding breath lightly before and during swallowing and coughing immediately after swallowing was administered to participants in Group 2. Phase 3: Post-therapy recording of outcome measures after the completion of the 10^{th} session.

Outcome measures included auditory-perceptual rating by judges using GRBASI scale, extraction of acoustic parameters which included Fundamental frequency (F0), $CPPS_{vowel}$, $CPPS_{speech}$, and EGG parameters (EGG jitter and EGG Contact Quotient-CQ).

The results of the study indicated several points of interest as listed below:

HSB therapy technique

- Auditory-perceptual protocol: The GRBASI scale showed improvements on all parameters. HSB showed potential for enhancing vocal fold closure and improving breath control leading to better voice quality in the participants of this group.
- Acoustic parameters:

  F0: Significant increase in F0, indicating better glottal closure and increased tension in the vocal folds.

  $CPPS_{vowel}$ and $CPPS_{speech}$: Improvements in CPPS values were observed suggesting more periodic voice signals and reduced glottal dysfunction.
- EGG parameters:

EGG jitter: Decrease in jitter values, indicating better stability and regularity of vocal fold movement.

EGG CQ: Mixed results were obtained with some participants showing improved vocal fold contact.

SGS therapy technique

- Auditory-perceptual protocol: Improvements were observed on all parameters in some participants, although there were instances of worsening as well.
- Acoustic parameters:

  F0: Increase in F0, reflecting better vocal fold closure.

  $CPPS_{vowel}$ and $CPPS_{speech}$: Improved CPPS values were observed in vowels but mixed results in continuous speech.
- EGG parameters:

  EGG jitter: Improvement in jitter values was obtained, suggesting better vocal fold vibration stability.

  EGG CQ: Varied results with some participants showing improvements and others showing decline.

Comparison of HSB and SGS Techniques

- Effectiveness: Both techniques showed beneficial effects on voice parameters, but no statistically significant differences were found between the two groups. However, based on the auditory-perceptual protocol, better results were observed on all parameters of the GRBASI scale for the HSB group. Relatively better findings were also noted in the acoustic and EGG parameters in HSB group participants. This indicates that the HSB technique was more encouraging in achieving glottal closure and consequent vocal behaviour than SGS technique.

- Implications: Both HSB and SGS techniques can be considered for improving voice quality in individuals with glottal dysfunction. However, a larger sample size is needed for more conclusive results.

Implications of the study

- HSB technique can be effective in enhancing vocal fold closure and improving voice quality. It is shown to be useful for patients with unilateral vocal fold paralysis and other glottal dysfunctions.
- The SGS technique is primarily used for swallowing disorders but shows potential for improving voice quality. It can also be considered for patients with glottal dysfunction to improve voice quality.

Limitations of the study and future directions

- The study comprised of small sample size consisting of eight participants (Group 1; n=4, Group 2: n=4). Replicating the study with a larger sample size may lend greater support to the findings.
- Long-term effects were not studied in the present study. The same can be explored in the future.
- Duration from the onset of the voice problem to the initiation of the treatment was not taken into consideration. The same can be accounted for in future studies.
- Further comparisons between HSB and other established voice therapy techniques can help in understanding their relative efficacy.

- The efficacy of HSB and SGS in a homogenous population of similar etiologies of glottal dysfunction can be done to eliminate the inconsistencies found in the current study.

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APPENDIX

अखिल भारतीय वाक् श्रवण संस्थान, मैसूरू - 570 006
ALL INDIA INSTITUTE OF SPEECH & HEARING: MYSORE – 6
वाक् भाषा विज्ञान विभाग/ DEPARTMENT OF SPEECH-LANGUAGE SCIENCES

Informed Consent Form for Dissertation Data Collection

Title: Efficacy of Half Swallow Boom in Individuals with Glottal Dysfunction

Guide: डॉ. के. येशोदा / Dr. K. Yeshoda
एसोसिएट प्रोफेसर इन स्पीच साइंसेज/ Associate Professor in Speech Sciences

Candidate: Ms. Drishti Sreenath (Reg. No: P01II22S123042) II MSc (SLP),

AIISH

I do hereby give consent to participate in the study titled "Efficacy of Half Swallow Boom in Individuals with Glottal Dysfunction". I have been briefed about the aim of the study which is as follows, to assess the effectiveness of the technique, Half Swallow Boom when administered to groups of individuals with glottal dysfunction.

I express my whole-hearted consent to participate. I have also been informed about the approximate time of testing and understand that the procedure is purely unharming with research benefits only. I agree to cooperate with the investigator in this study and for the project/official communication in journals/magazines/newsletter and research purposes.

Furthermore, I have been assured that there will not be any financial commitment on my part during the course of this study. It has been further stated that my identity as a participant in this study will be strictly confidential and will not be divulged without my express consent.

Having read the above, I express my voluntary consent for my participation in this study.

Sl. No.	Name and address with phone #	Signature with date