INVESTIGATION OF SWALLOW FUNCTIONS IN PERSONS WITH DYSPHONIA

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CERTIFICATE

This is to certify that this dissertation entitled **"Investigation of Swallow Functions in Persons with Dysphonia"** is a Bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration number P01II21S0003. 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

September 2023

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This is to certify that this dissertation entitled **"Investigation of Swallow Functions in Persons with Dysphonia"** is the result of my own study under the guidance of Dr. Swapna N, Professor of Speech Pathology, Head of Department of Clinical Sciences & Coordinator-Center for Swallowing Disorders, and under the co-guideship of Dr. Prakash T K., Professor, Department of Otorhinolayngology, 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.

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September, 2023

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What shall I render to the Lord

***For* all His benefits toward me?**

I will take up the cup of salvation,

And call upon the name of the Lord.

I will pay my vows to the Lord

Now in the presence of all His people.

I will offer to You the sacrifice of thanksgiving,

And will call upon the name of the Lord.

I will pay my vows to the Lord

Now in the presence of all His people,

In the courts of the Lord's house,

In the midst of you, O Jerusalem.

Praise the Lord!

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CHAPTER I

Introduction

Swallowing is a complex precise semiautomatic motor action of the muscles of the respiratory and gastrointestinal tract, that propels the food or liquid from the oral cavity to the stomach (Miller, 1986). The bolus from the mouth passes through the pharynx and into the esophagus after which it reaches the stomach. These acts of the food or liquid movement is conceptualized to occur in different phases such as oral preparatory, oral, pharyngeal, and oesophageal phases (Dodds et al., 1990; Miller, 1982). The preparatory phase involves preparing the bolus, such as mastication with saliva and the oral phase involves transferring the bolus into the pharynx after triggering the swallow reflex. The bolus moves into the esophagus through the upper esophageal sphincter in the pharyngeal phase. In the esophageal phase, the bolus is propelled into the stomach due to the contraction of muscles of the esophagus in a wave-like motion, known as peristalsis through the lower esophageal sphincter. Thus, the process of swallowing typically occurs automatically and without conscious effort. This act is governed by the nervous system and requires the coordinated interaction of the brainstem, peripheral systems, cortical, subcortical, and sensory-motor systems (Logemann, 1998; Miller 2008).

A critical event that occurs in the pharyngeal phase includes airway protection. During a swallow, the suprahyoid muscles contact which assists in the elevation of the hyolaryngeal complex. During this superior-anterior movement of the hyoid bone and larynx, the arytenoids medialize, false and true vocal folds and aryepiglottic folds adduct, preventing food/liquid from entering the lower airway or trachea. Additionally, the epiglottis swings down and covers the laryngeal vestibule to act as another layer of protection. The movement of the larynx also opens up the upper esophageal sphincter, which helps in the transfer of the bolus to the esophagus (Matsuo & Palmer, 2008; Okuda, Abe, Kim, & Ide, 2008).

These structures involved in airway protection also have a role in voice production. Though the larynx or vocal folds are the primary means of producing voice, they have an important role in swallow physiology. There is a close anatomic and functional relationship of the voice and swallowing systems. There is intersection of upper airway's neuromuscular innervation and the aerodigestive tract, hence patients with dysphonia may present with dysphagia (Hamdanet al., 2019). The larynx serves three functions which includes respiration, phonation and airway protection during swallow. Damage to the larynx or its tissues or surrounding structures can result in problems with either voice or swallowing or both. Thus, dysphonia is defined by changed vocal quality, pitch, loudness, or vocal effort that hinders communication or lowers quality of life related to the voice (Schwartz et al., 2009). Dysphagia is characterised as having trouble swallowing and having trouble getting the food bolus from the mouth to the stomach (Aziz et al., 2016).

Several etiologies cause voice and swallowing problems such as disease of connective tissue, paraneoplastic syndrome, degenerative diseases, tumors, trauma, Amyotrophic lateral Sclerosis (ALS), Parkinsonism, memory issues, aging, congenital conditions and structural disease (cervical webs, zenker's diverticulum, etc.), infections, metabolic disorders, side effects due to intake of iatrogenic medication, radiation, corrosives etc. (Cook & Kahrilas, 1999). Benign non-neoplastic lesions of the vocal fold that are non-inflammatory such as polyps, nodules, cysts, Reinke's edema, polypoid degeneration, and contact granuloma, which are associated with the injury caused due to vibration of the vocal folds can cause associated swallow difficulties (Cipriani et al., 2011). The swallowing difficulties include choking, globus sensation, frequent coughing before, during or after eating, frequent respiratory problems, and regurgitation, which could result if any events in the pharyngeal phase are affected.

The possible mechanisms that could lead to these swallowing difficulties include restricted movement of the laryngeal framework, reduced constriction of pharynx during swallowing, or alteration in the upper esophageal sphincter pressure during phonation (Hamdan et al., 2019). The ratio of pharyngeal constriction to upper oesophageal sphincter opening changes in cases with unilateral vocal cord paralysis (Domer et al., 2014) and causes a delay in the triggering of pharyngeal swallow and upper oesophageal sphincter relaxation. Studies have also reported that dysphagia in paralysis of the unilateral vocal cord is due to glottal insufficiency, reduced glottal competence and laryngeal movement, while other factors may include loss of airway protection, disturbances in upper esophageal sphincter pressure, decreased sensation in laryngopharyngeal mucosa, or persistent bolus residue in pharynx (Heitmiller et al., 2000; Nayak et al., 2002). On the other hand, non-neo plastic vocal fold lesions are commonly due to hyperfunctional voice usage. This can further increase the trauma at the middle portion of membranous portion of vocal folds causing vocal fold lesions, which can impede airway protection during a swallow. In muscle tension dysphonia, the laryngeal muscle tension results in improper laryngeal motion during swallowing, which in turn leads to swallowing difficulties.

A few studies have tried to describe the symptoms accompanying dysphagia among patients presenting with dysphonia. A study conducted by Kang et al. (2016) revealed that among the sixty-seven adult patients, 13 patients with abnormal muscle tension associated with voice issues, who attended voice therapy, also reported of resolved dysphagia symptoms. They concluded that laryngeal muscle tension can be a factor leading to dysphagia.

Another study done by McGareyJr, Barone, Freeman, and Daniero (2018) aimed at characterizing the symptoms associated with dyspnea and swallowing problems among 38 patients with muscle tension dysphonia (MTD). 44.7% of the population reported of dysphagia during a clinical examination. However, 60.5% had scores greater than three on Eating Assessment Tool-10 (EAT-10, Belafsky et al., 2008). The results revealed that patients who reported dysphagia also had greater scores on Voice Handicap Index-10 (VHI-10, Rosen et al., 2004) than those without dysphagia. They concluded that patients presenting diagnosed with MTD had a high rate of dysphagia in combination. The increased tension of the extrinsic muscles of larynx, which may restrict the hyolaryngeal elevation could have led to dysphagia.

Ghandour, Hadhoud, and ElFiky (2021) used Arabic EAT-10 to evaluate the symptoms of dysphagia in fifty dysphonic patients who had non-neoplastic vocal fold conditions (Ghandour et al., 2021). The authors found that 12 patients (or 24%) had dysphagia. The most common concern among these individuals was pain while swallowing because it takes more effort to swallow solid substances. However, the authors claim that the patients' concerns of phonasthenia may have been mistaken for swallowing issues. They came to the conclusion that non-neoplastic vocal fold lesions were not the cause of dysphagia.

Krasnodębska et al. (2021) examined dysphonic patients who had swallowing problems using surface electromyography. Fifty-eight individuals who were reported to have MTD were recruited initially, out of which 32 were later confirmed as MTD and 26 with abnormal swallow function. Each patient underwent otolaryngological, logopaedic, and phonatory examination. They were also made to fill Reflux Symptom

Index (RSI, Belafsky et al.,2002), EAT-10, Dysphagia Handicap Index (DHI, Silbergleit, et al., 2012), and Swallowing Disorder Scale (SDS, Krasnodębska et al., 2020), and outcome measures were correlated with surface electromyography while performing FEES. The results revealed that patients with MTD had greater scores in all the questionnaires than those with abnormal swallowing.

Acid reflux diseases are one of the main causes of the co-occurrence of voice and swallowing issues (LPR and GERD). The lower and upper esophageal sphincters, oesophagus, laryngeal structures, oral cavity, trachea, and lungs are just a few of the areas that the LPR caused by GERD can affect. Hidden signs of LPR and GERD are often a causal factor reported in ENT patients, especially in relation to dysphonia. Sataloff et al. (1991) described reflux laryngitis in 45% of voice professionals (265 out of 583) who needed medical intervention. Studies (Jin et al., 2014; Karkos et al., 2014; Lee et al., 2014) have reported that laryngeal contact granuloma is caused by gastric acid reflux with laryngo-pharyngeal reflux disease (LPRD). LPR is also commonly associated with aspiration, which can be due to defects in the pharyngo-esophageal sphincter closure or due to problems in the pharyngo-glottal closure. These patients and those with voice and swallowing disorders due to other causes may also present with laryngeal hypersensitivity. As laryngeal hypersensitivity can cause improper laryngeal movements during swallowing, it may result in dysphagia symptoms (Kang et al., 2016).

1.1 Prevalence of Dysphagia in Dysphonics

Heitmiller et al. in 2000 studied patients with unilateral vocal fold paralysis and reported aspiration in 38% and laryngeal penetration in 12% of them. Nayak et al. (2002) also reported penetration in 44.8% and aspiration in 23.9% of patients with unilateral vocal fold immobility. Zhou et al. (2019) reported that the prevalence of symptomatic dysphagia ranged from 55.6% to 69.0%, and the aspiration rate was 20.0% to 50.0% among patients with unilateral vocal fold immobility (UVFI).

Schiedermayer et al. (2020) looked into how the definition of dysphagia affected the prevalence and incidence of the condition in people with unilateral vocal cord palsy (UVP). Data on patient demographics, dysphagia questionnaire total scores, clinical evaluation dysphagia symptoms, and instrumental swallow assessment results were gathered from the records of people who had UVP diagnoses between 2013 and 2018.Up to 55% of patients reported having dysphagia, however, only 21% of them had symptoms severe enough to require instrumental evaluation. 87% of them reported aberrant findings, although 23% of those who were receiving Modified Barium Swallow (MBS) saw aspiration. The scores on the dysphagia questionnaire were more frequently abnormal in UVP patients with an iatrogenic than an idiopathic cause. According to the researchers, the definition of dysphagia as well as the UVP etiologic category affected the occurrence and severity of the condition.

Investigations have also been done into the prevalence of dysphagia in non-neoplastic vocal fold pathology, such as laryngitis, odema, nodules, etc. Hamdan, Khalifee, Jaffal, Ghanem, AbouRizk, and El Hage (2019) looked at the prevalence of dysphagia in these patients using EAT-10. Reinke edema (28.8%), laryngitis (24.4%), vocal fold nodules (17.7%), and polyps (13.33%) were the most prevalent vocal fold pathologies. 37.7% of the 45 dysphonia patients also had dysphagia. According to them, this prevalence was higher than the levels (16%–22%) described in the literature. The prevalence of laryngopharyngeal reflux disease, a confounding condition that has been reported to affect up to 50% of patients with dysphonia (Koufmann et al., 2002), has not, however, been investigated, and the researchers also claim that they did not use an objective measure to evaluate dysphagia.

1.2 Need for the study

From the studies done so far, there are pieces of evidence showing the presence of dysphagia in dysphonics. Given the numerous tasks the larynx performs and the complex relationship between the pharynx and the larynx's neuromuscular supply, dysphagia may exist in people with voice abnormalities.

Dysphagia may also be a common symptom that is often disregarded in patients presenting with dysphonia complaints. Individuals with dysphonia may experience swallowing issues, which are frequently covered up by the phonatory complaint (Ollivere et al., 2006). They may be more irritated or concerned with the problems in their voice than the problems in swallowing. Dysphagia may be overlooked, which can contribute to poor quality of life. Dysphagia can cause a number of clinical consequences, including dehydration, malnutrition, and aspiration pneumonia, if it is not treated. Patients with dysphagia have a lower quality of life since all these problems can have an impact on daily activities. Dysphagia is linked to higher disease and mortality rates. Therefore, early dysphagia detection is crucial to enabling effective treatments.

Most of the studies have used patient self-report tools such as EAT-10 to assess the presence of dysphagia, which is a self-administered tool (Ghandour et al., 2021; Hamdan et al., 2019; Krasnodębska et al., 2021; Kashima et al., 2021; Kang et al., 2021; McGarey et al., 2018; Schiedermayer et al., 2016). There is a need to confirm the presence of dysphagia using more objective assessments such as Gugging Swallowing Screen (GUSS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES). The images obtained through FEES are usually rated for penetration/aspiration using the Penetration and aspiration scale (PAS, Rosenbek et al., 1996) and the severity of residue in the vallecular and pyriform sinus region will be quantified using Yale Pharyngeal

Residue Severity Rating Scale (YPRRS, Neubauer et al., 2015). The images obtained through FEES will assist in pinpointing the underlying physiological impairment that leads to the swallowing problems. Direct observation of swallowing function is necessary for the accurate assessment of swallow function and aspiration risk.

Further, the investigation of reflux disease, which could contribute to voice and swallowing problems has rarely been undertaken. As reflux disease leads to backward flow of the gastric contents into the pharyngeal and laryngeal areas, it can ultimately lead to esophageal irritation and laryngeal injury. Reflux Symptom Index (RSI, Belafsky et al., 2002) is the tool that is commonly used to assess reflux. A retrospective chart review conducted by Ranjbar et al. (2022) investigated the prevalence of esophageal disorders in dysphonic population with LPR. The results indicated that about 24.8% (out of 109 participants) of the population had abnormalities in the peristaltic wave suggesting esophageal dysmotility. Around 12.6% of population also had dysfunction in both the upper and lower esophageal sphincter. As swallowing and phonation are closely related both anatomically and physiologically, clients with reflux disease can have a co-occurrence of esophageal dysmotility, which warrants further swallowing evaluation. Keeping these aspects in view, the present study was planned with the aim of investigating swallow function in persons with dysphonia.

1.3 Aim of the Study: To investigate the swallow function in persons with dysphonia.

1.4 Objectives:

1. To assess the relationship between scores obtained through EAT-10 (patient perspective of swallow) and scores of GUSS (clinician perspective of swallow).
2. To assess the relationship between scores obtained through subjective assessment (screening with GUSS) and instrumental assessment (FEES).

3. To investigate the relationship between reflux disease (scores on RSI) and scores of GUSS and FEES.
4. To assess the relationship between dysphonia severity (scores of CAPE-V) and dysphagia (scores of GUSS).

CHAPTER II

Review of Literature

Swallowing is a simple act that we often take for granted, yet it holds the power to bring pleasure, nourishment, and even a touch of mystery. From the satisfying gulp that quenches our thirst to the delicate swish that allows us to savour our favourite flavours, swallowing is a symphony of muscles, nerves, and sensations. Swallowing is a crucial and sophisticated behaviour that children learn very early in development which is essential for proper nutrition and hydration. The act of swallowing takes place in a hierarchical manner which can be explained through the physiology of swallow.

2.1 Physiology of Swallow

Swallowing is the passage of food or liquid bolus from the oral cavity (mouth) to the stomach via the pharynx and oesophagus. Pharynx serves as a passage for both air and bolus and the swallowing mechanism ensures that the food is propelled into the esophagus without the material entering the trachea and bronchi. This coordinated movement is the result of the reflexive and intentional activities of numerous muscles and cranial nerves in the oral cavity, pharynx, larynx, and oesophagus (Panara et al., 2023)

The Four Stage Model for drinking and swallowing liquids and the Process Model for eating and swallowing solid food are two paradigmatic models that are frequently used to describe the physiology of proper eating and swallowing. A three-stage sequential model was initially used to explain the typical human swallow. Depending on where the bolus was located, the swallowing process was divided into oral, pharyngeal, and esophageal stages (Dodds et al., 1990).

2.1.1 Oral Preparatory Stage

The liquid bolus is kept in the front region of the floor of the mouth or on the tongue surface against the hard palate, which is encircled by the upper dental arch (upper teeth), after being sipped from a cup or through a straw. To stop the liquid bolus from seeping into the oropharynx before swallowing, the tongue and soft palate make contact to close off the oral cavity from the back. If the seal is not perfect, liquid may escape into the pharynx.

2.1.2 Oral Propulsive Stage

During the oral propulsive stage, the posterior tongue dips to widen the back of the oral cavity while the tongue tip rises, touching the alveolar ridge of the hard palate just behind the upper teeth. The liquid bolus is squeezed back along the palate and into the pharynx as the tongue surface advances upward, progressively widening the area of tongue-palate contact from anterior to posterior. The pharyngeal stage usually starts during oral propulsion when consuming liquids.

The four step model was formed after the oral stage was separated into oral preparation and oral propulsive stages. The biomechanics and bolus movement during command swallows of liquids are adequately described by studies based on the four step paradigm. This model, however, is unable to capture the bolus movement and the act of eating solid food. To explain the process of eating and swallowing solid food, the Process Model of Feeding was developed (Hiiemae & Palmer, 1999).

2.1.3 Process Model

The four step sequential model, particularly when it comes to food transport and bolus production in the oropharynx, is of limited use in representing the normal eating process in people (Dua et al., 1997). Triturated (chewed and moistened) food frequently passes through the fauces for bolus production in the oropharynx (containing the valleculae) several seconds before the pharyngeal stage of a swallow when healthy subjects eat solid food. While food is still in the oral cavity and chewing is ongoing, more quantities of food can enter the oropharynx and accumulate there. Due to the overlap between the oral preparation, propulsive, and pharyngeal stages, this phenomena contradicts the four stage paradigm (Palmer et al., 1992).

2.1.3.1 Stage I transportation: When food enters the mouth, it is carried to the post-canine region by the tongue, which then rotates laterally to deposit the meal onto the occlusal surface of the lower teeth for processing.

2.1.3.2 Food Processing: Stage I transport is immediately followed by food processing. Food is processed when the size of the food particles is decreased by mastication and the food is made into a consistency that is best for swallowing by salivation. The process of chewing food continues until it is ready for swallowing. The movements of the tongue, cheek, soft palate, and hyoid bone are closely synchronised with the jaw's cyclic movement during processing.

During the oral preparation stage, when the bolus is held in the oral cavity, the posterior oral cavity is sealed by tongue-palate contact. The mouth and pharynx may communicate openly during food processing, in contrast, because the tongue and soft palate both move cyclically in tandem with jaw movement (Palmer et al., 1992; Matsuo & Palmer, 2015). As a result, there is no posterior oral cavity closing while eating. Chemoreceptors in the nose get the aroma of the food through air that is pumped into the nasal cavity by the jaw and tongue movements(Buettner et al., 2001; Palmer & Hiiemae, 2003).

Jaw movement and cyclical tongue movement during processing are synchronised.Jaw movements during processing are also significant in the vertical dimension and significant in the antero-posterior dimension(Palmer et al., 1997).

During chewing, the tongue also rotates on its long (anteroposterior) axis and glides mediolaterally. To keep food on the occlusal surfaces of the lower teeth, these actions are synchronised with cheek movement. During feeding, the hyoid bone also moves continuously, but its motion is more unpredictable than the motions of the jaw or tongue. The suprahyoid and infrahyoid muscles connect the hyoid mechanically to the cranial base, mandible, sternum, and thyroid cartilage. The hyoid plays a significant function in regulating the motions of the jaw and tongue because to its muscular connections (Mioche et al., 2002).

Stage II transport: The basic mechanism of stage II transport is the same as that for the oral propulsive stage with a liquid bolus: the anterior tongue surface first contacts the hard palate just behind the upper incisors, and the area of tongue-palate contact gradually expands backward, squeezing the triturated food back along the palate to the oropharynx when a portion of the food is ready to swallow(Saitoh et al., 2007). The basic mechanism of stage II transport is the same as that for the oral propulsive stage with a liquid bolus: the anterior tongue surface first contacts the hard palate just behind the upper incisors, and the area of tongue-palate contact gradually expands backward, squeezing the triturated food back along the palate to the oropharynx when a portion of the food is ready to swallow.

2.1.4 Pharyngeal stage

A pharyngeal swallow is a swift, consecutive action that takes place in less than a second. Food passage, which moves the food bolus through the pharynx and upper esophageal sphincter (UES) to the oesophagus, and airway protection, which isolates the larynx and trachea from the pharynx during food passage to stop food from entering the airway, are its two most important biological characteristics.As the bolus head enters the pharynx during the pharyngeal stage, the soft palate lifts and makes contact with the lateral and posterior walls of the pharynx, sealing the nasopharynx. Bolus regurgitation into the nasal cavity is avoided by elevating the soft palate. The bolus is forced up against the pharyngeal walls when the base of the tongue retracts. The bolus is compressed downward as a result of the pharyngeal constrictor muscles contracting successively from top to bottom. In order to decrease the size of the pharyngeal cavity, the pharynx also shortens vertically. During this stage, the vocal folds, the supraglottic portion of the laryngeal vestibule, the subepiglottic portion of the laryngeal vestibule, and the epiglottis are the four anatomically and functionally distinct sites, which help the airways to be protected during swallowing (Curtis & Hudson 1983; Curtis & Sepulveda 1983; Ekberg 1982). The supraglottic region of the laryngeal vestibule is the most important of these levels.

Elevating the pharynx and larynx is considerably more fundamentally important and is essentially a requirement for airway closure and constrictor activity. The thyroid cartilage moves towards the hyoid, protecting the airways, and the laryngeal vestibule closes to seal off the airways. The vocal folds and the epiglottis provide greater protection. Larynx closure occurs in a peristaltic-like motion that begins at the vocal folds and moves upward. It has been recognised that tongue-base pressure is what propels the bolus, and the tongue-base has been linked to a compensating function, particularly enhancing tongue-base activity to overcome weak pharyngeal constrictors. The pharyngeal constrictors stabilise the pharynx tube while the tongue drives the bolus forward. The tongue then seals the lumen behind the bolus to prevent retrograde escape (McConnel et al. 1988; Cerenko et al. 1989; McConnel 1988). A number of muscles are also involved during the pharyngeal phase of swallow, which are innervated by many nerves that help in synchronous action of bolus propulsion.

2.1.5 Esophageal Stage

From the lower portion of the UES to the lower esophageal sphincter (LES), the oesophagus is a tubular structure. In order to avoid stomach reflux, the lower esophageal sphincter is also tightened when at rest. During a swallow, it relaxes and lets the bolus pass through to the stomach. While the lower two thirds of the thoracic oesophagus are made mostly of smooth muscle, the upper third of the cervical oesophagus is primarily made of striated muscle. Because real peristalsis is controlled by the autonomic nerve system in the thoracic oesophagus, it differs greatly from pharyngeal bolus transport. A peristalsis wave moves the food bolus down to the stomach through the LES once it has passed through the UES and entered the oesophagus. A wave of relaxation that first accommodates the bolus is followed by a wave of contraction that propels it. These two waves make up the peristaltic wave. Peristalsis in an upright position is aided by gravity.

2.2 Role of Larynx in Swallowing and Voice production

2.2.1 The Overlap in Motor Function

For the production of voice, which is a secondary function of larynx, these three subsystems (respiratory, phonatory and resonatory) are necessary (Schneider & Satalof, 2007). The breathing is the power source for voice production. The respiratory system's breath support is later transformed into phonation at the larynx level. The voice produced at the vocal fold level would sound weak without the component of resonance. This resonance chamber which is situated high up in the neck helps to filter and amplify the sound produced. Vocal folds are an important component of the phonatory system. The vocal folds are located within the larynx (voice box) and play a crucial role in generating sound. When we speak or sing, the vocal folds vibrate, producing sound waves that resonate in the throat, mouth, and nasal cavity to create our unique voice. The vocal folds effectively operate as a valve between the speech tract and the respiratory tract when they abduct (move away from each other, starting together at midline) or adduct (move towards each other, finishing together at midline). Vocal fold vibration is possible due to several factors, including the fact that the vocal folds are situated within a fixed laryngeal framework, muscles within the larynx (intrinsic laryngeal muscles), vocal fold abduction and adduction, changes in the elastic properties of the vocal folds that affect their rate of vibration, and an outgoing airstream. The continuous pattern of opening and closing is produced by the flow of air past the tissues. This motion of the vocal folds during phonation are a result of both airflow (aerodynamic) and muscle (myoelastic) qualities. Subglottal pressure increases beneath the adducted vocal folds as phonation begins. The folds are blown apart and subglottal pressure decreases when pressure increases to overcome this resistance, which speeds up the flow rate through the glottis. According to the Bernoulli principle, because flow and pressure are inversely related, when flow increases, a brief pressure drop between the vocal folds takes place that also pulls the vocal folds back together. The vocal folds are also drawn back towards the midline by elastic tissue recoil, completing a full cycle of vibration. Subglottal pressure increases as the vocal folds are reapproximated to begin the process again.

However, the primary function of the larynx evolved biologically as a valve to safeguard the airway and lungs. As a result, it is situated where the esophagus and airway part ways. The vocal folds open to permit breathing and close to prevent food from entering the lungs while swallowing and speaking. There are number of muscles of the larynx which share these common functions of swallowing and voice production. The muscles of larynx play a major role in production of voice as well as protection of airway. Extrinsic and intrinsic laryngeal muscles that are connected to the larynx enable movement of either the laryngeal frame (for the extrinsic muscles) or the vocal folds within (for the intrinsic muscles). The larynx is supported, stabilized, and can change positions within the neck due to the extrinsic laryngeal muscles. The inferior constrictors, thyrohyoid, and sternothyroid muscles are included in this category. Two significant sets of muscles that originate above or below the hyoid bone are the suprahyoid and infrahyoid which attach to larynx in addition to the extrinsic laryngeal muscles. The digastric, stylohyoid, mylohyoid, geniohyoid, hyoglossus, and genioglossus are all parts of the suprahyoid muscle group. The thyrohyoid, sternohyoid, sternothyroid and omohyoid are parts of the infrahyoid muscle group.

During the pharyngeal stage of swallowing, the larynx can be seen and observed lifting and lowering. In most cases, the suprahyoid muscles lift the larynx by pushing the hyoid bone upward and closing of the laryngeal inlet. The following mechanisms are used to produce laryngeal closure. The epiglottis is lowered in a straightforward two-step process. The epiglottis first moves from an upright resting position to a transverse position. The elevation of the hyoid bone and the proximity of the thyroid cartilage to the hyoid bone can be attributed to this movement. Thus, the contraction of the stylohyoid, digastric, mylohyoid, and geniohyoid muscles, which lift the hyoid bone, causes this movement of the epiglottis. The thyrohyoid muscle also approximates the thyroid cartilage and hyoid bone making the closure to be more appropriate. Secondly, the thyroepiglottic muscle continues to be a viable option for lowering the epiglottis. This muscle faces the epiglottis in a direction that is advantageous when it is in the transverse position. The epiglottis will most likely be pulled down over the laryngeal inlet region if the thyroepiglottic muscle contracts. This motion is particularly significant when swallowing since laryngeal elevation can help prevent aspiration by protecting the airway. Clinically, high extrinsic laryngeal muscle tension may be indicated by laryngeal elevation during phonation, which is frequently a reliable marker of hyperfunctional voice use.

The infrahyoid muscles move the larynx and hyoid bone down in the neck. The thyroid cartilage is depressed by the sternothyoid, and the distance between the hyoid and the thyroid is reduced by the thyrohyoid which is very much essential during the swallow as mentioned above. These are the muscles which also depress the larynx to lower the pitch as well.

The main purposes of these motions of the extrinsic muscles are to shield the airway from food or liquid inhalation. When producing higher and lower pitches, the extrinsic laryngeal muscles also play a small role. The extrinsic laryngeal muscles do not appear to need to be very active to produce a decent speaking voice, but plays an essential role in swallowing.

There are five intrinsic laryngeal muscles on the other hand (cricothyroid, thyroarytenoid, lateral cricoarytenoid, posterior cricoarytenoid, and interarytenoids), each of which attaches to cartilages in the larynx to alter the relationship between the cricothyroid and cricoarytenoid joint, and thereby affect the position, length, and tension of the vocal folds. These muscles mainly involved in the adduction and abduction of the vocal folds during voice production as well as swallowing. Except the posterior cricoarytenoids, which is the only abductor muscle all the others coordinate in the adduction of the vocal folds. During the process of swallow, in order to protect the airway from the entrance of food particles the laryngeal structures closes or adducts as a safety mechanism. This closure happens from the glottis to the supraglottis level by closure of the vocal folds and that of the epiglottis as explained above. During this stage itself the upper esophageal sphincter also opens due to the constriction of the phygyngo-esophageal muscle. Therefore, the bolus passes safely into that of the esophagus without entering into the airway thus completing a safe swallow.

2.2.2 Swallowing and Voice production: The Overlap in Sensory Function

Swallowing also involves air under pressure, which is crucial voice production. This is accomplished by stimulating the laryngeal subglottic mechanoreceptors (Adzaku & Wyke, 1979).Though their purpose has not yet been fully understood, this sort of receptor has been identified (Widdicombe 1986). These receptors play an important role in swallowing in addition to breathing and voice production. The stimulation of subglottic receptors may possibly act as a signal to the brainstem's lower motoneurons that innervate the pharynx, indicating to the central nervous system (CNS) that the larynx is "ready" (i.e., protected) for the bolus passage into the pharynx.

According to Larson et al. (1994), safe swallowing depends on the perfect coordination of the respiratory and digestive systems, which is reflected in the closed topographic organisation of the respiratory, deglutitory, and branchial motor neurons. As a result of the neuroanatomical connection between subglottic receptors and branchial motor neurons for pharynx and larynx, the feedback from subglottic receptors may presumably affect the recruitment of motor neurons in the brainstem capable of activating the pharyngeal muscles during swallowing so that the force, speed, and duration of the muscular contraction are regulated (normalized) by the closing of the larynx. The stimulation of this reflex arc increases the number of pharyngeal motoneurons that, in turn, mediate a higher speed of the bolus transit ,decreased time of pharyngeal contraction (resulting in a quicker pharyngeal clearing), and a stronger muscular contraction. The mentioned factors make it clear that the respiratory, deglutitory, and phono-articulatory activities are strongly correlated, and that this correlation is dependent on the structural integrity of the organs performing these tasks.

Given the high degree of integration between these functions, dysfunctions may therefore be caused by harmful influence localised at different levels and differently influenced by various pathological events. If the anatomical aspects are integrated into the various functions, this integration also characterise pathological events that may affect effectors with a consequent impact on related functions.

2.3 Effect of Dysphonia on Swallow Function

Dysphonia is a term used to describe a group of voice disorders characterized by changes in the quality, pitch, loudness, or overall functionality of the voice. It refers to difficulties in producing normal vocal sounds due to abnormalities in the vocal folds or other structures involved in voice production (Rubin et al., 2005). A number of reasons can cause dysphonia which is discussed below.

The Classification Manual for Voice Disorders (ASHA, 2006) classifies causes of dysphonia into eight significant groups:

1. Structural Pathology: Malignant Epithelial Dysplasia of the Larynx, Benign Epithelial and Lamina Propria Abnormalities of the Vocal Fold (Vocal Nodules, Vocal Fold Polyps, Vocal Fold Cysts, Reactive Vocal Fold Lesion, Reinke's Edema and Polypoid Degeneration, Vocal Fold Scarring- Vocal Fold Sulcus/Sulcus Vocalis, Vocal Fold Granuloma and Contact Ulcer, Keratosis, Leukoplakia, and Erythroplasia, Recurrent Respiratory Papilloma (RRP), Subglottic and Laryngeal/Glottic Stenosis; Acquired Anterior Glottic Web and Vascular Lesions: Vocal Fold Hemorrhage, Hematoma, Varix, and Ectasia), Congenital and Maturational Changes Affecting Voice (Congenital Webs (Synechia), Laryngomalacia, Puberphonia: Mutational Falsetto and Juvenile Voice and Presbyphonia or Presbylaryngeus)

2. Diseases with inflammation: Cricoarytenoid and Cricothyroid Arthritis, Acute Laryngitis, Laryngopharyngeal Reflux and Chemical Sensitivity/Irritable Larynx Syndrome

3. Injury or trauma

4. Voice-related systemic issues: Endocrine Disorders (Hypothyroidism and Hyperthyroidism, Sexual Hormonal Imbalances and Growth Hormone Abnormalities (Hyperpituitarism) and Immunologic Disorders (Allergies)

5. Voice-harming aerodigestive disorders: Respiratory Diseases (Asthma and Chronic Obstructive Pulmonary Disease), Gastroesophageal Reflux Disease (GERD) and Infectious Diseases of the Aerodigestive Tract (Laryngotracheobronchitis (Croup) and Mycotic (Fungal) Infections: Candida)

6. Voice-related psychiatric or psychological conditions: Psychogenic Conversion Aphonia and Dysphonia, Factitious Disorders or Malingering and Gender Dysphoria or Gender Reassignment

7. Neurologic Voice conditions:

A. Peripheral Nervous System Pathology: Superior Laryngeal Nerve Paralysis: Unilateral or Bilateral; Recurrent Laryngeal Nerve Paralysis: Unilateral or Bilateral; Superior Laryngeal Nerve and Recurrent Laryngeal Nerve Paresis and Myasthenia Gravis

B. Movement Disorders Affecting the Larynx: Spasmodic Dysphonia(Adductor Spasmodic Dysphonia (ADSD) , Abductor Spasmodic Dysphonia (ABSD) and Mixed Adductor and Abductor Spasmodic Dysphonia) and Essential Vocal Tremor.

C. Central Neurologic Disorders Affecting Voice: Amyotrophic Lateral Sclerosis, Parkinson’s Disease, Multiple Sclerosis and Huntington’s Chorea

8. Other voice disorders: Vocal Abuse, Misuse, and Phonotrauma; Vocal Fatigue; Muscle Tension Dysphonia (Primary and Secondary); Ventricular Phonation (Plica Ventricularis); Paradoxical Vocal Fold Motion (Vocal Fold Dysfunction) or Episodic Dyspnea

A few studies have tried to profile the effects of dysphonia secondary to various etiologies on the swallow functions. Hamdan et al. (2019) studied the prevalence of dysphagia in persons with non-neoplastic lesions of the vocal fold. They found that two fifths of the population reported of swallowing difficulties. The authors discuss that the pathophysiology behind the dysphagia in this population mainly relies on the intersection of the neuromuscular innervation of the upper airway and digestive tract. The larynx moves anteriorly and is elevated during the pharyngeal phase of swallowing, simultaneously the epiglottis closes, the pharyngeal muscle contracts, and the upper esophageal sphincter relaxes. Thus, a swallowing issue could result from any of these steps being dysfunctional. But, on the other hand Ghandour et al. (2021) screened for dysphagia in dysphonic population with non-neoplastic lesions of the vocal folds. They however reported that the dysphagia that the patients were reporting of, had no connection to the underlying non-neoplastic lesion, as these lesions were superficially present and cannot extend beyond the mucosal layer and affect the muscles or the deep structure of larynx.

One of the other causes that has been extensively researched is the muscle tension dysphonia (MTD). Kang et al. (2016) studied the symptoms and theoretical framework in MTD. They hypothesized that improper laryngeal motion causes the dysphagia symptoms and the laryngeal muscle tensions can contribute to dysphagia. The work of McGarey et al. (2018) also supported the work of Kang et al. They found that increased muscle tension of the extrinsic laryngeal muscles in MTD patients could cause dysphagia in dysphonics because of their close existence of anatomical and physiological correlation between the voice and swallowing mechanism. The extrinsic laryngeal muscles could affect the hyolaryngeal elevation. The other potential cause mentioned by the authors is the upper esophageal sphincter dysfunction. Recently Krasnodbska et al. (2021) also investigated patients with MTD who had swallowing issues using surface electromyography. They found out abnormal EMG signal shapes of the submentalis muscles in persons having dysphonia and dysphagia and also increased signals values of infrahyoid muscles. They also observed lower movement of the submental muscles and increased muscular tension and functional asymmetry of the infrahyoid muscles.

The most common cause that has been recorded in the literature is the vocal cord paralysis. Zhou et al. (2019) studied prevalence of dysphagia in persons with unilateral vocal fold paralysis. The authors suggest that the possible pathophysiology could be the disruptions along the pathway that can lead to dysphagia, including retention of pharyngeal residue due to delayed swallow start and impaired pharyngeal squeeze, inadequate laryngeal elevation due to epiglottis immobility, and poor pharyngeal squeeze. The presence of dysfunctional epiglottis immobility, dysfunctional laryngeal elevation, and bolus residue in peripheral lesions suggested vagal nerve involvement and disturbed pharyngolaryngeal kinetics.

Thus, these underlying pathophysiologies can cause dysphagia in dysphonic population. In order to identify the presence of dysphagia a comprehensive evaluation has to be made. The dysphagia can be assessed in various ways ranging from basic screening to formal instrumental analysis.

2.4 Assessment of Dysphagia

The diagnosis of dysphagia requires the expertise of many different specialities, including otorhinolaryngology, gastroenterology, speech pathology, neurology, and radiology. These many medical professions use a range of clinical and instrumental diagnostic procedures.

Screening the patient is the first step in the diagnosis of oropharyngeal dysphagia. Based on the presenting symptoms, screening determines which patients are more likely to develop dysphagia and triages those who require more testing. A standardised screening test can be used to undertake screening at the bedside or in a clinic as soon as the patient's medical state permits.

Followed by screening is the clinical swallow assessment. The goal of the clinical swallow assessment (CSA) is to determine the aspiration risk as well as the potential location, severity, and prognosis of the swallowing issue in order to determine whether therapy is necessary and where to direct future instrumental examinations. A CSA includes a medical history check, physical exam, oral motor test, and evaluation of dietary consumption.

The most widely available instruments for the assessment of swallowing are Videofluroscopy and Fiberoptic Endoscopy (FEES). FEES evaluation protocol was proposed by Langmore et al. (1998). The FEES is a thorough swallow examination that serves two purposes: first, to assess dysphagia, and second, where necessary, to recommend and put into practise measures that allow for safe swallowing. Anatomical structures at rest and in motion are inspected, oropharyngeal secretions are located and managed, and the effects of swallowing different types of food and liquids are assessed as part of a thorough FEES examination. If dysphagia is found, various therapeutic interventions are carried out (with the endoscope in place) to see if postural (for example, head position), dietary (for example, bolus volume and consistency), and behavioural changes (for example, effortful swallow or two swallows per bolus) are effective in promoting safer and more effective oral alimentation.

On the other hand, the videofluoroscopic swallowing study (VFSS), also known as the modified barium swallow study is a radiographic approach, offers a direct, dynamic image of the function of the mouth, pharynx, and upper oesophagus (Logemann, 1986). Typically, a speech-language pathologist (SLP) and radiologist conduct a VFSS in a medical facility. The patient is given several food and beverage combinations mixed with barium (or another contrast agent), enabling the bolus to be seen on an X-ray during the swallow in real time. The VFSS is useful for determining whether aspiration has taken place. The VFSS is used to assess the anatomy and pathophysiology of oropharyngeal swallow function as well as to identify the presence, timing, and volume of aspiration (Martin-Harris et al., 2000).

Through these various methods swallowing can be assessed. In the past, a few studies have attempted to evaluate the swallowing in persons with dysphonia using various assessment methods.

2.5 Studies Evaluating Swallow Function in Dysphonics

There are few studies that have tried to study swallow function in dysphonics in the recent past. Kang et al. (2016) tried to investigate 67 individuals with idiopathic functional dysphagia, to identify symptoms, common diagnostic findings, patterns of therapies and referrals given, and the effectiveness of such interventions through a retrospective chart review. Those with dysphagia who had video-fluoroscopic swallow studies between January 1, 2013, and April 30, 2015 were the subjects of a chart review. To determine the therapy paradigms that were applied, the dysphagia symptomology, video-fluoroscopic swallow study, flexible laryngoscopy, and medical chart of each patient were examined. The results indicated that in 97% of patients, abnormal laryngeal muscle tension was found. Laryngeal hyperresponsiveness was also present in 82% of the individuals. Inflammation of the larynx without apparent cause was present in 52% of individuals. For evaluation, 27 patients were referred to speech-language pathology. Thirteen patients successfully completed a vocal treatment programme designed to release muscle tension. The 13 patients all claimed that their dysphagia symptoms have subsided. The authors concluded that the underlying aetiology of patients with idiopathic functional dysphagia may include laryngeal muscular tension and further investigation in means of a prospective study is required.

Similarly, McGareyJr, Barone, Freeman, and Daniero (2018) aimed to describe patients who have muscle tension dysphonia (MTD) and its accompanying dysphagia and dyspnea symptoms through a retrospective chart review done over a 14-month period, from October 2014 to December 2015. A diagnosis of MTD and dysphonia were found in 81 individuals. 38 patients were included in the analysis after meeting the exclusion criteria. All patients had undergone a perceptual voice examination, which was graded using the Grade Roughness Breathiness Asthenic Strain (GRBAS, Hirano et al., 1981) scale. All patients also completed the VHI-10, EAT-10, and CCQ (Clinical COPD Questionnaire, Van der Molen et al., 2003), which are validated patient reported outcome measures. The average number of reported dysphagia during clinical history and examination was 44.7% in individuals with a diagnosis of MTD. 60.5% of patients with MTD had an abnormal EAT-10 score. Patients with dysphagia and/or abnormal EAT-10 scores experienced voice impairment that was considerably worse than that of patients without dysphagia. Patients who reported dysphagia also considerably outperformed patients who simply reported dysphonia on the CCQ. The study concluded that patients with MTD who appear with dysphonia frequently also have concomitant dysphagia. According to the CCQ, patients who reported dysphagia had considerably worse self-reported voice impairment and more severe respiratory difficulties.

Krasnodębska et al. (2019) did a study to examine dysphonia in conjunction with the occurrence of swallowing disorders. The goals were to characterise the symptoms and figure out what proportion of participants with dysphonia also reported of swallowing issues.515 persons with vocal abnormalities who were hospitalised were included in the study. Functional dysphonia was identified in 175 individuals, along with 154 cases of chronic laryngitis, 110 cases of laryngeal paralysis, 12 cases of dysphonia associated with neurological disorders, and 64 cases of benign vocal folds. Patients whose medical histories suggested swallowing issues underwent additional diagnostic testing for dysphagia. These patients were examined with Fiberoptic Endoscopic Examination of Swallowing (FEES) and surface electromyography (SEMG). The questionnaires for the Voice Handicap Index (VHI, (Caffier et al., 2021), Eating Assessment Tool (EAT-10), Dysphagia Handicap Index (DHI), Reflux Symptom Index (RSI), Swallowing Disorder Scale (SDS) and Malnutrition Screening Tool (MST, Ferguson et al., 1999) were provided to the patients to complete. According to their reports, 11.8% of those who needed voice therapy also had swallowing issues, out of which 9.3% had dysphagia. Depending on the underlying condition, different percentages of respondents had swallowing issues; neurological disorders had the highest prevalence. Analysis of the relationship between the severity of dysphagia (as determined by the assessed grade, DHI, and EAT-10 results) and the severity of VHI revealed statistically significant relationships between the value of VHI and RSI in individuals with neurological disease, between the value of VHI and DHI in individuals with hyperfunctional dysphonia, and between the value of VHI and BMI and EAT-10 in individuals with chronic laryngitis. Additionally, statistically significant associations between the EAT-10 and DHI scores and the degree of dysphagia were identified. The post therapy results revealed a concurrent issue with an abnormal swallowing pattern which were seen in the electromyographic investigation when capturing the average and maximum amplitude from masseters. The authors concluded that medical history of voice abnormalities in these patients could be accompanied by a history of dysphagia. Depending on the underlying cause of the voice disorder, the characteristics of swallowing disorders vary, and 9.3% of patients have both concurrently.

Krasnodbska et al. (2021) also investigated dysphonic patients who had swallowing issues using surface electromyography. Initially, 58 people with MTD were enrolled, of which 32 later had their condition confirmed and 26 had impaired swallowing function. Otolaryngological, logopaedic, and phonatory examinations were performed on each patient. Along with filling out the RSI (Reflux Symptom Index), EAT-10 (Eating Assessment Tool), DHI (Dysphagia Handicap Index), and SDS (Swallowing Disorder Scale), they were also required to complete the FEES. Surface electromyography was used to link the outcome measures with the FEES. The findings showed that MTD patients scored higher on all questionnaires than patients with impaired swallowing. A logopaedic evaluation of the articulatory organs' structure and effectiveness as well as the evaluation of their basic functions found anomalies. Significantly increased infrahyoid muscle activity during swallowing was seen in patients who underwent EMG evaluation and logopaedic evaluation. Patients with non-normative swallowing patterns demonstrated considerably more asymmetry in their masseter and submental muscle average and maximum amplitudes. Patients who had more asymmetrical muscle mass scored higher on questionnaires. The authors concluded that in addition to prolonged swallows, individuals with MTD differ from those with non-normative swallowing patterns in their abnormal logopaedic evaluation results, muscular activity evaluated by SEMG, and the severity of their complaints.

Recently, Kang et al. (2021) also investigated if treatment aimed at reducing laryngeal muscle tension and enhancing laryngeal coordination alleviated the symptoms of dysphagia. It was a prospective study which included 20 participants. Esophagogastroduodenoscopy, high-resolution esophageal manometry with stationary impedance, Bravo pH probe off proton pump inhibitor, and videofluoroscopic swallow study in patients with reported dysphagia was performed. Patient also filled self-report indices which included the Newcastle Laryngeal Hypersensitivity Questionnaire (Vertigan et al., 2014), Reflux Symptom Index, Cough Severity Index (Shembel et al., 2013), Voice Handicap Index-10, Eating Assessment Tool Index, Perceived Stress Scale (Levenstein et al., 1993), and Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983). The results revealed that in all patients, abnormal laryngeal muscular tension was found. Of the patients, 40% had a confirmed diagnosis of gastroesophageal reflux illness. During strobolaryngoscopy, 65 percent of the patients displayed symptoms of non-specific laryngeal inflammation and laryngeal hyperresponsiveness. Following voice therapy which aimed at relieving muscle tension, all patients reported a mean recovery rate of 90%. They concluded that there is an association between laryngeal muscle tension and these patients' dysphagia symptoms, regardless of associated conditions.

Apart from MTD, voice disorders secondary to other etiologies co-occurring with swallowing issues were also studied. Ghandour, Hadhoud, and ElFiky (2021) tried to identify the various dysphagia symptoms in dysphonic patients with non-neoplastic vocal fold lesions in order to weigh the benefits of pairing swallowing therapy with voice intervention techniques. In fifty dysphonic patients who had non-neoplastic vocal fold disorders, they employed the Arabic EAT-10 to assess the symptoms of dysphagia. Twelve patients or 24 percent, had dysphagia, according to the authors. Because swallowing solids requires more effort, swallowing pain was the issue that these people were most worried about. The patients' complaints about phonasthenia, according to the researchers, might have been misdiagnosed as swallowing problems. They concluded that dysphagia was not brought on by non-neoplastic vocal fold lesions. They continued by saying that purely arbitrary screening tools like the AEAT-10 cannot validate the diagnosis of dysphagia.

Similarly in persons with unilateral vocal cord palsy (UVP), Schiedermayer et al. (2020) investigated how the definition of dysphagia affects the prevalence and incidence of the disorder. From the records of patients with UVP diagnoses between 2013 and 2018, information on patient demographics, overall scores on the dysphagia questionnaire, clinical evaluation dysphagia symptoms, and instrumental swallow assessment data were gathered. Only 21% of the patients who reported having dysphagia had symptoms severe enough to call for an instrumental evaluation, despite up to 55% of them having the condition. While 23% of individuals getting MBS (Modified Barium Swallow) saw aspiration, 87% of them reported abnormal results. Patients with UVP who had an iatrogenic cause as opposed to an idiopathic cause more commonly had abnormal dysphagia questionnaire results. The researchers found that the occurrence and severity of the problem were influenced by the UVP etiologic category as well as the definition of dysphagia.

To summarize, when patients complain of dysphonia, dysphagia may also be a prevalent symptom that is frequently ignored. Dysphonic people may have trouble swallowing, but this problem is typically hidden by the phonatory complaint (Ollivere et al., 2006). They can be more agitated or preoccupied with their voice issues than they are with their swallowing issues. There is a chance that dysphagia will go unnoticed, which can lower quality of life. If dysphagia is not treated, it can have a multitude of clinical effects, such as malnutrition, aspiration pneumonia, and dehydration, which can affect the quality of life. Higher illness and mortality rates are associated with dysphagia. As a result, detecting dysphagia in those with dysphonia, early is essential to enable the implementation of effective therapies.

A look into the existing studies revealed that only self-administered tool called the EAT-10 has been used in the majority of studies to gauge the presence of dysphagia (Ghandour et al., 2021; Hamdan et al., 2019; Krasnodbska et al., 2021; Kashima et al., 2021; Kang et al., 2021; McGarey et al., 2018; Schiedermayer et al. Using more objective tests, such as the Gugging Swallowing Screen (GUSS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES), is necessary to confirm the existence of dysphagia.

Furthermore, research into reflux disease, which may lead to voice and swallowing issues, has not been done very often. Reflux disease can eventually cause esophageal irritation and laryngeal damage because it causes the stomach's contents to flow backward into the pharyngeal and laryngeal regions. The instrument that is frequently used to evaluate reflux is the Reflux Symptom Index (RSI, Belafsky et al., 2002). Ranjbar et al. (2022) evaluated the incidence of esophageal problems in the dysphonic population with LPR by a retrospective chart analysis. Out of 109 participants, the results showed that 24.8% of the population had abnormalities in the peristaltic wave, which may indicate esophageal dysmotility. Approximately 12.6% of people also reported problems with their upper and lower esophageal sphincters. Because swallowing and phonation have a tight anatomical and physiological relationship, patients with reflux disease may also experience esophageal dysmotility, which calls for additional swallowing testing. The current study was designed with the goal of examining swallow function in persons with dysphonia while taking these factors into consideration.

CHAPTER III

Method

The present study aimed to investigate the swallowing functions in persons with dysphonia. A single group study design was adopted for the present study.

3.1 Participants

A sample of thirty adults (10 males and 20 females) in the age range of 18-50 years (Mean age: 30.8 years, SD: 9.2 years) with a diagnosis of dysphonia confirmed by means of stroboscopic evaluation by a team of specialists including a speech-language pathologist and an ENT professional were included in the study. The participants had dysphonia of varying severity which was assessed through the Consensus Auditory Perceptual Evaluation of Voice (CAPE V, Kempster et al., 2009) scores (mild - 15 participants, moderate – 11 participants and moderately-severe- 4 participants). This rating system is used with standardised reading material and offers ratings on a 100 mm visual analogue scale with severity anchors for overall severity, roughness, breathiness, strain, pitch, loudness, and the option to comment on resonance and other qualities like fry, pitch instability, and tremor. Greater scores are indicative of greater severity of voice problems.

Among the thirty, 8 had neoplastic lesions (like polyp or nodules), 5 had neurogenic voice disorder (unilateral vocal cord palsy), while the others had heterogeneous conditions which could not be grouped such as muscle tension dysphonia (MTD), glottic chink, sulcus vocalis, nodules with MTD, posterior glottis chink, etc.). They were recruited from among those who report to the Department of Clinical Services. Information regarding any active voice intervention being undertaken was also collected.

A questionnaire titled ‘World Health Organization Disability Assessment Schedule-Second Version (WHODAS 2.0)’, a 12-item short version based on the International Classification of Functioning Disability and Health (ICF) developed by WHO in 2010 was administered through an interview mode. This questionnaire provides a profile of functioning across six activity domains (i.e., cognition, mobility, self-care, getting along, life activities, and participation). The participants with any dysfunction in any of the six aforementioned domains were excluded.

All participants were non-smokers and were not regular consumers of alcohol. Participants who reported history of visual or auditory deficits or corrected hearing and vision were excluded from participation in the study. None of the participants exhibited prior or existing swallowing problems or any previous surgery in the head, neck, throat or esophagus (Pitts, Stierwalt, Hagerman, & Lapointe, 2017) or head and neck cancer, radiation/chemotherapy therapy or presence of tracheostomy tube. Participants were native Kannada speakers with minimum academic level of SSLC, or grade X. They also had no prior psychiatric, sensory-motor, or cognitive disorders and managed hypertension and diabetes. Also, participants who had recent history of respiratory tract infections were excluded from the study.

Following an explanation of the duration, goals, and methodology of the study, each participant was asked to sign a written informed consent form. The study adhered to the most recent version of AIISH "Ethical Guidelines for Bio-Behavioral Research Involving Human Subjects."

3.2 Tools/Instrumentation

The following tools were administered:

3.2.1 EAT-10 (Eating Assessment Tool): This is a screening tool for dysphagia, which is a self-administered questionnaire. It has been developed in various foreign languages as well as in a few Indian languages. The EAT-10-K was developed in Kannada by Krishnamurthy, Balasubramanium, and Hegde (2020). It is a reliable tool with good validity as quoted by the authors. It is a quick test with simple 10 questions to answer. Patient scores on a scale of 0 (no problem) to 4 (severe problem) for each of the questions and a cut-off point greater than three is considered to be dysphagia.

3.2.2 GUSS (Gugging Swallowing Screen): This is a clinician-administered screening tool developed by Trapl et al. (2007). This test was initially used as a bedside screening tool for dysphagia in stroke patients. Recently it has been also used in screening dysphagia in partial laryngectomy patients (Huang et al., 2020). This tool is a highly sensitive (90-100%) with a good specificity (between 50 and 88%) (Lee, 2019). Indirect and Direct Swallowing Tests are the two domains of the test. The direct swallowing test has three subtests: solids, semi-solids, and liquids which examine deglutition, involuntary cough, drooling, and voice alteration across these textures. The indirect swallowing test probes vigilance, cough and/or throat clearing, and saliva swallowing. Each subtest is scored using a point system, totalling to 20. The maximum score a patient can receive is 20, which indicates normal swallowing function without aspiration risk. The degree of dysphagia is determined by the score range. A score range of 15-19 suggest of slight dysphagia with a low risk of aspiration, while a score range of 10-14 suggest of moderate dysphagia with a risk of aspiration and a score range of 0-9 suggest of severe dysphagia with a high risk of aspiration.

3.2.3 RSI-K (Reflux Symptom Index-Kannada): This was developed by Nayak, Balasubramanium, and Gunjawate (2020) in Kannada. It is a 9-item self-administered outcome measurement for patients with LPR and takes very less time to administer. It is a reliable and valid tool as mentioned by the authors. Each of the items were scored from zero (no problem) to five(severe problem) with a maximum score of forty-five.

Any score above thirteen was considered as abnormal. Greater scores indicated greater reflux related problems. This tool helps in documenting the improved symptoms in patients with LPR.

3.3 Procedure

Participants were informed about the duration, the objectives, and the pattern of the study process, after which a written informed consent was obtained from each participant. A pilot study was done on two participants who met the inclusion criteria. The tools included in the study were filled up by the participants. This was done to assess the time taken and any other challenges faced in the administration.

All the participants were subjected to a general interview and their demographic details were obtained. The testing was carried out in a silent room with no distractions. Following this, the participants were asked to fill out the EAT-10-K, and RSI-K. The participants were instructed that whatever they felt or experience was the appropriate score for the questions, that had to be marked accordingly.

Next, the GUSS was administered by the investigator. Administration of GUSS was done in two parts, which assesses swallowing both directly and indirectly. In the indirect swallowing portion, the vigilance, cough or throat clearing and saliva swallowing was assessed, the vigilance was mainly to assess if the participant was alert for at least 15 minutes or not. The cough and/or the throat clearing assessed the voluntary capacity of the participant, they were made to clear the throat or cough two times. In the saliva swallow area, the participant was asked to swallow the saliva normally. From that if swallow was successful or not, or if any drooling was present or if there was any voice change (hoarse, gurgly, coated, weak) present after swallowing was assessed in detail. The direct swallowing assessment required intake of certain food items which included mashed banana or yogurt for semisolids, water for liquid and a marie gold cookie for solids. The participants were initially made to take semi-solids, then liquid and then solids. Participants were assessed for deglutition, voluntary cough if any, drooling and voice changes for each of the consistencies. The deglutition alone had brief description whether or not swallowing was possible or if swallowing was delayed or if swallowing was successful. The voluntary cough was looked for either before, during or after swallowing (until 3 minutes later) for all the three consistencies. The scores were given based on the performance of the participant. The indirect swallowing part gives a score out of five while the direct swallowing part gives a score out of fifteen, which adds up to a total of twenty. Any participant who scored less than twenty were subjected for further objective evaluation using FEES.

3.3.1 The Fiberoptic Endoscopic Examination of Swallowing (FEES) is a quantitative evaluation for documenting swallow safety and efficiency. ATMOS FEES portable mobile swallowing diagnostics by MedizinTechnik, Germany which incorporates a flexible chip-on-tip endoscope as well as a tablet PC with the appropriate software for video storage and reporting was used for the study. The ATMOS capture Suite software saves videos or photos in the active patient file, which can be analyzed frame by frame.

FEES evaluation protocol proposed by Langmore et al. (1998) was used for participants who failed the screening process of GUSS. The procedure was performed by an expert ENT professional along with the investigator. The steps involved in the assessment included structural evaluation, observation of secretion and accumulation, and functional evaluation of swallowing with different bolus consistencies (thin and thick liquid, semi-solid and solid). Penetration and aspiration scale (PAS, Rosenbek et al., 1996) was used to quantify the penetration/aspiration severity. The PAS is an 8-point scale, with 1 meaning that no material enters the airway and 8 meaning that material enters the airway, penetrates beyond the vocal folds, and no attempt is made to eject it. The severity of residue (vallecular and pyriform sinus region) was quantified using Yale Pharyngeal Residue Severity Rating Scale (YPRSR, Neubauer et al., 2015). The severity ratings vary from none, trace, mild, moderate, and severe for both the vallecula and pyriform sinus regions on a five-point ordinal rating scale. The finally obtained scores were computed for statistical analysis.

3.4 Test-retest Reliability: All the tools except FEES were re-administered on 20% of the population (6 participants) within a time period of 4 days from the initial administration of the questionnaires.

3.5 Inter-rater Reliability: FEES recordings of four participants were re-evaluated by another trained SLP and the scores were obtained, which were computed for the analysis.

3.6 Analysis

The five dependent variables under investigation for this study were EAT-10 scores, GUSS scores, RSI scores, PAS scores and YPRSR scores. The independent variable was dysphonia(severity) which was obtained from the CAPE-V scores and were subjected for analyses. The EAT-10, RSI and GUSS total scores were obtained by summing up each of the individual scores and were subjected for analyses.

3.6.1 Statistical analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS v26.0 for Windows; SPSS Inc., Chicago, IL) software. Since an assessment of the normality of data is a prerequisite for the statistical tests, the raw data was tested numerically with well-known tests of normality, the Kolmogorov-Smirnov and the Shapiro-Wilk test. Both the tests rendered that swallowing functions significantly deviated from normality. To find the association between the swallow functions and dysphonia, Spearman’s Rank Order correlation was carried out. For the comparison across various vocal cord pathologies, the data was categorised into only two groups: Non-neoplastic (8 participant) and Neurogenic (5 participant) vocal fold pathologies, as other samples were heterogenous in nature. In order to compare the RSI and GUSS scores across the groups, the data was tested for normality. The Shapiro-Wilk test of normality revealed that RSI scores were normally distributed while GUSS scores were not. Hence Independent t test was taken up for RSI scores across the groups and Mann-Whitney test was taken up GUSS scores across the group. The PAS and YPRSR scores were obtained only for limited samples (four) and hence statistical analysis could not be carried out for the same. The results obtained have been discussed in the next chapter.

CHAPTER IV

Results

The present study aimed to investigate the swallow function in persons with dysphonia. The objectives of the study were to assess the relationship between scores obtained through EAT-10-K (patient perspective of swallow) with scores of GUSS (clinician perspective of swallow), relationship between scores obtained through subjective assessment (GUSS) with instrumental assessment (scores of PAS and YPRRS on FEES) and between reflux disease (scores on RSI-K) with scores obtained on GUSS and FEES. The study also assessed the relationship between dysphonia severity and dysphagia severity. Since there were individuals with different vocal pathologies, the scores of RSI and GUSS were compared across different vocal pathologies.

The study included a sample of 30 adults (mean age=30.8 years; SD = 9.2 years) with dysphonia of varying severity (mild - 15 participants, moderate - 11 participants, and moderately-severe - 4 participants). The sample included 10 male and 20 female participants. The RSI-K and EAT-10-K questionnaires were given to the participants to complete. The clinician also administered GUSS on each of the participants. Higher scores of RSI-K (>13 out of 45) indicate the presence of reflux related issues, higher scores on EAT-10-K scores, (> 3 out of 40) indicate the presence of dysphagia, while, for GUSS, greater scores (>19 out of 20) indicate normal swallow or no dysphagia. Those participants who failed in GUSS were subjected to objective evaluation through FEES and the corresponding PAS and YPRSR scores were obtained. Only 7 out of 30 failed the subjective evaluation done by the clinician, among whom only 4 provided consent for the FEES procedure. All the tools except FEES were re-administered on 20% of the population (6 participants) within a time period of 4 days from the initial administration of the questionnaires. FEES recordings of four participants were re-evaluated by another trained SLP and the scores were obtained, which were computed for the analysis. The results of the study are described under the following sections:

1. Percentage of persons with dysphonia who had dysphagia
2. Association between scores obtained through EAT-10-K and scores of GUSS
3. Association between scores obtained through subjective and instrumental assessment.
4. Association between reflux disease (scores on RSI-K) and scores of GUSS.
5. Association between dysphonia severity and dysphagia severity.
6. Comparison of RSI-K and GUSS scores across vocal cord pathologies.

4.1 Percentage of persons with dysphonia who had dysphagia

Among the 30 participants, 4 (13.33%) reported of dysphagia on EAT-10-K and 7 (23.33%) were identified to have dysphagia through GUSS. This included the 4 participants who failed in EAT-10-K. The underlying etiologies in these seven participants were muscle tension dysphonia (3 participants), vocal nodules (1 participant), vocal palsy (2 participants) and anterior glottic chink with MTD (1 participant). Thus, these findings indicated that 23.33% of the persons with dysphonia had dysphagia. Among these 7 participants, only 4 consented for the procedure of FEES. In FEES, 3 participants had reduced swallow efficiency and one participant had reduced swallow safety and efficiency.

4.2 Association Between Scores Obtained Through EAT-10-K and Scores of GUSS

As mentioned in the previous section, 4 participants reported of dysphagia on EAT-10-K and 7 were identified to have dysphagia through GUSS, which included the 4 participants who failed in EAT-10-K. The correlation between the patient perspective of swallow (scores of EAT-10-K) and the clinician perspective of swallow (scores of

GUSS) was determined using Spearman's rank correlation test. The result revealed a moderate negative statistically significant correlation between the patient's perspective and clinician perspective of swallow {$r(28)= -0.50$, $p=0.02$}. The findings indicated negative correlation as lower scores on EAT-10-K (scores<3) indicate no swallowing difficulty, while higher scores on GUSS (score >19) are indicative of no swallowing difficulty. These findings indicated that there is a relationship between the scores on EAT-10-K and GUSS, however the correlation is not very strong, as there were three participants who passed EAT—10-K, while they failed in GUSS.

4.3 Association Between Scores Obtained Through Subjective and Instrumental Assessment

Another objective was to investigate the relationship between scores obtained through subjective assessment (screening using GUSS) and instrumental assessment using FEES (scores of PAS and YPRSR). However, this could not be taken up for statistical analysis as the sample size (4 participants) for FEES was small. Though 23.33% (7 out of 30 participants) of participants failed GUSS, only four (57.14%) persons provided consent for FEES. The FEES findings of the four participants have been depicted in table 4.1. The images seen in FEES were quantified using the PAS and YPRSR scale.

Table 4.1

Scores obtained by the participants on GUSS, PAS and YPRSR and their interpretation

Sl no.	Scores on GUSS	Vocal cord pathologies	Scores on PAS	Interpretation of PAS	Scores on YPRSR	Interpretation of YPRSR
1	19	?MTD secondary to Left vocal cord restricted movement	1	No material enters the airway	1	Coating on the pharyngeal mucosa; no pooling
2	19	MTD II and MTDIII	1	No material enters the airway	1	Coating on the pharyngeal mucosa; no pooling
3	19	Bilateral Vocal Cord Nodules	1	No material enters the airway	1	Coating on the pharyngeal mucosa; no pooling
4	18	Left vocal cord palsy	2	Material enters airway remains above the vocal folds and is ejected from the airway.	2	Mild residue in the pyriform fossa and valleculae.

It can be seen from the table that all the four participants had scores ranging between 18 to 19 on GUSS and between 1 and 2 on PAS and YPRSR.The scores on YPRSR indicated that three of them had coating in the pharyngeal fossa and one of them had mild residue in the pyriform fossa/ valleculae. The scores on PAS indicated that one participant had penetration (food entering airway, but remaining above the vocal folds and ejected). Thus, all the participants who had reduced scores on GUSS also were identified with compromised swallowing safety and efficiency on FEES. In the remaining three participants, FEES could not be done as they did not provide the consent.

4.4 Association between reflux disease and swallow assessment

The relationship between reflux disease using the scores on RSI-K and the swallow assessment using the scores of GUSS and PAS and YPRSR was investigated. Out of 30 participants, 7 failed RSI-K and had an indication of reflux disease. Out of the 7, only 4 participants had confirmed dysphagia (through GUSS).

The correlation between the scores of RSI-K and GUSS was determined using Spearman's rank correlation test. The results revealed a weak negative correlation between the RSI-K and GUSS {$r(28) = -0.38$, $p=0.03$}. This correlation was found to statistical significance at $p<0.05$. The findings are negatively correlated because lower scores on RSI (scores <13) indicate no swallowing difficulty, while on GUSS (score >19), higher scores are indicative of no swallow difficulty. These findings indicated weak association between reflux disease and swallow difficulty.

4.5 Association between severity of dysphonia and dysphagia

The correlation between the severity of dysphonia as assessed using CAPE-V and severity of dysphagia as assessed through GUSS was determined using Spearman's rank correlation test. The result revealed a moderate highly significant negative correlation {$r(28)= -0.59$ and $p=0.001$}.The findings are negatively correlated because lower rating on CAPE-V are indicative of lesser severity, while on GUSS (score <19), lower scores indicate of greater problem. These findings indicated that there was an association between the severity of dysphonia and dysphagia.

4.6 Comparison of RSI-K and GUSS scores between vocal cord pathology groups

The comparison of RSI-K and GUSS scores across various vocal cord pathology groups was carried out. The various vocal fold pathologies included non-neoplastic lesions (*n*= 8) and neurogenic (*n*=5), while the other etiologies were heterogeneous and could not be grouped. Descriptive statistical analysis was computed to compute the mean and standard deviation. Mann Whitney U test was performed to compare GUSS scores across these groups as it was not normally distributed and Independent t test was done to compare RSI-K scores since the data was normally distributed.

On comparison of the means of RSI-K between groups, it was seen that the mean of the neoplastic group (*M*=9.25, *SD*=5.99) was higher than the neurogenic group (*M*=7.80, *SD*=2.49). However, independent t test to compare the mean values between the groups revealed no statistically significant difference {$t(11)=0.51$, $p=0.20$)}.

On comparison of the means of GUSS scores between groups, it was seen that the mean of the neoplastic group (*M*=19.88, *SD*=0.354) was almost similar to the neurogenic group (*M*=19.20, *SD*=1.095). Independent t test to compare the mean values between the groups revealed no statistically significant difference {/*Z*/=13.50, $p=0.20$)}.

Thus, the results revealed no statistically significant difference in the scores of the GUSS and RSI-K between the vocal pathology groups. The findings suggest that swallow difficulty and reflux disease were not specific to a particular vocal cord pathology and could be present in both the groups.

4.7 Test-retest Reliability: The tools were readministered on 20% of the sample (n=6) within 4 days of assessment. Both the values were subjected for statistical analysis.

Cronbach's Alpha was done to check the test-retest reliability. The results revealed that there was excellent test-retest reliability ($\alpha = 1.0$).

4.8 Inter-rater reliability: The inter-rater reliability was done for FEES recordings and was determined for four participants by measuring the agreement between the two raters using Kappa coefficient. The results revealed that the Kappa value was 1, which indicated 100% agreement between Rater 1 and Rater 2 and was statistically significant.

To summarize the findings, the results revealed that 23.33% of the participants with dysphonia had dysphagia. The clinician perspective of swallowing had a relationship with client's perspective due to the moderate degree of correlation that was found between the two. Further, those who failed on GUSS, also were identified with compromised swallow safety and efficiency though FEES, The correlation of the RSI-K and GUSS was weak indicating that there is a low degree of association between reflux issues and dysphagia. Also the correlation between dysphonia severity and dysphagia severity was moderate- indicating that there was relationship between the two. The across group (various vocal fold pathologies) comparison with various test scores (RSI-K and GUSS) revealed that there was no significant difference among the groups. Further, the test-retest and the inter-rater reliability measurements were high. The results of the study are discussed in greater detail in the upcoming chapter.

CHAPTER V

Discussion

Dysphagia is a significant symptom that can have an effect on many areas of a patient's life. Dysphagia is linked to higher rates of morbidity and mortality and can cause a number of medical issues, such as aspiration pneumonia, starvation, and dehydration. Patients with dysphagia have a lower quality of life because malnutrition affects daily activities, including moving around and eating, and may be linked to tissue wasting and compromised organ function. Therefore, early detection of this issue is critical to ensure the implementation of the proper safeguards and solutions (Etges et al., 2014).

There exists a close neuroanatomical and physiological correlation between the mechanisms of swallowing and voice production. This close link between the mechanisms of swallowing and voice production makes it much riskier for the presence of swallowing problem in voice disorders or vice versa, making it much easier for the coexistence of the problem. Any disruption in one mechanism can affect the other adversely (Hamdanet al., 2019).

Individuals with dysphonia may experience swallowing issues, which are frequently covered up by the phonatory complaint (Ollivere et al., 2006). Most of the studies recorded in literature have used patient self-report tools such as EAT-10 to assess the presence of dysphagia (Ghandour et al., 2021; Hamdan et al., 2019; Krasnodębska et al., 2021; Kashima et al., 2021; Kang et al., 2021; McGarey et al., 2018; Schiedermayer et al., 2016). The investigation of reflux disease, which could contribute to voice and swallowing problems has rarely been undertaken.

Hence the present study aimed to investigate the swallow functions in persons with dysphonia with the objectives of assessing the relationship between scores obtained through EAT-10-K (patient perspective of swallow) and scores of GUSS (clinician perspective of swallow), to assess the relationship between scores obtained through subjective assessment (screening with GUSS) and instrumental assessment (FEES), to investigate the relationship between reflux disease (scores on RSI-K) and scores of GUSS and FEES, to assess the relationship between dysphonia severity (scores of CAPE-V) and dysphagia (scores of GUSS), and finally to compare the scores of RSI-K and GUSS across various vocal cord pathology groups (neurogenic and neoplastic). The study revealed several interesting findings and has been discussed under different sections in detail below.

5.1 Percentage of persons with dysphonia who had dysphagia

Around 13.33% of the participant reported of dysphagia and 23.33% were identified to have dysphagia by the clinician, indicating that persons with dysphonia have indications of swallowing impairment. This is in consonance with findings of Krasnodębska et al. (2020), where the authors indicated that 5-10% of population who have dysphonia have dysphagia. Hamdan et al. (2019) also reported 37.7% of the dysphonics diagnosed with non-neoplastic vocal fold pathology to have dysphagia.Another study done by Ghandour et al. (2021) used Arabic EAT-10 to evaluate the symptoms of dysphagia in fifty dysphonic patients who had non-neoplastic vocal fold conditions. The authors found that 12 patients (or 24%) had dysphagia.

The anatomical or functional changes that occur consequent to the vocal fold pathologies could have resulted in dysphagia in the participants of the present study. The underlying etiologies in the participants who had dysphagia were muscle tension dysphonia, vocal nodules, vocal palsy and anterior glottic chink. Studies have reported dysphagia in persons with dysphonia due to the restricted movement of the laryngeal framework, reduced constriction of pharynx during swallowing, glottal insufficiency, reduced glottal competence or alteration in the upper esophageal sphincter pressure during phonation (Hamdan et al., 2019; Heitmiller et al., 2000; Nayak et al., 2002). Further, non-neo plastic vocal fold lesions such as vocal nodules also affect airway protection during a swallow. The excessive laryngeal muscle tension in muscle tension dysphonia results in improper laryngeal motion, which can also affect swallow (Hamdan et al., 2019).

5.2 Patient and clinician perspective of swallow

The result in the current study revealed a moderate negative correlation between the patient's perspective and clinician perspective of swallow. The findings revealed that patients who reported about swallowing difficulty by themselves were found to be also presenting with swallow issues by the clinician. However, there was a small population (3 out of 30 participants) who did not report of any swallowing issues but were found to have swallowing difficulty by the clinician while administering GUSS. The ENT findings in them were left vocal cord restricted movements with (?) MTD, MTD and Right vocal cord palsy. On GUSS, all of them had swallowing issues with liquid consistency (50ml), which suggested of slight dysphagia with low risk of aspiration. The participants did not report these problems on EAT-10-K, possibly because of the lesser severity of the swallowing difficulty and greater severity of dysphonia. The severity of dysphonia could have masked the presence of swallow difficulties. It is also possible that the subtle signs of swallowing difficulties were missed by the participants. For example, in this study the GUSS score was 19 for a participant, which indicated slight dysphagia with no signs of aspiration, but on EAT-10-K, the participant had scored 0 indicating no swallowing difficulties, however, the dysphonia severity was moderately severe for the participant. Ollivere et al., (2006) also reported that individuals with dysphonia may experience swallowing issues, which are frequently covered up by the phonatory complaint. They may be more irritated or concerned with the problems in their voice than the problems in swallowing. Thus the findings implied that the profiling of swallow functions in persons with dysphonia by clinicians plays a critical role in the clinical decision making, as patients might not always report of swallowing difficulties, which if unnoticed could have an impact on the quality of life.

Studies in the past have not compared the client and clinician perspective of swallow in persons with dysphonia. Most of the studies recorded in literature have used patient self-report tools such as EAT-10 to assess the presence of dysphagia (Ghandour et al., 2021 & McGray et al., 2019). However, there are studies that have investigated the correlation of client perspective (using EAT-10 with objective evaluation (Hamdan et al., 2018; McGray et al., 2019; Krasnodębska et al. 2021), the results of which have indicated a good correlation between the two. This study is the first of its kind, which attempted to correlate the patient perspective with the clinician perspective of swallow in persons with dysphonia. The findings of the current study are in consonance with findings of Krasnodębska et al.(2021), wherein they studied the swallow functions in MTD patients using self-perceptual questionnaires like EAT-10 (Eating Assessment Tool), DHI (Dysphagia Handicap Index), RSI (Reflux Symptom Index) and SDS (Swallowing Disorder Scale) and surface electro-myography (SEMG) along with FEES and concluded that patients who reported of swallow issues in the questionnaire by obtaining higher scores also had abnormal signals signs in the SEMG.

5.3 Relationship between subjective and objective assessment

This objective of the study aimed to evaluate relationship between subjective assessment though screening of swallow difficulties (GUSS scores) and objective assessment (PAS and YPRSR scores obtained from FEES). Out of the seven participants who failed GUSS, FEES could be performed only on four participants, as consent was not provided by the others. Hence due to restricted sample size, statistical analysis could not be done. The findings indicated that all the four participants, who had scores ranging between 18 to 19 on GUSS also had scores ranging between 1 and 2 on PAS and YPRSR, which indicated compromised swallow safety and efficiency. The findings of each of the four participants have been described qualitatively below.

Participant 1: This participant, aged 44 years of age presented with the complaints of change in voice with pain in throat while speaking and no difficulty in swallowing. The stroboscopic evaluation done by ENT professionals indicated that he had (?)MTD with Left vocal fold restricted movement. The participant scored 0 in EAT-10, and was rated moderately severe hoarse voice in CAPE V, while he scored 19 in GUSS. Thus, the scores indicated that the participant passed in self-rating scale, while failed in the clinician rated scale. Thus, the participant became a candidate for objective analysis using FEES. The participant had obtained a score of 1 on both PAS and YPRSR scales indicating no material entering the airway and a coating of food on the pharyngeal mucosa and no indication of pooling of the food materials.

The swallow difficulty of this participant could be attributed to the restricted vocal cord movements due to excessive tension on both the extrinsic and intrinsic muscles of larynx,. Muscle tension dysphonia (MTD) is a persistent dysphonia that results from excessive laryngeal and related musculoskeletal tension and associated hyperfunctional true and/or false vocal fold vibratory pattern (Dworkin et al., 2000). It is basically divided into two major types: Primary MTD and secondary MTD. Primary MTD occurs in the absence of any current organic or psychogenic or neurological etiology, while secondary MTD is believed to originate as compensatory response to a primary etiology. This participant could possibly have had secondary MTD.

Kang et al. (2016) also reported that laryngeal muscle tensions can contribute to dysphagia. The findings of McGarey et al. (2018) also support the works of Kang et al. (2016) wherein they found that increased muscle tension of the extrinsic laryngeal muscles could cause dysphagia in dysphonics because of the close anatomical and physiological relationship between the voice and swallowing mechanism. The extrinsic laryngeal muscles could affect the hyolaryngeal elevation. The other potential cause mentioned by the authors is the upper esophageal sphincter dysfunction. Recently Krasnodbska et al. (2021) also investigated patients with MTD who had swallowing issues using surface electromyography. They found abnormal EMG signal shapes of the submentalis muscles in persons having dysphonia and dysphagia and also increased signal values of infrahyoid muscles. They also observed lower movement of the submental muscles and increased muscular tension and functional asymmetry of the infrahyoid muscles. Thus, these could be the potential cause b leading to dysphagia in this participant.

Participant 2: This participant, aged 42 years of age presented with a complaint of change in voice. The stroboscopic evaluation done by ENT professionals revealed MTD. He obtained a score of 2 in EAT-10, while he obtained a score of 19 in GUSS. The CAPE V rating scale indicated of moderately severe hoarse voice. Thus, the scores indicated that the participant passed in EAT-10, while failed in GUSS. Thus, the participant became a candidate for objective analysis using FEES. The participant had obtained a score of 1 on both PAS and YPRSR scales indicating no material entering the airway and a coating of food on the pharyngeal mucosa and no indication of pooling of the food materials. As discussed in the previous participant, the dysphagia in this participant could be also be due to the restricted mobility of the vocal fold due to excessive tension.

Participant 3: This participant aged 26 years presented with the complaints of change in voice with pain in throat while speaking and no difficulty in swallowing. The stroboscopic evaluation done by ENT professionals indicated that she had bilateral vocal cord nodules. This participant scored 13 on EAT-10, while she obtained a score of 19 on GUSS. Thus the scores indicated that the participant failed in both self-rating scale and in the clinician rated scale. Thus, the participant became a candidate for objective analysis using FEES. The participant had obtained a score of 1 on both PAS and YPRSR scales indicating no material entering the airway and a coating of food on the pharyngeal mucosa and no indication of pooling of the food materials.

Vocal cord nodules are non-neoplastic lesions of the superficial layer of lamina propria of the vocal folds. These lesions range in size from the size of a pinhead to a pea and are often bilateral and symmetric. They often start on the medial edge between the anterior third and posterior two-thirds of the actual vocal fold, or at the location of the vocal fold vibration with the greatest amplitude (Hirano et al., 1981).

FEES findings indicated that there was coating of food on the pharyngeal mucosa and no indication of pooling of food or material entering the airway. The possible pathophysiology in this participant could be mainly at the intersection of the neuromuscular innervation of the upper airway and digestive tract. The larynx moves anteriorly and is elevated during the pharyngeal phase of swallowing, simultaneously the epiglottis closes, the pharyngeal muscle contracts, and the upper esophageal sphincter relaxes. A swallowing difficulty could result from any of these steps being dysfunctional (Hamdan et al., 2019). However, Ghandour et al., (2021) screened for dysphagia in dysphonic population with non-neoplastic lesions of the vocal folds and reported no connection of dysphagia to the underlying non-neoplastic lesion as these lesions are superficially present and cannot extend beyond the mucosal layer and effect the muscles or the deep structure of larynx. This exhibited showed residue in the pyriform fossa which could be be due to the reduced laryngeal elevation during swallow

Participant 4: This participant, aged 37 years presented with the complaints of change in voice with vocal dryness and fatigue in throat, and difficulty in swallowing of liquid. The participant also had undergone thyroidectomy 12 years ago. The stroboscopic evaluation done by ENT professionals indicated that she had left vocal cord paralysis. This participant scored 5 on EAT-10 and 19 on GUSS. The CAPE V scores indicated moderate degree of hoarseness in voice. Thus the scores indicated that the participant failed in the EAT-10 and GUSS scale and consequently, FEES was done. The participant had obtained a score of 2 on both PAS and YPRSR scales indicating material entering the airway remaining above the vocal fold and ejected from the airway; and a mild residue on the pyriform sinuses and valleculae.

Vocal cord paralysis is a neurogenic condition where there is damage to cranial nerve X anywhere along its course, from the medulla to the larynx causing voice problems. It can be unilateral or bilateral and partial or complete. According to Tucker (1980), Unilateral Vocal Fold Pathology (ULVP) can be generically categorised into four groups: neoplastic (compression or infiltration of the Vagus or RLN), traumatic (surgery and nonsurgery), related to a medical condition, and idiopathic. Due to the injured true vocal fold's failure to fully adduct and meet the usually movable opposing true vocal fold, there is glottic incompetence. The paralysed vocal fold is immovable and held in the paramedian position, which is neither fully adducted nor abducted. For both inspiration and expiration (including efforts at phonation), the vocal fold stays in the paramedian position. As this happens the airway is patent for the food materials to enter easily and cause aspiration during swallowing.

This participant had UVFP (left cord paralysis). The possible pathophysiology could be the disruptions along the pathway that can lead to dysphagia, including retention of pharyngeal residue due to delayed swallow start and impaired pharyngeal squeeze, inadequate laryngeal elevation due to epiglottis immobility, and poor pharyngeal squeeze. The presence of dysfunctional epiglottis immobility, dysfunctional laryngeal elevation, and bolus residue in peripheral lesions suggested vagal involvement and disturbed pharyngolaryngeal kinetics (Zhou et al., 2019).

Thus, the findings indicated that GUSS is a more reliable and sensitive tool to screen for swallowing impairment in persons with dysphonia, as all the participants with reduced scores on GUSS had safety and efficiency issues on FEES. If FEES could have been done on other participants as well, it could have resulted in statistically high correlation between subjective and objective assessment.

5.4 Relationship between RSI (Reflux disease) with GUSS (Dysphagia):

The other objective of the study was to find the relationship between reflux disease with that of dysphagia. The results revealed a weak negative correlation between the RSI-K and GUSS. These findings indicated weak association between reflux disease and swallow difficulty. A study done by Krasnodębska et al. (2021) on patients with MTD using RSI, EAT-10, DHI, SDS questionnaires and SEMG, revealed that the RSI scores had a significant relation with that of SEMG signals (more infrahyoid and submental muscle amplitude) while swallowing, indicating that there is a relationship between reflux disease and dysphagia.

The reflux disease can affect the swallow mechanism. The pathophysiology giving rise to this disturbance has been discussed in the literature. They indicate that the laryngeal mucosa lacks protection and the repeated attacks of acid from the stomach which consists of a lipid bilayer and pH sensitive ion cells on the laryngeal mucosa can affect the mucosal layers of the larynx. (Johnston et al. 2004, 2007). Studies also state that dysmotility of esophagus as a possible underlying cause that might lead to dysphagia in persons with reflux disease (Caroll et al., 2012 and Cumpston et al., 2016). The reflux can also lead to the dysfunction of the upper and lower esophageal sphincter leading to dysphagia (Ranjbar et al., 2022).

5.5 Relationship between dysphonia severity (CAPE-V) and Dysphagia (GUSS)

The fifth objective was to find the correlation between dysphonia severityand dysphagia severity. The result revealed a moderate negative correlation indicating that greater the severity of dysphonia, greater was the severity of dysphagia. These findings indicated that there is an association between the severity of dysphonia and dysphagia.

McGarey et al. (2018) reported the same in their study where they investigated dysphagia in MTD population using various self-reported questionnaires (EAT-10, VHI-10 and CCQ). They found out that persons who self-reported of dysphagia had greater voice impairment. Another study done by Krasnodębska et al.(2021) revealed that there was a correlation between the scores of VHI and the abnormal activity of infrahyoid muscle (using SEMG) in patients who had MTDYet another study done by Kashima et al. (2021), reported that persons who had dysphagia also had higher scores on VHI indicating severe voice disorders.

5.6 Comparison of RSI-K and GUSS scores across various vocal cord pathology groups:

The last objective of the study was to compare the effect of various pathologies (non-neoplastic and neurogenic) on the presence of dysphagia and reflux disease. The results revealed no statistically significant difference in the scores of RSI-K and GUSS across the groups. The findings suggest that swallow difficulty and reflux disease were not specific to a particular vocal cord pathology and could be present in both the groups.

However, the mean on RSI-K was slightly higher in the group with non- neoplastic lesions.

A study done by Kavookjian et al. (2020) studied the overlap of RSI and voice symptoms in dysphonics. They compared the scores of RSI across various vocal cord pathologies like paresis or paralysis of vocal folds, vocal nodules/cyst/polyp, vocal cord atrophy, papilloma, malignancy, leukoplakia, spasmodic dysphonia, and MTD. Among these pathologies the RSI scores were highest among the paralysis patients (M=23.2; SD=11.2).In the present study, however, RSI scores were higher for the group with non-neoplastic lesions than neurogenic pathology. This could be attributed to the restricted sample size in both these groups.

Chapter VI

Summary & Conclusions

Dysphagia may be a common symptom that is often disregarded in patients presenting with dysphonia complaints. Individuals with dysphonia may experience swallowing issues, which are frequently covered up by the phonatory complaint (Ollivere et al., 2006). Most of the studies recorded in literature have used patient self-report tools such as EAT-10 to assess the presence of dysphagia (Ghandour et al., 2021; Hamdan et al., 2019; Krasnodębska et al., 2021; Kashima et al., 2021; Kang et al., 2021; McGarey et al., 2018; Schiedermayer et al., 2016). Further, the investigation of reflux disease, which could contribute to voice and swallowing problems has rarely been undertaken.

Hence the present study aimed to investigate the swallow functions in persons with dysphonia with the objectives of assessing the relationship between a) scores obtained through EAT-10 (patient perspective of swallow) and scores of GUSS (clinician perspective of swallow), b) scores obtained through subjective assessment (screening with GUSS) and instrumental assessment (FEES), c) reflux disease (scores on RSI-K) and scores of GUSS and FEES, d) dysphonia severity (scores of CAPE-V) and dysphagia (scores of GUSS), and e) to compare the scores of RSI-K and GUSS across various vocal cord pathology groups (neurogenic and neoplastic).

Single group design was used in the study, where 30 participants in the age range of 18-50 years (10 males and 20 females) with a diagnosis of dysphonia of varying severity (mild - 15 participants, moderate – 11 participants and moderately-severe- 4 participants) who were confirmed with the diagnosis of dysphonia by the ENT doctors as well as speech language pathologist and after meeting the inclusion and exclusion criteria, were included in the study. Among the thirty, 8 had neoplastic lesions (like polyp or nodules), 5 had neurogenic voice disorder (unilateral vocal cord palsy), while the others had heterogeneous conditions which could not be grouped (like MTD, glottic chink, sulcus vocalis, nodules with MTD, posterior glottis chink, etc.).

The tools used in the study were EAT-10-K, RSI-K, GUSS and FEES. EAT-10-K and GUSS are screening tools for dysphagia which are client and clinician administered respectively with good reliability and validity. RSI-K is a screening tool for reflux disease also with good reliability and validity. FEES on the other hand is used in instrumental analysis of dysphagia. The participants were instructed to fill EAT-10-K and RSI-K, while the clinician administered GUSS. Those who failed in GUSS were further investigated through FEES evaluation for profiling swallow safety and efficiency using the PAS and YPRSR scales. The scores of the participant were compiled and were subjected to statistical analysis.

Spearman's rank order correlation was used to assess the relationship between scores obtained through EAT-10-K and GUSS, reflux disease and scores of GUSS and dysphonia severity and dysphagia severity. Independent t test was used to compare the scores of RSI-K across various vocal cord pathology groups and MannWhitney test to compare GUSS scores across the groups.

The results revealed that 23.33% of the persons with dysphonia had dysphagia as identified though GUSS. These results indicates that dysphagia co-occurs with dysphonia. The results of the correlation between EAT-10-K and GUSS revealed a moderate negative correlation, indicating that participants who reported of dysphonia also reported of dysphagia. It was also found that the participants who failed on GUSS also had compromised swallow functions as revealed through FEES, though this could not be statistically computed due to the restricted sample size. The association between reflux disease and GUSS indicated a weak negative correlation indicating that there was a low degree of association between reflux disease and dysphagia. A moderate negative correlation was seen between dysphonia and dysphagia severity suggesting that there was a relationship between the two. The comparison of RSI-K and GUSS scores across various vocal cord pathologies indicated no significant difference, suggesting that swallow difficulty and reflux disease were not specific to certain vocal cord pathologies.

In conclusion the findings of this study revealed that dysphagia can co-exist with dysphonia and the importance of assessing for the same in persons with dysphonia through subjective and objective evaluation. It has also thrown some light upon reflux disease in dysphonics. However, since the sample size of those with dysphagia associated with dysphagia was small, caution needs to be exercised while generalizing the findings.

6.1 Implications of the study

- The present study provides insights into the swallow functions in persons with dysphonia.
- The study emphasises the importance of assessment of dysphagia in persons with dysphonia, which can pave way for swallow rehabilitation along with voice therapy.
- The study emphasises on the importance of clinician based evaluation of swallow functions in persons with dysphonia.
- The study provides insight of coexistence of reflux disease and swallowing issues in persons with dysphonia.

6.2 Limitations of the study

- The sample size was small restricting the generalization of findings
- Heterogeneity in the vocal cord pathologies limited the grouping of samples.

- Association between screening and instrumental evaluation of swallowing problems using an appropriate statistical analysis could not be obtained due to the limited sample size.

6.3 Future directions

- Various other factors (age, vocal cord pathology and greater sample size) that might impact the swallow functions of persons with dysphonia can be assessed.
- The effect of voice therapy on swallowing problems can be investigated.

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APPENDIX A

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MYSURU-06

CONSENT FORM

Information to the participant/caregiver

I, Ms. Angeline Stephy Deva. S, II MSc(SLP)student, as a part of my postgraduate research program, am studying the "Investion of Swallow Function In Person's with Dysphonia", under the guidance of Dr. Swapna. N, Professor of Speech Pathology and Coordinator-Centre for Swallowing Disorders, AIISH, Mysuru. This study has been taken up to help individuals with dysphonia to investigate swallow functions. The study involves self administration of certain tools as a part of screening process and if failing the criteria of the same, objective testing(FEES) will be done. The procedure is unharming and has only research benefits and the participants will not receive any financial benefits from it. Some of the assessment will be audio-video recorded and may be used for educational purposes including student training, presentation in seminars, and workshops and publication in journals. I therefore request you to participate in the present study with the assurance that your identity and this data will be kept confidential. There is no influence or pressure of any kind by the investigator or the investigating institute to your participation. Your kind co-operation in the study will go in a long way in helping us understand the swallowing in individuals with dysphonia.

Consent for participation

I have been informed about the aims, objectives, and the procedure of the study. The possible risk-benefits of my participation as human subject in the study are clearly understood by me. I will also be given the opportunity to ask questions about the study. I understand that I have the right to refuse participation as participant or withdraw my consent at any time. I am also aware that by subjecting myself to this study, I will have to give more time for assessments done by the investigator. The specific needs for assessment, instructions and complications that may arise during this period have been explained to me and it is understood that investigator or the institute is not held responsible. I have the freedom to write to the AIISH Ethical Committee chairman in case of any violation of these provisions without the danger of me being denied of any rights to avail the clinical services at this institute. I hereby give my full consent for enrolling in the swallowing investigation program.

I, ____, the undersigned, give my consent to be a participant for this study

Signature of the participant/caregiver   Signature of the investigator

Name, address, and phone number: Date: