TUTORIAL TO ASSESS PHARYNGEAL DYSPHAGIA USING FIBEROPTIC ENDOSCOPIC EVALUATION OF SWALLOWING (FEES)

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CERTIFICATE

This is to certify that this dissertation entitled **'Tutorial to Assess Pharyngeal Dysphagia using Fiberoptic Endoscopic Evaluation of Swallowing (FEES)'** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech Language Pathology) of the student Registration Number: 19SLP032. 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, 2021

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CERTIFICATE

This is to certify that this dissertation entitled **'Tutorial to Assess Pharyngeal Dysphagia using Fiberoptic Endoscopic Evaluation of Swallowing (FEES)'** has been prepared under my supervision and guidance. It is also been certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **'Tutorial to Assess Pharyngeal Dysphagia using Fiberoptic Endoscopic Evaluation of Swallowing (FEES)'** is the result of my own study under the guidance of a faculty at 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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CHAPTER 1

INTRODUCTION

India is the second most populated country in the world, with over 132 million people residing there. According to WHO, many factors influence a country's health statistics, including disease burden and mortality, mortality and morbidity specific to a cause, few infectious diseases, health service facilities, medical workforce, risk factors infrastructure, health expenditure and essential medicines, health inequities, socioeconomic statistics and demographics (World Health Organization, 2010) . Few of the health conditions identified as priority by WHO experts include Tuberculosis, Cancers, Diabetes, Cardiovascular diseases, Chronic Obstructive Pulmonary Disease and asthma and Oral diseases, which directly or indirectly could lead to disorders of swallowing.

As an allied health professional, our goal is to improve the health statistics of the country by catering to the needs of the patients and developing competency in the profession. Difficulty in swallowing, also called as dysphagia is a primary manifestation of a number of health conditions, and as speech-language pathologists (SLPs), it is our responsibility to assess and treat the dysphagia in these patients, so as to improve their overall quality of life. The word "dysphagia" comes from the Greek words "dys" for "disordered," and "phago" for "feed" or "swallow." Swallowing is defined as the “process of clearing food through the mouth, pharynx, and oesophagus into the stomach at an appropriate rate and speed” as defined by the ICF (World Health Organization, 2007). Swallowing is defined in the ICF as "digestive symptoms and signs" (World Health Organization, 2007). However, the phrase does not always imply the presence of a sickness or ailment, as some individuals may be completely unaware of their swallowing problems.

The oral preparatory phase, the oral transport phase, the pharyngeal phase, and the esophageal phase are the four phases of swallowing (Dodds et al., 1990). The first phase is fully voluntary, and it entails putting food into the mouth and getting ready to swallow. This comprises combining food with saliva, mastication, and the production of a cohesive bolus that is ready to swallow (Gaziano, 2002).The second phase of swallowing begins when bolus is propelled back into the oropharynx primarily by the action of the tongue(Truelson & Pearce, 1997). The oral swallow is ended and the pharyngeal swallow i.e third phase is activated when the leading edge of the bolus passes across any point between the anterior faucial arches and the point when the tongue base crosses the lower rim of the mandible. The tongue sends the bolus into the pharynx as the swallow is activated. When the tail of the bolus reaches the tongue base level, the tongue base retracts and the pharyngeal wall contracts. (Dodds et al., 1990). Several other crucial events occur during this phase that leads to airway protection. The fourth phase is fully automatic and is made up of peristaltic waves that drive the bolus to the stomach (Gaziano, 2002).

Disruption in any of the phases mentioned above can lead to dysphagia. Dysphagia can be clinically classified into three distinct types: oropharyngeal, esophageal and functional dysphagia (Souza et al., 2015). Oropharyngeal dysphagia is the difficulty in moving the bolus from the mouth to the esophagus. The feeling of difficulty transporting meals or liquids from the throat to the stomach is known as esophageal dysphagia. Functional dysphagia is a condition in which some people have dysphagia but no organic basis for their swallowing problems. (Hans Bogaardt, 2015).

Difficulty manipulating food in the oral cavity, difficulty producing saliva, difficulty digesting food, and difficulty swallowing are the most typical symptoms of oropharyngeal dysphagia. Nasal regurgitation, coughing, choking, gurgling or wet voice after swallowing, and unexplained weight loss are among symptoms that can lead to

complications such respiratory infections and aspiration pneumonia. Social isolation, anxiety, sadness, starvation, dehydration, and a poor quality of life are all linked to these issues. Dysphagia is particularly related with a high mortality rate. (Lenz et al., 2000).

Dysphagia is extremely common in the following patient populations: 8.1–80% of stroke patients, 11–60% of Parkinson's disease patients, 91 percent of elderly community-acquired pneumonia patients, and around 30% of individuals with brain injuries on a global scale.(Takizawa et al., 2016a). Dysphagia is estimated to occur between 11.6 and 87.5 percent among stroke patients in India, which is greater than the numbers reported in western studies. In India, the rate of pneumonia was found to be between 22.8 and 32 percent, which is twice as high as the global rate (15 %) and higher than other emerging countries such as Brazil (15 %) and Chile (23 %) (Krishnamurthy et al., 2020).

Thus, dysphagia should be assessed and treated at the earliest to prevent the complications. The goal of dysphagia evaluation is to discover the abilities and deficits in the swallowing mechanism, as well as the underlying pathophysiology and the degree to which these deficits can be addressed (Langmore & Logemann, 1991). The assessment procedure broadly involves a combination of subjective and instrumental assessment. Subjective assessment involves the use of observation or subjective measures to address the issues of nutritional status, swallow safety, diet modifications, suggestions for non-oral feeding, and the need for further instrumental assessment (Balasubramaniam, 2009). Various scales and tools are used for the comprehensive swallow examination. Instrumental evaluation is used in conjunction with clinical evaluation to determine the nature and severity of impairment in the structure and function of the oral, pharyngeal, laryngeal, and upper esophageal stages of swallowing, as well as to assess the impact of treatment strategies that may improve the swallow's safety and efficiency. “Fiberoptic Endoscopic Evaluation of Swallowing” (FEES) is one such instrumental assessment

procedure which is widely used to assess pharyngeal phase of swallowing. A fiberoptic endoscope is placed through the nose and into the throat to obtain direct visibility of structures involved in oral–pharyngeal transfer. It also provides indirect evidence of the pharyngeal–esophageal transfer during wet swallows. In addition, saliva swallowing (dry swallows) can be assessed.

A FEES can assist the SLP in determining which structures, particularly in the pharyngeal phase of swallow are not functioning properly. If the patient is aspirating, the FEES can detect it. FEES can also reveal whether a patient should avoid certain foods, or whether certain positions can assist them swallow more comfortably.

SLPs need to be patient-oriented and clinically competent as a rehabilitation professional. Hands-on training backed by adequate theoretical knowledge becomes necessary to serve our caseload. Students of Speech-language pathology need to have proper and updated knowledge of FEES, to be able to serve their patients having dysphagia. The detailed knowledge about FEES is often missed out during graduate programs which could lead to upcoming professionals feeling incompetent to conduct such assessments.

1.1 Need for the study

As many as thirteen Rehabilitation Council of India (RCI) approved colleges in India offering Master's program of Speech-language pathology include FEES in the curriculum (http://www.rehabcouncil.nic.in/). However, an exposure to the assessment of clients with dysphagia using FEES instrument depends on the availability of the equipment, patients and qualified professionals at the respective parent institute. As a consequence, some students of speech-language pathology may not be competent in analysing and interpreting

the images obtained through FEES, which compromises their clinical skills. Further, amongst the 13 institutes, 7 are institute based and 6 have hospitals attached to them (http://www.rehabcouncil.nic.in/). Students learning in hospital based set ups have an advantage of learning about FEES better, due to increased availability of clients, availability of FEES and the presence of qualified professionals, thereby increasing clinical exposure.

According to Indian Speech-Language and Hearing Association (ISHA), clinical and/or instrumental screening, assessment, diagnosis, and management of swallowing and feeding disorders is included as one of the clinical services offered by SLPs (https://www.ishaindia.org.in/). Despite instrumental assessment of swallowing being within the purview of the services provided by the SLP, in practice, FEES is performed by very few SLPs in India due to lack of clinical exposure and training courses. Most of the SLPs treating dysphagia tend to rely on subjective assessment for deciding the treatment plan, which gives an incomplete picture of the patient's actual swallow status.

Therefore, it is essential to provide in-depth knowledge and skills to develop competency of the SLPs, particularly in recognizing, analyzing and interpreting the normal and abnormal laryngopharyngeal anatomy and function, understanding the equipment used, identify anatomical landmarks, using the different scales to assess the severity of penetration/aspiration and deciding on the right swallow intervention to be chosen. One way of developing competency, as suggested by ISHA, is through the development of a tutorial for the SLPs incorporating the knowledge of basic anatomy and physiology of swallowing, examination and identification of structures and landmarks through endoscopic pictures, bolus administration, use of assessment scales to rate various parameters related to swallow, interpretation of FEES images and correlating the findings with medical history.

A look into the literature revealed that there are tutorials for videofluoroscopy (Wooi, Scott, & Perry, 2001) and assessment of voice using endoscopic evaluation (Patel et al., 2018), however no tutorial exists for evaluation of swallowing using FEES. There is a need for the development of a comprehensive learning tool suitable for students, so that the knowledge and importance of FEES is built-up from the ground level. Keeping these aspects in view, the present study was planned. A look into the literature revealed that dysphagia is a common manifestation of many health conditions. SLPs have a primary role when it comes to treating patients with dysphagia. In India, there are no standard guidelines for professionals to fall back on when treating dysphagia. Assessment of dysphagia is incomplete without instrumental assessment, as it gives an incomplete picture about what is really happening with the patient's swallowing mechanism. Currently, there are no certification courses or reading material specific to instrumental assessment of dysphagia in India. There is a need to develop comprehensive learning material which guides the learner about basics in step-by-step fashion.

1.2 Aim of the study

To develop a tutorial for assessment of pharyngeal dysphagia through (FEES).

1.3 Objectives

- To develop a tutorial which would include information about basic knowledge of FEES equipment, procedure and its implementation.
- To establish its content validity
- To assess the efficacy of the tutorial by administering it on students of speech-language pathology

CHAPTER 2

REVIEW OF LITERATURE

Swallowing normally requires the complex interplay of the oral, pharyngeal, laryngeal, and esophageal structures (Mankekar, 2015). The neuromuscular mechanism that executes and orchestrates the swallowing procedure is normally so seamless and effortless that it masks its complexity. The bolus is prepared for ingestion by the oral structure. Nasal regurgitation is prevented by elevating the soft palate and contracting the naso-pharyngeal posterior wall. Food cannot enter the airway due to the forward and upward movement of the larynx, the vicinity of the vocal cords and the motion of the epiglottis (Sebastian et al., 2014). The rear section of the tongue moves opposite to the posterior wall of the pharynx, forcing the bolus into the pharynx, which is then followed by peristalsis like movement of the pharynx. After the UES relaxes, the bolus enters the oesophagus. The oral phase is the volitional phase of swallowing, while the pharyngeal and esophageal phases are the involuntary stages. The normal human swallow was first characterised using a three-stage sequential paradigm (Mankekar, 2015; Matsuo & Palmer, 2008). The swallowing process was separated into three stages based on the position of the bolus: oral stage, pharyngeal stage and esophageal stage. Logemann (1988) later separated the first stage into oral preparatory and oral propulsive stages, resulting in the "four-stage model" (Matsuo & Palmer, 2008) . The biomechanics and movement of bolus during swallows of liquids on command are described by studies on the basis of "four-stage model" (Matsuo & Palmer, 2008).

Oral preparatory phase

A liquid material is kept in the anterior part of the mouth or on the tongue opposite to the hard palate enclosed by the upper dental arch when it is brought into the mouth via a cup or a straw (upper teeth). The contact between soft palate and tongue seals the oral cavity posteriorly, preventing the liquid material from spilling or leaking into the oral and pharyngeal cavity before swallowing. Fluids can seep in the pharynx in case the seal is inadequate, and this leakage is likely to increase with age (Matsuo & Palmer, 2008)

Oral propulsive phase

The tip of the tongue advances to contact the alveolar ridge of the hard palate during this stage, while the posterior part of tongue dips to open the back of the oral cavity. Squeezing the liquid bolus back down the palate and into the pharynx, the tongue surface travels upward, progressively widening the area of tongue-palate contact from anterior to posterior. The pharyngeal stage usually begins during oral propulsion when ingesting liquids. (Matsuo & Palmer, 2008)

Pharyngeal phase

During this phase, the pharyngeal swallow occurs as a swift successional activity that takes less than a second to complete. The soft palate lifts and touches the lateral and posterior walls of the pharynx during the pharyngeal stage, shutting the nasopharynx around the same time as the bolus head enters the pharynx. Regurgitation of bolus in the nasal cavity is avoided by elevating the soft palate. (Matsuo & Palmer, 2008). The bolus is pushed against the pharyngeal walls as the base of the tongue retracts. Squeezing the bolus downward, the pharyngeal constrictor muscles contract successively from top to bottom (Matsuo & Palmer, 2008). In order to lower the volume of the pharyngeal cavity, the pharynx also shortens vertically.

In human swallowing, a safe bolus passage through the pharynx without aspirating food is essential (Matsuo & Palmer, 2008). There are various airway protection systems in place to prevent foreign objects from being aspirated into the trachea before or during swallowing. Before opening of the upper oesophageal sphincter, the vocal cords contract and seal the glottis (gap between the vocal cords) and the arytenoids slightly tilt in a forward fashion to meet the base of epiglottis. Contraction of the suprahyoid and thyrohyoid muscles pulls the hyoid bone and larynx upward and forward. The larynx is tucked beneath the root of the tongue as a result of this displacement. To close the laryngeal vestibule, the epiglottis tilts backward. The mechanism of epiglottic tilting in humans is unknown, however it is thought to be linked to elevation of the hyo-laryngeal complex, constriction of pharynx, movement of bolus and retraction of tongue base.For bolus entrance into the oesophagus, the upper oesophageal sphincter (UES) must be opened. The inferior pharyngeal constrictor muscles, cricopharyngeus muscle, and the most proximal section of the oesophagus make up the UES (Sankhla & Bharambe, 2015). At rest, tonic muscular contraction closes the UES. The opening of the UES is influenced by three major elements. Firstly, relaxation of the cricopharyngeus muscle needs to occur before the UES opens or the bolus arrives. Secondly, the suprahyoid and thyrohyoid muscles both contract and lastly, the hyo-laryngeal complex is pulled forward by these muscles, which opens the sphincter. The bolus pressure as it descends, it dilates the UES, allowing it to open more easily.

Esophageal phase

From the lower half of the UES to the lower oesophageal sphincter, the oesophagus is a tubular structure (LES). At rest, the lower oesophageal sphincter is also tense to avoid stomach reflux. During a swallow, it relaxes, allowing the bolus to pass to the stomach. The upper one-third area of the cervical oesophagus is made up of striated muscle, whereas

the lower two-thirds is made up of smooth muscle. Because it is real peristalsis governed by the autonomic nervous system, bolus transport in the thoracic oesophagus differs from that of the pharynx (Dobie, 2021)

Eating, swallowing, and breathing are all closely synchronised (Matsuo & Palmer, 2008). Swallowing takes precedence over breathing in healthy people. Breathing stops for a few moments during swallow, due to both closure of the airway (elevation of the soft palate and epiglottic tilting) and neuronal suppression of respiration (brainstem). Swallowing begins during the expiratory part of breathing while ingesting a liquid bolus. During swallowing, the respiratory pause lasts for 0.5 to 1.5 seconds, and breathing resumes on expiration. This resumption is thought to be one of the mechanisms that prevents food from staying in the pharynx after swallowing from being inhaled. Respiration can resume with inspiration when making sequential swallows when drinking from a cup. The respiratory rhythm is also affected by solid meal consumption. With the initiation of mastication, the rhythm is disrupted. During mastication, the duration of the respiratory cycle shortens, whereas swallowing lengthens it. During eating, the "exhale – swallow – exhale" time link persists. Respiratory pauses, on the other hand, are lengthier and often occur well before swallowing.

2.1 Dysphagia

If there is disruption at any of the swallowing phases described above, dysphagia is said to occur. Dysphagia is the difficulty or discomfort experienced when swallowing, and it can be classified into three types: oral, pharyngeal, and esophageal, based on the stage of swallowing affected (Sebastian et al., 2014). Oral dysphagia affects the formation of food boluses or the positioning of food in the oral cavity due to a lack of strength or an inappropriate coordination of the oral muscles. Pharyngeal dysphagia is caused by a lack

of or delay in the triggering of the swallow reflex, whereas esophageal dysphagia is caused by mechanical malfunction of the oesophagus or esophageal sphincter.

Dysphagia can be caused by a range of diseases, such as a cerebrovascular accident or gastroesophageal reflux disease, or as a drug side effect (Ekberg, 2012; Spieker, 2000). The swallowing disorder can affect people of all ages, from newborns to the elderly, and it can be present in a variety of neurological disorders, including acute (e.g., bell's palsy, traumatic brain injury), congenital (cerebral palsy, cleft palate), chronic (static encephalopathy, gastroesophageal reflux disease), and degenerative (e.g., myasthenia gravis, Parkinson's disease) (Lazarus & Logemann, 1987) conditions. The swallowing issue in these people may contribute to life-threatening aspiration(Sebastian et al., 2014). Although oropharyngeal dysphagia is generally accompanied by a number of additional symptoms of neurologic and/or muscle problems, it is possible that oropharyngeal dysphagia is the only visible symptom.

Pharyngeal dysphagia occurs when there is a disruption in one or more structures involved in the pharyngeal phase of swallowing (Wooi et al., 2001). The lesion could be at the level of the cortex, subcortical structures, cranial nerves or spinal nerves. It could occur in combination with oral or esophageal dysphagia depending on the site and extent of lesion. Some of the symptoms of pharyngeal dysphagia can be observed directly through naked eyes and some are invisible to the eyes. The symptoms easily observed could be “nasal regurgitation, coughing, choking, regurgitation, food sticking in the throat, avoidance of certain consistencies and posture changes” (McHorney et al., 2002; Rommel & Hamdy, 2016; Roy et al., 2007; Wallace et al., 2000). The indirect symptoms which cannot be observed easily are “aspiration, weight loss, repeated chest infections, bronchitis and/or pneumonia” (Roden & Altman, 2013; Rommel & Hamdy, 2016).

Assessing the indirect symptoms is crucial for holistic management of the individuals suffering from dysphagia. Aspiration is a common symptom associated with pharyngeal dysphagia. Aspiration is the process of food or liquid entering the lungs. Below the vocal cords, there is an airway. The physical qualities and quantity of bolus are factors to consider in the presence or absence of aspirated material and the mechanisms of pulmonary clearance (Palmer et al., 2000). Although a causal relationship has not been shown, food and secretions play a crucial role in aspiration pneumonia. Aspiration of material below the glottis might result in complications such as oedematous laryngeal airway obstruction. In a person who is susceptible to aspiration pneumonia, aspiration of refluxed stomach secretions can produce pneumonitis, which can be mistaken for aspiration pneumonia caused by aspiration of anaerobic bacteria (Bartlett, 2020; Rommel & Hamdy, 2016). According to multiple studies, a poor swallow, which can lead to aspiration, may increase the risk of lower respiratory tract infections and pneumonia (Bartlett, 2020; Connolly, 2009; Marik & Kaplan, 2003).

Patients having oropharyngeal dysphagia are at risk for dehydration, which can lead to pneumonia as a result of decreased salivary flow, which can in turn lead to pathogen colonisation of the oropharynx, as well as lethargy, mental disorientation, and immunosuppression. Although there is some indirect evidence of a link between malnutrition, dehydration, and oropharyngeal problems, at the post-acute stage of rehabilitation, a substantial link has been documented in nursing home residents and stroke patients (Leibovitz et al., 2007; Palmer et al., 2001).

The oro-pharyngeal phase of swallowing must be accurately assessed since it poses the greatest clinical risk for dysphagic patients: tracheo-bronchial and aspiration complications. Furthermore, early detection of oro-pharyngeal dysphagia can help the

patient avoid malnutrition and dehydration, as well as considerable damage to his quality of life (Fattori et al., 2016)

Assessment of pharyngeal dysphagia could be tricky since it is difficult for a clinician to know what happens inside a person's throat without using external equipment. A careful and detailed history becomes very important along with subjective and objective assessments for proper diagnosis. In addition to clinical swallowing evaluation, assessing pharyngeal dysphagia warrants use of instruments such as FEES, Video fluoroscopic Swallowing Study (VFSS), pharyngeal manometry, scintigraphy(Fattori et al., 2016; Philpott et al., 2017).

2.2 History of FEES

Swallowing abnormalities were earlier assessed and managed by otorhinolaryngologists before 1980s using standard routine examination techniques. During the 1980s, SLPs started contributing their expertise to treat patients with swallowing problems(Hiss & Postma, 2003). However, dysphagia was largely unexplored and at a preliminary stage. Trial and error kind of a practice initially happened as SLPs used direct and indirect techniques to manage the patients, and it was realized gradually that there is a need for direct, objective and comprehensive system to assess swallowing. For example, if there is a bone injury, the doctor will ask you to get a X ray or CT scan done, without which you can only assume the extent of damage.

FEES was then introduced as a result of this realization with the combined effort of two SLPs and one otorhinolaryngologist (Langmore et al., 1988). Since then, FEES is performed in two ways. The otorhinolaryngologist either trains the SLP to do endoscopy and the SLP learns to do it independently or both the professionals are involved in the interpretation of FEES together. Both practitioners interpreted swallowing function after

the surgeon passed the endoscope. In recent years, an increasing number of otolaryngologists have gained abilities in swallowing physiology evaluation and treatment techniques, allowing them to do FEES without the help of a SLP. The exact role of both the professionals wasn't delineated clearly back then but the importance of FEES was established for assessment of dysphagia.

During FEES, a fiberoptic laryngoscope is inserted into the nasal cavity to observe the pharynx, larynx, and proximal trachea in order to assess and treat swallowing problems (Hiss & Postma, 2003). Langmore et al. presented the first study in 1988 outlining the use of flexible endoscopy for dysphagia assessment (Langmore et al., 1988). Since then, the process has been referred to as "videoendoscopic evaluation of dysphagia" (Bastian, 1993; Hiss & Postma, 2003) and "videoendoscopic evaluation of swallowing study" (Hiss & Postma, 2003; Spiegel et al., 1998), among other names. Moreover, labels such as "bedside endoscopic swallowing test" have been coined to describe a procedure similar to FEES (Hiss & Postma, 2003).

Aviv et al. created "Fiberoptic Endoscopic Evaluation of Swallowing Sensory Testing" (FEESST) in 1998, a procedure that uses FEES to measure swallowing and also tests laryngeal and pharyngeal sensory function (Aviv et al., 1998; Hiss & Postma, 2003). The sensory testing section of the FEESST assesses an individual's laryngeal and pharyngeal sensory thresholds objectively. To trigger the laryngeal adductor reflex, measured air pulses are delivered to the aryepiglottic folds along a separate scope tube (LAR). The more air pressure injected into the aryepiglottic folds to activate the LAR, more loss of laryngeal function would be observed (Hiss & Postma, 2003).

2.3 Personnel

There has been quite a debate regarding who is the right person to do FEES. Only SLP? Both SLP and otorhinolaryngologist? Or Only otorhinolaryngologist?.Flexible endoscopy was implemented by SLPs, but it was met with considerable resistance. To activate the LAR, increased air pressure is forced onto the aryepiglottic folds. In the area of speech pathology, the following were the most notable issues: Is this a procedure that the SLP can safely perform? Is it an instrument which is sensitive enough for determining the physiology of swallowing? Is it a relaxing procedure that won't have a detrimental impact on the end result? (Hiss & Postma, 2003). The answers to these issues arose through investigations as numerous SLPs and otolaryngologists gained expertise with this unique approach.

The implementation of FEES by SLPs was met with some resistance in the discipline of otolaryngology as well. There were two major concerns that emerged. SLPs may detect the absence or presence of anatomical disease outside of their field of practise because an otolaryngologist is not always present for or reviewing all testing (Hiss & Postma, 2003). It's possible to overlook disease at the level of nasal, pharyngeal, laryngeal and subglottic structures. As a result, SLPs are expected to address the issue of emphasising that the FEES is only used to assess and treat swallowing function in their official documents. SLPs, on the other hand, frequently use the FEES in a similar way that they use the MBS (Hiss & Postma, 2003). They look at swallowing physiology and look for techniques and patterns that can help people swallow more safely and efficiently. It wouldn’t be right to assume that SLPs make medical diagnosis using FEES or MBS by working outside the scope of his or her practice. Dysphagia, which is frequently induced by a traumatic, neurological incident or head or neck malignancy are the most common reasons for patients being referred for FEES. Instead of MBS, FEES should be offered for individuals who want to see their pharynx or larynx directly (Hiss & Postma, 2003)

Both SLPs and surgeons are debating whether an otolaryngological examination is required for each patient referred for swallowing evaluation (Hiss & Postma, 2003). This is a question that each facility must answer. However, the authors believe that a multidisciplinary approach to swallowing assessment and management is ideal, with the SLP and surgeon doing FEES simultaneously whenever possible and providing their areas of expertise. Another option is to have the FEES performed by a speech-language pathologist (SLP) so that real-time judgments about bolus consistency, techniques, and therapeutic manoeuvres can be made, and then have the otolaryngologist analyse the examination for laryngeal or pharyngeal disease later. This would enable the surgeon to diagnose disorders such as vocal cord immobility, mucosal lesions of larynx, compensatory paralysis, subglottic anomalies and characteristics suggestive of LPR, among others. Many facilities have the SLP or surgeon execute the examination without the assistance of the other disciplines due to time or productivity constraints. A regulatory statement on the roles was released in by the "American Academy of Otolaryngology-Head and Neck Surgery" (AAO-HNS) and the "American Speech and Hearing Association" (ASHA) in 1999 (Francis et al., 2015). According to the regulations, health professionals who are physicians are authorised and licenced to provide medical diagnoses regarding presence of swallowing disorders As a result, when used for reasons of medical diagnoses, FEES should be conducted and analysed by an otolaryngologist or any physician having knowledge of this procedure (Hiss & Postma, 2003)

2.4 Competency for performing FEES

Whether SLP or otorhinolaryngologist, the fact of the matter is to be able to do FEES, one has to have knowledge of endoscopy. Knowledge of endoscopy skills is not taught to SLPs in their graduate and post-graduate curriculums which warrants the need for dedicated courses to learn about FEES. Speech-language pathology is the field that deals

with the diagnosis and treatment of dysphagia (Ekberg, 2012). SLPs with experience in dysphagia and specialised training in fiberoptic endoscopy are authorised to use fiberoptic endoscopy to examine swallowing function and related functions of structures inside the upper aerodigestive tract (Hiss & Postma, 2003). Because SLPs have historically been the primary implementers of FEES, training requirements for an SLP to become effective in FEES have changed to reflect the present state of practise. ASHA has not authorised a certain number of hours of classroom training or endoscopy; however, ASHA released "Knowledge and Skills for SLPs Performing Endoscopic Assessment of Swallowing" in 2002 (ASHA, 2002), which included a suggested training programme. The following is the current state of practise for achieving FEES competency:

1. Demonstrate expertise in the evaluation and management of dysphagia patients

2. Receive ten to fourteen hours of intensive classroom instructions in FEES techniques, swallowing evaluation, and interpretation.

3. Observe ten to twenty FEES evaluations conducted for patients having dysphagia.

4. Conduct FEES procedure twenty five to fifty times under the guidance of an otolaryngologist or SLP competent in using flexible endoscopy.

Many surgeons have long been fascinated by the processes of swallowing in the pharyngeal and laryngeal cavities. Despite the fact that swallowing examinations fall under scope of practice of otolaryngologist, most surgeons recognise the need for further training because most medical programmes do not provide special training in swallowing assessment, management or swallowing rehabilitation (Hiss & Postma, 2003). Swallowing physiology instruction is provided to the majority of otolaryngologists who utilise FEES

in their practises through Continuing Medical Education seminars at national conventions or workshops devoted to these procedures (Hiss & Postma, 2003). When otolaryngologists conduct FEES in their practise, they should seek out for a SLP to whom the patients can be assigned for rehabilitation and follow-up. Swallowing rehabilitation programmes treat oral, pharyngeal, and laryngeal weakness and "discoordination," similar to how physical therapy addresses weak limb movement.

2.5 FEES v/s MBS

Two of the most important objective ways of assessing swallowing are FEES and Modified Barium Swallow (MBS). FEES has been routinely compared with MBS in terms of sensitivity and specificity in determining swallowing abnormalities. MBS is also called Videofluoroscopic Swallowing Study (VFSS). The videofluoroscopic swallowing study (VFSS) is frequently considered the instrument of choice by many practising swallowing specialists because it provides for real-time imaging of bolus flow in relation to movement of structures throughout the upper aerodigestive tract. The VFSS can also help identify the physiologic cause(s) of aspiration, which is when ingested material enters the trachea through the true vocal folds.(Robbins et al., 1999; Rosenbek et al., 1996), as well as the occurrence and timing of aspiration. FEES (the believed "gold standard") was compared to the MBS (the considered "gold standard") to see if it produced sensitive swallowing findings in terms of pharyngeal residue, aspiration, penetration and delay in initiation of swallow. According to reports, when it comes to these four swallowing parameters, “FEES is considered to be equally sensitive or more sensitive than MBS”. (Dodds et al., 1990; Ekberg & Sigurjónsson, 1982; Hiss & Postma, 2003; Logemann, 1999; Martin-Harris et al., 2000; Ramsey et al., 1955)

A study found that specificity was excellent for laryngeal aspiration and penetration and (0.92 and 0.75, respectively) and was good for premature spilling and residue in 21 patients. As a result, the first report comparing FEES with MBS found FEES to be superior (Schatz & Olson, 1991) no ther study performed both FEES and MBS in twenty eight patients with dysphagia in the second trial that looked at the accuracy of FEES in comparison to MBS. In terms of penetration and aspiration, they discovered a 14.3% disparity between the two tests, with the FEES detecting penetration and aspiration in cases when the MBS failed to detect penetration and aspiration.(Wu et al., 1997b).

Few authors found a 96 percent agreement between the two forms of silent aspiration examinations in 56 individuals(Leder et al., 1998). Leder and Karas reported that FEES and MBS agreed 100 percent on the parameters of aspiration and penetration in infants in 2000 (Leder & Karas, 2000). The clinical use of FEES was evaluated in thirty paediatric inpatients in a prospective study. Both FEES and MBS were given to seven patients at random. Only FEES was used to evaluate the remaining 23 subjects. Despite the lack of a control group to compare the management of the remaining 23 patients, the authors demonstrated that FEES allowed for personalised feeding recommendations and appropriate dysphagia management. FEES is just as sensitive as the MBS on normal swallowing features, but FEES is more likely to identify penetration and aspiration, according to these studies. FEES is a viable tool for dysphagia evaluation if a practitioner is skilled in both endoscopy and swallowing assessment.

MBS was utilised as a reference for FEES in prior investigations. Assessing the rate of aspiration pneumonia with and without using FEES, on the other hand, provides a different type of outcome metric. In 2001, the Evidence Based Practice Centre (EPC) released a paper on lowering pneumonia rates among stroke patients (Doggett et al., 2001). During a six month period when FEES was used to manage dysphagia, the number of cases of

aspiration pneumonia in a long-term care facility was compared to the number of cases of aspiration pneumonia during a comparable time when FEES was not used to control dysphagia. There were no cases of aspiration pneumonia in the six month period when FEES was used for dysphagia evaluations, compared to eleven cases in the six month period without FEES. The EPC determined that FEES was connected to a decrease in pneumonia rates. Although controlled studies of the predictive abilities of both FEES and MBS are sparse, preliminary reports indicate the importance of FEES in assisting examiners in managing dysphagia patients and therefore reducing the risk of aspiration pneumonia.

The goal of one study was to see if FEESST or MBS is better as a diagnostic test for assessing outpatients with dysphagia in terms of behavioural and nutritional treatment. In a hospital-based outpatient context, a randomised, prospective cohort outcome study was conducted.The diagnostic test used to guide feeding and behavioural therapy (postural modifications, tiny bits and sips, throat cleaning) was randomly assigned to 126 outpatients with dysphagia who were randomly randomised to either FEESST or MBS. The “pneumonia incidence” and “pneumonia-free interval” were the outcome variables. The patients were enrolled for a year and then monitored for the same amount of time. In 76 patients, 78 MBS tests were performed, with 14 patients (18.4%) getting pneumonia; in 50 patients, 61 FEESST evaluations were conducted, with 6 patients (12.0%) diagnosed with pneumonia. Whether dysphagic outpatients' nutritional and behavioural therapy is guided by MBS or FEESST results, their outcomes in terms of “pneumonia incidence” and “pneumonia-free” interval are nearly identical (Aviv, 2000).

2.6 Can FEES be called a “gold standard”?

A gold standard is a benchmark that can be achieved under suitable conditions. True, this isn't the ideal test, but it's the most accessible one with consistent and predictable results. (Cardoso et al., 2014).FEES has been shown to be a “gold standard” test in evaluating if a patient is showing penetration or aspiration compared to MBS on numerous occasions. As a result, FEES is frequently utilised as a baseline against which other swallowing examination procedures are measured.

FEES has also been utilised by researchers to describe the dysphagic characteristics of different clinical populations. As per the most recent Global Burden of Disease report, India accounts for about a quarter of all trauma deaths worldwide(Naghavi et al., 2015; Vos et al., 2015). Furthermore, traumatic brain injury (TBI) is the primary cause of mortality and disability in the trauma field, with low- and middle-income countries bearing the brunt of the burden. To address the growing number of deaths and disabilities caused by TBI, maximising prevention and optimising treatment will be important.A study was conducted to see if the FEES technique could be used to diagnose pharyngeal dysphagia in patients with acute TBI. The study enlisted the participation of 47 people. According to FEES, 17 of 47 subjects had pharyngeal dysphagia with aspiration. Nine of the 17 participants who aspirated did so silently. In patients with acute TBI, FEES was found to be an objective and sensitive method for diagnosing pharyngeal dysphagia, determining aspiration status, and making recommendations for oral or nonoral feeding (Leder, 1999).

Dysphagia is a late consequence that affects the lives of far more than one-fourth of people with nasopharyngeal carcinoma (NPC) who live long after radiation. For dysphagia evaluation, FEES was employed to differentiate functional and structural abnormalities in 31 dysphagic NPC patients. After swallowing, the large number of patients were discovered to aspirate (77.4 percent). A total of seventeen persons (54.8%) had tongue

atrophy, while nine people (29%) suffered vocal cord palsy. “Dry mouth (45.2%), velopharyngeal incompetence (58%), premature leakage (41.9%), delayed or absent swallow reflex (87.1%), poor pharyngeal constriction (80.6%), pharyngeal residue retention (83.9%), penetration or aspiration (93.5%), and silent aspiration (93.5%)” were among the symptoms experienced by these patients (41.9 percent). The researchers discovered that FEES might be used to identify key components of swallowing problems in irradiated NPC patients. This would be a compelling rationale to use FEES for more than simply swallowing safety screening, but also for research into the dynamic physiology of swallowing diseases. (Wu et al., 2000).

A study found that within 48 hours of extubation, patients who had been intubated for at least 48 hours were examined for swallowing difficulties using bedside FEES. Aspirators and nonaspirators were compared in terms of potential risk factors. Patients were followed up on any evidence of clinically significant aspiration and given dietary suggestions. The trial comprised 51 patients who required a minimum of 48 hours of intubation for mechanical ventilation and had no previous history of swallowing disorders. A speech pathologist performed FEES procedure. More than half of mechanical intubated patients, many of whom are silent aspirators, had swallowing difficulties after a minimum of 48 hours of intubation, according to findings of FEES. Clinically severe aspiration was prevented attributable to dietary suggestions based on FEES data(Ajemian et al., 2001a).

The authors of another study examined two screening procedures: the “50-ml water swallow test”, the “oxygen desaturation test” and a combination of the two called "bedside aspiration" with FEES assessment. The patients included in the study were diagnosed as having acute stroke. They were also put through a series of tests to see if they could swallow 50 mL of water in 10-mL dilutions. The patient was instructed to drink the entire

50 mL while sitting straight. After a 10-minute rest time following the aforementioned test, the finger probe of a pulse oximeter was put on the index finger of the patient's unaffected hand, with the patient in an upright position. All patients received a FEES assessment of their swallowing after the bedside clinical examination. To analyse the clinical swallowing evaluation's accuracy, the authors believe FEES is a stronger predictor of aspiration and subsequent pneumonia. (Lim et al., 2001).

A prospective study design was conducted by Rao et al. (2003) in which 11 patients underwent simultaneous FEES and VFSS examination. The sensitivity and specificity values were determined twice, once using the VFSS as the gold standard and then again using the FEES. It was found that when FEES was used as the gold standard, the sensitivity values were greater, and when VFSS was utilised as the gold standard, the specificity values were higher. The only exception is that thensitivity values for aspiration were similar regardless of whether the gold standard was VFSS or FEES. Thus, the existing literature revealed that FEES is now considered a gold standard method of examination for patients with swallowing difficulties.

2.7 FEES in Children

Pediatric dysphagia has a wide range of etiologies, and children with dysphagia frequently have a combination of symptoms. “A clinical oral motor/feeding assessment, radiographic examination (standard barium swallow, esophagram, and/or videofluoroscopic swallowing study), instrumental swallowing assessments, motility studies, and/or endoscopic procedures (microlaryngoscopy, bronchoscopy with bronchoalveolar lavage, esophagogastroduodenoscopy) to rule out structural and functional issues may all be part of the diagnostic battery” (Miller & Willging, 2020).

The clinical evaluation of dysphagia can be inaccurate in infants and children due to the increased likelihood of silent aspiration (Arvedson et al., 1994; Dodrill & Gosa, 2015; Pavithran et al., 2020; Weir et al., 2011). In this situation, instrumented assessment is critical. To avoid premature feeding or unnecessary feeding restrictions that could compromise his or her physical, social, and emotional well-being, the fitness for oral intake must be explicitly specified. Feeding issues are estimated to affect 25–45 percent of ordinarily developing children, with the frequency being much higher in children with developmental disabilities (Burklow et al., 1998; Reilly et al., 1996; Schwarz et al., 2001). Aspiration pneumonia is the most common cause of death in children. In order to assess dysphagia and aspiration in this population, it is critical to have a test that is both widely available and accurate.

Willging and colleagues were the first ones who investigated the application of FEES in paediatric population at “Cincinnati Children's Hospital Medical Center” (CCHMC) in Cincinnati, Ohio in 1993 (Willging, 1995). A pilot study was undertaken among twenty children, ranging in age from three to seven years old who were undergoing nasopharyngoscopy for resonance evaluation with authorization from the Cincinnati Children's Institutional Review Board. During a conventional nasopharyngoscopy operation, the endoscope was moved into the hypopharynx, and the children were instructed to swallow solids and liquid foods. The children tolerated the scope being advanced to the hypopharynx and were willing to eat and drink during the examination, allowing the vital aspects of the pharyngeal swallow to be observed.

At CCHMC, over 7,000 paediatric FEES operations have been successfully conducted on patients ranging from newborns to young adults (age 21). The use of FEES in the dysphagia diagnostic routine necessitates a thorough understanding of feeding maturation,

particularly as it relates to anatomic changes that are reflected in swallowing dynamics. It is critical to recognise the pathophysiology of swallowing in congenital and acquired disorders (structural, neurologic, metabolic, and cardiorespiratory) (Miller & Willging, 2020).

Further research into the FEES method was carried out in paediatric population with dysphagia who had a variety of diagnoses. VFSS and FEES was done simultaneously in a group of 6 patients ranging in age from four months to six years of age in one of the early studies. From both a videofluoroscopic and an endoscopic standpoint, the identical sequence of pharyngeal swallows were watched and compared. The swallows were compared for particular factors such as swallowing initiation time, laryngeal penetration, aspiration, and residual post swallow. Overall, the validity and reliability of the processes in judging swallowing parameters were found to be satisfactory.

Because of its widespread availability, ability to assess paediatric dysphagia at the bedside, and lack of radiation danger, FEES quickly acquired popularity and acceptance in the evaluation of paediatric dysphagia.

The diagnostic and rehabilitative use of routine FEES in the paediatric population was examined in a study. Thirty inpatients from a large metropolitan tertiary care teaching hospital's acute care unit were included in the study. 7 of 30 individuals (23%) were tested with both VFES and FEES on the same day, 23 of 30 subjects (77%) were only tested with FEES. Spillage, residue, laryngeal penetration, and aspiration were used to diagnose dysphagia. The blinded diagnostic results for the seven participants randomly randomised to both VFES and FEES, as well as the 23 subjects randomly assigned solely to FEES, were 100 percent in agreement. This was true for all bolus consistencies, including liquid, nectar-thickened liquid, puree, and solid, as well as anatomical sites, such as laryngeal

penetration and aspiration. Based on FEES and VFES tests, feeding recommendations were also 100 percent in accord (Leder & Karas, 2000)

Due to its semi-invasive nature and the small size of nasal passageways, FEES could be difficult to administer in an infant who is completely unwilling (Da Silva et al., 2010). In addition to lowering the threshold of accidental aspiration, crying, breath retention, and impulsive breathing can change swallow physiology. In addition to the reasons indicated above, the disadvantages include the inability to analyse oral and oesophageal phases, as well as the real pharyngeal swallow. The impact of several comorbidities further adds to the procedure's complexity. In summary, the right interpretation of FEES, particularly in infants, necessitates a high level of knowledge and experience.

2.8 Efficacy of FEES

Clinicians have long wished for the ability to anticipate aspiration without the need of an instrumental examination when establishing the safety of swallowing in dysphagic patients. Despite the fact that clinical bedside examinations have become more sophisticated over time, their sensitivity in predicting aspiration remains dubious. In an inpatient rehabilitation population, according to Splaingard et al. (1988), rigorous clinical bedside evaluation by a SLP is neither highly specific nor sensitive in diagnosing aspiration. Even the most skilled doctors, according to Logeman (1998), miss around 40% of aspirating patients during a bedside assessment. The presence of a voice quality defined as wet/hoarse, wet/gurgly, or wet dysphonic is a common sign used in clinical bedside examinations and considered sensitive in predicting aspiration.

The value of endoscopically visible oropharyngeal secretions in the hypopharynx and swallowing frequency in the prediction of food and liquid aspiration was studied retrospectively. A total of 69 people, including hospitalised old, nonhospitalized elderly,

and young normal participants, had undergone FEES. Prior to the presentation of food or beverage during the FEES, a four-level rating system for measuring the severity of accumulated oropharyngeal secretions was devised and used to rate patients. The collection of endoscopically visible oropharyngeal secretions within the laryngeal vestibule was revealed to be a strong predictor of food or liquid aspiration. When compared to non-aspirating hospitalised participants, there was a significant drop in the frequency of spontaneous swallows in aspirating hospitalised subjects (Murray et al., 1996).

The goal of a study was to see how successful FEES and the modified barium swallow test (MBST) were in treating dysphagia in patients. Eighty dysphagia patients were divided into three groups: 27 patients with oral, pharyngeal, or esophageal masses; 26 patients with neurogenic dysphagia; and 27 patients with no identifiable disease. Elevation of the soft palate, nasal regurgitation, pharyngeal residue, penetration, aspiration, and pooling of secretions in the pyriform sinus and vallecula were all examined using FEES and MBST. MBST was more effective in detecting aspiration and pooling in the vallecula in neurogenic dysphagia. The FEES only allowed for internal anatomy evaluation, mass visualisation, and laryngopharyngeal sensory discrimination (Gerek et al., 2005).

Because it involves a transnasal endoscope, some may consider FEES to be more invasive than VFSS. However, a prior research of 305 dysphagia patients found that nasal bleeding occurred only 1.1 percent of the time, and no patients reported substantial cardiac adverse events such choking, laryngismus, or a significant change in heart rate (Cohen et al., 2003).

Patients in intensive care units frequently require intubation and ventilator assistance for long periods of time. Swallowing dysfunction is common in people who have been on

mechanical breathing for a long time. Once the patient is extubated, intubation can produce transitory harm to the larynx, resulting in a reduction in protective mechanisms and an increased incidence of oropharyngeal secretions. The purpose of a study was to assess the anatomical damage induced by intubation, as well as the occurrence of aspiration/silent aspiration in patients after extubation, utilising FEES as a diagnostic and therapeutic technique. The study comprised 41 adult ICU patients who had been intubated for less than 48 hours. The authors looked at 41 patients, 19 (44%) of whom had laryngeal damage and 6 (14%) of whom had aspiration. During follow-up FEES after swallow therapy, all six patients who had aspiration originally restored their swallowing function completely (Ambika et al., 2019).

It has long been established that the level of expertise of nasal endoscopy examiners has little bearing on the FEES's reliability. A previous study demonstrated that even after merely listening to a 30-minute presentation, doctors with little training in nasal endoscopy were able to generate FEES and receive reliable evaluation results (Warnecke et al., 2009).

2.9 Complications due to FEES

For FEES and FEESST procedures, the endoscope must be passed through the nasal cavity, nasopharynx, and pharynx and it is possible (though unlikely) that the patient might experience some negative consequences as a result of this. Side effects such as discomfort, gagging, and/or vomiting, as well as complications such as anterior epistaxis, posterior epistaxis, mucosa laceration, allergic reactions/hypersensitivity to topical anaesthesia or nasal spray, adverse reactions to methylene blue vasovagal response, and laryngospasm, are all possible (Aviv et al., 2000, 2005; Cohen et al., 2003; Hiss & Postma, 2003; Wu et al., 1997a).

A retrospective study was conducted wherein 2,820 FEES examinations were observed to look for complications resulting due to FEES. Three physicians (otolaryngologists) performed the FEES examinations, and at least one SLP was present; thus, throughout each test, the physician who performed the examination was present, as were one or two SLPs. Discomfort, gagging and vomiting, three cases of anterior epistaxis, one case of posterior epistaxis, and three cases of vasovagal syncope were discovered (Andrea Nacci et al., 2016).

Another authors of a study looked at the safety of combining flexible endoscopic swallowing examination with sensory testing (FEESST). Over a 2.5-year period, endoscopic assessment of laryngopharyngeal sensory capacity followed by endoscopic visualisation of deglutition were conducted 500 times in 253 individuals with dysphagia.Patients were asked to rate the level of discomfort during the examination, as well as the presence of epistaxis, airway compromise, and significant changes in heart rate before and after the evaluation. There were three episodes of epistaxis that were self-contained. There were no cases of airway obstruction. Between pre- and post-test measures, there were no significant variations in heart rate (Aviv et al., 2000).

Another study aimed to see how common FEESST-related problems were in outpatient and inpatient settings, as well as to look at the patient diagnoses that led to FEESST. The authors conducted a four-and-a-half-year prospective investigation of FEESST problems in 1,340 consecutive examinations. Epistaxis incidence and airway impairment were the key outcome factors. Epistaxis affected 1 in every 1,340 people (0.07%). There were no cases of airway obstruction. Stroke was the most common reason for FEESST, followed by cardiac-related dysphagia, heart attack, congestive heart failure, or new arrhythmia after open heart surgery, and heart attack, congestive heart failure, or new arrhythmia after

open heart surgery. Head and neck cancer, lung disease, chronic neurologic disease and acid reflux disease were the remaining causes (Aviv et al., 2005).

A prospective study recruited 23 hospitals where FEES was conducted on a routine basis for a wide range of swallowing disorders. The majority of the exams were performed in an acute care institution (70.5%), with 20.5 percent of patients enrolled in rehabilitation clinics and 9.0 percent examined as outpatients. In 2% of examinations, complications were recorded. The most common side effects were epistaxis, decreased awareness, and the development of bradycardia. All of these issues were self-limiting and resolved in a matter of minutes without the need for assistance. The endoscopist's experience had no bearing on the occurrence of problems. In fact, FEES performed by endoscopists with 200–500 inspections under their belts had the highest rate of problems. This study revealed that FEES is a safe treatment with only minor changes in cardiovascular parameters when conducted by less experienced doctors. FEES had a major impact on dysphagia management, and FEES was shown to offer a clinically useful assessment of total dysphagia severity (Dziewas et al., 2019).

2. 10 Status in India

Dysphagia practice in India has begun only since 2000s and has been growing ever since (Krishnan & Goswami, 2018). India still has a long way to go before dysphagia intervention can be recognised solely as a dedicated profession and realise its true importance. The professionals primarily working in the area of dysphagia are Otorhinolaryngologists or ENTs, Neurologists, Pediatricians, Gastroenterologists and SLPs. It can be said that management of dysphagia is truly a team approach (Krishnan & Goswami, 2018). Most SLPs cater to a population requiring both speech and swallowing services, with very few dedicated to working with dysphagia. The

practicing SLPs need to consider the cultural variations and its influence on the caseload. Currently, there are no standard guidelines for dysphagia management in India for the professionals to refer (Rangarathnam & Desai, 2020). It is important to understand the practice patterns of professionals to know how the management is structured. Dysphagia management essentially consists of history taking, clinical swallowing examination, instrumental assessments if warranted and therapeutic planning. A study by Rangarathnam and Desai tried to investigate the practice patterns of SLPs in India. Around 37% of SLPs had never completed an instrumental assessment before beginning therapy and a small percentage (5%) of SLPs always completed instrumental assessments (Rangarathnam & Desai, 2020). When it comes to using instruments in clinics, there are a variety of factors to be taken care of such as cost of equipments, clinical setup, access to funding agencies, institutional policies, manpower and healthcare professionals with appropriate training. In the same study, 53% of SLPs reported having access to FEES equipment facilities and around 45% reported having videofluoroscopy facilities. Also, 49% of SLPs did not have any experience conducting instrumental assessments. Three reasons can be attributed to this finding i.e., lack of training, lack of equipments and limited support from other professionals.

Lack of training is a serious concern as it can lead to unstructured practice patterns with lower outcome. There is a need for quality training centers and educational materials for speech language pathology students and professionals to learn about how to carry out instrumental evaluations such as FEES and VFSS. Other practical aspects such as how to procure the instrument, maintenance of the instrument and using it for research purposes should also be taught.

There are few studies done in the western countries to teach endoscopic skills to graduate students of speech language pathology using a variety of learning models. Lack of competency in performing endoscopy evaluations poses a challenge to learn the required clinical skills for dysphagia management.

Graduate and postgraduate students of speech language pathology need to be trained to have the basic knowledge and skills of endoscopy. Migiro(2010) conducted a study to train graduate students of speech language pathology about FEES using human simulation and non-human simulation. Simulation practice is essentially a way to learn the required clinical skills, practice, get feedback without the complications and uncertainties of real experience. This is done by practicing the necessary skills on a manikin, also called as artificial simulator. Eighteen students of speech language pathology having completed course in studying dysphagia underwent training to practice endoscopic skills on a human simulator, i.e., manikin and nonhuman simulator. It was found that there was no significant difference between performance of students with human v/s non-human simulator.

Another study by Robinson and Dennick (2015) suggested different learning models to teach endoscopy skills to SLPs. They emphasized the importance of learning in a practical one-to-one manner under supervision by a mentor facilitated better learning skills in students. The qualities of the mentor are also important such as being instructional, providing constructive feedback and identifying students' zone of proximal development.

Bolton et al (2020) provided a framework for SLPs who work with dysphagia patients who are referring for and/or performing a FEES examination. According to them all SLPs should have current and up-to-date clinical practise in dysphagia, as well as some videofluoroscopy experience. All SLPs pursuing FEES certification should be confident

and proficient at the highly specialised dysphagia practitioner level C (RCSLT Dysphagia Competency Framework).

A study investigated whether SLPs use endoscopy as part of their clinical use. 53% of SLPs use laryngeal endoscopy for voice evaluations and 62% reported they do not use, however they would want to learn required skills. It emphasizes on the fact that endoscopy must be augmented with clinical judgement skills to arrive at a diagnosis and decide the management plan (Robinson & Dennick, 2015a).

Most of the studies related to training of endoscopy have been with respect to voice disorders.

A study by Wooi et al. (2001) used instructional teaching and learning paradigms with undergraduate students to interpret videofluoroscopic swallow studies. VFSS, also known as modified barium swallow, is a radiographic procedure that provides a direct, dynamic view of oral, pharyngeal, and upper esophageal function during swallowing. During this procedure, the SLP presented food and liquid mixed with barium. The barium was necessary to view structures via videofluoroscopy during the swallow. Knowledge of the anatomy and physiology of swallowing, radiograph examination and identification of structures and landmarks, and the use of an assessment scale such as the Bethlehem Assessment Scale (BAS) to interpret VFSSs were among the topics covered in the sessions. Their knowledge of radiographic anatomy and their ability to interpret videofluoroscopic tests had a statistically significant link. The findings support the idea that new graduates should have access to recognised postgraduate training in order to strengthen and polish their abilities in interpreting videofluoroscopic examinations and, as a result, produce more accurate dysphagia assessments.

To summarize, swallowing is a complex process and necessary for the survival of human beings. Any person having a swallowing disorder requires attention as it could pose a threat to the life. As clinicians, we need to be equipped with adequate knowledge regarding assessment and intervention for people having swallowing problems. FEES is an instrumental assessment procedure which is commonly used to assess pharyngeal dysphagia and decide intervention on the basis of findings. Despite being recognised as a gold standard, the knowledge and applicability of FEES remains inadequate. SLPs have a major role on conducting FEES procedures with or without an otorhinolaryngologist. At the graduate and postgraduate level, FEES is studied as a subtopic under the broad topic of dysphagia in Indian speech and hearing colleges. There is a need of developing competency at the student level so that they come out as better informed and confident professionals. An indepth look at the existing literature revealed that there are no tutorials available for learning about FEES. Keeping this in view, the present study aimed to develop a comprehensive tutorial in a easy to read manner to build competency and knowledge in learning about FEES

CHAPTER 3

METHOD

The present study aimed to develop a tutorial to assess pharyngeal dysphagia using Fiberoptic Endoscopic Evaluation of Swallowing (FEES). The tutorial is developed for students of speech-language pathology as well as the practicing speech-language pahologists. The study was carried out in the following phases:

3.1 Phase 1-Development of the tutorial

This phase consisted of different steps.

3.1.1 Step 1- Compilation of information from various sources

Information about FEES, preparing the client for FEES, the procedure to conduct FEES, identifying various structures during FEES with and without bolus, bolus administration, and different scales administered during FEES examination and choosing the best scale, protocol used to document the findings and its interpretation were compiled from various sources. Sources included articles from digital databases such as Pubmed, Cochrane reviews, Scopus and Google Scholar, books, videos, blogs, websites etc.

3.1.2 Step 2: Sequential organization of information

The information compiled was organized under six different chapters in a systematic and sequential manner. In the first chapter, the anatomical structures relevant for FEES were included. The structures focused were the nasal, pharyngeal and laryngeal structures. The written description was supported with necessary graphics for better understanding. The second chapter included the description of the equipment required for FEES. Although the instrumentation was not discussed extensively, a brief overview of the important equipment such as the endoscope, chip camera and light source was included. The third

chapter comprised of information on identifying the anatomical landmarks of FEES with and without the bolus, which forms the basis for interpreting FEES findings. The fourth chapter included the protocol of FEES and information on normal variability. Fifth chapter included the various standardized scales used while administering FEES such as Penetration-Aspiration Scale and Yale pharyngeal residue severity scale. The final chapter included the description of common conditions that warrant a FEES examination supported with videos, which would assist the reader in interpreting FEES images.

The language used while writing was simple and lucid for ease of comprehension of learners. Necessary graphics were included under each chapter to support the textual material. Each chapter was supplemented with ten questions at the end to assess learner knowledge. The questions were of both multiple-choice and short answer type depending on the content of the chapters.

3.2 Phase II-Content validation

Content validation of the tutorial was done by obtaining feedback from one Otorhinolaryngologist and three Speech-language pathologists. The otorhinolaryngologist was included since they have a role in conducting FEES assessments. The Otorhinolaryngologist and Speech-language pathologists with a minimum professional qualification of master's degree, and having a clinical experience of atleast two years with FEES were included. The Speech-language pathologists who were involved in teaching dysphagia in post graduate programs were also included. All the professionals included for the content validation were orally informed about the nature, purpose and procedure of the study and their consent was obtained. They were also informed about the instructions and time frame for the completion of the validation. The developed tutorial was mailed to the experts for their opinion. A demographic data sheet was given to them to identify their

qualification, practice setting, number of years of experience etc. A feedback rating questionnaire (adapted from Manual for Non-fluent Aphasia Therapy in

Kannada, Goswami et al., 2011) was used to judge the appropriateness of the tutorial. It consists of a 3-point rating scale (0 indicating poor, 1 indicating fair and 2 indicating good). The parameters for which rating was given were simplicity, relevancy, trainability, arrangement, appropriateness of pictures and questions. In addition, there was a remarks section, where the professionals could state their remarks in terms of deleting or modifying or adding any content in the tutorial, along with appropriate rationale for the same. The consent letter and content validation form has been included in the appendix A.

3.3 Phase III-User Validation

Participants: The tutorial developed was assessed for its effectiveness on five participants (1 male and 4 females) in the age range of 19-22 years, who were students of speech-language pathology.

Inclusion criteria:

- Students of speech-language pathology studying in RCI approved institutions.
- I MSc (SLP) students, as they would have obtained a basic knowledge about swallowing and its disorders in the V and VI semester during their undergraduation.

Exclusion criteria:

- Students suffering from hearing or visual impairment.
- Students having undergone training in FEES procedure and interpretation.

Procedure: A google form questionnaire was developed by including the questions (multiple choice questions, true/false, and short answers) at the end of each chapter. The questionnaire has been attached in the appendix B. The five participants were asked to read all the chapters of the tutorial and answer the questions in the google form before and after reading the tutorial. All ethical procedures were followed. An informed consent was

obtained from the participants before participation. The detailed process of assessing the user validation has been described below.

Step 1-Obtaining Pre-test scores: The participants were provided with the google form questionnaire. They were asked to submit the same in a specified time limit. Each question carried 1 point for the correct answer and 0 point for incorrect answer. The overall score for each participant was calculated.

Step 2- Reading of the tutorial: After the first step was completed, the participants were asked to read the chapters in the tutorial. A specific time limit of 3 days was provided to thoroughly read the chapters.

Step 3- Post-test scores: The participants were asked to solve the same google form questionnaire as given before, to check if the scores improved after reading the tutorial. A specified time limit was provided to submit the questionnaire. The scores were calculated in a similar manner as mentioned above.

3.4 Phase IV- Obtaining feedback

All the participants were asked to fill a feedback form consisting of ten questions related to content of the tutorial. They were supposed to rate 1 to 5 (1=strongly agree, 5=strongly disagree), depending on whether they agreed with the statements in the form. Provision was also made to obtain suggestions to improve the content of tutorial. The feedback form has been included in appendix C.

Analysis: The total pre and post test scores obtained from all the participants were averaged. Descriptive statistics were computed to obtain mean, median and standard deviation. Non parametric test Wilcoxon Signed Rank Test was used to compare the pretest and posttest average scores using SPSS software version 26. Wilcoxon Signed Rank Test was used to compare pre and post-test scores chapter wise. The responses of feedback form were analyzed descriptively.

CHAPTER 4

RESULTS

The outcome of the present study was a tutorial to assess pharyngeal dysphagia using Fiberoptic Endoscopic Evaluation of Swallowing (FEES). A tutorial is supposed to guide the reader in a step-by-step manner to be able to practice and implement the desired skills. This tutorial was prepared by compiling and organizing the information pertaining to FEES from various sources. The tutorial consists of six chapters which will guide the reader to understand FEES in a simple yet comprehensive manner. The content of the chapters in the tutorial have been summarized below:

1. Chapter I- *Anatomy and physiology of nose, pharynx and larynx*: In this chapter, the anatomy and physiology of swallowing has been explained with the help of supporting pictorial representations. Since the text is explained with respect to endoscopy, the anatomy of nose has been included as well. The pharyngeal and laryngeal structures are also explained. Pictures of anatomy of nose, pharynx and larynx are included to support the text for better understanding.

2. Chapter II-*Equipment requirement for FEES*: The technical aspects of FEES have been explained in this chapter. The equipment required, their parts and the rationale is the focus. Parts of FEES equipment primarily include the endoscope, light source and chip camera for recording purposes. All the main parts have been explained in detail with necessary graphics wherever required. Basic knowledge about endoscopy instrument is essential for the clinician to be mindful of what they are using, if not everything. A team of engineers and technicians will have better knowledge about the parts and use of each equipment, therefore the equipment setup is always a collaborative effort. A list of manufacturers and dealers is provided in the last chapter who can be contacted for procuring the equipment in India.

3. Chapter III- *Identification of structures and landmarks on still FEES images with and without bolus:* This chapter deals with the images obtained during a FEES examination and how they appear with bolus and without bolus. Readers will be able to understand this chapter better if they have understood the first chapter because it reviews the anatomical structures. The FEES images in this chapter have been arranged in a sequence, the way it is seen during an actual FEES examination. When the scope is advanced through the nares, the nasal cavity structures are visualised followed by the oropharynx and larynx. This sequence has been described in detail in the chapter. The anatomical structures have been labelled on every image in the same sequence. Once the reader has familiarized with FEES images without bolus, images with bolus are introduced. A brief description about bolus types and volumes has also been included and explained in detail in the next chapter which focusses on the protocol of FEES. The normal variability in the anatomy across individuals and its implications have also been explained at the end of this chapter.

4. Chapter IV-*Protocol for FEES:* The protocol for administering FEES as given by Langmore in the year 1988 was adhered to. The need for obtaining consent and preparing the patient for the examination has been explained. The protocol consists of two main sections i.e., 1) anatomic-physiologic assessment which includes assessing the nasal, pharyngeal and laryngeal structures and functions at rest and 2) direct examination of swallowing food and liquid using different bolus types and volumes. The details of assessment including the tasks and their rationale have been explained in detail. Special considerations that need to be kept in mind while assessing the paediatric population have also been included.

5. Chapter V- *Interpretation and rating of parameters using various scales:* This chapter focusses on standardized rating scales used while conducting a FEES examination. These

scales provide an estimate about the efficiency and safety of the patient's swallowing ability. The rating scales have been explained along with supporting pictures for better understanding.

6. Chapter VI- *Learning to interpret FEES images:* This is the most clinical chapter among all chapters of this tutorial. The reader will be able to interpret the commonly observed disorders causing swallowing problems on a FEES examination and the way to interpret such conditions. For ease of understanding, signs of dysphagia are categorized into before and after swallow. A video link is attached after every condition for the reader to have visual feedback. Seven conditions have been described including spillage, aspiration, unilateral and bilateral vocal cord paralysis, Parkinson's disease, head and neck cancer and cricopharyngeal spasm, which can be compared with normal swallow to improve understanding.

After the final chapter, additional supplementary information of procuring the FEES instrument and its pricing in India has been included.

The tutorial was validated for its content by three speech-language pathologists and one otorhinolaryngologist. To check for effectiveness of the tutorial, it was validated by five participants, who were students studying Masters in speech-language pathology. The results of the content validation and user validation have been presented under two sections:

1. Qualitative analysis of content validation
2. Quantitative analysis of user validation

4.1 Qualitative analysis of content validation

Three speech-language pathologists and one otorhinolaryngologist were approached to validate the tutorial for its content. The experts rated the chapters of the tutorial on various parameters such as simplicity, appropriateness, relevancy etc. The experts were asked to provide a rating between 0 and 2 (0-Poor, 1-Fair, 2-Good) for each of the parameters as depicted in the table 4.1. All the experts provided a rating of 2, i.e., 'good' for the parameters such as simplicity, relevancy for all the six chapters. Three out of four experts gave a rating of 2 for other parameters such as trainability, arrangement, appropriateness of pictures and appropriateness of questions for all six chapters. A rating of 1 i.e. 'fair' was given by one expert for trainability, arrangement, appropriateness of pictures and appropriateness of questions for all chapters. A rating of 0 i.e., poor was given for appropriateness of pictures for chapter 4 by one expert.

Table 4.1

Responses of content validation

Chapter No.	Sim.			Rel.			Train.			Agmt.			Appr. of pictures			App. of questions		
	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
	P	F	G	P	F	G	P	F	G	P	F	G	P	F	G	P	F	G
1	-	-	4	-	-	4	-	1	3	-	1	3	-	1	3	-	1	3
2	-	-	4	-	-	4	-	-	4	-	1	3	-	1	3	-	1	3
3	-	-	4	-	-	4	-	1	3	-	1	3	-	1	3	-	1	3
4	-	-	4	-	-	4	-	1	3	1	-	3	1	-	3	-	1	3
5	-	-	4	-	-	4	-	1	3	-	1	3	-	-	4	-	1	3
6	-	-	4	-	-	4	-	-	4	-	1	3	-	-	4	-	-	4

Note. Sim=Simplicity, Rel=Relevancy, Train=Trainability, Agmt=Arrangement, App of pictures=Appropriateness of pictures, App of questions=Appropriateness of Questions, P=Poor, F=Fair, G=Good

Though the experts have rated the chapter as fair to good, few suggestions were given. The suggestions have been consolidated in the table 3 along with the responses and justification.

They also gave suggestions to improve the content of the tutorial for each chapter. The suggestions provided by the experts were to add information about physiology of swallowing, anatomical pictures in the anterior-posterior plane in the first chapter and suction channels in the endoscope in the second chapter. For the third and fourth chapter, suggestions were provided by the experts to organize the content and add expected normal responses with the protocol of FEES. In the final chapter, it was suggested to reduce the duration of the videos and to retain the exact portion which depicts the condition. Based

on the suggestions, some of the changes were incorporated to improve relevancy and readability of the tutorial, while the others were not. The details of the same along with the rationale for not including the changes have been depicted in table 4.2.

Table 4.2

Summary of suggestions provided by the validators and the changes incorporated

Chapter No. and title	Feedback obtained	Changes incorporated
1. Overview of structures seen through FEES	Lucid, easy to understand. May add a short section on physiology of swallowing. Include anterior/superior view of structures and correct sentence structure errors.	Physiology was not added as a separate section since it has already been explained for each structure. Added pictures with anterior superior view.
2. Equipment requirement for FEES	Simple, clear and precise. May comment on flexible endoscopes having an additional suction channel. The number of pictures could be reduced to one and the language could be more formal and neutral	Added information about suction channel. Some sentences were modified to keep the language formal and neutral.
3. Still FEES images with and without bolus of healthy individuals	Focus should be on structures relevant for FEES, and in the order one would see. For example, no focus on velum at rest, velum elevated as seen from nasal vanity. Identification of uvula	All the structures mentioned in this chapter are in the sequence as would be seen on FEES, therefore the information was retained. Greater number of

	/base of the tongue or valleculae. Questions also should include only identification of structure as that is the learning objective.	questions that focussed on identification of structures were added as suggested.
4. Protocol for lministration of FEES	Requires reorganization. The pictures provided are not appropriate. The focus should be on reaching certain anatomical landmarks, assessment of structure and tasks provided to assess the function. The reader should be able to clearly understand what to do at what points. It could have been better if tasks are explained and expected normal responses could be focused in detail.	The pictures representing the sequence of FEES were organized to suit the text better. Each task of the protocol was explained in a sequence with details of rationale for doing the tasks. For every task, supporting images of FEES were added for readers to comprehend how the task would be visualized on endosocopy. The expected normal responses were added as pictorial representations for each task in the protocol.
5. Rating scales used ıring FEES	Not updated. There are other residue scales and objective assessment scales published. The language of writing could be more formal.	The scales mentioned in this chapter are standardized, having good reliability, validity and most commonly used. Other scales such as Secretion

		Severity Rating Scale and DIGEST were included. Language of writing was made formal.
6. Learning to terpret FEES images	It would be better if you provide an assessment sheet for readers to practice, like a workbook. Video length can be shortened to make the video more content specific	A blank sample record form and case study was included at the end of the chapter for learners to practice interpretation. Video duration was trimmed to focus on the exact pathology. Video links were also added for each condition.

The experts also provided some general comments which were as follows:

- The tutorial is relevant and clinically useful for students of speech-language pathology, who would want to practice dysphagia management or pursue further studies in the domain of dysphagia.
- The written information of the chapters of the tutorial is lucid and easy to understand.
- The videos included as a part of the tutorial is useful for understanding the normal as against abnormal swallows.

The final version of the tutorial developed has been attached as appendix D.

4.2 Quantitative analysis of user validation

To determine the extent to which the participants understood the content in the tutorial, they were made to answer the questions at the end of the chapters, before and after reading the tutorial. The pre and post-test scores at the end of each chapter were computed for each participant and averaged across all participants. Descriptive statistics was computed and mean, median and standard deviation have been depicted in Table 4.3. It was seen that the post-test mean average scores were higher than the pre-test mean average scores. Further, the mean scores of post-test were higher compared to the mean scores of the pre-test of all the chapters, except of the fourth chapter, which were comparable. The pre and post-test mean average scores were analysed statistically using non-parametric Wilcoxon signed rank test. The results indicated a significant difference between pretest and post-test scores ($Z=2.03$, $p < 0.04$).

Table 4.3

Mean, Median and Standard Deviation of pre and post-test scores for each chapter

Chapter No.	**Scores**	**Mean**	**Median**	**Standard deviation**
Chapter 1	Pre-test	4.40	4.00	0.55
	Post-test	9.60	10.0	0.55
Chapter 2	Pre-test	4.60	5.00	1.14
	Post-test	9.40	10.00	0.89
Chapter 3	Pre-test	3.40	4.00	0.89
	Post-test	9.00	9.00	0.71
Chapter 4	Pre-test	4.40	4.00	1.14
	Post-test	4.40	4.00	1.14

Chapter 5	Pre-test	4.00	4.00	0.71
	Post-test	9.60	10.00	0.55
Chapter 6	Pre-test	3.60	4.00	1.14
	Post-test	9.60	10.00	0.55
Pre-test average scores		4.07	4.00	0.28
Post-test average scores		8.53	8.50	0.39

To check whether there was a significant difference across all chapters, comparison of pre-test and post-test scores of each chapter was statistically carried out Wilcoxon Signed Rank Test, the results of which are shown in Table 4.4. The results revealed a significant difference for all chapters except the fourth chapter.

Table 4.4

/z/ and p values of pre and post-test scores for each chapter

Chapter No.	**/z/ value**	**P value**
Chapter 1	2.04	0.04
Chapter 2	2.06	0.03
Chapter 3	2.07	0.03
Chapter 4	0.00	1.00
Chapter 5	2.03	0.04
Chapter 6	2.03	0.04

Feedback acquisition: Finally, a form was given to all the participants to obtain a feedback about the tutorial. This was done through google forms which consisted of ten objective statements. Provision was also made for them to provide any other suggestions/comments about the tutorial. Participants were asked to rate from 1 to 5 (1=strongly agree, 5=strongly disagree) for each of the statements. The results obtained for the objective questions in the feedback form has been depicted in Table 4.5. Almost all the participants provided ratings of 1 and 2 for the statements i.e., strongly agree and agree, which indicated that the participants found the tutorial useful in understanding FEES, with organized and relevant content, which was interesting to read and written in an simple and comprehensive manner. The suggestions obtained were mainly comments such as “It was informative”, “It was helpful” and “It was clinically useful”.

Table 4.5

Frequency and percentage of responses for the objective questions in the feedback form

Statement	Frequency and percentage of responses	
	Strongly agree	**Agree**
1. Learning objectives for every chapter were accurate.	4 (80%)	1 (20%)
2. Content of tutorial was in line with learning objectives.	3 (60%)	2 (40%)
3. The content of the tutorial was organised.	4 (80%)	1 (20%)
4. The content of the tutorial was interesting to read.	4 (80%)	1 (20%)
5. The language in which chapters were written was easy to comprehend.	4 (80%)	1 (20%)
6. The pictures were clear and conveyed information written in the tutorial appropriately.	3 (60%)	2 (40%)
7. The tutorial was informative.	4 (80%)	1 (20%)
8. The questions at the end of the chapters were in line with learning objectives.	3 (60%)	2 (40%)
9. The tutorial is clinically useful for students who want to learn about FEES.	5 (100%)	-
10. I would recommend other students to read the tutorial.	4 (80%)	1 (20%)

To summarize, the outcome of the study was a tutorial on FEES for the speech-language pathologists. This tutorial was validated by expert professionals including an otorhinolaryngologist and three speech-language pathologists. The experts were positive about the content of the tutorial and expressed their opinion that it was a clinically useful tool not just for students, but professionals as well who were interested in the area of dysphagia and eager to learn about FEES. A few changes were suggested which were incorporated, following which, the tutorial was checked for its usability. The content of the tutorial was provided to five participants, who were students of speech-language pathology. A significantly higher post-test scores indicated that the tutorial was effective in increasing the understanding about FEES procedure. Later, a feedback form was given to the participants to obtain their perspectives regarding usefulness of the tutorial. Almost all the participants provided ratings of 1 and 2 for the statements i.e., strongly agree and agree, which indicated that the participants found the tutorial useful in understanding FEES, with organized and relevant content, which was interesting to read and written in an simple and comprehensive manner.

CHAPTER 5

DISCUSSION

The main outcome of the study was the development of a FEES tutorial tailored to undergraduate and postgraduate students of speech-language pathology and the practicing speech-language pathologists. The main intention was to have a readily accessible self-learning guide to refer and develop competency in a way which would help them as professionals serving patients with dysphagia. The table 5.1 below depicts the rationale for including the information covered under all the different chapters of the tutorial.

Table 5.1

Rationale for developing the content of chapters

Chapter No.	Title	Rationale for inclusion of the information
1	Overview of structures seen through FEES	The anatomy and physiology of structures relevant for FEES i.e. nasal, pharyngeal and laryngeal structures were included as this forms the foundation of knowledge required to learn about FEES. A Knowledge about where the structures are located and what specifically to see can help in the assessment of FEES.
2	Equipment requirement for FEES	A basic understanding of FEES equipment is necessary for SLPs as they need to be aware of the main equipment needed and how it works.
3	Still FEES images with and without bolus of	Before conducting the procedure and interpreting FEES findings, clinicians must have enough practice locating the relevant structures on FEES and identifying normal

	healthy individuals	versus abnormal with and without bolus, therefore this chapter was developed.
4	Protocol for administration of FEES	This chapter forms the crux of the entire tutorial as it outlines the exact steps the clinician needs to perform for assessing pharyngeal dysphagia in an individual.
5	Rating scales used during FEES	Scales to assess penetration/aspiration and residue are useful during assessment procedures, as they help determine the severity of the condition, based on which treatment recommendations can be made.
6	Learning to interpret FEES images	This chapter is one of the most important chapters of this tutorial in which, the exact signs and symptoms are outlined for common clinical conditions which need to be looked for by a clinician to differentiate between normal versus abnormal swallow. This information would facilitate practice in interpreting FEES images in different clinical scenarios.

The tutorial is unique by itself as it comprises of not just theoretical information, but it also includes supporting graphical representations and videos for better and easy understanding. The language used for the tutorial is simple and easy to read. It allows readers to learn whenever and wherever they want. The tutorial can be completed regardless of time or location. The reader can take pauses and repeat parts as needed. If the reader has basic knowledge about FEES, it is easier to review or skip chapters. It may be easier to learn from the tutorial, particularly for those who have learnt English as a

second language as they may be able to learn better and easier through written communication than through vocal communication.

The tutorial was validated by gathering expert opinions from otorhinolaryngologist and speech-language pathologists. Both these professionals were involved in the content validation process as FEES is carried out sometimes as a collaborative effort in which the otorhinolaryngologist inserts the scope and observes the structures as scope is advanced and the speech-language pathologist provides bolus for observing swallowing mechanism and interprets the FEES images to identify the underlying physiological impairment that leads to dysphagia. A rating scale was provided to them which consisted of few parameters such as relevancy, simplicity etc. along with an additional comment section. Each of the parameters was given a score between 0 and 2 (0-Poor, 1-Fair, 2-Good) by the experts. Overall, a positive verbal feedback was received from all the professionals as they found tutorial relevant and clinical useful. All the experts rated all chapters as good in terms of simplicity and relevance. Three experts rated the parameters of trainability, layout, appropriateness of visuals, and appropriateness of questions of all chapters as good, while one expert rated these as fair. However, one expert rated the appropriateness of pictures in Chapter 4 as poor. They also provided some additional suggestions pertaining to each chapter and necessary modifications wherever deemed appropriate.

The tutorial was checked for its efficacy by administering it on five participants, who were students of I MSc studying speech-language pathology. The results showed a significant improvement in the post-test scores of chapters (1,2,3,5,6). These chapters focused on anatomy of endoscopic structures, instruments required, spotting the important anatomical structures, familiarising with various assessment scales and interpretation of FEES findings for normal and abnormal swallow. This finding revealed that the students were able to understand the content of these chapters. However, a significant difference

was not seen between the pre and post-test scores of chapter IV. This chapter focused on the protocol of FEES and the normal variability observed among individuals. Such a finding could possibly be attributed to the difficulty the participants had in understanding and visualizing the tasks of the protocol. A video was added as a supplementary material which included demonstration of the FEES procedure. It is expected that this change would facilitate better comprehension of the content of chapter four. Overall, the findings revealed the effectiveness of the tutorial as a self-learning guide in training students about various aspects of FEES.

Finally, a feedback form was given to the participants to obtain their opinion and experience of reading the tutorial. Ten objective statements were given to the students to rate between 1 to 5 (1-strongly agree, 5-strongly disagree). Out of ten statements, the 'strongly agree' was chosen for 76% of the statements and the 'agree' option was chose for 24% of the statements by the participants. Specific to every statement, 80% of the respondents strongly agreed and 20% agreed for statements such as the learning objectives of the chapters were accurate, the tutorial was organized, interesting to read, informative, language used was easy to comprehend and they would recommend others to read the tutorial. 60% of the respondents had strongly agreed and 40% agreed for statements such as content of the chapters was in line with learning objectives, pictures were clear and conveyed the information appropriately and questions at the end of the chapters were in line with learning objectives. All the respondents i.e. 100% of them strongly agreed for the tutorial being clinically useful to the readers. Overall, a positive feedback was obtained since most of them commented that they found the tutorial helpful and useful. They also pointed out that there was a need for having such learning materials for students so that they can develop competency in a specific domain. Thus, from the findings of the study it

can be concluded that tutorial was useful to students as shown with the significantly improved post-test training scores and feedback.

Students of speech-language pathology/Speech-language pathologists need to be certified for practicing FEES. However, this may not be practically possible for all of the professionals due to various problems such as cost, accessibility to training etc. Under such circumstances, such a self-learning material or tutorial would be helpful for those who are interested in dysphagia. There are studies that compare the efficiency of online course to traditional, face-to-face lectures on FEES for both graduate students studying medical education and graduate students studying speech language pathology programmes. Group 1, the traditional group, attended face-to-face lectures with an audience response system, whereas Group 2, the online group, took an online, interactive course. The key outcome measure was the FEES knowledge test scores before and after the course. The overall findings of this study demonstrated that after completing the FEES training course, participants in both groups gained statistically significant improvement in knowledge and self-efficacy, regardless of the course delivery modality. A FEES self-efficacy questionnaire with a 5-point Likert answer scale was used to assess changes in course participants' self-efficacy to interpret the FEES process. All of the self-efficacy questions showed statistically significant changes from pre- to post-course, regardless of research group (Brady et al., 2018). In the present study as well, significant difference was found between pre and post test scores, though the mode of learning was different. This indicates that irrespective of the way information about FEES is learnt, it can result in increase in knowledge among the end users.

The findings are consistent with other studies in which learning models were used to teach endoscopy skills to graduate students of speech-language pathology (Robinson & Dennick, 2015b). The learning models used in this study are some of the most widely used

for the purpose of imparting education. Constructivistic, Humanistic, and Experiential learning models were used in this study. Constructivism is a student-centered learning theory based on students' previous experiences and knowledge being combined to form understanding and knowledge. Humanism is even more individualistic than constructivism, emphasising freedom of choice and autonomy. Experiential learning, as the name implies, is based on personal experience. The Nottingham EEL course was created to increase training in endoscopy by providing participants with enriched learning that leads to autonomous practise. The course consisted of four days of instruction (two sessions of two days) spread out over six months, as well as one "virtual" day with a local mentor in the student's home clinical setting. Learners were respected and their existing knowledge was acknowledged and built upon in the EEL course (Gagné et al., 1969). For each process that they performed, the students examined protocol materials, such as setting up equipment and laryngeal evaluation protocols, to ensure that they were functioning and assessing logically and documenting the visual characteristics accurately. As part of the more formal curriculum, they gained access to the academic and practical experiences they required. The most challenging component, according to students, was transitioning from theoretical frameworks to implementing actual abilities, though they were taught by the mentors. In the present study, the tutorial developed is for self-learning and is augmented with videos, which will supplement the learning and will possibly bridge the gap between theory and practice.

FEES and VFSS are two instrumental evaluation procedures used for assessing dysphagia. The clinical interpretation of a videofluoroscopic swallow study (VFSS) has been condemned for its lack of consistency and inter-rater reliability. Objective VFSS measurements have been devised, reported, and proved to be valid and trustworthy in order to address this. However, there is a lack of extensive clinical adoption. Lack of training

and excessive time spent performing measurements have been listed as reasons (Nordin et al., 2017). Several attempts have been made to train graduate level students for understanding and interpreting videofluoroscopic studies. It would be worthy to look at the existing literature for training students in interpreting VFSS studies, to be extrapolated for teaching FEES.

A study was carried out in which graduate students of speech-language pathology were given modules about videofluoroscopic swallow studies and their knowledge was tested using a pre and post-test questionnaire (Wooi et al., 2001). The researchers looked at how learners' theoretical understanding of anatomy and physiology, as well as their ability to recognise radiographic anatomy, influenced their ability to analyse VFSS. Students in speech-language pathology received 5 hours of training, provided once a week for five weeks. Students met the 75% accuracy requirement on eight VFSS assessments for anatomy and swallow physiology knowledge after training, and they excelled at identifying radiographic landmarks. The VFSS scores of the students were related to their anatomy and physiology and radiographic landmark assessments. Regrettably, the study did not specify the standard by which the students were judged. It's also impossible to determine the impact of training on students' results without a pre-test. The positive relationship between theory outcomes and VFSS ratings, on the other hand, implies that theoretical learner strengths may influence VFSS training response. In the present study as well, significant difference was seen between pre and post test scores, though the mode of learning was different.

The findings of this study is consistent with another study which looked at the impact of 4 hours of training on the radiographic detection of head and neck structure and oropharyngeal swallowing issues (Logemann et al., 2000). A 5-hour session included 30-minute pre- and post-tests requiring identification of head and neck anatomy as well as

oropharyngeal swallowing difficulties, as well as a 4-hour training time. The results revealed a considerable improvement in both radiographic anatomy and swallowing problems detection. The extent of past dysphagia experience was adversely linked with the change in pre- and post-test measurements. Similar studies with clinicians or students with dysphagia experience are needed to determine the number of hours of education required for students to achieve a desirable degree of accuracy in their identifications. For the present study, number of hours for completion of the training material was not specified, hence it paves the way for future research to decide the exact number of hours required for students to learn such educational training materials.

To summarize, the study involved the development of a tutorial for FEES, which includes information on understanding anatomy of structures important for FEES, the equipment required to conduct FEES, identifying the important landmarks on a FEES examination, administering the protocol and learning interpretation of FEES findings. The same was validated by a group of experts who gave their valuable suggestions and feedback for improving the content. Based on the changes suggested, modifications were made to the tutorial and administered on five participants. The higher post-training scores showed promising results in terms of usefulness of the tutorial. A positive feedback was also received from these participants.

CHAPTER 6

SUMMARY AND CONCLUSIONS

The ability to swallow is a gift of survival and a way to enjoy eating and drinking the food we love. Although it seems like an easy process when a person swallows, it is quite complex in reality. The speech-language pathologist has a key role to play in understanding swallow physiology and applying the knowledge into clinical practice. Being a professional course in itself, the students studying speech-language pathology are expected to start practicing and treat patients as soon as they graduate. This requires them to be adept with knowledge and competency during assessment and intervention process. Swallowing therapy is one of the many disciplines a SLP is involved in as a rehabilitation professional, which requires them to be competent in identifying, evaluating and treating swallowing disorders.

The FEES method is an instrumental evaluation procedure that is routinely used to assess pharyngeal dysphagia and decide on treatments based on the results. Despite its status as a gold standard, FEES knowledge and applicability are still lacking. SLPs play an important role in FEES procedures, whether they are performed with or without the assistance of an otorhinolaryngologist. In the speech and hearing institutions/colleges spread across India, FEES is studied as a subtopic under the course of dysphagia at the graduate and postgraduate levels. There is a need to foster competency in students so that they can emerge as more knowledgeable and confident professionals. An in-depth review of the literature revealed that there were no tutorials available for learning about FEES. With this in mind, the current study was planned with the aim of developing a tutorial in an easy-to-read format to help students of speech-language pathology and the speech-language pathologists working in the area of dysphagia to gain competency and knowledge about FEES.

It is hoped that this tutorial would serve as a self-learning educational material. The tutorial was developed in three phases. Phase I involved the development of the content of the tutorial. Information from various educational sources such as textbooks, research articles, dedicated websites for speech-language pathologists, blogs etc. was compiled and organized into different chapters. The information went on to be divided into six chapters. The first chapter dealt with anatomical knowledge from endoscopic point of view i.e., nose, pharynx and larynx highlighting their role in swallowing. The second chapter included information about the technical aspects of FEES, i.e., equipment required and rationale for using them. The third and fourth chapter covered information on identifying the anatomical landmarks and administering the FEES protocol respectively. Anatomical landmarks used to describe FEES images with and without bolus, boluses of various sizes and consistencies utilised, and the normal various seen in healthy individuals were specifically included in the third chapter. The FEES procedure, as described in the fourth chapter, is divided into two parts: Part I consists of a review of the anatomical and physiological structures seen during endoscopy and Part II comprises of swallow study using different bolus volumes and consistencies. The fifth chapter is the shortest one and dealt with various scales to determine severity of impairment during the administration of protocol. The final chapter helps differentiate between normal and abnormal swallow using endoscopy videos supported with examples of different clinical conditions routinely encountered. All the chapters have a list of questions at the end to check the comprehension of the reader. A list of companies in India from whom FEES equipment can be procured was also included at the end of the tutorial for any professional who would want to include FEES in practice.

The tutorial was further validated by an otorhinolaryngologist and three speech-language pathologists having experience of working with FEES for minimum two years

as part of Phase II. The suggestion and feedback given by experts were utilized for improving the content of the chapters. For the first chapter, it was suggested to add information regarding physiology of swallowing, include pictures in the anterior posterior view and rectify the grammatical errors. Since information about physiology had already been included along with anatomical structures, no separate section was added. A section for suction channel was suggested to be added and the reduction of the usage of technical terminologies about the equipment was suggested for second chapter. For third and fourth chapter, rearrangement of pictures, adding questions that focus on the identification of structures and adding expected normal responses for every task in the protocol was suggested. For the last two chapters, it was suggested to add information regarding standardized scales and reduce the duration of the videos for different conditions. All these changes suggested were incorporated.

Further, Phase III involved evaluating the efficacy of the tutorial by providing the same to postgraduate students of speech-language pathology. The questions at the end of chapters were provided to them and scores were obtained before and after reading the tutorial. The results revealed significant difference in the form of overall improved post-test scores compared to pre-test scores, indicating the tutorial was successful in improving the knowledge of students about FEES. A chapter-wise comparison was done to see if chapter specific improvement was noted. Improvement of scores for all chapters was observed except the fourth chapter. A video was added as a supplementary material which included demonstration of the FEES procedure to facilitate better comprehension of the content of chapter four.

Finally, the same participants were given a feedback form as part of Phase IV to obtain their feedback about the tutorial. They were provided with ten objective questions to grade on a scale of 1 to 5 (1-strongly agree, 5-strongly disagree). Almost all the participants

provided ratings of 1 and 2 for the statements i.e., strongly agree and agree, which indicated that the participants found the tutorial useful in understanding FEES, with organized and relevant content, which was interesting to read and written in an simple and comprehensive manner. The suggestions obtained were mainly comments such as “It was informative”, “It was helpful” and “It was clinically useful”.

To conclude, this tutorial developed as a part of this study seems to be effective in enhancing the knowledge and skill pertaining to the FEES procedure as the tutorial includes theoretical and practical information supplemented with necessary videos. This tutorial would serve as an educational guide for the students of speech-language pathology, practicing SLPs and other professionals keen on learning about FEES. This tutorial will serve as a ready reference for the SLPs who wish to practice FEES. It would serve as a step-by-step guide to develop the knowledge and skills required to be competent to carry out instrumental examination using FEES, work with other professionals and provide justice to the service delivery. The upcoming professionals who would use this tutorial would be more confident in assessing pharyngeal dysphagia using FEES and making the right decisions pertaining to various aspects of dysphagia management. If assessment is done appropriately, only then can better management be possible.

However, there are a few limitations to this study which needs to be noted. First, the sample size for user validation was limited. Considering that the tutorial was developed for graduate and postgraduate students, its efficacy was evaluated with postgraduate students only. Further, this tutorial cannot replace the certification required for practicing FEES. It can only be used as a standalone learning material for the reader to know more about FEES. The reader has to undergo the requisite certification for performing FEES from a competent authority to be able to implement FEES. These limitations suggest possibilities for future research on expanding the use of such educational self-learning

materials. It is suggested to use this self-learning material in institutions where certification for FEES is provided as it would combine theoretical knowledge as well as hands-on learning. The tutorial can also be used during the practical training for the undergraduate and postgraduate students of speech-language pathology. This can also be used for those speech-language pathologists who come in for refresher courses in dysphagia. It is recommended that the effectiveness of the tutorial should be confirmed by administering the questions at the end of chapters on large number of graduate and postgraduate students. The self- learning versus teaching by faculty can also be compared. Further, patient education materials regarding what is FEES and why is it done can be developed.

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APPENDIX A

CONTENT VALIDATION FORMAT

Kindly rate the chapters based on the parameters given below using the following rating scale:

0- Poor, 1- Fair, 2- Good,

Chapters	Simplicity	Relevancy	Trainability	Arrangement	Appropriateness of pictures (size, color and appearance)	Appropriateness of questions	Comments
CHAPTER 1 Endoscopic anatomy of nose, pharynx and larynx							
CHAPTER 2 Preparing for FEES							
CHAPTER 3 Identify structures and landmarks on still FEES images and graphics with and without bolus							
CHAPTER 4 Protocol of FEES							
CHAPTER 5 Interpretation and rating of parameters using various scales							
CHAPTER 6 Learning to interpret FEES images							

VALIDATION CRITERIA CHECKLIST

Kindly provide your rating and remarks based on the following parameters:

Simplicity	If content is explained in simple language
Relevance	If content is relevant to the topic of the study
Trainability	If the tutorial can be used as a training tool for interested students
Arrangement	If the sequence of the chapters and or the sections in each chapter is presented appropriately
Appropriateness of pictures	If size, color and appearance of the pictures included in each chapter is appropriate
Appropriateness of questions	If practice questions are framed appropriately along with the answer keys

APPENDIX B

USER VALIDATION QUESTIONNAIRE

User Validation

I, Tanvi Sanghavi invite you to participate in my dissertation titled "Tutorial to Assess Pharyngeal Dysphagia using Fiberoptic Endoscopic Evaluation of Swallowing (FEES)". I request participants to fill the following questionnaire which assesses your knowledge about FEES. After filling out the questionnaire, participants will be provided with the chapters to their respective email ids. The participants are expected to read through the chapters and attempt the questions again.

Thank you for your participation.

*Required

1. Email *

2. I consent to participate in the study. *

Mark only one oval.

- ◯ Yes
- ◯ No

Participant details

3. Name *

4. Please mention the class you are studying in. *

Mark only one oval.

- ◯ Msc I SLP
- ◯ Intern

5. Do you have any previous experience of working/observing in a hospital setup? *

Mark only one oval.

- ◯ Yes
- ◯ No

6. Have you observed FEES procedure previously? *

Mark only one oval.

- ◯ Yes
- ◯ No

7. If yes, please mention the duration of your posting during which you observed FEES procedure.

_____

CHAPTER 1- OVERVIEW OF STRUCTURES SEEN ON FEES

8. Why is endoscopy done? *

Mark only one oval.

- ◯ To visualize swallow structures using radiation
- ◯ To help visualize swallow structures not visible to naked eye
- ◯ To visualize swallow structures using pressure transducer
- ◯ None of these

APPENDIX C

FEEDBACK FORM

Feedback form

I would like to thank all the participants to make time to be validate my dissertation as an end user. I request you to fill this feedback form based on your experience reading the chapters of the tutorial. Do give honest reviews.

Once again, thank you.

*Required

1. Name *

2. Learning objectives for every chapter were accurate. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

3. Content of tutorial was in line with learning objectives. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

4. The content of the tutorial was organised. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

5. The content of the tutorial was interesting to read.

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

6. The language in which chapters were written was easy to comprehend. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

7. The pictures were clear and conveyed information written in the appropriately. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

8. The tutorial was informative. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

9. The questions at the end of the chapters were in line with learning objectives. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

10. The tutorial is clinically useful for students who want to learn about FEES. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

11. I would recommend other students to read the tutorial. *

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

12. Please mention if you have any comments/suggestions regarding the tutorial. *

APPENDIX D

TUTORIAL TO ASSESS PHARYNGEAL DYSPHAGIA USING FIBEROPTIC ENDOSCOPIC EVALUATION OF SWALLOWING (FEES)

INTRODUCTION

If you are a practicing speech-language pathologist or a student of speech-language pathology, who strongly believes that clinical swallow examination alone is not always sufficient to diagnose swallowing impairments (particularly pharyngeal type) and genuinely is concerned about swallow safety and want to identify the presence of aspiration and its cause and type by carrying out an instrumental evaluation, you have accessed the right resource. To be able to use and advocate any instrumental procedure for diagnostic purposes in swallow clinics and to impress on other professionals about how it adds value to your assessment and management, you must have thorough knowledge about it. This tutorial focusses on one such instrumental procedure, which is now widely used by Speech-language pathologists (SLPs) and Otorhinolaryngologists.

Fiberoptic Endoscopic Evaluation of Swallowing (FEES) is considered as one of the gold standard procedures to assess individuals with swallowing impairments. FEES is an instrumental assessment used to assess the pharyngeal phase of swallow. It involves passing a thin flexible endoscope transnasally (though the nose) to obtain a superior view of pharynx, larynx and upper aerodigestive tract. It enables the visualization of base of the tongue, nasopharynx, velopharynx, hypopharynx and the larynx. The anatomic structures of nasal, pharyngeal and laryngeal spaces are observed following which direct examination is done using bolus of different types and sizes.The range of movement, symmetry, and coordination of base of tongue, pharyngeal wall and other endolaryngeal structures are visualized during saliva swallow (dry swallow) and the swallow of food and liquid of different consistencies (wet swallow). Pooling or accumulation of secretions or food residue in the valleculae and pyriform sinuses is also noted. It also helps us to determine the safety and efficiency of different swallowing management options such as maneuvers and compensatory techniques(Hiss & Postma, 2003).

Since FEES only provides motor information during swallow, an extension of FEES procedure was developed referred to as FEESST (Fiberoptic Endoscopic Evaluation of Swallowing with Sensory Testing).FEEST provides an accurate indication of sensory function during swallow, which inturn reflects the degree of awareness of bolus in the oropharynx and the need to protect the airway. In the FEEST procedure, the supraglottic larynx is stimulated using a small puff of air, delivered in close proximity to the laryngeal mucosa, which results in elicitation of the laryngeal adductor reflex (LAR). The reflex can

be seen in the form of closure response of vocal folds for both right and left sides, the presence of which indicates that the sensation of the larynx is intact. FEES can be combined with FEESST, both of which can be carried out using the same instrument.

According to Miller, Schroeder,and Langmore(2020), FEES has proved to be a safe procedure in patients. FEES provides anatomical information and movement of structures in the pharyngeal phase, a phase which is invisible, unlike the oral phase which is relatively visible during the clinical swallow examination and therefore easy to assess without instruments. Another main advantage of FEES is that it helps to detect penetration and/or silent aspiration, which are missed out during subjective assessment. It is radiation free and more sensitive to detecting pharyngeal residue as compared to videofluoroscopic swallow study(Jonathan E. Aviv, 2000; Hee Jung et al., 2011; Wooi et al., 2001).

FEES is often used as a benchmark assessment tool from which other methods of swallowing evaluation can be determined (Hiss & Postma, 2003).Studies have commented on the benefits of using FEES across a spectrum of clinical population including paediatrics (Hartnick et al., 2000; Lefton-Greif, 2008; Miller & Willging, 2020), stroke(Leder & Espinosa, 2002; Lim et al., 2001; Takizawa et al., 2016b), traumatic brain injury (Leder, 1999), critical care(Ajemian et al., 2001b) and head and neck cancer(Denk et al., 1997; Gaziano, 2002; King et al., n.d.; Menon, 2018; Wu et al., 2000).

As per official statement of ASHA (2005), SLPs with expertise in dysphagia and specialized training in fiberoptic endoscopy are qualified to use this procedure independently for the purpose of assessing swallowing function and related functions of structures within the upper aerodigestive tract. However, the SLPs without a certification can also perform the assessment of swallow using FEES, with theotorhinolaryngologist performing the endoscopy, while the SLP conducting other aspects of the examination, which includes directing the patient through appropriate tasks and manoeuvres as required for a complete and comprehensive examination, directing the ENT to achieve the desired view, interprets, communicates and documenting findings. These two professionals, through their combined efforts can perform the swallowing assessment and arrive at the diagnosis and decide the further course of action(Moore, 2005).

FEES is an instrumental procedure that requires in-depth knowledge and skills than commonly known to SLPs. The entire tutorial is divided into seven chapters, which takes you right from the basic knowledge of anatomy and physiology of structures seen

through FEES, the basic equipments required, identifying various anatomical structures on a FEES image with and without bolus, protocol of FEES, using various standardized scales for interpretation of FEES and lastly, being able to interpret normal swallow versus different clinical conditions using FEES videos. At the end of each chapter, a list of questions have been added to check comprehension. Please do attempt to answer these questions for a better learning experience. The information provided in the tutorial will assist you as SLPs in the assessment of swallowing disorders using FEES. This tutorial can also be used a handy guide for students of speech-language pathology who are interested to learn more about this procedure. Although the tutorial is developed for interested students and professionals, do note the information provided in the tutorial does not help in implementation of FEES. The interested candidate can opt for certification courses available in the western countries to start practicing FEES. ASHA (American Speech and Hearing Association) has released "Knowledge and Skills for Speech-Language Pathologists Performing Endoscopic Assessment of Swallowing" in 2002, which included a suggested training programme. The following is the current state of practise for achieving FEES competency:

1. Demonstrate expertise in the evaluation and management of dysphagia patients.

2. Receive 10 to 14 hours of comprehensive classroom training in flexible endoscopic techniques, swallowing evaluation, and FEES interpretation.

3. Observe 10 to 20 FEES procedures performed on dysphagia patients.

4. Under the direct supervision of an otolaryngologist or speech therapist skilled in the use of flexible endoscopy, pass a flexible endoscope for the purpose of FEES 25 to 50 times.

CHAPTER I

OVERVIEW OF STRUCTURES SEEN THROUGH FEES

Deglutition, also called swallowing is an extremely important process for the survival of human beings. Swallowing involves the movement and coordination of several structures in the aerodigestive tract. When the muscles of the swallowing organs or nerves that govern these organs are disordered, disrupted, damaged or destroyed, swallowing can get impaired. A swallowing disorder includes either a total inability to swallow (aphagia) or a difficulty in swallowing (dysphagia), which affects the quality of life of the individual. A speech-language pathologist (SLP), who is involved in the rehabilitation of swallowing disorders requires a great deal of knowledge about the normal anatomy and physiology of swallowing. *To understand what is abnormal, a clinician (SLP) needs to understand what is normal.*

As students of speech-language pathology, we learn about the anatomy and physiology of body structures important for speech and swallowing in the beginning of undergraduate programs, after which we are expected to have the basic knowledge throughout our professional journey. It could get difficult to remember all the information at once, therefore this chapter is meant to provide a refresher course on the basic anatomy and physiology of swallowing.However, this chapter focuses on the anatomy and physiology as would be seen during FEES examination. The anatomical structures primarily consist of nose, soft palate, pharynx and larynx. It is the same sequence in which an endoscope would be advanced during the procedure, details of which are discussed in the chapter.

Learning objectives:

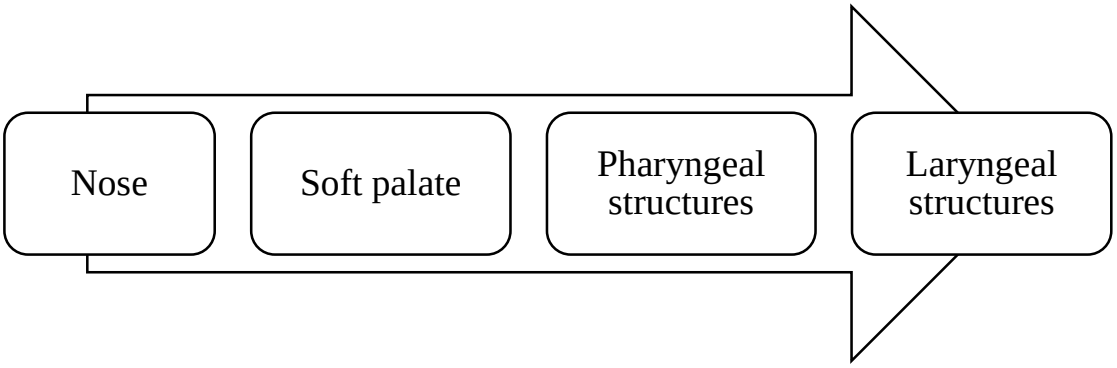
At the end of this chapter, you will be able to:

1. **Understand the anatomy of structures as viewed on FEES**
2. **Understand the significant physiological events occurring during pharyngeal phase of swallow**
3. **Understand the relevance of these structures during assessment using FEES**

The anatomical structures viewed on FEES are in the order ofnasal, pharyngeal, laryngeal cavity and the upper part of the esophagus as shown in Figure 1. Each structure is described with respect to its structure, function and the order in which it would be observed during endoscopy. Let us look at each structure one by one and their role in the process of swallowing.

Figure 1

Structures observed through FEES.



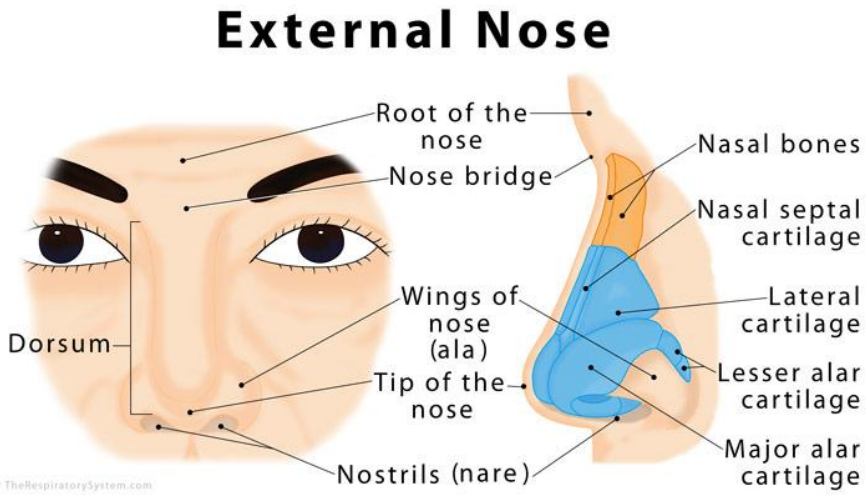
The Nose

The nose is the first organ that would come in contact with the endoscope. Any one nostril, with a wide opening offering least resistance to the scope is selected for the insertion. The nasal structures are assessed as the scope is continuously inserted until it reaches the soft palate (velum). This section describes the structuresin the nose relevant to the procedure of endoscopy, which serve as landmarks for insertion of the scope.

The nose originates between the eyes and ends just above the upper lip. The midline nasal septum divides the nose into left and right divisions. Access to the nasal cavity is present through the nares, present at the base of the nose, also called as the nasal valve. The nose gets its stability and flexibility with the help of bony and cartilaginous components underlying it.The anatomy of nose can be seen in the figure 2.

Figure 2

Anatomy of the nose. (Source: https://www.therespiratorysystem.com/nose/)



Before we go any further, do you know as to why we need the nose? Although it looks like two weirdly shaped structures on the face, it has immense contribution in helping us stay alive. The air entering the nose is important for respiration; a process which needs to be coordinated with swallowing.Breathing can occur through nose or mouth and swallowing takes place in the mouth. There is a space common to both these processes.This space is the pharynx. At this point, you need to know that breathing temporarily stops during swallow. As you can see in the figure below, after inhalation, exhalation temporarily pauses during swallowing, also called swallow apnea and resumes again. Another important function of nose is that it gives sensation of smell, preparing you for your meal.

Figure 3

Breathing and swallowing coordination. (Source: https://link.springer.com/article/10.1007/s00455-019-10050-9/figures/4)

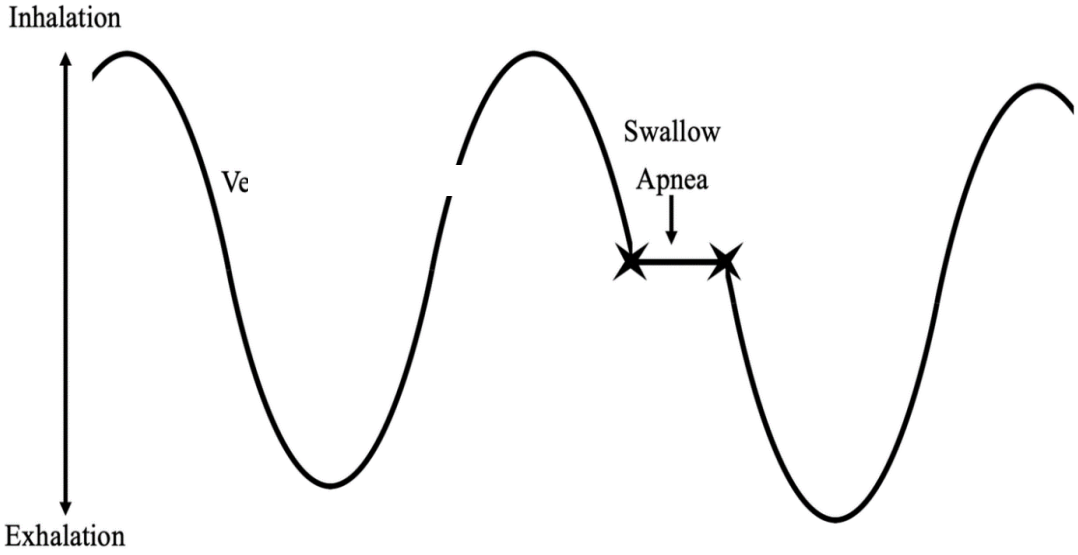
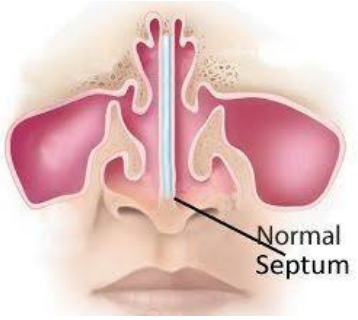


Figure 3:

The nose can be visualised as two parts, anterior and posterior portion. The anterior third of the nasal septum is made up of quadrilateral cartilage and anterior nasal spine. The vomer bone and perpendicular plate of the ethmoid bone make up the posterior portion of the nasal septum.

Figure 4

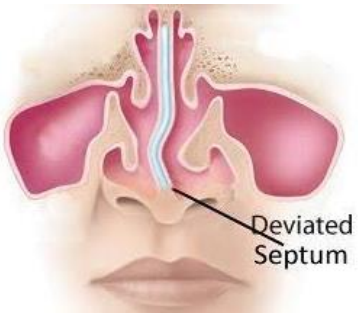
Normal septum. (Source: https://www.drugs.com/health-guide/deviated-septum.html)



The nasal septum is an important structure which gives a base and support to the nose. The nasal septum divides into left and right nasal cavitites. Deformity of the septum can lead to cosmetic problems and loss of functions of the nasal cavity. About one third of the population has some type of nasal obstruction (Fettman et al., 2009). A deviated septum can be identified when the nasal septum gets displaced to one side. This causes blocking of one of the nostrils leading to reduced airflow and breathing difficulty. In such a case, scope must be inserted through the nostril having greater space for the scope to advance.

Figure 5

Deviated septum. (Source: https://www.drugs.com/health-guide/deviated-septum.html)

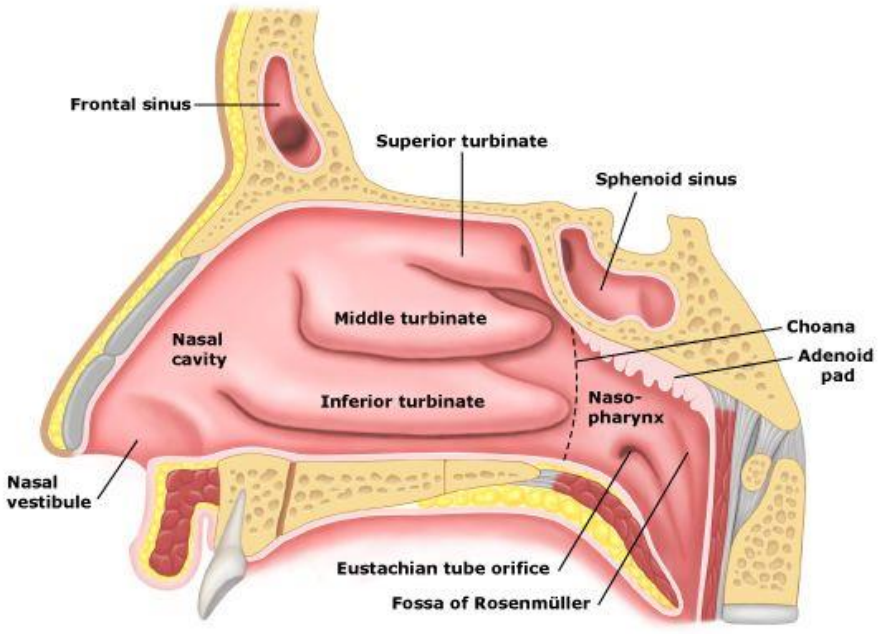


The lateral wall of the nasal cavity is quite uneven and has multiple openings from the nearby sinuses. The first structure that can be visualized on the lateral wall is the turbinates. The term turbinate, is derived from the unique scroll-like formation similar to shell like-shape, therefore it is also called as conchae. The turbinates can be divided into superior,

middle and inferior portions, as can be seen in figure 4. The superior and middle turbinates are derived from the ethmoid bone, whereas the inferior turbinate is a bone in itself. Below the inferior turbinate, one can find the floor of the nose. Usually the widest space to insert the scope is along the floor of the nose between the septum and the inferior turbinate. The scope needs to be inserted into the nostril to the point where the hard and soft palate merge (nasopharynx). The turbinates can be observed in figure 6 and figure 7.

Figure 6

Lateral wall of nose. (Source: [https://favpng.com/png_view/bat-skeleton-structure-inferior-nasal-concha-anatomy-of-the-human-nose-png/03nF7xB7)](https://favpng.com/png_view/bat-skeleton-structure-inferior-nasal-concha-anatomy-of-the-human-nose-png/03nF7xB7)

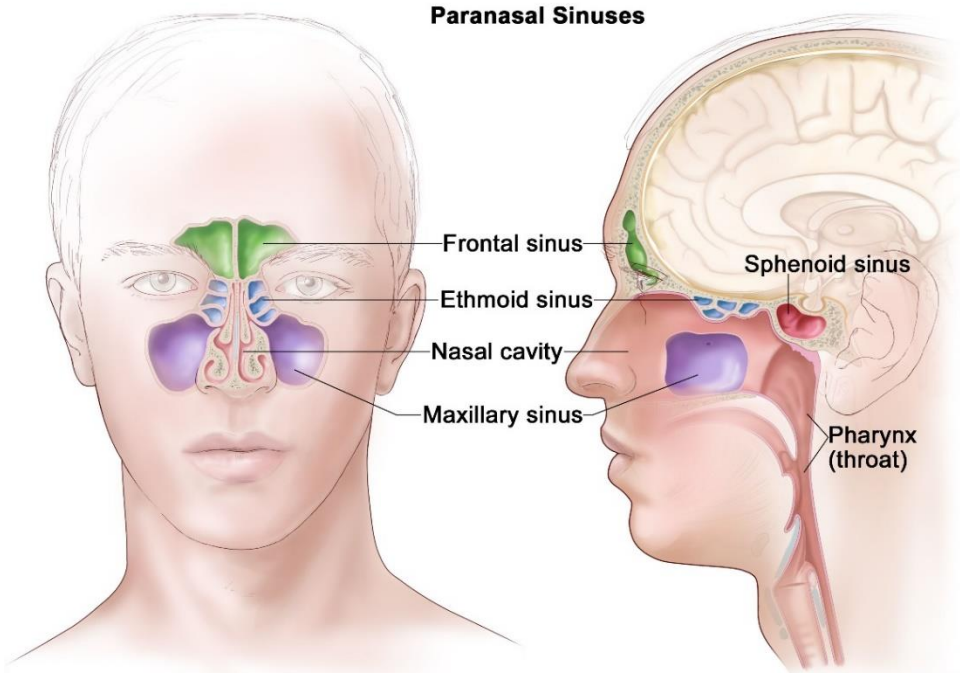


The structures discussed above, i.e turbinates and nasal cavity are important in understanding the drainage system of the paranasal sinuses of the nose. There are four main paranasal sinuses, viz., frontal sinus, ethmoid sinus, maxillary sinus and sphenoid sinus. The frontal sinuses are located above the eyes, maxillary sinuses are below the eyes, ethmoid sinuses are between the eyes and sphenoid sinuses are present at the back of the

nose.These structures are explained so that one is able to observe the landmarks while the scope is being inserted and judge if the scope is going in the right direction.

Figure 7

Paranasal sinuses. (Source: [https://www.cancer.gov/publications/dictionaries/cancer-terms/def/paranasal-sinus)](https://www.cancer.gov/publications/dictionaries/cancer-terms/def/paranasal-sinus)



Soft palate

Velum or soft palate is the next structure that is visible on endoscopy. From an endoscopic point of view, once the scope reaches the nasopharynx, the soft palate can be visualized as a smooth structure at the end of the nasal cavity.

The soft palate is lined by mucous membrane and consists of palatine aponeurosis (flattened tensor velipalatini tendon), taste buds, mucous glands, and muscles. The space between velum and the pharyngeal wall is called the velopharyngeal port, which is important for separatingoral from nasal cavity. Elevation of the soft palate closes off the velopharyngeal port, preventing nasal regurgitation. Depression of the soft palate opens up the velopharyngeal port. This function is important for the purpose of both speech and swallowing, such that distinction of oral and nasal sounds is facilitated and nasal regurgitation (entry of bolus into the nasal cavity) is prevented. This lowering and

elevation of the soft palate needs to be noted during endoscopy. Velar function is assessed at this point to check for patency of the velopharyngeal port.The patient isasked to phonate /ee/, /ss/ and other plosive, fricative sounds. The timing of velar contraction can be checked by asking the patient to alternate between oral and nasal sounds such as ‘duh-nuh’.

Figure 8

Coronal view of pharynx and soft palate.

(Source:https://www.facebook.com/ClinAnat.OperSurg/posts/anatomy-and-topography-of-the-pharynx/2219157624783891/)

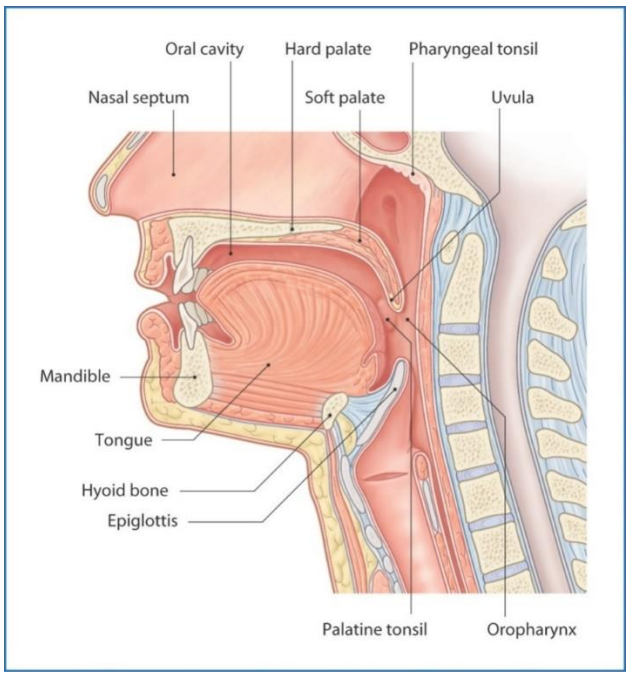
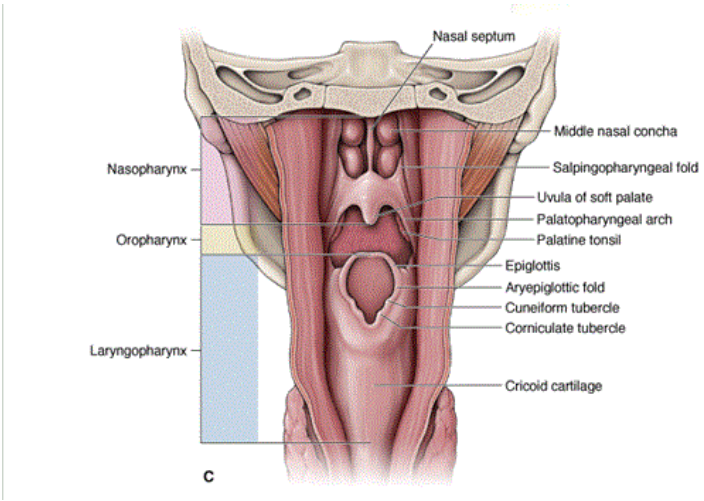


Figure 9

Anterior-Superior view of pharynx.

(Source:https://www.google.com/url?sa=i&url=https%3A%2F%2Fbasicmedicalkey.com%2F)



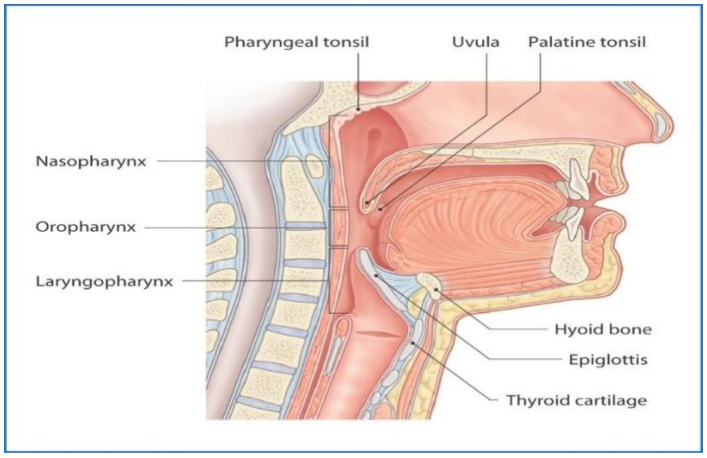
Pharynx

The next structure to be seen on the endoscopy is the oropharynx, one of the subdivisions of the pharynx. The pharyngeal cavity is the common passage for air and food. It is a cylindrically shaped tube extending from base of the skull to the cricopharyngeus. The most common classification of pharynx divides it into three parts, namely nasopharynx, oropharynx and laryngopharynx (or hypopharynx). The nasopharynx extends from nasal choanae to the level of nasopharyngeal isthmus. The oropharynx extends from nasopharyngeal isthmus to the level of hyoid bone. The laryngopharynx extends from the hyoid bone to the level of larynx and the esophagus. Pharynx is a conical fibromuscular tube, which is 12-14 cms long. It is wide at the level of hyoid (5 cms) and narrowest at the caudal end (1.5 cm). The pharyngeal swallow is a quick sequential activity that takes less than a second to complete. It has two important biological characteristics: (1) food passage, which propels the food bolus through the pharynx and UES to the oesophagus; and (2) airway protection, which isolates the larynx and trachea from the pharynx during food passage to prevent food from entering the airway. The soft palate lifts and touches the lateral and posterior walls of the pharynx during the pharyngeal stage, shutting the nasopharynx around the same time that the bolus head enters the pharynx. Bolus regurgitation into the nasal cavity is avoided by elevating the soft palate. The bolus is pushed against the pharyngeal walls as the base of the tongue

retracts. Squeezing the bolus downward, the pharyngeal constrictor muscles contract successively from top to bottom. The pharynx also shortens vertically, reducing the pharyngeal cavity's capacity. In human swallowing, a safe bolus passage through the pharynx without aspirating food is essential(Matsuo & Palmer, 2008).At this point, all other exit spaces need to be shut off so that bolus can travel easily to the esophagus. These exit spaces are nasal cavity (closed by the velum), mouth (closed by lips) and lower airway (closure of vocal folds).

Figure 10

Divisions of normal pharynx. (Source:https://basicmedicalkey.com/wp-content/uploads/2016/06/f010-001-9780323077798.jpg)



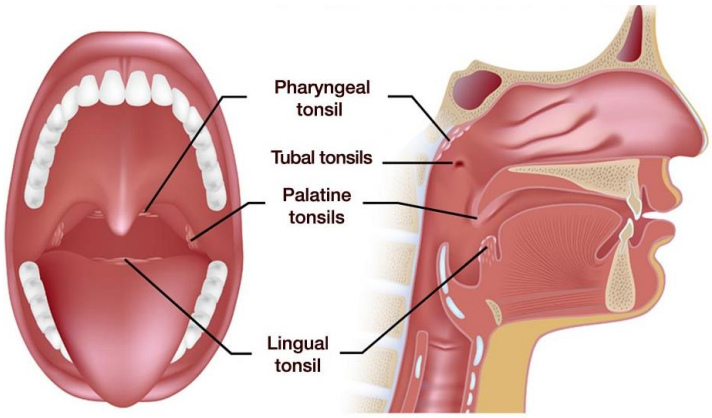
:

Nasopharynx- The nasopharynx corresponds to first and second cervical vertebra (C1-C2). It is attached to the base of the cranium and forms the structure fornix pharyngis. The hard palate and Passavant's muscle form the level of its inferior margin. It is continuous below with the oropharynx and communicates anteriorly with the nasal cavities. The lateral walls are formed by the margins of the superior constrictor muscle and the pharyngobasilar fascia. The pharyngeal tonsils lie in the mucosa in the midline of the roof of the nasopharynx. The mucosal layer is quite irregular as it covers the lingual tonsils, but still visible. The pharyngeal and lingual tonsils are quite visible on examination. The palatine tonsils are not easily visible during endoscopy. This can be visualized by having the patient perform a Müller maneuver, which involves sniffing while the mouth and nose are closed. The tonsils consist of lymphoid tissues which help fight infections, thereby

serving an important function. Clinician will be able to observe if there is inflammation of tonsils (tonsillitis) on endoscopy.

Figure 11

Tonsils in various regions of oropharynx.
*(Source:*https://www.studiodentaire.com/en/glossary/tonsil.php)

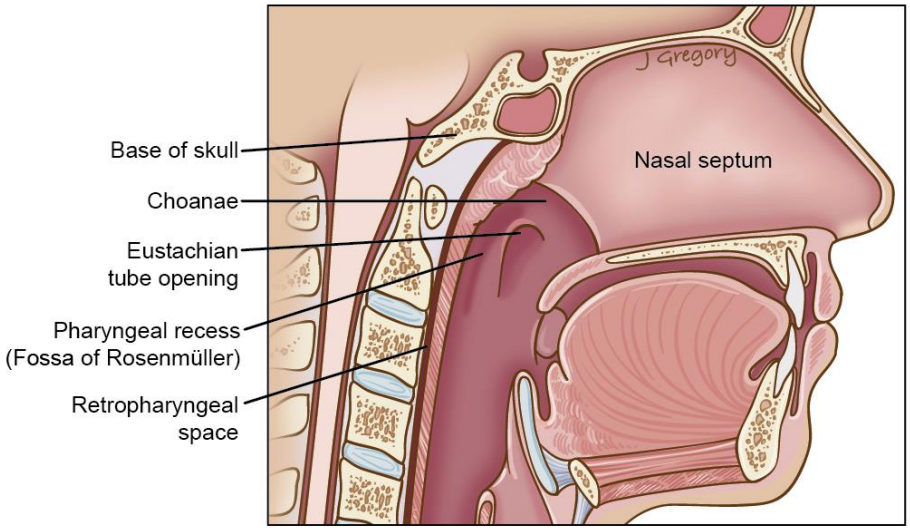


The Eustachian tube openings lie in the posterolateral walls of the nasopharynx on either side. It opens during swallowing and yawning and its repeated movement helps to maintain the normal atmospheric pressure. Patency of eustachian tube is important during swallowing. The Eustachian tube opening along with the cartilaginous Eustachian tube, the levatorvelipalatini muscle, and the overlying mucosa form the torus tubarius.Some causes of ET dysfunction could be scar tissue in the nasopharynx, middle ear problems, narrowing and formation of strictures. Endoscopy can help identify signs of patulous ET(Cetin et al., 2018; Di Martino et al., 2005; Han et al., 2017; Sanu et al., 2018).The recess, called the fossa of Rosenmüller, is situated slightly posterior and superior to the torus tubarius. The fossa is majorly covered with nasopharyngeal mucosa which is commonly seen as a site for nasopharyngeal carcinoma.(Amene et al., 2013). Mucosal folds in the nasopharynx cover the salpingopharyngeus (salpingopharyngeal fold) and levatorvelipalatini muscles. The two muscles open the cartilaginous end of the eustachian tube by pulling in opposite directions during swallowing.

Figure 12

Anatomy of nasopharynx.

(Source:https://www.standardofcare.com/showarticle.php?artid=7150)



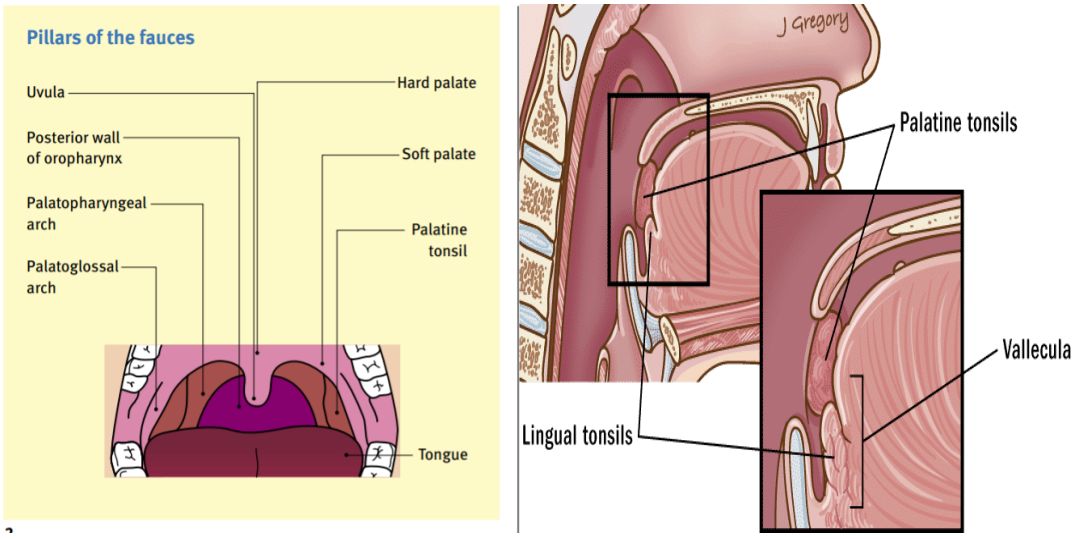
Oropharynx- The oropharynx is the region of the pharynx posterior to the oral cavity. It extends from the inferior level of the soft palate to the upper margin of the epiglottis. Anteriorly, the oropharynx includes the base of tongue which is an important landmark to be noted during the procedure. The tongue base retracts towards the posterior pharyngeal wall during a swallow which creates the pressure to drive the bolus through the pharynx. The tongue base mobility is checked during the procedure by asking the person to move the tongue towards the back of the mouth (tongue retraction). In order to visualize more of the oropharynx, the person can be asked to protrude the tongue. This opens the valleculae, an area of the base of the tongue that is often obscured by the epiglottis. The vallecula is an important landmark to be assessed. One needs to check whether they are symmetrical and if there is pooling of secretions in one or both valleculae. Additionally, one needs to check for any abnormal findings such as swelling, lesions or masses.

Posterior wall of the oropharynx is anterior to the second and third cervical vertebrae. This contracts towards the tongue base during a normal swallow (pharyngeal medialization), which again creates pressure to drive the bolus through the pharynx. During the procedure, this needs to be visualized. Any anatomical abnormalities, change

in colour, etc. needs to be documented.The pharyngeal medializationis checked by asking the patient to phonate a high pitched "ee".It includes the posterior one-third of the tongue (tongue base with collection of lymphoid tissue, the lingual tonsils), palatine tonsils, soft palate, oropharyngeal mucosa, and constrictor muscles. The posterior part of the tongue exerts pressure on the posterior pharyngeal wall to make the ramp ready for the bolus. At this point, the lateral pharyngeal walls also support by approximating towards each other. When the bolus crosses the base of tongue, swallow is said to be triggered. It can get collected in the space between tongue base and epiglottis i.evalleculae. The anterior palatoglossal arch (overlying the palatoglossus muscle) and the posterior palatopharyngeal arch (overlying the palatopharyngeusmuscle) are present in the lateral oropharyngeal wall. The palatine tonsils lie in the tonsillar fossa between the two arches. Both the arches help in separating the oropharynx from the nasal cavity.

Figure 13

Anatomy of oropharynx. (Source: https://thancguide.org/cancer-types/throat/pharyngeal/oropharyngeal/anatomy/)

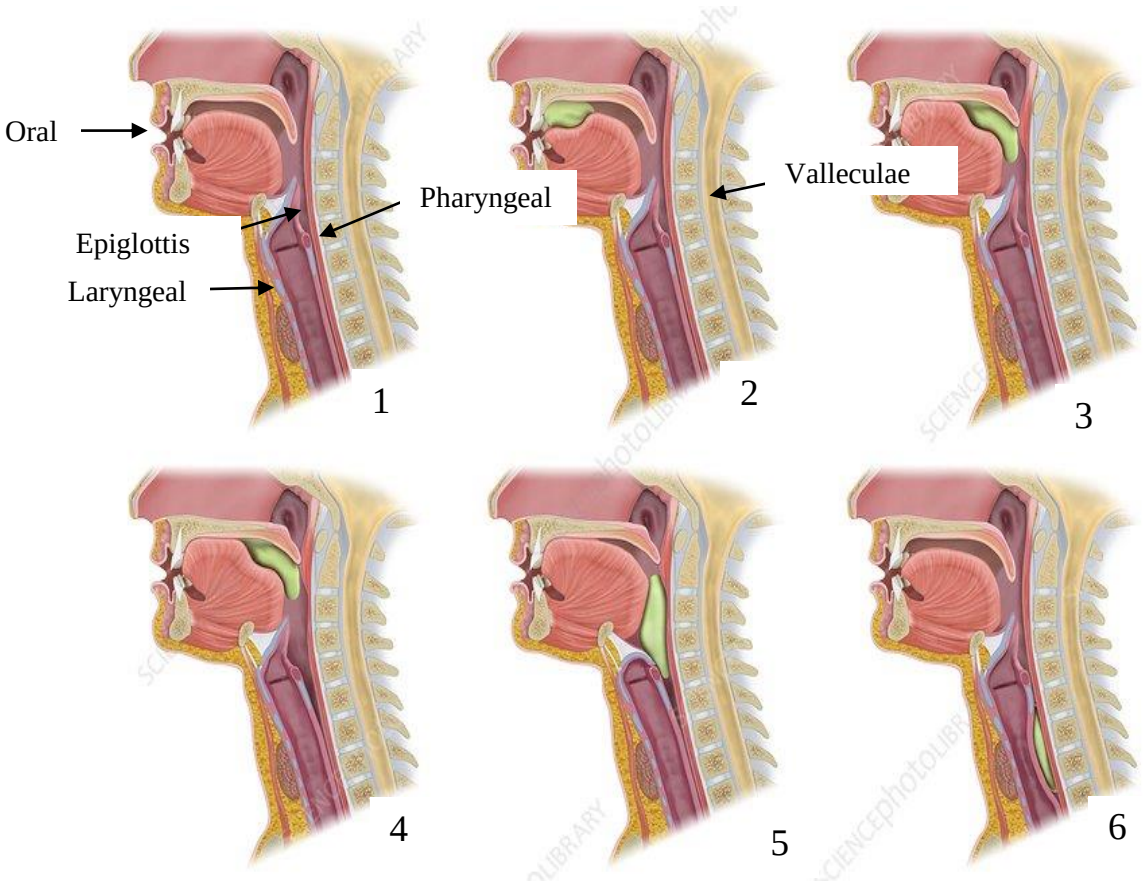


Hypopharynx- The hypopharynx or laryngopharynx, extends from the level of the hyoid bone (and valleculae) to the cricopharyngeus. As the tip of the scope is advanced to the level of the uvula in the hypopharynx, the epiglottis will be visible. The shape of the epiglottis needs to be assessed during the scopy. If it curls touching the base of the tongue, it could prevent the material from entering the valleculae. Once the bolus is collected in the valleculae, a series of movements begin to seal off the lower airway. It starts progressively from bottom to up. First, the vocal folds adduct thereby closing the glottis.

Next, the false vocal folds and arytenoids bend to contact the epiglottis before the upper esophageal sphincter opens. The epiglottis performs aerial dance movement by tilting backwards, also called as “epiglottic inversion”. The additional push is given by superior and anterior movement of the hyoid bone due to the thyrohyoid and suprahyoid muscles.

Figure 14

(1) Oral, pharyngeal and laryngeal structures at rest (2) Bolus (green) formed in the oral cavity (3) As the swallowing action starts, the bolus is pushed towards the back of the mouth with the tongue. (4) As muscles in the throat contract, the tongue moves further back and the bolus moves down the throat (5) Epiglottis inversion and anterior movement of hyoid takes place (6) The bolus enters the oesophagus, where smooth muscle contractions as part of a process called peristalsis move it downwards to the stomach. (Source:https://www.sciencephoto.com/media/1030898/view/swallowing-mechanism-illustration)



The hypopharynx is continuous superiorly with the oropharynx and inferiorly with the cervical esophagus (level of C6). The posterior oropharyngeal wall continues inferiorly as the posterior wall of the hypopharynx, behind which lies the retropharyngeal space.The pyriform sinus is a pear-shaped anterolateral recess situated on either side of the hypopharynx. It is related anteriorly to the posterior paraglottic space of the larynx. The apex of the pyriform sinus lies at the level of the true vocal cord. The lateral wall of the pyriform sinus is formed above by the thyrohyoid membrane and below by the thyroid cartilage. The lateral surface of the aryepiglottic fold forms its medial wall. During the process of swallowing, solids and liquids are directed via the pyriform sinuses into the cervical esophagus, while the vocal folds close, so that the food does not enter the lungs through the trachea. Individuals diagnosed with pharyngeal dysphagia may have post swallow residue in the pyriform sinuses. During the procedure, the shape and symmetry of the pyriform sinus needs to be assessed. Additionally, one needs to check for any abnormal findings such as swelling, lesions or masses.

Larynx

The larynx is situated in the inferior portion of the pharynx and is readily accessible to endoscopic examination; in fact, the earliest laryngoscope was a simple modified dental mirror. It spans across third to the sixth cervical vertebrae (C3-C6). Anatomy of the larynx can be divided into the supraglottis, the glottis, and the subglottis. Glottis is another term for the vocal folds.

The main endoscopic features of the supraglottis are the midline epiglottis and the two folds that extend downward from it to the arytenoid complex in the posterior supraglottis. The epiglottis, as explained earlier, shows itself in variations but is usually slightly curved, with its concave surface facing posteriorly. As this surface extends down toward the anterior commissure of the glottis, in some patients a notable protuberance in the midline, known as the operculum, may be seen.The anterior commissure can be seen between the two vocal folds at the top portion. It is a common site for rise of mass size lesions such as vocal nodule, vocal polyps etc.(Ford et al., 1994; Grant, 1998; Krespi & Meltzer, 1989; Prades et al., 2017).

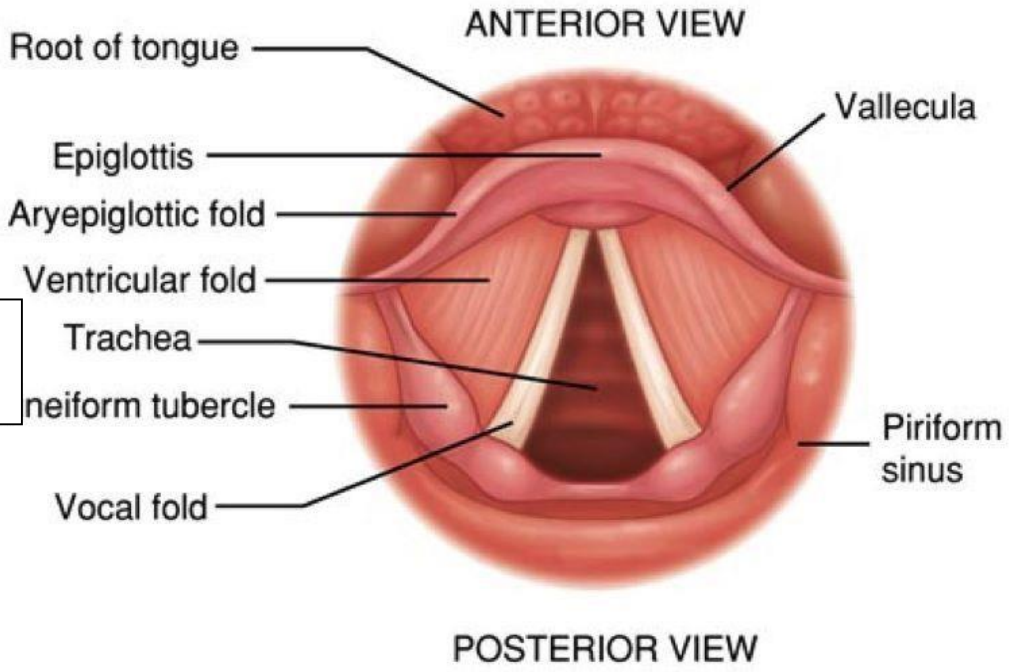
The glottis closes at three levels to protect the airway during a swallow: True vocal fold closure, false vocal fold closure and base of epiglottis to aryepiglottic folds. The larynx elevates and moves forward during a swallow which protect the airway from aspiration and pulls open the cricopharyngeal sphincter, which helps bolus to pass into the esophagus.

It is important to assess the ability to adduct or close the vocal folds, which can be done by asking the person to hold breath. The colour and its position should be assessed. Additionally, the presence of abnormal findings such as swelling, lesions or masses on the vocal folds should also be documented.

Laterally, the aryepiglottic folds extend down to the arytenoids. The inferior free edges of the supraglottic structures are known as the false vocal folds.The laryngeal ventricles are the only structures thatseparate the false vocal folds from the glottis itself. The aryepiglottic folds and false vocal cords also should be assessed for color, position and any other abnormal findings.

Figure 15

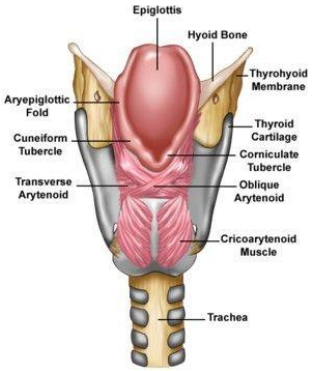
Anatomy of vocal folds as seen on endoscopy. (Source: https://cramdvoicelessons.blog/encyclopedia/supraglottic-distortion/)



(False vocal folds)

Figure 16

Anterior-Superior view of larynx. (Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.pinterest.com%2Fpin%2F326651779224324575%2F)



Paired arytenoid cartilages and the small accessory structures that cover them (the corniculate and cuneiform), dominate the posterior supraglottis(figure 17). The body of the arytenoid features two major prominences, the muscular process extends laterally and is not visible endoscopically; however, the vocal process, which is the posterior attachment of the vocal fold, can be visualized.

Although the superior surface is the region that is most accessible for examination, pathology can be present on any or all of the surfaces. The infraglottic surface of the vocal fold extends laterally as it heads inferiorly, corresponding to the underlying structure of the conuselasticus. The inferior part of the larynx is the subglottis. Although there is no standard consensus to demarcate its superior boundary, posteriorly it extends downupto to the cricotracheal junction. A commonly used rule states that the subglottis begins 5 mm inferior to the vocal fold anteriorly but 10 mm posteriorly, reflecting the great height of the cricoid in the back and its much smaller size anteriorly. Although the subglottis may have stenotic lesions, malignancy, or inflammation, in general, it is the area of the larynx with the lowest prevalence of pathology. This area may be examined in most cooperative unsedated patients by carefully approaching the area with a flexible endoscope without touching any mucosa, which can trigger cough or other reactions. It is preferred to direct the scope at the anterior commissure and then aim the adjustable portion of the scope posteroinferiorly.

Highlights:

- During FEES the nasal, oro-pharyngeal and laryngeal structures are visualized
- Major landmarks for endoscopy in the nasal cavity include the nasal turbinates, lateral wall of nose and the septum
- Major landmarks for endoscopy in the Nasopharynx includes the Adenoid, fossa of Rosenmuller, and the soft palate
- Major landmarks for endoscopy in the Oropharynx includes the base of tongue, epiglottis, and valleculae

Test your knowledge

Multiple Choice Questions

1. Why is endoscopy done?

a) To visualize swallow structures using radiation

b) To help visualize swallow structures not visible to naked eye

c) To visualize swallow structures using pressure transducer

d) None of these

2. Name the structure through which the scope is insertedinto the nasal cavity during FEES.

a) Through both nares

b) Through one of the nares

c) Through nasal bridge

d) Through nasal turbinates

3. What is the first structure to be observed on the lateral wall of the nose?

a) Nasal choanae

b) Nasal turbinates

c) Soft palate

d)Paranasal sinuses

4. How can clinicians identify the soft palate endoscopically?

a)Curved structure at the beginning of nasal cavity

b) Curved structure at the end of nasal cavity

c) Smooth structure at the end of nasal cavity

d) Smooth structure at the beginning of nasal cavity

5. Which part of the oropharynx is not easily visible during endoscopy?

a) Lingual tonsils

b) Soft palate

c) Posterior pharyngeal wall

d) Palatine tonsils

6. Which part of the larynx is known for least prevalence of pathology?

a) Subglottis

b) Supraglottis

c) Vocal cords

d) Arytenoids

7. What is the phenomenon which occurs when vocal folds adduct?

a) Epiglottic flexion

b) Epiglottic extension

c) Epiglottic inversion

d) None of these

8. Where does pharyngeal residue get collected in larynx?

a) Pyriform recess

b)Valleculae

c) Epiglottis

d) Oropharynx

9. Which of the following does not get visualized during endoscopy?

a) False vocal cords

b) True vocal cords

c) Muscular process of arytenoids

d) Vocal process of arytenoids

10. Where should clinicians direct the scope **first** in the laryngeal area?

a) Anterior commissure

b) Posterior commissure

c) Posteroinferiorly

d) All of the above

‘

CHAPTER II

EQUIPMENT REQUIREMENT FOR FEES

Before we start learning about the FEES instrument and its specifications, do you know who should we be thankful to? Think of the professionals who work round the clock to make human life easier and comfortable. They are the engineers. Without them, it would not be possible to have such instruments in the first place.

Imagine you have got a new mobile phone. You would be interested in knowing all the functions and specifications, right? You would not want to buy a phone without knowing the brand, feasibility, pricing, longevity, care and maintenance and most importantly, specifications of the camera. Just like that, when you have a FEES instrument by your side or when you want to buy one, you need to be aware of basic mechanism of endoscopy and the equipments required for it for better use and understanding of the entire procedure.

Learning objectives:

At the end of this chapter, you will be able to:

1. **Describe the equipment required for FEES**
2. **Understand the rationale behind using the equipments**
3. **Understand basic types of FEES instruments**

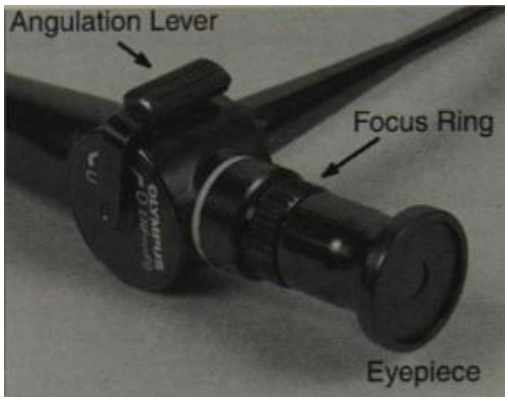
The Greek prefix “endo” means inside or within, therefore endoscopes were first used in 1860’s to visualize the internal body organs. For the purpose of this chapter, we will restrict the meaning of endoscopy to be used for swallowing evaluation. It looks like a long thin tube which is to be inserted through a body cavity as can be seen in the figure.

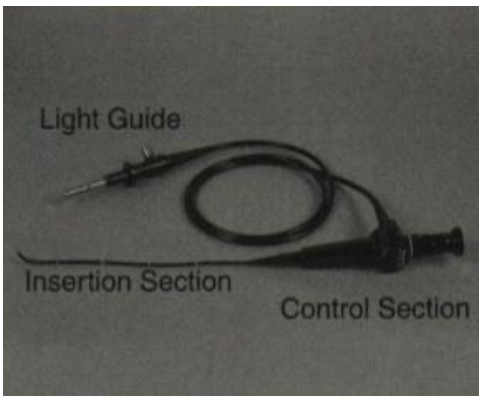
Figure 17

Endoscope.

Figure 18

Parts of scope.





How does an endoscope become a laryngoscope? It depends on the purpose we use the endoscope for. If we use it for voice evaluation, we call fiberoptic laryngoscopy (FOL). If we use it to assess swallowing, we call it Fiberoptic Endoscopic Evaluation of Swallowing (FEES). As it can be seen in the figure, parts of the scope can be understood in two sections: insertion and control.

Insertion section

Any advancement in technology leads to a smaller version of the previous one with more features. Similarly, there has been reduction in the size of the insertion portion of scope over the years, because we want minimal interruption of the scope and maximum visualization of the internal body structures. The insertion portion is the long black tube which will be inserted from the patient's nares till the level of upper pharynx. At the end of the scope, you can see a small rounded structure, called the objective lens. Structurally, it consists of multiple optical fibers enclosed in bundles. The function of the fibers is to transmit the images from the distal lens to the proximal lens. The typical diameter of the scope is kept 3-4 mm for comfortable insertion and removal.

Although the lens provides pixel quality image, it can lead to distortion effects.This phenomenon occurs because of using a wide angle lens, which could lead to enlargement of the image in the middle portion.This can be avoided by having a referenced endoscope image with known object size and other essential information compared to a distorted target image in order to determine their relationship and estimate the true size and get other information from the target image (Hsu et al., 2005).

Control section

Flexibility of the scope is enhanced with the help of control section which allows moving the scope to achieve a wide angle field of view, also called angulation. This can be done by manipulating the angulation lever as seen in the figure. The base of the palm is used for manipulation of the scope. A modern fiberscope provides as much as 130 degree angle view. The control section of the scope can have additional channels for suction, water or air depending on the purpose and use.

Light source

As the name suggests, light source is going to illuminate the mucosal surface by reflecting lightwith the help of xenon or halogen source.This is done with the help of optical transmitter and receiver. These are pressure transducers responsible for converting electrons to photons, which when received by a detector converts photons back to electrons. It is believed that xenon provides more natural light to view the mucosal surface, whereas halogen gives out a bluish hue.

Light Source= Optical transmitter + Optical receiver

Both the optical transmitter and optical receiver are connected to the eye piece of the scope. A simple light source device comprises of a bulb and cooling fan.

Figure 19

Mechanism of light source.

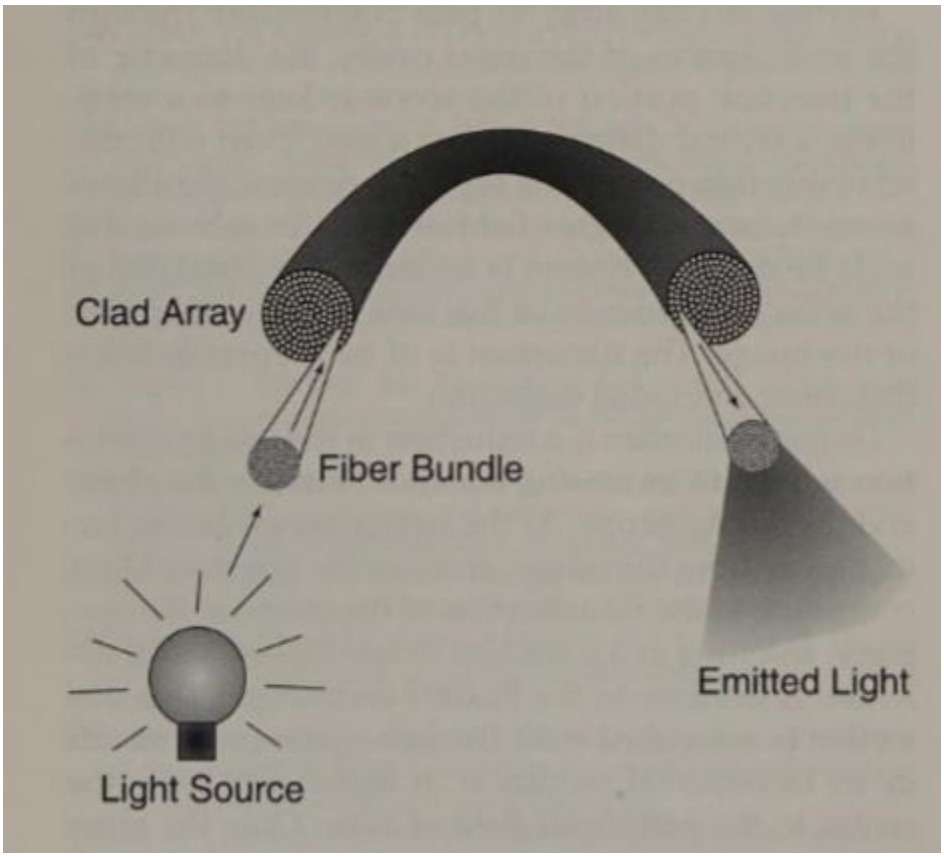
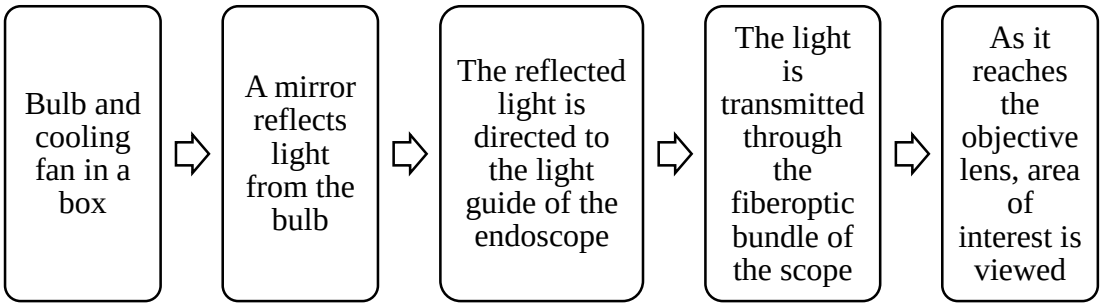


Figure 20

Summary of mechanics of light source.



As it can be observed in the above flowchart, bulb and the cooling fan are essential parts of the light source. A mirror placed inside the light source reflects light from the bulb.The reflected light is directed into a beam that is directed toward the endoscope's light guide. The light is then sent through a separate fiberoptic bundle from the image-carrying bundle. From the light guide to the distal tip of the scope, the light-carrying bundle travels the length of the scope, where it is dispersed by the lens system to brighten the area of interest.

Some endoscopes have channels for the delivery of air, suction, or water in addition to the light bundles. Fine, flexible devices such as suction tubes, snares, biopsy forceps, or gripping forceps can go from an opening in the control portion of the scope to the distal tip of the endoscope through these channels.

Several critical qualities must be present in a suitable suction/biopsy channel material.

- To ease movement of the bending portion, it must be flexible and capable of bending 240 degrees in a one-inch diameter circle.
- The material must be tough enough to maintain its circular shape while still being malleable enough to avoid putting strain on the delicate fibre bundles.
- It should not buckle when flexed, allowing instruments to slide through smoothly. The channel's inner surface, which comes into touch with the equipment, should be solid, slick, and long-lasting.
- Chemically resistant channel tubing must be resistant to alcohol, disinfectants, mild acid sterilants, and bodily fluids.
- To enable for leak testing and automated reprocessing, the channel and seals must be able to sustain pressures of up to 20 pounds per square inch.
- The material's ability to be fastened to a fitting is another crucial feature. To avoid binding or snagging the other internal components, the tubing's exterior surface must be smooth.

A vacuum is pulled through the suction channel in the light guide tube up through the body when the suction pump is turned on and its tubing is linked to the endoscope. The suction valve is meant to let air into the suction system from the outside. The air leak is sealed when the valve is activated, and vacuum is transmitted through the biopsy channel to the tip. If the biopsy valve is not in place and in excellent functioning order, outside air

will escape into the system, preventing a vacuum from reaching the distal tip. It can be used to suction the pharyngeal secretions if the patient is unable to clear himself.

Figure 21

Suction channel of the endoscope.
(Source:https://www.google.com/url?sa=i&url=https%3A%2F%2Flink.springer.com%2Fchapter%2F)

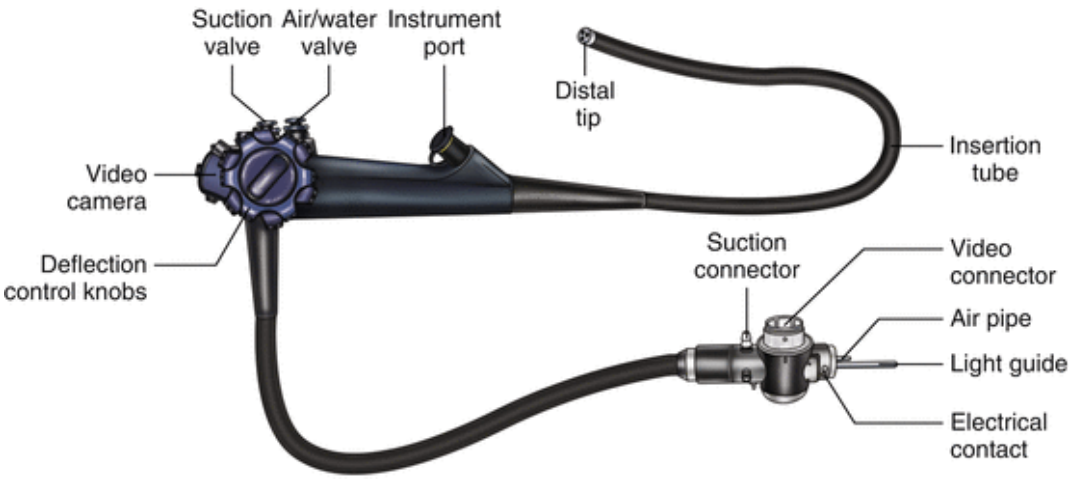


Figure 22

Chip camera

The examiner can look at the image of interest by directly looking through the eyepiece or using a chip camera, which would convert the image to a video signal as shown in the figure17. This function facilitates recording and viewing as many times the examiner wants on a video recorder. This portion is made up of another lens system which is attached to the eyepiece of the endoscope and a charged coupler device. The charged coupler device is responsible for converting the light directed to the eyepiece into video signal which is displayed on a video monitor and recorded using a videocassette recorder. It is common to find chip cameras having “auto-iris” function nowadays, which basically means it adjusts the amount of light to be transmitted for different surfaces. For example, the pharynx squeezes around the scope when a patient swallows reflecting a bright white light, also called “white-out”. The endoscopy will give us information of swallowing before and after a patient swallows and not during the swallow due to whiteout.

FEES instrument are available as workstations wherein endoscopy is one of the modules along with cervical auscultation, surface electromyography and others. They are also called stand-alone equipments. It can be available as a portable unit in a suitcase like box which is a great advantage for bedside evaluations. A list of the manufacturers and equipments designed by them for endoscopy is available in the chapter 7.

Highlights:

- Endoscope helps to view any body orifice; the one used for swallowing structures is called FEES
- Main parts of the endoscope are fiberscope, chip camera and light source
- The scope has two sections: the one which is inserted in the body cavity and another which provides flexibility to the scope called insertion and control section respectively
- Typical diameter of the scope is 3-4 mm
- Light source is used to view the mucosal surface
- Chip camera will convert the image captured to video signal to be viewed later
- When the pharynx squeezes around the endoscope, bright white light is emitted called white out
- Endoscopy provides information about before and after swallow and not during the swallow due to white out

Test Your Knowledge

1. What does an endoscope do?

a) Scan the organ of interest

b) View the organ of interest

c) Trace the organ of interest

d) Enlarge the organ of interest

2. What is the typical diameter of the scope?

a) 1-2 mm

b) 3-4 mm

c) 5-6 mm

d) 7-8 mm

3. What property allows the endoscope to be flexible?

a) Termination

b) Elevation

c) Angulation

d) Automatization

4. What is the function of light source?

a) To flash light

b) To illuminate the scope

c) To convert photons to electrons

d) To convert electrons to photons

5. Which device converts light into video signal?

a) Charged coupler device

b) Lens system

c) Chip camera

d) Angulation lever

6. What is the phenomenon called when the pharynx squeezes around the endoscope?

a) Black out

b) White out

c) Black in

d) White in

7. What is it called if you can use FEES in multiple settings?

a) Standalone equipment

b) Portable equipment

8. What is it called if the lens automatically adjusts the amount of light on different surfaces?

a) Auto-light

b) Auto-tech

c) Auto-iris

d)Auto-transfer

9. To what extent can fiberscope provide angulation view?

a) 70 degrees

b) 90 degrees

c) 130 degrees

d) There is no specific number

CHAPTER III

STILL FEES IMAGES WITH AND WITHOUT BOLUS OF HEALTHY INDIVIDUALS

We have now reached the most important part of tutorial i.e. being able to identify important landmarks on still FEES images. We have already seen an overview of anatomy and physiology of structures required for swallowing, now let us see how they look from the eyes of an endoscope.

Learning objectives:

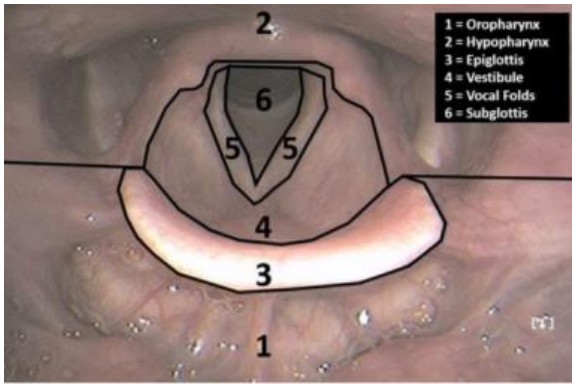
At the end of this chapter, you will be able to:

1. **Understand process of endoscopy in a step by step manner**
2. **Familiarize with FEES images with and without bolus**
3. **Identify important anatomical landmarks of FEES image**
4. **Understand normal variability of structures in healthy individuals**

One important point to keep in mind is that the diagrams, graphics and animated videos which we see in books and online are not always truly representative of how the structures look during endoscopy. The best way to study anatomy is watch videos and familiarize yourself with graphics representing real pictures. Line drawings and animated videos help supplement your knowledge but you must not rely on them for studying human anatomy. The figure below depicts the anatomical landmarks as seen on FEES.

Figure 23

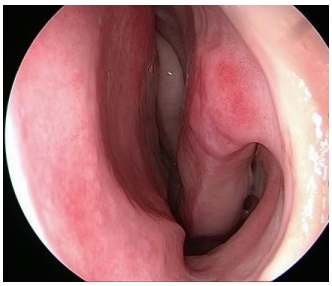
Anatomic landmarks as seen on FEES including oropharynx. (1), hypopharynx (2), epiglottis (3), laryngeal vestibule (4), vocal folds (5) and subglottis (6) (Source: https://doi.org/10.1007/s00455-020-10131-0)



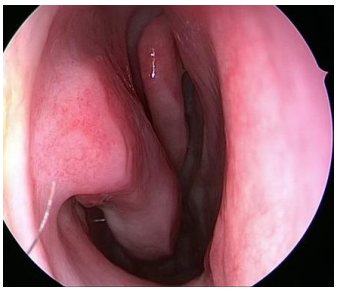
Now that you have got your background knowledge about anatomy and basics of endoscopy, we are ready to take a step ahead learning about FEES. It is typically done in two parts, once without the bolus and then with the bolus. When it is done without the bolus, we are interested in looking at the shape, size and configuration of structures at rest and how much does it deviate from the normal. The clinician must spend enough time observing the appearance and function of structures because it will help when we assess with the bolus. Bolus can be of different sizes and consistencies that are introduced in a graded manner during FEES.

FEES images without bolus

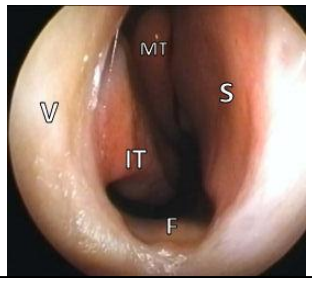
Imagine yourself to be the one doing FEES. You will observe the structures in the same sequence as can be seen below



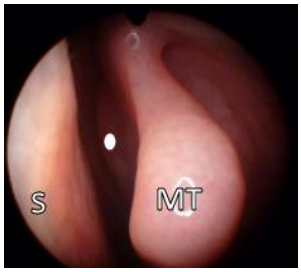
Right nasal cavity



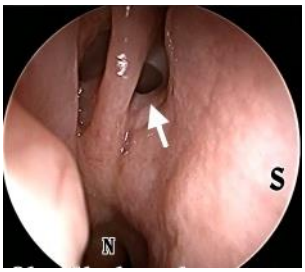
Left nasal cavity



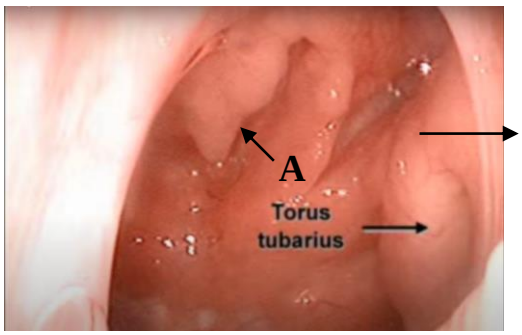
V-Vestibule, S- Nasal Septum, MT- Middle Turbinate, F-Floor of Nose, IT- Inferior Turbinate



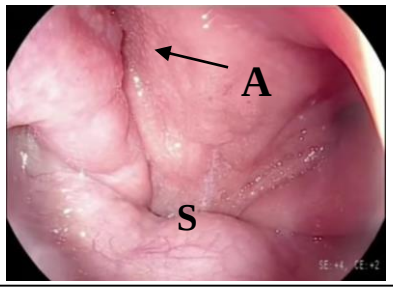
Normal superior turbinate barely visible (oval)



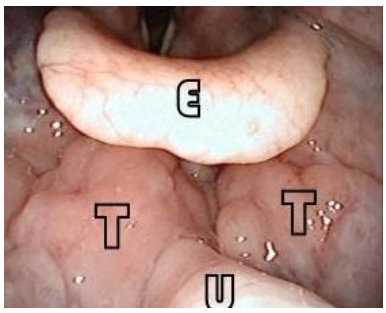
A-Adenoid S- Soft palate



Arrow-Patent sphenoid sinus N-Nasopharynx S-Septum



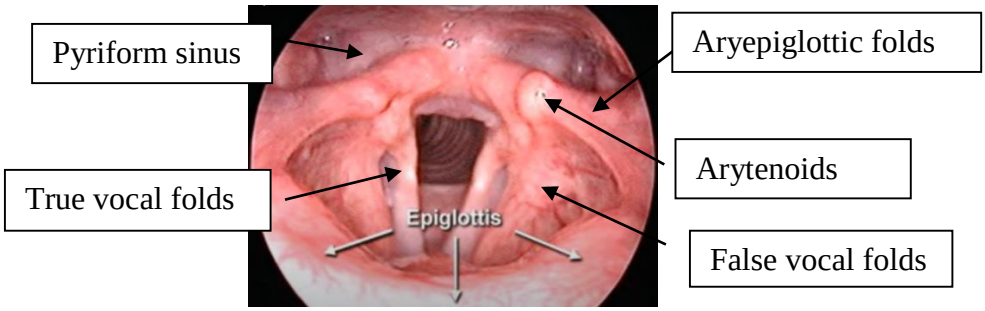
A-Adenoid RF-Rosenmuller Fossa



E-Epiglottis T-Tongue U-Uvula/Soft palate

Figure 24

FEES Images in a sequence without bolus. (Source: https://doi.org/10.1007/s00455-020-10131-0)



FEES images with bolus:

During the second part of FEES procedure, boluses of different consistencies (thin liquid, thick liquid, pureed and solid) are used. There are standard boluses recommended, which will be dealt with in the next chapter. The person will be expected to swallow these boluses in small volumes/sizes which could range from 1ml to 20 ml or half a cookie to one cookie). During bolus administration, various food dye/colouring agents can be used to improve endoscopic visualization and detect residues in spaces like valleculae, pyriform recess, subglottis etc. However, use of such agents has been contraindicated by some authors to avoid exposing the patient to foreign chemicals ((Labeit et al., 2019)add authors here). Clear FEES images can also be obtained with natural foods such as milk, curd, and cookie. The decision to use or not use remains with you, if you feel confident identifying structures and important events of swallow without food dye, then it will not be necessary to use it. Below you can find images with blue dye, green dye, milk and plain water.

Figure 25

FEES images with milk (left) and white dyed water (right). (Source: https://doi.org/10.1007/s00455-020-10131-0)

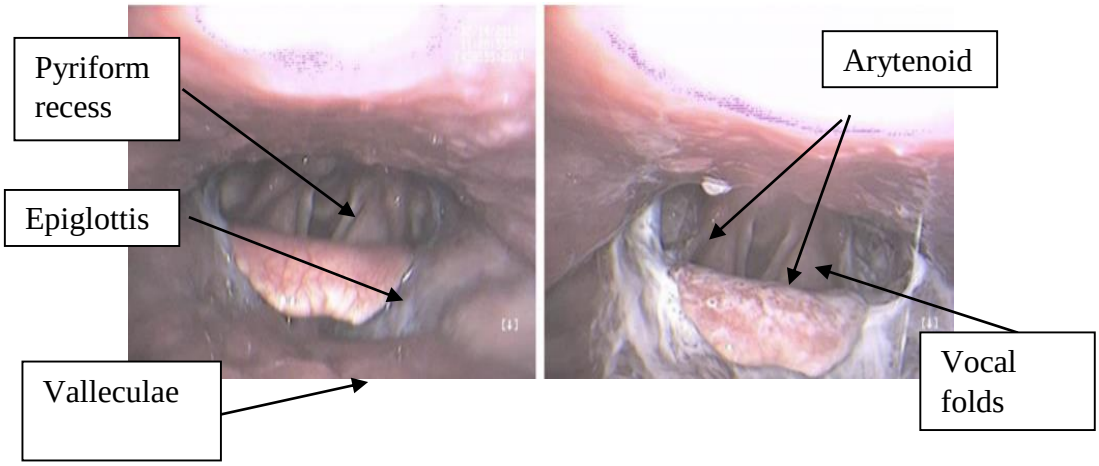
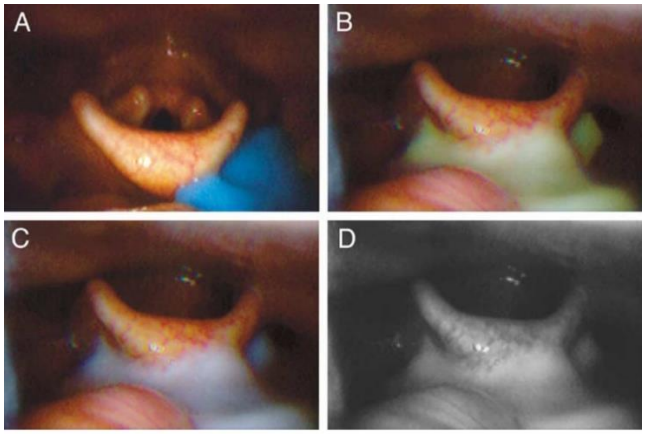


Figure 26

FEES images with blue dyed bolus (A), non blue-dyed bolus of vanilla pudding (yellow) (B), non blue-dyed bolus of skim milk (white) (C) and monochrome food bolus (black and white) (D). (Source: https://doi.org/10.1007/s00455-020-10131-0)



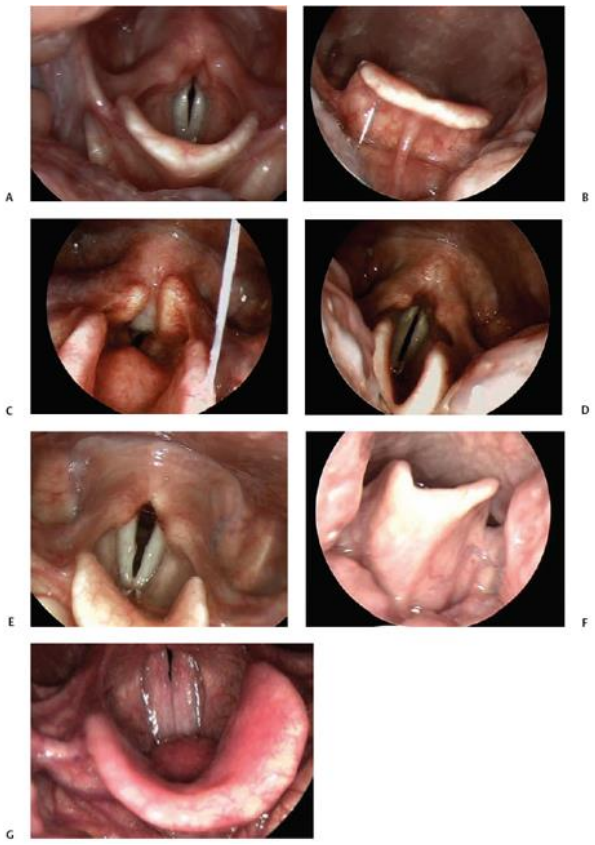
The landmarks outlined above are critical in understanding the "normal" anatomy of swallow before studying the disordered population. Having said that, within normal swallow also, there can be many variations with respect to size, shape and symmetry of structures, but eventually the structures are able to function adequately despite the variations. Few such variations are listed below:

- The laryngeal vestibule can be of many sizes and shapes, which determines how easily bolus can flow through the hypopharynx into the esophagus.
- Position and shape of the epiglottis is of utmost importance as it is one of the primary structures which would be providing protection to the larynx against aspiration. It will also decide the dimensions of the vallecular spaces that will hold up the bolus that spills in the hypopharynx. If the epiglottis rests on the tongue, it will wipe out the vallecular space and the bolus will be directed towards the laryngeal surface leading to penetration.
- The aryepiglottic folds which are low-lying may create shallow lateral channels and cause a bolus to spill in the laryngeal vestibule laterally, especially at the aryepiglottic folds

- Arytenoids that lie close to the posterior pharyngeal wall reduce the post-cricoid space and increase the possibility of bolus spilling over the arytenoids and laryngeal vestibule.
- The hypopharynx dimensions will determine the pharyngeal width and circumference. A narrow pharyngeal wall will reduce the width and depth of lateral spaces which could eventually make the bolus fall into the larynx.

Figure 27

(A) *Typical appearance of the epiglottis during laryngeal imaging.* ***(B)*** *In this image, the epiglottis has less curvature as seen from the lingual surface of the structure. The vallecula is open and easily visualized in this example.* ***(C)*** *This is an example of an omega-shaped epiglottis. The rim is U-shaped.* ***(D)*** *Asymmetry of the epiglottis is within the range of normal variation. This example demonstrates an asymmetric and very curved epiglottis.* ***(E)*** *This epiglottis has a "normal" amount of curvature but is asymmetric, with an L-shape.* ***(F)*** *This lingual surface view of the epiglottis reveals the asymmetry in the shape of the epiglottic cartilage.* ***(G)*** *The base of the epiglottis is quite prominent. (Source: https://entokey.com/normal-laryngeal-variability/)*



Such variations do not interfere with swallowing in normal healthy individuals, though aspiration and penetration have been reported. However, this occurs to a lesser extent due to some compensations that occur at the pharyngeal level. A study conducted in 2018 observed events of penetration and aspiration in 203 healthy adults across the life span by studying the effects of age, sex, bolus type, bolus volume and bolus delivery. Interestingly, they found that 50% of the participants penetrated and 18% aspirated among the healthy cohort. Silent aspiration due to poor sensation at laryngeal level was found to be present in 75% of the participants. (Butler et al., 2018)

Physiological markers such as old age (more than 70 years), bolus of milk instead of water and larger volumes (15 or 20 mL) increases the odds of penetration and aspiration. The next thing that comes to our mind naturally is, what do these findings mean from a clinical standpoint? Do they develop complications like that observed for group of individuals having swallowing disorders, or does a compensation mechanism exist? The same group of healthy adults were taken up for a computed tomography examination to find that there were no signs of pneumonia or bronchopulmonary disease, which suggests some kind of compensation by swallow structures that do not interfere with swallowing function.

One interesting finding is that males demonstrated greater penetration than females for larger bolus volumes than smaller bolus volumes. The reasons for such a finding are:

- Males are observed to have more geniohyoid atrophy.
- Posterior position of the hyoid bone
- Later onset of laryngeal closure
- Shorter laryngeal closure
- Less posterior isometric tongue strength
- Lower pharyngeal peak pressures

Thus, it is important to look at patient's history, swallowing ability, risk factors and other physiological markers and not consider aspiration as the only benchmark to diagnose a swallowing impairment.

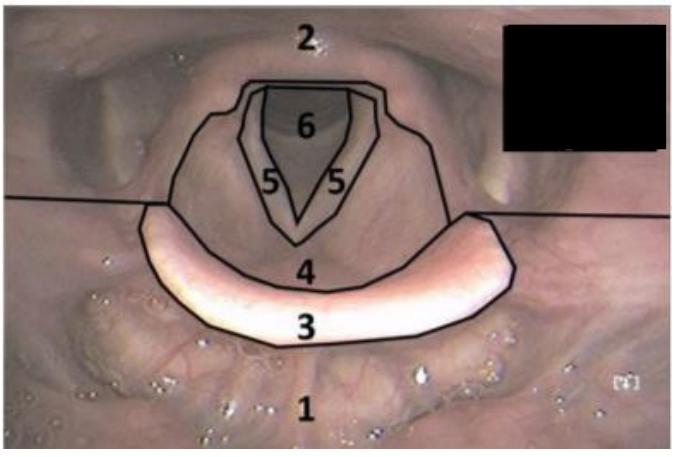
Highlights:

- FEES is done once without the bolus and with bolus
- Bolus of different size and consistencies are utilized which can be visualized using natural foods without the use of dye
- Normal anatomy involves many variations in the laryngeal vestibule, epiglottis, arytenoids, aryepiglottic folds and hypopharynx, but eventually they are able to function adequately
- Physiological markers such as age, bolus size and volume influences the extent of penetration and aspiration
- A holistic perspective is required while assessing the patient's swallowing impairment

Test your Knowledge

Multiple Choice Questions:

1. Label the structure labelled 3 in the below diagram.



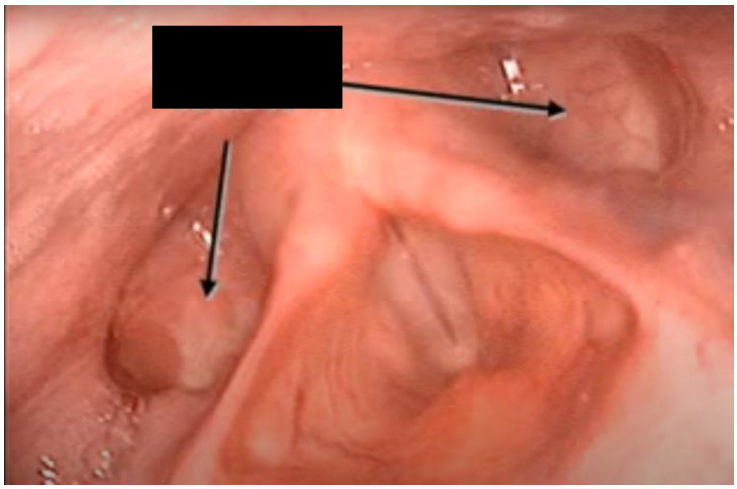
a)Subglottis

b)Supraglottis

c) Epiglottis

d) Pyriform sinus

2. Label the space indicated by the black arrows.



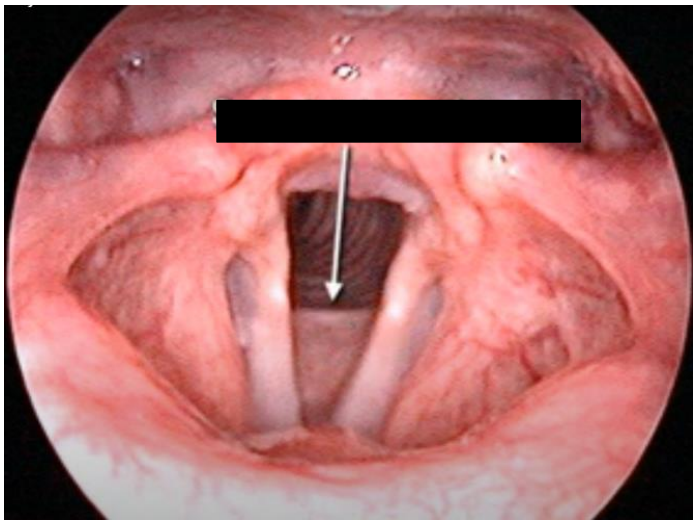
a)Valleculae

b) Pyriform sinus

c) Epiglottis

d)Subglottis

3. If bolus passes through this region, it means the bolus is aspirated. Which region is it?



a) Supraglottic region

b) Subglottic region

c) Glottic region

d) None of the above

4. What is the best way to learn about anatomical structures of endoscopy?

a) Study line drawings

b) Draw out the structures

c) Study endoscopic structures

d) Do all the above

5. “All normal healthy individuals have the same configuration, size, symmetry of structures”. Comment if this sentence is true or false.

a) True

b) False

c) Maybe

6. “Aspiration is a phenomenon which occurs in both healthy individuals and individuals having swallowing impairments with the latter having more frequency”. Comment whether this sentence is true or false.

a) True

b) False

c) Maybe

7. Think of all physiological markers that a speech- language pathologist must look for in a patient with swallowing impairment _____

8.Is it possible to have a difference of swallowing impairment based on gender?

a) Yes, males have it more

b) No, females have it more

c) It is the same for both

9. What would happen to the bolus if the pharyngeal wall is narrow?

a) It won’t make any difference

b) There could be higher chances of bolus falling into the larynx

c) The bolus would be stuck in the larynx

10. What happens when there is silent aspiration?

a) Laryngeal sensations are reduced

b) Laryngeal sensations are increased

c) Laryngeal sensations are unchanged

d) Laryngeal sensations are not related to silent aspiration

CHAPTER IV

PROTOCOL FOR ADMINISTRATION OF FEES

In this chapter, we will be discussing about the protocol for FEES as well as the steps you need to know about before trying out the protocol such as obtaining consent, preparing the patient for the evaluation and ensuring oral hygiene.

Learning objectives:

At the end of this chapter, you will be able to:

1. **Understand the importance of obtaining consent before evaluation**
2. **Prepare patient before evaluation begins**
3. **Administer the two-part protocol**
4. **Understand the protocol for paediatric population**

I. Informed consent

FEES is a diagnostic procedure to assess the pharyngeal phase of swallow and is being increasingly used by clinicians, however, it is not without risks. The extent of complications depends on the skill of the examiner, severity of the condition, cooperation from the patient, associated medical problems. The risks involved with FEES stress the importance of informing the patient of these, which is called as “informed consent”. Since there is always a 1% chance of error, every time you put the patient at any risk, you must inform the patient about the possible complications that could arise during or after the procedure so that atleast, they are able to deal with the situation better and you do not have a lawsuit in your hands. The format for obtaining the informed consent is provided in Figure 25, which could be modified based on the place of work. Some of the common complications that could arise in the order of frequency of occurrence (Nacci et al., 2016) are listed below.

1. Discomfort

2. Gagging

3. Vomiting

4. Anterior epistaxis (Nose bleed from anterior portion of nasal cavity that requires medical attention)

5. Posterior epistaxis (Nosebleed from posterior portion of nasal cavity that requires medical attention)

6. Laceration of mucosa (skin tear or cut in the nasal mucosa)

7. Vasovagal episodes (Slowing of heart rate, fainting)

8. Adverse reactions to topical anaesthetic

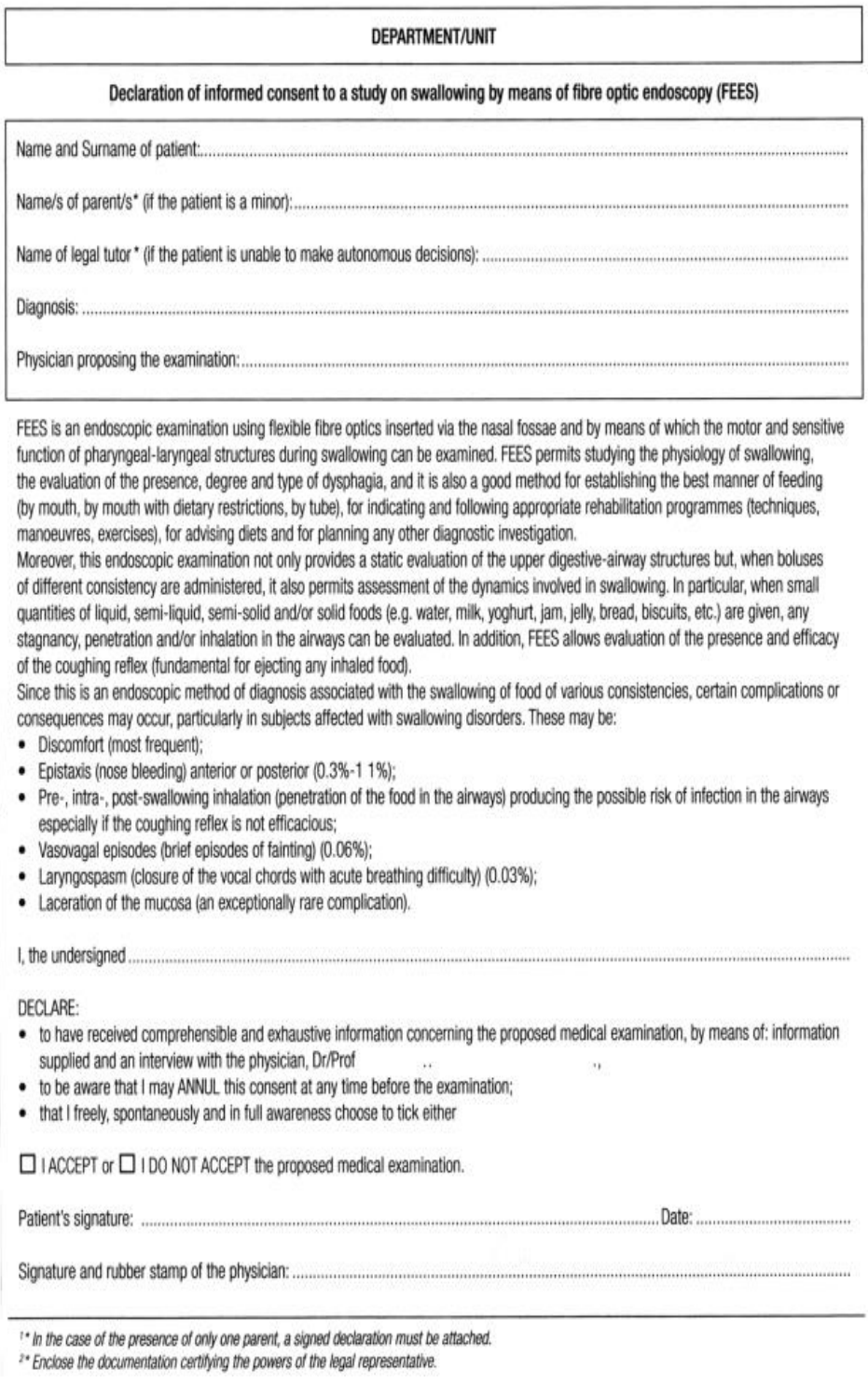
9. Adverse effect of methylene blue

10. Laryngospasms (sudden spasms of vocal folds)

Most of these symptoms are self-limiting and hence, FEES is known as a safe procedure with minimal complications. Given below is a published informed consent form (A. Nacci et al., 2008).

Figure 28

Informed Consent. (Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2644994/)



DEPARTMENT/UNIT

Declaration of informed consent to a study on swallowing by means of fibre optic endoscopy (FEES)

Name and Surname of patient:.....

Name/s of parent/s* (if the patient is a minor):.....

Name of legal tutor * (if the patient is unable to make autonomous decisions): .....

Diagnosis: .....

Physician proposing the examination:.....

FEES is an endoscopic examination using flexible fibre optics inserted via the nasal fossae and by means of which the motor and sensitive function of pharyngeal-laryngeal structures during swallowing can be examined. FEES permits studying the physiology of swallowing, the evaluation of the presence, degree and type of dysphagia, and it is also a good method for establishing the best manner of feeding (by mouth, by mouth with dietary restrictions, by tube), for indicating and following appropriate rehabilitation programmes (techniques, manoeuvres, exercises), for advising diets and for planning any other diagnostic investigation.
Moreover, this endoscopic examination not only provides a static evaluation of the upper digestive-airway structures but, when boluses of different consistency are administered, it also permits assessment of the dynamics involved in swallowing. In particular, when small quantities of liquid, semi-liquid, semi-solid and/or solid foods (e.g. water, milk, yoghurt, jam, jelly, bread, biscuits, etc.) are given, any stagnancy, penetration and/or inhalation in the airways can be evaluated. In addition, FEES allows evaluation of the presence and efficacy of the coughing reflex (fundamental for ejecting any inhaled food).
Since this is an endoscopic method of diagnosis associated with the swallowing of food of various consistencies, certain complications or consequences may occur, particularly in subjects affected with swallowing disorders. These may be:

- Discomfort (most frequent);
- Epistaxis (nose bleeding) anterior or posterior (0.3%-1 1%);
- Pre-, intra-, post-swallowing inhalation (penetration of the food in the airways) producing the possible risk of infection in the airways especially if the coughing reflex is not efficacious;
- Vasovagal episodes (brief episodes of fainting) (0.06%);
- Laryngospasm (closure of the vocal chords with acute breathing difficulty) (0.03%);
- Laceration of the mucosa (an exceptionally rare complication).

I, the undersigned .....

DECLARE:

- to have received comprehensible and exhaustive information concerning the proposed medical examination, by means of: information supplied and an interview with the physician, Dr/Prof .. ,,
- to be aware that I may ANNUL this consent at any time before the examination;
- that I freely, spontaneously and in full awareness choose to tick either

☐ I ACCEPT or ☐ I DO NOT ACCEPT the proposed medical examination.

Patient's signature: ..... Date: .....

Signature and rubber stamp of the physician: .....

[1]* *In the case of the presence of only one parent, a signed declaration must be attached.*
[2]* *Enclose the documentation certifying the powers of the legal representative.*

II. Cleaning of the mouth

It is not uncommon to find patients who come for FEES examination as having poor oral hygiene or dependent on others for their oral care. It is preferable to have the mouth clean and free of any whitish/yellowish coloration or debris which if aspirated, can lead to infections in the lungs. In a hospital setup, a nurse will usually be available to clean the patient's mouth. In scenarios where the nurse is not available, the clinician can take up the responsibility. A clean mouth will facilitate better taste and sensation of the bolus which can help facilitating swallowing. Below you can find the steps to clean a patient's mouth prior to evaluation.

Figure 29

Lukewarm drinking water and salt (left) Patient can be asked to gargle water with salt before the evaluation (right). Source: (https://fullfact.org/health/gargle-salt-vinegar-water-coronavirus/)

III. Preparation of bolus

Bolus of different consistencies and volumes need to be provided to assess swallow safety. Hence collect the food materials of various consistencies required for the administration of the protocol. The bolus consistencies commonly used in the Indian context are:

Thin liquid- Milk/buttermilk

Slightly thick liquid- Yoghurt

Purred- Mashed banana

Hard solid- Cookie (Biscuit)

Others: Pills (if the patient complaints of difficulty in swallowing pills)/any other foods which the patients find it difficult to swallow

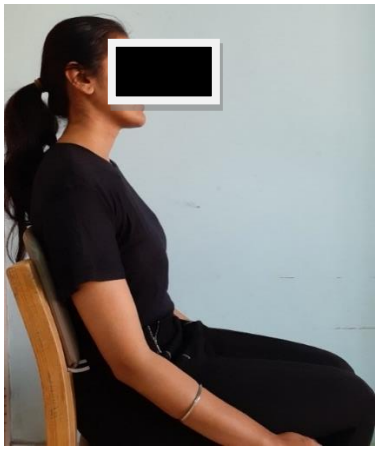
Care should be taken when choosing foods and liquids for diabetic patients so that sugar content is kept to a minimum. Because the patient is required to swallow small volumes, only minimal amounts of foods and liquids are needed for the study.

If water is used, the one or two drops of green or blue food dye needs to added until it shows up as a bright color distinguishable from the mucosal secretions of oro and hypopharynx. Some clinicians choose to not add any food dye to avoid exposing the patient to foreign chemicals. In such a case, milk is an ideal option as it coats the mucosa enough to be visualized. Water is avoided if the focus is to detect aspiration (bolus below the level of the vocal folds) as it can often be confused with bodily secretions. Other food items such as milk, yoghurt, mashed banana and biscuit does not require a dye to be added with it as these are visible. Other feeding utensils such as spoon, straws, cups and syringes must be kept ready to place the bolus within the mouth. In addition, gloves and hand sanitizer must also be kept handy for the clinician to use.

IV. Patient positioning: Ask the patient to sit in the posture that is typical when a person eats, with hip, knee and ankle flexion at 90 degrees and head upright aligned in midline.

Figure 30

Upright posture during assessment.



Observe the postural pattern for any abnormal and incorrect postures. In case the patient has any medical conditions which cause intolerance to such a position (e.g., hypotension and vertigo), position them with their hips at 45 degrees. Below is a flowchart of different postures from most efficient to least efficient.

Figure 31

Most to least preferred posture while feeding. (top to bottom)

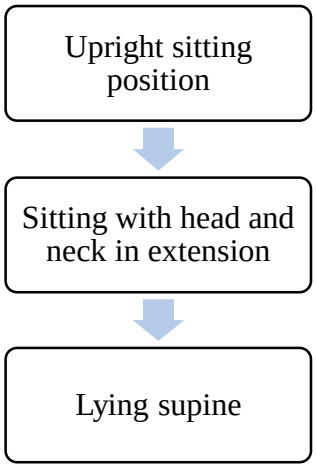


Figure 32

Head and neck in extension posture.

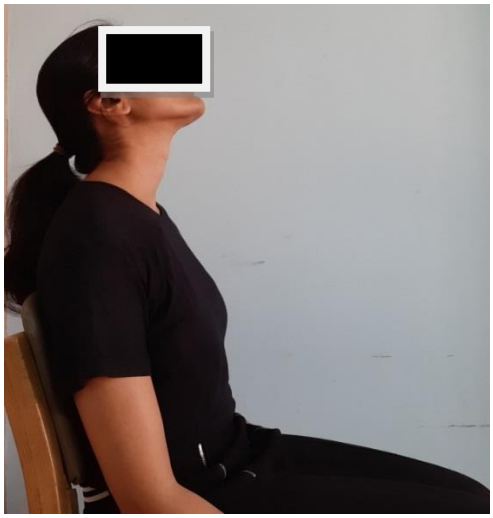


Figure 33

Lying supine posture.

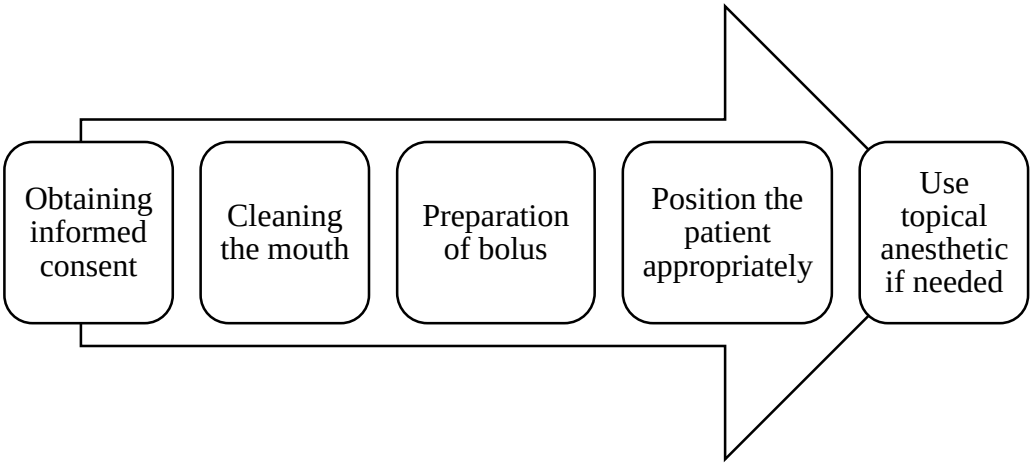
The upright sitting position has been found to be the most safe and comfortable posture for swallowing. Swallowing with head/neck extension causes increased space of the laryngeal vestibule and narrowing of the valleculae which can affect the mechanics of upper esophageal sphincter. Lying supine can decrease the control of the bolus as gravity comes into effect and can put the patient at risk for aspiration.

V. Patient preparation

Prior to inserting the flexible fiberoptic endoscope, you could determine if a topical anaesthetic needed to be used. Most patients are able to tolerate the passing of the scope through the nose without significant discomfort. However, some patients may find the procedure uncomfortable or painful. In such cases, apply a topical anaesthetic such as 2 percent Lidocaine to the nostril with a cotton-tipped swab. Then wait for 5 minutes for the anesthetic to take effect before proceeding. It is better not to spray anesthetics because they can reach the pharynx and cause a loss of sensation which can interfere with the swallowing function.

Figure 34

Summary for preparing a patient for FEES

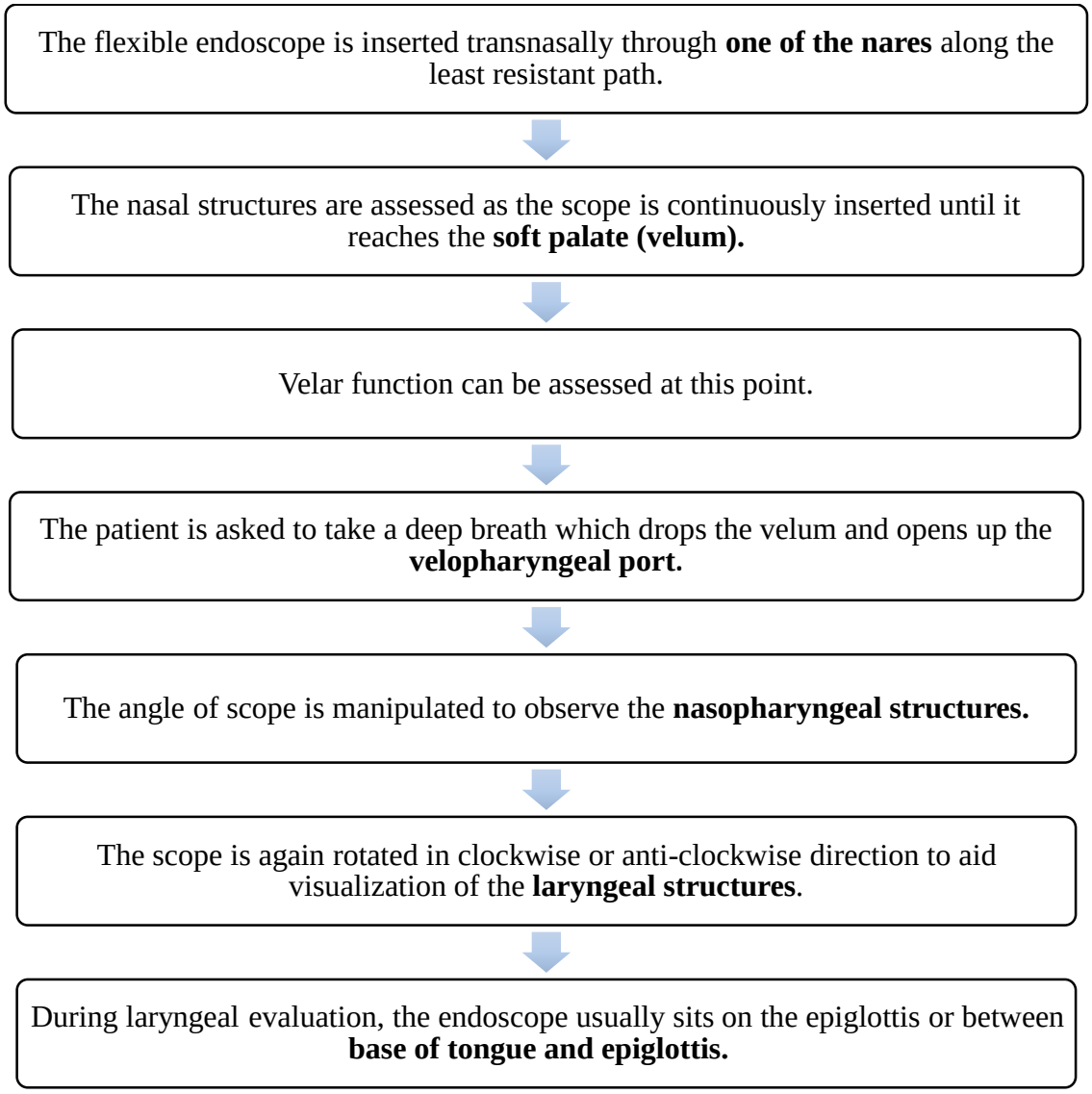


VI. Insertion of the endoscope

The clinician can perform a simple occlusion test to decide the nostril through which the endoscope can be inserted. Here, ask the patient to occlude one of the nostrils and monitor their own nasal airflow. The nostril which feels clearer is taken up for insertion. Visually inspect the nose to determine the best location for insertion. In many patients, the best location is along the floor of the nostrils. A small amount of lubricant can be applied to the end of the scope to reduce friction and improve patient comfort as the scope passes through the nose. Insert the scope till the point where the hard and soft palate merge (nasopharynx). At this point the patient is asked to perform certain tasks which gives us an idea about the patient's velopharyngeal competency, these tasks are explained in detail in the next section. The scope is then further inserted down the pharynx to observe the actual swallowing function. Here again the patient is asked to do certain tasks which provides information about the mechanism of pharynx and larynx in swallowing.

Figure 35

A flowchart describing the structures observed on insertion of endoscope.



VII. Protocol

Various protocols have been suggested in the literature by different authors according to the convenience, availability of time and resources for carrying out the FEES examination. Although the word 'protocol' seems like a rigid term, it is quite fluid in nature due to the variations of different clinical settings and cultural background. Here, we will be looking at the original protocol by Langmore (2001). The protocol for FEES is essentially divided into two components, Part I deals with anatomic-physiological assessment and Part II comprises of direct examination of swallowing food and liquid. A pre-swallow assessment (part I) is done to gain an overview of the anatomic structures and

to observe whether the oropharyngeal movements are finely coordinated or weak, sluggish and disco-ordinated. A swallow assessment (part II) is done to assess swallowing impairment if any. If swallow impairment is detected, it will be easier to hypothesize the cause by correlating the findings from the first part of the assessment.

PART I- ANATOMIC-PHYSIOLOGIC ASSESSMENT

1) Velopharyngeal closure

As soon as the endoscope is inserted in the nasal cavity, you need to follow the 'dark light' and observe the symmetry and integrity of structures until you reach the soft palate. Test for velopharyngeal competency by asking the patient to phonate /ee/, /ss/ and other plosive, fricative sounds. The timing of velar contraction can be checked for by asking the patient to alternate between oral and nasal sounds such as 'duh-nuh'. Velopharyngeal closure should also be assessed for during dry swallow. Velopharyngeal closure can be observed with movement of velum, i.e. resting and elevated state as can be seen in the figure below.

Task: Phonate /ee/, /ss/ Alternate between oral and nasal sounds- 'duh-nuh'

Figure 36

A-Adenoid, S-Soft palate (Velum) in the retracted state.

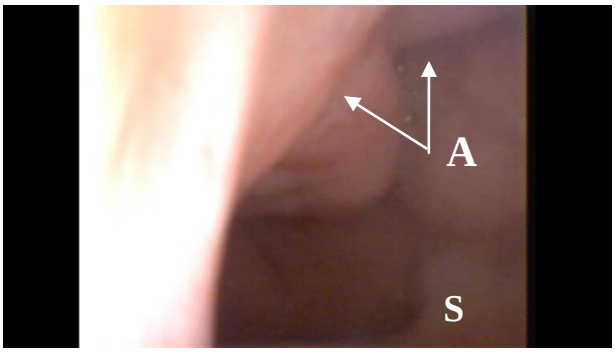
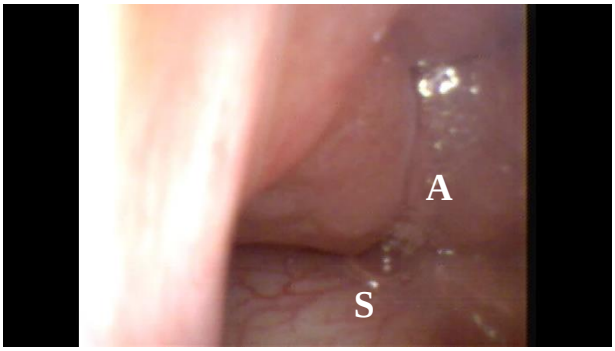


Figure 37

Velum in the elevated state



2) Visualizing the pharynx and larynx at rest

After passing the level of velopharyngeal closure, rotate the scope downward and insert it further until it reaches the level of the uvula. This is the hypopharynx. Now you can view the tongue base, posterior pharyngeal walls and the endolarynx (structures within the laryngeal vestibule). Advance the scope to the midpoint of the epiglottis and then you can view the false vocal cords, true vocal cords, arytenoids and subglottic shelf in the trachea. Observe the symmetry of base of tongue, shape and resting position of the epiglottis, configuration of the posterior pharyngeal wall, depth of vallecular space and pyriform sinuses. In case the patient has a non-oral feeding tube, you should look for the diameter of the tube (large bore or small bore) to know if size of the tube interferes with the swallowing mechanism of the patient.

Optional task: Hold breath and puff out cheeks forcefully (also called Valsalva maneuver) will enhance the visualization of pyriform sinuses and give an idea about the depth of pyriform recesses.

3) Observation of secretions

Clinician should look at the secretions in the region of hypopharynx in the form of a moist mucosal surface with some amount of pooling in valleculae and pyriform sinuses. This can be measured using the Yale Pharyngeal Residue Severity Rating Scale, which has been discussed in the next chapter.

Note: It is common for the patient's secretions or food or liquid materials to block the view by adhering to the lens of the scope. The lens can be cleared by turning the tip of

the scope to the posterior pharyngeal wall and wiping the collected material. Another technique to clear the lens is to pull the scope up lightly, which may release the material that is clinging to the tip of the scope.

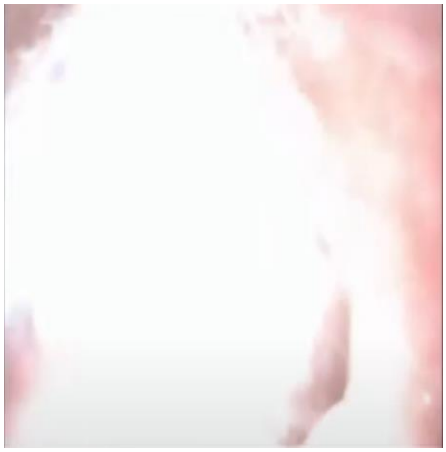
4) Swallow frequency: It is important to note the frequency of dry swallows as the presence of endoscope itself should be stimulating the salivary glands and facilitating swallow. If such spontaneous swallow is not observed, patient may be asked to swallow on cue. If the patient is still not able to swallow, the reason must be investigated. It could be one of these reasons:

1. Patient has a swallow apraxia and therefore is not able to follow the command.
2. Patient has xerostomia due to effects of radiation therapy and thus is not able to generate saliva in the mouth.
3. Patient is cognitively impaired to understand the task.

Note: During a swallow, the endoscopic field of view is blocked by either velum or base of the tongue (depending on the location of the scope) as they make contact with the posterior pharyngeal wall. The pharyngeal sallow cannot be seen because the light from the endoscope is reflected off the tissue it makes contact with. This reflection results in a flash of light that can be seen on the monitor for approximately half a second. This phenomenon is called ‘white out’, the picture of which is provided in the figure below.

Figure 38

White-out observed on FEES during swallowing.



5) Observation of base of tongue and pharyngeal function

Speech task: Say “ball” or postvocalic /l/ Non-speech task: Manipulate the tongue against resistance (Pulling the tongue and asking the patient to retract it) High /ee/ sound, cough, gargle

Ask the patient to say the postvocalic /l/ sound, observe the rapid posterior tongue movement and make a note of its symmetry and integrity as can be seen in the figure below. Followed by the speech task, non-speech task can be administered. Pull the tongue of the patient with a gauze pad and ask the patient to retract it. During retraction the tongue can push the epiglottis back and approximate the posterior pharyngeal wall. The high pitched /ee/ sound can facilitate visualizing the medialization of pharynx and elongation of true vocal folds (refer figure). Some of these tasks can be skipped in case the patient is not able to follow through due to presence of any comorbidities.

Figure 39

Base of tongue in the resting position.

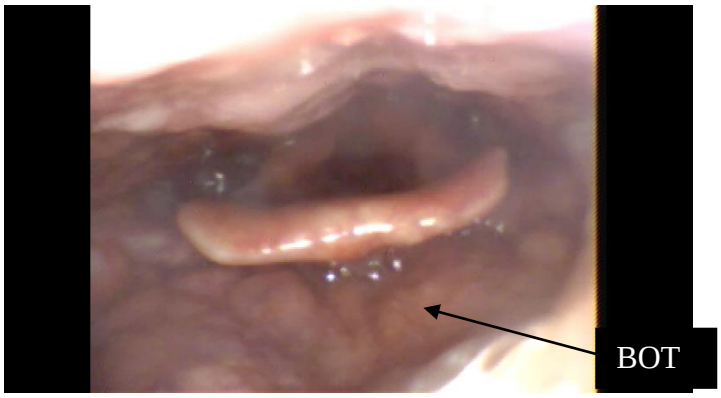


Figure 40

Base of tongue in the retracted state when patient says /ball/.

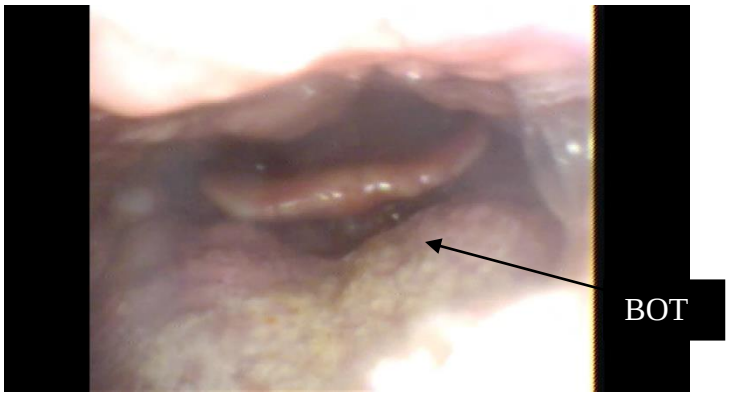
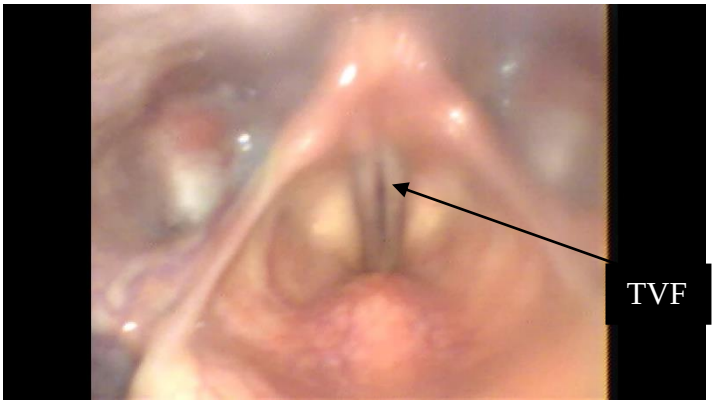


Figure 41

True vocal folds in the elongated state when the patient phonates /ee/.



5) Observation of laryngeal function

Task: Hold breath lightly to assess if the patient can adduct true vocal folds completely
Hold breath tightly to assess if the patient can adduct true and false vocal folds completely
Hold breath for 7 seconds to assess if patient can sustain airway protection with ease
Cough, grunt to elicit maximum glottal closure in case all above have failed.

The larynx is a structure which is most visible during endoscopy and thus you must spend as much time as possible observing the mechanics of swallow in and around the larynx. A simple observation that must be made initially is of breathing, at rest and during speech. We know that vocal folds abduct with the action of posterior cricoarytenoid muscle, therefore its integrity can be commented upon during tasks of inhalation and phonation.

Phonation tasks are also a part of FEES protocol to get a clear and detailed picture of amplitude and symmetry of vocal folds. Ask the patient to phonate /ee/, which facilitates upward movement of the larynx and anterior movement of the epiglottis, revealing the whole length of vocal folds. Check for any glottic chink, if any. Ask the patient to say

/ee-ee-ee/ and glide from low pitch to high pitch, in order to get more information about the symmetry of vocal folds. This also provides information about approximation of the arytenoids, true and false vocal folds. The high pitched /ee/ sound can facilitate visualizing the narrowing of laryngeal lumen and elevation of the larynx.

Coming to the most important function of larynx i.e. protection of airway, which is important for swallow safety. After observing the movement of vocal folds in respiration and phonation tasks, clinician will be giving a slightly difficult task of breath holding. During breath holding the vocal folds are adducted completely and forcefully which renders their capacity into use. Other tasks like coughing and grunting also help achieving glottis closure. The patient is asked to hold the breath lightly first to check if the vocal folds are adducting completely. Next, the patient is asked to hold the breath tightly if both true and false vocal folds are able to adduct completely as depicted in the figure below.

Figure 42

Partially adducted true and false vocal folds when the patient is asked to hold breath lightly.

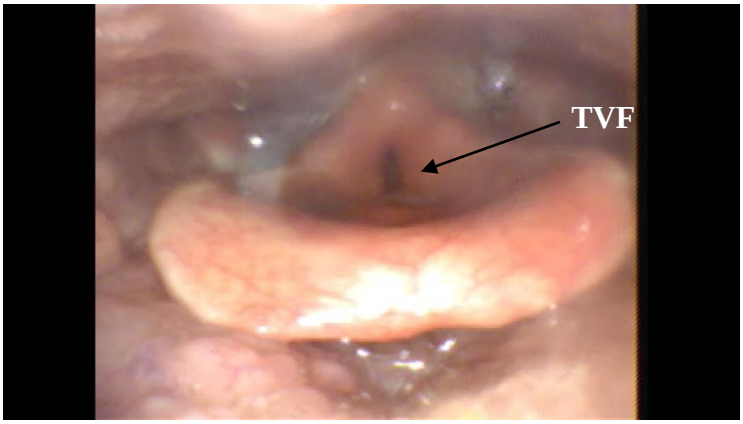
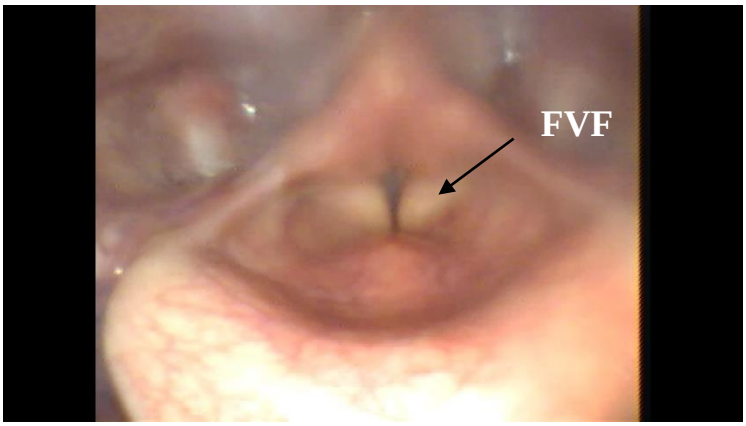


Figure 43

Fully adducted true and false vocal folds when the patient is asked to hold breath tightly.



6) Sensory Testing

Laryngeal sensations can be checked for by observing the patient's response to endoscope in the oro and hypopharynx, contact of the endoscope with the structures of hypopharynx, ability to clear the residue by swallowing or expectorating and aspiration of any food or liquid material. Clinician can look for signs such as excessive blinking of eyes, tearing of eyes and clearing throat.This procedure is called Fiberoptic Endoscopic Evaluation of Swallowing Sensory Testing (FEESST, Aviv et al., 1998).Lightly touch the base of tongue and lateral pharyngeal wall with the tip of the scope and look for any visible reaction. The arypeiglottic folds and epiglottis is one of the most sensitive structures in the hypopharyngeal area which can also be palpated. If the sensation is intact, it will produce a forceful cough.

Air pulse stimulator can also be used for a more objective testing, if this facility is available in the instrument being used. The flexible laryngoscope used here contains an internal port which delivers air pressure at a controlled rate. The endoscope is positioned along the aryepiglottic folds to elicit the laryngeal adductor reflex (LAR) about 2 mm away from the test site.The intensity of the stimulus is delivered in random trials of ascending and descending order by 1mmHg. A total of 6 trials are delivered in this manner. The mean of the lowest detected pressures from the six blocks that elicited the LAR is called the patient's sensory threshold. If LAR is not elicited with a standard air pulse of 50 ms, then a maximum intensity of 10mmHg air-pulse pressure is given. If no response is observed,

the value on stimulator is recorded as the sensory threshold. Images of elicitation of LAR for right and left arytenoid can be viewed in the following images.

Laryngopharyngeal sensory discrimination thresholds:
Normal-<4.0 mmHg air-pulse pressure
Moderately impaired-4.0-6.0 mmHg air-pulse pressure
Severely impaired->6.0 mmHg air-pulse pressure

Figure 44

Right arytenoid for assessing laryngeal sensation.

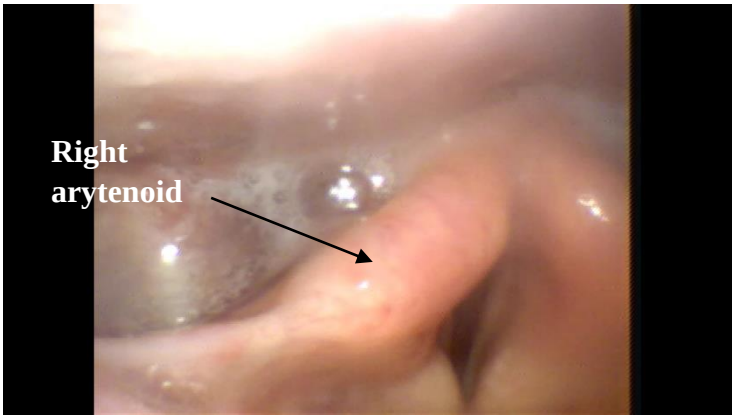
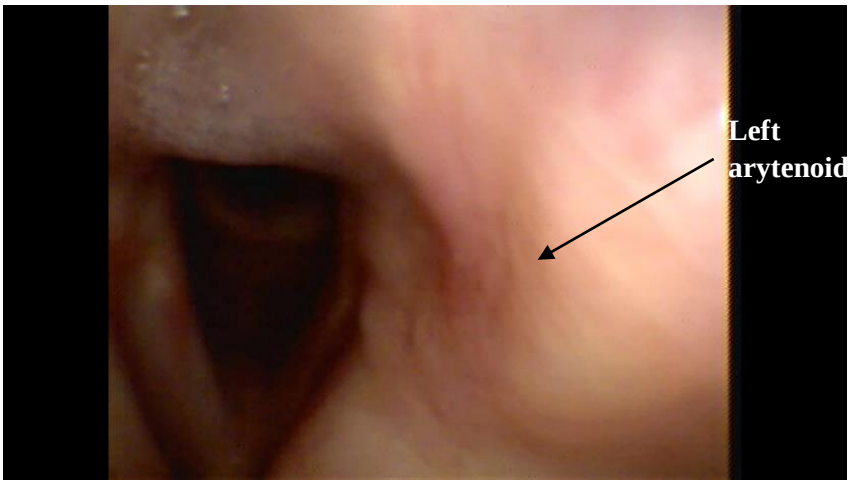


Figure 45

Left arytenoid for assessing laryngeal sensation.



PART II- DIRECT EXAMINATION OF SWALLOWING FOOD AND LIQUID

This section involves directly observing the swallowing behaviour of the patient with food material of varying consistencies. It is recommended to allow the patient to self-feed themselves so that you can observe swallow behavior during normal eating and drinking patterns. It allows us to observe the way the patient holds the food material, manipulates to bring it till the level of mouth and finally feed themselves. If that is not possible, you may take the responsibility or ask the caregiver to feed the patient. The following table depicts the sequence for administering the bolus during FEES.

Table 1

Bolus administration during FEES.

Quantity	**Utensil**
<5 mL (3ml), if the patient is medically fragile and pulmonary clearance is poor	Using a 10cc or 12cc syringe
5 mL (1 teaspoon)	Spoon
10 mL	Spoon
15 mL (1 tablespoon)	Small cup
20 mL (heaping tablespoon)	Cup
Single swallows (50 mL)	Cup
Consecutive swallows	Cup or straw

The following images depict visualisation of FEES when various bolus materials are given to the patient such as thin and thick liquid. The patient is first instructed to eat or drink the food material as they would normally. They are asked to hold the bolus in the mouth and swallow all at once.

Figure 46

FEES image containing green dyed bolus of thick liquid (curd).

Figure 47

FEES image containing green dyed bolus of thin liquid (milk).

Figure 48

FEES image containing green dyed bolus of semi-solid (banana).

Figure 49

FEES image containing green dyed bolus of hard solid (marie gold biscuit.)

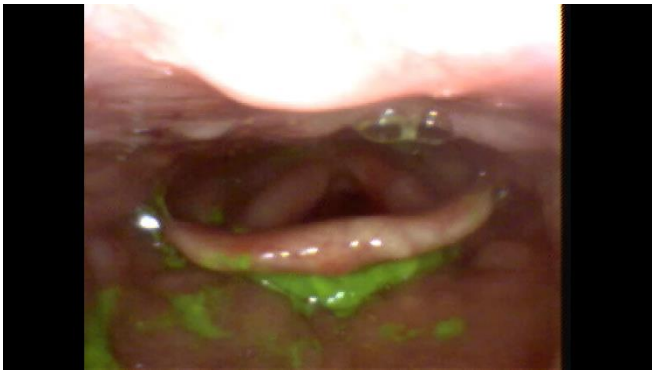


Figure 50

FEES image after swallow.

Repeat the same sequence with other consistencies. The cookie can be initiated as 1/4th, followed by half and then full. Also if the patient has difficulty swallowing any other food/pill, that can be provided.

Note: If the patient is NPO, it would be best to start with a consistency that would be safe for the patient to tolerate and move to more difficult consistencies. For example, if the patient has a pulmonary compromise, it would be better to start with thin liquids as it is better tolerated by the lungs than any other consistency.

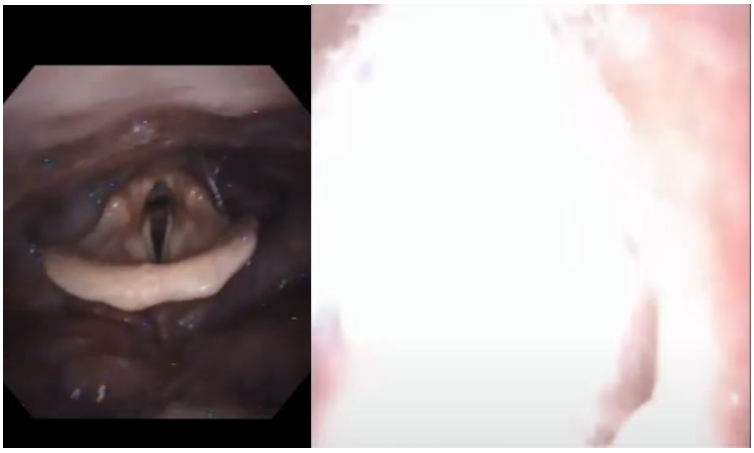
Oral Stage: FEES does not allow the oral phase to be examined as the endoscope is positioned through the nasal cavity, therefore inferences are made about the lingual movements that indicate a swallow initiation. The instruction given here is, “Hold this in your mouth until I ask you to swallow”. Clinician should look for any spillover in the region of hypopharynx before swallow initiation, oral transit time, movement of back of

the tongue. Any spillover (premature spillage) that may occur suggests inefficient linguavelar seal.

Once the bolus passes the level of base of tongue and rim of mandible and swallow has been initiated, a “white-out” occurs in which the endoscope comes into contact with the pharynx and reflects a white light. Thus, FEES does not give us information about what happens during the swallow.

Figure 51

FEES image before swallow (left) FEES image of white-out during swallow (right).



After white-out occurs, the endoscopic view may be blurred because of food particles attaching to the endoscope or the mucosal secretions covering the surface of the endoscope. The endoscope can then be positioned again by inserting it through a different angle.

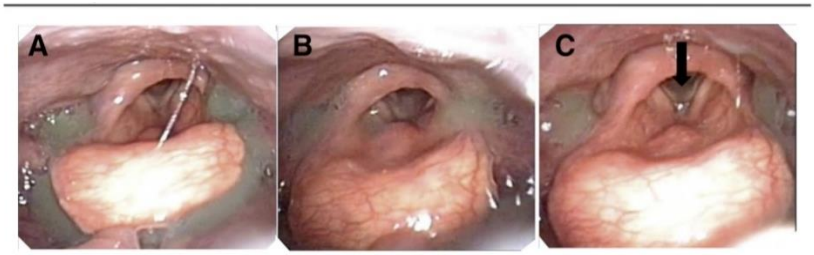
So, if white-out occurs and we cannot see what happens during swallowing how do we know when a patient has aspirated? Experienced clinicians will be able to detect aspiration before the swallow and even immediately after the patient has swallowed by replaying the recording and analyzing it frame by frame.

Signs to look for to detect presence of aspiration before swallow: If the bolus travelled into the laryngeal vestibule before the arytenoids begin to close

Signs to look for to detect presence of aspiration after swallow: 1. Residue beneath the vocal folds in the subglottic area 2. Residue on the true vocal folds 3. Residue in pyriform sinuses 4. Patient has reduced or absent laryngeal sensations

Figure 52

(A) Green dyed bolus residue collected in the vallecular and pyriform sinus space (B) Mild penetration (bolus above the level of the vocal folds) observed (C) Penetration and aspiration noted. Aspiration shown with the black arrow in the subglottis. (Source: https://link.springer.com/content/pdf/10.1007%2Fs00455-016-9766-y.pdf)



If the patient displays laryngeal penetration or aspiration with any one consistency and volume, use your discretion before continuing with the next greater volume. For example, if the patient aspirates on 3ml bolus of thin liquid, do not provide 5 cc because of the aspiration risk. A rule of thumb is to repeat the consistency on which aspiration took place to confirm presence of aspiration and if it still occurs, that particular consistency should no longer be used by the patient. After the swallow, patient can be asked whether they feel all the bolus is gone? It gives an insight about whether they are aware of the residue being present or not. The patient should be asked to cough to see if he/she is able to clear the residue on their own from the surface it has fallen into.

At this point, before proceeding to the next consistency, try appropriate strategies or maneuvers on the patient to check if it reduces aspiration. If these do not decrease the occurrence of aspiration, you may choose to continue the study with another consistency. However, it should also be noted that some patients who aspirate on a small volume of a particular consistency, may not aspirate on a larger volume of the same consistency.

Effect of therapeutic maneuvers and compensatory strategies

Depending on the findings, various maneuvers can be tested to observe if it has any influence over the swallowing mechanism. For example, for a patient having aspiration, the supraglottic swallow or super supraglottic swallow can be tested during FEES to see whether it has any effect in reducing aspiration. If a patient displays unilateral pharyngeal weakness with vallecular and pyriform sinus pooling on the right side, then the patient

should be asked to turn his head to the right side when swallowing a bolus to note its effect on swallowing function. If residue decreases, it indicates that this strategy could be used for this patient to improve swallow safety.

The beauty of FEES is that it allows you to do your assessment and intervention in a single setting. It can also be used as biofeedback to provide a visual representation of swallow to the patient.

FEES Ice Chip Protocol

This is an adaption of the standard FEES protocol for the following population:

1. Patients who are very ill
2. Patients with compromised immune system
3. Patients with poor pulmonary clearance
4. Patients who have not eaten by mouth for several weeks

A clinician may be hesitant to try giving feeds using food and liquid in such a group of patients due to fear of patient aspirating. For the same reason, ice chip protocol has been introduced.

The procedure is similar to the standard FEES protocol, the only difference is the bolus provided that is in the form of solid ice chips. The advantage of using such a bolus is:

1. It is better than thin liquid as bolus flow cannot be controlled with a thin liquid
2. It provides the necessary tactile and thermal stimulation to stimulate the higher cortical centers

Protocol for Infants and Children

The protocol for infants and children does not vary much compared to adults, but there are some obvious differences and requirement of skills from the yourside as a clinician, that becomes important before administering FEES. You can find the way in which candidacy can be determined for FEES in a child in the table below.

Table 2

Indications and Contraindications for pediatric FEES

Indications for Paediatric FEES	Contraindications for Paediatric FEES
Patient is nil by mouth and readiness for oral feed trials has to be determined	Complete nasal obstruction or atresia of choanae
Difficulty with oral secretion management is suspected	Pharyngeal stenosis obstructing the view of hypopharynx
Abnormality in the larynx or pharynx which could affect swallowing function	Severe micrognathia and glossoptosis
Incomplete information on Videofluoroscopy (VFSS) or avoid exposure of radiation on VFSS	Severe medical conditions

The first step before any procedure is cooperation from the patient, which may be less from children, as they may not be aware of the need and importance of FEES. A clinician dealing with children below 5 years of age must have appropriate developmental toys, distracting materials and reinforcing items to maximize cooperation from the child. It might also help to have videos of children sitting through the examination (if you get lucky to find such children). Prior to testing (two days before), the child can be familiarized with the testing room and the equipment to be used. It would reduce the anxiety and uncertainty during the day of evaluation. You can also ask the parents to bring their own utensils, which can be used during bolus administration.

Anesthesia: The use of anaesthesia works well with the children, as it minimizes discomfort and improves cooperation from the patient. However, the use of nasal spray is best avoided in children with severe neurological impairment, seizure disordersand suspected difficulty with management of secretions.

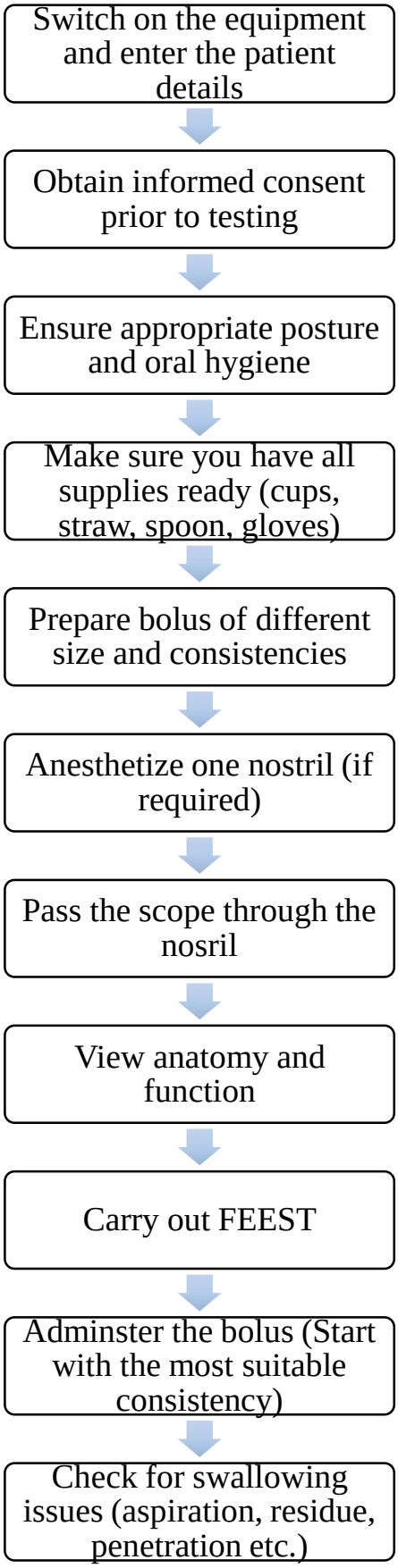
Choice of Endoscope: Most commonly a paediatric endoscope, not less than 3.5 and 4.0 mm, can be used with infants and children comfortably. Although there are differences in anatomy, size and symmetry of structures, a few endoscopic sizes should suffice for use.

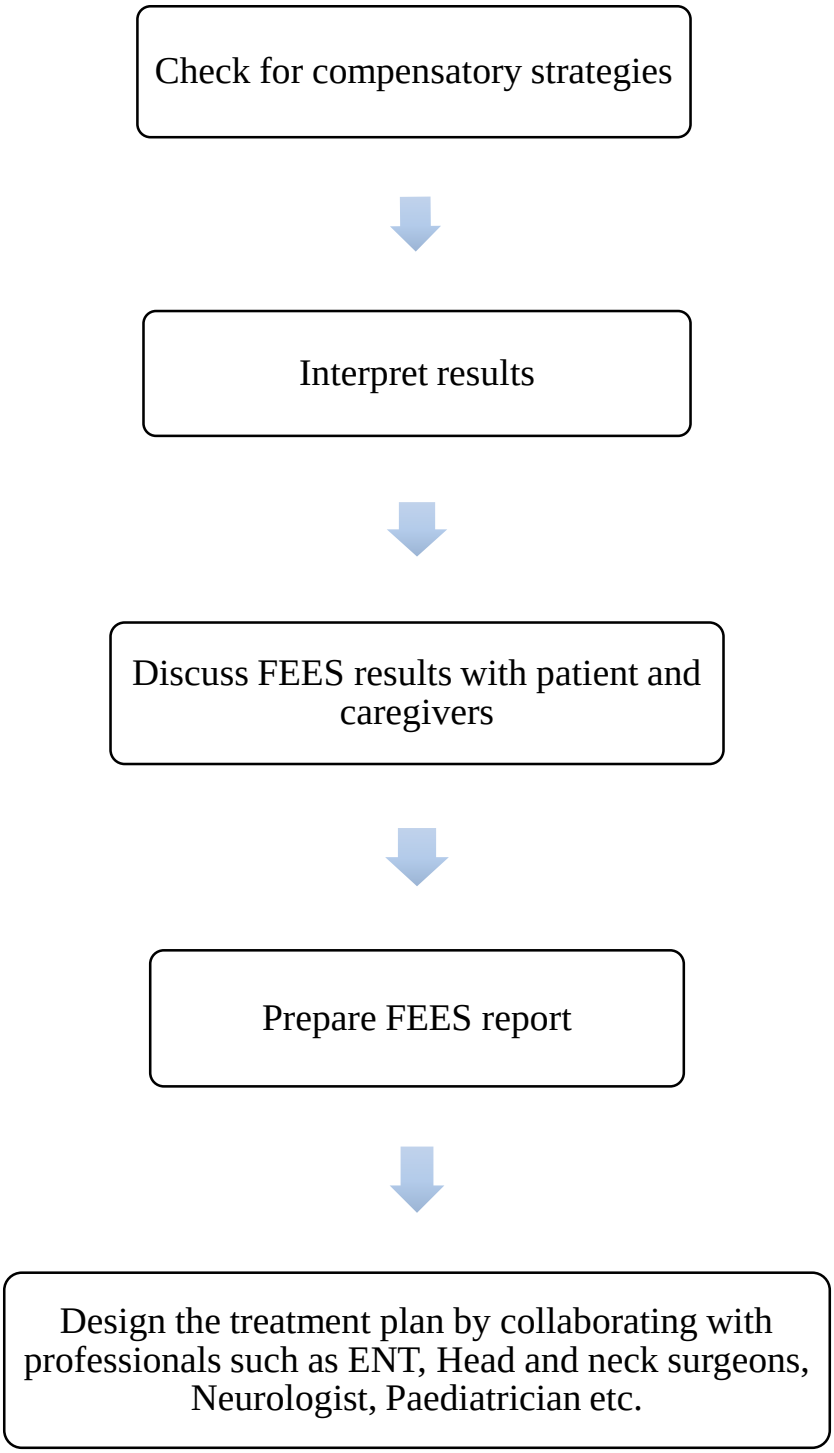
Variation in protocol: An obvious variation in protocol will be modification in the speech tasks as the child may not be verbal or could be having few vocalizations. The primary aim of the examination would be to assess safety and efficiency of swallow, more so presence of laryngeal penetration/aspiration or both in addition to observing the symmetry and integrity of structures.

Documentation of findings

After the completion of the FEES study the SLP and the otolaryngologist should discuss the results so that the interpretation is in agreement between the two disciplines. Fill in the format shown in the appendix and include the recommendations for treatment. Next, discuss the FEES results and recommendations with the patient and caregiver.

Highlights:


Switch on the equipment and enter the patient details
Obtain informed consent prior to testing
Ensure appropriate posture and oral hygiene
Make sure you have all supplies ready (cups, straw, spoon, gloves)
Prepare bolus of different size and consistencies
Anesthetize one nostril (if required)
Pass the scope through the nosril
View anatomy and function
Carry out FEEST
Adminster the bolus (Start with the most suitable consistency)
Check for swallowing issues (aspiration, residue, penetration etc.)


Check for compensatory strategies
Interpret results
Discuss FEES results with patient and caregivers
Prepare FEES report
Design the treatment plan by collaborating with professionals such as ENT, Head and neck surgeons, Neurologist, Paediatrician etc.

Test Your Knowledge

Questions:

1. Who introduced the standard FEES protocol?

a) IanessaHumbert

b) Susan Langmore

c) Jeri Logemann

d) Michel Steele

2. The entire protocol is a two-part assessment procedure, is this statement true or false?

a) True

b) False

3. Which is the best position for patient to feed?

a) Sitting upright

b) Sitting with head and neck extended

c) Lying supine

d) None of these

4. Why do you think it is important to clean the patient's mouth before starting the assessment?

a) Bacterial debris can cause infection

b) Patient may aspirate the debris

c) The fungal/bacterial particles can reduce sensation on the tongue

d) All of the above

5. Part 1 of FEES protocol i.e. anatomic-physiologic assessment is also called as:

a) Post swallow assessment

b) Mid-swallow assessment

c) Pre swallow assessment

6. Is it possible to observe what happens **during** swallowing in FEES assessment?

a) Yes

b) No

c) Maybe

7. Why do we ask the patient to hold breath during assessment? What can we infer?

a) It gives an idea of patient's breath holding capacity

b) It gives an idea whether vocal folds are adducting completely

c) It tells whether the patient is a smoker

d) It gives an idea whether vocal folds are abducting completely

8. During second part of the assessment, what food material can you use for soft solid consistency assessment _____?

9. What should be done if patient aspirates once on a given consistency?

a) Trial feed should be repeated to confirm presence of aspiration

b) The consistency on which patient aspirated should no longer be given

c) Ignore and continue testing

d) Call for emergency help

10. When is Ice Chip protocol used?

a) Patients who are very ill

b) Patients who are immune compromised

c) Patients who have not eaten by mouth since weeks

d) All of the above

CHAPTER V

RATING SCALES USED DURING FEES

Welcome to the fifth chapter, after all the information heavy chapters previously, I have tried making this one light. So far we have learnt the basic anatomical structures of endoscopy, setup and equipment required and procedure of FEES. A little more patience and dedication from your end and soon we will be familiar with most aspects of FEES. After taking all precautions and administering the protocol, what next? To be able to interpret the findings of FEES, you need to know about a few rating scales that help you make decisions regarding the swallow status of the patient. These scales make documentation more precise and objective, facilitates better communication with other professionals and brings uniformity in documentation of findings of FEES. I will try not to bore you with exhaustive list of assessments that creates confusion about what to use when, but a few must-know tools that one must be aware of.

Learning objectives:

At the end of this chapter, you will be able to:

1. **Familiarize with various rating scales**
2. **Learn about clinical use of each scale**
3. **Learn about advantages and disadvantages of each scale**

1. Yale Pharyngeal Residue Severity Scale

Residue (stasis) is the bolus which remains in the hypopharynx after swallowing. Literature says that normal healthy adults have 40-50% of trace residue at some point during FEES. So how do we differentiate it from abnormal swallow?

The residue that stays for healthy individuals will be cleared on one or two attempts by coughing or doing multiple swallows.Patients with swallowing impairment may have residue left in the vallecular and pyriform sinuses in the left or right sides or both and difficulty expelling it out.It is important to determine the proportion of residue as it can be aspirated and entered in the lungs. If the patient does not have cough reflex or a weak cough, he/she will be unable to clear out the secretions.

To determine the amount of residue, there are various scales available that can be used during the procedure. The most efficacious and evidence based scale is the Yale Pharyngeal Residue Severity Scale is used which tells us the severity of residue present in the vallecula and pyriform sinuses. These findings are based on subjective impression and clinical expertise of the SLP and ENT.

Figure 53

Yale Pharyngeal Residue Severity Scale. (Source: https://www.semanticscholar.org/paper/The-Yale-Pharyngeal-Residue-Severity-Rating-Scale%3A-Neubauer-Rademaker/4f5ac5a5f8af9e508420051cb85d7f05b5c43f3c)

Table 6 Definitions for severity of vallecula residue

I	None	0 %	No residue
II	Trace	1–5 %	Trace coating of the mucosa
III	Mild	5–25 %	Epiglottic ligament visible
IV	Moderate	25–50 %	Epiglottic ligament covered
V	Severe	>50 %	Filled to epiglottic rim

Table 7 Definitions for severity of pyriform sinus residue

I	None	0 %	No residue
II	Trace	1–5 %	Trace coating of mucosa
III	Mild	5–25 %	Up wall to quarter full
IV	Moderate	25–50 %	Up wall to half full
V	Severe	>50 %	Filled to aryepiglottic fold

Figure 54:

(A) No residue (B) Trace coating of mucosa (C) Epiglottic ligament visible (D) Epiglottic ligament covered (E) Filled to epiglottic rim. (Source: https://www.semanticscholar.org/paper/The-Yale-Pharyngeal-Residue-Severity-Rating-Scale%3A-Neubauer-Rademaker/4f5ac5a5f8af9e508420051cb85d7f05b5c43f3c)

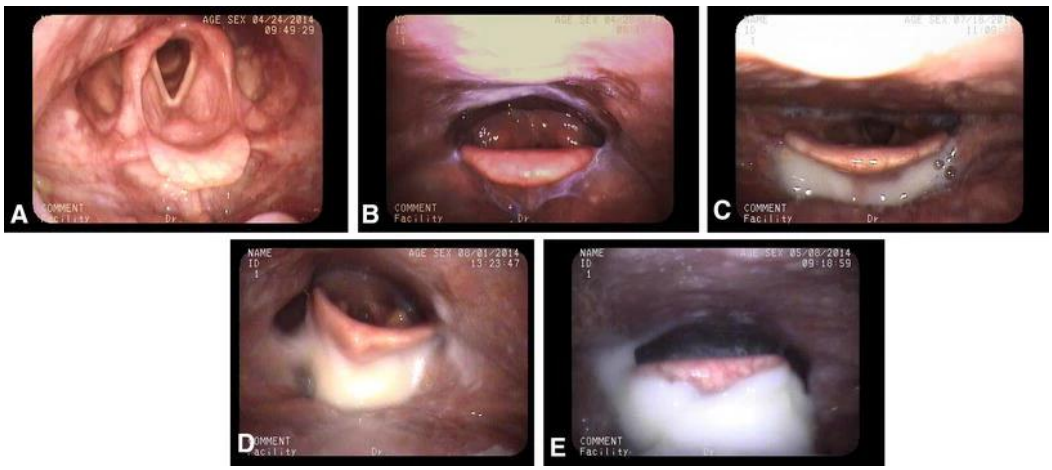
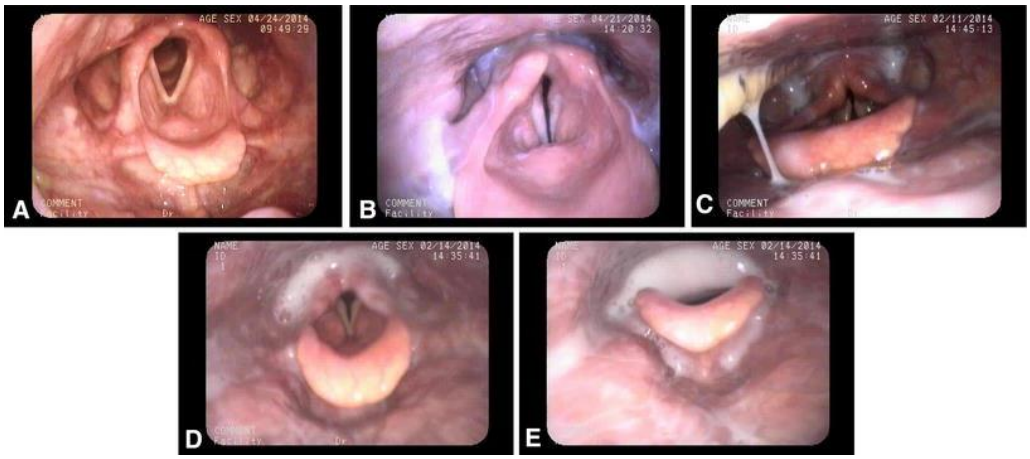


Figure 55

(A) No residue (B) Trace coating of mucosa (C) Up wall to quarter full (D) Up wall to half full (E) Filled to aryepiglottic fold.
(Source:https://www.semanticscholar.org/paper/The-Yale-Pharyngeal-Residue-Severity-Rating-Scale%3A-Neubauer-Rademaker/4f5ac5a5f8af9e508420051cb85d7f05b5c43f3c)



This scale is easy to use and interpret and can help track progress of the patient. It improves the accuracy of FEES interpretation, however the interpretation is subjective.

The Yale Pharyngeal Residue Severity Rating Scale has met its stated purpose of providing accurate and trustworthy data on the location and severity of pharyngeal residue found during FEES.

Two professional judges looked over 261 FEES evaluations and chose a no residue example as well as three exemplars for vallecula and pyriform sinus residue (trace, mild, moderate, and severe). 20 raters with a mean of 8.3 years of experience (range 2–27 years) performing and interpreting FEES randomised hard-copy colour photos of the no residue, 12 vallecula, and 12 pyriform sinus exemplars by residue position for hierarchical categorization. All images were rated for severity by the same 20 raters two weeks apart, with the order of image presentations randomised. The severity assessments of vallecula and pyriform sinus residues had excellent intra-rater reliability, inter-rater agreement, and concept validity.

The Yale Pharyngeal Residue Severity Scale's applicability, adaptability, and efficacy are easily proved. A representative pre-therapy swallow, for example, is assigned a severe vallecula residue severity rating (anatomically defined as the vallecula filled up to the epiglottic rim). For a specified period of time, an intervention approach, such as effortful swallow or double-swallow, is used, and a representative post-therapy swallow is given a moderate vallecular residue severity grade (anatomically defined as mild pooling with epiglottic ligament visible). (Neubauer et al., 2015)

2. Modified Penetration-Aspiration Scale

Penetration-Aspiration Scale devised by Rosenbek et al. in 1996 is a scale to rate the amount of penetration and aspiration in the laryngeal vestibule. It is one of the most widely used clinical tools by SLPs worldwide. It helps assess three basic features:

1. Extent of airway invasion

2. The residue present after the swallow

3. Patient’s reaction to the event

The original PAS scale consists of ratings from level 1 to level 8 for determining the entry of bolus above or below the level of vocal folds and whether any effort is made by

the patient to eject out the bolus. Modified PAS scale (Steele & Grace-Martin, 2017) redefined levels 2 and 3 for detecting penetration and level 4 and 5 for detecting aspiration. It is a simplified version of the original PAS scale with ratings from 1 to 5.

This scale tells us about the safety of swallow which is the primary concern while rehabilitating any patient with dysphagia.

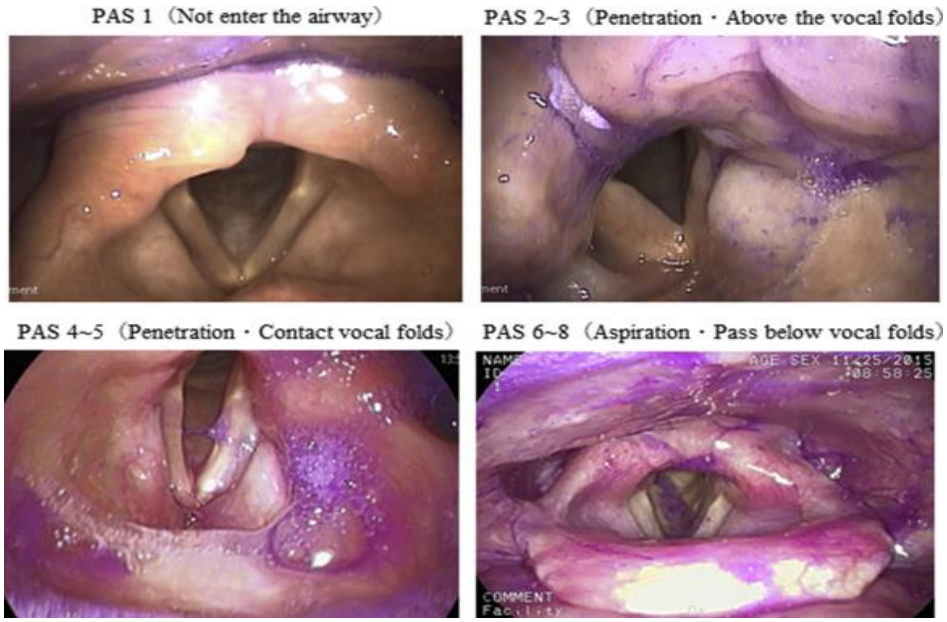
Figure 56

Penetration-Aspiration Scale and its Modified version. (Source: https://www.archives-pmr.org/article/S0003-9993(18)31442-4/abstract)

Penetration-aspiration scale	Modified penetration-aspiration scale
1. Material does not enter the airway	1. Material does not enter the airway
2. Material enters the airway, remains above the vocal folds, and is ejected from the airway	2. Material enters the airway, remains above the vocal folds
3. Material enters the airway, remains above the vocal folds, and is not ejected from the airway	
4. Material enters the airway, contacts the vocal folds, and is ejected from the airway	3. Material enters the airway, contacts the vocal folds
5. Material enters the airway, contacts the vocal folds, and is not ejected from the airway	
6. Material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway	4. Material enters the airway, passes below the vocal folds, and effort is made to eject
7. Material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort	
8. Material enters the airway, passes below the vocal folds, and no effort is made to eject	5. Material enters the airway, passes below the vocal folds, and no effort is made to eject

Figure 57

Images of penetration and aspiration according to Penetration Aspiration Scale. (Rosenbek et al., 1996). (Source: https://www.archives-pmr.org/article/S0003-9993(18)31442-4/abstract)



This scale helps in quantifying penetration and aspiration, may help with differential diagnosis of swallowing disorders and can help track progress of the patient, however again just like with the previous scale, the interpretation is subjective.

The Penetration-Aspiration Scale was created to enable for accurate assessment of specific penetration and aspiration events seen during videofluoroscopic swallowing evaluations. It was never meant to quantify all of these instances. Users are left to specify the amount and timing of penetration and aspiration events using other mechanisms (Rosenbek et al., 1996). Although not originally created for this purpose, the PAS has recently been used in research and clinical practise with flexible endoscopic assessment of swallowing (FEES), despite the fact that no other similar type of scale has been validated for use with FEES. The PAS provides a scalable means of monitoring penetration and aspiration to identify normal from aberrant swallows and to examine the effects of swallowing treatments, despite not being designed for use with FEES. (Butler et al., 2010, 2011)

Studies have found good interrater and intrarater reliability of using Penetration-Aspiration Scale with FEES (Butler et al., 2015; Colodny, 2002; Kelly et al., 2007). PAS

scores were assigned to 35 swallows by nine specialists with differing FEES experience (beginning, intermediate, and advanced). Following short-term (one day) and long-term (one week) retest intervals, initial evaluations were repeated. PAS was consistently employed with FEES regardless of skill level; however, it is unclear whether the PAS was used correctly. That instance, a rater could have routinely given an inaccurate PAS level to a swallow, but the dependability was great as long as he or she did so consistently. (Butler et al., 2015) Thus, reliability and validity of PAS scale for FEES was established.

There are other scales as well such as Secretion Severity Rating Scale (McKaig & Murray, 1999), Dynamic Imaging Grade of Swallowing Toxicity (DIGEST) (Hutcheson et al., 2017) and various other scales used during FFEES assessment to estimate the pharyngeal residue and amount of penetration and aspiration, however these go beyond the scope of this chapter therefore aren't discussed.

Highlights:

- Yale Pharyngeal Residue Severity Scale and Penetration Aspiration Scale are two most widely used tools used during FEES assessment.
- Yale Pharyngeal Residue Severity Scale can be used to rate the residue at the vallecuale and pyriform sinus
- Penetration Aspiration Scale and its modified version can be used to quantify the extent of penetration and aspiration in the laryngeal vestibule.

Test your knowledge

1. Name the scale used most widely for determining safety of swallow

_____

2. Name the scale used for determining residue after swallow

_____

3. Normal healthy individuals have no residue in the hypopharyngeal area. Comment whether this sentence is true or false?

a) True

b) False, normal individuals will also have some amount of residue

4. What information can you obtain from PAS scale, apart from how safe is the swallow? _____

5. How many levels does modified PAS have? _____

6. Identify the location of residue and assign appropriate rating according to Yale Pharyngeal Residue Severity Scale.

7. Identify the location of residue and assign appropriate rating according to Penetration Aspiration Scale.

8. The term stasis refers to:

1. Peristalsis	2. Delay
3. Transit time	4. Residue

9. How is the original PAS scale different from the modified version?

CHAPTER VI

LEARNING TO INTERPRET FEES IMAGES

We are aware of the fact that FEES helps us to observe swallowing ability before and after, and NOT during the swallow. Clinical decision making skills are an integral part of rehabilitation plan in dysphagia management. Observing real graphics and videos can help you with decision making abilities with respect to assessment and management. In this chapter, we will assist you in looking at certain signs associated with some common conditions that interfere with swallowing ability. You can find a link attached to the videos of FEES below the description of every condition. The videos can also be viewed through a CD which will be made available with the tutorial. I would recommend you to watch the video and read the description to gain a better understanding. For every condition, Modified Penetration-Aspiration Scale scores and Yale Pharyngeal Residue Severity rating has been provided in the description. Note that every patient presents with different complaints and the severity of condition is influenced by a variety of factors. The signs listed below are by no means exhaustive; these will help you merely to identify the condition. A normal swallow has been described first so that it is easy to identify the signs of dysphagia.

Learning objectives:

At the end of this chapter, you will be able to:

1. **Identify signs of a normal swallow during FEES**
2. **Identify various signs of common swallowing disorders observed during FEES**
3. **Interpret FEES findings using case examples**

1. Normal swallow

What to look for?

Before swallow:

- Symmetry of nasal cavity
- Normal velopharyngeal closure
- Symmetry of epiglottis
- Symmetry of false vocal folds
- Symmetry of true vocal folds
- Symmetry of cricopharyngeal structures
- Laryngeal adductor reflex will be present

After swallow:

- No pooling of secretions
- Brisk white out can be seen
- Clearance of residue (little amount of residue is normal)
- Some amount of penetration and aspiration is normal
- Normal oral transit time
- Normal pharyngeal transit time

Video link:
https://drive.google.com/file/d/1wgHbVxHPrcf1ACxuQhvyXojtRkplUMsZ/view?usp=sharing

Brief description: As soon as the scope enters the hypopharynx, the vocal folds seem to be moving symmetrically. The laryngeal adductor reflex is elicited by touching the arytenoids with the scope, following which the laryngeal adduction is observed and coughing response is seen. After this, a mildly thin liquid is administered i.e water using green dye. A brisk white-out can be observed. No pooling of secretions is seen. Next, pureed material is given with green dye. Mild residue is observed in the vallecuale, however no penetration or aspiration. Modified PAS score of 1 and YPRS rating 1 can be given.

2. Spillage

Spillage: Before the patient is ready to swallow, some amount of bolus trickles down the throat.

What to look for?

Before swallow:

- Before swallow happens, bolus reaches the throat

After swallow:

- Multiple attempts to swallow
- Inability to clear residue

Treatment:

- Oral containment of bolus
- Cueing strategies
- Cueing to swallow

Video link: https://drive.google.com/file/d/1yCrIGbN4hDE5sV-UQe70ysn9urioQsHg/view?usp=sharing

Brief description: A thin liquid i.e milk is given to the patient and it is observed that before the patient is ready to swallow, some amount is trickled down the pharynx. The residue can be observed in both the valleculae and the pyriform sinus. No penetration or aspiration is observed. Modified PAS score 1 and YPRS rating 3 can be given.

3. Aspiration

Aspiration: Entry of bolus beyond the level of true vocal folds.

What to look for?

Before swallow:

- As soon as scope is entered, air bubbles can be observed
- Delayed pharyngeal swallow

After swallow:

- Coughing or choking behavior in case of overt aspiration
- Bolus observed below the level of vocal folds without any overt signs in case of silent aspiration
- Inability to clear residue
- Compensatory strategies

Video link: https://drive.google.com/file/d/1yH92KaXTUlYSSN1S_-jpa6hKxIBDBhTv/view?usp=sharing

Brief description: As soon as the scope is inserted down into the pharynx, air bubbles of saliva can be observed. The air bubbles can be observed even below the level of vocal folds, thereby indicating silent aspiration. No coughing or tearing response can be observed. No consistencies were tried with the patient to avoid further risk of aspiration. Modified PAS score 5 can be given as the material passes below the level of vocal folds but no effort is made to eject it out.

4. Unilateral Vocal Cord Paralysis

Unilateral vocal cord paralysis: Immobility or restricted mobility of one of the vocal cords. This will lead to inefficient closure of the vocal folds

What to look for?

Before swallow:

- Pooling of saliva in the pyriform recess on the damaged side
- Delayed pharyngeal swallow

After swallow:

- Bolus observed at or below the level of vocal folds resulting in penetration or aspiration
- Inability to clear residue

Treatment:

- Head turn and chin tuck to the left side
- Vocal strengthening exercises
- Pharyngeal strengthening exercises
- Supraglottic swallow
- Supersupraglottic swallow
- Mendelsohn Maneuver
- Compensatory strategies

Video link: https://drive.google.com/file/d/1yOIsDJOLSjm33KQA6ox-ty7tjDeB92NS/view?usp=sharing

Brief description: In the video, a classic case of left vocal fold paralysis can be seen. When the scope is inserted into the pharynx, pooling of secretions can be observed. The secretions can reduce the visibility for few seconds, so the examiner needs to wait until the secretions are cleared. The right vocal fold can be seen to be moving but not the left vocal fold. Secretions are pooled more towards the left pyriform sinus. Modified PAS score of 3 and YPRS rating 3 can be given.

5. Bilateral Vocal Cord Paralysis: Immobility or restricted mobility of both the vocal cords. This will severely affect their ability to adduct or abduct thereby preventing airway protection. Bolus can easily be trapped into or below the vocal folds leading to penetration or aspiration.

What to look for?

Before swallow:

- Minimal or absent laryngeal adductor reflex
- Absent cough reflex

After swallow:

- Bolus observed at or below the level of vocal folds resulting in penetration or aspiration
- Inability to clear residue
- Thin liquid easily tolerated

Treatment:

- Postural modifications
- Bolus size modifications
- Cyclic ingestion

Video link: https://drive.google.com/file/d/1yqjsDAy9592f0mJzPJfnHplU0ea4AfSx/view?usp=sharing

Brief description: In cases of bilateral vocal fold paralysis, cough reflex or the laryngeal adductor reflex will be either absent or minimal. The airway will always be open due to immobility of the vocal folds. The patient in the video is using a feeding tube as can be seen on the left side. A mildly thick material in the form of ice-cream was given to the patient which required multiple attempts to be swallowed. No penetration or

aspiration could be observed. Modified PAS score of 1 and YPSR rating of 2 can be given.

6. Parkinson's Disease: It is a neurodegenerative disease that primarily affects movement of the individual. The four cardinal signs of PD are:

1. Resting Tremors: Generally unilateral, can occur anywhere in the body including tongue, lips, jaw
2. Bradykinesia: Slowness of movement
3. Rigidity: It is characterized by increased resistance while performing a movement.
4. Loss of postural reflexes: Flexed posture in the neck and trunk can be observed, usually in the later stages.

These signs significantly affect posture and movement of the individual which has an impact on swallowing. The following table describes the signs observed before and after swallow for a patient with Parkinson's disease:

What to look for?

Before swallow:

- Difficulty in manipulating bolus
- Difficulty initiating a swallow
- Lingual sweeping action
- Pooling of secretions
- Sluggish laryngeal adductor reflex
- Delayed pharyngeal swallow

After swallow:

- Multiple attempts to swallow
- Bolus observed at or below the level of vocal folds resulting in penetration or aspiration
- Inability to clear residue

Treatment:

- Postural modifications
- Bolus size modifications
- Cyclic ingestion

Video link:
https://drive.google.com/file/d/1yoStOiaDSpAnV9d3KzsvSHHXz6dDFhy-/view?usp=sharing

Brief description: The patient taken for FEES assessment is using a feeding tube. When the scope is inserted down the pharynx, pooling of secretions can be observed in the vallecuale as well as pyriform sinuses. Laryngeal adductor reflex was elicited by stimulating the arytenoids, it was observed to be sluggish. A green dyed pureed material is given to the patient. Multiple attempts to swallow can be observed. A brisk white out is not observed. The pureed is collected in the interarytenoid space because of reduced hyolaryngeal elevation. Mild penetration can be observed. PAS score of 2 and YPRS rating of 3 can be given.

7. Dysphagia after Head and Neck Cancer

Disruption in dysphagia following head and neck cancer due to surgical procedures and effects of radiation/chemotherapy. The severity of dysphagia depends on the location of lesion, size of lesion, treatment given and side effect of medications. Xerostomia i.e dryness of mouth is a common side effect which occurs due to medications. In case of oral cancers, videofluoroscopic swallow study may be a better option to visualize the oral phase. Below you can find few signs which are commonly observed post chemo and radiation therapy.

What to look for?

Before swallow:

- Trismus- Reduced mouth opening
- Xerostomia- Dryness of mouth leading to difficulty in bolus manipulation
- Laryngeal edema
- Swollen epiglottis
- Redness and inflammation
- Pooling of secretions
- Swollen true and false vocal folds

After swallow:

- Multiple attempts to swallow
- Inability to clear residue

Treatment:

- Stimulation with cold and sour bolus
- Postural modifications
- Bolus size modifications in case of trismus
- Cyclic ingestion
- Liquid wash
- Thinner consistency

Video link: https://drive.google.com/file/d/1yqjsDAy9592f0mJzPJfnHplU0ea4AfSx/view?usp=sharing

Brief description: When the pharynx is visualized through the scope, edema of the larynx can be observed. Inflammation and redness of the epiglottis can be seen. Pooling of secretions is observed in the vallecuale. Because of swollen epiglottis, it is difficult to visualize the vocal folds. A green pureed material is given to the patient, which resulted in a brisk white-out. PAS score cannot be given since vocal folds are not visualized clearly, YPRS rating of 2 can be given.

8. Cricopharyngeal spasm

The cricopharyngeus muscle, also called the upper esophageal sphincter is always in a state of contraction. It opens when we want to swallow and allows safe passage of

bolus.It is sometimes called as globus sensation i.e feeling of lump in the throat due to overly constricted muscle in the throat. It could be disturbing to the patient while swallowing his/her on saliva. Treatment generally involves botox injection or prescription of muscle relaxants.

What to look for?

Before swallow:

- Pooling of secretions
- Swollen true and false vocal folds

After swallow:

- Multiple attempts to swallow
- Relaxation of cricopharyngeal sphincter will be absent
- Inability to clear residue

Treatment:

- Shaker's exercise
- Mendelson Maneuver
- Botulinum Toxin Injection
- Cyclic ingestion
- Liquid wash

Video link: https://drive.google.com/file/d/1fub9Jo-T-NZ_-_JJbExgmcKcs2fMUvE9/view?usp=sharing

Brief description: When the scope is inserted into the pharynx, the cricopharyngeus can be observed as tensed and contracted. A green dyed pureed material is given to the patient. Few attempt to swallow can be seen an residue is observed after swallow. The secretions have blurred the image for a while, although a brisk white out can be observed. Modified PAS score of 1 and YPSR rating of 3 can be given.

Note: If by any chance you are interested in two cents in this tutorial, I want to emphasize on how important is your personality as a clinician once you start doing FEES. It requires a blend of time management, presence of mind and clinical decision

making skills. Imagine a hospital set up with continuous rush of patients having difficulty in the most basic function of life relying on you to seek help. It does need you to be responsible, stick to schedules, document findings, communicate with medical and allied professionals and most importantly, treat the person and not the condition. Hopefully, this acronym summarizes the soft skills you need as a clinician.

Faith is important in the sense, have faith you will be able to help the patient with the best of your knowledge. Do not hesitate to ask for opinions from colleagues and other professionals if in doubt.

Empathize with the patient to better understand what they are going through, their access to services, personal barriers and facilitators to best help them

Experience matters. Grab every little opportunity you get to learn about swallowing disorders.

Safety comes first. Always ensure your treatment plan is about achieving swallowing safety and then move to efficiency.

Also, remember to not be too hard on yourself. It is a learning curve so mistakes are obvious initially, you just never have to stop learning.

Additional video resources:

1. https://youtu.be/AaXDHYijLhs - FEES

2.https://youtu.be/wibHDnKykZU-Pediatric airway endoscopy

3. https://youtu.be/Zjy5Reao_DA- NG Tube airway insertion

4. https://youtu.be/ht-65PTLr9I-Muller's maneuver

Test your Knowledge

1. What is it called when bolus enters below the level of vocal folds?

a) Spillage

b) Penetration

c) Aspiration

d) White out

2. Think of signs which can be observed when spillage occurs in a FEES examination.

3. What compensatory strategy would you prescribe for a case with unilateral vocal cord paralysis?

a) Head extension

b) Head tilt

c) Chin tuck

d) Both c and d

4. What consistency should be advised in cases of aspiration?

a) Soft solid

b) Semisolid

c) Thin liquid

d) Hard solid

5. In which case would the laryngeal adductor reflex be absent or minimal?

a) Parkinson's disease

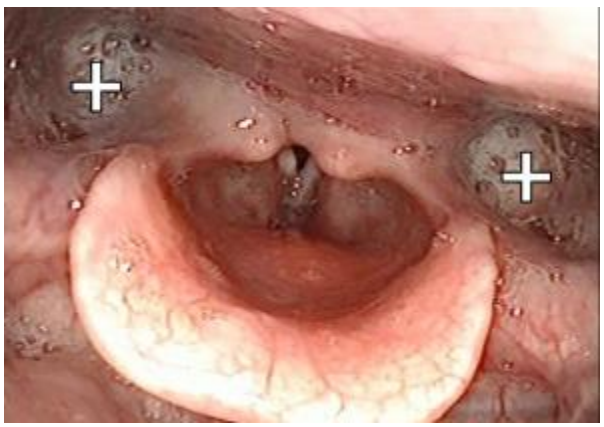
b) Unilateral Vocal Cord Paralysis

c) Bilateral Vocal Cord Paralysis

d) Cricopharyngeal spasm

6. Lingual sweeping action is observed in which kind of cases?

7. What do you find abnormal in the below FEES image?



Source: www.otorhinolaryngologyportal.com

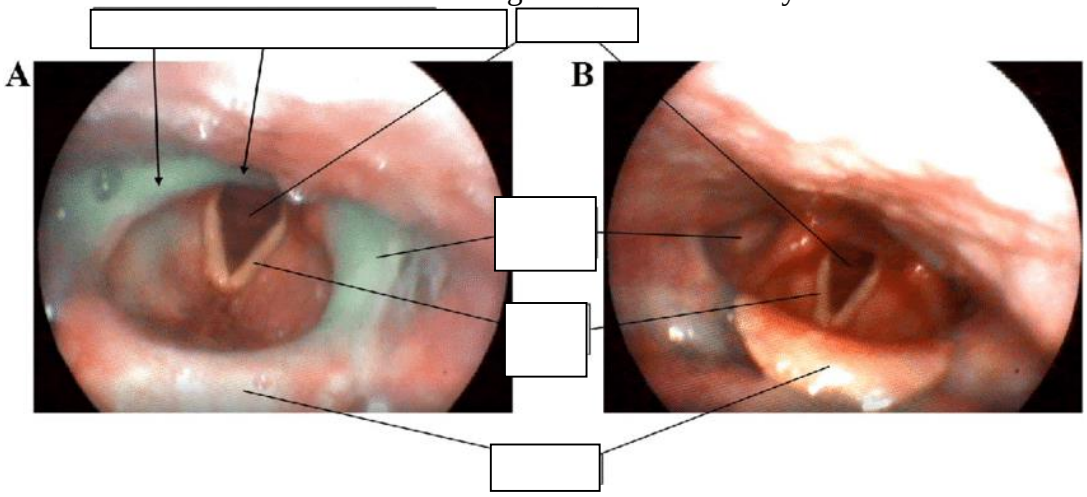
a) Pooling of saliva

b) Spillage

c) Lingual sweeping

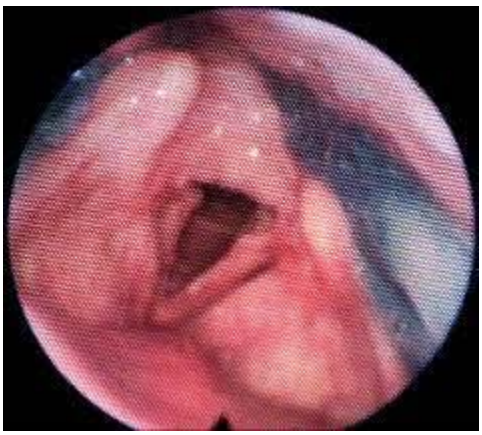
d) Aspiration

8. Label the boxes for the FEES images below and identify the condition.



Source: https://www.researchgate.net/figure/Fiber-optic-evaluation-of-swallowing-FEES-before-a-and-after-b-IVIg-treatment_fig1_341584223

9. Identify the condition for the FEES image below.



Source: https://prd-medweb-cdn.s3.amazonaws.com/documents/billwilkerson/files/Day1_SLPbreakout_Bartow_Aerodigestive%20course%20-%20FEES-2%20%5BCompatibility%20Mode%5D.pdf

a) Aspiration

b) Spillage

c) Penetration

d) Xerostomia

FEES RECORD FORM

I. Pertinent History, Oral Sensorimotor Skills, Anesthesia, Positioning

• Pertinent History/Past Medical History

• Reason for referral

• Diagnoses: (list)

• Oral Motor Assessment

○ Oral intake

○ Enteral feeding mode and schedule

○ Orofacial symmetry and tone at rest

○ Range and strength of oral motor movements

• Anesthesia

○ Afrin/Pontocaine

○ Viscous Lidocaine

• Positioning During FEES Exam

II. Anatomy and Physiology

• Appearance of Hypopharynx and Larynx at rest

○ Symmetry/Erythema/Edema/ Supraglottic collapse/Post-cricoid swelling/Post-cricoid venous plexus/Pachydermia

• Vocal Cord Mobility

• Secretion Management & Swallow Frequency

○ Frequency of spontaneous swallowing

○ Amount of secretions in hypopharynx

○ Standing secretions: location

○ Attempts to clear

○ Response to aspiration of secretions

○ Vocal quality: □ normal □ intermittent wet vocal quality □ consistent wet vocal quality

• Sensation: □ normal threshold □ decreased threshold □ Response to light touch pharyngeal walls □ Response to light touch of epiglottis

III. Swallowing Assessment

Swallowing Onset Time

Liquids: □ Timely swallow onset □ Delay in onset ___ seconds

Puree: □Timely onset □ Delay in onset: __ seconds

Pharyngeal Residue

○ Bolus Type:

○ Location:

○ Required multiple swallows to clear □

○ Responsive to verbal cue to use additional swallows to clear □

○ Used spontaneous swallows to clear □

IV. Response to Compensatory Strategies

• Alterations in Positioning

• Response to Postural Maneuvers

• Alterations in Rate of Intake

• Use of Effortful Swallow Strategy

• Alternation of Solids/Liquids to clear pharyngeal residue

CASE STUDY

Mr. A is a 45 year old male who complains about difficulty swallowing solids and liquids since six months. He has consulted ENT doctor regarding the complaint three months back. The ENT reported normal findings of vallecular, pyriform sinus, vocal folds and posterior cricoid. Mr. A works at a pharmacy shop and reports to be underpaid. The difficulty of swallowing began due to fatigue related work according to him. He also reported that when he stopped working, he did not have difficulty in swallowing. He prefers to eat solid food as compared to liquid consistency.

The following tests were conducted for this patient:

1. Oral Peripheral Mechanism Examination: The structural and functional integrity of articulators involved in speech production are assessed during an oral peripheral mechanism evaluation. The oral cavity was thoroughly examined, including the range, symmetry, and strength of the articulators such as the lip, jaw, tongue, and velum. All of the articulators were found to be in good structural and functional condition.

Table 3

Oral Peripheral Mechanism Examination findings

	Range	Symmetry	Strength
Lip	✓	✓	✓
Jaw	✓	✓	✓
Tongue	✓	✓	✓
Velum	✓	✓	✓

2. Cranial Nerve Assessment: Swallowing is largely dependent on the cranial nerves V, VII, IX, X, and XII. Mr. X was instructed to complete a series of tasks in order to test the functioning of the cranial nerves. He had no trouble doing the tasks, excluding the possibility of cranial nerve involvement.

Table 4

Cranial Nerve Assessment (McCullough & Martino, 2013) findings

	Functions:	Findings:
Trigeminal Nerve (CN V)	Jaw Mobility, strength, nge open/close against sistance, Exaggerated ıewing	Normal
Facial Nerve (CN VII)	Lip retraction, Protrusion, ırsing, Raising Eyebrows	Normal
Glossopharyngeal ((CN IX	Gag reflex, Feeling of nsation at the posterior ırt of tongue, faucial arches ıd Tonsils	Normal
Vagus Nerve (CN X)	Cough strength, Cough uality (Wet or Dry), Voice ı sustained phonation, ariation in pitch	Normal
Hypoglossal Nerve (CN II)	Tongue Mobility, rength- Protrusion/ ateralization against sistance	Normal

3. Clinical Swallowing Evaluation: The most critical step in diagnosing dysphagia is a CSE. To assess swallowing function, Mr. X was asked to consume different food consistencies from a glass, starting with liquids (water) and then solids (biscuits). Before, during, and after swallowing, he showed no signs of aspiration. A provisional diagnosis of psychogenic dysphagia was made, however findings need to be correlated with instrumental assessment.

Signs	Results
Pocketing	Normal bolus preparation, chewing and mastication, tongue peristalsis, and bolus
Leakage	

Poor bolus formation	propulsion. Normal swallowing reflex and cricopharyngeal sphincter functioning were elicited.
Slow transport	
Swallow delay	
Coughing	
Throat clearing	
Wet, gurgly voice	
Nasal regurgitation	

4. Four Finger Test: Fingers were placed in the neck region to determine laryngeal elevation. The elevation was robust, and a one-finger width raise was evoked in a timely manner.

5. Fiberoptic Endoscopic Evaluation of Swallowing:

I. Pertinent History, Oral Sensorimotor Skills, Anesthesia, Positioning

• Pertinent History/Past Medical History: **C/o difficulty swallowing solid and liquid food since six months, no history of weight loss, preferred consistency is solid food, CSE revealed no signs of dysphagia**.

• Reason for referral- **Subjective findings to be correlated with instrumental assessment findings**

• Diagnoses: **?Psychogenic Dysphagia**

• Oral Motor Assessment

○ Oral intake- **Complains of food getting stuck in the throat during swallowing when working, does not face difficulty outside the workplace**

○ Enteral feeding mode and schedule- **Does not use enteral feeding**

○ Orofacial symmetry and tone at rest-**Normal**

○ Range and strength of oral motor movements-**Normal**

• Anesthesia- NA

○ Afrin/Pontocaine

○ Viscous Lidocaine

• Positioning During FEES Exam- **Patient was explained about the need to do FEES using patient education videos.Informed consent was obtained prior to assessing patient using FEES. The patient was made to sit comfortably on a high chair in an upright sitting posture.**

II. Anatomy and Physiology

• Appearance of Hypopharynx and Larynx at rest

○ **When the scope was entered into the pharynx, trace amount of bubbling was observed around the vocal folds. Symmetry of vocal folds, arytenoids, false vocal folds, pyriform sinus was noted. Tone was also observed to be normal.**

• Vocal Cord Mobility- **Symmetrical and complete**

• Secretion Management & Swallow Frequency

○ Frequency of spontaneous swallowing – **Patient could follow the command of dry swallow as soon as the instruction was given.**

○ Amount of secretions in hypopharynx- **Trace amount of secretions**

○ Standing secretions: **Around the laryngeal vestibule**

○ Attempts to clear: **Present**

○ Response to aspiration of secretions-**No aspiration observed**

○ Vocal quality: □ **Normal** □ intermittent wet vocal quality □ consistent wet vocal quality

• Sensation: □ **Normal threshold** □ decreased threshold □ Response to light touch pharyngeal walls

III. Swallowing Assessment

Swallowing Onset Time

Liquids: □ **Timely swallow onset** □ Delay in onset ___ seconds

Puree: □**Timely onset** □ Delay in onset: __ seconds

Pharyngeal Residue

Residue was observed in trace amounts in the pyriform sinus however it could be cleared by the patient with multiple swallows.

Bolus consistencies of semisolid, soft solid, thin liquid and thick liquid were given to the patient in varying quantities. He could perform swallow all consistencies safely and efficiently.

IV. **Response to Compensatory Strategies**

No compensatory strategy was tried with patient as no abnormality was observed during the assessment.

• Alterations in Positioning

• Response to Postural Maneuvers

• Alterations in Rate of Intake

• Use of Effortful Swallow Strategy

• Alternation of Solids/Liquids to clear pharyngeal residue

Video link for FEES video: https://drive.google.com/file/d/1wUTXCp1VQ6fQDcC5is8VpsQ_giNEv8_J/view?usp=sharing

Looking at all the findings, patient was diagnosed with psychogenic dysphagia. Psychogenic dysphagia is a unique clinical issue that requires special attention from Swallowing Therapist. In situations of psychogenic dysphagia, a complete case history, OPME, cranial nerve assessment, and CSE are required for diagnosis by exclusion. Taking a thorough case history is critical since it not only influences the evaluation path but also aids us in identifying the potential site and type of dysphagia. Patients with

psychogenic dysphagia have reported fear of swallowing, difficulties swallowing specific consistencies, difficulties commencing the pharyngeal swallow, and globus feeling. Counseling is the main focus in the treatment of people with psychogenic dysphagia since they have underlying psychological symptoms such as anxiety and depression.

PROCUREMENT AND PRICING OF INSTRUMENTS

Here is a list of companies dealing with sale of endoscopy equipment in India with contact details. These companies also sell other medical equipment which may not be relevant to us. FEES procedure is still an upcoming and developing arena for SLPs and otorhinolaryngologists, therefore it is difficult to find companies dedicated for sale of FEES equipment. However, any flexible endoscope can be used for the purpose of swallowing examination.

Name of the Company	Equipment	Address & contact details
Techno Medico Services	Surgical Operating Microscopes, Electro medical equipment, Endoscopes, light sources, CCD camera, Endoscopes, Flexible endoscopes	111/112 Meghdhanush, Sadara road, Baroda 390020 India Telephone :091 - 265 - 2330214 Fax :091 - 265 - 2330214
Boss Pharmaceuticals	Exporters & Importers of Herbal Medicines, Food &diatory Supplements, Natural Colours, Essential Oils. Importers & Exporters of Diagnostic Instruments, Laparoscopy Instruments, Endoscopy instruments	Pl.no. 16A, 1,Om-Dwarka soc, 2,Shivaji street Ganesh Nagar, Dombivali (w), Thane, Maharashtra 421202 India Telephone：91 - 251 – 2404041
Kashmir Surgical Works	Ophthalmic, ENT and fiber optic endoscopy equipments& instruments	1888 B / 10, Baldev Nagar, Ambala, Haryana Telephone：91-171-2540154

Mysore Wifiltronics Pvt Ltd	Endoscopy equipment	1FA Hootagalli Industrial Area, Mysore, Karnataka, India Telephone :91-821-2402535 Fax Number :91-821-2402735 Fax :91-821-2402735
Endosys International	Equipment for: Laparoscopy, linimally Invasive Surgery, Urology, ynecology and Endoscopy.	C/149, Oshiwara Industrial Centre, Opp. Bus Depot, New Link Road, Goregaon West, Mumbai Maharashtra 400 104 India Telephone：91 - 22 – 28760841
Genuine medical private limited	High end medical devices	D10/3, Okhla industrial area-Phase II, New Delhi, India, 91-11-40513
Sushrut Electro edicals	Endoscopic equipments& struments	63, United Western society, "Adiparna" Apartments, NavSahyadri, Karve Nagar, Pune M.S. 411052 India Telephone :91 - 20 - 25410776 Fax Number :91 - 20 - 25410776

Ambalsoft fotech private nited	Medical Software, Capture ITPro, ndoscopy Software, Colpo ITPro, olposcopy Software,Medical Imaging oftware,	32 / 11, Pitchu Street, Mylapore Telephone :91-44-24640228 Mobile phone :919840031811 Fax Number :91-44-24612008
Pee bee india	Endoscopy, Pelviscopy, ndoscopic Camera	Mahavir apt,B-12,Pantnagar,Ghatkopar ,Mumbai, Maharastra Telephone :91 - 22 - 25122833
Divine MeditechPvt Ltd	Digital Video Colposcope, Gynecology Equipment,Endoscopy Light Sources, Patient Monitors	Plot 18, Phase III, Industrial Area Tahliwal, District Una, Himachal Pradesh, India Telephone :91-1975-257232 Mobile:91-9313033556 Fax Number :91-11-22374182
Suvina nterprises	Endoscopy / laparoscopy surgical instruments (5/10 mm), telescopes, fiber optic cable, etc. main activity is manufacturing / repair of instruments, karlstorz	Kandivali, Bombay Telephone :91 - 22 - 8286949158
Nidhi Meditech ystem	Lithotripter, Uroflowmetry, Urology, Endoscopy, Surgical, Disposable, Healthcare, Medical Equipment,	A-207, 'Tirthraj ' Complex, Opp. V. S. Hospital, Ellisbridge, Ahmedabad , Gujarat

		Telephone :91 - 79 - 26578422
SCS System	Urological Instruments, Laproscopy, Endoscopy, Orthopaedic Equipment,	4/12,Devi Nagar, Karampakkam, Porur chennai, Tamilna du

ANSWER KEY

CHAPTER 1

1. b) To help visualize structures not visible to naked eye

2. b) Through one of the nares

3. b) Nasal turbinates

4. d) Smooth structure at the end of nasal cavity

5. d) Palatine tonsils

6. a) Subglottis

7. b) Muller Manuever

8. a) Pyriform recess

9. c) Muscular process of arytenoids

10. a) Anterior commissure

CHAPTER 2

1. b) Video tower
2. c) 300 mm
3. d) Both a and c
4. c) Avoid directly looking at it
5. a) Reduce exposure time of the camera

6. b) False, the procedure can be carried out without using it

7. c) Color, coating and opacity

8. b) False, with appropriate selection of bolus material, pharyngeal structures can be visualized

9. Milk, smoothies, icecream shakes

10. a) Gloves, face mask, apron

11. b) FEES is an invasive procedure which could result in complications

12. b) Discomfort and gagging

13. a) Use nasal spray

14. b) It could vary from place to place

15. d) Nose bleeding

CHAPTER 3

1. c) Epiglottis

2. b) Pyriform sinus

3. b) Subglottic region

4. d) Do all the above

5. b) False

6. a) True

7. old age (more than 70 years), bolus of milk instead of water and larger volumes (15 or 20 mL) increased the odds of penetration and aspiration

8. c) It is the same for both

9. a) White milk is found to cause more aspiration than water

10. a) Laryngeal sensations are reduced

CHAPTER 4

1. b) Susan Langmore

2. a) True

3. a) Sitting upright

4. d) All of the above

5. c) Pre swallow assessment

6. b) No

7. b) White out

8. Banana, soft cake

9. a) Trial feed should be repeated to confirm presence of aspiration

10. d) All of the above

CHAPTER 5

1. Penetration-Aspiration Scale

2. Yale Pharyngeal Residue Severity Scale

3. b) False, normal individuals will also have some amount of residue

4. Cough reflex, presence of laryngeal sensations

5. 5

CHAPTER 6

1. Aspiration

2. Bolus reaches the throat, multiple attempts to swallow, inability to clear residue

3. Head tilt to stronger side, chin tuck

4. Thickened liquids

5. Bilateral vocal cord paralysis

6. Oral and pharyngeal phase

7. Head and neck cancer; oral phase will be affected leading to difficulty in bolus manipulation

8. Parkinson’s disease

9. False, some amount of aspiration is commonly observed in normal healthy individuals.

10. Reduced opening of mouth, observed in cases of head and neck cancer.