"STROBOSCOPY AS A DIAGNOSTIC TOOL FOR EVALUATION OF DYSPHONIA"

By

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MASTER OF SURGERY

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DR. SHILPA POTNURU

LIST OF ABBREVIATIONS

%	Percentage
GRBAS	Grade Roughness Breathiness Asthenia Strain
ASHA	American Speech and Hearing Association
CAPE-V	Consensus Auditory Perceptual Evaluation of Voice
VHI	Voice Handicap Index
VRQOL	Voice Related Quality Of Life
FOX	Voice Outcome Survey
VAPP	Activity And Participation Profile
WHO	World Health Organization
SERF	Stroboscopy Evaluation Rating Form
VF	Vibration Factor
EF	Edge Factor
HSV	High Speed Videoendoscopy
VLS	Videolaryngostroboscopy
IDL	Indirect Laryngoscopy
B/L	Bilateral
TB	Tuberculosis
N	Normal
R_X	Treatment
M_X	Management
VDL	Videolaryngoscopy
SD	Standard Deviation
Yrs	Years
M	Male

F Female

ABSTRACT

Aim: The aim of this study is to assess the value of videostroboscopy as a diagnostic tool for evaluation of dysphonia.

Materials & Methods: All patients who presents with symptoms of dysphonia at Shri B.M Patil Medical College Hospital and Research Centre, Vijayapur in the Department of Otorhinolaryngology between October 2015 to May 2017. The patients were assessed clinically (history. Clinical examination and indirect laryngoscopy) and then subjected to videolaryngoscopy examination. Videostroboscopy was then carried out in these patients.70° rigid stroboscope connected to a strobe unit is used to visualize patients larynx and video recorded will be studied for stroboscopic parameters.

Study design: Prospective Cross-sectional study.

Results: The present study was conducted in 113 patients presenting with dysphonia to our outpatient department. The efficiency of videolaryngoscopy was 75.22% and videostroboscopy was 93.2%. Videostroboscopy showed significant change in the diagnosis in 13.27% patients. This change in diagnosis had subsequently helped in changing the treatment plan in 4.4%.

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Conclusions: The efficacy of stroboscopy (93.5%) in diagnosing dysphonia is superior than videolaryngoscopy (75.22%). In a small but significant 13.27%) patients stroboscopy resulted in change of diagnosis. Change in diagnosis in stroboscopy also resulted in the change in the plan of treatment in 4.4% patients. Videostroboscopy is also an easy, non-invasive and office procedure which can be performed under local anesthesia. As there is significant change in diagnosis and treatment plan, it must be included in the routine complete office voice examination of dysphonic patients.

Key Words: Dysphonia, Videolaryngoscopy, Videostroboscopy, Hoarseness, Vocal cord Pathologies

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INTRODUCTION

Speech is one of the unique quality that sets man apart from all other living organism. It is the best way of communication between human beings. Voice disorders isolate a person from the society but could also have deep impact on emotional and occupational aspect of life. Patients who have vocal abnormalities; particularly in professional voice users, voice disorders likely to threaten their livelihood.

Voice disorders are common.[1] The data of prevalence of voice disorders have been scarce and have ranged from 0.65 to 15 % in the general population.[2]

The term phonation is defined as physical and physiological characteristics produced by the vocal cord vibration. The abnormality of the phonation is termed as dysphonia. Dysphonia has been reported in up to 0.98% of patients,[3] presenting to ENT OPD. The prevalence rate was higher among females as compared to males (1.2% vs. 0.7%) and among those >70 years of age (2.5%).

Most benign vocal disorders present with dysphonia. The lesions are vocal cord cysts, polyps and nodules which are surgically resectable. Preoperative evaluation of these lesions is done based on OPD procedures like indirect laryngoscopy and endoscopy. Many finer details of vocal cord movement cannot be assessed. The diagnostic accuracy from history and physical exam excluding laryngoscopy is only 5% compared with a 68.3% accuracy following initial endoscopic laryngeal evaluation.[4]

The addition of videostroboscopy provides useful real-time information regarding the nature of vibration, an image to detect the vocal cord pathology and a permanent video record of the complete examination for future reference. Even though it fulfils several important requirements of a complete office voice examination, it is not accepted and routinely used due to its cost and efficacy not being proven.

However, stroboscopy is not new. Vocal tract imaging using a continuous light source was first reported by Maneul Gracia (1855).[5] In 1895, internist Oertel used a stroboscopic light source with a laryngeal mirror to investigate voice production. The operative principle of stroboscopy is based on Talbot's law and it states that the image persists on the retina for 0.2 second after exposure, therefore images presented at intervals less than 0.2 second are fused together, producing a montage of apparent motion. The frequency of the examinees sustained voice is picked up by a microphone and triggers the stroboscopic light source. The strobe light is produced at frequency several hertz slower than the vocal frequency to produce illusion of a slow motion.

As the effective treatment is based on correct diagnosis, this study was done to prove the efficacy of videostroboscopy so that it can be included in routine evaluation of dysphonia.

OBJECTIVE OF THE STUDY

The aim of this study is to assess the value of videostroboscopy as a diagnostic tool for evaluation of dysphonia.

REVIEW OF LITERATURE

History:

Guy B Babington in 1829, is credited to have viewed the upper larynx with ‘glottoscope’, a unique instrument as he combined a reflecting dental mirror and tongue depressor into one clinically practical unit.[(6)]

Hoarace Green (1838), considered as a ‘Pioneer of Larngoscopy in America (Father of American Laryngology)’ is credited to have achieved direct visualization of the larynx. He is also credited to many ‘firsts’, amongst which is the first larngoscopic operative procedure.[(7)]

Manuel Garcia (1854), a Spanish singing teacher is considered by many as The ***Father of Larngoscopy***. He demonstrated to The London Royal Society of Medicine of indirectly viewing his own larynx using two mirrors and sun as light source. It is his tireless advocacy and persistent desire to perfect his technique that earns Garcia a mention in the history of endoscopy.

In the year 1857, Professor Ludwig Turckin Vienna, was experimenting with indirect larngoscopy by using angulated mirrors to reflect and focus daylight on glottis. Despite his relentless efforts he was not able to visualize the glottis. Johann Czermak,[(8)] an eminent in Physiology (Budapest) borrowed instruments from Professor Ludwig Turckin. Johann achieved higher results as he modified the reflective plane mirror to a concave mirror with a central hole to see through and he also used external light source. The continuous efforts of these two pioneers could bring the indirect laryngoscope to this daylight.

Merell Mackenzie (1870) developed the art of indirect laryngoscopic examination. He also biopsied larynx under indirect laryngoscopic examination.[(9)]

The larynx was assessed using mirrors (indirect view) until 23 April 1895, when Alfred Kirstein (1863—1922) of Germany for the first time described direct visualization of the vocal cords. Kirstein performed the first direct laryngoscopy in Berlin, using an esophagoscope which he modified and named this device an autoscope. It is believed that death of Emperor Frederick III in 1888 encouraged him to develop this device.[10]

Gustave Killein (1909) discovered the suspension laryngoscopy which was later modified by Albrecht and Brunning. It basically consists of two parts laryngoscope and suspension crane.[11]

Yankeur (1910) designed direct laryngoscope for binocular vision.In 1913, Chevalier Jackson reported the usage of direct laryngoscopy for intubating the trachea.

Jackson introduced new laryngoscope blade that had a light source at the distal tip, instead of kirstein's proximal light source. This new blade had a component to allow room for passage of an endotracheal tube or bronchoscope.[12]

Jako (1958) attempted to use Zeiss operating microscope. Priest and Wedowski (1960) first reported microlaryngoscopy.[13]

Embryology:

The larynx appears, phylogenetically, as a constrictor –dilator mechanism in the airway. The larynx develops primarily from branchial arch derivatives in the human embryo. At 6 weeks after fertilization the primordium, the epiglottis is seen at the base of third and fourth pharyngeal arches. By 8 weeks, the arytenoids, cricoids, cuneiform and thyroid cartilages are easily distinguishable. At 10 weeks, the vocal folds are evident and at seven months a definite larynx is formed.

The larynx is situated in front of hypopharynx opposite the 3rd -6th cervical vertebrae. The skeletal elements of larynx are composed of cartilages, muscles and ligaments. The cartilages are moved with respect to one another by muscles. It is lined by mucous membrane which is continuous above and behind with pharynx and below with larynx.[14]

Anatomy of Larynx:

Laryngeal cartilages and joints:

Laryngeal cartilages form the frame work of larynx. There are 3 paired and 3 unpaired cartilages[14]. The unpaired cartilages are thyroid cartilage, cricoid cartilage and epiglottis. Paired cartilages are arytenoid, corniculate and cuneiform cartilages. Thyroid, cricoids and greater part of arytenoids cartilages are hyaline cartilages and they ossify later in life. The corniculate, cuneiform, epiglottis and tip of the arytenoids cartilages are elastic fibrocartilage and do not undergo ossification. The principal joints of the larynx on each side are cricothyroid joint and cricoarytenoid joint.

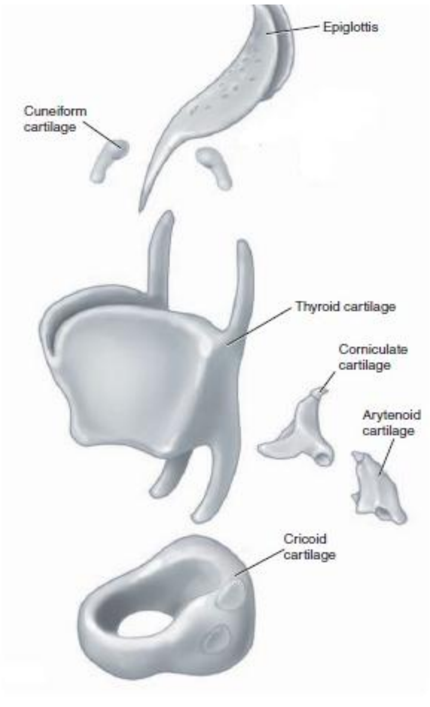

Figure 1:Laryngeal cartilages

Thyroid Cartilage:

Thyroid cartilage is the largest of all the cartilages the larynx. There are two leaf like laminae which are joined in the midline of the body. Superiorly both the lamina remain disconnected which is called as the thyroid notch (also called as Adam's apple). Posteriorly there are extensions from the superior and inferior extensions of the larynx called as superior and inferior cornua respectively. The superior cornua articulates with the greater horns of the hyoid bone and the inferior cornua forms a synovial joint with the facet on cricoid cartilage (the cricothyroid joint). At the junction of superior cornua with thyroid ala, a protuberance called superior tubercle is found. The superior tubercle is of significance because it marks the point 1 cm anterior and superior to which the superior laryngeal artery, nerve and lymphatics pierce the thyrohyoid membrane.

The sternothyroid and the thyrohyoid muscles are attached to the anterior surface of the thyroid laminae at the oblique line. The inferior pharyngeal constrictor muscles insert on the posterior border of each thyroid ala. The relationship of the internal laryngeal structures to the surface anatomy of the thyroid cartilage is important in planning the placement of the window for thyroplasty. The level of the vocal fold lies closer to the lower border of the thyroid cartilage lamina than to the upper and to its midpoint, as frequently stated. The thyroplasty window should be correctly placed to avoid medialization of the false vocal folds or ventricular mucosa.

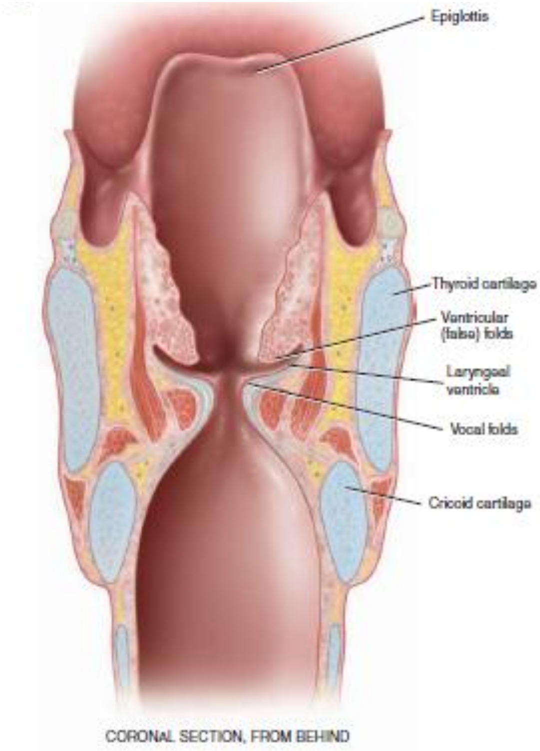

Figure 2:Coronal section of larynx from behind

Cricoid cartilage:

This cartilage is signet ring shaped and the only laryngeal cartilage to encircle the airway completely. The cricoid cartilage articulates with the thyroid cartilage's inferior cornua by cricothyroid joint superiorly. It articulates inferiorly with first tracheal ring via membranous attachments. The vertical height of cricoid cartilage anteriorly was of only about 3–4 mm and 20–30 mm posteriorly. The superior margin of the cricoids cartilage has a steep slope from anterior to posterior. This slope leaves an window anteriorly where the cricothyroid membrane lies.

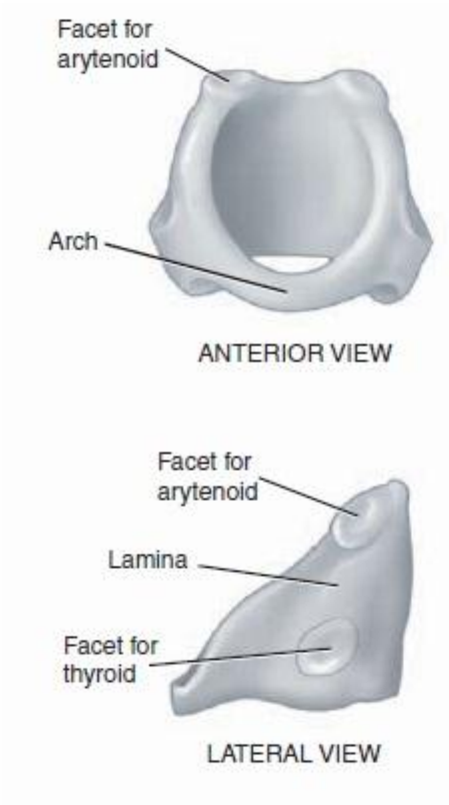

Figure 3:Cricoid cartilage-AP VIEW and LATERAL VIEW

Epiglottis:

The epiglottis is an oblong, feather-shaped yellow fibroelastic cartilage forming anterior wall of laryngeal inlet. The petiole at its inferior end attaches to the inner surface of the thyroid cartilage laminae just above the attachment of vocal cords. It plays major role in prevention of aspiration during food ingestion. It is displaced posteriorly by contraction of tongue base and elevation of larynx. The laryngeal vestibule is closed by sphincteric closure of larynx at glottis and supraglottic level in conjunction with the superior surface of epiglottis.

Arytenoid cartilage:

The arytenoid cartilages are two in number and pyramidal in shape. These cartilages articulate with cricoid cartilage by cricoarytenoid joint posteriorly. Each arytenoid has vocal process medially and muscular process laterally. The vocal process gives attachment to the vocal ligament medially and major intrinsic muscles to the muscular process laterally for vocal fold movement.

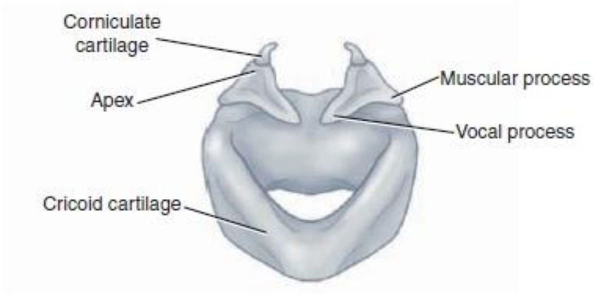

Figure 4:Arytenoid cartilage

Cuneiform and Corniculate cartilages:

The cuneiform cartilages are also two in number, rod shaped and made up of elastic cartilages situated on top of and move with corresponding arytenoid. They are completely embedded in the aryepiglottic folds. The corniculate cartilages are small, paired and fibroelastic cartilages that sit on each arytenoids laterally. These provide additional structural support to the aryepiglottic folds.

Laryngeal ligaments and membranes:

There are two types of ligaments-intrinsic and extrinsic. The intrinsic ligaments are elastic membrane of the larynx, which forms the fibrous frame work, the median cricothyroid ligament and thyro-epiglottic ligament.

Extrinsic ligaments unite the laryngeal cartilages to the skeletal structures outside larynx. They are thyrohyoid membrane, median thyrohyoid ligament, lateral thyrohyoid ligament, cricotracheal membrane and hyoepiglottic ligament.

Cricothyroid joint:

The cricothyroid joint is a type of synovial joint connecting the inferior cornua of the thyroid cartilage with cricoids facets. The two major actions at this joint are anteroposterior sliding and rotation of the inferior cornua of thyroid cartilage on the cricoid cartilage .On contraction, cricothyroid muscle pulls the thyroid ala anteriorly and closes the anterior visor angle between the thyroid and the cricoid cartilage. This movement results in increasing the distance between the anterior commissure and the vocal processes which causes lengthening and tenses the vocal folds. Manipulation of this joint can control pitch in cases of paralytic dysphonia. Subluxation of this joint decreases the anterior cricothyroid angle and thus helps in medialization procedures of vocal fold tightening.

Cricoarytenoid joint:

The cricoarytenoid joint is a synovial joint covered by capsular ligament connecting the base of arytenoids and facet on the cricoids lamina. The cricoarytenoid joint movement alters the space between the vocal processes of the both arytenoids and also between each vocal process and the anterior commissure. The intrinsic laryngeal muscles action on the arytenoids alters the position and shape of the vocal folds. Each cricoarytenoid joint makes an angle of 45 degrees with cricoid cartilage in horizontal and produces sliding, rocking and twisting movements.

Quadrangular membrane and conus elasticus:

The quadrangular membrane is a portion of fibroelastic membrane lying superior to the ventricle. It runs anteriorly from the lateral aspects of the epiglottis, and wraps around posteriorly attaching the arytenoids. The superior border of the membrane is formed by the mucosa covered aryepiglottic fold and inferior border forms vestibular ligament lying on the false cords. The quadrangular membrane extends inferiorly and forms the medial wall of the pyriform sinus.

The thick fibroelastic support structure of the glottis and subglottis originates inferiorly from the superior border of the cricoid cartilage and extends superiorly to attach to the anterior commissure and vocal processes. Anteriorly, the conus elasticus is continuous with the cricothyroid membrane and forms the lateral portion of cricothyroid ligament. The conus elasticus rolls medially within the substance of the vocal fold and forms vocal ligament at medial end.

Suspension of larynx:

The skeletal elements of the larynx are suspended in the neck by elastic structures superiorly and inferiorly. The major superior suspension is via stylohyoid ligaments from the base of skull to the lesser horns of the hyoid bone. The hyoid bone attaches to larynx, through thyrohyoid membrane. The cricoids cartilage is suspended from the thyroid cartilage by the articular ligaments and by the cricothyroid membrane, also known as the conus elasticus or cricovocal membrane.

The secondary suspension of larynx deals with fine movements of arytenoid cartilages. The quadrangular membrane suspends the arytenoids from the epiglottis.Below the larynx, the cricotracheal membrane connects the larynx to the trachea.

Laryngeal muscles:

Laryngeal muscles are of two types, Intrinsic and Extrinsic muscles. The intrinsic muscles of larynx links the laryngeal cartilages with one another. The extrinsic laryngeal muscles links the larynx with the neighbouring structures.(15)

Intrinsic muscles of larynx namely abductors of vocal cords i.e posterior crico arytenoids muscle, adductors of vocal cords are three pairs lateral cricoarytenoid muscle, transverse portion of the interarytenoid muscle, external portion of the thyroarytenoid muscle. Tensors of the vocal cords are cricothyroid muscle, internal portion of thyroarytenoid (vocalis) muscle. The laryngeal inlet is opened by thyro-epiglotticus muscle. Closers of laryngeal inlet are oblique portion of interarytenoid muscle and aryeepiglotticus muscle.

Extrinsic muscles connect larynx with neighbouring structures. The primary elevators are thyrohyoid, suprahyoid muscles (digastrics, stylohyoid, mylohyoid, geniohyoid, hyoglossus, genioglossus), depressors (sternothyroid), infrahyoid muscles (sternohyoid and omohyoid).

Cavity of larynx

Cavity of larynx is divided into three parts by two folds of mucous membranes- false cords and true vocal cords into vestibule, ventricle and subglottic region.

Mucous membrane of larynx

The epithelium of mucous membrane is ciliated columnar in the larynx except anterior surface of epiglottis, upper half of posterior epiglottis, superior margins of aryepiglottic folds and the margin of vocal folds where it is stratified squamous rather respiratory and without mucous glands.[16]

The vocal folds

The vocal folds are membranous folds extending anteriorly from the middle of thyroid cartilage to the vocal process of the arytenoids cartilages posteriorly on either side.[17] Hirano (1977) described the multi-layered structure of vocal fold into five layers. The mucosal layer is divided into epithelial layer and lamina propria, which consists of superficial, intermediate and deep layers.[18] The underlying stiff layers allows the superficial mucosa to vibrate freely due to the loose nature of the tissue. The epithelium layer is secured to superficial lamina propria through the basement membrane zone.[19]

The vocal fold mucosa is highly specialized for its vibratory function. The superficial layer is the squamous epithelium which protects the deeper layers and are responsible for vocal cord hydration. The most superficial layer (superficial layer of the lamina propria, or SLP) is acellular and gelatinous in nature, composed of loosely arranged fibres of collagen and elastin in the matrix. The space between the superficial and intermediate layer of lamina propria is called reinke’s space providing the cushion.

The intermediate layer of the lamina propria adds elastic mechanical integrity to the vocal fold. The more denser and the deeper layer is composed of collagen fibres and contributes to the durability of the layer. The intermediate and deep layer together forms the vocal ligament. The vibration of the sound is produced by movement of the superficial layer of the lamina propria and the squamous epithelium over the underlying muscle and ligament. The vocal fold mucosa and vocal ligament cover the vocalis muscle. The anterior two third of the true vocal cord is membranous and posterior one third is respiratory or cartilaginous on endoscopic visualization.

The anterior end of the edge of the vocal fold consists of mass of collagenous fibres, which appears to be attached to the inner perichondrium of the thyroid cartilage anteriorly called anterior macula flava. Similar structure seen on the posterior end of the vocal fold which is attached directly to the arytenoid cartilage is called posterior macula flava. These structures serving as cushions prevents the mechanical damage to the vocal folds caused due to vibration. The superficial layer of lamina propria and collagenous deep layer grows thicker and denser with age. The elastic fibres of the intermediate layer and the vocalis muscle becomes loose and atrophies with age and thus become thinner.

Blood supply of larynx

The main arterial supply to the larynx is derived from the laryngeal branches of superior and inferior thyroid arteries. The superior laryngeal artery arises from superior thyroid artery at the level of hyoid bone and moves medially along with the internal branch of the superior laryngeal nerve and enters the thyrohyoid membrane 1 cm anterior and superior to the superior tubercle. The cricothyroid branch of the superior thyroid artery runs along the inferior surface of the thyroid cartilage and pierce the cricothyroid membrane and then ascend on the internal surface of the thyroid cartilage. The branches of this artery are susceptible to damage during thyroplasty. The main supply of this branch is to cricothyroid joint and the muscle. The second major arterial supply to the larynx is derived from the inferior laryngeal artery, a branch of the inferior thyroid artery. This artery combines with branches of the superior laryngeal artery after entering larynx between the inferior constrictor muscle fibres.

Lymphatic drainage of larynx

The vocal folds divide the larynx into two parts.

1. Supraglottic-lymphatic vessels from supra-glottis drain into upper deep cervical nodes.
2. Subglottic- lymphatic drainage from subglottis drain into lower deep cervical nodes through prelaryngeal and pretracheal lymph nodes.

Nerve supply of larynx

Larynx is mainly supplied by the vagus nerve. The internal branch of superior laryngeal nerve provides sensory innervations to the larynx above the vocal cords. The external branch of superior laryngeal nerve innervates the cricothyroid muscle. The other muscles of larynx as well as the mucous membrane below the vocal cords are supplied by the recurrent laryngeal nerve.(14)

Physiology of Larynx:

Functions of the larynx:

The larynx has a sphincteric valve action in the neck. It is composed of rigid skeleton and inner lining with series of elastic folds. These folds are attached superiorly to the skull and inferiorly to the trachea. The external and internal muscle activity of active folding and unfolding are required for functional activity of larynx.

Human larynx has four major functions, namely

1. Airway opening for respiration and closure for protection of the respiratory system.
2. Effort closure
3. Swallowing
4. Phonation

Protection of the lower airway:

Phylogenetically, the earliest function to develop was the protection of the lower airway. Sphincteric airway protection is undoubtedly the most important laryngeal function. But, in man the sphincter serves other functions as well, such as facilitating cough and phonation.

Position of larynx relative to other structures in the upper airway influences function. In neonates, the larynx is positioned high in the airway so that epiglottis is locked into the nasopharynx posterior to the soft palate. This arrangement helps the infant to suckle and breathe simultaneously. During growth epiglottis descends from its formerly high cervical position to a lower position relative to the other structures of the upper airway. The low cervical position of larynx in the adult human is not constant. During deglutition, the larynx in the adult is elevated and anteriorly displaced so that the supraglottic portion projects towards the nasal cavity. This position facilitates the epiglottis and aryepiglottic folds to displace the food laterally. This protective function of the epiglottis is enhanced by the ability of the superior portion to fold posteriorly over the laryngeal inlet. The aryepiglottic folds are approximated by the contraction of the superior division of the thyroarytenoid muscle. Concurrently with the contraction of thyroarytenoid muscle, the pre-epiglottic fat pad is pressed against the thyroid cartilage and the hyoid bone, pushing the base of epiglottis towards the raised ventricular bands. This completes the first tier of laryngeal protection.

The second tier of protection occurs at the ventricular folds, which are closed together under the strong contraction of the fibres of the thyroarytenoid muscle that lie lateral to the folds. The third tier of protection occurs at the level of vocal cords and bronchi, if any food particles enter the larynx.

Larynx plays a part in the mechanism of respiration by reflex adjustments of glottis aperture. The respiratory contribution of larynx was suggested by Negus in 1949. He observed the opening of glottis just before the inhalation of air by diaphragm descent. The neurophysiology of this activity is under direct control of medullary respiratory centre. He showed that glottis opening occurs along with recurrent laryngeal nerve periodic activity and this periodicity is aggravated by increase blood CO_2 levels and obstruction of airway and decreased by hypocapnia (CO_2 wash out due to hyperventilation).

Larynx has a role in controlling expiration also. Respiratory frequency mainly depends on expiratory flow and duration. Hence, the respiratory rate varies with duration of expiration. The larynx exhibits sphincteric valvular effect of ventilator resistance and is responsible for the control of expiratory phase of respiration. Contraction of cricothyroid muscle during expiration causes vocal cord lengthening increasing the glottis size. This causes decrease in the resistance of airway and shortens expiratory duration. The control of respiratory rate is under larynx through this mechanism.

Effort Closure:

Effort closure is a process which involves capturing the air within the thorax to contain intrathoracic pressure, so that thorax acts as fulcrum for the upper limbs. Firm adduction of both vocal folds prevents expulsion of air and subsequently chest collapse. This mechanism is responsible for providing fixed origin for arm and shoulder muscles during strenuous activity involving upper limbs (e.g.- grunting while lifting heavy objects, pushing a car and climbing).

Deglutition:

The main function of the larynx in deglutition is to prevent food bolus and other substances entering into the respiratory system. This is attained by simultaneous contraction of the aryepiglottic folds, the true vocal cord, the false vocal folds along with approximation of epiglottis to larynx by elevation of larynx. The act of swallowing occurs into two phases- oral and pharyngeal phase. The voluntary oral phase is further divided into oral preparatory phase and oral transport phase. In oral preparatory phase, the food is grinded with the help of teeth and thoroughly mixed with saliva to form a soft bolus. The food bolus is then pushed into oropharynx in the oral transport phase.The involuntary pharyngeal phase of swallowing starts when the food bolus reaches the posterior one third of the tongue. The food bolus is directed into vallecula by epiglottis and then into pyriform sinuses. The principal role of larynx in the pharyngeal phase is to prevent the food bolus entering into airway. This is achieved by glottis closure from approximation of false vocal folds and true vocal folds and larynx with epiglottis. The closure of glottis by adduction of vocal folds takes approximately 2.3 seconds.

Phonation

The complex mechanism of phonatory control, coordinate central and peripheral components. The larynx responds to central commands from linguistic and motor centres. The motor cortex in the precentral gyrus receives the signals and then sent to the motor nuclei in the brainstem and spinal cord. These signals are transmitted to the respiratory, laryngeal and articulatory muscles that are responsible for speech and voice production. These messages are influenced by the higher centres including the cerebral cortex, cerebellum and basal ganglia exerting fine control of respiration, phonation and articulation.

Initiation of voice-

Immediately before phonation, the vocal folds rapidly abduct to allow the intake of air. Wyke (Il) has termed this the 'pre-phonatory inspiratory phase' Subsequently, the vocal folds are adducted by the contraction of the lateral cricoarytenoid muscles. The vocal note is generated by pulmonic air (air from the lungs) as it is exhaled between the adducted vocal folds. The vocal folds working together, therefore, constitute a vibrator which is activated by the exciter, the exhaled air. The production of the vocal note at this point is the result of the repeated vibratory movement of the vocal folds, known as vocal fold oscillation. The mobility and deformability of the vocal folds determines the ease with which vocal fold vibration can be initiated.[20] Subglottic air pressure increases below the adducted vocal folds until it reaches a level which overcomes their resistance and blows them apart, thus setting in motion the vibratory cycles which result in phonation. The vocal folds, in common with all vibrators, have a degree of inertia which has to be overcome in order for phonation to occur. The amount of air pressure required to begin voicing is known as the 'phonation threshold pressure. The size and tension of the vocal folds in combination with the viscoelastic properties of the vocal fold cover will affect the phonation threshold pressure.[21]

Theories of sound production-

1. Aerodynamic theory

The glottal cycle begins with accumulation of air pressure against convergent walls of subglottis, the result of exhalation of air against closed vocal folds. The rising air column parts vocal folds apart and compresses the tissues of vocal folds as it passes through. The inherent elasticity and decreased intraluminal pressure causes closure of glottis. Once it comes to normal configuration, cycle repeats.[17]

2. Neurochronaxic theory

In 1950, a neurochronaxic theory was suggested by Hussin which stated that frequent impulses were generated from the higher center in central nervous system to recurrent laryngeal nerve which in turn stimulated thyroarytenoid muscle contraction resulting in vocal cord vibration.[22]

This neurophysiologic mechanism regulates the vocal cord shape and the position. The contraction of cricothyroid muscle causes adduction of vocal folds which is mandatory for sound production. Additionally, the thyroarytenoid muscle provide fine tuning of the vocal cords. The vibratory mass of both vocal cords, tensile strength of the vocal cords, functional damping at high pitches and subglottic pressure are the factors on which frequency of vibration is dependent.[23]

3. Hirano's body cover body theory

The vocal cord has three layers of which the most superficial layer (Epithelium and superficial layer of lamina propria) encloses the vocal ligament and vocalis muscle. The vibration of mucosa does not correspond to that of the rest of the body. The body of vocal folds is relatively inelastic. Wave propagated in mucosal cover starts in inferomedial aspect of vocal folds and moves laterally as superior edges of vocal fold separate inferior edges close.[24]

The breathing mechanism continues to build up the subglottic pressure, which withstood for a certain time by the vocal cords, but eventually overcomes the resistance offered by the obstruction, thus forcing the cords apart. There is an immediate out flow of air through the glottis and this gives rise to a fall in pressure on the underside of the cords (Bernoulli effect). The return of cords to their closed position is due to the combined effects of the restoring force of their own elasticity and the rarefaction due to the Bernoulli effect. This cycle of opening and closing continue as long as muscular action is maintained to adduct the cords and the subglottic pressure is high enough to force them apart.

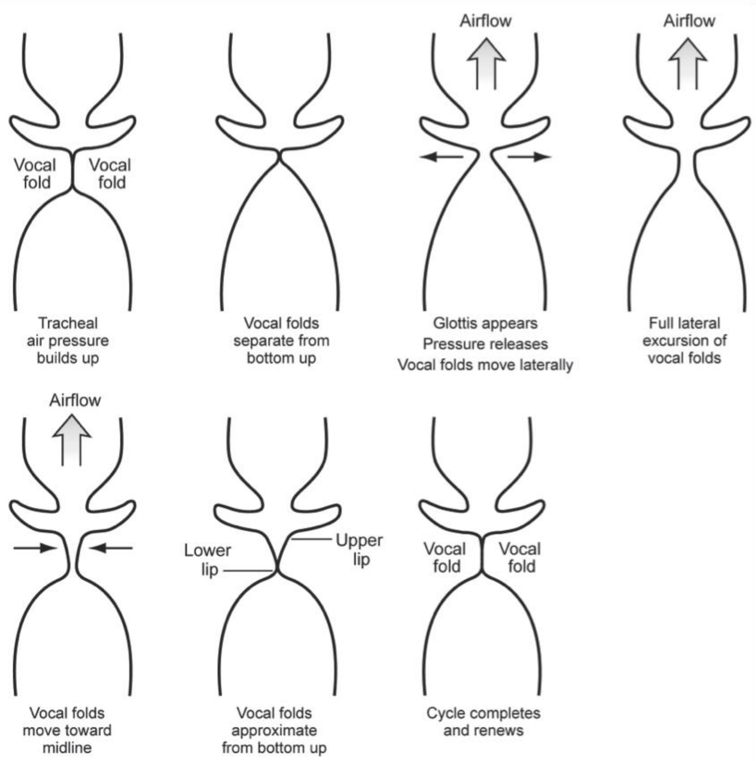

Figure 5: Bernoulli Effect, Movement of Vocal cords during Phonation

Voice quality disorders (Dysphonia):

Dysphonia, defined as any impairment of the voice or difficulty speaking. Blake Simpson et al has described in detail the importance of history taking in hoarseness.[25] Inciting factors like upper respiratory infection, history of trauma, endotracheal intubation, traumatic life events, duration, aggravating and relieving factors, past medical history including pulmonary or respiratory disorders, autoimmune conditions, allergic rhinitis and sinusitis, endocrine disorders, radiation therapy, previous treatment, psychiatric problems, past surgical history, medications, social history and occupational history are important.

According to Dettelbach et al., a patient's complaint of hoarseness must be attended carefully. The cause though may appear trivial, but a life-threatening disease could be the underlying problem. The laryngologists goal is hence to provide an accurate and quick diagnosis so that proper treatment can be started, at once.(26)

Dettelbach et al., emphasizes the key points in history taking for patients with hoarseness. According to him the key points are alcohol, abuse, asthma, cough, dysphagia, heart burn, hemoptysis, neck lumps, odynophagia, otalgia, smoking, stridor, throat pain, thyroid disease and professional voice use.

Clinical examination includes detailed history taking, general examination, systemic examination, local examination, indirect laryngoscopic examination and other tests to determine vocal cord function.

Traditionally the vocal cord examination is performed with laryngeal mirror since the time of Garcia in 1854. Stroboscopy was one of the first methods used to study the vocal fold vibration (Musehold 1913). Glottographic techniques have been used in speech research laboratories since 1950.

According to Eiji Yanagisawa et al., videographic documentation of larynx can be achieved by fibreoptic videolaryngoscopy, telescopic videolaryngoscopy and microscopic videolaryngoscopy.(27) Fibreoptic videolaryngoscopy permits simultaneous voice and videorecording. Telescopic videolaryngoscopy is an effective method of documenting normal physiology and pathology of the larynx.(28) It is particularly important for precise evaluation of structural changes of larynx. Microscopic videolaryngoscopy is the most effective and convenient method of teaching and documenting microsurgery of larynx.

Aetiology of Dysphonia:

In elderly patients, dysphonia is mainly multifactorial but there are four important causes which include:

1. Systemic illness induced voice alterations
2. Presbyphonia
3. Vocal Misuse
4. Laryngeal pathology

Voice changes secondary to systemic diseases:

Several systemic diseases affect the voice production. Most of them are frequently seen in aged patients Voice production affected by respiratory disorders are mainly due to derangement of expiratory volume levels and incoordination of breathing. Long term cough induces laryngeal injury. Recent studies have proved that prolonged steroid inhalers result in laryngeal dysfunction. The usage of spacer devices and gargling after the inhalation is found to be protective. Hypothyroidism is also considered to be one of the important cause for hoarseness. The laryngeal examination shows swollen vocal folds because of accumulation of mucopolysaccharides in the submucosal layer. Early intervention by supplementing thyroxine can help in reverting dysphonia by remodelling of vocal cords. Diseases affecting nervous system like Parkinson's disease and stroke can cause voice change. In Parkinson's disease, there is decrease dopaminergic surge in central nervous system due to which patients usually have delay in voice production and cannot alter the intensity of voice. Voice produced is asthenic, breathy and rough. Medical line treatment for these systemic disorders will improve symptoms. Surgical modalities such as Teflon injections into the vocal folds have been proven beneficial. As stroke affects the relationship between phonation, voice and language, these patients present with dysphonia. Gastro-oesophageal reflux disease causes inflammation to laryngopharynx due to acid or pepsin. This requires long term treatment with full dose of proton pump inhibitors (eg, omeprazole 40mg, once daily) of six weeks.

Presbylaryngis:

The voice related changes in the elderly patients of above 50 years after excluding other laryngeal disorders is termed as Presbylaryngis. There are many treatment modalities like speech therapy, vocal fold augmentation, regenerative medicine, surgery etc.

Vocal Misuse:

Vocal misuse (muscle tension dysphonia) is a hyper functional voice disorder characterized by synergistic and antagonistic action of the muscles leading to change in vocal cord position and tension between both vocal cords. Sometimes, there might be structural damage to the vocal cord resulting in certain lesions like nodules. Vocal misuse is associated with different aetiology including psychosocial issues, professional voice users and constant laryngeal irritation. The patients are managed conservatively.

Laryngeal pathology:

The three main entities of larynx causing dysphonia are vocal cord palsy, benign and malignant disorders of larynx.

Vocal cord palsy:

Vocal fold palsy is one of the frequent cause of voice change in elderly. The etiology is varied. The recurrent laryngeal nerve palsy lesion is suspected. Endoscopy and high resolution computer tomography from base of the skull to mediastinum is done to identify the lesion. The paralysed vocal fold assumes lateral position forming glottic gap which cannot be compensated by other vocal cord. The voice is hence weak and breathy. The patient may present with weak cough, choking and aspiration sometimes. Medialization techniques are proven to be successful in these cases.

Benign lesions of Larynx:

The incidence of each aetiological factor contributing to hoarseness varies in different studies. According to Fred D Minifie et al., polyps occur most often on the phonating edge of one or both vocal cords and rapidly result in hoarseness.(29) Polyps may be broad based or pedunculated. Variations of the polypoid change contain old haemorrhage or organising, thrombosed vessels or dense connective tissue. The etiology of polyps is not definitely known but may involve residual edema from prior upper respiratory infection, acute vocal trauma such as shouting which causes a ruptured vessel. Vocal cord polyps may be unilateral or bilateral and are divided clinically into three types- fusiform, pedunculated and generalized. They are inflammatory in nature and arise initially as edema in the submucosal layer of connective tissue in the vocal cord. Nodules are most commonly originating at the junction of anterior one third and posterior two thirds of the vocal cord.

According to P.E.Robin, the vocal nodules are caused due to excessive strain and improper voice usage.(30) Correct use of voice helps in preventing or treating the disease. Steven R Jones et al., opines that papilloma is the most common benign lesion of the larynx. In laryngeal neoplasms, human papilloma virus is the main etiological factor.(31) It has been postulated that compromised immune system may predispose to the development of papilloma. Laryngeal papillomas commonly occur on true vocal cords.

Ono S et al., opines that hoarseness post intubation is caused due to bleeding in the submucosal layer of the vocal folds and recurrent nerve palsy due to compression of vocal cord and recurrent laryngeal nerve by tracheal tube and traction of the recurrent nerve by rotation of the neck.[32]

David C Hanson et al., has classified neurologic voice disorders as flaccid paresis/paralysis, spastic paresis, dyskinetic movement disorders, ataxia, apraxia and mixed spastic or flaccid paresis.

Malignant lesions of Larynx:

As per Cosmo Erno et al., the most common malignant tumours of the larynx was found to be squamous cell carcinoma. The incidence of squamous cell carcinoma was more than 90 percent. They are classically divided into in situ, micro invasive and deeply invasive. [33]

Laryngeal squamous cell carcinoma is the eleventh most common carcinoma in men. Depending on the site of origin, the patient presents with different symptoms. The patient usually present with local symptoms or else those related to metastatic spread. The different symptoms include voice change, difficulty in swallowing, stridor, earache etc. The examination using direct laryngoscopy and biopsy is mandatory in these cases. There are several ways of treating laryngeal cancer but organ preservation is the prime modality in most cases as the quality of life is affected without functioning larynx.

Evaluation of dysphonia

Clinical scores to assess the severity of dysphonia

a. **GRBAS:**

Japan Society of Logopedics and Phoniatrics proposed a new scheme for perceptual evaluation of voice which is most widely used worldwide. It is a four point scale wherein 0 = normal, 1=mild, 2= moderate, and 3=severe. The GRBAS score stands for grade, roughness, breathiness, asthenia and strain. Hoarseness is defined as perceived rough, harsh or breathy quality to voice. Breathiness is whispery voice which is seen in recurrent nerve paralysis, vocal cord nodules, laryngeal cancer, acute corditis vocalis and vocal cord atrophy. Asthenia is a weak voice heard in psychosomatic aphonia and myasthenia gravis. Strain occurs in conditions such as spasmodic voice disorders and laryngeal cancers.

Auditory-perceptual methods like GRBAS have many benefits like simplicity, reproducibility, expediency, and inexpensiveness. However, these judgments are vulnerable to variety of errors and biases.(34) Perceptual evaluation of voice has become a key in diagnosing many different aetiologies of dysphonia. Perceptual evaluation not only aids in spotting the diagnosis, but it also aids in assessing the severity and type of hoarseness (muscle tension dysphonia and spasmodic dysphonia).(35)

The inter and intra judge reliability of different parameters of voice is the “Achilles Heel” in voice research. GRBAS is aimed at decreasing this defect. It was successful to some extent because of the clinical superiority of such ratings which formed the standard against other measures. Recent studies have shown that intra-rater and inter-rater reliability differ greatly from study to study.(36) The GRBAS has been recommended as the standard for evaluation of dysphonia by practising UK voice clinicians.[35] Inexperienced listeners rated voices as more severely damaged than experienced listener.[37]

A multidimensional set of minimal basic measurements suitable for all common causes of dysphonia is proposed. It includes five different approaches: perception (grade, roughness, breathiness), videostroboscopy (closure, regularity, periodicity, mucosal wave and symmetry), acoustics (jitter, shimmer, Fo-range and softest intensity), aerodynamics (phonation quotient), and subjective rating by the patient.[38]

b. **CAPE-V:**

American Speech and Hearing Association (ASHA) have developed a new method for evaluating the voice. Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) attributes are 1. Overall Severity 2. Roughness 3. Breathiness 4. Strain 5. Pitch 6. Loudness. Results are rated as follows, Mildly deviant (MI), Moderately deviant (MO), Severely deviant (SE). CAPE-V is designed to overcome the inter and intra rater variability, describe the severity of auditory-perceptual attributes of a voice disorder. CAPE-V is also useful in determining the anatomic and physiological basis of dysphonia and to opine regarding the need of further investigations.

The studies comparing CAPE-V and GRBAS show slightly better results for CAPE-V in terms of good inter-rater reliability of perceptual judgment of voice quality.[39]

c. **Voice handicap index:**

A 30-item questionnaire Voice Handicap Index (VHI) is a preset questionnaire introduced by Jacobson et al.,[40] answered by the patient himself to find out the severity of dysphonia.VHI also evaluates treatment efficacy, which has excellent reproducibility and criterion based validity. Voice disorders have a significant impact on patients physical, emotional and functional quality of life.[11] It was George Engel who said that doctors should look into biological, psychological and social dimensions of a disease.[(41),(42)]

Quality of life measurements reflect the patient's experiences and recognise the centrality of patient's vision.[(43)] Finding the biopsychosocial impact of a voice problem, such as identifying the patients level of function in daily and professional life and calculating the emotional effects of the disorder. A negative biopsychosocial impact results in a more negative influence on quality of life. Several method and scales have been developed to quantify the biopsychosocial impact of voice disorders, e.g. the measurements of Smith *et al.*,[(44)] the "voice-related quality of life"(V-RQOL) scale,[(45)] the "Voice Disability Index",[(46)] the "Therapy Outcome Measures", the "Voice Outcome Survey (FOX)" and the "Activity and Participation Profile (VAPP)". The most frequently used inventory is the VHI tool (Voice Handicap Index).

The VHI is a helpful instrument to evaluate the subjective perception of the biopsychosocial impact of a voice disorder. However, it is a general questionnaire that is not specific enough to detect profession-related voice problems.VHI scores are not significantly different between males and females, and tend to decrease with age. The VHI is a useful patient based assessment tool to observe the changes in self-perception of a voice handicap after treatment.[(47)]

A significant relationship is observed between the objective voice parameters of female teachers with dysphonia and voice handicap index tool. This study concluded that voice handicap index tool is significant when used for assessing dysphonia in occupational dysphonic patients. In reference to the WHO multidimensional concept of health as physical, mental and social well-being, the VHI should be included in the assessment of voice problems in teachers as a important instrument of comprehensive voice evaluation.[48]

The Otorhinolaryngologist can be assisted in performing this basic set of measurements by a qualified and trained speech therapist. In summary, two of the dimensions are considered objective (in so far as the subject is cooperating normally):aerodynamics and acoustics; two other dimensions are objective but rated subjectively by the examiner (however, ratings can be made blindly by a panel): recording of a voice sample and videostroboscopy; and one dimension remains totally subjective (self-rating by the patient).[49]

The VHI and the voice laboratory measurements gives separate information. However, the correlation between VHI and some laboratory measurements increases in populations with voice disorder of the same origin.[50]

Investigations to evaluate Dysphonia

Indirect larngoscopy:

The indirect laryngoscopy is one of the important outpatient procedure done for assessing the larynx. It is a procedure free of complications except excessive gag reflex and inability to assess the lesion due to in-expertise. It is mainly done to detect the cause for hoarseness, foreign body removal etc. The instruments essential for the procedure include indirect laryngoscopy mirror, a headlight, gauze, 10% lignocaine spray, alcohol lamp or hot water. Headlight and mirror are used for light focus. The hot water is used for prevention of fogging to the mirror.

The patient is made to sit opposite to the examiner with straight back and chin pointing upward which is sniffing position. The patient should be seated in little lower position. The patient is sprayed with lignocaine to anaesthetize the pharynx. Temperature of the mirror should be checked on the back of the hand to ensure the hotness.

Procedure

i) Patient is made to sit comfortably and protrude his tongue out. The tongue is pulled out with thumb and middle finger and held with guaze. Index finger is used for lifting the upper lip or moustache in men.

ii) The mirror is directing into the mouth without touching the posterior pharyngeal wall and base of tongue to avoid gag reflex. During breathing movements, the mirror side is pressed against soft palate and uvula and tilted downwards for laryngeal visualization. The mirror is changed to different angles to visualize the whole larynx

iii) Patient is directed to inspire and expire.The mirror is passed and details of vocal folds are noted. Patient is asked say “ee” to look for the mobility of vocal fold.

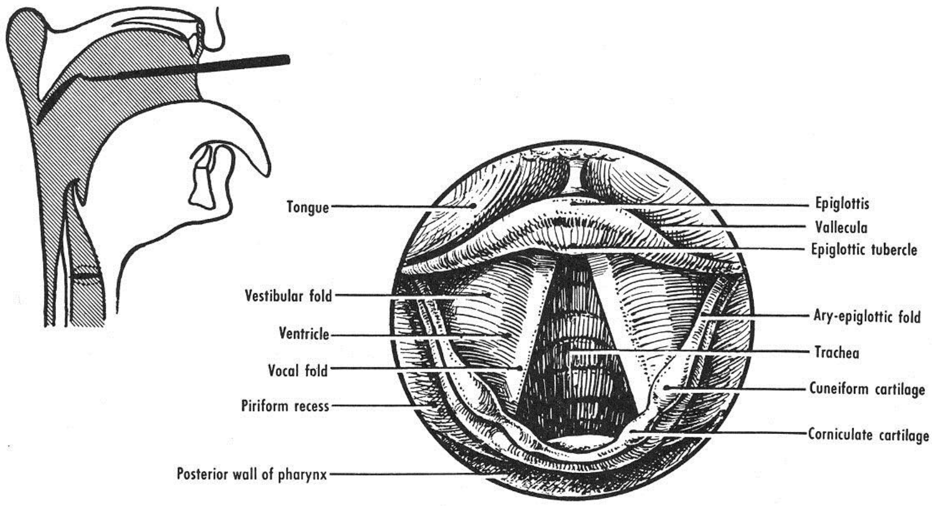

Figure 6: Laryngeal anatomy in indirect laryngoscopy

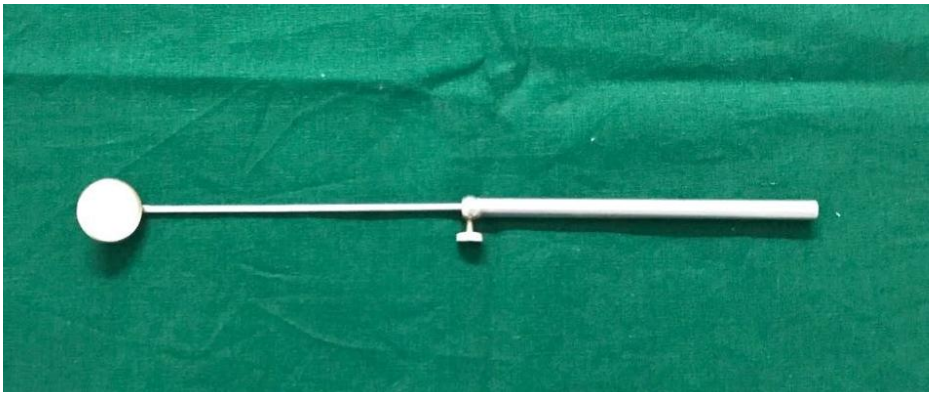

Figure 7: Indirect Laryngoscope Mirror

Videolaryngoscopy

Video-laryngoscopy also called direct laryngoscopy, although larynx visualization is by indirect measure using flexible or rigid endoscope. Laryngeal images can be projected on a monitor. VL is done as a investigation modality for diagnosing laryngeal pathologies, as a treatment modality in cases of laryngeal foreign bodies and a pre-requisite in cases of nasal intubation.

Videostroboscopy

(a) History:

The history of stroboscopic light to examine the larynx dates to 1874, when Oertel conceived the idea to use strobe light to visualize larynx and this light was interrupted using a perforated wheel.(51),(52) However, it was not until the invention of electricity in the year 1895 that his idea conceptualise. Members of scientific community did not accept the technique due to its own demerits like improper control of frequency of flashing, poor light source and the pictures. After a gap of hundred years, H.E. Edgerton and associates used the discharging tubes for stroboscopy and an oscillator for controlling the flashing rate and frequency. On these principle, the evolution of stroboscopy took place. Dr. J.W. Vanden Berg at the University of Groningen, Dr. Rolf Timke at the University of Hamburg, Dr. Hans von Leden at the University of California and Dr. Elimar Schonharl in Erlanger are considered pioneers of modern strobolaryngoscopy. They penned it in 1960 for the world to know. The modern stroboscopy evolved in years giving us a high-quality image with good illumination due to developments in audio and video recording technology, optical image resolutions and fibreoptic light sources. Over the time stroboscopy has evolved as the diagnostic tool for assessment of vocal fold, viscoelastic properties of phonatory mucosa and different vocal cord pathologies.[53]

(b) Principle:

Videostroboscopy is misinterpreted as slow-motion photography; it is an illusion created by slow motion created using strobe light which illuminates the vocal folds at different points of different vibration cycles. Each image is presented to the eye for 0.2 seconds and if more than 5 images are presented per second then the viewer perceives them as slow motion. This phenomenon is called Talbot’s law. Using the strobe light two effects are created i.e. running phase and stop or locked phase. In running phase, light is flashed faster or slower than the fundamental frequency which creates an illusion of slow motion. In stop phase the strobe light flashes at a rate that is matched with the frequency of the vocal fold vibration, hence creating an illusion that the vocal folds are not moving at all.

(c) Equipment

A videostroboscopic unit comprises mainly of a stroboscopic light source, an endoscope, a microphone, a video camera and recorder. There are two ways stroboscopy can be performed one is rigid and other is using a flexible endoscope. Flexible endoscope has an advantage as it can observe laryngeal behaviour from different positions and can be passed through narrow supraglottic aperture to visualize the glottic area. The main disadvantage of this method is the distal illumination of low intensity which is difficult for viewing.

Rigid endoscopy has the advantage of creating optimal image to assess phonatory mucosal pliability because of its magnification and brighter image. During the whole procedure, the patients tongue is held out by the examiner which disturbs the natural phonatory posture of the pharynx and larynx. Other requirements patient should have good tolerance and favourable anatomy. To predict the adequacy of trans oral stroboscopy, Mallampati classification system is useful.

Figure 8: Videostroboscopic unit

(d) Technique:

i) The patient is made to relax and sit in the chair opposite to the examiner.

ii) The patient is given Kirstein position i.e., leaning forward with the neck flexed and the head extended at the atlanto-occipital joint.

iii) Topical anaesthesia is applied to the posterior aspect of tongue and posterior oropharynx

iv) The patients tongue is held out by the examiner and the rigid telescope is introduced. The examiner focuses the telescope on the vocal cords. The sub-epithelial vasculature of vocal fold must be examined.

v) Defogging is done by dipping the scope in hot water.

vi) Patient is made to undergo various vocal tasks using “ee” sound.

(e) Parameters

i) **Fundamental frequency**: The fundamental frequency is measured to fix the light frequency. Strobe light is produced at much slower frequency in comparison to the vocal frequency and thus produces an illusion of a slow-motion vibratory cycle. A still image can be produced in locked mode when the frequency becomes identical.

ii) **Periodicity**: It refers to time at which each vibratory cycle repeats itself.

iii) **Amplitude**: The amplitude is defined as the horizontal excursion from the midline. It is one of the most important parameter seen in stroboscopy as it can assess the degree of vocal fold amplitude during vocal fold vibration which is subjective and can also be compared. Amplitude and glottis closure are mainly dependent on the intensity and pitch (decreases on higher pitch when compared to lower pitch)

iv) **Symmetry:** The symmetry is assessed by comparing the vibratory activity of both vocal cords. They are considered symmetrical when both vocal cords have identical activity.

v) **Glottic closure**: The complete approximation of both vocal folds is considered normal. The posterior glottis chink is considered as healthy especially in females.

vi) **Mucosal wave**: Mucosal wave pattern is one of the most important parameter of stroboscopy which must be observed properly. It is wave which travels over the vocal folds and also within the mucosa. The wave begins in the subglottic area, travels inferiorly along the free edge and then superiorly over the vocal fold. This mucosal wave activity should be assessed at a different level of intensity-low, medium and high range. It is mainly the assessment of pliability and functional characteristics of lamina propria layer of vocal fold. The diseases affecting the lamina propria layer tends to have decreased mucosal wave pattern.

(f) Merits

i) It is an out-patient procedure

ii) Convenient and easy

iii) Excellent video quality

iv) Reproducibility

(g) Demerits

i) Costly equipment

ii) Inter observer differences are present

iii) Alters the natural phonatory mechanism

iv) It records phases of different vibratory cycles and present as one cycle.

In 1987, Sataloff et al., estimated in a series of 486 examinations that stroboscopy was useful in diagnosing voice disorders in one third of the professional voice users.(54)

Bless (1991) discussed the stroboscopic differences between males and females, children and-adult males, and younger adults and geriatric adults. She found that males had longer closed phases and more complete glottal closure than females. Children had shorter closed phases than adult males, and geriatrics had more asymmetry, larger glottal gaps, greater aperiodicity, and reduced amplitude than younger adults. Bless noted, "Failure to identify the normal findings can lead to incorrect clinical judgement about laryngeal structure and function".(55)

Sataloff, Spiegel, and Hawkshaw (1991) conducted a similar study of 377 stroboscopic procedures performed in their clinic. They found that stroboscopy modified the diagnoses of 47% of the patients revieving an initial examination using laryngoscopy.(56)

Joel A. Sercarz, Gerald S. Berke, David Amstein, Bruce Gerrat described a new computerized tool for analysing voice that permits the quantitative analysis of individual videostroboscopic images. The aim of their research was to do objective measurement of the function of larynx and to study the pathophysiology. They even described their method in comparison to the previous methods and discussed the advantages and disadvantages of the new technique. The clinical and research applications were also mentioned in the study.(57)

Few studies have examined the validity of stroboscopy. Three studies compared stroboscopy to the reference standard of laryngoscopy without stroboscopy, Casiano, Zaveri, and Lundy (1992) found that stroboscopic examinations altered the diagnosis and treatment outcome in 14% of 292 patients initially examined with laryngoscopy. Functional dysphonia or unilateral vocal cord paralysis patients were most benefited by stroboscopic evaluation.(58)

Bless and Hirano (1993) discussed four issues that can influence an examiner's interpretation of a stroboscopic evaluation: (1) the knowledge of vocal fold vibration and its relation to sound production (2) thorough knowledge of normal anatomy and physiology of larynx (3) the examiner's skill to perform the procedure and (4) experience.(59)

Romado (1996) compared Stroboscopy with laryngoscopy in 732 patients and found stroboscopy, "to be useful or essential in 68% of the cases " Stroboscopy modified the initial diagnosis, determined through use of laryngoscopy, in approximately 17-23% of his cases.(60)

In addition, Elias et al., reviewed stroboscopic evaluations of 65 healthy singers and found 58% of the singers presented abnormal stroboscopic findings despite no voice complaints. These findings included reflux laryngitis, vocal fold asymmetry, and small benign masses.(61)

The reliability of descriptive ratings of stroboscopic assessments has come under scrutiny. Poburka and Bless (1998) found low levels of intra and inter-judge agreement in stroboscopic ratings. They proposed a new rating form with a 4-5-hour training procedure to increase reliability. However, they found that use of the new form following 4-5 hours of training did little to improve the intra- and inter-judge reliability in experienced examiners.(62)

Poburka (1999) attempted to address the issue of intra- and inter-rater reliability by developing a visual, as opposed to a scalar rating form, called the SERF. While he reports good inter-judge reliability (86%) using SERF. Only three judges participated in this study. In addition, he reported that phase closure, symmetry, regularity were difficult to rate and had low overall inter judge reliability. Several studies have documented normal variations in glottal appearance during the stroboscopic assessment.[63]

Juergen Wendler (2004) proposed that stroboscopy is a valuable qualitative tool which provides criterias regarding different voice disorders and is useful in documentation to be compared with time and between different patients. The recent developments in microstroboscopy, endostroboscopy and conditions of stroboscopic examination were kept in mind while reviewing the history and application of stroboscopy.The applicability of video recordings and quantitative measures are considered in cases of functional and organic dysphonia. Standardization of stroboscopic methods and data interpretation are given utmost importance.[64]

George Thomas, Suma Susan Mathews, Shipra B. Chrysolyte, and V. Rupa in 2007 published Outcome analysis of benign vocal cord lesions by videostroboscopy, acoustic analysis and voice handicap index. The vibratory function of vocal cord gets affected by different benign vocal cord lesions causing dysphonia.[65]

Study by Ahmed M. Rasheed (2008) was done regarding the efficacy of stroboscopy in diagnosing the hoarseness. The stroboscopic examination contributed significantly as it modified the diagnosis made by other means in 8 cases (19%), which resulted in change of treatment modality. Surgery could be avoided in 4 cases and was encouraged in another 4 cases.[66]

Rosa Hernåndez Sandemetrio, Pilar Nieto Curiel, José Dalmau Galofre, and Marta Forcada Barona (2010) explained contribution of stroboscopy in the diagnosis of voice disorders. The stroboscopic examination provides functional information for deciding between microsurgery, speech therapy and combined treatment. In 90% cases, the relation between preoperative stroboscopic diagnosis and intaoperative findings was present according to the study.(67)

Study by Richard T. Kelley, Raymond H. Colton, Janina Casper, Ashley Pasema and David Brewer (2011) on evaluation of stroboscopic signs showed various stroboscopic parameters of vocal fold vibration related with the 'Vibration Factor' (VF) (mucosal wave, amplitude, vibratory behaviour, and periodicity) and the vocal fold edge related with the "Edge Factor"(EF). Scores for vibration factor and edge factor were utilized to grade the dysphonia and to differentiate several vocal cord pathologies. The severity of dysphonia was more related to VF than the EF. The calculation of these two factors were done by using these three parameters (amplitude, vibratory behaviour and edge).(68)

Nawka T, Konerding U. (2012) evaluated the inter judge reliability of stroboscopic parameters with Poburka's Stroboscopy Evaluation Rating Form(SERF). He observed that inter judge reliability is very less in parameters like glottal closure, phase closure, phase symmetry, and regularity. So, he advised that these parameters should not be evaluated with stroboscopy. Remaining parameters can be evaluated with stroboscopy provided two raters were involved.(69)

The present role of stroboscopy in assessment of the vocal fold vibration, has been evaluated by Daryush D. Mehta and Robert E. Hillman (2012). They stated that the stroboscopy continues to be the investigation of choice for imaging of vocal cord vibration, but recent developments in technology such as High Speed Videoendoscopy (HSV) have drawn clinical attention and being used as adjunct imaging modalities to assist stroboscopy assessment.[(70)]

Fleischer S, Hess M. (2012) demonstrated the utility of videostroboscopy in patients with dysphonia. Videostroboscopy provides additional information to voice assessment, as it always involves perceptual voice assessment and endoscopy of the larynx. Videostroboscopy helps in distinguishing between benign vocal fold lesions, invasive processes. It also helps in differentiating various forms of functional disorders.[(71)]

Printza, Triaridis, Themelis, Constantinidis (2012) studied stroboscopy for benign laryngeal pathology in evidence based health care.[(72)] For one third of the study's population stroboscopy established the diagnosis (43 patients, 28.8%) by identifying the etiology of dysphonia or changing the initial diagnosis. For an additional number of patients it modified the choice of treatment (7 patients, 4.7%). For about one third of the cases (48 patients, 32.2%), stroboscopy offered additional information regarding dysphonia. One third of the patients examined (51 patients, 34.4%) had no benefit from the stroboscopic examination. One patient had an early invasive lesion.

Study by Hansa Banjara et al., on demographic and videostroboscopic assessment of vocal pathologies showed successful treatment of bilateral vocal fold lesions depends on the accuracy of the diagnosis.[(73)] The application of stroboscopy to the study of vocal fold vibration has led to dramatic advances in the understanding the vocal fold physiology. Laryngeal stroboscopy is the state of the art diagnostic tool and this technique provides valuable information about the nature of the vibration and a visual image that can be used both for immediate analysis and as a permanent record for comparison of repeated examination later.

Study done by virgilijusuloza, aurelijavegiene, ru ta pribuisiene , and viktoras s aferis. related to quantitative evaluation of video laryngostroboscopy and reliability of the basic parameters showed moderate to almost perfect levels (ICC 0.46—0.90) of inter rater reliability for most of the basic VLS parameters.[(74)] The ICC of the inter-rater reliability was highest for symmetry of glottal image; the most problematic VLS parameter for rating was mucosal wave on the healthy side. ICC of the test-retest reliability was 0.71-0.95, $P < 0.001$. An optimum system of VLS parameters discriminating normal and pathological subgroups with sensitivity 96.3% and specificity 100% included glottal closure and mucosal wave on the affected.

Yiu EM, Lau VC, Ma EP, Chan KM, Barrett E. studied reliability of laryngostroboscopic evaluation on lesion size and glottal configuration. This study evaluated the inter and intra judge variability of four basic visual perceptual parameters such as lesion anatomy and glottal configuration in stroboscopy.[(75)] The findings indicated that the evaluation of static structures (like lesion size rating, the anteroposterior supraglottic compression, and the glottal closure) are relatively reliable method. The evaluation of dynamic structures such as the vocal fold mucosal wave and amplitude were of low reliability.

Danasekaran Veerappapillai Sellapampatti, Shankar Radhakrishnan Dhanyan Harshidan gave assessment of malignant and non-malignant lesions of the vocal cord using videostroboscopy. Stroboscopy is most useful in identifying and differentiating malignant and non-malignant vocal-fold pathologies. The stroboscopic characteristics were assessed for quantification of the stroboscopic examination findings, however there were subjective problems in the evaluation of the results.[76]

"Laryngoscopy, stroboscopy and other tools for the evaluation of voice disorders" a study done by Sulica L is involved in discussion and analyses of the diagnosis and management of voice disorders. This study describes dysphonia as a sign and symptom rather than diagnosis, and analyses its principles and methods of evaluation and their respective advantages and disadvantages.[77]

In this present study, we are assessing the role of stroboscopy in diagnosing the Etiology of dysphonia patients in a sample of 113 patients using karlstorz rigid video stroboscope.

MATERIALS AND METHODS

The present study “Stroboscopy as a diagnostic tool for evaluation of dysphonia” A Hospital Based Study was done in BLDEU’s Shri B. M. Patil Medical College, Hospital and Research Centre, Vijayapur during the period of October 2015 to May 2017.

Study group and method of collection:

113 patients were selected at random from the patients who presented with symptoms of dysphonia and evaluated by means of

1. Proper history
2. Clinical examination including general and systemic examination
3. Indirect laryngoscopy
4. Video laryngoscopy
5. Video stroboscopy

Procedure:

- The patients will be assessed clinically (history. clinical examination and indirect laryngoscopy) and then subjected to videolaryngoscopic examination.
- Videostroboscopy was then carried out in these patients.70° rigid stroboscope connected to a strobe unit is used to visualize patient’s larynx and video recorded will be studied for stroboscopic parameters.
- Videostroboscopy was done with by seating the patient in the examination chair at a height comfortable for the examiner. The patient leans forward with the neck flexed and the head extended at atlanto-occipital joint (Kirstein position).

- Once in the appropriate position, it is often helpful to apply topical anaesthesia (10% lignocaine) to the posterior aspect of the tongue as well as posterior oropharynx. The microphone is placed against the thyroid lamina.
- With mouth open and tongue protruded, the examiner retracts the tongue anteriorly and carefully inserts the rigid telescope. To avoid condensation on the scope, the tip of telescope is dipped in hot water/savlon just prior to the beginning of examination.
- Patients during examination are instructed to say-

  1. Sustained "ee" at patients most comfortable pitch and loudness.

  2. "ee" on inhalation.

  3. Glide midrange to high, sustaining the high note.

  4. Glide midrange to low, sustaining the low note.

  5. Quiet "ee"

  6. Loud "ee"

  7.Sustained "ee" at most comfortable pitch using locked mode.
- Evaluation criteria in stroboscopic examination include symmetry, amplitude, periodicity, glottis closure and mucosal wave patterns.
- The documented videos of videolaryngoscopy and videostroboscopy are then analysed.

Inclusion Criteria

1. All patients presenting with complaints of dysphonia in Department of Otorhinolaryngology, Shri B.M. Patil Medical College from October 2015 to March 2017.

2. Age between 18-65 years.

Exclusion Criteria

1. Patients with functional dysphonia.

2. Patients with neurogenic dysphonia

3. Patients with age less than 18 years and above 65 years.

4. Patients who are pregnant.

5. Patients who are not cooperative even after topical anaesthesia with xylocaine spray.

Sample Size

Prevalence rate of voice disorders is 8% (0.65-15%) at 95% confidence interval and at ± 5% margin of error, the sample size is **113**.

$$n = \frac{Z_\alpha^2 \times p \times (100-p)}{d^2}$$

Zα= Z value at α level=95%

p=prevalence value

d=margin of error

Statistical analysis

All characteristics were summarized descriptively. For continuous variables, the summary statistics of N, mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries. Chi-square (χ^2)/ Freeman-Halton Fisher exact test was employed to determine the significance of differences between groups for categorical data. The difference of the means of analysis variables between two independent groups were tested by unpaired t test. If the p-value was less than 0.05, then the results were considered to be statistically significant otherwise it was considered as not statistically significant. Data was analyzed using SPSS software v.23.0. and Microsoft office.

RESULTS

Table: 1 Sex distribution of the cases

Sex	N	%
Male	65	57.5
Female	48	42.5
Total	113	100

Graph 1: Sex distribution of the cases

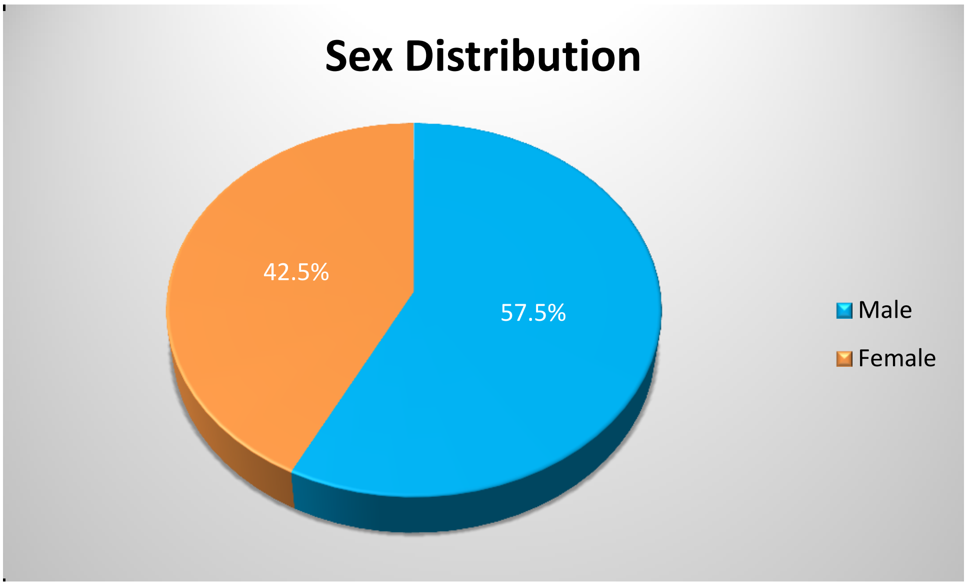

Table 2:
Sex ratio

M/F ratio	1.4

Table 3: Age distribution of the cases

Age (Yrs.)	**N**	**%**
10-20	6	5.3
21-30	16	14.2
31-40	26	23
41-50	18	15.9
51-60	29	25.7
>60	18	15.9
Total	113	100

Graph 2: Age distribution of the cases

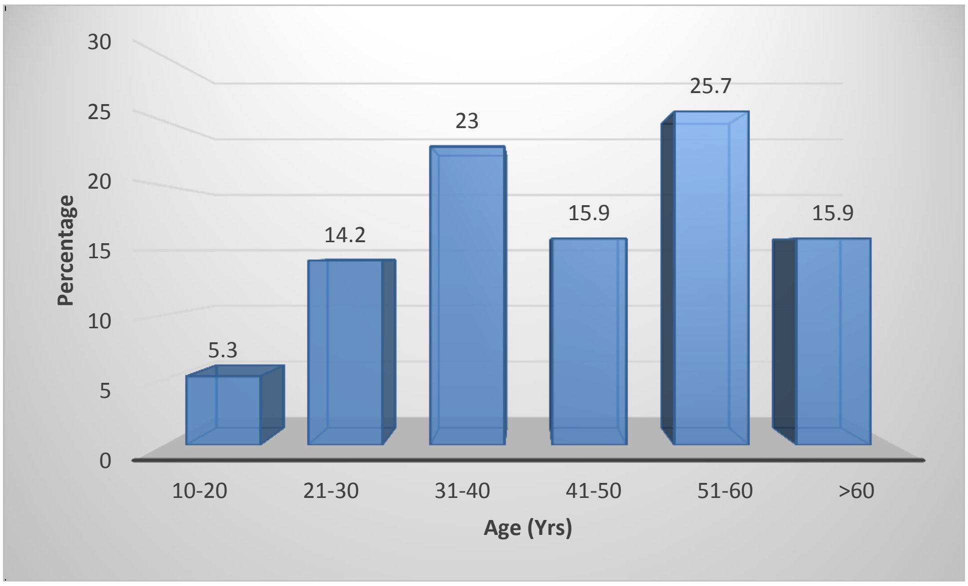

Table 4: Mean Age of the cases

	Minimum	Maximum	Mean	SD
Age (Yrs)	18	65	45.4	14.64

Table 5: Occupation distribution of the cases

Occupation	**N**	**%**
Professional voice users	11	9.7
Non-Professional voice users	102	90.3
Total	113	100

Graph 3: Occupation distribution of the cases

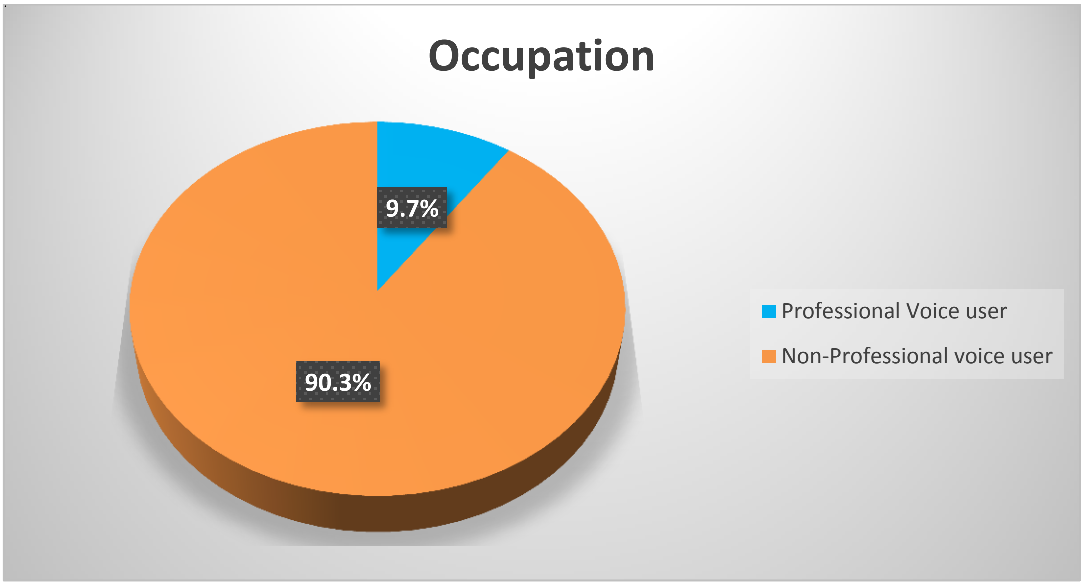

Table 6: Chief complaint of the cases

Chief Complaint	**N**	**%**
Change in voice	62	54.9
Change in voice with additional complaints	51	45.1
Total	113	100

Graph 4: Chief complaint of the cases

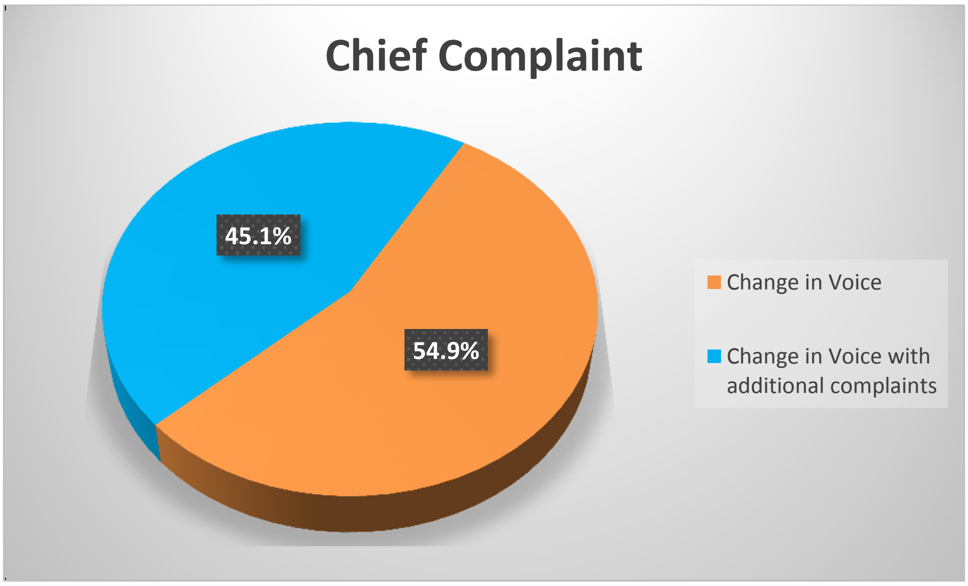

Table 7: Duration of chief complaints (in months) of the cases

Duration (Months)	N	%
<1	23	20.4
1-2	31	27.4
3-4	23	20.4
5-6	10	8.8
>6	26	23
Total	113	100

Graph 5: Duration of chief complaints (in months) of the cases

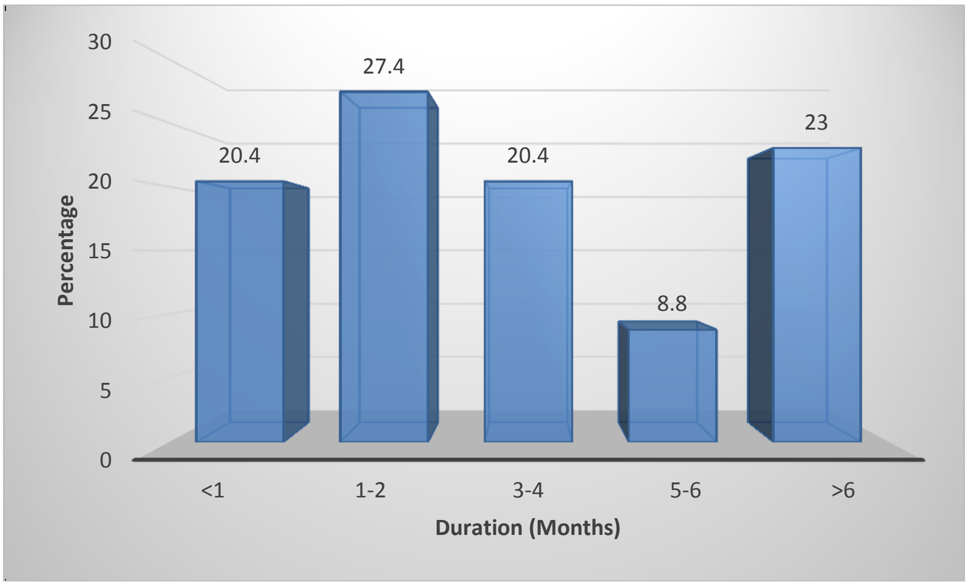

Table 8: Mean Duration of chief complaint (in months) of the cases

	Minimum	Maximum	Mean	SD
Duration (Months)	0.03	158.2	9.7	25.1

Table 9: Duration (in months) of the cases according to diagnosis:

Categories	**N**	**Minimum**	**Maximum**	**Mean**	**SD**
Bowed Vocal cords	4	3.0	12.2	7.3	3.8
Carcinoma	19	0.3	12.2	3.8	4.0
Cyst	9	1.0	30.4	8.8	9.0
Dysphonia Plica Ventricularis	2	4.0	4.0	4.0	0.0
Hypothyroidism	2	0.3	0.5	0.4	0.2
Laryngeal Web	2	1.0	4.0	2.5	2.1
Laryngitis	18	0.0	24.3	3.4	6.1
Left vocal cord atrophy	1	0.5	0.5	0.5	-
Leukoplakia B/l vocal cords	1	0.3	0.3	0.3	-
Nodules	18	0.3	36.5	8.4	9.9
Normal	7	0.1	158.2	25.6	58.5
Palsy	12	0.1	121.7	32.5	53.8
Papilloma	3	3.0	6.0	4.0	1.7
Polyp	10	0.7	73.0	9.8	22.3
Reinkes edema	1	3.0	3.0	3.0	-
Sulcus Vocalis	1	2.0	2.0	2.0	-
TB laryngitis	1	0.5	0.5	0.5	-
Vocal cord granuloma	1	2.0	2.0	2.0	-
Vocal cord Hyperkeratosis	1	4.0	4.0	4.0	-

Table 10: Mean Fundamental Frequency of the cases

	Minimum	Maximum	Mean	SD
Fundamental Frequency	58	524	193.6	106.5

Table 11: Fundamental Frequency of the cases in males and females in different diagnosis

Categories	Males					Females				
	N	Minimum	Maximum	Mean	SD	N	Minimum	Maximum	Mean	SD
Bowed Vocal cords	2	160	280	220.0	84.9	2.0	284.0	331	307.5	33.2
Carcinoma	15	58	246	117.8	63.9	4	231	320	276.8	44.8
Cyst	5	85	356	195.8	100.0	4	220	410	281.8	89.6
Dysphonia Plica Ventricularis	2	74	165	119.5	64.3	-	-	-	-	-
Hypothyroidism	-	-	-	-	-	2	178	270	224.0	65.1
Laryngeal Web	1	112	112	112.0	-	1	290	290	290.0	-
Laryngitis	10	70	444	165.1	127.1	8	78	524	272.0	132.5
Left vocal cord atrophy	1	89	89	89.0	-	-	-	-	-	-
Leukoplakia B/l vocal cords	1	123	123	123.0	-	-	-	-	-	-
Nodules	7	64	402	159.3	128.7	11	200	387	290.5	56.9
Normal	3	70	120	87.3	28.3	4	204	325	243.5	55.5
Palsy	6	60	228	117.8	78.8	6	168	300	236.0	43.1
Papilloma	-	-	-	-	-	3	278	380	341.3	55.3
Polyp	7	67	259	127.3	75.7	3	210	270	230.0	34.6
Reinkes edema	1	92	92	92.0	-	-	-	-	-	-
Sulcus Vocalis	1	96	96	96.0	-	-	-	-	-	-
TB laryngitis	1	70	70	70.0	-	-	-	-	-	-
Vocal cord granuloma	1	76	76	76.0	-	-	-	-	-	-
Vocal cord Hyperkeratosis	1	109	109	109.0	-	-	-	-	-	-

Table 12:
Personal History

Personal History	**N**	**%**
Nil Significant	37	32.7
Smokers	26	23
Vocal abuser	19	16.8
Vocal abuse with smoking	2	1.8
Gastro-esophageal reflux	10	9
Alcoholics	19	16.8
Total	113	100

Graph 6: Personal History

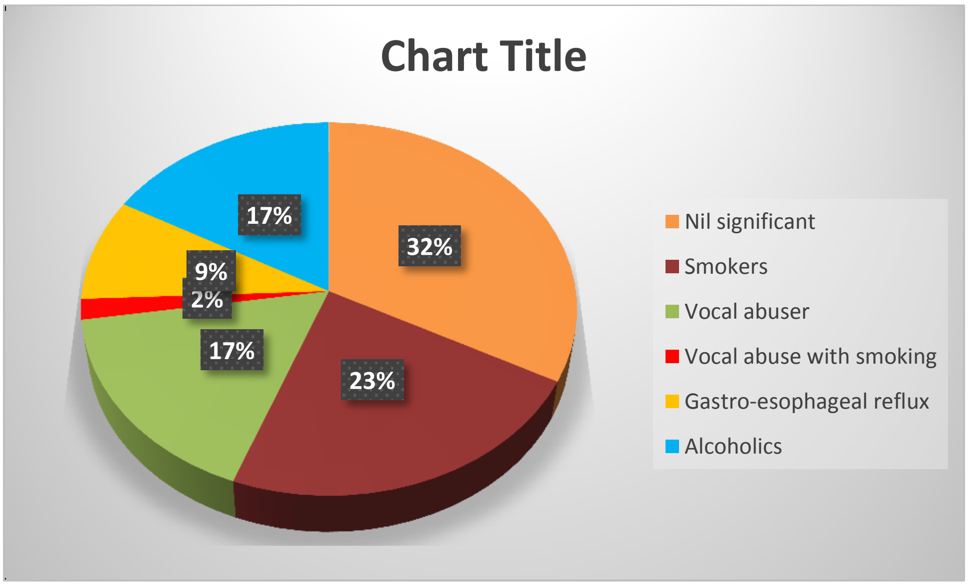

Table 13: Indirect Laryngoscopy diagnosis

Indirect Laryngoscopy	**N**	**%**
Cannot be done	16	14.2
Normal	33	29.2
Positive finding	64	56.6
Total	113	100

Graph 7: Indirect Laryngoscopy

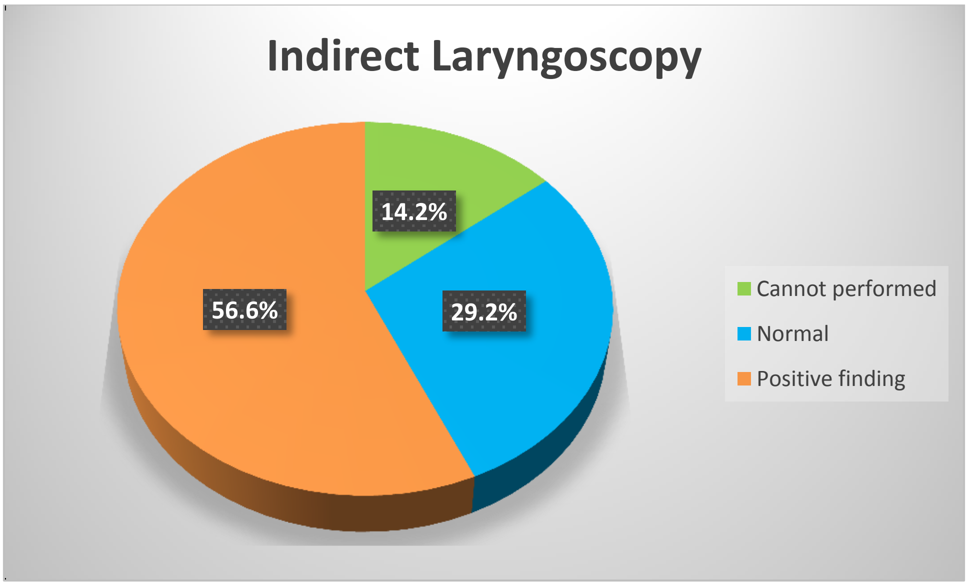

Table 14: Videolaryngoscopy findings

Videolaryngoscopy	**N**	**%**
Normal	13	11.5
Positive finding	100	88.5
Total	113	100

Graph 8: Videolaryngoscopy findings

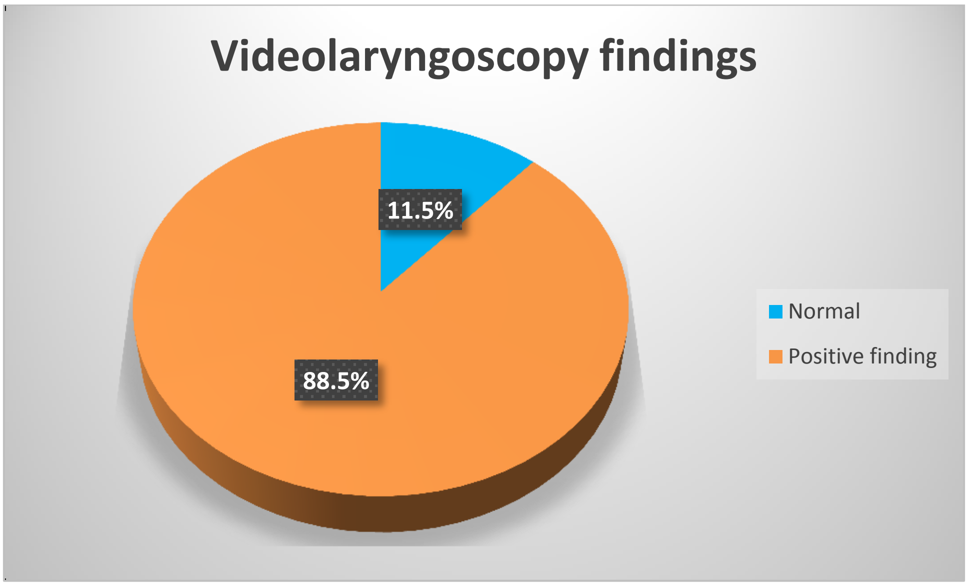

Table 15: Stroboscopic findings

Stroboscopy	N	%
Normal	7	6.2
Positive finding	106	93.8
Total	113	100.0

Graph 9: Stroboscopic findings

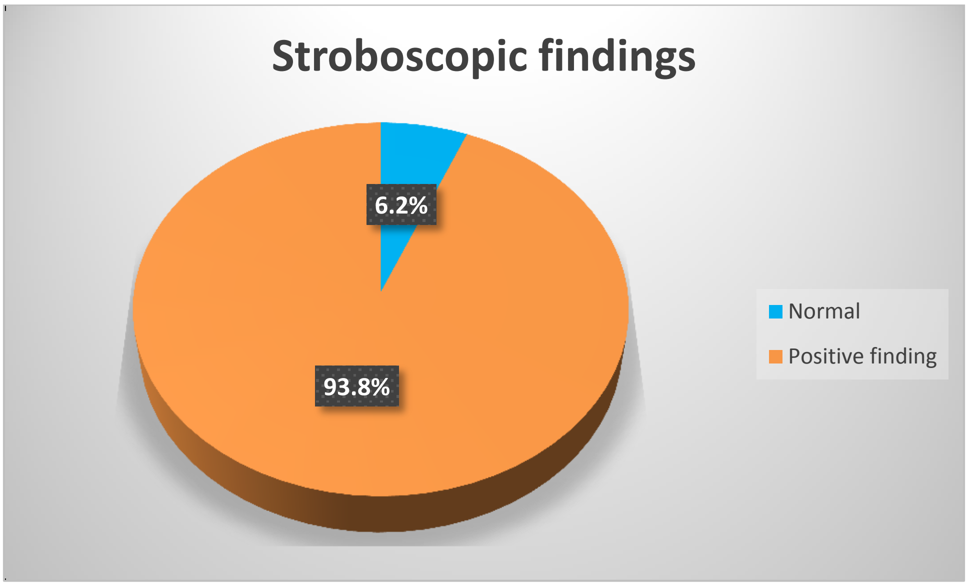

Table 16: Parameters of Stroboscopy in all patients

Parameter	N	%
Symmetry		
Asymmetrical	32	28.3
Cannot be rated	2	1.8
Symmetrical	79	69.9
Total	113	100
Periodicity		
B/l irregular	9	8
B/l regular	68	60.2
Cannot be rated	2	1.8
Left irregular	20	17.7
Right irregular	14	12.4
Total	113	100
Glottic closure		
Cannot be rated	2	1.8
Complete	54	47.8
Hour-glass	21	18.6
Incomplete all through the length	21	18.6
Incomplete anterior portion	4	3.5
Incomplete posterior portion	5	4.4
Spindle shaped	6	5.3
Total	113	100
Amplitude		
Absent B/l	2	1.8
Absent on left side	4	3.5
Absent on right side	2	1.8
Cannot be rated	2	1.8
Decreased B/l	8	7.1
Decreased on left	23	20.4
Decreased on right	12	10.6
Normal both sides	60	53.1
Total	113	100
Mucosal Wave		
Cannot be rated	2	1.8
Decreased bilateral	15	13.3
Decreased on left	16	14.2
Decreased on right	15	13.3
Normal both sides	65	57.5
Total	113	100

Graph 10: Parameters of stroboscopy in all patients

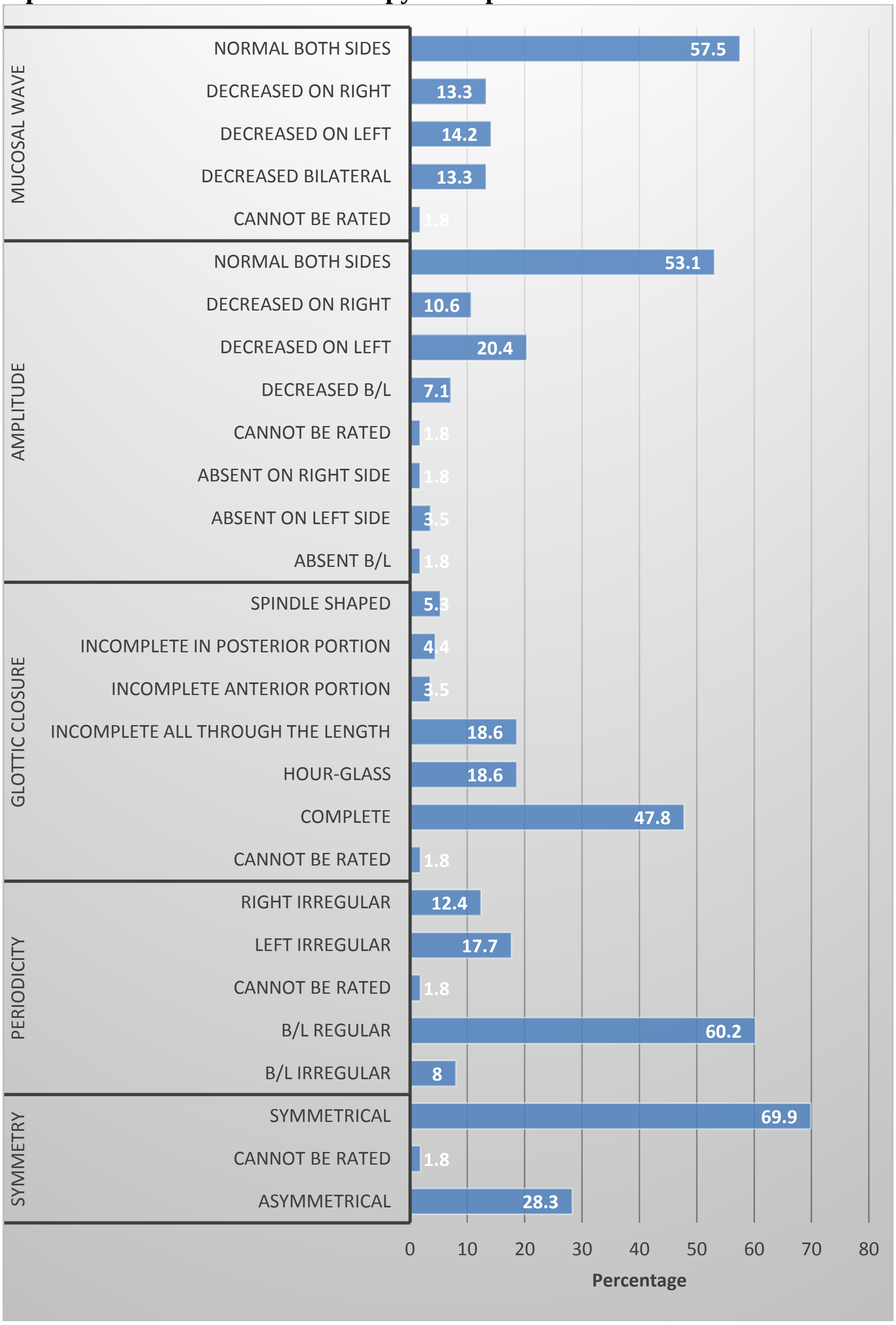

Table 17: Vocal cord Pathologies

Categories	N	%
Bowed Vocal cords	4	3.5

Carcinoma	19	16.8
Cyst	9	8
Dysphonia Plica Ventricularis	2	1.8
Hypothyroidism	2	1.8
Laryngeal Web	2	1.8
Laryngitis	18	15.9
Left vocal cord atrophy	1	0.9
Leukoplakia B/l vocal cords	1	0.9
Nodules	18	15.9
Normal	7	6.2
Palsy	12	10.6
Papilloma	3	2.7
Polyp	10	8.8
Reinkes edema	1	0.9
Sulcus Vocalis	1	0.9
TB laryngitis	1	0.9
Vocal cord granuloma	1	0.9
Vocal cord Hyperkeratosis	1	0.9
Total	113	100

Graph 11: Categories of Vocal cord Pathologies

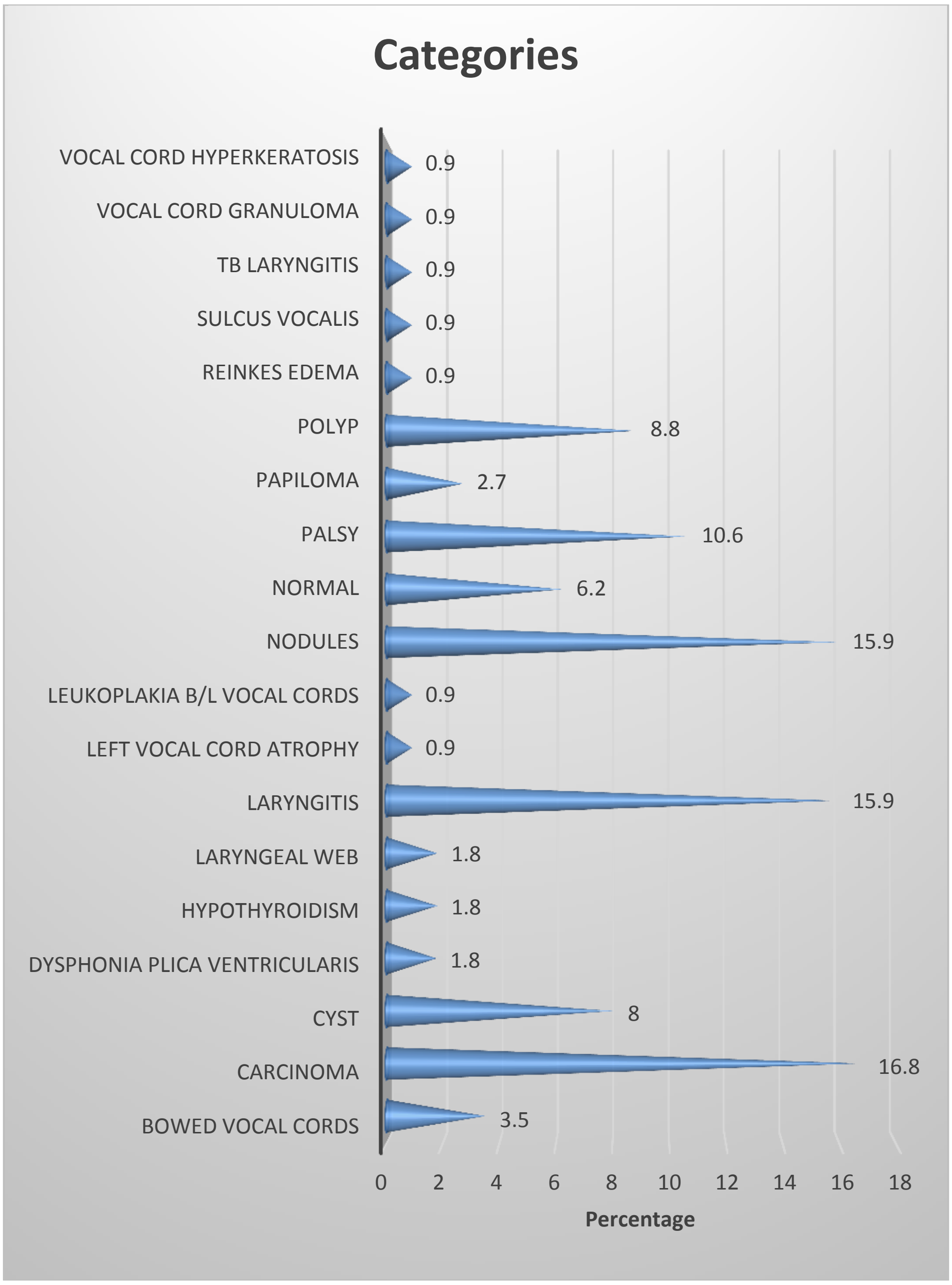

Table 18: Sub categories of Vocal cord pathologies

Categories	Diagnosis	N	%
Carcinoma	Hypopharyngeal cancer	6	5.3
	Subglottic Carcinoma	1	0.9
	Supra glottic carcinoma	6	5.3
	Trans-Glottic cancer	6	5.3
Laryngitis	Acute Laryngitis	6	5.3
	Chronic Laryngitis	8	7.1
	Refluxive laryngitis	4	3.5
Palsy	B/l abductor vocal cord palsy	5	4.4
	Unilateral vocal cord palsy	7	6.2

Graph 12: Sub categories of vocal cord pathologies

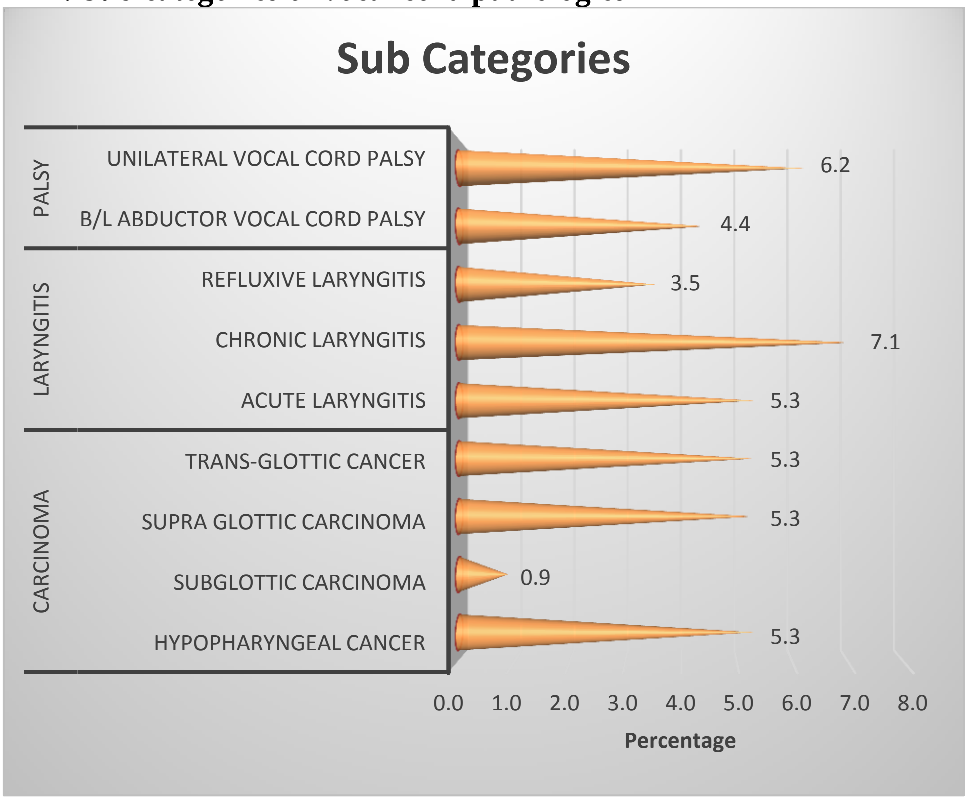

Table 19: Distribution of various vocal cord pathologies by Age

Categories	**10-20**	**21-30**	**31-40**	**41-50**	**51-60**	**>60**	**Total**
Bowed Vocal cords	0	0	1	0	3	0	4
Carcinoma	0	0	2	3	7	7	19
Cyst	0	1	2	3	1	2	9
Dysphonia Plica Ventricularis	0	0	0	0	1	1	2
Hypothyroidism	0	2	0	0	0	0	2
Laryngeal Web	2	0	0	0	0	0	2
Laryngitis	0	5	3	5	4	1	18
Left vocal cord atrophy	0	0	0	0	0	1	1
Leukoplakia B/l vocal cords	0	0	1	0	0	0	1
Nodules	2	4	8	2	1	1	18
Normal	1	0	2	0	3	1	7
Palsy	1	1	1	2	6	1	12
Papilloma	0	0	2	0	0	1	3
Polyp	0	3	2	2	2	1	10
Reinkes edema	0	0	1	0	0	0	1
Sulcus Vocalis	0	0	0	0	0	1	1
TB laryngitis	0	0	1	0	0	0	1
Vocal cord granuloma	0	0	0	1	0	0	1
Vocal cord Hyperkeratosis	0	0	0	0	1	0	1
Total	6	16	26	18	29	18	113

Table 20: Distribution of various vocal cord pathologies by sex

Categories	Male	Female	Total	P value
Bowed Vocal cords	2	2	4	0.757
Carcinoma	15	4	19	0.038
Cyst	5	4	9	0.901
Dysphonia Plica Ventricularis	2	0	2	0.220
Hypothyroidism	0	2	2	0.097
Laryngeal Web	1	1	2	0.828
Laryngitis	10	8	18	0.854
Left vocal cord atrophy	1	0	1	0.388
Leukoplakia B/l vocal cords	1	0	1	0.388
Nodules	7	11	18	0.081
Normal	3	4	7	0.418
Palsy	6	6	12	0.577
Papilloma	0	3	3	0.041
Polyp	7	3	10	0.403
Reinkes edema	1	0	1	0.388
Sulcus Vocalis	1	0	1	0.388
TB laryngitis	1	0	1	0.388
Vocal cord granuloma	1	0	1	0.388
Vocal cord Hyperkeratosis	1	0	1	0.388
Total	65	48	113	-

Table 21: Distribution of various vocal cord pathologies by duration of chief complaint (in months)

Categories	**<1**	**1-2**	**3-4**	**5-6**	**>6**	**Total**
Bowed Vocal cords	0	0	1	1	2	4
Carcinoma	3	9	2	2	3	19
Cyst	0	1	3	1	4	9
Dysphonia Plica Ventricularis	0	0	2	0	0	2
Hypothyroidism	2	0	0	0	0	2
Laryngeal Web	0	1	1	0	0	2
Laryngitis	7	6	1	1	3	18
Left vocal cord atrophy	1	0	0	0	0	1
Leukoplakia B/l vocal cords	1	0	0	0	0	1
Nodules	4	3	3	1	7	18
Normal	1	1	2	1	2	7
Palsy	2	4	2	0	4	12
Papilloma	0	0	2	1	0	3
Polyp	1	4	2	2	1	10
Reinkes edema	0	0	1	0	0	1
Sulcus Vocalis	0	1	0	0	0	1
TB laryngitis	1	0	0	0	0	1
Vocal cord granuloma	0	1	0	0	0	1
Vocal cord Hyperkeratosis	0	0	1	0	0	1
Total	23	31	23	10	26	113

Table 22: Distribution of various vocal cord pathologies by symmetry

Categories	Asymmetrical	Cannot be rated	Symmetrical	Total	P value
Bowed Vocal cords	0	0	4	4	0.195
Carcinoma	7	2	10	19	0.222
Cyst	6	0	3	9	0.756
Dysphonia Plica Ventricularis	0	0	2	2	0.364
Hypothyroidism	0	0	2	2	0.364
Laryngeal Web	0	0	2	2	0.364
Laryngitis	0	0	18	18	0.003
Left vocal cord atrophy	1	0	0	1	0.523
Leukoplakia B/l vocal cords	0	0	1	1	0.523
Nodules	1	0	17	18	0.017
Normal	0	0	7	7	0.082
Palsy	7	0	5	12	0.299
Papiloma	1	0	2	3	0.861
Polyp	7	0	3	10	0.932
Reinkes edema	1	0	0	1	0.523
Sulcus Vocalis	0	0	1	1	0.523
TB laryngitis	0	0	1	1	0.523
Vocal cord granuloma	0	0	1	1	0.523
Vocal cord Hyperkeratosis	1	0	0	1	0.523
Total	32	2	79	113	-

Table 23: Distribution of various vocal cord pathologies by periodicity

Categories	B/l irregular	B/l regular	Cannot be rated	Left irregular	Right irregular	Total	P value
Bowed Vocal cords	0	4	0	0	0	4	0.724
Carcinoma	2	10	2	2	3	19	0.531
Cyst	1	2	0	2	4	9	0.272
Dysphonia Plica Ventricularis	0	2	0	0	0	2	0.438
Hypothyroidism	0	2	0	0	0	2	0.438
Laryngeal Web	0	2	0	0	0	2	0.438
Laryngitis	1	17	0	0	0	18	0.355
Left vocal cord atrophy	0	0	0	1	0	1	0.585
Leukoplakia B/l vocal cords	0	1	0	0	0	1	0.585
Nodules	2	14	0	1	1	18	0.910
Normal	0	7	0	0	0	7	0.135
Palsy	2	3	0	5	2	12	0.296
Papilloma	0	1	0	1	1	3	0.352
Polyp	1	1	0	6	2	10	0.288
Reinkes edema	0	0	0	1	0	1	0.585
Sulcus Vocalis	0	0	0	1	0	1	0.585
TB laryngitis	0	1	0	0	0	1	0.585
Vocal cord granuloma	0	1	0	0	0	1	0.585
Vocal cord Hyperkeratosis	0	0	0	0	1	1	0.648
Total	9	68	2	20	14	113	-

Table 24: Distribution of various vocal cord pathologies by glottic closure

Categories	Can not be Rated	Complete	Hour-glass	Incomplete all through the length	Incomplete in anterior portion	Incomplete in posterior portion	Spindle shaped	Total	P value
Bowed Vocal cords	0	1	1	0	0	0	2	4	0.050
Carcinoma	2	8	0	6	3	0	0	19	0.170
Cyst	0	1	5	1	0	1	1	9	0.856
Dysphonia Plica Ventricularis	0	2	0	0	0	0	0	2	0.782
Hypothyroidism	0	2	0	0	0	0	0	2	0.782
Laryngeal Web	0	1	0	0	1	0	0	2	0.014
Laryngitis	0	18	0	0	0	0	0	18	0.322
Left vocal cord atrophy	0	1	0	0	0	0	0	1	0.846
Leukoplakia B/l vocal cords	0	1	0	0	0	0	0	1	0.846
Nodules	0	7	9	1	0	1	0	18	0.005
Normal	0	6	0	0	0	0	1	7	0.688
Palsy	0	0	0	12	0	0	0	12	0.122
Papilloma	0	0	0	1	0	1	1	3	0.250
Polyp	0	2	6	0	0	1	1	10	0.002
Reinkes edema	0	1	0	0	0	0	0	1	0.530
Sulcus Vocalis	0	1	0	0	0	0	0	1	0.530
TB laryngitis	0	1	0	0	0	0	0	1	0.530
Vocal cord granuloma	0	0	0	0	0	1	0	1	0.495
Vocal cord Hyperkeratosis	0	1	0	0	0	0	0	1	0.846
Total	2	54	21	21	4	5	6	113	-

Table 25: Distribution of various vocal cord pathologies by amplitude

Categories	Absent B/l	Absent on left side	Absent on right side	Cannot be rated	Decreased B/l	Decreased on left	Decreased on right	Normal both sides	Total	P value
Bowed Vocal cords	0	0	0	0	0	0	0	4	4	0.706
Carcinoma	0	2	1	2	1	2	1	10	19	0.003
Cyst	0	0	0	0	0	4	4	1	9	0.286
Dysphonia Plica Ventricularis	0	0	0	0	0	0	0	2	2	0.793
Hypothyroidism	0	0	0	0	0	0	0	2	2	0.793
Laryngeal Web	0	0	0	0	0	0	0	2	2	0.793
Laryngitis	0	0	0	0	2	1	0	15	18	1.000
Left vocal cord atrophy	0	0	0	0	0	1	0	0	1	0.763
Leukoplakia B/l vocal cords	0	0	0	0	0	0	0	1	1	0.854
Nodules	0	0	0	0	2	1	1	14	18	0.917
Normal	0	0	0	0	0	0	0	7	7	0.608
Palsy	2	2	1	0	2	4	1	0	12	0.009
Papilloma	0	0	0	0	1	1	1	0	3	0.630
Polyp	0	0	0	0	0	6	4	0	10	0.652
Reinkes edema	0	0	0	0	0	1	0	0	1	0.464
Sulcus Vocalis	0	0	0	0	0	1	0	0	1	0.763
TB laryngitis	0	0	0	0	0	0	0	1	1	0.854
Vocal cord granuloma	0	0	0	0	0	1	0	0	1	0.763
Vocal cord Hyperkeratosis	0	0	0	0	0	0	0	1	1	0.854
Total	2	3	2	2	8	23	12	60	113	-

Table 26: Distribution of various vocal cord pathologies by mucosal wave

Categories	Cannot be Rated	Decreased bilateral	Decreased on left	Decreased on right	Normal both sides	Total	P Value
Bowed Vocal cords	0	0	0	0	4	4	0.718
Carcinoma	2	1	4	4	8	19	0.160
Cyst	0	0	3	5	1	9	0.354
Dysphonia Plica Ventricularis	0	0	0	0	2	2	0.801
Hypothyroidism	0	1	0	0	1	2	0.252
Laryngeal Web	0	0	0	0	2	2	0.801
Laryngitis	0	5	1	0	12	18	0.204
Left vocal cord atrophy	0	0	1	0	0	1	0.716
Leukoplakia B/l vocal cords	0	1	0	0	1	1	0.707
Nodules	0	2	0	1	15	18	0.406
Normal	0	0	0	0	7	7	0.624
Palsy	0	4	4	2	2	12	0.916
Papilloma	0	1	1	1	0	3	1.000
Polyp	0	0	1	1	8	10	0.533
Reinkes edema	0	0	0	0	1	1	0.860
Sulcus Vocalis	0	0	1	0	0	1	0.716
TB laryngitis	0	1	0	0	0	1	0.707
Vocal cord granuloma	0	0	0	0	1	1	0.860
Vocal cord Hyperkeratosis	0	0	0	1	0	1	0.707
Total	2	15	16	15	65	113	-

Table 27: Change in diagnosis in Stroboscopy compared to Videolaryngoscopy

Changed Diagnosis	**N**	**%**
Not changed	98	86.7
Changed	15	13.3
Total	113	100

Graph 13: Change in diagnosis in Stroboscopy compared to Videolaryngoscopy

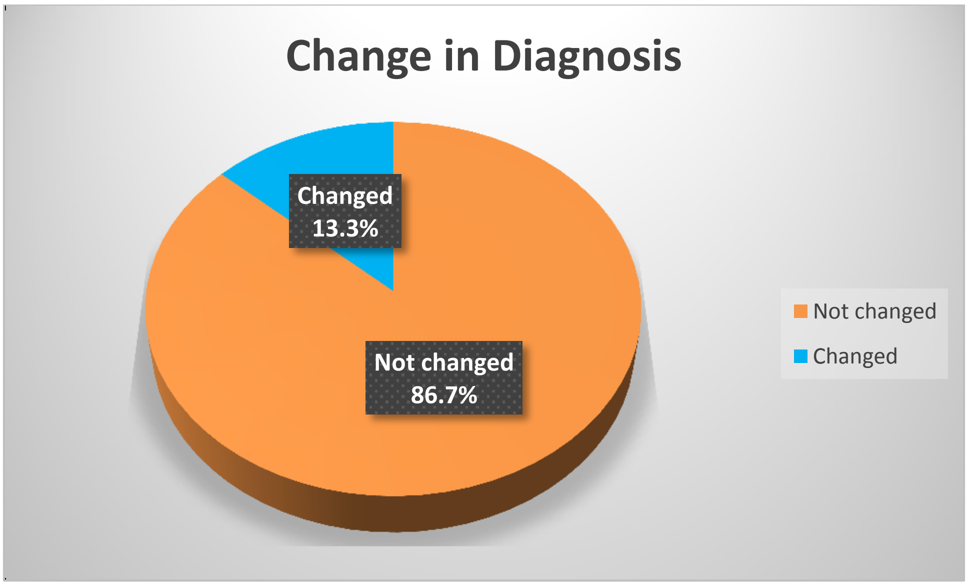

Table 28: Parameters of stroboscopy in cases where diagnosis is changed

VDL Diagnosis	Stroboscopic Diagnosis	Fundamental frequencies	Symmetry	Periodicity	Glottic closure	Amplitude	Mucosal Wave
B/l vocal cord nodules	B/l vocal cord nodules with Reinkes edema	276	Normal	B/l irregular	Hour-glass	Decreased B/l	Decreased B/l
Normal	Vocal cord cyst	220	Normal	B/l regular	Complete	Normal both sides	Normal both sides
Normal	B/l vocal cord nodules	77	Normal	B/l regular	Complete	Decreased on left	Normal both sides
Normal	Hypothyroidism	270	Normal	B/l regular	Complete	Normal both sides	Decreased B/l
Normal	Contact ulcer with bamboo nodule on rt vocal cord	276	Normal	Right irregular	Incomplete all through the length	Decreased on right	Normal both sides
Normal	B/l vocal cord nodules	291	Normal	B/l regular	Incomplete in posterior portion	Decreased B/l	Normal both sides
Normal	B/l vocal cord nodules	96	Normal	B/l regular	Complete	Normal both sides	Normal both sides
Normal	B/l vocal cord nodules	120	Normal	B/l regular	Hour-glass	Normal both sides	Normal both sides
Normal	Left vocal cord atrophy	89	Asymmetrical	Left irregular	Complete	Decreased on left	Decreased on left
Thickened left vocal cord	Sulcus Vocalis	96	Normal	Left irregular	Complete	Decreased on left	Decreased on left
Unilateral vocal nodule	B/l vocal cord nodules	82	Asymmetrical	B/l regular	Hour-glass	Normal both sides	Decreased on right
Vocal cord cyst	Intracordal cyst	206	Asymmetrical	Right irregular	Hour-glass	Decreased on right	Decreased on right
Vocal cord polyp	B/l vocal cord nodules	200	Normal	B/l regular	Complete	Normal both sides	Normal both sides
Vocal cord polyp	Vocal cord granuloma	76	Normal	B/l regular	Incomplete in posterior portion	Decreased on left	Normal both sides
Vocal cord ulcer	B/l vocal cord nodules	200	Normal	B/l regular	Complete	Normal both sides	Normal both sides

Table 29: Change in diagnosis in stroboscopy in patients with normal indirect laryngoscopy

Diagnosis	**N**	**%**
Acute Laryngitis	3	2.7
B/l vocal cord nodules	10	8.8
B/l vocal cord nodules with Reinkes edema	1	0.9
Bowed Vocal cords	2	1.8
Chronic Laryngitis	3	2.7
Contact ulcer with bamboo nodule on right vocal cord	1	0.9
Hypopharyngeal cancer	1	0.9
Hypothyroidism	2	1.8
Left vocal cord atrophy	1	0.9
Normal	4	3.5
Refluxive laryngitis	1	0.9
Sulcus Vocalis	1	0.9
Vocal cord granuloma	1	0.9
Vocal cord polyp	2	1.8
Total	33	29.2

Table 30: Planned Treatment

Planned Treatment	**N**	**%**
Conservative Management	64	56.6
Surgery	49	43.4
Total	113	100

Table31: Final Treatment

Final Treatment	**N**	**%**
Conservative Management	60	53.1
Surgery	53	46.9
Total	113	100

Graph 14: Planned Treatment vs Final Treatment

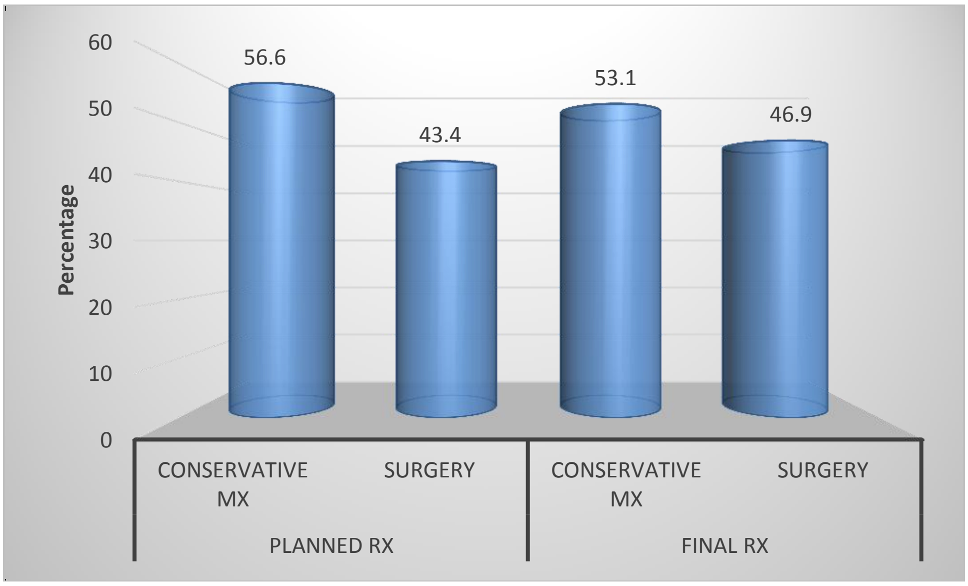

Table 32: Change in treatment after stroboscopy

Changed Treatment	**N**	**%**
Not changed	108	95.6
Changed	5	4.4
Total	113	100

Graph 15: Change in treatment after stroboscopy

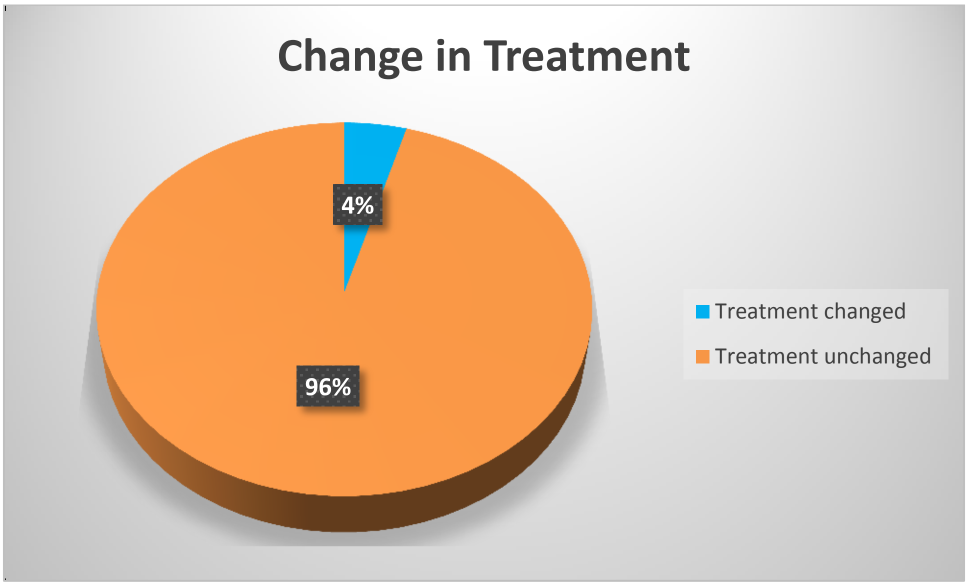

Table 33: Details of cases with change in treatment after stroboscopy

Diagnosis in VDL	Diagnosis in Stroboscopy	Planned Treatment	Final Treatment
B/l vocal cord nodules	B/l vocal cord nodules with Reinkes edema	Conservative Management	Surgery
Normal	Contact ulcer with bamboo nodule on right vocal cord	Conservative Management	Surgery
Normal	Left vocal cord atrophy	Conservative Management	Surgery
Vocal cord cyst	Intracordal cyst	Conservative Management	Surgery
Vocal cord polyp	Vocal cord granuloma	Surgery	Conservative Management

DISCUSSION

Age

In our study, 113 patients with dysphonia were evaluated. The age ranged from 18 years to 65 years. In our study the mean age of presentation was 45.4 years with a standard deviation of 14.64 years. The most common decade of presentation was fifth decade. In similar study conducted by Thomas et al.,[65] in 30 patients, the age range was 18 years to 62 years with a mean of 36.53 years. In a study conducted by Rasheed et al.,[66] age ranged from 14 years to 60 years with most common decade of presentation being third decade. In a study by Sandemetrio et al.,[67] the mean age of presentation was 38.6 years. In study done by Banjara et al.,[73] the age varied from 11 years to 80 years and most common decade of presentation was third decade. In a similar study conducted by Printza A et al.,[72] age ranged from 18-84 years and mean age of presentation was 51.4 years with a standard deviation of 16.90 years. In a study by Sellapampatti et al.,[76] age of the patients ranged between 16 years to 80 years and the mean age was 49.7 years.

Gender

In our study of 113 patients, 65(57.5%) were male and 48(42.5%) were female with a male to female ratio of 1.4:1. Similar male predominance was observed in Sellapampatti et al.,[76] 67(63.8%) were males and 38(36.2%) were females. In study by Banjara et al.,[73] male to female ratio was 1.5:1. However, few studies showed a different scenario. In study by Sandemetrio et al.,[67] out of 91 patients 70 were female and 21 were male with a clear female predominance. In study by Rasheed et al.,[66] there were 23 males (53.5%) and 20 females (46.5%) with a male to female ratio of 1.12:1. In study by Printza A et al.,[72] there were 80 females and 66 males with a male to female ratio of 1.21.In a similar study by Richard T Kelly et al., there were 23 males and 30 females. In this study, p value was significant in patients with carcinoma for males and papilloma for females respectively.

Occupation:

10% (11 cases) of 113 study patients are professional voice users. The history of vocal abuse was high in these subsets of patients.

Chief complaint and duration:

55% patients of 113 have presented with only dysphonia as chief complaint, in 45% patients there were additional complaints like dysphagia, throat pain, fever epigastric burning sensation.. 70% of patients presented with symptoms of less than 4 months duration. Patients with unilateral vocal cord palsy has the highest duration of complaints whereas patients with acute laryngitis have mean duration of 2-3 days. In a similar study conducted by Banjara et al.,(73) 44% patients presented symptoms duration of less than 3 months.

Risk Factors:

In our study of 113 patients, major risk factors for dysphonia were vocal abuse and smoking. Out of 113 patients, 26 patients (23%) had history of smoking, 19 patients (16.8%) had history of vocal abuse,10 (9%) patients had history suggestive of gastro esophageal reflux disease and 19 (16.891%) patients were alcoholics.

In study by Rosa Hernåndez Sandemetrio et al.,(67) 40 patients (44%) reported vocal abuse, of which 67% were due to work; 47 patients (52%) were smokers, and 9 patients (9.8%) reported gastro esophageal reflux symptoms. In similar study by Printza A et al.,(72) the percentage of smokers was 25.33% of the participants, and 39.3% of participants laryngopharyngeal reflux was identified etiological factor. In a similar study conducted by Sellapampatti et al.,(76) of 105 cases 59 were smokers, 39 were alcoholics and 33 had vocal abuse history.

Indirect Laryngoscopy:

In our study of 113 patients, IDL was attempted in all 113 cases, however IDL could not be done in 16 cases. Positive findings were seen in 64 cases and no abnormality was seen in 33 cases. In 16 cases, IDL could not be performed due to various anatomical and physiological cases like overhanging epiglottis, excessive gag reflex and non-cooperation of the patients.

Vocal cord Pathologies

In our study of 113 patients, there were 19 (16.8%) cases of carcinoma, 18 (15.95%) cases of vocal cord nodules, 18 (15.95%) cases of laryngitis, 12 (10.6%) cases of vocal cord palsy, 10 (8.8%) cases of vocal cord polyps, 9 (8%) cases of vocal cord cyst and 3 (2.7%) cases of vocal cord papilloma. There are 2 (1.8%) cases each of dysphonia plica ventricularis, hypothyroidism and laryngeal web. Vocal cord atrophy, leukoplakia, reinkes edema, sulcus vocalis, T.B. laryngitis, vocal cord granuloma, vocal cord hyperkeratosis are seen in one (0.9%) patient each. In seven (6.2%) the cause of the dysphonia could not be identified.

In similar study conducted by Sellapampatti et al.,(76) of total 105 patients laryngeal nodule seen in 12 (17.9%) and laryngeal cancer seen in 10 (14.9%). In 9 (13.4%) cases normal finding is noted. In study conducted by Banjara et al.,(73) the most common diagnosis is vocal cord nodule (25 cases), followed by laryngeal cancer (12cases). There was no diagnosis in 3 cases. In a study by Sandemetrio et al.,(67) vocal cord edema is most common diagnosis followed by vocal cord polyp. (25% edema, 21.8% polyps, 7.6% nodules, 8.2% mucosal cysts, 7.1% intracordal cysts, 12.5% sulcus, 1.6% mucosal bridges, 6% contact lesions, 2.2% vascular lesions, 5.4% keratosis and 1.1% fibrosis). In a study by Thomas et al.,[65] 97 cases of benign vocal cord lesions were seen, of which vocal cord nodule (22.3%) is most common.

No detectable abnormality:

113 cases had undergone indirect laryngoscopy, videolaryngoscopy and stroboscopy, of which 7(6.25%) cases showed no detectable abnormality in all the three modalities (idl, vdl and stroboscopy). In a similar study conducted by Banjara et al.,[73] 7 patients of 112 (6.25%) showed no detectable abnormality. In a study done by Sellapampatti et al., [76]19 cases of 105 cases, 18% showed no detectable abnormality in all the three studies. In a study done Printza A et al.,[72] 2 patients of 150 (1.3%) showed no detectable abnormality.

Stroboscopic Parameters:

i) **Symmetry of vocal Cords -**

In our study of 113 patients, stroboscopic assessment could not be performed in 2 cases. Vocal cord symmetry was significant in laryngitis and nodules with all cases showing symmetrical vocal cords except for one case of nodules. Vocal cord symmetry is seen in 79 (69.91%) cases and asymmetry is seen in 32 (28.3%) patients. All the cases of bowed vocal cords, dysphonia plica ventricularis, hypothyroidism, laryngeal web, laryngitis, b/l vocal cord leukoplakia, sulcus vocalis, tuberculous laryngitis and vocal cord granuloma showed symmetrical vocal cords. There were 19 cases of laryngeal cancer of which 7 showed asymmetries and 10 showed symmetry of vocal cords, in 2 cases stroboscopic assessment could not be completed. In total of 9 cases of vocal cord cyst, 6 patients showed asymmetrical vocal cords and 3 patients showed symmetrical vocal cords. In vocal cord palsy patients which included bilateral vocal cord palsy and unilateral vocal cord palsy, 7 patients showed asymmetry of vocal cords and 5 patients showed symmetrical vocal cords. There were 10 patients of vocal cord polyps, 7 of them had asymmetrical cords and 3 had symmetrical cords. In patients with Reinke's edema, Vocal cord hyperkeratosis and left vocal cord atrophy, vocal cords are asymmetrical.

In similar study done by Banjara et al.,[(73)] lesions like bilateral abductor palsy, acute laryngitis, chronic laryngitis, vocal nodule and sulcus had statistically significant relationship with symmetry of vocal cord, as these lesions usually involves both vocal folds. In cancer, polyp, palsy and cyst has statistically significant relationship with asymmetry of vocal cord, as these lesions usually involve unilateral vocal cord. Similar results were observed in study by Nagata et al.,[(78)] in which they observed symmetry of waves in case of vocal cord nodules. Vocal fold symmetry remains intact in the absence of abnormalities along the glottal margin[(78)]. In a study by Sellapampatti et al.,[(76)] vocal cord cancer, polyp, and cyst had shown a significant association with asymmetry of the vocal cord; whereas, acute and chronic laryngitis, nodule, abductor palsy, and congestion had shown a significant relationship with symmetry of the vocal cords. In study by Sercarz et al.,[(79)]vocal cord vibration asymmetry was most consistent finding in vocal cord palsy. In study by Ahmed M. Rasheed,[(66)] vocal cord symmetry was observed in patients with vocal cord nodule and asymmetry was observed in patients with intracordal cyst and polyp.

ii) **Amplitude of Vocal Cord Vibration:**

In our study of 113 patients, amplitude was normal both sides in 60(53.1%) cases. An abnormality was seen in 51 (45.13%) cases (Amplitude was decreased in 43 cases, there was absolutely no movement in 8 cases). Stroboscopic assessment could not be performed in 2 cases. Amplitude was normal bilaterally in all the cases of Bowed vocal cords, dysphonia plica ventricularis, Hypothyroidism, Laryngeal web, TB laryngitis and Vocal cord hyperkeratosis. Out of 9 cases of vocal cord cyst patients, 8 of them showed decreased amplitude on ipsilateral side and remaining one patient had normal amplitude. In patients with vocal cord nodule majority (15 of 18) had normal amplitude while other 3 patients had decreased amplitude. In 19 patients of carcinoma 3 patients had absent movement of vocal cords due to fixation, decreased amplitude is seen in 5 cases, and normal amplitude seen in 10 cases. Majority of the laryngitis patients (15 out of 18) have normal amplitude and 3 had decreased amplitude. All the three cases of papilloma, one case of reinke’s edema, vocal cord granuloma, and sulcus vocalis had decreased amplitude. In all the 12 cases of vocal cord palsy either there is absent (5 cases) or decreased (7 cases) amplitude.

In similar study done by Hansa Banjara et al.,[(73)] abductor palsy and vocal palsy shows statistically significant relationship with the decreased amplitude. Bowing, acute laryngitis, chronic laryngitis, cyst, nodule, polyp, and sulcus vocalis had statistically significant relationship with normal amplitude of vocal cord. In study by Danasekaran Veerappapillai Sellapampatti et al.,[(76)] on assessment of malignant and non-malignant lesions of the vocal cord using videostroboscopy, abductor palsy and cancer showed a statistically significant relation with the decreased amplitude; acute laryngitis, chronic laryngitis, cysts, nodules, and polyps had a statistically significant relationship with normal amplitude of vocal cord vibration. In their study increase in amplitude was not seen in any of the case, this result is similar to our study. In study by Ahmed M. Rasheed,[(66)] vocal cord vibration amplitude was observed in patients with vocal cord nodule, intracordal cyst and in patients with polyp; which was decreased.

iii) **Mucosal Wave**:

Mucosal wave was normal bilaterally in 65 (57.2%) cases. It was decreased unilaterally in 31(27.3%) cases. Mucosal was decreased bilaterally in 15 (13.2%) cases. In all patients with bowed vocal cords, dysphonia plica ventricularis, reinkes edema, vocal cord granuloma, leukoplakia of bilateral vocal cords and laryngeal web the mucosal wave is normal bilaterally. In patients with vocal cord nodule (18 cases), 15 had normal mucosal wave bilaterally and 3 patients had decreased mucosal wave. Majority (8 out of 10) of the patients with vocal cord polyp had normal mucosal wave, 2 had decreased mucosal wave pattern. Out of 9 patients with vocal cord cyst 8 had decreased mucosal pattern and one had normal pattern. In patients with laryngitis 1/3rd patients (6 of 18) had decreased mucosal wave pattern. In carcinoma half of the patients mucosal wave pattern was preserved. In majority of the patients with vocal cord palsy (10 of 12) had decreased mucosal pattern, due to loss of stiffness of vocal cord.

Similar observations were made in study by Hansa Banjara et al.,[(73)] that is bowing, nodule, palsy and sulcus vocalis shows statistically significant relationship with normal mucosal wave pattern. Similarly, decreased or absent mucosal wave can be observed on the side of the cyst because of displacement of lamina propria. Vocal folds with small polyps generally had intact mucosal wave while larger polyps showed prominent decreased mucosal wave amplitude Shohet et al.,[(80)] compared stroboscopic findings between cysts and polyps. They observed that the mucosal wave was the most important parameter in differentiating cysts from polyps. They also found the mucosal wave to be diminished or absent in 100% of vocal fold cysts, and wave to be present in 80% of Polyps. In study by Printza A et al.,[72] patients with an initial diagnosis of vocal fold nodules stroboscopy contributed to the characterization of nodules based on the presence of uninterrupted mucosal wave. Mucosal wave can be absent because of mass effect with large polyps or intact with broader-based polyps. In study by Ahmed M. Rasheed,[66] mucosal wave was absent in polyp, cyst and nodule cases. In study by Sercarz et.al.,[79] showed decreased in mucosal wave was due to loss of stiffness of vocal cord in cord palsy, which deferred from findings in our study.

iv) **Glottic Closure**:

Glottic closure is complete in 54 cases (47.8%), and incomplete in 57 cases (50.4%). It could not be rated in 2 cases (1.8%). In the category of incomplete there are 21 patients with hour glass defect, 6 patients with spindle shaped defect and 30 patients of incomplete closure either along the length, posterior or anteriorly. Glottic closure is only significant ($p<0.05$) in cases of vocal cord bowing (spindle shaped defect), vocal cord polyp (Hour glass defect), and vocal cord nodules (Hour glass defect). Glottic closure was hourglass shaped in bilateral vocal nodule and polyps (p value 0.005 and 0.002 respectively). Spindle shaped closure was observed in vocal cord bowing (p value 0.05). Incomplete closure was typically seen in unilateral vocal cord palsy as it was difficult to approximate in the midline.

Similar findings were observed in study by Hansa Banjara et al. (2012)[73] Hourglass shaped glottic closure was found in vocal nodule which was statistically highly significant as value showed by Chi square, as these lesions were generally bilateral and symmetric. Incomplete closure of vocal cord showed a significant relationship with vocal cord palsy due to absence of motion of unilateral vocal cord. In study by Ahmed M. Rasheed (2008);[66] similar findings were observed, that is hour glass gap was observed in cases with nodules, incomplete closure in cases of intracordal cyst and irregular closure in polyp cases.

Spindle shaped glottic closure significantly related to bowing of vocal cords. In study by Sellapampatti et al. (2014),[76] on assessment of malignant and non-malignant lesions of the vocal cord using videostroboscopy; the videostroboscopic finding showed hourglass shaped glottic closure in the vocal nodule, which was found to be statistically significant. Polyp, chronic laryngitis, and congestion showed a statistically significant relationship, with complete glottic closure (contrary in our study, where polyp showed significant relationship to hourglass shaped glottic closure). Incomplete closure of the vocal cord showed a significant relationship with abductor palsy, due to the absence of motion of the unilateral vocal cord.

v) **Periodicity:**

In our study all 9 cases of vocal cord cyst showed aperiodicity. 9 of 19 carcinoma patients had aperiodic waves.Only 4 cases of 19 vocal cord nodule had aperiodic waves.

Similar findings were observed in study of demographic and Videostroboscopic assessment of vocal pathologies, done by Hansa Banjara et al. (2012).[73] In abductor palsy. laryngitis, bowing, cancer, cyst, nodule and vocalis the corresponding Chi square values shows statistically significant relationship with periodicity of vocal cord. However, vocal cord palsy showed significant relationship with aperiodicity of vocal cord because of decreased or absent phase closure. In study by Ahmed M. Rasheed (2008)[66] similar findings were observed that is vocal cord nodules show periodic motion and cases with polyp and cyst had aperiodic vibrations.

Diagnostic value of Stroboscopy:

In our study stroboscopy helped in changing the diagnosis in 15 (13.3%) cases. Diagnosis remained unchanged in 98 (86.7%) cases when compared with videolaryngoscopy. Stroboscopy has changed line of management in 5(4.4%) cases. 5 patients were changed to surgical management and in 1 patient surgery was prevented.

Similar findings are noted in study by Rahul et al.,[81] in which stroboscopy changed diagnosis in 33% cases. Stroboscopy gave additional information in 7.5% cases. Diagnosis remained unchanged in 60% cases.

Similar findings were observed in study by Sataloff RT et al.,[56] They noted diagnosis before and after stroboscopy prospectively for 377 stroboscopy procedures. In 53% of the procedures, stroboscopy resulted in no change in diagnosis. In 18%, preprocedure diagnoses were found to be incorrect. The procedure has proven very helpful in modifying diagnoses in 47%, and confirming uncertain diagnoses in many of the other patients studied. Other similar study by Casiano RR et al.,[58] includes 292 dysphonic patients who underwent indirect as well as videolaryngoscopy with and without stroboscopic examination.

Videostrobolaryngoscopy was found to alter the diagnosis and treatment outcome in of the patients. In study by Ahmed M. Rasheed ,[66] a small but significant percentage of patients (19%), the use of stroboscopy resulted in changes of diagnosis so as to alter the management plan, thereby avoiding unnecessary surgical and or medical therapies.

In our study stroboscopy had major role in differentiating between lesions like nodule, cyst, polyp which sometimes appear similar on laryngoscopy. Study by Shohet et al.,[80] they determined that the mucosal wave was the most important parameter in differentiating cysts from polyps. They also found the mucosal wave to be diminished or absent in 100% of vocal fold cysts, and wave to be present in 80% of polyps. Printza A et al.,[72] observed that diagnostic value of stroboscopy was found to be greater for certain pathological conditions like sulcus vocalis, vocal fold cysts, scars, muscle tension dysphonia, vocal fold atrophy with a small gap and nodules. Study by Fleischer S. et al.,[71] showed that videostroboscopy can help in differentiating between benign vocal fold lesions, invasive processes, vocal fold scarring and functional disorders. Stroboscopy can discriminate different types scarring and functional disorders, and point to the correct treatment of small lesions (nodules, small polyps and cysts) and point to the correct treatment without delay.

These findings were similar to study done by Bigenzahn et al.,[82] which showed that stroboscopic evaluations permit to detect early infiltrative processes of the vocal folds. In study by Printza A et al.,[72] one third of the cases (32.2%) stroboscopy offered additional information regarding the cause of dysphonia. The procedure has proven very helpful in modifying diagnoses in 47%, and confirming uncertain diagnoses in many of the other patients studied.

Change in Treatment after Stroboscopy:

In our study stroboscopy change the diagnosis in 15 (13.3%) cases. However, the course of treatment has been changed only in 5 (4.4%) patients. In 4 patients the management changed to surgery from conservative medical management. The diagnosis of these patients were reinkes edema, bamboos nodule, vocal cord atrophy and intracordal cyst. In one patient with diagnosis of vocal cord polyp, the diagnosis was changed to vocal cord granuloma resulting in avoidance of surgery.

In a similar study done by Rasheed et al. (2008)[66] stroboscopy resulted in change in treatment in 8 cases (19%) of 43 cases which is contrary to our study. This could be due to less sample size of the Rasheed at al study.

In our study stroboscopy was found useful in cases of vocal fold benign pathologies like sulcus vocalis, vocal cord polyps, vocal cord cyst. In most of the patient's additional findings such as early nodular changes were seen. Stroboscopy was found less useful in malignancies which can be attributed to the advanced disease T3/T4 lesions in our patients. According to Mehlum et al.,[83] stroboscopy was useful and successful in identifying all early invasive of laryngeal cancers and 66% of non-invasive cancers.

Limitations of the study:

- Fibre optic laryngoscopy is one of the most commonly used tool for evaluation of dysphonia which was not used in this study.
- Due to small sample size, there were fallacies in comparison to larger studies .
- It was a hospital based study, hence the etiology of dysphonia in the community could be different.

Strengths of the study:

- This study was done by single examiner to overcome inter-judge reliability issues.
- All the patients underwent indirect laryngoscopy, video laryngoscopy, and videostroboscopy which helped in comparing their efficacy in diagnosing dysphonia.
- We have used a high-resolution video stroboscopy which not only helped in diagnosing the “accurate etiology” in patients with dysphonia but also in “altering the management” of the patients.

CONCLUSIONS

- The efficacy of stroboscopy (93.5%) in diagnosing dysphonia is superior than videolaryngoscopy (75.22%).
- In a small but significant (15patients, 13.27%) patients stroboscopy resulted in change of diagnosis.
- Change in diagnosis on stroboscopy also resulted in the change in the plan of treatment in 4.4% patients.
- Videostroboscopy is a one of the most important diagnostic tool for evaluation of different vocal cord pathologies as it is easy to perform, non-invasive and office procedure which can be done under local anesthesia.
- Accurate diagnosis could be made in certain benign laryngeal pathologies like nodules, cysts, sulcus vocalis and polyps using stroboscopy when compared to laryngoscopic examination. However further studies are needed to assess the impact on health care costs and patient outcomes.

SUMMARY

Complex motion of vibratory margin of the vocal fold is necessary for normal voice. The videostroboscopy evaluates the viscoelastic properties of the phonatory mucosa. Alterations of the parameters suggests the underlying lesion which may not be evaluated by other procedures like indirect laryngoscopy and endoscopic examination. The present study was conducted in 113 patients presenting with dysphonia to our outpatient department.

- The male preponderance was seen in cases of laryngeal carcinoma (P value 0.038) can be attributed to smoking. The female preponderance was seen in laryngeal papilloma in our study (P value 0.041).
- Symmetry of vocal cords was unaffected in patients with vocal cord nodules and laryngitis. (P value 0.03 and 0.017 respectively).
- In all patients with vocal cord palsy amplitude is decreased or absent (P value 0.009), due to immobile vocal cords.
- Mucosal wave pattern was reduced in large vocal cord nodules, cysts, polyps, cancer, laryngitis.
- Glottic closure was hourglass shaped in bilateral vocal nodule and polyps (p value 0.005 and 0.002 respectively). Spindle shaped closure was observed in vocal cord bowing (p value 0.05). Incomplete closure was typically seen in unilateral vocal cord palsy as vocal cords cannot approximate to midline.
- The correct diagnosis was made using stroboscopy in certain disorders like nodules, cysts, sulcus vocalis, vocal cord atrophy where it was difficult to come to conclusion with videolaryngoscopy. This change in diagnosis had subsequently helped in changing the treatment plan and avoidance of surgery also in few patients.

- The efficiency of videolaryngoscopy was 75.22% and videostroboscopy was 93.2%.
- Videostroboscopy showed significant change in the diagnosis in 13.27%, proving its superiority over videolaryngoscopy in diagnosing etiology of dysphonic patients.
- Videostroboscopy changed treatment plan in 4.4% patients.

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ANNEXURES

ETHICAL CLEARANCE CERTIFICATE

B.L.D.E.UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR – 586103

INSTITUTIONAL ETHICAL COMMITTEE

NO/58/2015
20/11/15

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 17-11-2015 *at* 03 pm *scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has accorded Ethical Clearance.*

Title "Stroboscopy as a diagnostic tool for Evaluation of Dysphonia"

Name of P.G. Student : Dr Shilpa Potnuru
Dept of Otorhinolaryngology

Name of Guide/Co-investigator : Dr. R.N. Karadi
Prof & HOD, of Otorhinolaryngology

DR.TEJASWINI VALLABHA
CHAIRMAN

CHAIRMAN
Institutional Ethical Committee
BLDEU's Shri B.M. Patil
Medical College,BIJAPUR-586103.

Following documents were placed before E.C. for Scrutinization
1)Copy of Synopsis/Research Project
2)Copy of informed consent form.
3)Any other relevant documents.

PROFORMA

1) NAME: CASE NO:

2) AGE: IP NO:

3) SEX: DOA:

4) RELIGION: DOS:

5) OCCUPATION: DOD:

6) RESIDENCE:

7) CHIEF COMPLAINTS:

8) HISTORY OF PRESENTING ILLNESS:

9) PAST HISTORY:

- Diabetes mellitus
- Hypertension
- History of any previous surgery.

10) FAMILY HISTORY:

11) GENERAL PHYSICAL EXAMINATION:

Pallor: Present/Absent

Icterus:	Present/Absent
Clubbing:	Present/Absent
Generalized Lymphadenopathy:	Present/Absent
Build:	Poor/Medium /Well
Nourishment:	Poor / Medium / Well

12) VITALS

PR:

BP:

RR:

Temp:

13) OTHER SYSTEMIC EXAMINATION:

- Respiratory System
- Cardiovascular System
- Central Nervous System
- Per Abdomen examination

14) INDIRECT LARYNGOSCOPY

15) VIDEOLARYNGOSCOPY:

16) VIDEOSTROBOSCOPY:

1. Fundamental frequency:

2. Symmetry

   1. Symmetrical
   2. Asymmetrical   In amplitude   In phase   Both

      Right

      Left

3. Periodicity (Regularity)   Regular   Irregular   Inconsistent

      Right

      Left

4. Glottic closure

   1. Complete
   2. Incomplete

      Along entire length   Spindle shape   Sandglass shape

      Irregular shape   Anterior portion   Posterior portion

      Inter cartilaginous portion   6&7   Others: ……………….

   3. Inconsistent

5. Amplitude

   1. Right   ++++   +++   ++   +   0
   2. Left   ++++   +++   ++   +   0

6. Mucosal wave

   1. Right   ++++   +++   ++   +   0
   2. Left   ++++   +++   ++   +   0

7. Non-vibrating portion

1. Right

None Occasionally-Partially Occasionally-Entirely

Always-Partially Always-Entirely

2. Left

None Occasionally-Partially Occasionally-Entirely

Always-Partially Always-Entirely

18) INFERENCE:

19) COMMENTS:

B. L. D. E. UNIVERSITY

RESEARCH CONSENT FORM

TITLE: **Stroboscopy as diagnostic tool for evaluation of dysphonia.**

Name of the researcher- Dr. Shilpa Potnuru, Junior Resident, Dept. of Otorhinolaryngology, B. L. D. E. Hospital.

Guide- Dr. R. N. Karadi, Professor and Head of the department, Dept. of Otorhinolaryngology, B. L. D. E. Hospital.

1. **Purpose of research:**

   This study is useful academically as well as clinically to know about characteristics of human voice in dysphonia.

2. **Procedure:**

   I understand that, the procedure of study will involve evaluation of various physiological/physical parameters. The procedure will not interfere with any of my physiological parameters and they are non-invasive

3. **Risk and discomforts:**

   I understand determination of these voice parameters will bit cause any risk to my health.

4. **Benefits:**

   I understand that my participation in my study may not have any benefit to me but this may have a potential beneficial effect in the field of laryngology.

5. **Confidentiality:**

   I understand that medical information produced by this study will become part of institutional records and will be subject to the confidentiality and regulation of the said institute. Information of sensitive personal nature will not be part of medical record, but will be stored in investigators research file and identified only by a code number. The code key connecting two numbers will be kept in a separate secured location.

   If data are used for publication in the medical literature and publishing purpose no names will be used and other identities such as photographs, audio and video tapes will be used only with my special written permission. I understand I may see the photographs and the video tapes and the audio tapes before giving permission.

6. **Request for more information:**

   I understand that I can ask more questions about the study at any time. I will be informed if any significant new finding discovered during study.

7. **Refusal or withdrawal from participation:**

   My participation is voluntary, I may refuse or withdraw my consent and discontinue participation in study. I also understand research may terminate my participation at any time.

I understand that by my agreement to participate in this study, I am not waving any of my legal rights.

I confirm that ___________________________(researcher) has explained to me all the above facts thoroughly in my own language and therefore I agree to give consent to participate as a subject and research project.

Signature of Patient: -

VIDEOLARYNGOSTROBOSCOPIC IMAGES OF CASES

Figure 9: Left vocal cord granuloma

Figure 10: Reinke's edema

Figure 11: Right vocal cord fibrous polyp

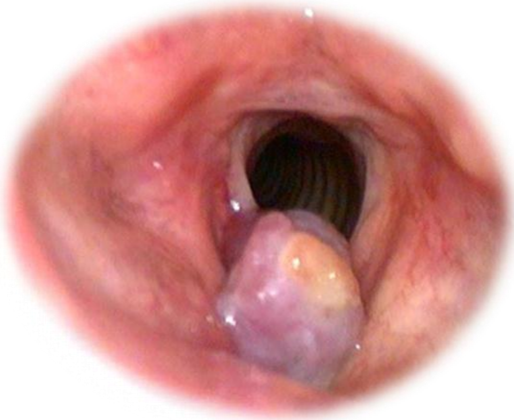

Figure 12: Supraglottic cancer

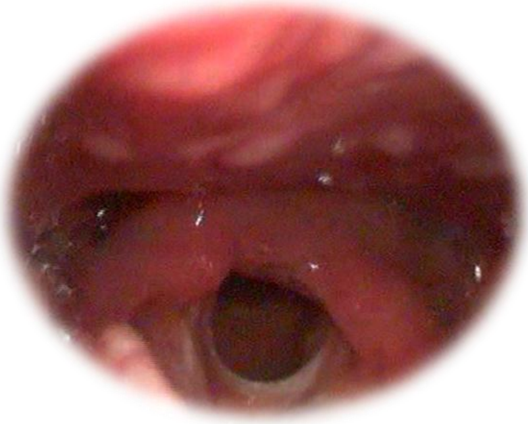

Figure 13: Anterior glottic web

Figure 14: Anterior and posterior glottic web

Figure 15: Left vocal cord polyp

Figure 16: Left vocal cord polyp with right arytenoid dislocation

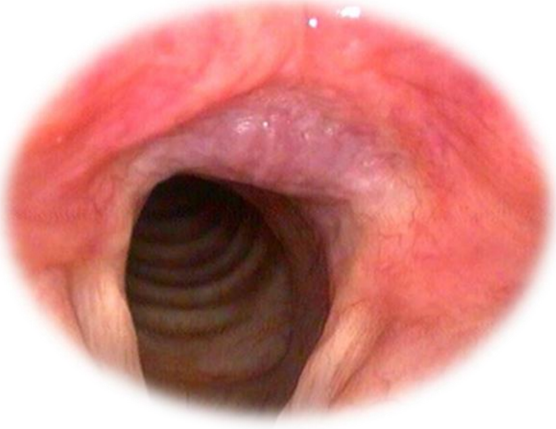

Figure 17: Laryngeal reflux disease

Figure 18: Vocal cord hyperkeratosis

Figure 19: Left vocal cord cyst

Figure 20: Bilateral vocal cord nodules

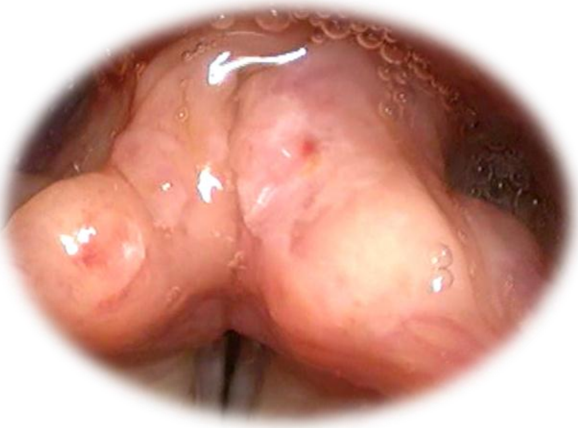

Figure 21: Laryngeal tuberculosis

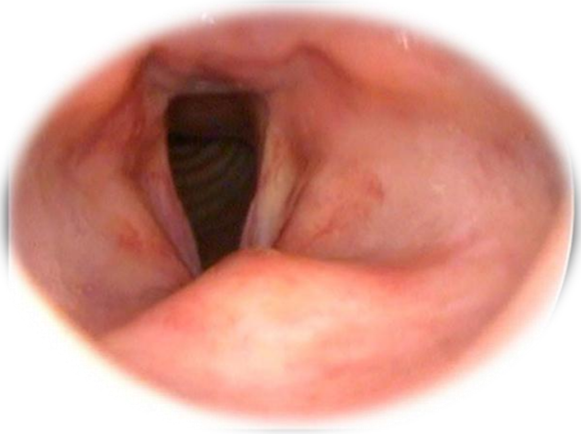

Figure 22: Sulcus vocalis

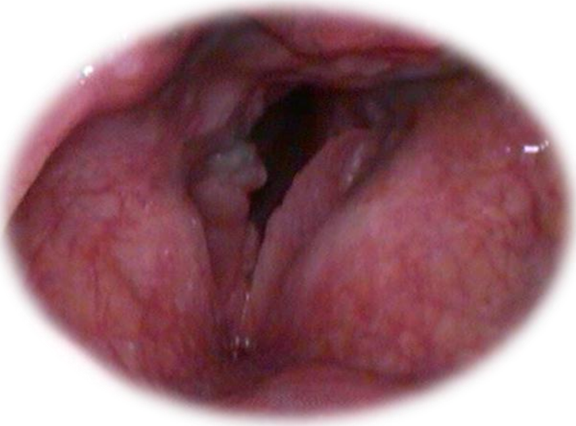

Figure 23: Right glottic cancer

Figure 24: Vocal cord palsy

PHOTOGRAPHS

KEY TO MASTER CHART

IDL	- Indirect Laryngoscopy
VL	- Videolaryngoscopy
VLS	- Videolaryngostroboscopy
F0	- Fundamental Frequency
Dx	- Diagnosis
Mx	- Management
Rx	- Treatment
Rt	- Right
Lt	- Left
VC	- Vocal Cord
B/L	- Bilateral
H/O	- History of
Ca	- Carcinoma
M	- Male
F	- Female
Tb	- Tuberculosis
Ant	- Anterior