A Dissertation on

" RADIOFREQUENCY ASSISTED PLASMA ABLATION AND CARBON DIOXIDE LASER IN BENIGN LESIONS OF LARYNX – A RANDOMIZED COMPARATIVE STUDY "

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with partial fulfillment of the regulations

for the award of the degree of

M.S.ENT (BRANCH – IV)

COIMBATORE MEDICAL COLLEGE,

COIMBATORE

MAY 2018

CERTIFICATE

This is to certify that this dissertation on "**RADIOFREQUENCY ASSISTED PLASMA ABLATION AND CARBON DIOXIDE LASER IN BENIGN LESIONS OF LARYNX – A RANDOMIZED COMPARATIVE STUDY**" is a bonafide research work done by **DR. MURALIMOHAN K.**, under my guidance during the academic year 2015 to 2017.

This has been submitted in partial fulfilment of the award of **M.S. Degree in ENT (Branch IV)** by THE TAMIL NADU DR. MGR MEDICAL UNIVERSITY, Chennai – 600 032.

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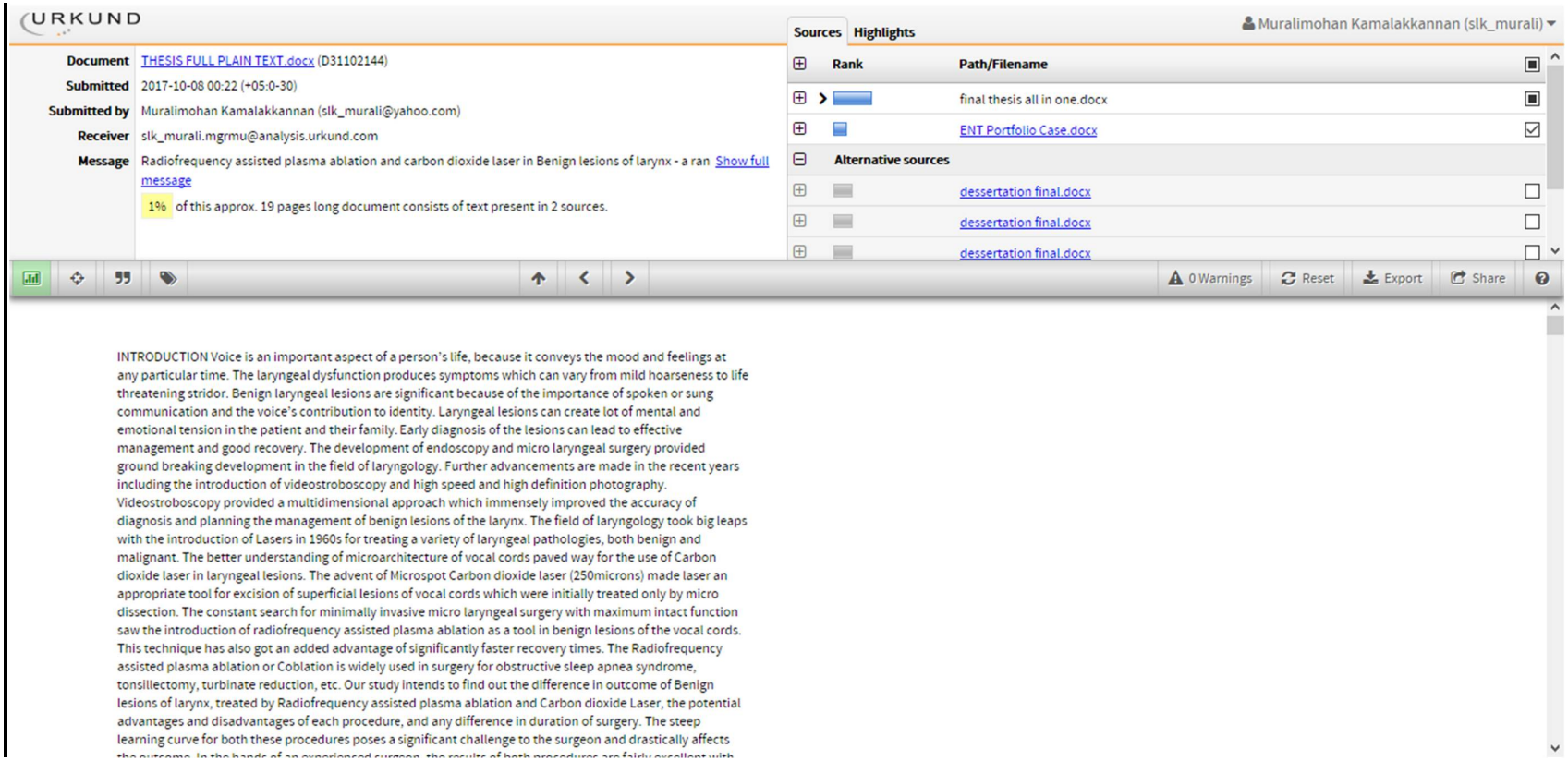
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INTRODUCTION Voice is an important aspect of a person's life, because it conveys the mood and feelings at any particular time. The laryngeal dysfunction produces symptoms which can vary from mild hoarseness to life threatening stridor. Benign laryngeal lesions are significant because of the importance of spoken or sung communication and the voice's contribution to identity. Laryngeal lesions can create lot of mental and emotional tension in the patient and their family. Early diagnosis of the lesions can lead to effective management and good recovery. The development of endoscopy and micro laryngeal surgery provided ground breaking development in the field of laryngology. Further advancements are made in the recent years including the introduction of videostroboscopy and high speed and high definition photography. Videostroboscopy provided a multidimensional approach which immensely improved the accuracy of diagnosis and planning the management of benign lesions of the larynx. The field of laryngology took big leaps with the introduction of Lasers in 1960s for treating a variety of laryngeal pathologies, both benign and malignant. The better understanding of microarchitecture of vocal cords paved way for the use of Carbon dioxide laser in laryngeal lesions. The advent of Microspot Carbon dioxide laser (250microns) made laser an appropriate tool for excision of superficial lesions of vocal cords which were initially treated only by micro dissection. The constant search for minimally invasive micro laryngeal surgery with maximum intact function saw the introduction of radiofrequency assisted plasma ablation as a tool in benign lesions of the vocal cords. This technique has also got an added advantage of significantly faster recovery times. The Radiofrequency assisted plasma ablation or Coblation is widely used in surgery for obstructive sleep apnea syndrome, tonsillectomy, turbinate reduction, etc. Our study intends to find out the difference in outcome of Benign lesions of larynx, treated by Radiofrequency assisted plasma ablation and Carbon dioxide Laser, the potential advantages and disadvantages of each procedure, and any difference in duration of surgery. The steep learning curve for both these procedures poses a significant challenge to the surgeon and drastically affects

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DECLARATION

I solemnly declare that this dissertation entitled "**RADIOFREQUENCY ASSISTED PLASMA ABLATION AND CARBON DIOXIDE LASER IN BENIGN LESIONS OF LARYNX – A RANDOMIZED COMPARATIVE STUDY**" was done by me at Coimbatore Medical College Hospital during the academic year 2015 – 2017 under the guidance and supervision of **Prof. DR. A.R.ALI SULTHAN, M.S. ENT, DLO.**

The dissertation is submitted to the Tamil Nadu Dr. MGR Medical University, towards partial fulfilment of the requirement for the award of **M.S. Degree in ENT (Branch IV).**

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CONTENTS

ABBREVIATIONS USED

PCA	Posterior Crico Arytenoid
Hz	Hertz
CO_2	Carbon dioxide
RRP	Recurrent Respiratory Papillomatosis
LASER	Light Emission by Stimulated Emission of Radiation
KTP	Potassium titanyl phosphate
NdYAG	Neodymium doped Yttrium Aluminium Garnet
nm	nanometer
W	watt
Coblation	radiofrequency assisted plasma ablation
RF	Radiofrequency
VHI	Voice Handicap Index
MPT	Maximum Phonation Time
LPR	Laryngo Pharyngeal Reflux

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INTRODUCTION

Voice is an important aspect of human life, because it conveys the mood and feelings at any particular time. The laryngeal dysfunction produces symptoms which can vary from mild hoarseness to life threatening stridor. Benign laryngeal lesions are significant because of the importance of spoken or sung communication and the voice's contribution to identity. Laryngeal lesions can create lot of mental and emotional tension in the patient and their family, more so in the case of professional voice users. Early and accurate diagnosis of the lesions can lead to effective management and good recovery.

The development of endoscopy and micro laryngeal surgery provided ground breaking development in the field of laryngology. Further advancements are made in the recent years including the introduction of videostroboscopy and high speed and high definition photography. Videostroboscopy provides a multidimensional approach which immensely improves the accuracy of diagnosis and planning the management of benign lesions of the larynx.

The field of laryngology took big leaps with the introduction of Lasers in 1960s for treating variety of laryngeal pathologies, both benign and malignant. The better understanding of microarchitecture of vocal

cords paved way for the use of Carbon dioxide laser in laryngeal lesions. The advent of Microspot Carbon dioxide laser (250microns) is an appropriate tool for excision of superficial lesions of vocal cords which were initially treated only by micro dissection.

The constant search for minimally invasive micro laryngeal surgery with maximum intact function saw the introduction of radiofrequency assisted plasma ablation as a tool in benign lesions of the vocal cords. This technique has also got an added advantage of significantly faster recovery. The Radiofrequency assisted plasma ablation or Coblation is widely used in ENT surgeries like obstructive sleep apnea syndrome, tonsillectomy, turbinate reduction, etc.

Our study intends to find out the difference in intra operative & post-operative outcome of Benign lesions of larynx, treated by Radiofrequency assisted plasma ablation and Carbon dioxide Laser, the potential advantages and disadvantages of each procedure, and any difference in duration of surgery. The steep learning curve for both of these procedures poses a significant challenge to the surgeon and drastically affects the outcome. In the hands of an experienced surgeon, the results of both procedures are fairly excellent with reduced surgical times and almost no complications.

AIM OF THE STUDY

- To compare the treatment outcome in Benign lesions of larynx using Radiofrequency assisted plasma ablation and Carbon dioxide laser
- To find out whether there are significant or potential adverse effects of either procedure
- To determine whether any of these procedures is preferred treatment of choice in specific conditions

REVIEW OF LITERATURE

The medical literature was searched to identify studies and reviews relevant to benign lesions of larynx, their diagnosis, and management relevant to usage of radiofrequency assisted plasma ablation and Carbon dioxide laser. The list of studies included in this review are as follows:

Aniket et al[49] studied the incidence of various types of benign lesions of larynx and their modes of clinical presentation, etiological factors and correlate the clinical and histopathological diagnosis. They found out the male preponderance of the lesions, with vocal cord polyps and nodules constituting the majority of the cases. Voice abuse was found to be the most common precipitating factor and hoarseness is the most common presenting symptom.

Similar study by **Om Prakash et al**[53] also reiterated the above facts. They also added that non-neoplastic lesions are more common, and the peak incidence is at the 4 – 5th decades.

Printza A[52] et al studied the diagnostic value of Videostroboscopy in benign lesions of larynx and stressed the benefits of diagnosing small lesions of the vocal cords which were otherwise normal during unremarkable endoscopy, which is more important especially for professional voice users.

Mami Kaneko et al[50] studied about the optimal period of voice rest after surgery for effective recovery. They suggested that absolute voice rest for a period of at least 2 weeks is essential for recovery.

Sharon S. Tang et al[51] studied the timing of voice therapy after surgery, they found out greater gains in vocal function and quality if the patients are started on voice therapy preoperatively and then continued postoperatively.

Wang ZY et al[55] analysed the outcome of benign lesions of larynx treated by radiofrequency ablation and found out that the technique is minimally invasive causing minimal trauma, less bleeding, high safety and causes very few complications. They also discuss about the wide applications of radiofrequency ablation in ENT.

Anant Chouhan et al[56] also did a study on Microscopic surgery with coblation for benign laryngeal lesion – recurrent respiratory papillomatosis. They found similar advantages like less bleeding, short procedure duration, fewer complications.

The National Institute for Health and Clinical excellence and British Association of Otolaryngologists[47] conducted a review of the safety and efficacy of radiofrequency ablation in recurrent respiratory papillomatosis. They found out reduced number of frequency of

procedures needed to maintain airway, but they were uncertain of the advantage over other gold standard methods like laser and cold steel excision.

The evolution of lasers in laryngology was studied by **Asil Tahir**[54], in which he discusses about the principles of laser surgery, the application of Carbon dioxide laser in larynx, other photoangiolytic lasers that can be used. He observed that promising results can be obtained by the use of laser in laryngeal lesions by way of improved hemostasis and effective tangential dissection.

Hardik Shah et al[48], compared the efficacy of laser with conventional techniques in treatment of benign vocal cord lesions. They found out that postoperative pain and intraoperative bleeding was less in patients treated with laser. But surgical technique for laser requires expertise and more training.

THE LARYNX

The human larynx is a complex organ which participates in the diverse roles of airway protection, respiration, and phonation. Based on Negus's observations[5] the order of priority of these roles is:

(1) protection of the lower airway,

(2) respiration,

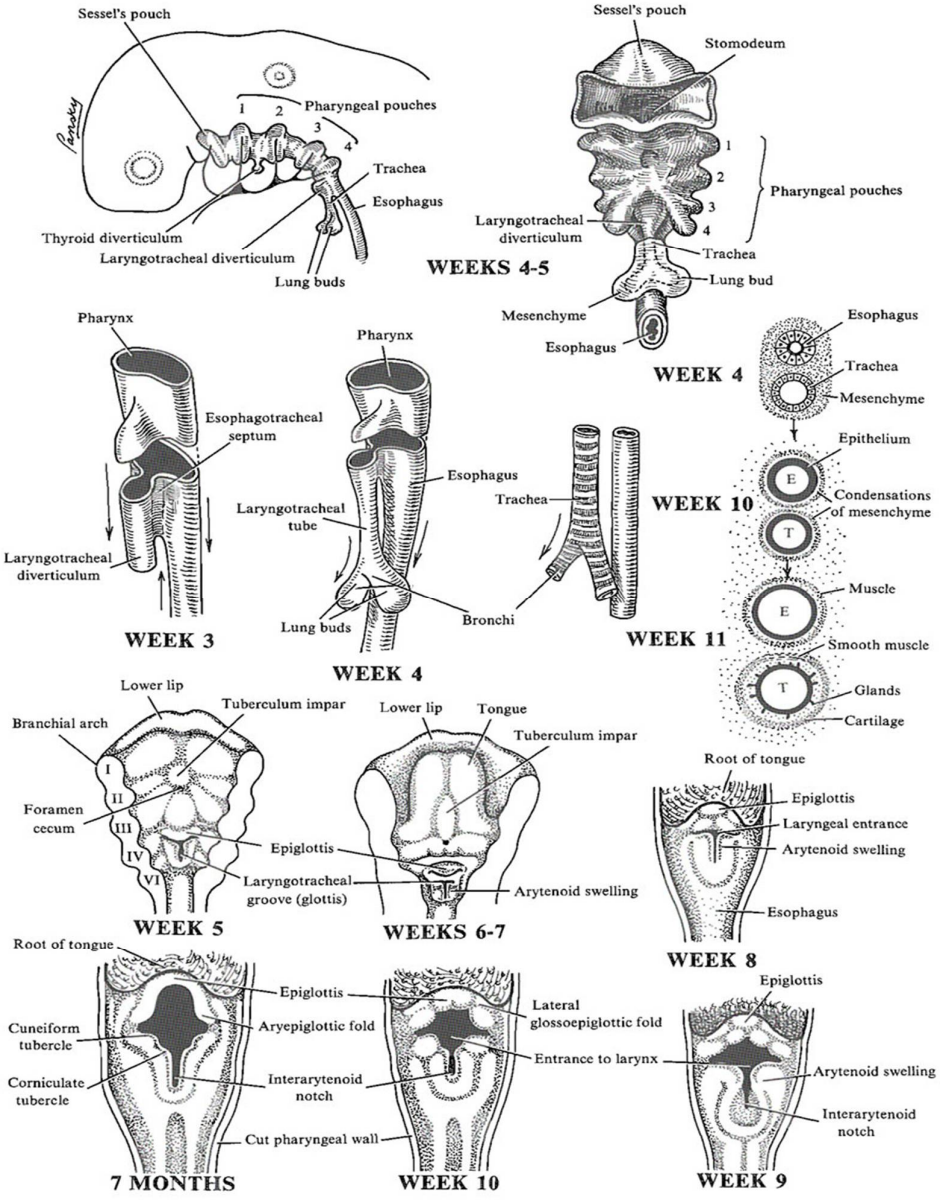
(3) phonation.

To perform these roles, the internal and external structures of the larynx interact under precise neural control, producing the most complex laryngeal functions.

EMBRYOLOGY:

The larynx, trachea and lungs develop during the fourth week of embryologic development.

The laryngotracheal or respiratory diverticulum begins as a thickening in the ventral wall of the foregut lumen immediately caudal to the fourth branchial arch. The lining of this diverticulum is derived from the endoderm of the primitive foregut. As the diverticulum elongates, it is invested by the splanchnic mesenchyme which gives rise to cartilaginous and muscular structures. The caudal end begins to dilate at the end of the fourth week to give rise to the bronchopulmonary buds, giving rise to the primordial lungs. Esophagus forms as a result of continued ventrocaudal elongation of the diverticulum as an outgrowth of the caudal aspect of the foregut.



Development of Larynx

EMBRYOLOGICAL DERIVATIVES	
STRUCTURE	**SOURCE**
Laryngeal mucosa	Endoderm of cephalic part of foregut
Laryngeal cartilages	Mesenchyme
Epiglottis	Hypobranchial eminence
Upper part of thyroid cartilage	4th branchial arch
lower part of thyroid, cricoid, corniculate and cuneiform cartilages	6th branchial arch

The epithelial lining of larynx is derived from the endoderm. Laryngeal cartilages are derived from the mesenchymal elements of 4th and 6th arches. Epiglottis derived from the hypobranchial eminence (which is a proliferation of mesenchyme in the ventral ends of 3rd and 4th arches).

The primitive pharyngeal floor, which is the site of origin of the larynx, becomes the glottis. The segment of foregut which separates the primitive pharyngeal floor formed by the 4^{th} branchial pouch becomes the supraglottic portion. Cephalic portion of the respiratory diverticulum forms the subglottic portion.

At birth, the larynx is situated in a much higher position at the C2 or C3 level, whereas in adults it is in the level of C3 – C6. During first several years of life, larynx will develop at an accelerated rate, epiglottis

will achieve its mature shape. During growth and maturation, the descent of hyoid bone and larynx occurs, a phenomenon which is unique to humans, necessary for the larynx to perform its complex functions.

LARYNGEAL CARTILAGES

THRYOID CARTILAGE

Shield shaped cartilage, protects the inner anatomy of larynx. Consists of two wings – alae or laminae, which is open posteriorly and fused in midline – in males making an angle of 90 degrees, thereby forming a laryngeal prominence called Adam's apple, whereas in females the prominence is absent due to the more obtuse fusing angle of 120 degrees. Superiorly the fusion is deficient which forms the thyroid notch.

Posterior border each lamina elongated superiorly and inferiorly thereby forming the superior and inferior horn or cornu. The Inferior cornu articulates with a facet on the cricoid cartilage to form the cricothyroid joint. The superior cornu attaches to the greater cornu of the hyoid bone via lateral thyrohyoid ligament. This ligament may contain small triteceal cartilages.

At the attachment of the superior cornu to the ala of thyroid cartilage, a protuberance called superior tubercle is found. This superior

tubercle is of clinical significance as it marks the point 1cm below which the neurovascular bundle – the superior laryngeal artery and the nerve, pierce the thyrohyoid membrane.

The sternothyroid and thyrohyoid muscles attach to the thyroid laminae at the oblique line on the anterior surface. The posterior edge of each thyroid laminae receives the attachment of the inferior pharyngeal constrictor muscle.

The level of vocal cords lies closer to the lower border of the thyroid lamina when compared to the upper border – it is not at the midpoint, which is very important for the correct placement of window during thyroplasty to avoid medialisation of ventricular bands.

CRICOID CARTILAGE

This is the only cartilage in the entire laryngeal framework to completely encircle the airway. It is signet ring shaped, comprises of deep broad quadrilateral lamina posteriorly 20-30mm in height, and a narrow arch 3-4mm in height anteriorly. Near the junction of the arch and lamina, a facet is present onto which the inferior cornu of the thyroid cartilage articulates. The lamina has sloping upper margins, containing articular facets for the arytenoid cartilages. A vertical ridge is present in the midline of the posterior surface of the lamina which gives attachment to

the longitudinal muscle of esophagus, and produces a shallow concavity on each side which gives origin to the posterior cricoarytenoid muscle.

ARYTENOID CARTILAGES

These are paired, and placed close to each other on the upper and lateral borders of the cricoid lamina. Each arytenoid is a irregularly shaped three-sided pyramid with anteromedial projection called vocal process, which serves as attachment site for vocal cord and a lateral projection called muscular process, to which posterior and lateral cricoarytenoid muscles are attached.

Anterolateral surface, which is between the two processes, is divided into two fossae. Upper triangular fossa gives attachment to the vestibular ligament, and the lower fossa to the vocalis and lateral cricoarytenoid muscles.

Apex, which is flattened, articulates with the corniculate cartilage. The medial surface is covered by mucous membrane which forms the lateral boundary of the intercartilaginous portion of the rima glottidis. Posterior surface is entirely covered by the transverse arytenoid muscle. The base provides a smooth articulating surface for articulating with the cricoid. The posterior cricoarytenoid ligament which is firm, prevents forward movement of the arytenoid.

ACCESSORY CARTILAGES – CORNICULATE AND CUNEIFORM

The corniculate cartilages are two small, conical, nodules made of elastic cartilage which articulate forming a synovial joint or sometimes fuse with the apices of the arytenoid cartilages.

The cuneiform cartilages are also small, and made of elastic cartilage, placed in each margin of the aryepiglottic fold.

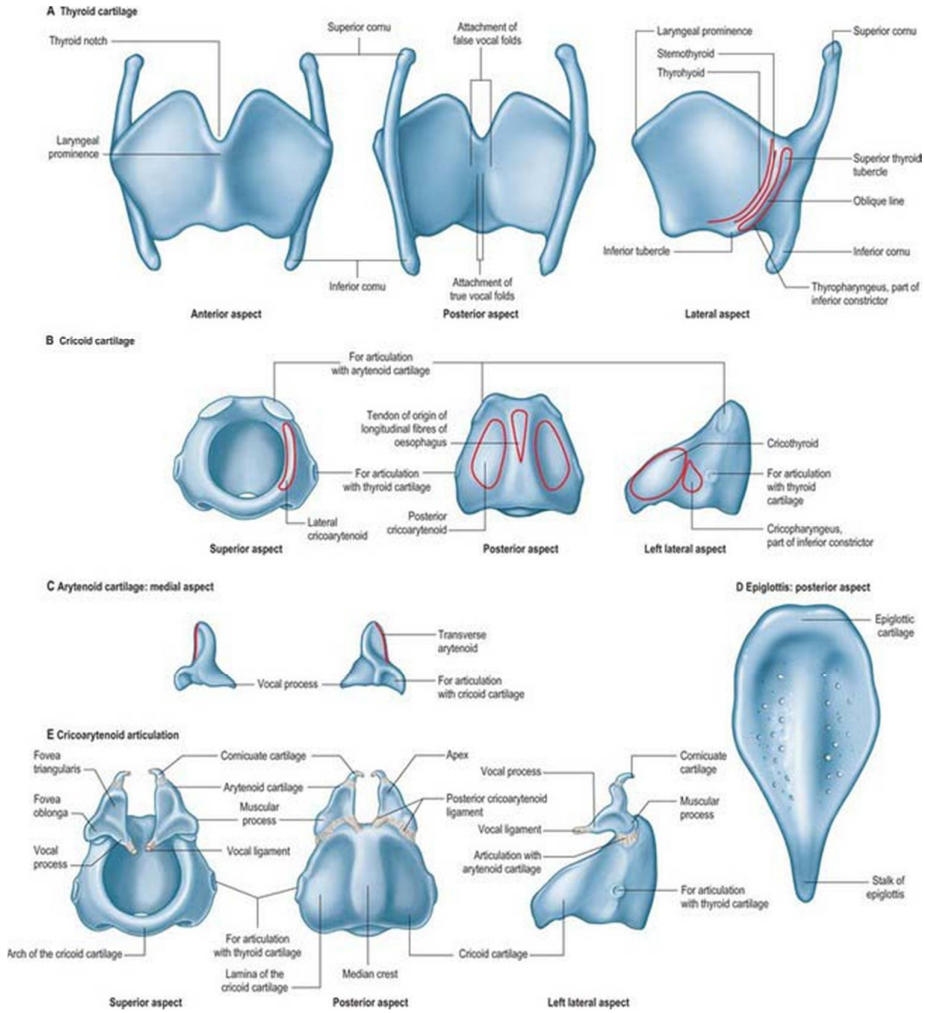
EPIGLOTTIS

This is an oblong, leaf like sheet of elastic cartilage, which is attached, at its inferior end to the inner surface of the thyroid laminae, just above anterior commissure, by the thyroepiglottic ligament. this inferior end is called petiole. Upper broad part is directed upwards and backwards and the superior margin is free.

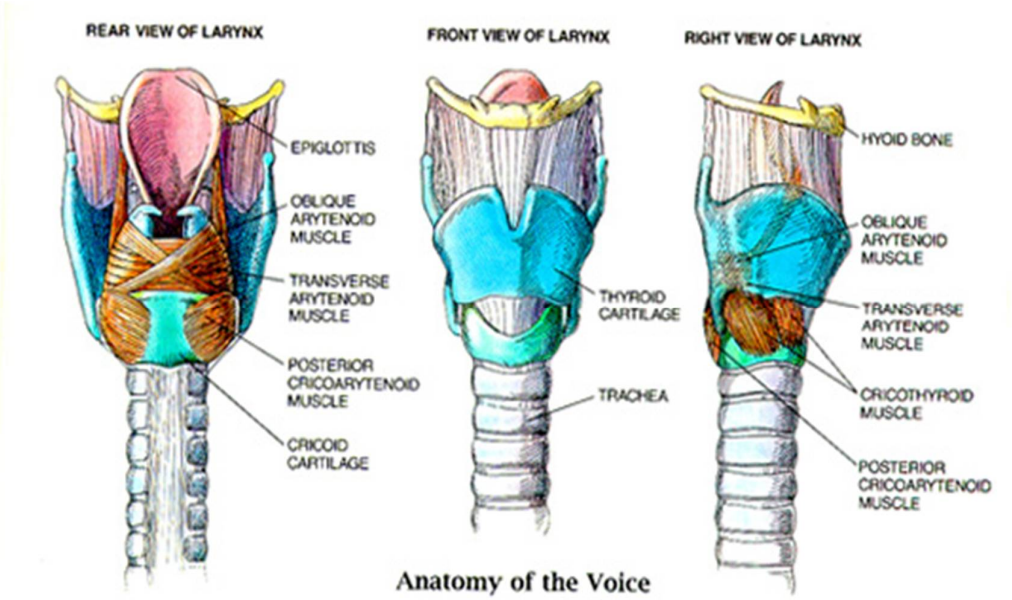
The sides of the epiglottis is attached to the arytenoid cartilages by the aryepiglottic folds, the free edge of which, together with free edge of epiglottis, form the boundary of the inlet of the larynx. The posterior surface is concave with a small central projection, the tubercle, in the lower part. On the anterior surface, the mucous membrane is reflected on to the posterior part of the tongue and the lateral pharyngeal wall forming the depression called vallecula.

The hyoepiglottic ligament connects lower part of epiglottis to the hyoid bone. The space between the epiglottis and thyrohyoid membrane which is filled with fatty tissue and lymphatics, termed the Preepiglottic space of Boyer.

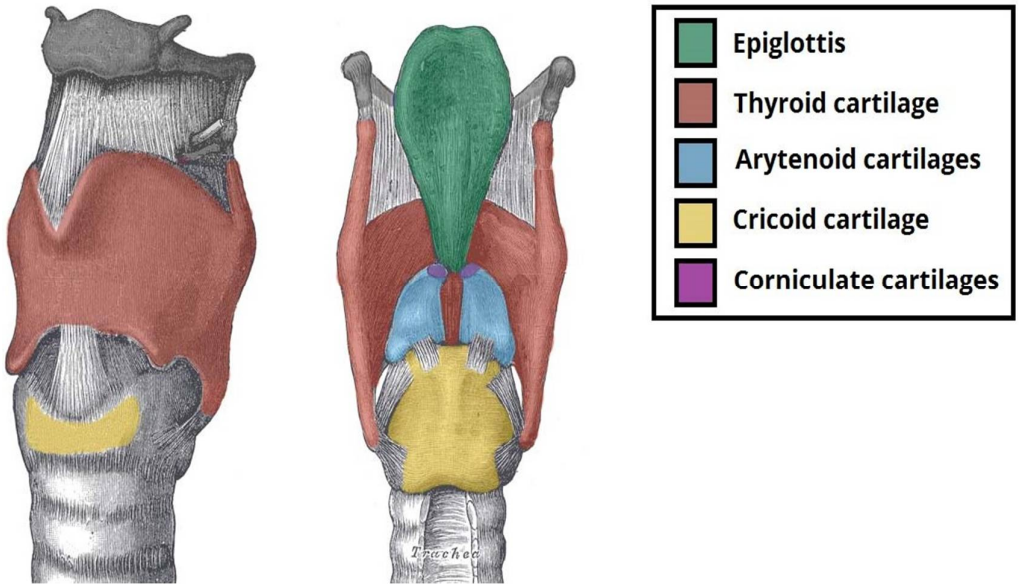
In infants and newborn, the epiglottis is omega shaped, which is long, deeply grooved, floppy. This aids in protection of nasotracheal airway during suckling.



Cartilages of Larynx



Anatomy of the Voice



Cartilages of Larynx

LARYNGEAL JOINTS

CRICOTHYROID JOINT

It is a synovial joint, formed by the articulation of inferior cornu of thyroid cartilage and the facets on the cricoid lamina. The joint permits anteroposterior sliding and rotation of inferior thyroid cornu upon the cricoid. The subluxation of this joint result in exaggerated decrease in anterior cricothyroid angle (thereby aiding medialisation procedures which provide vocal cord tightening).

CRICOARYTENOID JOINT

Also a synovial joint, its action changes the distance between the vocal process of the both arytenoids and also between each vocal process to the anterior commissure. The joint permits sliding, rocking and twisting motion. The combined action of intrinsic laryngeal muscles on the arytenoids causes alteration in the position and shape of the vocal cords.

LARYNGEAL MUSCULATURE

INTRINSIC LARYNGEAL MUSCLES

These primarily are responsible for altering the length, shape, tension and spatial position of vocal cords. There are three major adductors, one abductor and one tensor muscle.

ADDUCTORS

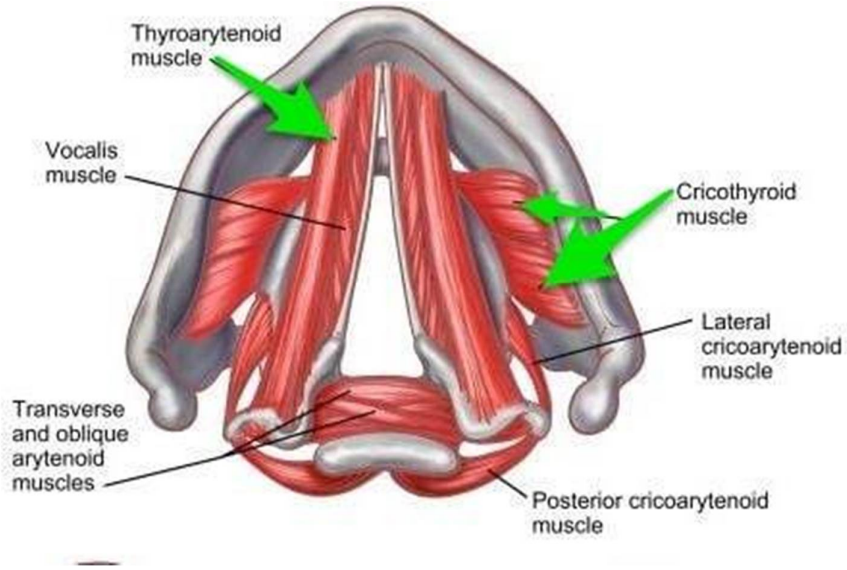
LATERAL CRICOARYTENOID MUSCLE

Paired, attached to muscular process medially to the superior border of cricoid laterally. Contraction causes adduction and lengthening of vocal cords.

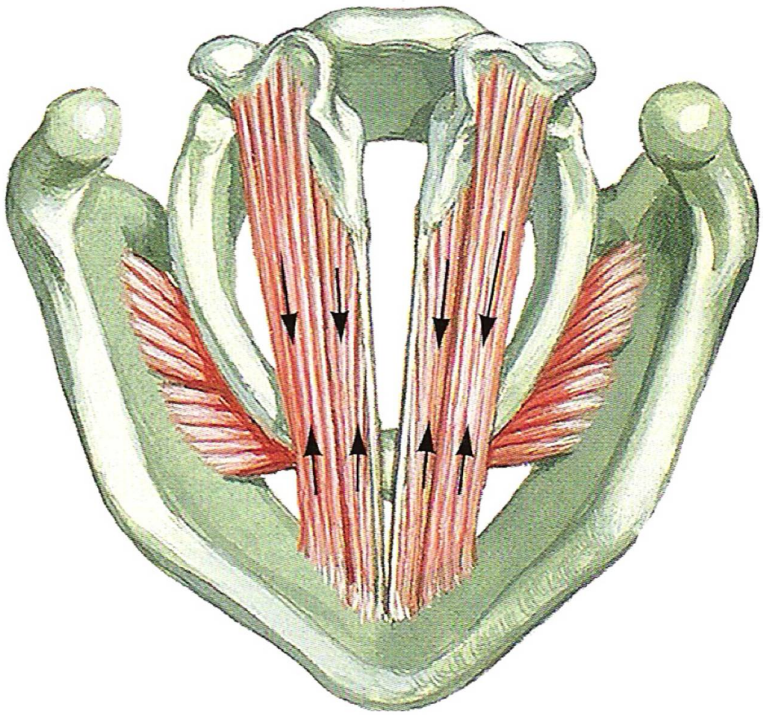
THYROARYTENOID MUCSLE

Consists of two parts – internus and externus.

External part attaches anteriorly at anterior commissure, posterolaterally on the lateral surface of arytenoid. Contraction causes both vocal process to be brought closer, thereby vocal cords shortened and adducted.



Muscles of Larynx



Action of vocalis and thyroarytenoid muscles

Shortening (relaxation) of vocal ligaments

Also called **Vocalis**, the internal part arises from anterior commissure, inserts to vocal process of arytenoid. Contraction causes vocal cords to be shortened and thickened.

INTERARYTENOID MUSCLE

Non paired, consists of both transverse and oblique fibres. Contraction causes arytenoid adduction, causing closure of posterior glottis and narrowing of laryngeal inlet.

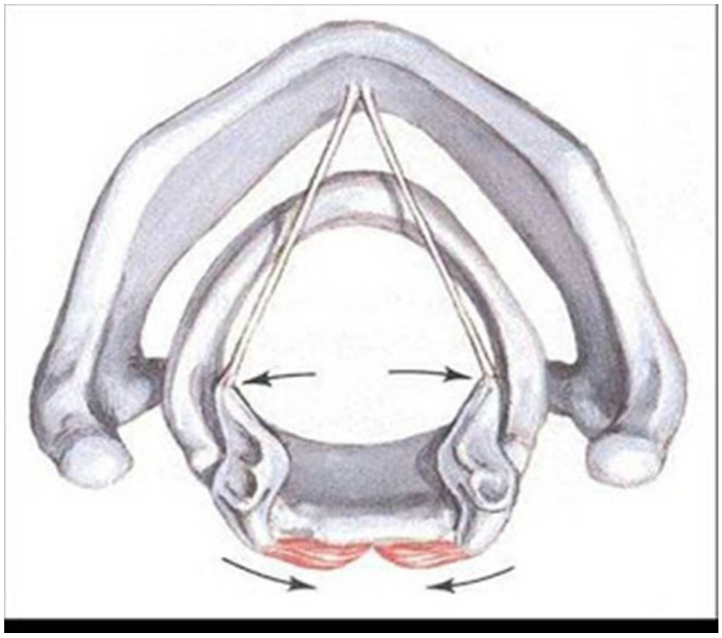
ABDUCTOR

POSTERIOR CRICOARYTENOID MUSCLE[4]

Arises from posterior cricoid lamina, runs diagonally, insert to muscular process of arytenoid. Contraction causes vocal fold abduction. This is the only abductor and principal controller of the glottis airway. Consists of two muscle bellies – horizontal belly, the medial portion of PCA, courses obliquely and attaches to medial aspect of muscular process, whereas vertical belly, the lateral portion of PCA, courses more vertically to attach to lateral aspect of muscular process.

Horizontal belly cause true vocal cord abduction, while Vertical belly plays a major role in changing vocal cord length and tension.

Posterior Cricoarytenoid Muscle



TENSOR

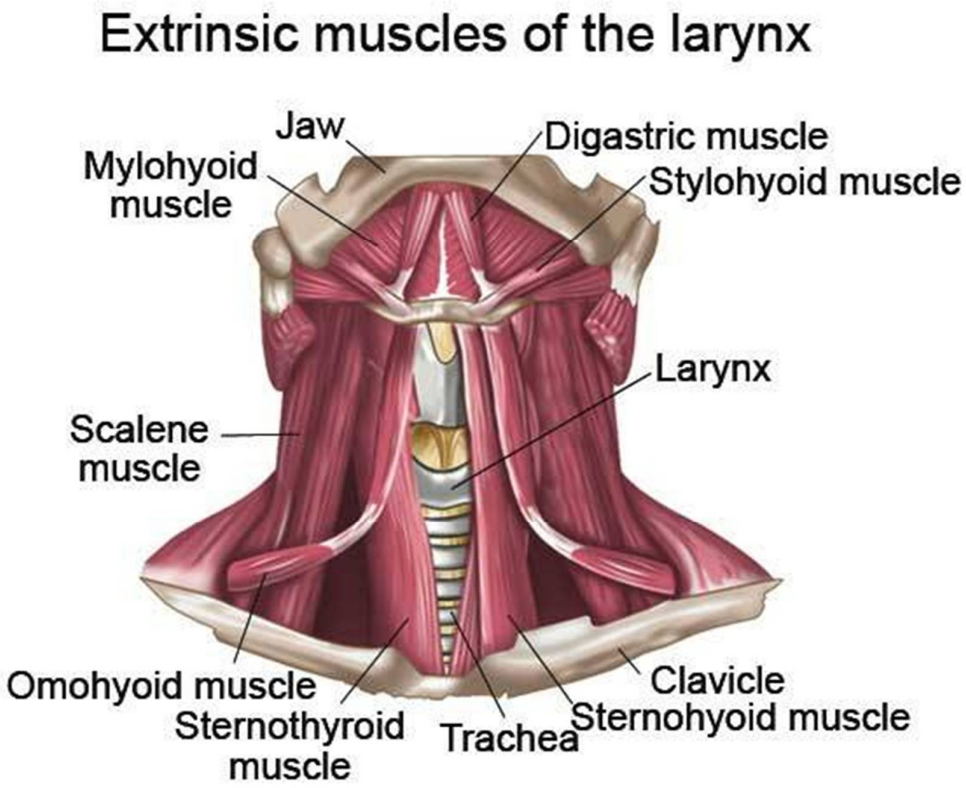
CRICOTHYROID MUSCLE

This muscle is located on the external surface of laryngeal cartilages.

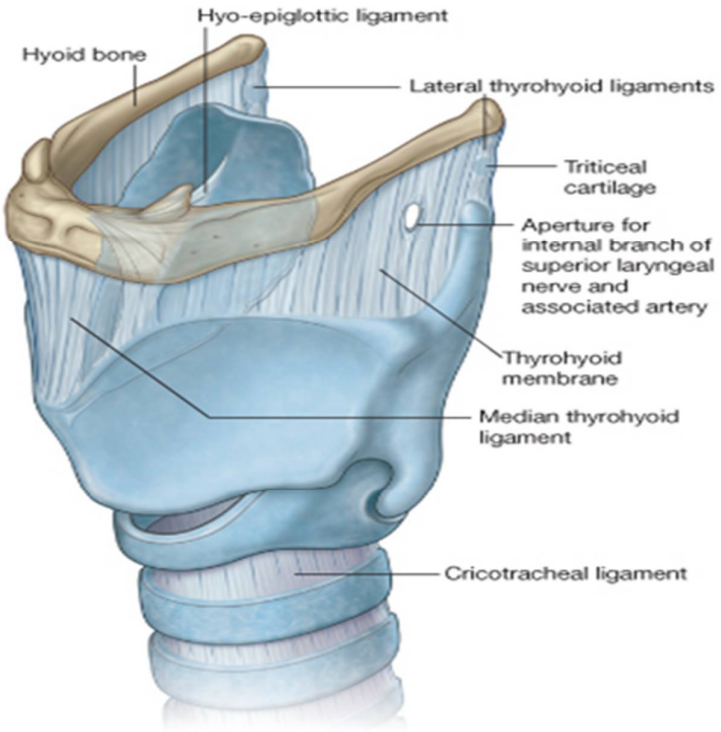
This also contains two bellies. The pars recta, more vertical belly, arise from superior rim of cricoid and inserts to inferior rim of thyroid cartilage. The pars obliqua, runs more obliquely. Contraction causes cricothyroid space narrowing anteriorly, resulting in lengthening, tightening and thinning of vocal cords, thereby increasing frequency.

EXTRINSIC LARYNGEAL MUSCLES

Infrahyoid strap muscles (sternothyroid, sternohyoid and thyrohyoid), mylohyoid, digastric, geniohyoid and stylopharyngeus – all these muscles act in conjunction to provide stability to larynx.



FIBROELASTIC TISSUES OF THE LARYNX



QUADRANGULAR MEMBRANE

Attaches anteriorly to the lateral margins of the epiglottis, curves posteriorly to attach to arytenoid and corniculate cartilages. This structure and the overlying mucosa contribute the aryepiglottic folds. Each fold forms part of medial wall of each pyriform fossa. The inferior edge contributes the vestibular ligament.

CONUS ELASTICUS

This is thicker, also called cricovocal ligament or cricothyroid ligament, attaches below to upper border of cricoid. The free upper

border constitutes the true vocal cord. Anteriorly the membrane is thickened in midline, called cricothyroid ligament.

INTERIOR OF THE LARYNX[2]

The cavity of larynx extends from laryngeal inlet to the lower border of cricoid, divided by the vocal cords and the vestibular folds into three compartments.

Superior vestibule – above vestibular folds, the ventricle lies between vestibular folds and the vocal folds, subglottic space extends from the vocal folds to the lower border of the cricoid cartilage.

Pre-epiglottic space of Boyer, is a wedge shaped space in front of epiglottis, bound anteriorly by thyrohyoid ligament and hyoid. This space continues laterally on both sides with **Paraglottic space of Tucker**[10], that is bound by thyroid lamina laterally, conus elasticus and quadrangular membrane medially and pyriform fossa mucosa posteriorly.

GLOTTIS

The rima glottidis or glottis is the fissure between both vocal cords anteriorly and between vocal processes and base of arytenoids posteriorly. Average length of glottis varies between 23mm in men and 16-17mm in women.

SUBGLOTTIS

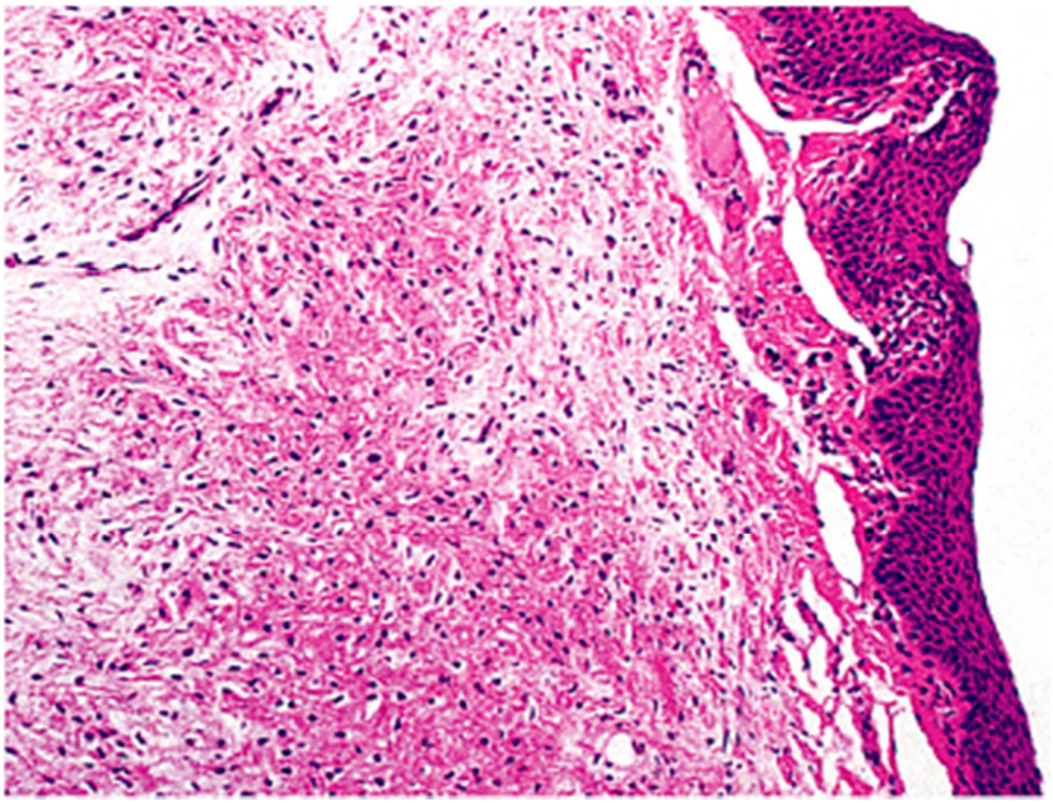
This portion extends from the level of the vocal cords to the lower border of the cricoid cartilage.

MICROANATOMY OF THE VOCAL CORDS[1]

Vocal cords are two fold like structures which extend from angle of thyroid cartilage to the vocal process of the arytenoid cartilages. Each cord is a multi-layered structure. This complex microanatomy allows the loose and pliable superficial mucosal layers to vibrate freely over the stiffer under layers.

The most superficial layer is the stratified squamous epithelium. Deep to this layer is the lamina propria which is subdivided into three layers – superficial, intermediate and deep, with increasing rigidity. The superficial lamina propria is composed of extracellular matrix, water and loose collagen and elastin, in a gelatinous matrix. The intermediate and deep lamina propria mainly contains collagen and elastin. These two layers form the vocal ligament. The potential space between superficial and intermediate lamina propria is called Reinke's space.

The anterior two thirds of the endoscopically visualised true vocal cords is the phonatory, or the membranous portion, whereas the posterior one third is the aphonatory (respiratory), or cartilaginous portion.



Ultrastructure of the Vocal Cord

The layered structure is not uniform in along the length of the vocal cord. At the anterior end, a mass of collagenous fibres appear connected to the inner perichondrium of thyroid cartilage. Posterior to this mass, there is another mass of elastic fibres, which is continuous with intermediate lamina propria, called Anterior Macula Flava. Similarly at the posterior end of the membranous part of the vocal cord also a mass of elastic

fibres, called Posterior Macula Flava, is present. These structures serve as cushions to protect the vocal cords from mechanical damage during phonation.

Thus from a mechanical point of view, the layers can be reclassified as

- Cover – epithelium and superficial lamina propria
- Transition – intermediate and deep lamina propria
- Body – vocalis muscle

<table>
<tr><th colspan="2">FIVE TISSUE LAYERS</th><th colspan="2">BODY COVER MODEL[3]</th></tr>
<tr><td colspan="2">EPITHELIUM</td><td rowspan="2">MUCOSA</td><td rowspan="2">COVER</td></tr>
<tr><td rowspan="3">LAMINA PROPRIA</td><td>SUPERFICIAL</td></tr>
<tr><td>INTERMEDIATE</td><td rowspan="2">VOCAL LIGAMENT</td><td rowspan="2">TRANSITION</td></tr>
<tr><td>DEEP</td></tr>
<tr><td colspan="2">THYROARYTENOID MUSCLE</td><td>MUSCLE</td><td>BODY</td></tr>
</table>

VASCULATURE OF THE LARYNX[2,6]

The arterial supply is by the superior and inferior laryngeal arteries. Superior laryngeal artery is a branch of superior thyroid artery, which in turn arises from the external carotid artery, enters the thyrohyoid

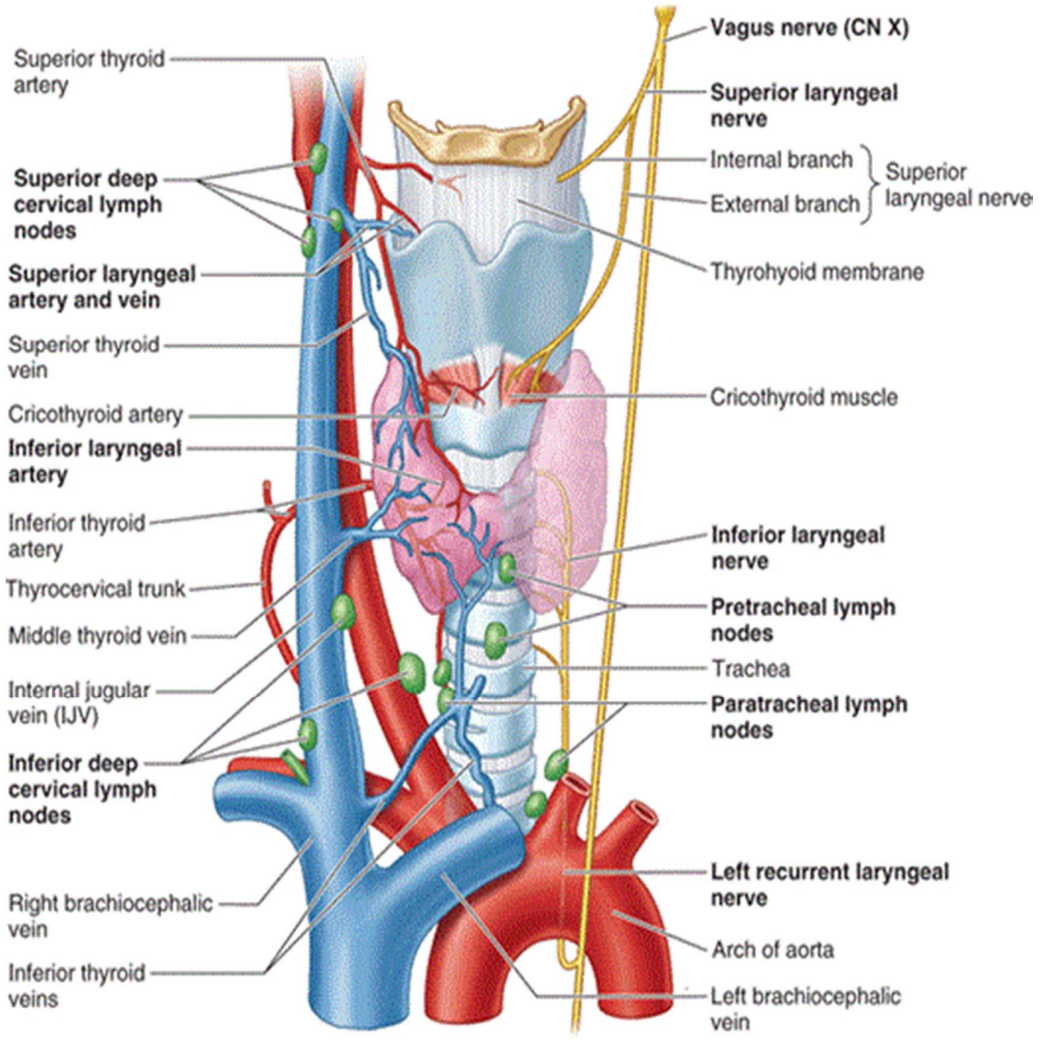
membrane 1 cm anterior and superior to the superior tubercle. Inferior laryngeal artery is a branch of inferior thyroid artery, which enters the larynx between the fibres of inferior constrictor muscle and anastomoses with branches of the superior laryngeal artery.

The venous supply mirrors the arterial supply.

LYMPHATIC DRAINAGE

Part of larynx above vocal cords drained by vessels accompanying superior laryngeal vein, empty into upper deep cervical lymph nodes, whereas the zone below vocal cords drain along with inferior laryngeal vein, into the prelaryngeal and pretracheal nodes, then to the lower deep cervical nodes.

The vocal cords is devoid of any lymphatics and acts as a watershed between upper and lower zones.



Blood Supply of Larynx

NERVE SUPPLY

The superior laryngeal nerve, branch of vagus, supplies sensation to the glottis, supraglottis (internal branch) and motor supply to cricothyroid (external branch).

The recurrent laryngeal nerve, also a branch of vagus, enters larynx posteriorly adjacent to the cricothyroid joint. It innervates ipsilateral

posterior cricoarytenoid, interarytenoid, lateral cricoarytenoid, terminates in thyroarytenoid. Thus the recurrent laryngeal nerve supplies all the intrinsic muscles of the larynx except cricothyroid muscle. It also supplies glottic and subglottic mucosa.

PHYSIOLOGY OF LARYNX[7]

The most primitive function is protection of lower airway. In humans, the larynx has evolved into a very complex and highly specialized organ not only for airway protection and control of respiration, but also for sound and phonation. The laryngeal reflexes are also important in airway protection against external stimuli and foreign bodies, they are – laryngospasm, the strongest laryngeal reflex, others are evolved reflexes like coughing, apnea, bradycardia, hypotension, etc.

PHONATION

Phonation is one of the most complex and highly advanced of the laryngeal functions. It is the ability of the larynx to couple phonation with articulation and resonance which allows for production of speech. The vocal cords, as observed by frontal tomography and videostroboscopy, vibrate at 100 – 300 Hz during normal conversation, and more than 1000 Hz during singing. The movement of the vocal cords, whether during

quiet respiration or in phonation, is a complex activity controlled by the combined activity of all the laryngeal muscles.

The thyroarytenoid and the lateral cricoarytenoid exhibit a burst like activity at the onset of phonation, then fade during sustained phonation. The interarytenoid muscle has an increased latency of contraction, which allows for sustained contraction during prolonged phonation. The cricothyroid increases the pitch and volume, whereas the posterior cricoarytenoid shows greatest activity during deep inhalation and sniffing action.

Phonation requires complex and precise communication between the central nervous system and the peripheral phonatory organs. Other factors like lung capacity, compliance of the chest wall, anatomy of the nasal, pharyngeal and oral regions, mental status, etc. also play a role.

The sequence of sound production starts at the activation of Broca's area, transmitted to motor cortex (precentral gyrus), which in turn stimulates motor nuclei in brainstem and spinal cord. The impulse is then processed by the respiratory, laryngeal and the articulatory musculature which in turn produces movement of the phonatory organs that result in production of sounds known as voice. Additional refinement is done by

the feedback mechanism, extrapyramidal and autonomous nervous system.

The initiation of voice requires vocal cords to rapidly abduct to allow the intake of air. This is called Prephonatory inspiratory phase by Wyke[9]. The production of voice then involves

- **A power source** – coordinated functions of diaphragm, abdominal and chest muscles, lungs and chest wall. The pulmonary reserve is filled as a consequence, followed by the movement of air towards subglottis, thereby increasing subglottic pressure which in turn causes the air to flow between adducted vocal cords leading to their vibration.

- **Oscillator** – four main parts of larynx involved are skeleton, mucosa, intrinsic and extrinsic muscles.

- **Resonance chamber** – pharynx, oral cavity, nose, paranasal sinuses, and also chest to some extent. This helps to amplify the produced sound.

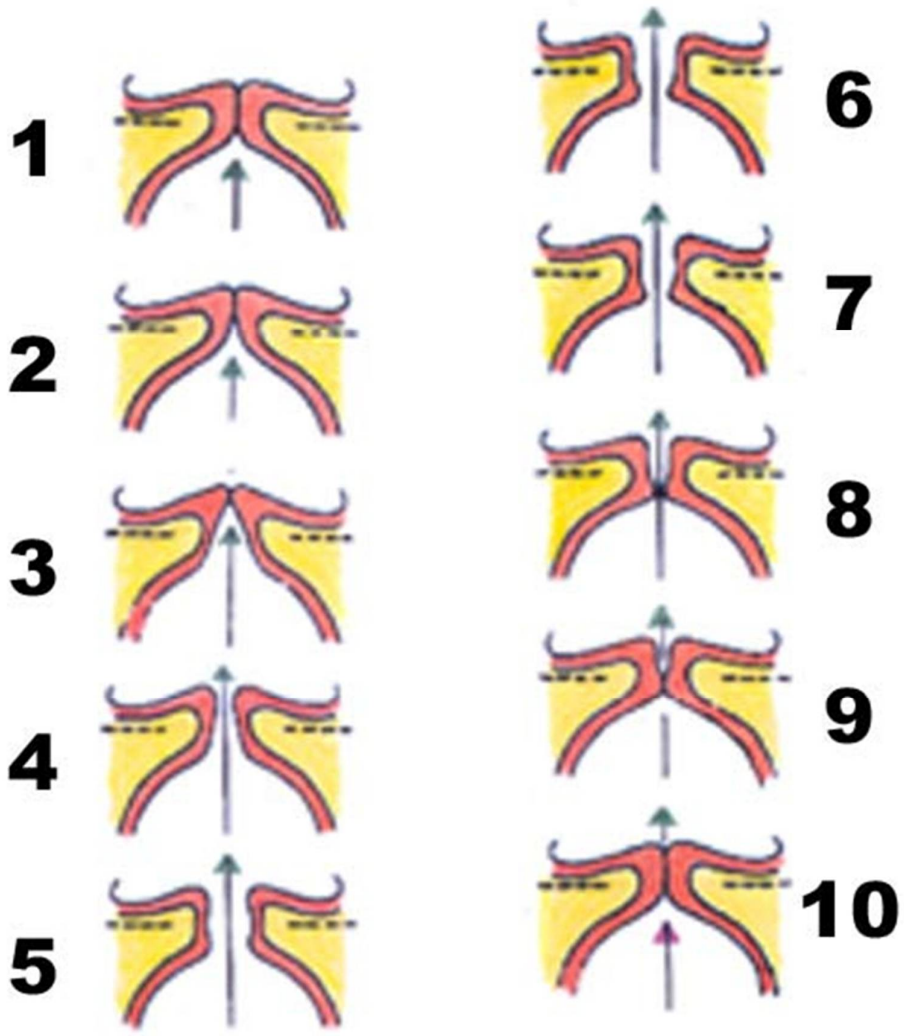
THE GLOTTAL CYCLE

Each vibratory cycle of the vocal cords has three phases

- Adduction
- Aerodynamic separation

- Recoil

As the subglottic pressure increases, the resistance of the adducted vocal cords is overcome; the vocal cords then peel apart from the inferior border. Later superior margin is separated thereby releasing a puff of air. This leads to drop in the subglottic pressure, the myoelastic tension of vocal cords exceeds which causes them to approximate. This is assisted by aerodynamic forces (Bernoulli's principle). Again subglottic pressure begins to increase till the vocal cords are pushed apart. This completes one Glottal cycle. It is the number of cycles per second that determines the frequency or pitch of the sound. This model of voice production is called **myoelastic – aerodynamic theory**.



GLOTTAL CYCLE

CLINICAL ASSESSMENT OF VOICE DISORDERS

NORMAL VOICE

Usually described as

- Audible, clear and stable
- Appropriate for age and sex

- Able to fulfill linguistic functions
- Not easily fatigable
- No associated discomfort or pain

DISORDERED VOICE

Usually multifactorial, these are the main processes that contribute to disordered voice.

- Inadequate breath support (energy) – severe structural and inflammatory pathology in lower airway or chest wall, weakness of respiratory muscles, primary abnormal breathing patterns, etc.
- Dysfunction of vibratory apparatus – muscle tension dysphonia, neuromuscular disorders, structural and inflammatory changes in vocal cords, etc.
- Ineffectiveness of vocal tract resonating chamber – structural abnormality, neuromuscular deficits, inflammation, muscle tension imbalance of any part will affect the resonance characteristics and hence the voice quality.

ASSESSMENT OF VOICE[21]

CLINICAL ASSESSMENT

All the patients with voice disorder should be treated by a team of Otolaryngologist and Speech pathologist. Availability of videostroboscopy is a key element in aiding with the early diagnosis.

HISTORY

Detailed history taking is of utmost importance which includes

- Nature and duration of the problem
- Accentuating and relieving factors
- Lifestyle issues
- Other comorbid conditions contributing to the symptoms
- Patient's requirements and expectations for outcome
- Patient's complaints – changes in voice quality, pitch, inability to raise the voice, reduced stamina, reduced ability to communicate, other throat symptoms
- Emotional and psychological factors

Self assessment questionnaires like the Voice Handicap Index, Voice related quality of life, Voice symptom scale, etc. have been

developed on the basis of symptoms of patients attending outpatient department with voice problems.

ENDOSCOPIC EXAMINATION

After arriving at a preliminary diagnosis based on the history, the examination of larynx is done to confirm the same. A rigid endoscope (70 degrees), high definition camera with a stroboscopic light source gives the best quality of imaging of the mucosal wave. Flexible nasendoscope allows examination of entire vocal tract.

Patient is asked to do phonatory (sustained phonation of vowel sounds) and non phonatory (coughing, sniffing) tasks, each anatomical subsite is checked for the offending pathology.

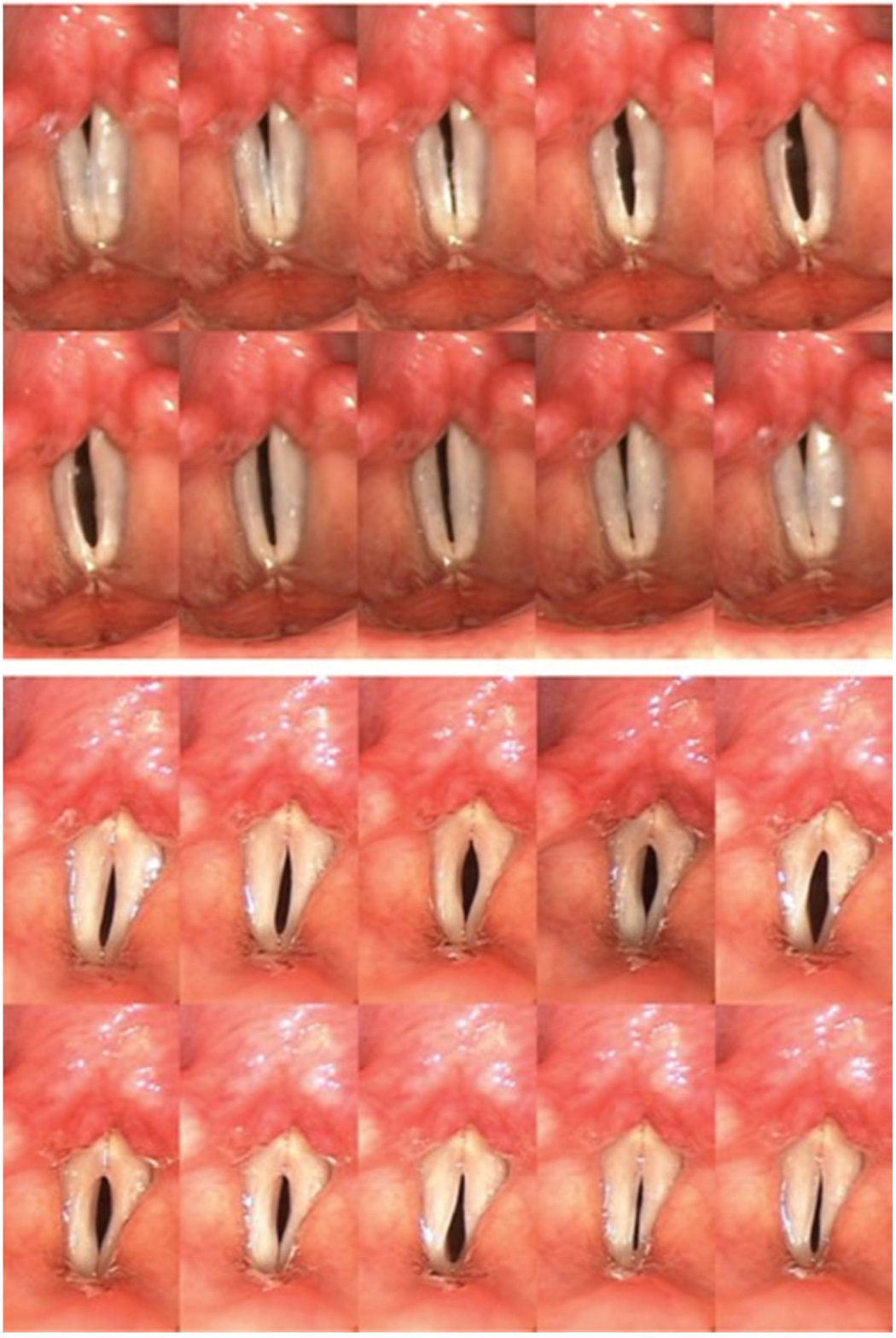
VIDEOSTROBOSCOPY[12, 14-19]

It provides a slow motion perception of the mucosal waveform of the vibrating vocal cords. The following parameters are assessed:

- Fundamental speech frequency
- Periodicity – regularity of successive mucosal waves
- Symmetry
- Glottic closure – complete or incomplete

- Mucosal wave – correlate of the pliable cover displacement relative to body of the vocal cord. Focal abnormalities can be detected.

Based on the diagnosis arrived, appropriate protocol for management is planned according to the nature of the disease and patient's requirements.



Glottal cycle - Videostroboscopy

PREOPERATIVE VOICE THERAPY[20]

It is mainly aimed at coordinating voice production and breathing, a process termed as Pneumophonic coordination. Voice therapy primarily treats the cause and not the consequence. A short preoperative therapy is provided to all patients planned for surgery as it prepares the patient for the long term postoperative period of voice rehabilitation.

BENIGN LESIONS OF THE LARYNX[25, 26]

The benign lesions include vocal nodules, vocal polyps, Reinke's edema, laryngeal cysts, laryngeal webs, laryngoceles, granulomas, recurrent respiratory papillomatosis, sulcus vocalis, vascular lesions, amyloidosis, chronic granulomatous diseases, etc. Most patients present with disordered voice or dysphonia. All the patients who were diagnosed with benign laryngeal pathology should undergo trial voice therapy before definitive surgery is planned. Other contributing factors must be addressed to prevent any recurrence after surgery. Compliance to postoperative voice rehabilitation is also very important for avoiding recurrence.

VOCAL CORD NODULES

Also called "Singer's nodules". These are benign, localised, usually bilateral, mucosal swellings of the medial surface of membranous

portion of the vocal cords. Vocal nodules are typically located at the junction of anterior and middle thirds of the vocal cords. This results from voice misuse or abuse in prepubertal age and non professional singers with poor singing technique, thereby causing phonotrauma.

Treatment involves voice therapy and education, which plays an integral role. About 90% cases will become asymptomatic with voice therapy alone. Surgery may be considered for patients with persistent symptoms despite complying with voice therapy.

VOCAL CORD POLYPS[27]

These are generally unilateral, also resulting from phonotrauma. It is an inflammatory pseudotumour of the vocal cord, which is frequently seen in middle aged men who are smokers. Polyps are usually situated at the junction of anterior and middle thirds of vocal cords, may be pedicled or sessile, with a variable size. Edematous polyps are usually pink in colour whereas Hemorrhagic polyps are bright red in colour. Sometimes there may be associated sulcus glottidis which must be treated alongside.

Treatment is always surgical, with preoperative and postoperative voice therapy.

REINKE'S EDEMA

Also called **Diffuse polypoidal corditis**, usually seen in persons with history of excessive smoking and voice abuse. A clear predilection among middle aged women is noted. It results from fluid accumulation in the Reinke's space. Patients usually present with dysphonia, sometimes, if the lesion is causing mass effect, may present with dyspnea and stridor.

Treatment is multimodal, aimed at smoking cessation and avoiding voice abuse and in addition, speech therapy. Surgery is done in severe cases, using cold techniques or CO2 laser.

LARYNGEAL CYSTS

Mucous retention cysts: These are formed due to cicatrical obstruction of mucous gland ducts, usually unilateral, appear translucent and lined by cuboidal or columnated epithelium.

Epidermoid cysts: These contain accumulated keratin in the subepithelial layer. Also called intracordal cysts, these are usually the result of repeated trauma due to vocal abuse.

Treatment involves medical therapy to reversing or eliminating precipitating factors like allergy, acid reflux, etc. If symptoms are

persistent, then surgery is planned after few sessions of voice therapy followed by long term voice rehabilitation.

LARYNGOCELES

It is an abnormal, air filled dilatation or herniation of the ventricle of Morgagni. When filled with air, they communicate with the laryngeal lumen. Sometimes the neck of sac may get obstructed leading to mucocele, which later gets infected and becomes laryngopyocele.

Classification depends on their location – internal, external or combined. Internal Laryngoceles are confined within the thyroid cartilage. External Laryngoceles lie outside the cartilaginous framework. Combined Laryngoceles span both the inside and outside of the thyroid cartilage.

Surgery is the only definitive treatment.

GRANULOMAS

These are usually unilateral, located on the posterior third of the vocal cords, i.e. vocal process of the arytenoids. Common causative factors are gastroesophageal reflux, traumatic or prolonged intubation, voice misuse.

Treatment is surgical, after addressing the causative factors.

RECURRENT RESPIRATORY PAPILLOMATOSIS

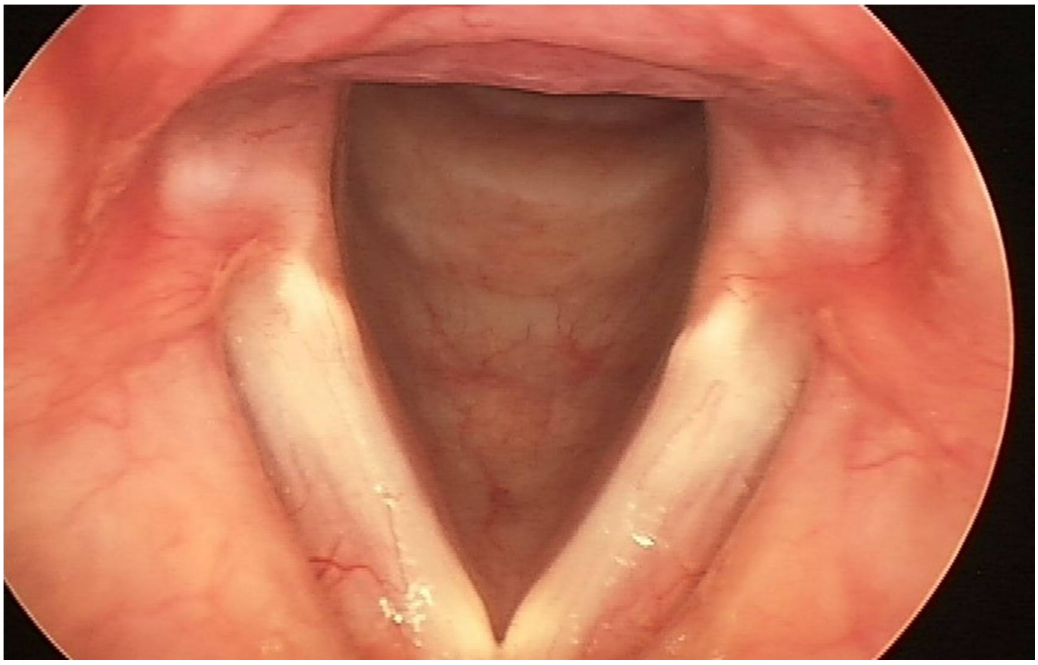
It is a benign epithelial tumour, which presents as a warty, exophytic mass, which can occur in aerodigestive tract where there is increased airway turbulence. Primarily involves larynx, but aggressive lesions may also involve trachea, bronchi, pharynx or tonsils. The disease is caused by Human Papilloma Virus (types 6 & 11, with the latter having worst prognosis). Unique bimodal age distribution is noted – juvenile onset RRP and the adult onset RRP. The disease has a male preponderance of 4:1 ratio. Malignant transformation may occur in 1 – 7% of cases. Surgery is the standard treatment of choice with adjuvant treatment with Cidofovir, Interferon, and effective control of Gastro esophageal reflux also being considered.

SULCUS VOCALIS

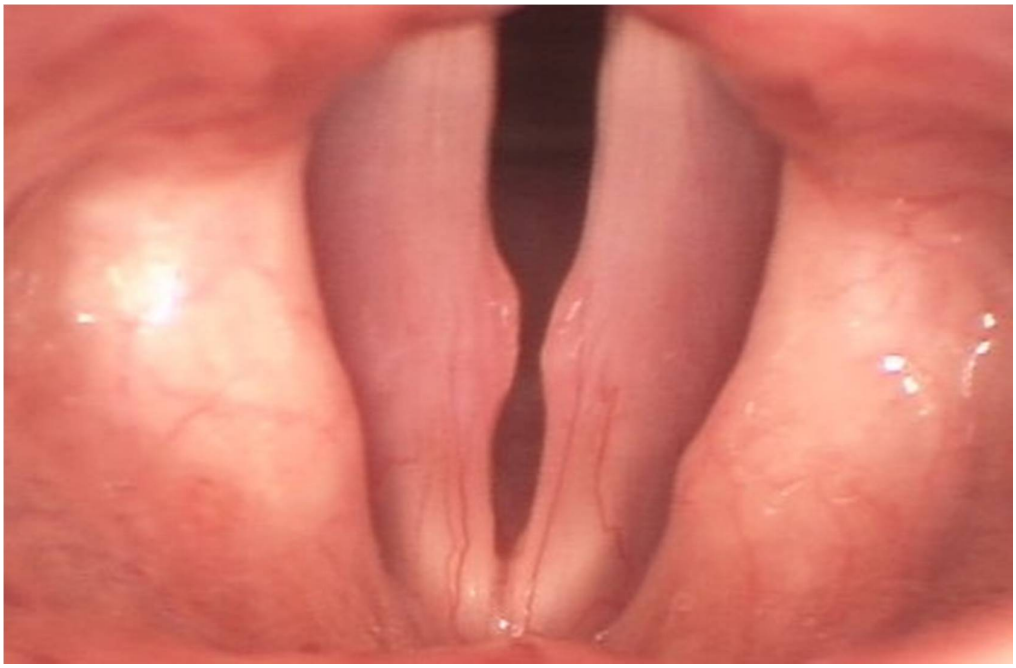
A groove that is present along the vocal cord mucosa, though subtle, can cause voice dysfunction. Classified into three types:

- Physiologic or pseudosulcus
- Sulcus vergeture – deficient area upto superficial lamina propria
- Sulcus vocalis – epithelial lined pocket extending to deeper layers

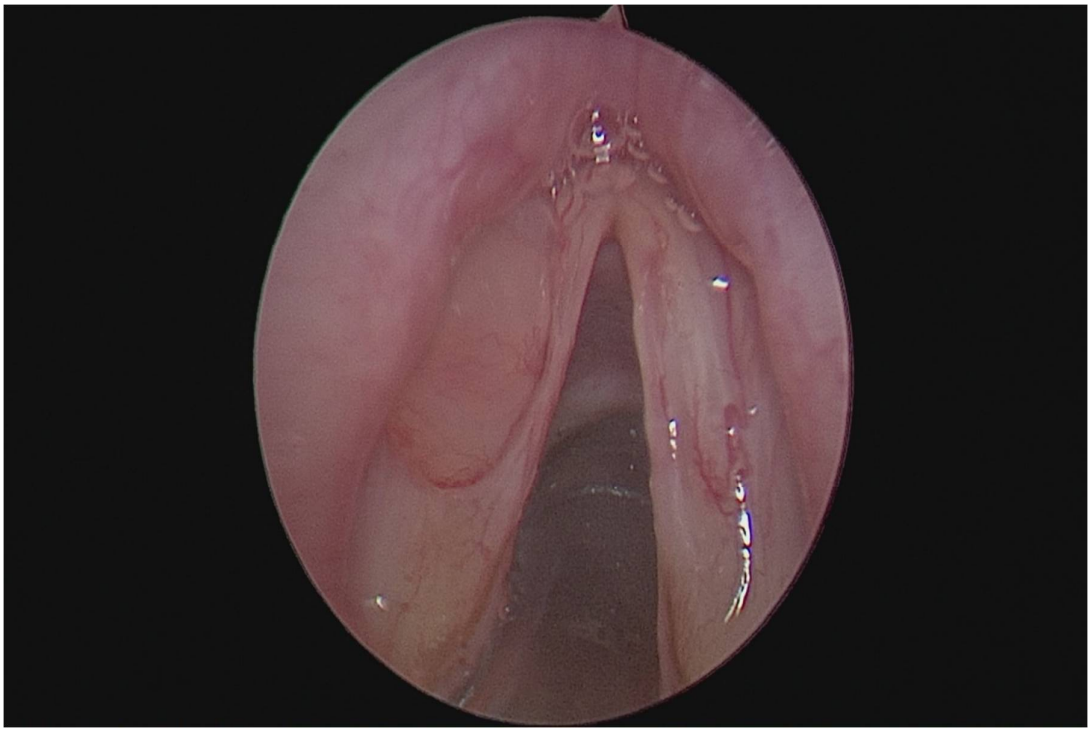
Treatment is surgical if the symptoms are severe and no benefit is achieved by speech therapy.



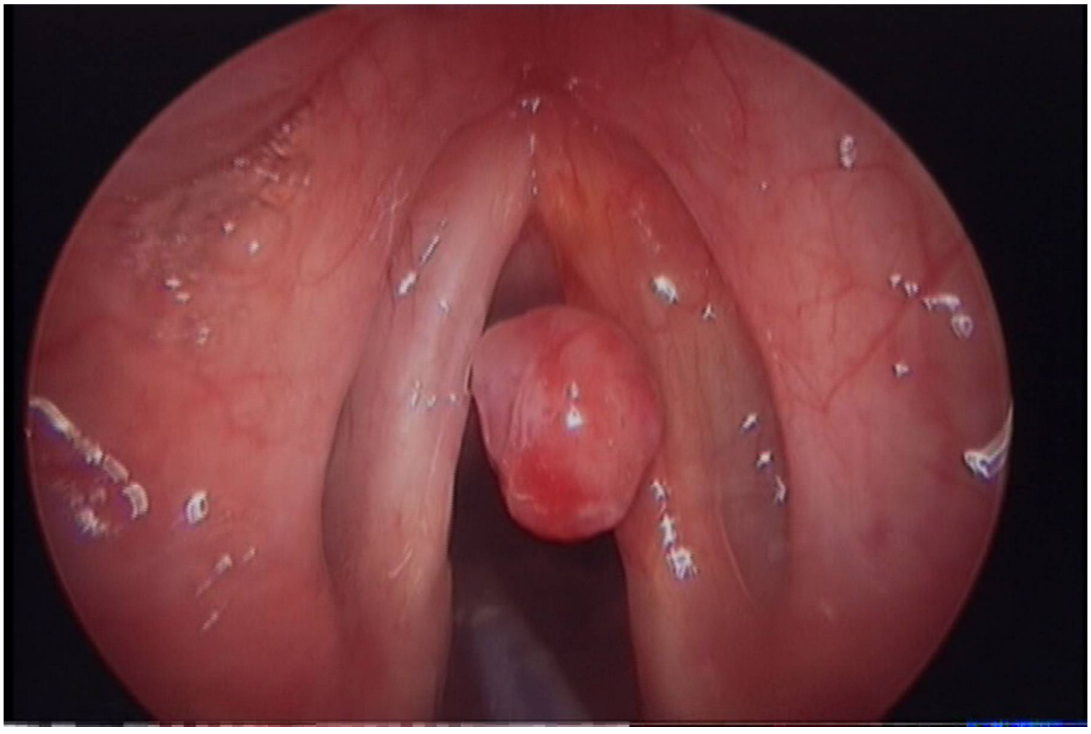
Healthy Larynx

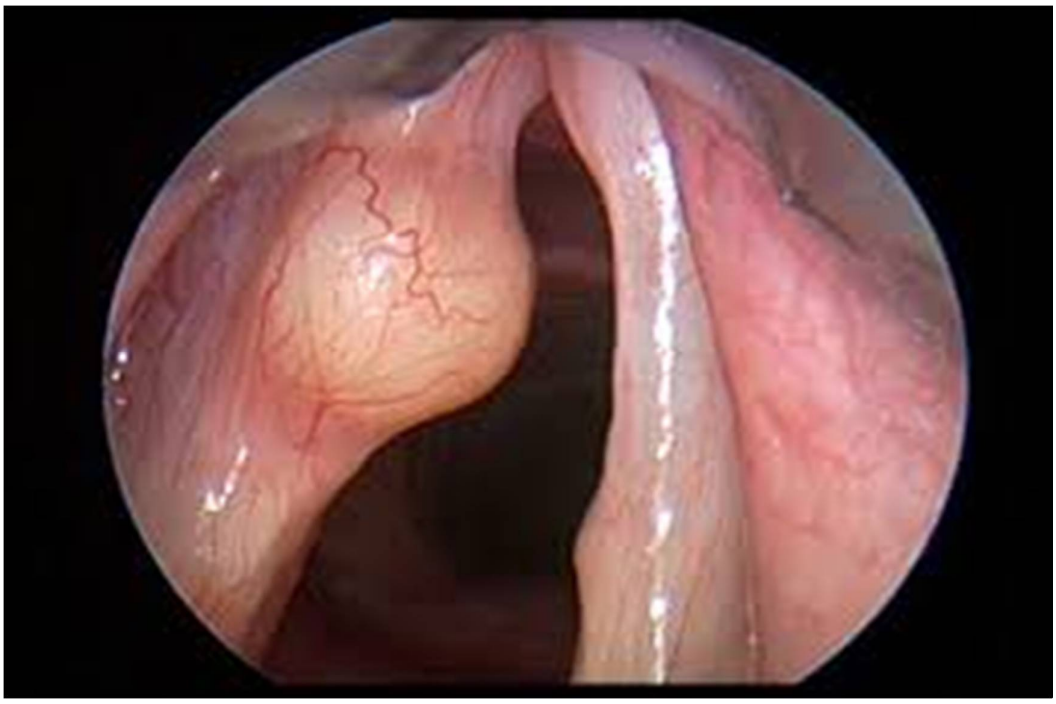


Vocal Nodule

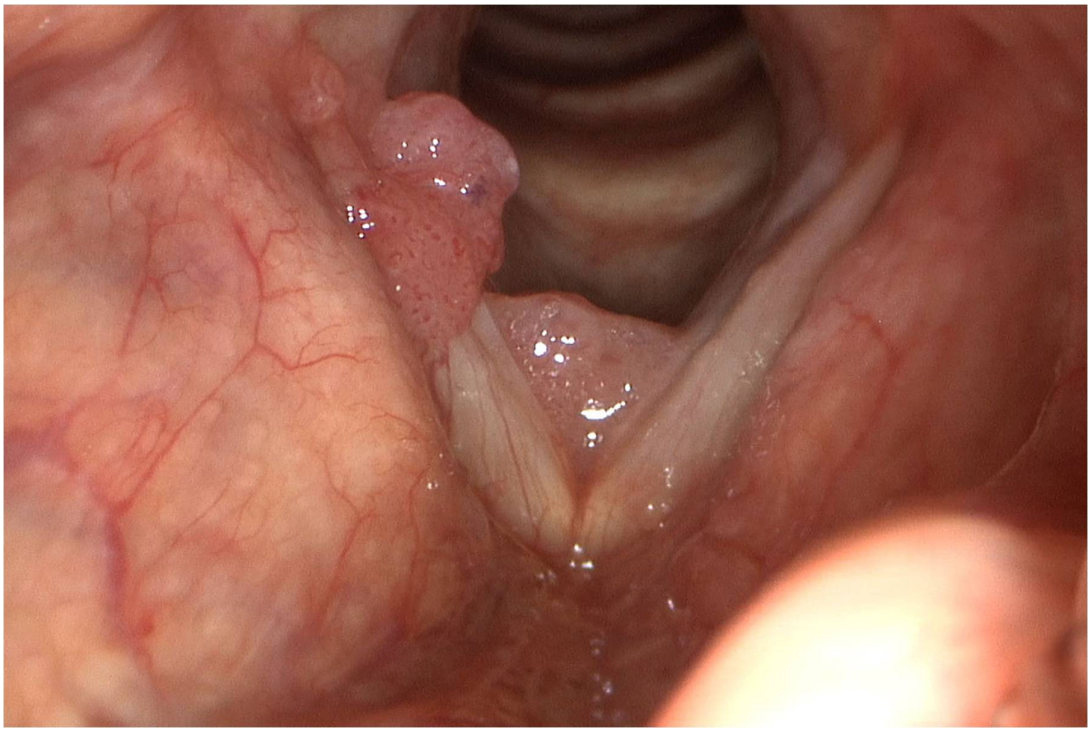


Vocal Polyp

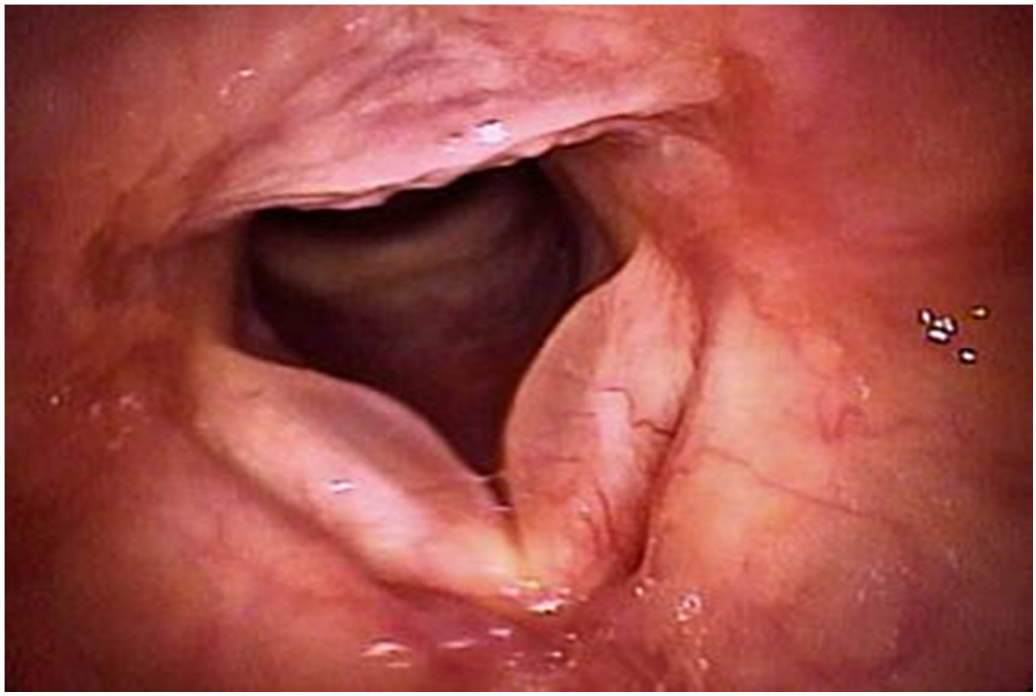




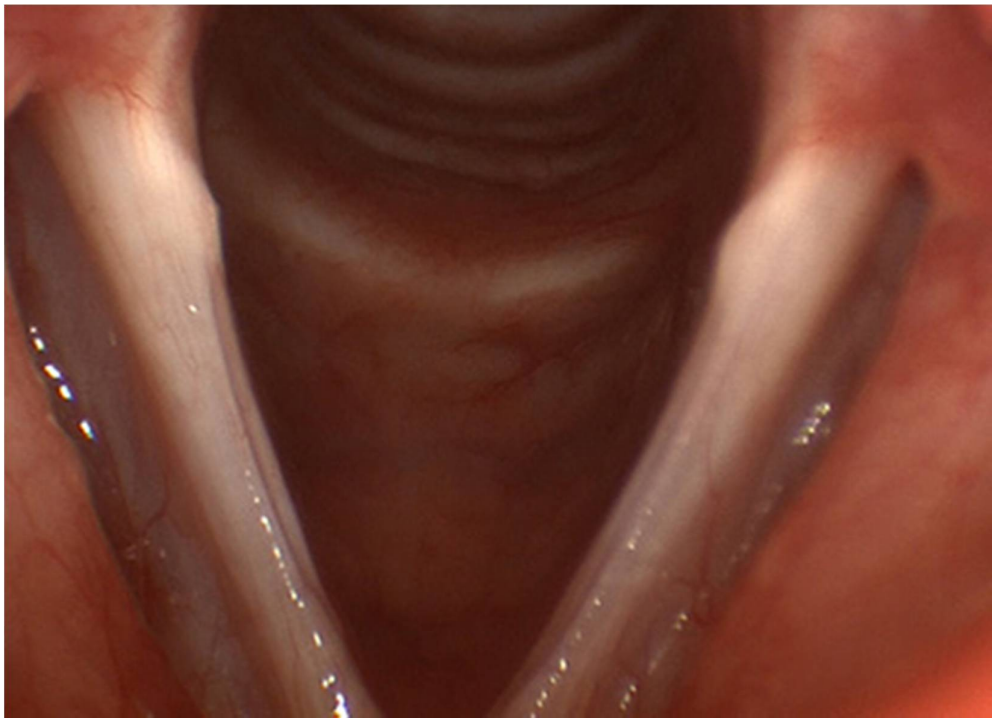
Intracordal Cyst



Laryngeal Papilloma



Reinke's Edema



Sulcus vocalis

LASERS IN LARYNGOLOGY

Albert Einstein first discussed about Stimulated Emission in 1917, and in 1958, Townes published theoretic calculations termed LASER. In 1961, Neodymium doped was developed, followed by Nd-YAG and Argon in 1964. LASER was introduced in otolaryngology by Strong and Jako[33] in 1972, it can be used for incision, excision and vaporization of tissue.

LASER is an acronym for **Light Amplification by the Stimulated Emission of Radiation**. Light beam has 4 main properties – intensity, coherence, high collimation and monochromaticity.

Amplification – the electromagnetic emission released is amplified by an external power source to produce an intense beam, that excite atoms, which results in emission of photons from the atoms, thus creating a chain reaction.

Stimulated emission of radiation – spectrum of wavelengths ranging from 200nm (ultraviolet) to 10000nm (infrared).

The most common lasers used in surgery are:

- 500nm – Argon laser
- 532nm – Potassium-titanyl-phosphate (KTP) laser

- 585nm – Dye laser
- 1060nm- Neodymium Yttrium Aluminium Garnet (NdYAG) laser
- 10600nm – Carbon dioxide (CO_2) laser

COMPONENTS OF SURGICAL LASER

1. Active medium of laser
2. Power source to pump energy
3. Optical chamber

LASER INTERACTION WITH TISSUE

Mitashi et al in 1976 described the interaction of laser with human tissue. Four possible interaction may occur when a laser beam makes contact with the tissue:

1. Reflection – beam neither absorbed nor does pass through
2. Transmission – beam not absorbed but passes directly through
3. Absorption – beam fully absorbed by the tissue
4. Scatter / dispersion – beam partially absorbed, transmitted, and scattered by the tissue

CARBON DIOXIDE LASER

The wavelength of Carbon Dioxide Laser is 10600nm. This is best suited for absorption by water, which is an important characteristic, because absorption of this wavelength into soft tissue (90% water content) will concentrate the energy, thereby permitting little heat to dissipate into the surrounding tissues as described by Mitashi et al in 1976.

Mechanism of action:

The CO2 laser light is transformed within the tissue into thermal energy, raising the temperature to 100 degree Celsius, vaporizes the tissue's water content. This makes CO2 laser a precise cutting tool, ideal for excision of small lesions located on vocal cords. It also gives depth of penetration with minimal damage to surrounding tissues. It has got a good hemostatic capability (limited to capillaries 0.5mm diameter).

The endoscopic use of CO2 laser with a microspot technology[36] (250microns size) permits excellent precision and good hemostasis, which is not always the case with cold instruments. The development of microspot manipulator[46] facilitated tissue excision with precise cutting and minimal damage to surrounding mucosa and underlying vocalis muscle.

The CO2 laser has been used in various laryngeal lesions[40], and is especially effective for:

- Vocal cord polyps
- Large sessile nodules
- Vocal cord cysts
- Laryngeal cysts
- Vocal cord granulomas
- Laser assisted myoneurectomy in Spasmodic dysphonia
- Subtotal arytenoidectomy and Unilateral posterior cordectomy in Bilateral abductor palsy
- Glottic webs
- Reinke's edema
- Biopsy in Chronic laryngitis follow up
- Recurrent respiratory papillomatosis

OTHER LASERS OF CLINICAL SIGNIFICANCE:

NEODYMIUM YTTRIUM ALUMINIUM GARNET LASER

Wavelength of 1060nm, hence poorly absorbed by water, penetrates tissue deeply, especially well absorbed by pigmented and vascular tissue. It is mainly used in the tracheobronchial tree. The thermal effect goes beyond its immediate area of visible impact, so care must be taken to apply it in brief pulses of 1 second or less at a power setting below 50W.

DIODE LASER

Sturdy and compact semiconductor laser, portable and requires minimal maintenance. The disadvantage is that the variability in penetration during cutting.

HEMOANGIOLYTIC LASERS

532nm KTP laser and 585nm pulse dye laser both are best absorbed by oxyhemoglobin, therefore useful in vascular lesions such as papillomas and dysplasias.

RADIOFREQUENCY ASSISTED PLASMA ABLATION[28]:

Otherwise termed coblation, this is first discovered by Hira V. Thapliyal and Philip E. Eggers. This involves non thermal volumetric tissue removal through plasma dissociation. This technology uses the principle that when an electric current is passed through a conducting fluid (like cold saline), a charged layer known as the plasma is generated, which has the tendency to accelerate, gain energy, and break bonds between the cells ultimately resulting in volumetric reduction of the tissue.

Otolaryngological surgeries where coblation technology has been found to be useful include:

1. Adenotonsillectomy
2. Tongue base reduction
3. Tongue channeling
4. Uvulo palato pharyngoplasty
5. Cordectomy
6. Removal of benign lesions of larynx including papilloma[29]
7. Kashima's procedure for bilateral abductor paralysis

8. Turbinate reduction

9. Nasal polypectomy

Components of coblation system:

1. RF Generator

2. Foot pedal controller

3. Irrigation system

4. Wand

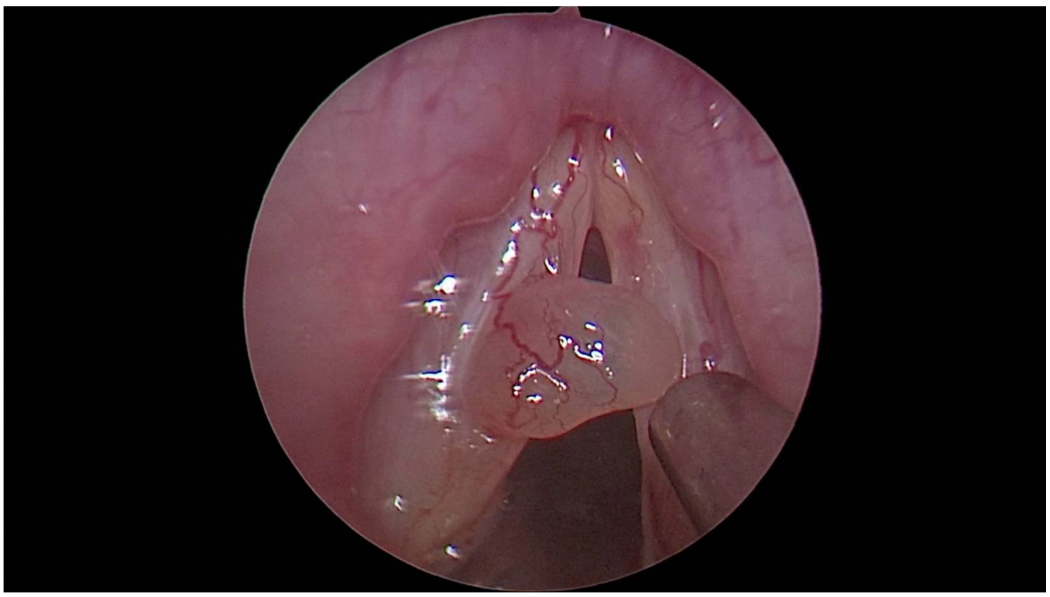
	Coblation	**Other electrosurgical devices**
Temperatures	$40 – 70^0$ C	$400 – 600^0$C
Thermal penetration	Minimal	Deep
Effects on Target tissue	Gentle removal / dissolution	Rapid heating, charring, burning
Effects on surrounding tissue	Minimal dissolution	Inadvertant charring / burning

Procise LW Wand

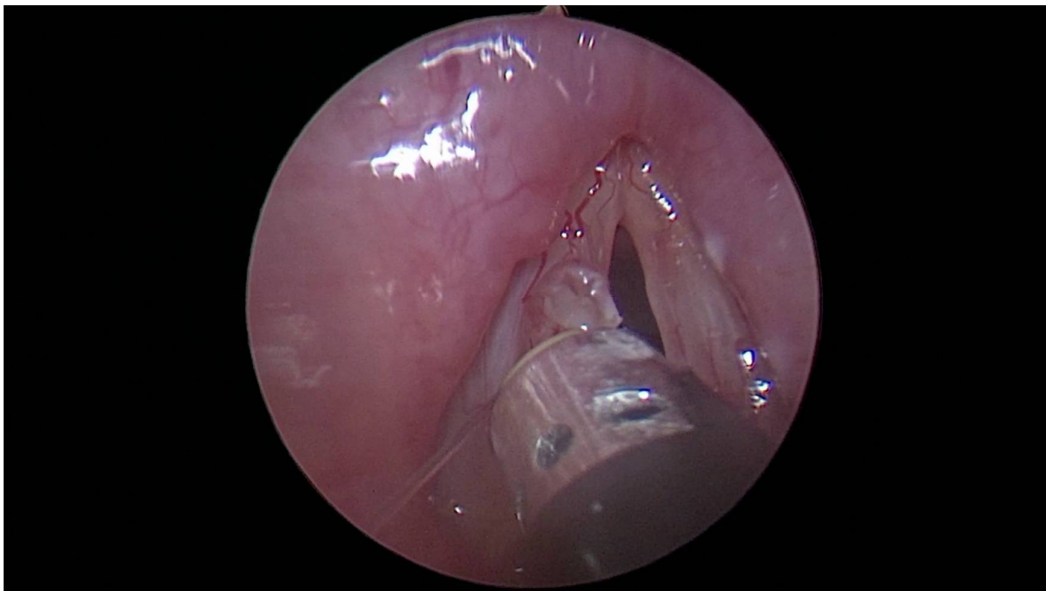
With a default set up of 7 for ablation and 3 for coagulation, this wand has got the following advantages:

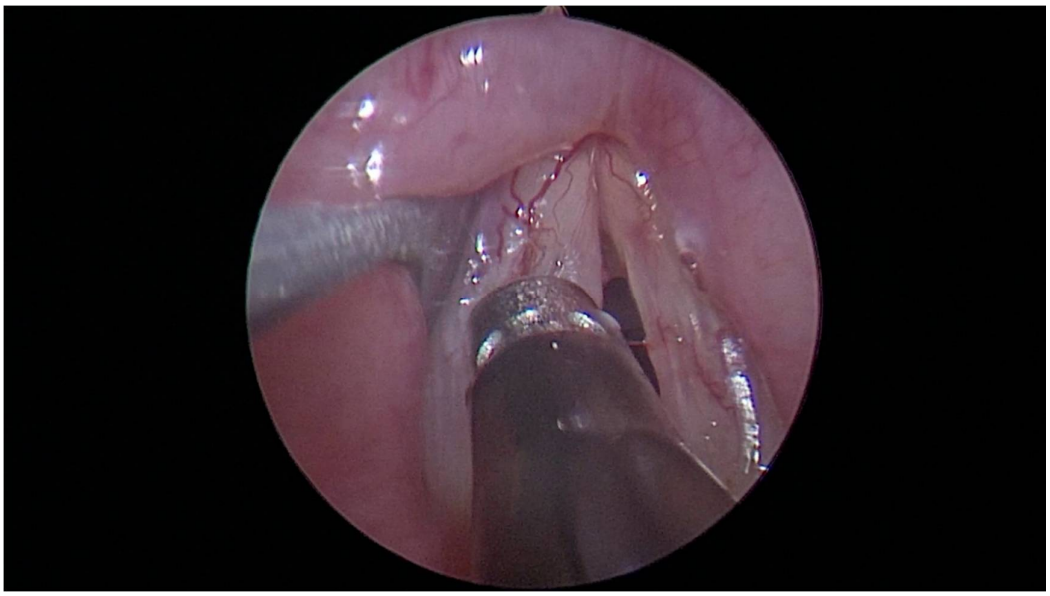
- Efficient bipolar ablation and coagulation
- Long and malleable – offers increased surgical field visualization, excellent adaptability to the individual's anatomy, adequate access to anterior commissure
- Integrated saline irrigation and suction – provides optimum saline delivery to active electrodes irrespective of the orientation

All these factors collectively help in reduced surgical times and overall complications and more importantly improved precision even for anterior commissure lesions, which is of paramount importance in laryngeal surgeries.

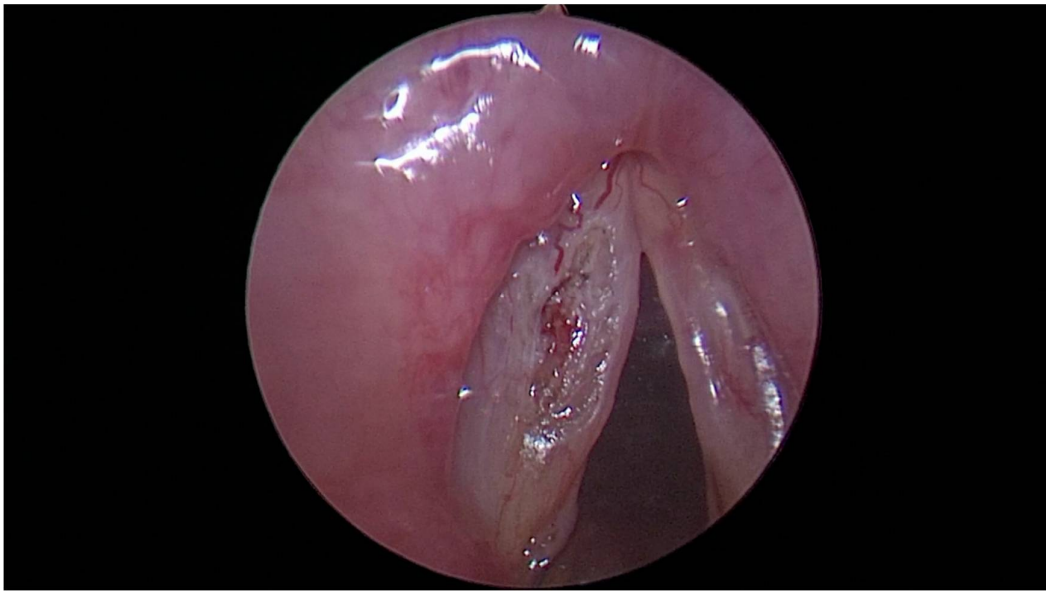


Vocal Polyp





Procise LW Wand in action



Immediate Post Operative period

MATERIALS AND METHODS

TYPE OF STUDY:

Prospective Randomized Double Blind Clinical Trial

STUDY PERIOD:

June 2015 to May 2017

NUMBER OF CASES:

30

SOURCE OF DATA:

Patients who were presenting to ENT Outpatient department, Government Coimbatore Medical College Hospital, Coimbatore, with voice complaints.

INCLUSION CRITERIA:

All patients who are 18 years or older (to exclude the possibility of inconsistencies in voice during puberty), diagnosed to have Vocal cord polyps, vocal cord nodules, mucous retention cysts, epidermoid cysts, Reinke's edema, recurrent laryngeal papillomatosis, etc.

EXCLUSION CRITERIA:

Persons diagnosed to have

- malignant lesions
- pregnant women
- mentally impaired persons
- persons with comorbid medical conditions who cannot tolerate general anesthesia
- patients who show good response with voice therapy and medical management

METHODOLOGY:

Adult patients who were presenting to ENT OPD with voice complaints like hoarseness, breathy or rough voice, diplophonia, etc. are evaluated. Complete head and neck examination and Indirect laryngoscopy examination (with topical 10% lignocaine spray if required) was done. Patients suspected to have benign lesions of the larynx like vocal cord polyps, vocal cord nodules, Reinke's edema, recurrent laryngeal papillomatosis, intracordal cysts, etc. are subjected to Videostroboscopy and diagnosis is confirmed. The patients are randomly

allocated for the proposed treatment modalities – Radiofrequency assisted plasma ablation and Carbon dioxide laser.

Pretreatment voice assessment was made using Voice Handicap Index – 10 (subjective) and Maximum Phonation Time (MPT).

VOICE HANDICAP INDEX – 10:

It is a self reporting questionnaire[23, 24] by the patient regarding the voice symptoms, a set of 10 questions, and the response was graded on a scale of 0 – 4. Based on the response by the patients, the scores are obtained. Generally scores greater than 11 is considered significant for voice pathology.

	VHI-10 statement	Score				
1.	My voice makes it difficult for people to hear me.	0	1	2	3	4
2.	I run out of air when I talk.	0	1	2	3	4
3.	People have difficulty understanding me in a noisy room.	0	1	2	3	4
4.	The sound of my voice varies throughout the day.	0	1	2	3	4
5.	My family has difficulty hearing me when I call them throughout the house.	0	1	2	3	4
6.	I use the phone less often than I would like to.	0	1	2	3	4
7.	I'm tense when talking to others because of my voice.	0	1	2	3	4
8.	I tend to avoid groups of people because of my voice.	0	1	2	3	4
9.	People seem irritated with my voice.	0	1	2	3	4
10.	People ask, "What's wrong with your voice?" 0 1	0	1	2	3	4

VHI : Voice Handicap Index
0 = never, 1 = almost never (occasionally), 2 = sometimes, 3 = almost always, 4 = always

MAXIMUM PHONATION TIME (MPT):

This is calculated by asking the patient to take a deep breath, then sustain a vowel sound like “ah” or “ee” for as long as possible in pitch and loudness in which the patient is comfortable on one exhalation. The time[22] is recorded in seconds using a stopwatch. Two more of such attempts are made. The longest time recorded of the three is taken into account for calculation of MPT. The value is considerably reduced in cases with voice pathology.

MAXIMUM PHONATION TIME	
SEX	TIME (SECONDS)
MEN	25 – 35
WOMEN	15 - 25

VIDEOSTROBOSCOPY:

Preoperative Videostroboscopic findings[19] were also recorded with respect to 4 parameters:

- Glottal closure
- Regularity
- Mucosal wave
- Symmetry

All the patients were subjected to preoperative voice therapy[13] to prepare the patient for a prolonged postoperative voice rehabilitation.

SURGERY:

The patients who agreed to participate in the study, with duly signed consent forms, were randomly assigned to receive radiofrequency assisted ablation or laser excision.

All the patients were operated under general anesthesia with endotracheal intubation with the finest possible tube diameter. Then Kleinsasser's Suspension Laryngoscope was introduced with a rigid endoscope connected to a high definition camera and a monitor.

For Radiofrequency assisted ablation:

Procise LW Wand with integrated cable was used with a foot pedal controller, the base of the lesion in the vocal cord was traced as it is held with a forceps, and the base was then cut and ablated till the basal attachment was completely cut off.

For Carbondioxide laser excision:

Endotracheal intubation with a laser safe tube was done. Operating microscope with a focal length of 400 mm was used after introducing the

Suspension Laryngoscope. Carbondioxide microspot laser (250 microns) with superpulse mode was used, and adequate care was taken to dissect the lesion in the most superficial plane as possible, to avoid any trauma to the deep layers of the vocal cord.

Specimens were sent to histopathology for accurate tissue diagnosis. All the patients were given a dose of 8mg Dexamethasone IV intraoperatively. Surgical duration is noted. Complications, if any, are noted. All the patients were advised strict voice rest for first 2 weeks following surgery.

Postoperative follow up was done at 2 weeks and 8 weeks from the day of surgery. Videostroboscopic parameters and Voice assessment with Voice Handicap Index – 10 and Maximum Phonation Time are recorded. The outcome was compared and final analysis of results was done.

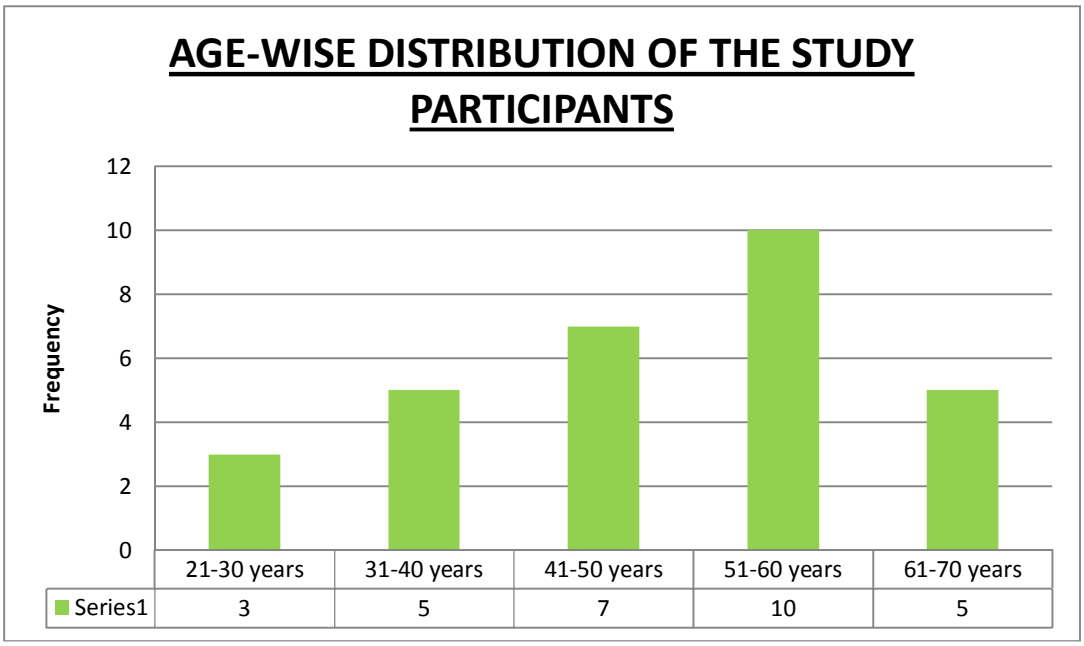
Outcome:

The cure was defined as the subjective feeling of improved voice quality and normal bilateral vocal cord mobility with constant periodicity and normal mucosal wave. The pre and postoperative MPT scores at 2 weeks and 8 weeks, pre and post-operative VHI scores are also taken into consideration.

OBSERVATION AND ANALYSIS

AGE –WISE DISTRIBUTION OF THE STUDY PARTICIPANTS

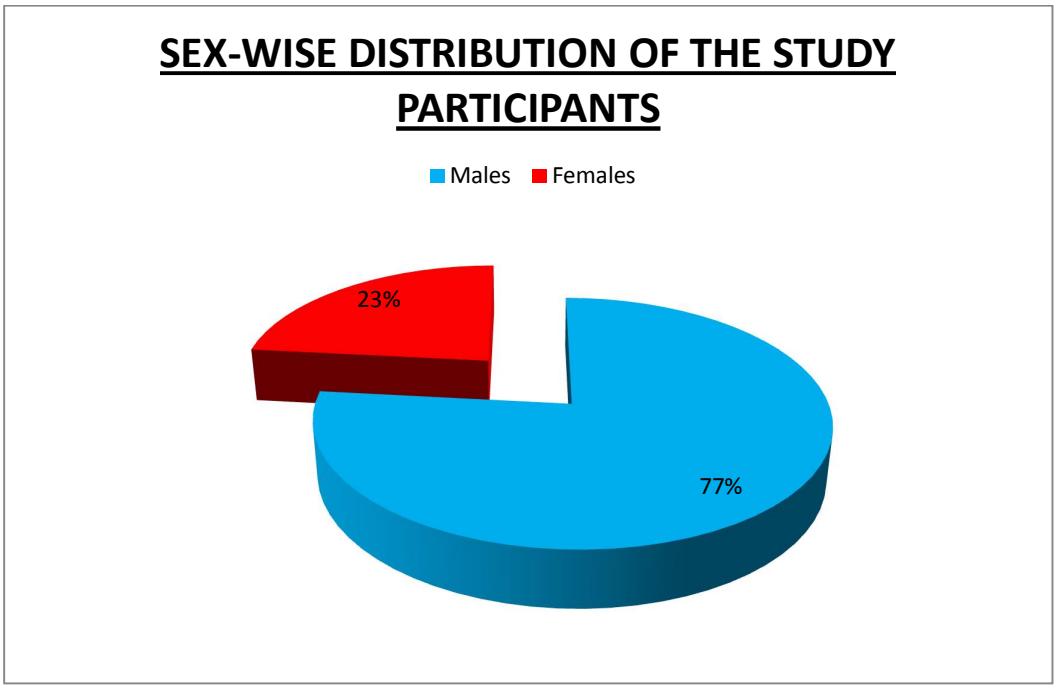
Age-Group	Frequency	Percentage
21-30 years	3	10.0
31-40 years	5	16.7
41-50 years	7	23.3
51-60 years	10	33.3
61-70 years	5	16.7
Total	30	100.0



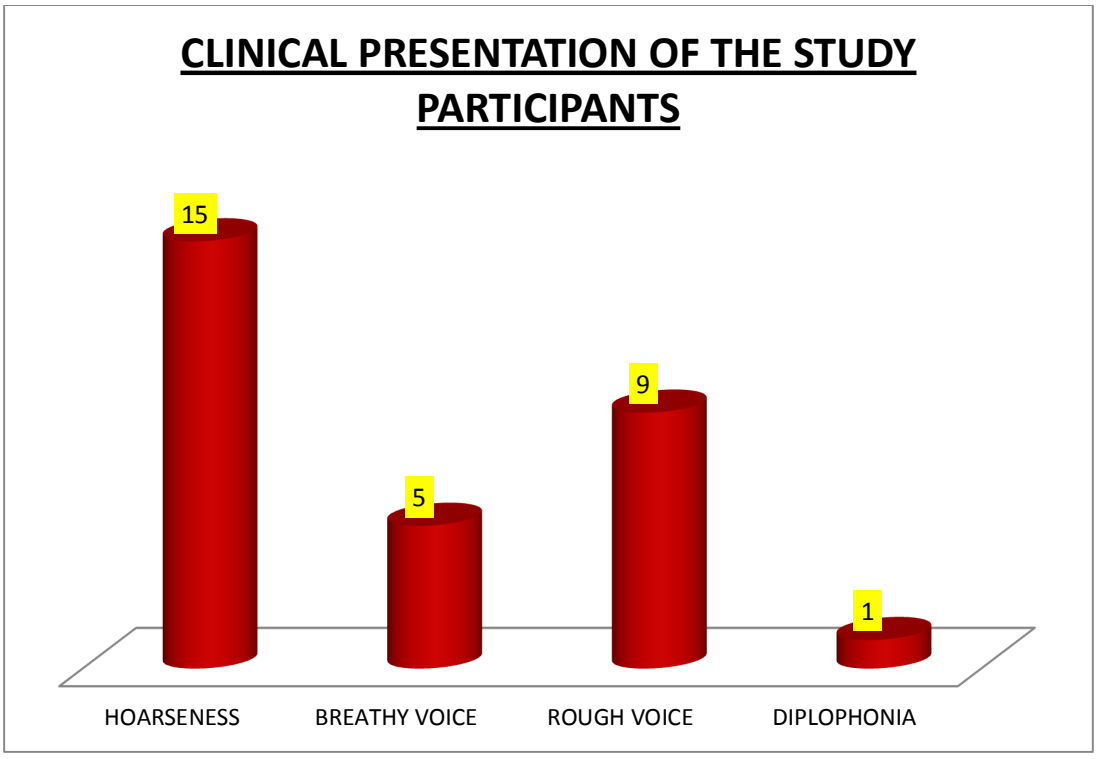
AGE					
	N	Minimum	Maximum	Mean	Std. Deviation
AGE	30	26	65	48.17	11.859

SEX-WISE DISTRIBUTION OF THE STUDY PARTICIPANTS

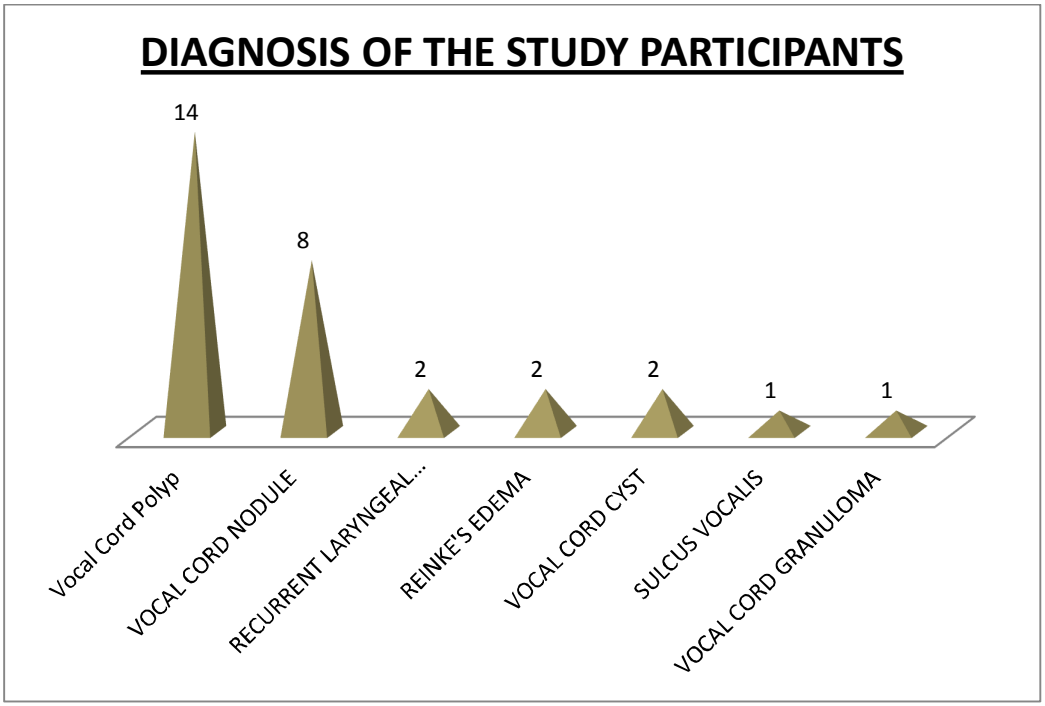
Sex	Frequency	Percentage
Males	23	76.7
Females	7	23.3
Total	30	100.0



Clinical Presentation	Frequency	Percentage
HOARSENESS	15	50.0
BREATHY VOICE	5	16.7
ROUGH VOICE	9	30.0
DIPLOPHONIA	1	3.3
Total	30	100.0

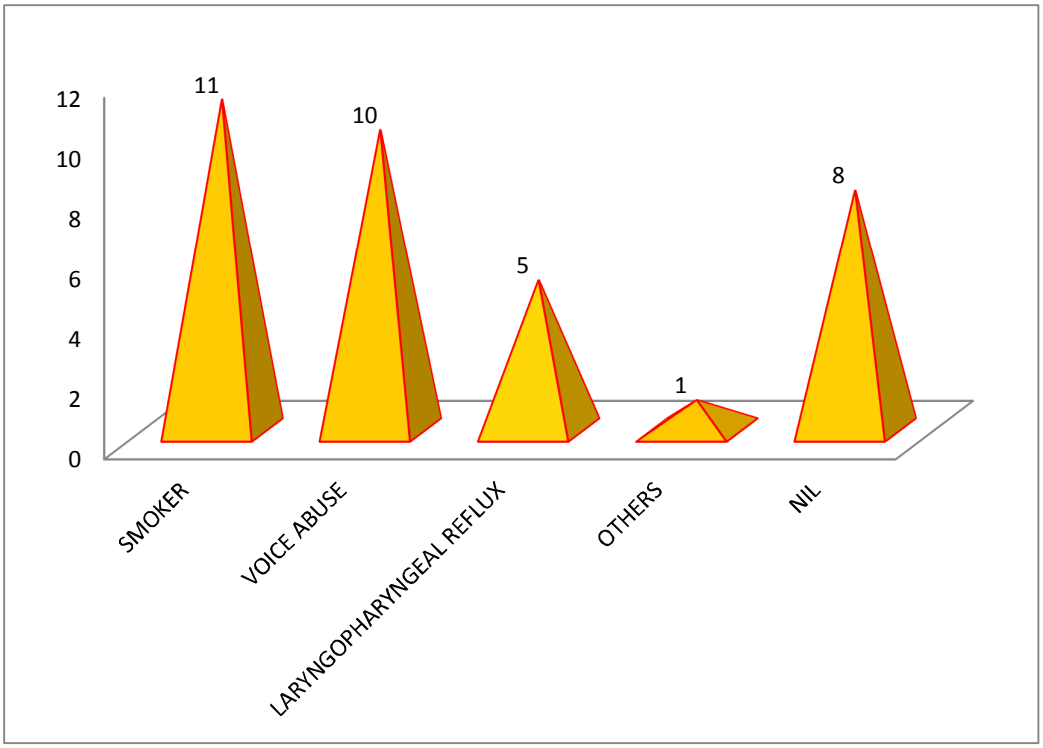


Diagnosis	Frequency	Percentage
VOCAL CORD POLYP	14	46.7
VOCAL CORD NODULE	8	26.7
RECURRENT LARYNGEAL PAPILLOMATOSIS	2	6.7
REINKE'S EDEMA	2	6.7
VOCAL CORD CYST	2	6.6
SULCUS VOCALIS	1	3.3
VOCAL CORD GRANULOMA	1	3.3
TOTAL	30	100.0



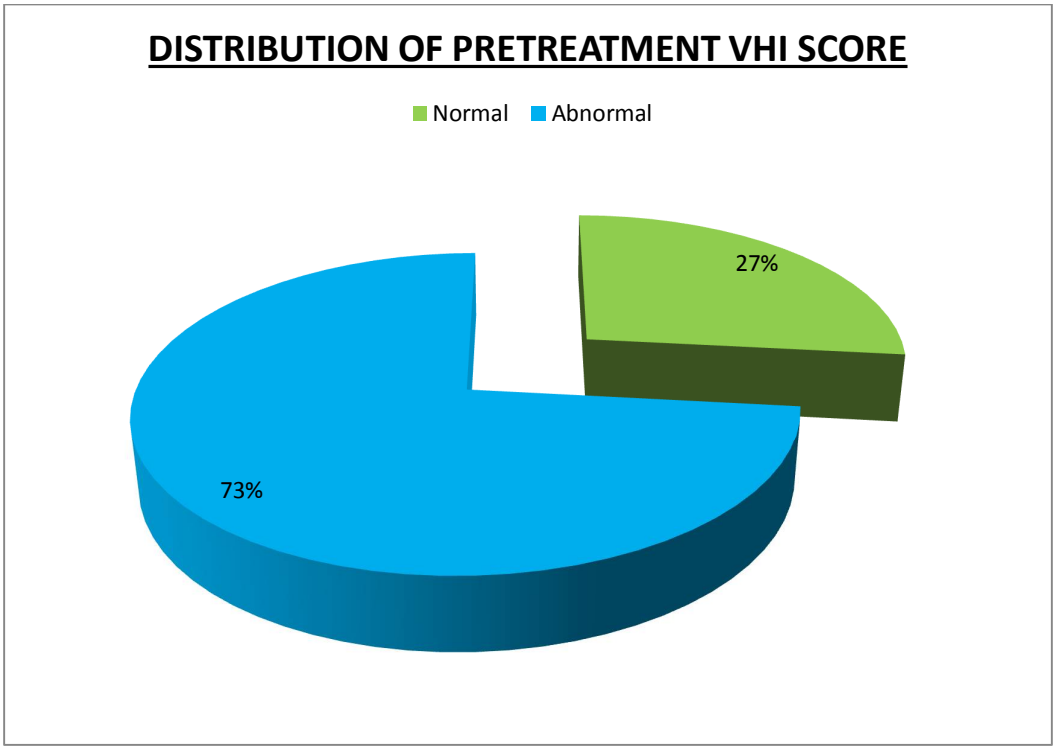
RISK FACTORS/ PRECIPITATING FACTORS

Precipitating / Risk factors	Frequency	Percentage
SMOKER	11	36.67
VOICE ABUSE	10	33.33
LARYNGOPHARYNGEAL REFLUX	5	16.67
OTHERS	1	3.3
NIL	8	26.7



DESCRIPTIVE STATISTICS					
	N	Minimum	Maximum	Mean	Std. Deviation
PRE TREATMENT VHI SCORE	30	11	18	13.00	1.894

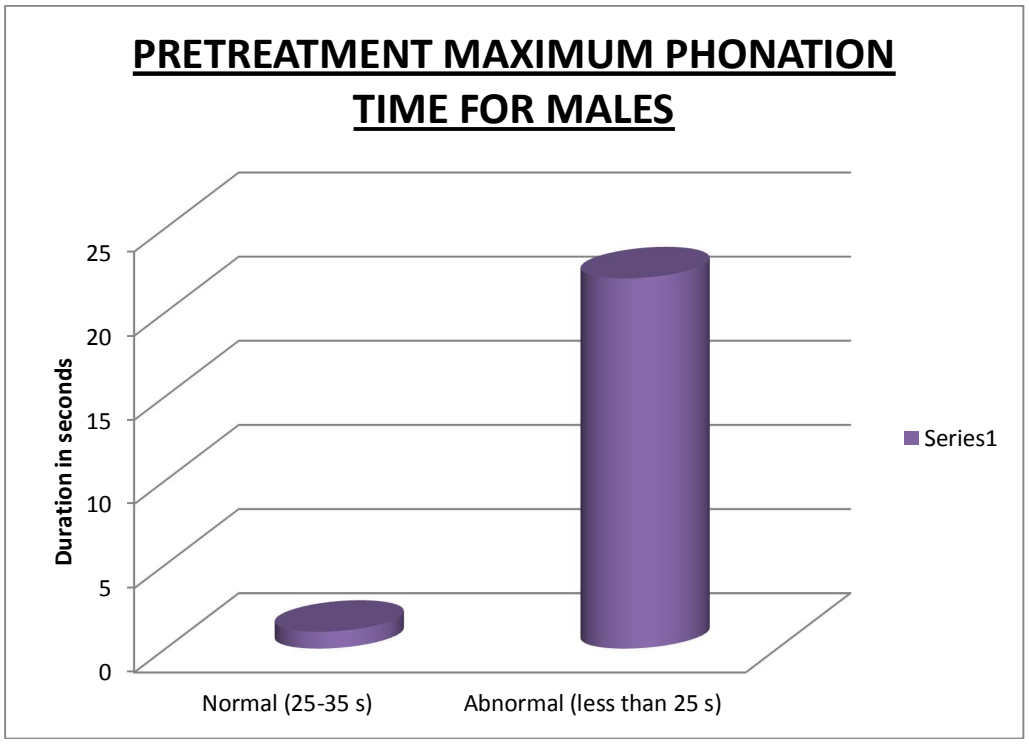
VHI Score	Frequency	Percentage
Normal	8	26.7
Abnormal	22	73.3
Total	30	100.0

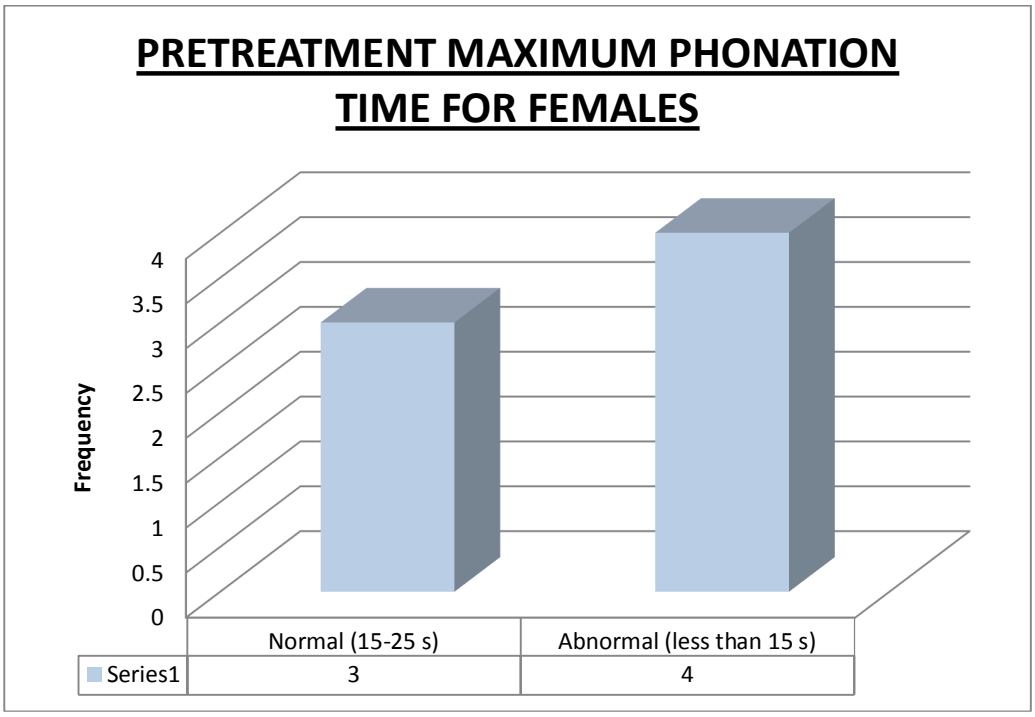


DESCRIPTIVE STATISTICS					
	N	Minimum	Maximum	Mean	Std. Deviation
PRE TREATMENT MPT SCORE	30	12	26	18.47	3.159

PRETREATMENT MPT

Gender	Duration	Frequency	Percentage	Total
Females	Normal (15-25 s)	3	42.9	7
	Abnormal (less than 15 s)	4	57.1	
Males	Normal (25-35 s)	1	4.3	23
	Abnormal (less than 25 s)	22	95.7	

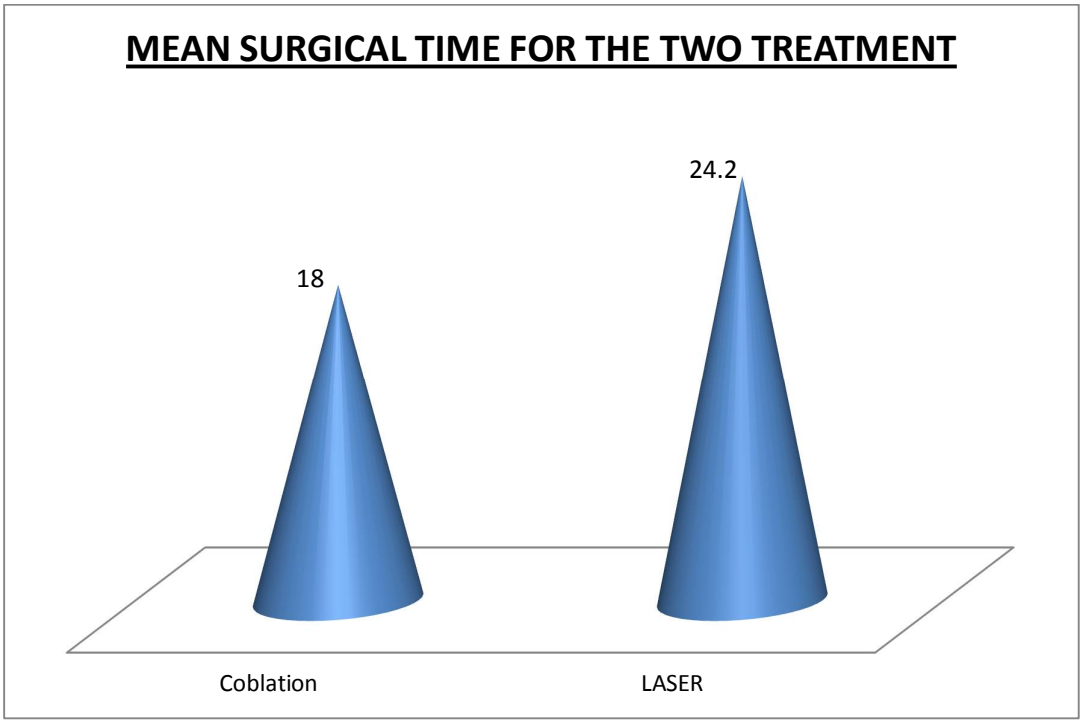

PRETREATMENT MAXIMUM PHONATION TIME FOR MALES
Duration in seconds
25
20
15
10
5
0
Normal (25-35 s)
Abnormal (less than 25 s)
Series1


PRETREATMENT MAXIMUM PHONATION TIME FOR FEMALES
Frequency
4
3.5
3
2.5
2
1.5
1
0.5
0
Normal (15-25 s)
Abnormal (less than 15 s)
Series1
3
4

Treatment Groups	Frequency	Percentage
Coblation Therapy	15	50
Laser Therapy	15	50

SURGICAL TIME (IN SECONDS)

Treatment Method	Minimum	Maximum	Mean	SD
Coblation	10	30	18.00	5.398
LASER	18	30	24.20	4.296



COMPARISON BETWEEN TWO METHODS

Treatment Method	Mean In seconds	SD	Non-parametric Test (Mann Whitney U test)	P value
Coblation	18.00	5.398	0.41	**.002**
LASER	24.20	4.296		

The mean difference between the two methods is 6.2 seconds and it is obvious the duration for coblation therapy is less compared to LASER treatment and is found to be statistically significant by Mann Whitney U test

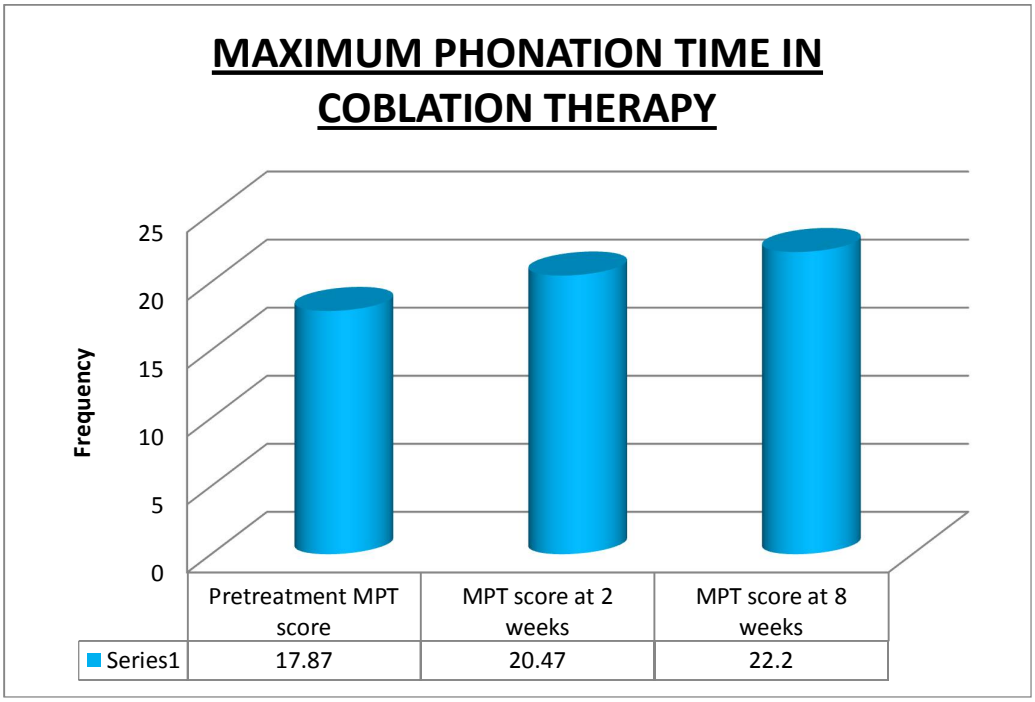
COMPLICATIONS

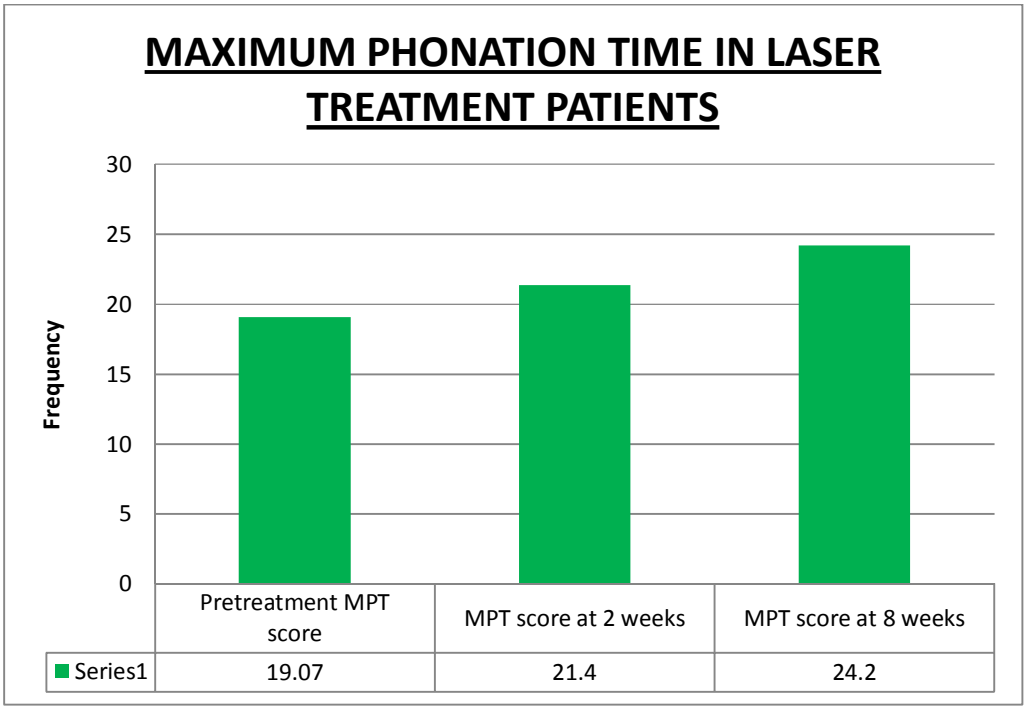
Treatment Groups	Frequency	Complications
Coblation Therapy	15	NIL
Laser Therapy	15	NIL

In both treatment modalities there are no complications

RECOVERY TIME

Treatment Method	MPT Score	Minimum	Maximum	Mean	SD
Coblation Therapy	PRE TREATMENT MPT SCORE	12	26	17.87	3.833
	MPT SCORE AT 2 WEEKS	14	28	20.47	3.944
	MPT SCORE AT 8 WEEKS	14	28	22.20	4.459
Laser Therapy	PRE TREATMENT MPT SCORE	14	23	19.07	2.282
	MPT SCORE AT 2 WEEKS	17	27	21.40	2.720
	MPT SCORE AT 8 WEEKS	20	31	24.20	3.385


MAXIMUM PHONATION TIME IN COBLATION THERAPY
Frequency
25
20
15
10
5
0
Pretreatment MPT score
MPT score at 2 weeks
MPT score at 8 weeks
Series1
17.87
20.47
22.2


MAXIMUM PHONATION TIME IN LASER TREATMENT PATIENTS
Frequency
30
25
20
15
10
5
0
Pretreatment MPT score
MPT score at 2 weeks
MPT score at 8 weeks
Series1
19.07
21.4
24.2

COMPARISON OF MPT SCORE WITHIN THE TREATMENT GROUPS

Treatment Method	MPT Score	Mean	SD	Mann Whitney U Test	P value
Coblation Therapy	PRE TREATMENT MPT SCORE	17.87	3.833	84.5	**<0.05**
	MPT SCORE AT 2 WEEKS	20.47	3.944		
Laser Therapy	PRE TREATMENT MPT SCORE	19.07	2.282	91.5	.381
	MPT SCORE AT 2 WEEKS	21.40	2.720		

Treatment Method	MPT Score	Mean	SD	Mann Whitney U Test	P value
Coblation Therapy	MPT SCORE AT 2 WEEKS	20.47	3.944	91.50	.381
	MPT SCORE AT 8 WEEKS	22.20	4.459		
Laser Therapy	MPT SCORE AT 2 WEEKS	21.40	2.720	87.00	.289
	MPT SCORE AT 8 WEEKS	24.20	3.385		

Treatment Method	MPT Score	MEAN	SD	Mann Whitney U Test	P value
Coblation Therapy	PRE TREATMENT MPT SCORE	17.87	3.833	82	**<0.05**
	MPT SCORE AT 8 WEEKS	22.20	4.459		
Laser Therapy	PRE TREATMENT MPT SCORE	19.07	2.282	56	**<0.05**
	MPT SCORE AT 8 WEEKS	24.20	3.385		

COMPARISON OF MPT SCORES BETWEEN THE TWO GROUPS

	TREATMENT	N	Mean	Std. Deviation	F value	P value
PRE TREATMENT MPT SCORE	1	15	17.87	3.833	4.183	.306
	2	15	19.07	2.282		
MPT SCORE AT 2 WEEKS	1	15	20.47	3.944	3.005	.457
	2	15	21.40	2.720		
MPT SCORE AT 8 WEEKS	1	15	22.20	4.459	1.990	.177
	2	15	24.20	3.385		

VHI SCORE

	Minimum	Maximum	Mean	Std. Deviation
PRE TREATMENT VHI SCORE	11	18	13.00	1.89
POST TREATMENT VHI SCORE	5	13	8.03	1.93

TREATMENT		Minimum	Maximum	Mean	Std. Deviation
Coblation	PRE TREATMENT VHI SCORE	11	16	13.60	1.72
	POST TREATMENT VHI SCORE	5	13	8.93	1.90
LASER	PRE TREATMENT VHI SCORE	11	18	12.40	1.92
	POST TREATMENT VHI SCORE	5	10	7.13	1.55

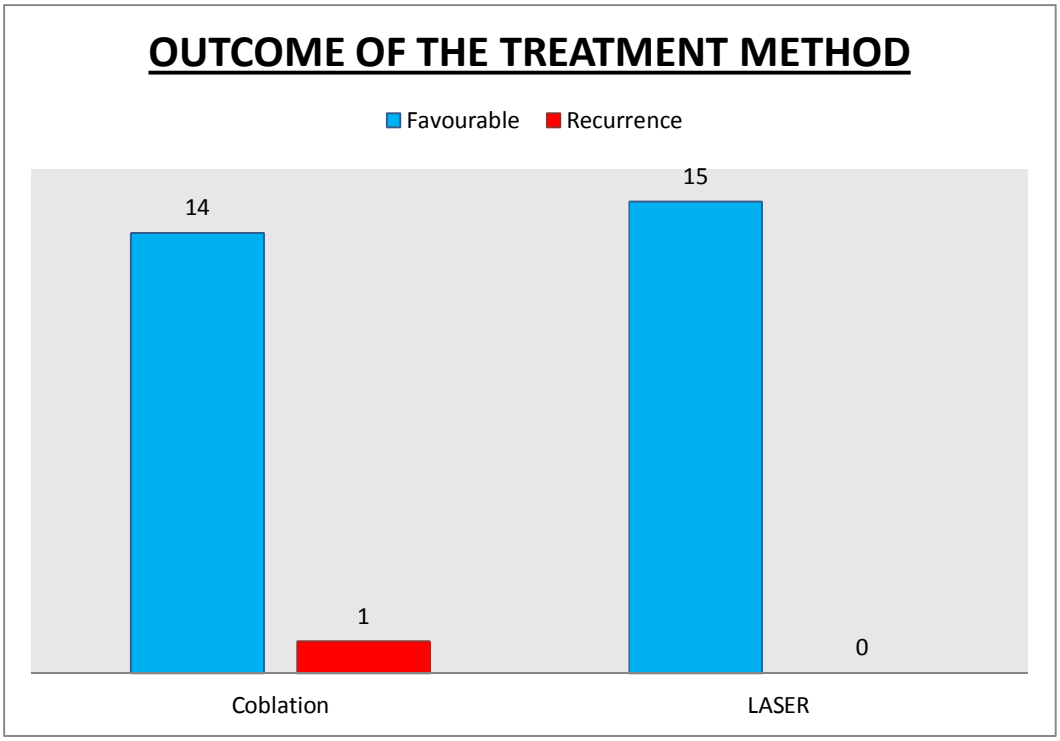
COMPARISON BETWEEN THE VHI SCORE

Treatment Method	VHI Score	MEAN	SD	Mann Whitney U Test	P value
Coblation Therapy	PRE TREATMENT VHI SCORE	13.60	1.72	11.06	**<0.05**
	POST TREATMENT VHI SCORE	8.93	1.90		
Laser Therapy	PRE TREATMENT VHI SCORE	12.40	1.92	18.4	**<0.05**
	POST TREATMENT VHI SCORE	7.13	1.55		

GROUP STATISTICS VHI						
	TREATMENT	**N**	**Mean**	**Std. Deviation**	**F value**	**P value**
PRE TREATMENT VHI SCORE	1	15	13.60	1.724	.018	.082
	2	15	12.40	1.920		
POST TREATMENT VHI SCORE	1	15	8.93	1.907	.029	.008
	2	15	7.13	1.552		

OUTCOME

Gender	Outcome	Frequency	Percentage
Coblation	Favorable	14	93.3
	Recurrence	1	6.7
LASER	Favorable	15	100.0
	Recurrence	Nil	-



DISCUSSION

This study was intended to compare the outcome in Benign lesions of Larynx treated using Radiofrequency assisted plasma ablation and Carbon dioxide Laser. The study also aimed to find out whether there are any significant complications in any of the procedure and whether one method is preferred over another in any circumstance.

This study is a **prospective randomized double blind clinical study**.

30 patients with voice complaints who were diagnosed with benign lesions of the larynx are selected and randomly allocated into two groups of 15 each. The two groups were identically evaluated and prepared for surgery. Pretreatment attributes, surgical and recovery times, post treatment improvement was evaluated and compared.

Hoarseness was the most common presenting symptom, followed by roughness. Of the total 30 cases, 15 presented with hoarseness, 9 presented with roughness, 5 presented with breathy voice, diplophonia was present in one patient.

In men smoking was the main risk factor associated with the benign laryngeal lesions. Out of 23 men in the study group, 11 were

smokers, which is a significant proportion. In women voice abuse was the main precipitating factor causing the voice symptoms. Other important risk factor in both genders is uncontrolled laryngopharyngeal reflux. One patient had history of previous endotracheal intubation following which he developed Vocal cord granuloma.

Pretreatment VHI-10 Score:

22 of the 30 patients had abnormally high VHI scores, the remaining 8 patients had a borderline VHI scores, which further highlights the importance and clinical ease of using this tool as a reliable indicator of voice dysfunction. The mean VHI score is 13.00 with a standard deviation of 1.894.

Pretreatment MPT score:

95.7% of males and 57.1% of females in the study group had abnormal pretreatment MPT score. The mean MPT score of the study population was 18.47 with a standard deviation of 3.159.

Surgical Times:

The mean surgical time of Coblation surgery is 18.00 minutes, with a standard deviation of 5.398, whereas for Carbon dioxide Laser, the mean time is 24.20 with a standard deviation of 4.296.

The mean difference of 6.2 between the two methods shows that the surgical times with coblation method are significantly lower than that of Carbondioxide laser (Mann Whitney U Test 0.41, p value <0.05).

Recovery times:

MEAN MPT SCORE	PRETREATMENT	2 WKS POSTOP	8 WKS POSTOP
COBLATION	17.87	20.47	22.2
LASER	19.07	21.40	24.20

The Mean MPT score in the coblation group showed statistically significant improvement after 2 weeks postoperatively, with further improvement after 5 weeks postoperatively. In Laser group, mean MPT score did not show significant improvement at 2 weeks, but eventually showed improvement at 8 weeks.

One case of recurrence was a case of Laryngeal papilloma, which occurred at a site different from the previous surgery done at our hospital, and was successfully treated by second surgery, following which the patient is symptom free.

Based on the above observation, it can be inferred that though both the methods are similar in terms of outcome, Laser surgery has significantly longer surgical times, and recovery also takes slightly longer when compared to Coblation surgery. This is attributable to the fact that Coblation carries less risk of injuring surrounding tissue, and that it operates at a much lesser temperature (40 – 70 degrees Centigrade) than that of Laser, which, on the other hand operates at 300 degrees Centigrade, which may cause heat damages in the lamina propria and deep tissues of the vocal cords.

LIMITATIONS OF THE STUDY:

Because of the lack of availability of acoustic and aerodynamic analyses in our current set up, we mainly used videostroboscopic assessments and patient perceived tools like Voice Handicap Inventory 10, Maximum phonation time, etc.

CONCLUSION

This study suggests that Radiofrequency assisted plasma ablation and Carbon dioxide Laser both are excellent treatment modalities for the surgical management of Benign Lesions of the Larynx in the hands of an experienced surgeon.

There were no detectable differences in the outcome between the two methods and there were no complications in any of these methods.

The delay in recovery times, as evidenced by lower MPT scores at 2 weeks for Laser can be attributed to the fact that it operates at a higher temperature thereby causing more thermal damage to surrounding tissues. But at the end of 8 weeks, the scores are similar to both modalities.

Coblation, though an excellent tool with much lower complications than any other electrosurgical modalities, carries a huge disadvantage of incurring cost of wands. This is not the case in Laser, as the setup involves one-time investment with no incurring cost thereafter.

The importance of preoperative evaluation using Videostroboscopy as a diagnostic tool vastly improves the accuracy of the diagnosis, and also acts as an essential tool in assessing the recovery of the patients.

Moreover the importance of preoperative voice therapy in preparing the patient for much more prolonged post-operative voice rehabilitation is also stressed in our study. Adequate voice rest of at least 2 weeks with strict adherence to post-operative voice therapy is absolutely essential to ensure proper healing and improved outcome in these patients.

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PROFORMA

RADIOFREQUENCY ASSISTED PLASMA ABLATION AND CARBON DIOXIDE LASER IN BENIGN LESIONS OF LARYNX – A RANDOMIZED PROSPECTIVE DOUBLE BLIND CLINICAL TRIAL

PRE OPERATIVE DETAILS:

CASE NO.:

PATIENT ID:

NAME:

AGE / SEX:

ADDRESS:

PRESENTING COMPLAINTS:

PAST HISTORY:

RISK FACTORS / PRECIPITATING FACTORS:

GENERAL EXAMINATION:

ENT EXAMINATION:

INDIRECT LARYNGOSCOPY EXAMINATION:

LARYNGEAL ENDOSCOPY:

VIDEOSTROBOSCOPIC ASSESSMENT:

BASIC INVESTIGATIONS:

Complete hemogram

Renal function tests

Random blood sugar

Chest X ray

Electrocardiogram

Urine routine examination

ANESTHETIC WORK UP / FITNESS:

PRE OPERATIVE MPT AND VHI SCORES

PRE OPERATIVE VOICE THERAPY

SURGERY NOTES:

POST OPERATIVE FOLLOW UP:

	AT 2 WEEKS	AT 8 WEEKS
VIDEOSTROBOSCOPY		
M P T		

	AT 8 WEEKS
V H I	

CONSENT FORM

I Mr. / Mrs. / Miss. _____ aged ____ years, S/D/o _____ residing at _____ _____ is requested to be a participant in the study titled "*Radiofrequency assisted plasma abalation and Carbon dioxide Laser in Benign lesions of larynx – a Prospective Randomized double blind trial*" conducted by Dr. Muralimohan K., a postgraduate trainee in the Department of ENT, Coimbatore Medical College Hospital, Coimbatore. I understand that I am eligible for the study as per the inclusion criteria, and I also assure that I will answer any question and give any clarification about the study by agreeing to participate in this study.

TOPIC OF RESEARCH

Radiofrequency assisted plasma abalation and Carbon dioxide Laser in Benign lesions of larynx – a Prospective Randomized double blind trial

PURPOSE OF RESEARCH

- To compare the treatment outcome in Benign lesions of larynx using Radiofrequency assisted plasma ablation and Carbon dioxide laser

- To find out whether there are significant or potential adverse effects of either procedure
- To determine whether any of these procedures is preferred treatment of choice in specific conditions

PROCEDURES INVOLVED IN THE STUDY

Out patients in the ENT OPD, Coimbatore Medical College Hospital, who presented with voice complaints were evaluated. Those who were diagnosed with benign lesions of the larynx, confirmed by videostroboscopy were taken up for surgery – coblation or carbon dioxide laser – randomly after preoperative voice therapy. Then the post operative follow up is done at 2 weeks and at 8 weeks. The parameters are compared.

DECLINING FROM PARTICIPATION

You are hereby made aware that the participation in this study is purely voluntary and honorary, and you have all rights to decline from participating at any point of time prior to or during the study.

PRIVACY AND CONFIDENTIALITY

You are hereby assured that your privacy is respected and all the information will be strictly confidential.

AUTHORIZATION TO PUBLISH RESULTS

The results may be published for scientific purposes or will be presented in scientific groups. In both the cases neither the identity will be revealed nor the privacy will be violated.

Signature / Left thumb impression of the patient

Station

Date

Signature / Left thumb impression of the witness

Station

Date

ஒப்புதல் படிவம்

பெயர் -

பாலினம் -

வயது -

முகவரி -

அரசு கோவை மருத்துவக்கல்லூரியில் காது மூக்கு தொண்டை மருத்துவ துறையில் பட்ட மேற்படிப்பு பயிலும் மாணவர் க.முரளிமோகன் அவர்கள் மேற்கொள்ளும் ஆய்வில் செய்முறை மற்றும் அனைத்து விவரங்களையும் கேட்டு கொண்டு எனது சந்தேகங்களை தெளிவுப்படுத்திக் கொண்டேன் என்பதை தெரிவித்துக் கொள்கிறேன்.

நான் இந்த ஆய்வில் முழு சம்மதத்துடன், சுய சிந்தனையுடனும் கலந்து கொள்ள சம்மதிக்கிறேன்.

இந்த ஆய்வில் என்னுடைய அனைத்து விபரங்கள் பாதுகாக்கப்படுவதுடன் இதன் முடிவுகள் ஆய்விதழில் வெளியிடப்படுவதில் ஆட்சேபனை இல்லை என்பதை தெரிவித்துக் கொள்கிறேன். எந்த நேரத்திலும் இந்த ஆய்விலிருந்து நான் விலகிக் கொள்ள எனக்கு உரிமை உண்டு என்பதையும் அறிவேன்.

இப்படிக்கு

KEY TO MASTER CHART

CLINICAL HISTORY	H	HOARSENESS
	B	BREATHY VOICE
	R	ROUGH VOICE
	D	DIPLOPHONIA
	O	OTHERS
PRECIPITATING / RISK FACTORS	S	SMOKER
	A	VOICE ABUSE
	R	LARYNGOPHARYNGEAL REFLUX
	O	OTHERS
VHI - VOICE HANDICAP INDEX	11 AND ABOVE	ABNORMAL
	LESS THAN 11	NORMAL
MPT - MAXIMUM PHONATION TIME	MALES	25 - 35 SECONDS
	FEMALES	15 - 25 SECONDS
OUTCOME	F	FAVOURABLE - TREATED AND DISEASE FREE
	R	RECURRENCE

MASTER CHART

S. NO	PATIENT'S NAME	AGE	SEX	CLINICAL HISTORY	PRECIPITATING / RISK FACTORS	DIAGNOSIS	PRE TREATMENT VHI SCORE	PRE TREATMENT MPT SCORE	PRETREATMENT VIDEOSTROBOS COPY								TREATMENT	SURGICAL TIME	COMPLICATIONS	POST TREATMENT VIDEOSTROBOS COPY AT 2 WEEKS								MPT SCORE AT 2 WEEKS	POST TREATMENT VIDEOSTROBOS COPY AT 8 WEEKS								MPT SCORE AT 8 WEEKS	POST TREATMENT VHI SCORE AT 8 WEEKS	OUTCOME
									GLOTTAL CLOSURE		REGULARITY		MUCOSAL WAVE		SYMMETRY					GLOTTAL CLOSURE		REGULARITY		MUCOSAL WAVE		SYMMETRY			GLOTTAL CLOSURE		REGULARITY		MUCOSAL WAVE		SYMMETRY				
									COMPLETE	INCOMPLETE	REGULAR	IRREGULAR	NORMAL	ABNORMAL	SYMMETRICAL	ASYMMETRICAL				COMPLETE	INCOMPLETE	REGULAR	IRREGULAR	NORMAL	ABNORMAL	SYMMETRICAL	ASYMMETRICAL		COMPLETE	INCOMPLETE	REGULAR	IRREGULAR	NORMAL	ABNORMAL	SYMMETRICAL	ASYMMETRICAL			
1	JAGANNATHAN	54	M	H	S, R	VOCAL CORD NODULE	16	19	*			*		*	*		C	15	NIL	*		*		*		*		24	*		*		*		*		25	10	F
2	KANDASAMY	58	M	H	R	VOCAL CORD NODULE	18	21	*			*		*		*	L	30	NIL	*		*		*		*		26	*		*		*		*		29	10	F
3	SELVI	47	F	B		RECURRENT LARYNGEAL PAPILLOMATOSIS	14	14		*		*		*		*	C	30	NIL									15									15	11	F
4	SUBRAMANI	55	M	H	S	L VOCAL CORD POLYP	12	18		*		*				*	L	25	NIL	*		*		*		*		20	*		*		*		*		22	8	F
5	MUTHUSAMY	48	M	R	S	VOCAL CORD NODULE	11	19	*			*		*	*		L	25	NIL	*		*		*		*		21	*		*		*		*		23	6	F
6	MURALI	59	M	H	S	R VOCAL CORD POLYP	13	17		*				*		*	C	15	NIL	*		*		*		*		20	*		*		*		*		24	10	F
7	NAGARAJAN	60	M	H	S, R	VOCAL CORD NODULE	14	18	*			*		*		*	L	22	NIL	*		*		*		*		21	*		*		*		*		22	8	F
8	LAKSHMANAN	61	M	H	S	VOCAL CORD NODULE	15	20	*			*		*	*		C	12	NIL	*		*		*		*		22	*		*		*		*		26	9	F
9	BHUVANESWARI	26	F	B	A	L VOCAL CORD POLYP	11	14		*		*		*		*	L	22	NIL	*		*		*		*		17	*		*		*		*		20	6	F
10	MURUGAN	45	M	R	S, A	REINKE'S EDEMA	16	15	*			*		*	*		C	25	NIL									18									19	9	F
11	KUMARASAMY	33	M	R	A	L VOCAL CORD POLYP	11	22		*		*		*		*	L	20	NIL	*			*		*		*	23	*		*		*		*		25	7	F
12	KUPPUSAMY	39	M	B		R SULCUS VOCALIS	13	16		*		*		*		*	C	20	NIL	*		*			*	*		18	*		*		*		*		19	10	F
13	SATHYAMOORTHY	61	M	H	S	R VOCAL CORD POLYP	12	20		*		*		*		*	L	25	NIL	*		*		*		*		20	*		*		*		*		26	6	F
14	SIVARAJ	57	M	H	A	L VOCAL CORD POLYP	13	22	*			*		*		*	C	15	NIL	*		*		*		*		24	*		*		*		*		28	9	F
15	KRISHNAN	53	M	H	A	R VOCAL CORD POLYP	11	17		*		*		*		*	L	30	NIL	*		*		*		*		19	*		*		*		*		20	6	F
16	MASANAM	60	M	H	A	L VOCAL CORD POLYP	14	18		*		*		*		*	C	15	NIL	*		*			*	*		19	*		*		*		*		21	9	F
17	SUBRAMANIAN	46	M	R	S	L VOCAL CORD POLYP	12	20		*		*		*		*	L	18	NIL	*		*		*		*		24	*		*		*		*		29	5	F

18	DHANIKASALAM	44	M	R	O	L VOCAL CORD GRANULOMA	13	22		*		*		*		*	C	20	NIL	*			*		*		*	23	*		*		*		*		24	7	F
19	MAHARIBA	29	F	B	A	R VOCAL CORD POLYP	11	23		*		*		*		*	L	26	NIL	*		*		*		*		27	*		*		*		*		31	7	F
20	NATRAJ	56	M	H	R	VOCAL CORD NODULE	12	26	*			*		*		*	C	15	NIL	*		*		*		*		28	*		*		*		*		28	7	F
21	SATHISHKUMAR	31	M	R		L VOCAL CORD POLYP	14	19		*		*		*		*	L	30	NIL	*		*		*		*		21	*		*		*		*		23	10	F
22	MUTHURAJ	41	M	R		R VOCAL CORD CYST	12	17		*		*		*		*	C	18	NIL	*		*		*		*		18	*		*		*		*		19	9	F
23	PARAMESHWARI	45	F	D		L VOCAL CORD CYST	12	16		*		*		*		*	L	30	NIL	*		*			*	*		18	*		*		*		*		21	8	F
24	AROON	62	M	H	R	VOCAL CORD NODULE	11	21	*			*		*	*		C	10	NIL	*			*		*		*	26	*		*		*		*		27	7	F
25	RAMACHANDRAN	52	M	H	S,A	L VOCAL CORD POLYP	14	20	*			*		*		*	L	20	NIL	*		*		*		*		22	*		*		*		*		23	8	F
26	UMAMAHESWARI	35	F	R		RECURRENT LARYNGEAL PAPILLOMATOSIS	15	13		*		*		*		*	C	25	NIL									14									14	13	R
27	RAMATHAL	61	F	H	S,A	REINKE'S EDEMA	16	12	*			*		*	*		C	20	NIL									19									20	9	F
28	KARUPPASAMY	35	M	R		R VOCAL CORD POLYP	12	19		*		*		*		*	L	20	NIL	*		*		*		*		21	*		*		*		*		26	7	F
29	VAJRAVEL	65	M	H		VOCAL CORD NODULE	11	20	*			*		*		*	L	20	NIL	*		*		*		*		21	*		*		*		*		23	5	F
30	UMAMAHESWARI	27	F	B	A	L VOCAL CORD POLYP	11	16		*		*		*		*	C	15	NIL	*		*		*		*		19	*		*		*		*		24	5	F