A PRE AND POST-SURGICAL COMPARISON OF ACOUSTIC, AERODYNAMIC AND PERCEPTUAL ANALYSIS OF VOICE IN PATIENTS WITH VOCAL FOLD POLYP

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MAY-JUNE 2012

CERTIFICATE

This is to certify that this dissertation entitled **"A PRE AND POST-SURGICAL COMPARISON OF ACOUSTIC, AERODYNAMIC AND PERCEPTUAL ANALYSIS OF VOICE IN PATIENTS WITH VOCAL FOLD POLYP"** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech language Pathology) of the student (**Registration number: 10SLP007**). This has been carried out under the guidance of a faculty of this Institute and has not been submitted earlier to any other university for the award or any other diploma or degree.

MYSORE,
MAY-JUNE 2012

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CERTIFICATE

This is to certify that this dissertation entitled **"A PRE AND POST-SURGICAL COMPARISON OF ACOUSTIC, AERODYNAMIC AND PERCEPTUAL ANALYSIS OF VOICE IN PATIENTS WITH VOCAL FOLD POLYP"** has been carried out under my guidance. It is also certified that this has not been submitted earlier to any other university for the award or any other diploma or degree.

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DECLARATION

I hereby declare that this dissertation entitled **"A PRE & POST-SURGICAL COMPARISON OF ACOUSTIC, AERODYNAMIC AND PERCEPTUAL ANALYSIS OF VOICE IN PATIENTS WITH VOCAL FOLD POLYP"** is the result of my own study under the guidance of Mr. R. Rajasudhakar, Lecturer in Speech Sciences, Department of Speech-Language Sciences and Co-guidance of Dr. H. Sundara Raju, Professor of ENT, Department of ENT, All India Institute of Speech & Hearing, Mysore, and has not been submitted earlier to any other university for the award of Diploma or Degree.

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“Dedicated to ma lovely parents

sarmaji and geethamma”

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

"The living voice is that sways the soul" - Pliny the Younger.

Voice is the sound produced by the vibration of vocal folds and modified by the transfer function of the vocal tract. Voice communication begins at birth and it influences nearly every part of human interaction and culture. As an auditory perceptual term it means the audible sound produced by the larynx, which embodies parameters such as pitch, loudness, quality and variability.

The production of voice requires the interaction of many physiologic processes. The vocal fold serves as an energy transducer that is responsible for converting aerodynamic power into acoustic power. Voice is produced when the lining tissue of the vocal folds, the mucosa, is put into oscillation and changes a steady stream of air into a rhythmically interrupted airstream. The air comes from thelungs and the power pushing the air out of the lungs comes from the contraction of the abdominal and chest muscles; and the relaxation and recoil of the diaphragm. Thus anything that hampers the normal action of the diaphragm, chest, or abdominal muscles may have a great impact on the voice.

Voice disorder arises when an individual's pitch, loudness or quality differs from voice characteristics of typical speakers of similar age, gender, cultural background and geographic location, or when an individual indicates that his/her voice is not sufficient to meet daily needs, even if it is not perceived as deviant from others (Stemple, Glaze, & Klaben, 2004). Voice disorders results from etiologies that arise from factors including structural, medical,psychogenic and neurologic

alterations of respiratory, laryngeal and vocal tract mechanisms, maladaptive or inappropriate voice use.

Structural pathologies include nodules, vocal polyps and granulomas etc. which cause alteration in the histological organization of the vocal folds. The lesion location (whether membranous region or cartilaginous region), extent of lesion in terms of size and depth of penetration with in the histologic layers of the vocal folds contributes to the vocal quality that results from the disorder. Apart from vocal nodules, vocal polyps are the most common structural pathology occurring in adults in the age range of 22- 45years. Vocal fold polyps are extensions of the epithelium that emerge on the free edge of the vocal folds. They usually result from vocal trauma (Deem & Miller, 2000).

The primary voice symptom in individuals with vocal polyp would be hoarseness. Acoustic signs in vocal polyp would be similar to those of vocal nodules. Because of extra mass at the midpoint of the vibratory vocal fold, vibratory characteristics would be affected which results in altered/affected acoustic, aerodynamic and even perceptual quality of voice. Small polyps are usually soft and deformable on contact and they generally exhibit normal or increased amplitude of the mucosal wave during voicing. Voice is usually lowered by the increased mass of the vocal fold.

The treatment for vocal fold polyps must be individualized according to the patient's vocal demands and expectations, the size and location of the mass and the severity of the voice changes. Unlike vocal nodules, vocal polyps rarely resolve with voice therapy and hence most often requires surgical excision. The effectiveness of

such medical treatments can be assessed using objective and subjective analysis of voice before and after the treatment. Various tools are available to analyse voice both objectively and subjectively. The usefulness of different acoustic and aerodynamic software programs have been studied, and also the correlation of such objective tools and perceptual scales were also studied in the past. However, no standard measures of voice function are available. Since voice is multidimensional and voice disorders often require pharmaceutical, surgical and non-medical treatments, both subjective and objective evaluation must be mandatory in order to assess the efficacy of the treatment process.

Need for the study

There is a dearth of literature related to voice characteristics in vocal fold polyp conditions, and the existing studies in this premise focused on to find the differences between vocal fold polyp patients and those with normal larynges in terms of perceptual, acoustic and other measurable or observable physiological signs. But, most of the studies failed to document/classify the voice characteristics based on the lesion type, size and location. A systematic documentation of voice characteristics in vocal fold polyp condition using acoustic, aerodynamic and perceptual measures are also limited in both Western as well as in Indian literature. There is a growing trend around the world on issues related to evidence based practice. The team comprising of otolaryngologist and speech language pathologist should provide the best possible practice to the client with voice pathology. Inorder to serve this purpose, there is a need to empirically document the voice parameters prior to and following the treatment process.

Aim of the study

The present study aimed to investigate the efficacy of microlaryngeal surgery in patients with vocal fold polyp by comparing the acoustic, aerodynamic and perceptual characteristics of voice before and after surgery.

Objectives of the study

The objectives of the study were three fold;

1. To analyse the acoustic, aerodynamic, and perceptual parameters of voice in patients with vocal fold polyp.

2. To investigate the effect of vocal fold polyp size, type, lesion location and lesion laterality on acoustic, aerodynamic and perceptual parameters of voice in patients with vocal fold polyp.

3. To analyse and compare acoustic, aerodynamic and perceptual parameters of voice in patients with vocal fold polyp before and after microlaryngeal surgery.

Implications of the study

i). The study would augment the Indian literature on the evidence based practice in voice disorder treatment aspects.

ii). The results of the present study would help speech language pathologist (SLP) to understand and correlate the effect of vocal polyp size, location and its type on acoustic, aerodynamic parameters and on the quality of voice.

iv). The study results would augment the knowledge of acoustic, aerodynamic and perceptual changes of voice before and after surgery due to vocal pathology (vocal fold polyp).

CHAPTER II

REVIEW OF LITERATURE

Vocal fold polyps are benign lesions usually occurring on the anterior one-third of the vocal fold. They often occur on the free edges and are usually unilateral.

Incidence and Prevalence

According to literature vocal polyps are most common structural pathology occurring in adults in the age range of 22- 45years, with slight predominance in females and rarely in children. The vocal polyps constitute approximately 7.7% of the patient's seen in ENT practices (Coyle, Weinrich, & Stemple, 2001). According to Bastian (1998) vocal fold polyp are common in men, particularly those engage inintermittent severe voice abuse. These ratios differaccording to existing literature.Many other authors have noted that the incidence was greater in men i.e. 74% (Behrendt, 1964) and 78% reported by Kleinsasser (1974).According to Salmon (1979), men are affected twice as frequently as women.Benjamin (1998) reported that vocal fold polyps are found in adults of all ages though most present between the ages of 20 and 60; and women (52%) were more frequently affected than men (48%). It is probable that the high level of employment of women and the adverse working conditions that may affect the gracile larynx of women.

Types

Pathologically vocal fold polyps are acellular, with thickened epithelium over superficial lamina propria and increased vascularity in an abundant delicate fibrin stromal matrix. They have more vasculature and less organised collagen than do nodules. Vocal fold polyps may be reddish or whitish, small or large,

sessile/broad-based (blister-like) or pedunculated/fusiform (footlike projection or attached to a stalk). It can also be haemorrhagic (have an associated feeding blood vessel) or non-haemorrhagic.

Histologically vocal fold polyps are classified into 4 types:

a. Myxoid: It is characterised by an abundance of edematous stroma appearing as lakes of pale-gray fluid beneath the epithelial layer.
b. Vascular type: It is characterised as having large, ectatic, vascular-like spaces often filled with blood.
c. Hyaline: It consists of masses of eosinophilic hyaline material within the stroma.
d. Fibrous: It consists of mildly to moderately cellular proliferations of spindled to fusiform cells.

Causes

Several factors can contribute to the development of vocal fold polyp, such as vocal abuse or overuse, chronic infections of upper air-way, allergy, smoking and gastroesophageal reflux (GER). In a prospective study done by Martins, Defaveri, Domingues, and Silva (2011)reported Tabagism (addiction to tobacco) as an important causal factor of vocal fold polyp. Tabagism accounted for about 51.31%, and alcoholism accounted for only 20%. 47% of the subjects in the study reported of gastroesophageal symptoms, 61% reported vocal overuse and 32% reported naso-sinusal symptoms. GER and respiratory infections are responsible for the inflammatory process that affects the laryngeal mucosa, predisposing the patient to the development of laryngeal lesions.

Pathophysiology

The pathophysiology involves chronic trauma to the microvasculature of the superficial lamina propria, secondary to acute or chronic vocal trauma, followed by bleeding, fibrin exudation, thrombosis, and capillary proliferation, fibrosis and basophilic or hyaline degeneration. Edema, fibrosis and vascular proliferation prevailed in vocal fold polyp as reported by Remacle, Degols, and Delos (1996) studied by revising 163 histological slides of vocal lesions. Light microscopic studies have been reported histological alterations such as predominance of epithelial hyperplasia, increase in the number of blood vessels in the lamina propria, inflammation and edema. The histological alterations have vocal trauma as the main cause, associated with the harmful effects of smoking, GER and repeated upper air-way infections on the laryngeal mucosa.

Signs and symptoms

The voice symptoms associated with vocal fold polyp varies from mild to severe depending upon the size and location of the lesion and its interference with the glottic closure during phonation. The mass of the cover of vocal fold will be increased and stiffness of the cover depends on the nature of the pathology, but the mass and stiffness of the transition and the body of vocal fold will be unaffected. The most typical voice symptoms include hoarseness, roughness or breathiness. The primary voice symptom would be hoarseness. If the polyp is pedunculated it will fall into the subglottis during phonation and may not alter the voice quality, but rather causes a sensation of breathing difficulty, particularly during inspiratory phase of breathing (inspiratory stridor).

Zhang and Jiang (2004) proposed a non-linear model to study chaotic vibrations of vocal folds with unilateral vocal fold polyp. In the study the authors found that bifurcation diagrams which showed the vocal polyp size, stiffness and damping had important effects on the vibratory characteristics of the vocal folds. They also found that an increase in polyp size tended to induce sub-harmonic patterns and chaos. In their model with a polyp, the vocal fold polyp introduces extra nonlinear stiffness and collision to the vocal folds, which produces disturbances to the glottal closure and glottal airflow and leads to vocal fold asymmetry.

Acoustic characteristics

The most widely used parameter for acoustic analysis of pathological voices is perturbation measures. Physiologically the presence of perturbation in the voice signal is indicative of some degree of irregularity in vocal fold vibration. Several specific contributing factors have been hypothesised for the same such as momentary fluctuations in neuromuscular activity, subtle asymmetries in vocal fold shape and stiffness, aerodynamic turbulence and systolic pressure shifts in vocal fold blood vessels. Although these factors contribute to the small degree of waveform aperiodicity observed in normal voices, more severe perturbations are almost always secondary to pathology.

Acoustic signs in vocal polyp would be similar to those of vocal nodules. Because of extra mass at the midpoint of the vibratory vocal fold increased aperiodicity of vibration, increased frequency perturbation and greater hoarseness, reduced phonational and dynamic range, increased jitter and shimmer, greater spectral noise would be the acoustic characteristics. These acoustic parameters vary

depending on the location and size of the lesion. Davis (1981) reported a pitch perturbation quotient (PPQ) of 0.60% and an amplitude perturbation quotient (APQ) of 11.68% for one patient with vocal fold polyp, which was higher when compared with the normal PPQ of 0.42% and APQ of 6.14%.

Morente et al. (2001) conducted an objective evaluation of 100 voices of healthy adults and 60 adults with nodules and polyps. They found statistically significant differences in fundamental frequency (F0), jitter and shimmer values between healthy and pathological voices. They found that in the healthy group, mean F0was 139.72 Hz in men and 267.33 Hz in women, jitter was 0.24 and shimmer was 2.10. In patients with polyps the F0 values were reduced with a mean F0 of 119.75 Hz in men and 218.26 Hz in women;whereas the jitter and shimmer values were higher i.e. jitter was 0.50 and shimmer was 4.34.

Aerodynamic characteristics

Aerodynamic analysis of voice involves measuring changes in air volume, flow and pressure during phonation. Variation in these parameters allows insight in to both respiratory and laryngeal performance. In patients with vocal fold polyp increased airflow may be present if the polyp interferes with complete glottal closure and because of excessive air escape through glottis, breathiness would be perceived. Iwata, Esaki, Iwami, and Mimura (1976) pointed out the difference in air flow rates with respect to unilateral versus bilateral vocal fold polyp. They reported an average airflow rate of 253 mL/sec for 29 male patients and 247 mL/sec for 19 female patients with unilateral polyp; and airflow rates of 256 mL/sec for 8 male patients and 359 mL/sec for 8 female patients with bilateral vocal fold polyp. The

values were high for unilateral polyp condition than normal larynges condition. However bilateral polyp condition leads to more air-leakage than unilateral polyp.

Al-Malki (2005) conducted an experimental controlled study to evaluate the effect of vocal fold polyps on aerodynamic measures. The study included two groups; Group I consisted of 31 adult patients (20 males and 11 females) with a mean age of 40.7±10.6 years with vocal fold polyps (16 had polyp on right-side, 11 had polyp on left-side and 4 had bilateral polyp); Group II consisted of 30 normal adult subjects (18 males and 12 females) with a mean age of 35.6±12.9 years. Both the groups were subjected to aerodynamic analysis using Aerophone II. Nine parameters were assessed, which included (1) Vital capacity (VC), (2) Maximum phonation time (MPT), (3) Phonation quotient (PQ), (4) Mean flow rate (MFR), (5) Mean SPL, (6) Subglottic pressure (P_{sub}), (7) Glottal aerodynamic input power (P_g), (8) Glottal efficiency (E_g), (9) Glottal resistance (R_g). The results showed a significant increase in MFR, PQ, P_{sub}, P_g for Group I compared to Group II; and a significantly decrease in MPT and R_g. The author concluded that phonatory gap caused by the presence of vocal polyp and subsequent air leakage can be attributed to the above findings. The author did not explain the aerodynamic differences with respect to right-sided versus left-sided polyp and unilateral versus bilateral polyp conditions.

Perceptual characteristics

In individuals with vocal fold polyp, the perceptual characteristics reported in literature are hoarseness, roughness or breathiness. Colton et al. (1997) studied 25 patients with vocal fold polyp, where 35% of women and 17% of men exhibited a moderate level of dysphonia, whereas 22% of women and 4.35% men exhibited

severe degree of dysphonia. According to them the polyp group exhibited a greater severity of dysphonia than nodule group. Several other recent studies also reported perceptual differences when compared with normal subjects (Giovanni et al., 1999; Uloza et al., 2005; & Katusic et al., 2008).

Most of the perceptual studies done on individuals with vocal fold polyp where GRBAS scale was employed (Giovanni et al., 1999; Uloza et al., 2005; & Katusic et al., 2008). The grade, roughness, and breathiness parameter were more explored, since they are more intuitive and natural, which thus lead the raters to less subjectivity than asthenia and strain.

Management

The preferred management option for structural lesions is phonosurgery and voice conservative procedures. Unlike vocal nodule, vocal polyps would not resolve with voice therapy. It often requires phonosurgery, especially if there is no improvement following voice conservation program. A combination of phonosurgery and voice rehabilitation therapy is optimal choice for vocal polyp. According to Deem andMiller,(2000) small polyps rarely disappear spontaneously. More often treatment is required which typically involves surgical removal of the lesion. Once a polyp is removed, voice therapy is usually recommended to instruct how to decrease vocally abusive behaviors. Voice therapy would help to avoid the recurrence of vocal fold polyp and decrease hoarse and breathy voices (Deem & Miller, 2000).

Since it is rare for polyps to disappear spontaneously, they are often subject to microsurgery (Bouchayer & Cornut, 1991) or surgical removal (Sataloff, 1997). The occasional small, early haemorrhagic polyp will resorb completely with several

months of conservative treatment, although surgical removal is typically required to return the vocal fold to its normal appearance, vibratory function and to return the voice to normal capabilities (Bastian, 1998). One study by Srirompotong, Saeseow, and Vatanasapt (2004) reported six cases of small vocal polyps that completely resolved using conservative treatment.

For small benign lesions like vocal polyp microlaryngeal surgeries are the optimal choice. Until 1985, Hirano (1985) described the histology of vocal fold; vocal fold stripping were the most common surgical approach for benign lesions, which results in loss of mucosal vibration and loss of voice quality in many patients. The knowledge of the histological layers of vocal fold made possible to remove the lesions without disturbing the deep layers. Endolaryngeal phonomicrosurgery is the common procedure done for these benign lesions. These phonosurgeries were aimed to improve vocal function based on vocal fold physiology principles. Phonomicrosurgery requires use of small, delicate surgical instrumentation and is done with maximal control via high power microlaryngoscopy for optimal results, by a trained Otolaryngology surgeon. The goal of each phonosurgery is to restore normal laryngeal physiology. The success of each surgical procedure depends on the voice quality after the treatment. The effect of phonosurgery on voice can be assessed by comparing the voice before and after the surgery by means of perceptual evaluation, since it is considered to be the "gold standard" procedure over the years; and it should be supplemented with objective voice evaluation.

Related Studies

Woo, Casper, Colton, and Brewer (1994) examined the aerodynamic and laryngovideostroboscopy (LVS) on 50 patients (26 unilateral vocal fold polyp, 9 polypoid degeneration with Reinke's edema, 5 intrafold cyst, 5 benign hyperplasia, 4 sulcus vocalis and 1 vocal fold nodule) before and after microlaryngeal surgery for benign vocal fold lesions. The authors found significant differences in post-operative findings with a lowering of mean flow rate, an increase in glottal efficiency and an increase in maximum sound pressure level along with an acceptable perceptual voice quality.

Giovanni, Revis, and Triglia (1999) conducted a prospective study to find out the sensitiveness of oral air-flow measures along with other acoustic measures for the assessment of voice improvement after phonosurgery. The authors compared the objective, aerodynamic and acoustic measurement of voice before and after phonosurgery in 27 patients with lesions such as nodules, vocal polyp, Reinke edema and epidermic cyst. Sustained phonation of vowel /a/ was recorded, one day before surgery and 3 months after surgery. GRABS scale was employed for perceptual analysis and objective measures analysed were oral air-flow, jitter and shimmer. The authors found that oral air-flow was significantly greater in patients with poor perceptual results than those with good perceptual results; and hence oral air-flow on a sustained vowel allows simple, quick and reliable clinical assessment of the outcome of phonosurgery and can be used in association with conventional acoustic measurements such as jitter and shimmer.

Uloza, Saferis, and Uloziene (2004) investigated the efficacy of Endolaryngeal Phonomicrosurgery (EPM) using perceptual and acoustic assessment of voice before and after surgery. Phonation of sustained vowel /a/ was recorded and evaluated twice: before and 2-weeks after EPM. The experimental group included 148 patients with vocal nodules (25 females within the age range of 19-50years), vocal polyp (32 males within the age range of 16-53years), papilloma (12 males within the age range of 17-53 years and 12 females within the age range of 15-67 years), glottic carcinoma (17 males within the age range of 48-75 years) and unilateral vocal fold paralysis (50 females within the age range of 22-73 years); andthe control group included 88 persons (43 males and 45 females within the age range of 22-63years) with no voice complaints and no laryngeal pathology. For perceptual evaluation the authors used the GRABS scale. Acoustic parameters such as fundamental frequency, percent of jitter and shimmer and normalized noise energy (NNE) were measured using Dr. Speech software from Tiger Electronics.

The authors found that all the parameters were significantly higher in the experimental group and both perceptual and acoustic assessment revealed statistically significant improvement of voice in vocal fold nodules and polyp patients after EPM. The authors also found the restoration of normal voice when the lesions were removed post-operatively, i.e. the acoustic parameters of experimental group were as close to the control group and thus provided an accurate and documentable evidence of the results of surgical treatment.

Ragab, Elsheikh, Saafan, and Elsherief (2005) conducted a prospective randomized controlled study to investigate the efficacy and safety of two radio-surgical procedures for benign superficial vocal fold lesions. The two procedures

considered for the study were radiofrequency phonosurgery and cold-knife excision. A total of 50 patients (27males and 23 females) with a mean age of 37±12 were included. The pathologies considered were vocal fold nodules (9 cold knife and 11 radiofrequency), vocal fold polyp (14 cold knife and 13 radiofrequency) and Reinke's edema (2 cold knife and 1 radio frequency).

The researchers compared both perceptual and acoustic analysis prior to surgery and after the surgery. For perceptual analysis three phoniatrists rated the voice samples on a simplified version of the GRABS scale (GRB), using a 4 point grading system. Inorder to assess the patient's acceptability of his/her own voice, a visual analogue scale (VAS) were used. The computerised voice laboratory was used to analyse acoustic parameters like jitter and shimmer. The researchers did not find any significant difference between the two surgical procedures i.e., cold-knife and radio-frequency phonosurgery, in terms of VAS, GRB and also with respect to acoustic analysis ($p > 0.05$). But the perceptual evaluation (GRB and VAS) showed a significant improvement from pre- to post-operative conditions ($p < 0.001$). The jitter and shimmer values also showed a significant reductionafter surgery. The researchers concluded that the radio-phonosurgeries (both cold knife and radio-frequency) can be used for benign vocal fold lesions as an effective method, which results in less amount of damage/risk to laryngeal structures and thereby improved voice quality after the surgery.

Toran and Lal, (2010) objectively analysed the changes in vocal quality in a group of patients with vocal polyps before and after microlaryngeal phonosurgery (MLPS). A total of 23 patients with unilateral (15 patients) and bilateral (8 patients) vocal fold polyp participated in the study, out of which 12 were males and 11 were

females. The mean age considered for the study was 43.9 (±12.3) years. Flexible fibre optic and video-stroboscopic examination were performed as a part of laryngeal examination. Voice therapy for a minimum of two sessions was provided for all the patients before the MLPS. Voice samples of continuous phonation of vowel /i/ at habitual pitch level were recorded using Dr. Speech software. Three times the recording was done and the median values were considered. The authors considered only 4 acoustic parameters which included fundamental frequency (F0), jitter, shimmer and harmonic- to noise- ratio (HNR). The recordings were done before and also done between third and fourth week following MLPS. The authors found a significant reduction in all the values except jitter value, following MLPS. This study supported the results of Zeitels, Hillman, and Desloge (2002), where they reported a significant reduction in shimmer but not in jitter values following MLPS. The authors thus documented objectively the changes in voice quality in patients with vocal polyps following MLPS. But the authors did not discussed about the acoustic measures with respect to gender difference or with respect to lesion type (unilateral versus bilateral, and its size).

Petrovic-Lazic, Babac, Vukovic, Kosanovic, and Ivankovic (2011) investigated the acoustic correlates of vocal quality of patients with vocal fold polyp, before and after endolaryngeal phonomicrosurgery (EPM). The study group included 46 females aged 18-61 years with vocal fold polyp and 21 age and gender matched control subjects. The voices of the study group were recorded and analysed twice: before EPM and 3-weeks post surgically. Sustained phonation of vowel /a/ was recorded and analysed using MDVP software. The authors measured seven acoustic parameters: fundamental frequency variation (vF0), frequency perturbation measure [jitter (%)] and amplitude perturbation measure [shimmer (%)], NHR

(noise to harmonic ratio), voice turbulence index (VTI), pitch perturbation quotient [PPQ (%)], amplitude perturbation quotient [APQ (%)]. The authors found that all the parameters of patient group were higher compared to the control group and the scores improved significantly (become better) after EPM. The authors also found that the multi-dimensional voice analysis was useful to evaluate the pre and post-operative voice status.

One of the Indian studies of this kind was conducted by Nerurkar, Narkar, Joshi, Kalel, and Bradoo (2007). A total of 30 cases with hoarseness of voice due to benign organic lesions of the vocal folds (20 polyps, 6 sub-epithelial cysts, 2 nodules and 2 respiratory papillomas) participated in the study. The authors performed one to one matching of similar pathological lesions.Both acoustic and aerodynamic analysis of voice was done before and after microflap surgery with and without infiltration technique using cold instruments. Fundamental frequency, jitter and shimmer were considered for acoustic analysis, whereas maximum phonation time was the only aerodynamic parameter studied. All the parameters improved in both with-infiltration and without-infiltration group, but infiltration group showed statistically significant improvement. The jitter and shimmer values showed a reduction following surgery, the fundamental frequency in all patients returned to normal values for their respective age and gender.

Another recent study conducted by Verma, Pal, and Raj (2010), where the authors tried to investigate the improvement of voice characteristics following phonosurgery. 100 subjects with organic lesions of the vocal fold comprising of all age group and gender were subjected to acoustic analysis before and after the surgery using VAGHMI speech analysis program. They found significant

improvement in parameters such as fundamental frequency, harmonics to noise ratio, jitter, shimmer and s/z ratio after phonosurgery; which helped in identifying the degree of hoarseness and the severity related to the vocal lesion. The authors considered only four acoustic measures and did not consider aerodynamic and perceptual measures in their study.

Most of the published studies were not reflected the multi-dimensional characteristics of voice as some did not considered acoustic, aerodynamic and perceptual aspects of voice. For example, studies done by Woo et al. (1994); Nerurkar et al. (2007); Verma et al. (2010) and Petrovic-Lazic et al. (2011) did not included the perceptual analysis of voice. Also, studies done by Toran et al. (2010); Verma et al. (2010)and Petrovic-Lazic et al. (2011) did not considered aerodynamic measures of voice. Hence there is a need to empirically document the treatment efficacy by considering the three aspects of voice like acoustic, aerodynamic and perceptual domains before and after surgery.

The present study aimed to investigate the efficacy of microlaryngeal surgery (MLS) in patients with vocal fold polypby consideringthe acoustic, aerodynamic and perceptual characteristics of voice before and after microlaryngeal surgery.

CHAPTER III

METHOD

Subjects

Tenpatients who consulted the speech language clinic at AIISH with the complaint of change in voice, who were later diagnosed as having vocal fold polyp were considered for the study. The diagnosis of vocal fold polyp was confirmed by the ENT doctor using video-endoscopy. Out of the ten participants, 8 were males and 2 were females. They were within the age range of 42-66 years (mean age: 55.2 years). Table 3.1 shows the details of the subjects along with lesion information.

Table 3.1: *Details of the ten subjects*

Subjects	**Age/ Gender**	**Size of the lesion**	**Type of the lesion**	**Laterality of the lesion**
Patient A	63 years/ Male	Large	Pedunculated	Bilateral
Patient B	42 years/ Male	Large	Sessile	Unilateral (Right vocal fold)
Patient C	61 years/ Male	Large	Sessile	Unilateral (Right vocal fold)
Patient D	65 years/ Male	Large	Pedunculated	Unilateral (Right vocal fold)
Patient E	52 years/ Male	Medium	Pedunculated	Unilateral (Right vocal fold)
Patient F	66 years/ Female	Large	Pedunculated	Unilateral (Right vocal fold)
Patient G	46 years/ Female	Large	Sessile	Unilateral (Left vocal fold)
Patient	42	Mediu	Sessile	Unilateral

H	years/ Male	m		(Left vocal fold)
Patient I	65 years/ Male	Mediu m	Peduncula ted	Unilateral (Right vocal fold)
Patient J	50 years/ Male	Mediu m	Peduncula ted	Unilateral (Right vocal fold)

Procedure

The acoustic, aerodynamic and perceptual voice assessments were carried out for the ten subjects one or two days before the surgery. The same voice assessments were repeated three weeks post-operatively for the three subjects who underwent MLS.

Instrumentation

1. Acoustic analyses were measured using Multi-Dimensional Voice Program (MDVP) software of CSL 4500 model (KAY PENTAX, New Jersy, USA).
2. Aerodynamic analyses were measured using RMS Helios 701 model Spirometer [Recorders and Medicare Systems (P) limited, Chandigarh, India].
3. Perceptual analyses were done using GRABS scale.

Acoustic analysis

The seven acoustic parameters considered for the present study are,

1. Variation in fundamental frequency (vF0)
2. Frequency perturbation measure [jitter (%)]
3. Amplitude perturbation measure [shimmer (%)]
4. Noise to harmonic ratio (NHR)
5. Voice turbulence index (VTI)

6. Pitch perturbation quotient [PPQ (%)]
7. Amplitude perturbation quotient [APQ (%)]

Task for acoustic analysis

The participants were seated comfortably in a noise free room. The distance between the microphone and mouth was kept constant at 5 cm and the subjects were asked to phonate /a/ vowel for atleast4 seconds at a comfortable pitch and loudness.

Aerodynamic analysis

The four aerodynamic measures analysed are,

1. Maximum phonation duration (MPD)
2. S/Z ratio
3. Forced vital capacity (FVC)
4. Mean air-flow rate (MAFR)

Task for aerodynamic analysis

(1) *Maximum phonation duration (MPD)*: The subjects were asked to sustain the vowel /ah/ as long as possible at a comfortable pitch and loudness level after a deep inhalation. Three trails were carried out and the longest duration of the three trials, was taken as MPD.

(2) *S/Z ratio*: The subjects were asked to take a deep breath and sustain /s/ sound as long as possible in one exhalation without straining and the time taken to sustain the sound /s/ was noted. Then, the subjects had to sustain /z/ sound as long as possible. The s/z ratio is the ratio of the duration of sustained /s/ to the duration of sustained /z/.

(3) *Forced vital capacity (FVC)*: The subjects were seated comfortably with their back straight, and the mouth piece of the instrument was held in position. The subjects were then asked to exhale air as fast and forcefully as possible into the mouth piece by having adequate lip seal after a deep inhalation.

(4) *Mean air-flow rate (MAFR)*: The subjects were asked to take a deep breath and phonate /ah/ vowel as long as possible at a comfortable pitch and loudness level into the mouth piece by having adequate lip seal. It is measured by dividing the amount of air-flow expired by the duration of phonation.

Perceptual analysis

Two listeners (Listener 1 and Listener 2) performed the perceptual analysis of the voice samples. The listeners were two speech language pathologists (SLP) having adequate experience in diagnosis and treatment of voice disorders. The GRBAS scale was used for the perceptual rating. The thirteen samples (10 pre-surgical and 3 post-surgical), were randomized before the presentation and the listeners were kept blind regarding the diagnosis of the subjects. The edited three second duration sample of /ah/ phonation was played to the listeners using headphones, and were asked to rate the five parameters on a 4-point rating scale, where 0 indicates normal, 1 indicates slight disturbance, 2 indicates moderate disturbance, and 3 indicates severe disturbance. GRBAS scale was used, since it is a widely accepted standard perceptual scale and also it has been considered as gold-standard for voice evaluation. Studies have shown that GRBAS scale parameters are reliable based on low intra-rater and inter-rater variances, and relevant for practical use (Dejonckere et al., 1993). The GRBAS scale was developed by Japanese Society of Logopedics and Phoniatrics as a minimum analysis of voice quality for use by all

members of the voice clinic team. The voice quality would be rated on five parameters, which includes:

Grade (G) – the overall degree of hoarseness or severity of the voice abnormality.

Roughness (R)– the psychoacoustic impression of the irregularity of vocal fold vibration.

Breathiness (B) – the psychoacoustic impression of the extent of air leakage through the glottis.

Asthenia (A) – the overall weakness or lack of power in the voice.

Strain (S) – the psychoacoustic impression of hyper-function during phonation.

Statistical analysis

A. **Acoustic data**: Statistical analysis was performed using SPSS 16.0 for Windows (SPSS Corporation, Chicago, IL). One sample t-test was employed to find out the mean and standard deviation of the pre-surgical acoustic parameters for the ten patients and also employed to compare between the mean values of the pre-surgical acoustic parameters of ten patients and the expected normative database for statistical significant differences. The pre-surgical acoustic parameters were also analyzed employing Mann-Whitney U-test to find out the significant difference in terms of lesion size and lesion type.

B. **Aerodynamic data**: SPSS 16.0 software was used for statistical analysis. The mean and standard deviation value for the aerodynamic parameters were calculated and was compared with the normative values. Mann-Whitney U-test was employed to

find out whether there is any significance of difference in terms of size and type of lesion.

C. **Perceptual data**: For checking the inter-judge reliability, Cronbach's Alpha test was employed using SPSS 16.0.

CHAPTER IV

RESULTS & DISCUSSION

The study was aimed to find out the effectiveness of microlaryngeal surgery in patients with vocal fold polyp by comparing the voice parameters before and after surgery. In addition, the study also tried to find out the effect of vocal polyp size, type, lesion location and lesion laterality on the acoustic, aerodynamic and perceptual parameters of voice in patients with vocal polyp.

The results of the study are discussed under four main headings:

A. Acoustic Analysis

i. Comparison of the pre-surgical acoustic parameters

The mean and standard deviation for the seven acoustic parameters for the ten subjects were tabulated in table 4.1. The mean values were compared with the database (expected norm) values. The study found that all the acoustic parameters (except VTI) have shown significant difference when compared with the expected norms ($p < 0.05$).

Table 4.1: *Mean and standard deviation (SD) of acoustic parameters*

S. No.	Parameters	Mean value of participants		Database (Expected Norms)	*p*-value
		Mean	SD		
1	vF0 (%)	18.54	19.47	0.94	.019*
2	Jitter percent (%)	6.58	4.40	0.59	.002*
3	Shimmer percent (%)	15.53	8.58	2.52	.001*
4	NHR	0.37	0.24	0.12	.010*
5	VTI	0.11	0.09	0.05	.07
6	PPQ (%)	4.25	2.92	0.34	.002*
7	APQ (%)	12.18	6.57	1.99	.001*

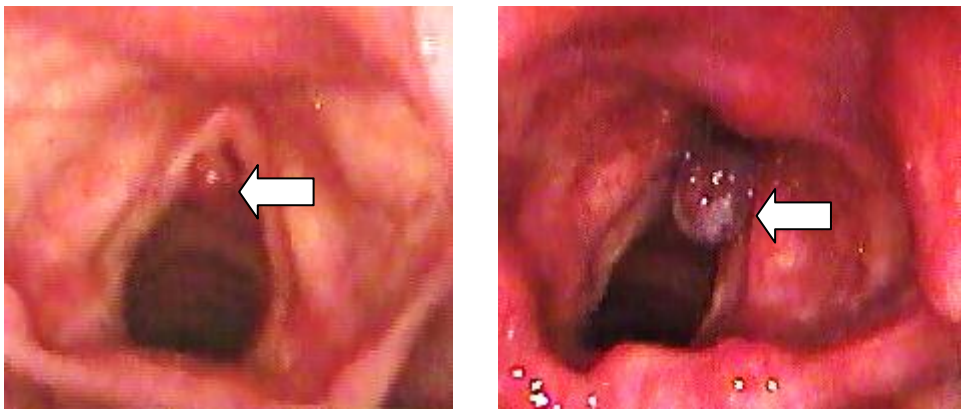
The fundamental frequency variation (vFo) gives the standard deviation of variation in fundamental frequency. The fundamental frequency during sustained phonation is assumed to be steady with no variations, but if there is any lesion in the vocal fold which impedes the normal vibratory characteristics, the fundamental frequency may altered. In this study, the mean vF0 for the patients with vocal fold polyp was 18.54% which is higher than the expected norms and the difference was significant at 0.05 levels. The jitter and shimmer values were the most frequent acoustic measure used for most of the study. These two measures are sensitive parameters, which give information about cycle to cycle variability of frequency and amplitude, respectively. Jitter is considered to be the main measure for micro-instability in vocal fold vibration. In this study both jitter and shimmer values were higher than the expected norm with a significant *p*-value of .002 and .001, respectively. PPQ is the relative evaluation of the period-to-period variability in pitch with in the analysed voice sample with a smoothing factor of five periods. It

measures the short-term irregularity of the pitch period of the voice. Likewise, APQ measures the relative period-to-period variability of the peak to peak amplitude with in the analyzed voice sample at smoothing of eleven periods. Higher PPQ and APQ values are expected for breathy and hoarse voice. The present study found significantly higher PPQ and APQ for the patient group. NHR and VTI constitute the two noise related measures in this study. NHR value for the patient group showed a significantly higher value when compared to the database norms (*p*-value of .01). VTI value also found to be higher in patients with vocal fold polyp compared with norms but it was not statistically significant. Incomplete glottal closure because of the presence of polyp in the vocal folds leads to air leakage, which impose more noise component to the voice.

Davis (1981) reported higher PPQ and APQ values in patients with vocal fold polyp. The results of the present study were also in consonance with studies done by Uloza et al. (2004) who reported higher jitter and shimmer values for patients with vocal fold polyp. Petrovic-Lazic (2011) also reported higher jitter, shimmer, NHR, VTI, PPQ and APQ values in patients with vocal fold polyp.

ii. Comparison of acoustic parameters as a function of size of the lesion (medium versus large)

The endoscopic image of large and medium sized polyp is shown in figure 4.1.



(a) (b)

Figure 4.1: *Endoscopic images of medium (a) and large (b) sized vocal fold polyp*

Mann-Whitney U-test was employed to find out whether any significant differences exist among the acoustic parameters of those patients with medium sized polyp and large sized polyp. The medium sized group consisted of 4 patients and large sized group consisted of 6 patients. Out of the seven acoustic parameters, only two i.e. shimmer percent (p of 0.033) and APQ (p of 0.038) showed a significant difference. Table 4.2 shows the mean and results of Mann-Whitney U-test between medium size and large size polyp group for acoustic parameters.

Table 4.2: *Mean and the results of Mann-Whitney U-test for acoustic parameters for lesion size comparison*

S.No.	Parameters	Mean for Medium sized group	Mean for Large sized group	*p*- value
1	vF0 (%)	8.7	25.09	.201
2	Jitter percent (%)	3.67	8.5	.136
3	Shimmer percent (%)	8.45	20.24	.033*
4	NHR	0.21	0.47	.055
5	VTI	0.09	0.12	.198
6	PPQ (%)	2.4	5.48	.136
7	APQ (%)	6.44	16	.038*

iii. Comparison of the acoustic parameters as a function of type of lesion (sessile versus pedunculated)

The endoscopic image of sessile and pedunculated vocal fold polyp is shown in figure 4.2.

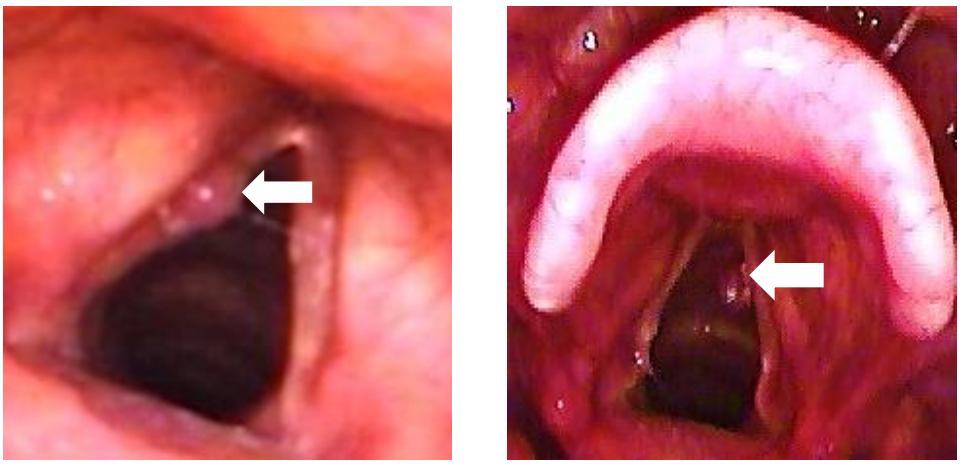


Figure 4.2: *Endoscopic images of sessile and pedunculated vocal fold polyp*

Mann-Whitney U-test was employed to find out the significance of difference in terms of type of lesion, i.e. to find out the significance of difference for the sessile vocal fold polyp group and pedunculated vocal fold polyp group. The sessile group consisted of 4 patients and the pedunculated group consisted of 6 patients. The study found that the acoustic parameters like NHR and PPQ were similar. The *p* value for the group difference was greater than .05 for all the parameters, indicative of no significance difference. Table 4.3 shows the mean and results of Mann-Whitney U-test between sessile and pedunculated group for acoustic measures.

Table 4.3: *Mean and the results of Mann-Whitney U-test for acoustic parameters for lesion type comparison*

S.No.	Parameters	Mean for sessile group	Mean for pedunculated group	*p*- value
1	vF0	10.57	23.85	.522
2	Jitter percent (%)	6.96	6.32	1.000
3	Shimmer percent (%)	16.58	14.82	.831
4	NHR	0.34	0.38	.748
5	VTI	0.08	0.13	1.000
6	PPQ (%)	4.38	4.16	.831
7	APQ (%)	13.65	11.20	.831

iv. Comparison of acoustic parameters in terms of lesion location (anterior versus posterior) and laterality of lesion (unilateral versus bilateral) could not be done, since there was no representational group for the comparison.

B. Aerodynamic Analysis

i. Comparison of pre-surgical aerodynamic parameters

The mean values for the four aerodynamic measures for the patient group was calculated and compared with the expected normative range which is depicted in table 4.4. All the mean values showed a difference from the expected normative range.

Table 4.4: *Mean and normative value for aerodynamic parameters*

S.No.	Parameters	Normative range	Mean value of participants
1	MPD	>15 secs	7.99 sec
2	s/z ratio	0.9 to 1.1	1.3
3	FVC	>2.5 liters	1.7 liters
4	MAFR	80-180 cc/sec	238.6 cc/sec

The mean values of participants showed a lower MPD values, higher s/z ratio, lower FVC values and higher MAFR values. The lower MPD values can be due to more air escape through open glottis because of the presence of polyp. The s/z ratio indicates the respiratory and/or phonatory efficiency. A value of 0.9 to 1.1 is considered as normative range. In the present study, the mean value of s/z ratio was slightly above the expected norm indicative of laryngeal dysfunction in patient group i.e. the co-ordination between the laryngeal and respiratory system gets altered due to the presence of vocal fold polyp. The lower FVC values in patients with vocal fold polyp can be attributed to the incomplete glottal closure because of the presence of vocal polyp. The aperiodicity of the vocal fold vibration due to the presence of polyp can be the reason for greater MAFR values.

The results of the present study were in consonance with the findings of other existing literature in this regard. Iwata et al. (1976) reported higher air flow rates for vocal fold polyp patients. The results were also in agreement with the findings of Al-Malki (2005) who reported a significant increase in mean air-flow rate and a significant decrease in maximum phonation time. The present study found relatively lesser FVC value when compared to normative value.

i. Comparison of aerodynamic parameters in terms of size of lesion (medium versus large)

The parameters were analyzed for finding whether any differences exist in groups with medium sized polyp group and large sized polyp group, by employing Mann-Whitney U-test. The results showed no significant difference among the two groups (p> .05). The mean aerodynamic values between medium sized versus large sized group were shown in table 4.5.

Table 4.5: *Mean and the results of Mann-Whitney test values for aerodynamic parameters for lesion size comparison*

S.No.	Parameters	Mean for medium sized group	Mean for large sized group	*p*- value
1	MPD	10.11	6.58	.334
2	s/z ratio	1.3	1.2	1.000
3	FVC	1.99	1.45	.136
4	MAFR	228.16	245.6	.670

ii. Comparison of aerodynamic parameters in terms of type of lesion (sessile versus pedunculated)

The aerodynamic parameters were also analyzed to see whether any significance of difference exist among sessile versus pedunculated group. Table 4.6 shows the mean and *p*-value for aerodynamic parameters between sessile and pedunculated group. The results showed no significant difference exist among the two groups ($p > .05$).

Table 4.6: Mean and *p-value for aerodynamic parameters for lesion type comparison*

S.No.	Parameters	Mean value of sessile group	Mean valve of pedunculated group	*p*- value
1	MPD	9.75	6.82	.334
2	s/z ratio	1.21	1.37	.240
3	FVC	1.89	1.5	.522
4	MAFR	260.5	223.94	.286

Iwata et al. (1976) reported higher air-flow rates for patients with bilateral vocal fold polyp than unilateral polyp patients. But in this study no such findings could be done, since there was no representational group for the laterality (unilateral versus bilateral) comparison. The present study did not find any difference in aerodynamic parameters between sessile and pedunculated group.

C. Pre and post-surgical comparison of acoustic and aerodynamic parameters

Out of 10 patients with vocal fold polyp, only 3 patients (Patient A, B and C) underwent microlaryngeal surgery. The pre and post comparison of acoustic and aerodynamic parameters are discussed for individual patients, which are as follows;

Patient A

The acoustic and aerodynamic parameters of patient A was measured before and after microlaryngeal surgery and values obtained is shown graphical representations in figure 4.3 and 4.4, respectively. All the seven acoustic parameters showed a reduction following microlaryngeal surgery. The MPD value increased from 4.5 secs to 15 secs following surgery and also FVC values showed an increase from 1.67 liters to 2.65 liters after the surgery, which is indicative of improved glottal closure. The s/z ratio reduced to 1.1, indicating normal respiratory and laryngeal co-ordination. MAFR value showed a reduction from 371cc/sec to 213 cc/sec, indicating reduced aperiodicity of vocal fold vibration.

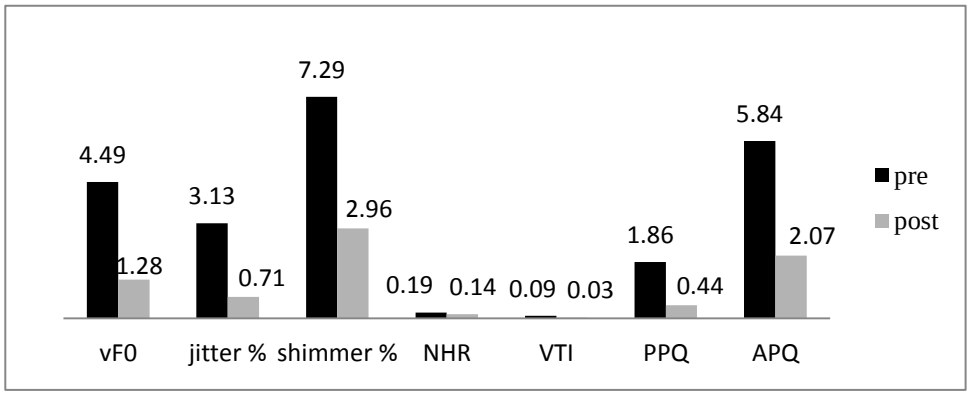


Figure 4.3: *Pre and post-surgical values of acoustic parameters of patient A*

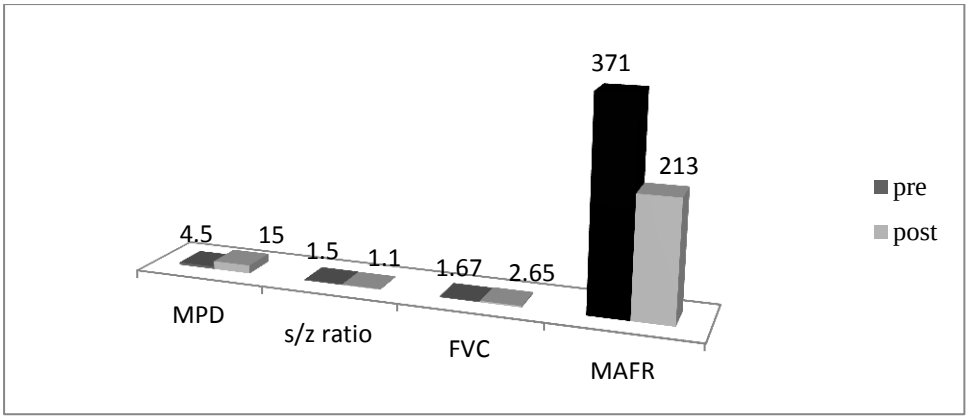


Figure 4.4: *Pre and post-surgical values of aerodynamic parameters of patient A*

Patient B

The pre and post-surgical acoustic and aerodynamic values are shown in figure 4.5 and 4.6, respectively. All the seven acoustic parameters showed a reduction following the surgery, indicative of efficacy of the surgical treatment. The MPD and FVC values showed an increase following surgery indicating improved respiratory and laryngeal efficiency. The s/z ratio decreased to 1.1 indicating normal laryngeal and respiratory co-ordination. The MAFR values showed a reduction from 343 cc/sec to 172 cc/sec, which falls within the normative range of 80-180 cc/sec.

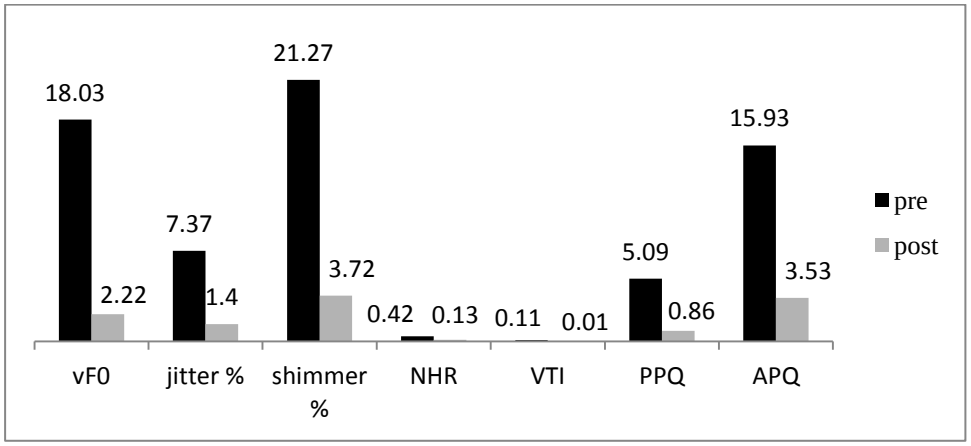


Figure 4.5: *Pre and post-surgical values of acoustic parameters of patient B*

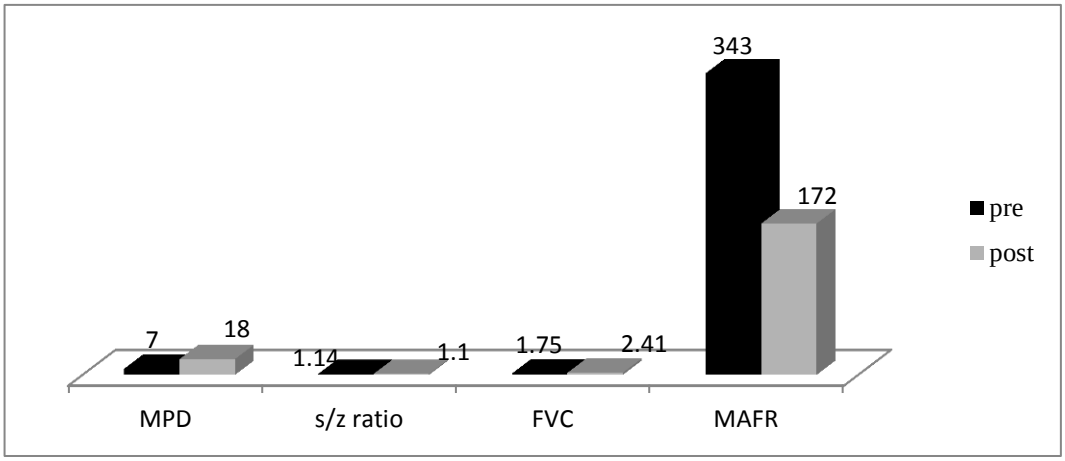
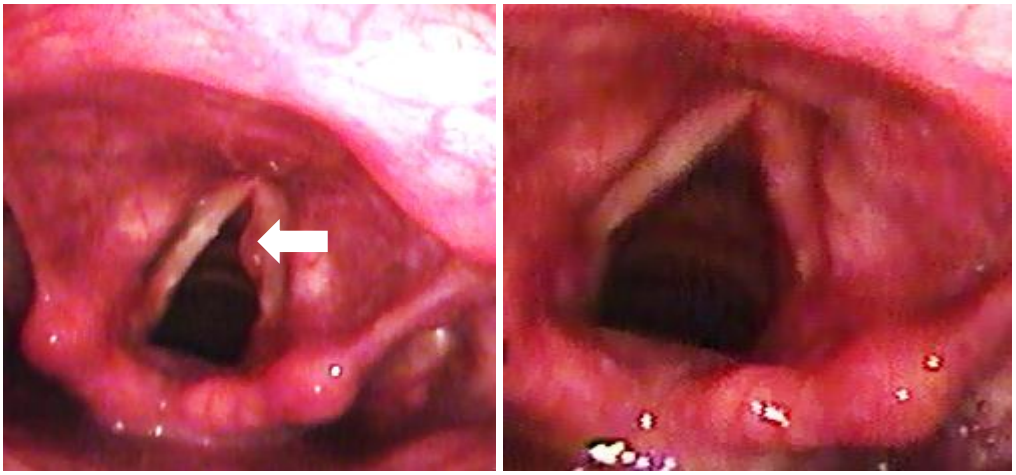


Figure 4.6: P*re and post-surgical values of aerodynamic parameters of patient B*

Patient C

Pre-surgical endoscopy revealed a large sessile polypoidal mass on the right vocal fold at the junction of anterior one-third and posterior two-third of the vocal fold. The surface of the mass was smooth. Patient C underwent microlaryngeal surgery and reported back with improved voice quality. Post-operative endoscopy revealed little congestion of the right vocal fold, otherwise normal vocal fold movement. The histological report revealed gelatinous polyp of 0.5 cm with no evidence of granulomas or malignancy. The pre and post-surgical endoscopic image of patient C is shown in figure 4.7.



(a) (b)

Figure 4.7: (a) *Pre and (b) post-surgical endoscopic image of Patient C*

The figure 4.8 and 4.9 represents the graphical representation of pre and post-surgical acoustic and aerodynamic values, respectively. The seven acoustic parameters considered for this study showed a reduction following surgery indicating improvement after surgery. The MPD and FVC values improved following surgery. The s/z ratio and MAFR values also improved and falls within the normative range.

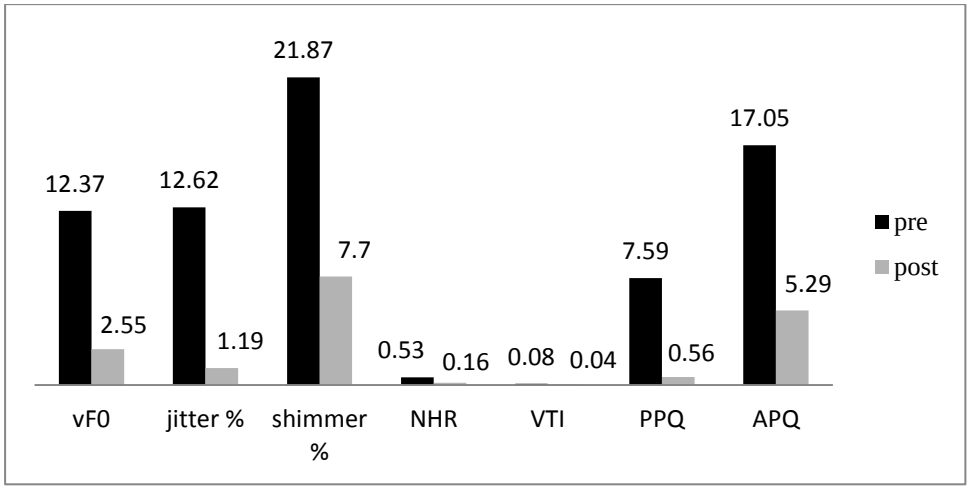


Figure 4.8: *Pre and post-surgical values of acoustic parameters of patient C*

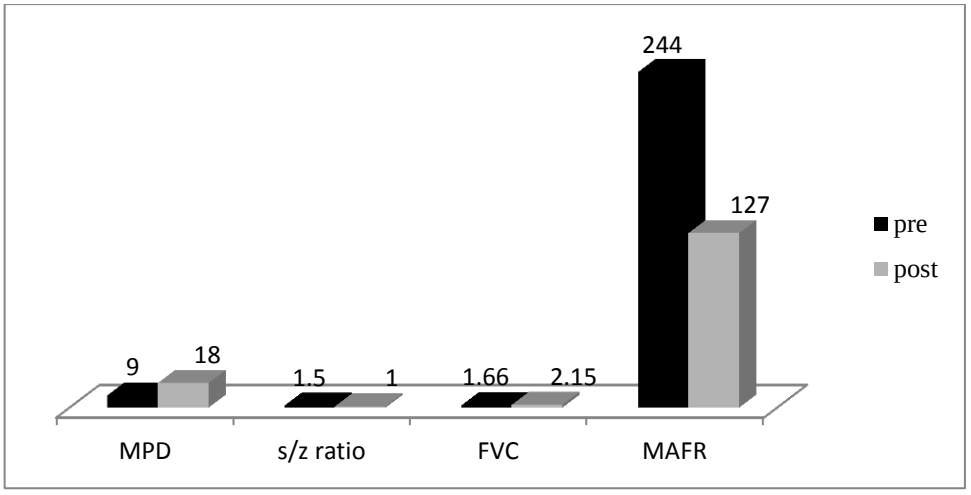


Figure 4.9: *Pre and post-surgical values of aerodynamic parameters of patient C*

The result of the present study was in consonance with existing studies done on this premise. Uloza et al. (2004) reported significant improvement of voicein vocal fold polyp patients after phonosurgery on parameters such as jitter and shimmer.

Ragab et al. (2005) and Nerurkar et al. (2007) also reported reduced jitter and shimmer values following phonosurgery in patients with vocal fold polyp. Zeitels et al. (2002) and Toran and Lal (2010) reported a reduction in shimmer and HNR values following microlaryngeal surgery. Verma et al. (2010) reported improved HNR, jitter, shimmer and s/z ratio following phonosurgery in patients with organic lesions. Furthermore, Petrovic-Lazic (2011) reported improvement in all the seven acoustic parameters considered in their study following phonomicrosurgery in patients with vocal fold polyp.

Hence, the result of the present study reveals the efficiency of the microlaryngeal surgery which improved the acoustic as well as aerodynamic parameters of voice following surgery.

D. Perceptual Analysis

i. Perceptual analysis of voice of 10 patients with vocal fold polyp

Table 4.7: *Perceptual analysis by listeners using GRBAS scale for the vocal fold polyp patients*

Parameter	**Listener 1**	**Listener 2**
Grade	2.8	1.9
Roughness	2.6	1.8
Breathiness	3	1.8
Asthenia	2.7	1.8
Strain	2.9	1.7
Mean	**2.8**	**1.8**

The perceptual evaluation by listener 1 indicated that the patient with vocal fold polyp has moderate to severe (mean of 2.8) disturbance on all parameters of GRBAS scale, whereas the listener 2 indicated it as slight to moderate (mean of 1.8) disturbance on all the parameters. Table 4.7 shows the results of GRBAS scores rated by two listeners.

Previous studies on perceptual analysis of voice in patients with vocal fold polyp reported moderate to severe disturbances of voice. Result of the present study supports the findings of Ragab et al. (2005), in which vocal fold polyp patients showed moderate to extreme level of deviance on a simplified version of GRBAS scale.

ii. Pre and post-surgical comparison

The perceptual ratings done by the two listeners before and after the microlaryngeal surgery are shown in figure 4.10 for Patient A; 4.11 for Patient B and 4.12 for Patient C. The ratings after surgery showed improvement in voice quality along 5 parameters in all the 3 patients. This supports the studies by Giovanni, et al. (1999); Uloza, et al. (2004); and Sameh, et al. (2005), who reported improved voice quality on perceptual ratings using GRBAS scale.

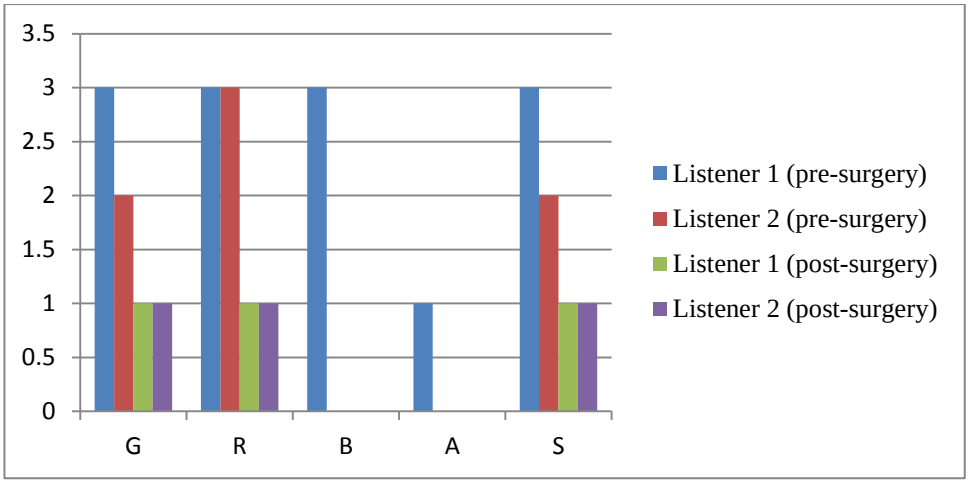


Figure 4.10: *Pre-post perceptual rating scores by two listeners for patient A*

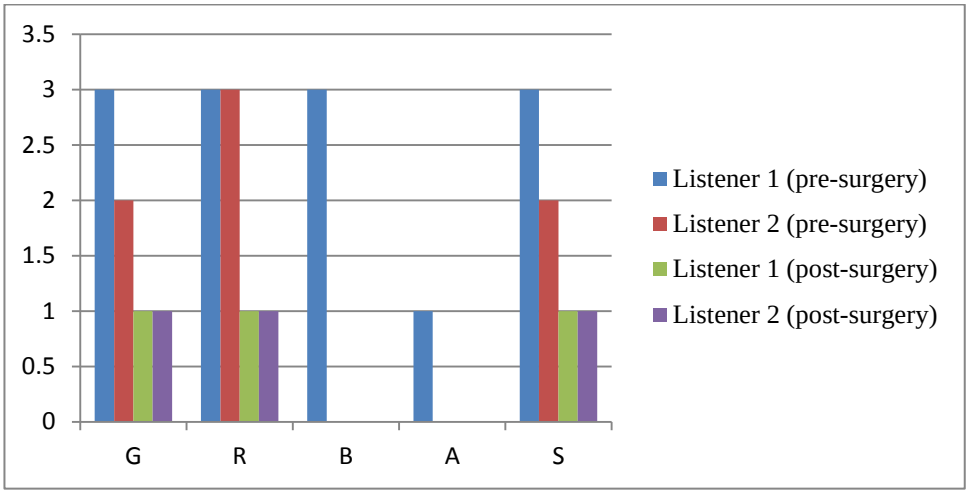


Figure 4.11: *Pre-post perceptual rating scores by two listeners for patient B*

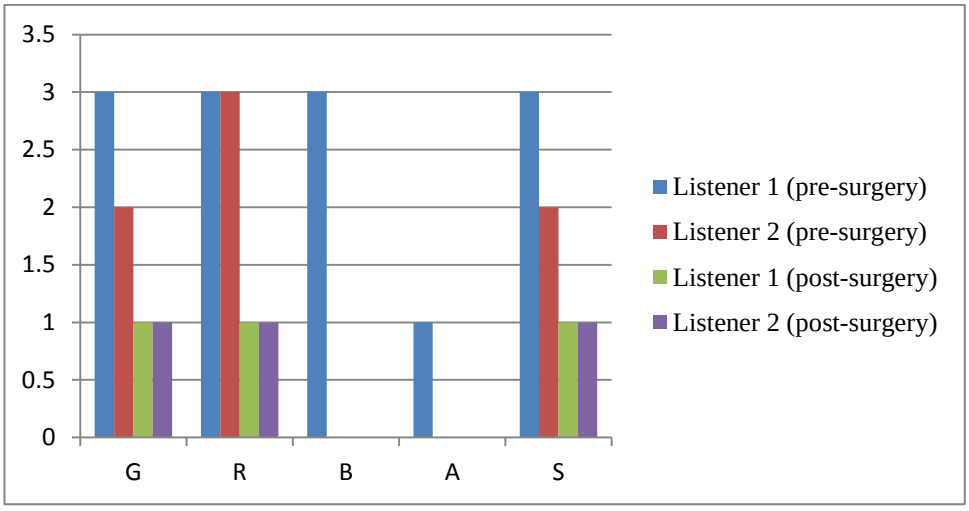


Figure 4.12: *Pre-post perceptual rating scores by two listeners for patient C*

iii. Inter-rater reliability

Table 4.8: *Cronbach's Alpha values showing inter-rater reliability of two listeners (1 and 2) across five perceptual parameters*

Parameters	Cronbach's Alpha
Grade	.912*
Roughness	.827*
Breathiness	.753*
Asthenia	.708*
Strain	.809*

The perceptual ratings for the GRBAS scale by the two listeners for the 13 voice samples were analyzed for inter-rater reliability employing Cronbach's alpha test and test results are shown in Table 4.7. The values were significant (>.07) indicative of good reliability among the two listeners for perceptual evaluation of voice.

CHAPTER V

SUMMARY AND CONCLUSIONS

Vocal fold polyp is one among the organic lesions of the vocal fold which is capable of changing the vocal quality of a person by inducing histopathological changes in the vocal fold structure. Vocal fold polyp is a benign superficial lesion of the vocal fold which arises from epithelium and lamina propria. It occurs in the anterior one-third of the vocal fold and usually is unilateral. Vocal polyps can be sessile or pedunculated. The cause can be vocal abuse or misuse (vocal trauma).

Unlike vocal fold nodules, vocal polyps rarely resolve with voice rest or voice therapy. Most often it requires surgical excision. Microlaryngeal surgical procedure is often recommended. The effectiveness of surgery can be studied by measuring the vocal parameters subjectively and objectively. Various studies have been done in this premise using perceptual rating scales and computerized voice laboratory and have found improvement in voice parameters following surgical management.

In the scenario of evidence based practice there is a lack of literature in Indian context documenting the voice characteristics in patients with laryngeal lesions (vocal fold polyp).

The objectives of the study were three fold. The primary objective was to analyze the acoustic, aerodynamic and perceptual parameters of voice in patients with vocal fold polyp. The second objective was to find out whether there is any difference in the acoustic and aerodynamic parameters with respect to size, lesion location, lesion type and laterality of lesion (vocal fold polyp). The third objective

was to find out the effectiveness of microlaryngeal surgery in patients with vocal fold polyp by measuring the acoustic, aerodynamic and perceptual parameters of voice, before and after the surgery.

Ten subjects (8 males and 2 females) with vocal fold polyp, diagnosed confirmed by SLP and ENT doctor on the basis of video-endoscopy participated in the study. They were within the age range of 42-66 years (mean age 55.2 years). Out of the 10 subjects, 3 subjects underwent microlaryngeal surgery. The acoustic parameters measured were vF0, jitter, shimmer, NHR, VTI, PPQ and APQ using MDVP software and the aerodynamic parameters measured were MPD, s/z ratio, FVC and MAFR measured by RMS Helios spirometer. The above parameters were measured for all the 10 patients with vocal fold polyp. For three of them, the same was done after 3 weeks of surgery. The perceptual analysis was performed by two experienced SLPs on GRBAS scale.

The present study compared the measured parameters of patients with the normative values. The study determined the differences in acoustic and aerodynamic parameters of voice as a function of lesion size (medium versus large) and lesion type (sessile versus pedunculated). The inter-rater reliability among the two listeners for the perceptual task was also analyzed.

The results of the study were in consonance with the existing literature in this regard. The study results found significant difference in acoustic parameters except VTI, when compared to database norm. Also the aerodynamic parameters were affected in the 10 subjects with vocal fold polyp. The study found significant difference for shimmer and APQ values among the medium and large sized polyp group, but no significant difference was found for the type of lesion. There was no

significant difference found for the aerodynamic measures in terms of both size and type of lesion. But the study could not analyze the difference in acoustic and aerodynamic measures in terms of lesion location and laterality since such representative sample was not there in the study.

The 3 patients who underwent microlaryngeal surgery were reviewed after 3 weeks of post-surgery. Voices of the 3 patients were recorded for perceptual analysis. The acoustic and aerodynamic analysis of voice were measured and compared with their pre-surgical values. It was found from the study that, the seven acoustic parameters showed reduced values following microlaryngeal surgery. The aerodynamic parameters like MPD and FVC showed increased values following surgery. The MAFR and s/z ratio decreased and falls within the normative range following microlaryngeal surgery.

The perceptual ratings by the two listeners showed affected voice quality for the 10 patients. The inter-rater reliability among the two listeners was found to be statistically significant for all the parameters rated perceptually. Also the perceptual ratings followed by surgical management by the same listeners showed improved voice quality for the 3 patients.

The results of the present study revealed several points of interest;

First, the patients with vocal fold polyp had shown abnormal acoustic parameters on measures such as vF0, jitter, shimmer, NHR, VTI, PPQ and APQ, which are not within the database norm considered for the present study. ***Second,*** the patients with vocal fold polyp also had abnormal aerodynamic parameters of voice as a result of the mass (vocal polyp). ***Third,*** the listeners judged the voice samples as

moderate-severely deviant on GRBAS rating scale. ***Fourth,*** after the third week following surgical management, the acoustic parameters (except VTI) returned to the normative value. Also, the aerodynamic parameters showed improved values that fall within the normative range. ***Fifth,*** the vocal polyp size (medium versus large) did not have any significant effect on aerodynamic parameters. Shimmer and APQ are the only two acoustic parameters that showed significant difference in terms of lesion size. ***Sixth,*** the vocal fold type (sessile versus pedunculated) did not show any effect on acoustic and aerodynamic parameters of voice measured. ***Seventh,*** after surgery, GRBAS scores showed improved perceptual ratings by the listeners.

Limitations of the study

- The study consisted less number of participants (patients with vocal fold polyp).
- The study had time constraints and the long term efficacy was not studied i.e. after 4 and 6 weeks of surgery, etc.
- The study considered the usage of contemporary microlaryngeal surgery and not any specific surgical technique.

Based on the above lines, the **suggestions for future research directions** are,

- The study can be replicated using more number of subjects with equal representational samples in all groups.
- Apart from inter-rater reliability, intra-rater reliability could also be studied.
- Other benign lesions of vocal fold (cysts and Reinke's edema) can be considered for pre and post-surgical comparisons.
- Self-rating questionnaires like V-RQL (voice related quality of life) and VHI (voice handicap index) by patients can be used in the pre-post comparison.

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