Outcome analysis of benign vocal cord lesions by videostroboscopy, acoustic analysis and voice handicap index

George Thomas · Suma Susan Mathews · Shipra B. Chrysolyte · V. Rupa

Abstract

Benign vocal cord lesions affect vibratory vocal fold function resulting in significant dysphonia. A prospective study of 30 patients with benign vocal fold lesions was undertaken at our centre to compare the pre and post operative voice using videostroboscopy, voice analysis and voice handicap index. The vibratory pattern of the cord improved as evidenced by the stroboscopic parameters-symmetry, mucosal wave and glottic closure ($p < 0.05$). Voice analysis showed a trend towards normalcy but the values obtained did not attain statistical significance. Voice handicap index showed a reduction in the total and the subscales scores. Videostroboscopy along with acoustic analysis and voice handicap index are useful tools in the objective and subjective assessment of the effectiveness of treatment in patients with benign vocal cord lesions. Their routine use in a voice clinic is recommended.

Keywords Benign vocal fold lesions · Videostroboscopy · Voice analysis · Voice handicap index

Introduction

Benign vocal cord mass lesions are commonly encountered causes of dysphonia which are often surgically correctable. They include lesions like vocal polyps, vocal cysts, vocal nodules and Reinke's edema. Since 1854 when Manuel Garcia first observed the movement of his own vocal cords using a laryngeal mirror and sunlight as the light source, a number of techniques for demonstrating laryngeal anatomy have evolved. Preoperative evaluation of these lesions initially by indirect laryngoscopy or direct rigid laryngoscopy, gave way to the use of transnasal flexible fiberoptic endoscopy in the eighties. The introduction of the videostroboscope into ENT practice has revolutionized the assessment of vocal cord pathology [1, 2]. With the advent of commercially available stroboscopes, the evaluation of these lesions as well as other laryngeal pathologies has become more comprehensive.

Stroboscopy was first employed by Oertel in 1878 to examine the larynx [3]. He used a pulsatile light generating device with a laryngeal mirror. This was the precursor of the modern stroboscope. Stroboscopy involves the use of high speed flashes of light at a frequency slightly lower or higher than the frequency of the patient's vocal fold vibrations. The image thus obtained is an optical illusion of slow motion based on Talbot's law i.e. the persistence of an image on the retina for 0.2 seconds after exposure. Stroboscopy can be performed with either a flexible laryngoscope or a rigid 70° or 90° angled telescope. Rigid stroboscopy provides brighter, clearer and more magnified images. With technological advances and video recording equipment; videostroboscopes are now being used more often to visualize the vocal folds and its vibratory function.

In vocal cord lesions, distortion of the voice signal can be demonstrated by acoustic analysis [4]. A variety of software is available for voice analysis. PRAAT programme, created by Paul Boersma and David Weenik of the Institute of Phonetics Sciences of the University of Amsterdam is one such programme which can be used for acoustic analysis.

G. Thomas¹ · S. S. Mathews² · S. B. Chrysolyte³ · V. Rupa⁴ (✉)

¹Registrar

²Senior Lecturer

³Audiologist, Speech and Language Pathologist

⁴Professor & Head of ENT

Department of ENT, Christian Medical College,
Vellore

Christian Medical College

Vellore - 632 004

E-mail: ent3@cmcvellore.ac.in

Fax: 0416 - 2232035

Tel: 0416 - 2283483

A combination of laryngeal videostroboscopy and acoustic analysis in a dysphonic patient helps to evaluate vocal cord abnormalities in detail. However, these two modalities alone do not specifically evaluate the resulting handicap as the patient perceives it. Use of a structured questionnaire to evaluate the quality of life in these patients is required for this [5–8]. One of the most widely used dysphonia-specific quality of life questionnaire is the Voice Handicap Index (VHI) developed by Jacobson et al in 1997 [5].

The aim of this prospective study was to observe videostroboscopic changes, measure the acoustic parameters and administer VHI before and after microlaryngeal surgery in patients with benign vocal cord lesions. By analyzing the stroboscopy findings, acoustic data and VHI scores pre and post treatment, the effect of surgical excision of benign vocal cord lesions on vocal fold vibration and the resultant voice can be defined. The use of these three modalities as an office tool for evaluating voice pre and postoperatively in the Indian population was also explored.

Material and Methods Subjects

Between August 2005 and July 2006, patients with clinical evidence of a benign vocal cord lesion, above the age of 12 years who presented to the ENT department of our hospital, a tertiary care referral centre, were enrolled in the study. Adult patients who had no cardio-pulmonary disease were included in the study. Each patient underwent flexible laryngoscopy followed by videolaryngostroboscopy, acoustic analysis and administration of VHI preoperatively. All patients underwent microlaryngoscopic excision of the benign vocal cord lesion with biopsy under general anaesthesia in the conventional manner. Three months postoperatively, these patients were evaluated by videolaryngostroboscopy, acoustic analysis and VHI and the findings noted.

The methodology and the features that were evaluated using these three tests were as follows:

Videostroboscopy

Videostroboscopy was performed using the Karl Storz stroboscope system which consists of a 90° rigid telescope which is illuminated by a high performance xenon light for stroboscopy, a microphone which is placed on the telescope to record the voice signal from which the fundamental frequency is extracted and used to control the rate of firing of the stroboscopic light, an endoscope video camera and a flat screen monitor (Fig. 1).

The procedure was first explained to the patient to obtain the maximum co-operation. The patient was seated facing the examiner. 10% lignocaine topical spray was used to spray the larynx to eliminate the gag reflex. The patient was asked to protrude the tongue which the examiner held with a gauze piece outside the mouth. The telescope was then introduced into the oropharynx and the position adjusted

to bring the vocal folds into view. As the patient phonated, when the frequency of the light pulse was less or greater than the frequency of the vocal fold (between 1 and 2 Hz) a slow motion movement of the cord was appreciable.

The output picture and sound was captured into a computer without compression and analyzed later. The stroboscopy picture was analyzed by the endoscopist to note:

1. Symmetry
2. Mucosal wave on the vocal fold
3. Glottic closure (completeness of glottic closure)

Acoustic Analysis

The voice of each patient was recorded in a sound-treated room with the microphone held at 30 cm from the patient. A low impedance commercial microphone was used for recording the sound signals. The signal was recorded without amplification or filters to a Windows based desktop computer. The recordings were in 'wav' format. Each subject was asked to phonate vowels /a/, /e/ and /i/ in their modal tone at comfortable intensity after a deep inspiration. To avoid acoustic variability due to initiation and termination, only the mid portion of each voice signal was analyzed. Analysis was done using PRAAT version 4.3.22. and the values for parameters like fundamental frequency, jitter, shimmer and harmonics-to-noise ratio were obtained.

Voice Handicap Index

All patients were interviewed preoperatively and postoperatively and the VHI administered. These 30 statements in the VHI measure the physical, functional and emotional aspects of their voice problems. The total scores and each subscale scores were calculated and compared between groups. The threshold for significant change was based on values determined by Jacobson et al during the validation of the questionnaire [5]. Possible scores could range from 0 to 120. A change of 18 points in the total score and 8 points in the subscales was considered significant.

Statistical Analysis

All statistical analysis was done using the SPSS programme version 11. McNemar's test was used to compare paired categorical/ discrete measurements. 'Rather paired t test' was used to compare continuous measurements.

Results

Of the 30 patients (Age range 18–62 years; mean age of 36.53 years) included in the study, 22 patients had a unilateral lesion (15 on the right cord and seven on the left) and eight patients had bilateral lesions. The benign lesions observed were vocal polyps, nodules, cysts and a post-operative scar on the vocal cord (Fig. 2).

Fig. 1 Stroboscopy set up

1-Telescope with video camera, 2-Flat screen monitor, 3-Stroboscopy light source, 4-Computer

Fig. 2 Types of vocal cord lesions

Videostroboscopy

The mucosal wave was absent in 13 patients on the right cord and in 9 patients on the left. Following surgery the mucosal wave was observed in 27 (90%) patients on the right cord and in 26 (86.66%) patients on the left cord. The glottic closure which was incomplete, improved to complete closure in 96.66%. This was statistically significant

Table 1 Stroboscopic Analysis (N=30)

Observation	Present pre op	Present post op	p value
Symmetry	2	26	<0.0001
Mucosal wave (right)	17	27	0.001
Mucosal wave (left)	21	26	0.016
Glottic closure	0	29	<0.0001

Table 2 Voice analysis

Parameters	Pre-operative values	Post-operative values
Fundamental Frequency (Hz) Male	176	178.36
Female	205.65	202
Jitter (%) Modal /e/	2.324	1.741
Shimmer (%) Modal /e/	4.097	3.098
Harmonic-to-noise ratio (dB) Modal /e/	14.273	15.699

Table 3 Vhi Scores

Domain	Pre operative scores		Post operative scores	
	Mean	Standard deviation	Mean	Standard deviation
Functional	15.50	8.245	13.03	9.159
Physical	16.97	8.019	11.73	8.546
Emotional	11.50	7.899	5.93	5.759
Total	43.9333	20.75628	30.7000	20.77656

($p < 0.0001$). Muscle tension dysphonia (MTD) was seen in 7 (23.3%) patients preoperatively and in 11 (33.3%) post-operatively. Symmetry was restored in most patients ($p < 0.0001$).

Acoustic Analysis

There was no remarkable change noted in the fundamental frequency after surgery. The parameters of jitter, shimmer and harmonics-to-noise ratio were analysed (Table 2).

Table 4 Voice Usage and VHI Scores

Domain	Level II pre op	Level II post op	Level III pre op	Level III post op	Level IV pre op	Level IV post op
Functional	13.9	15.9	21	10.75	15.83	11.8
Physical	18.7	16.4	21	8	14.88	9.75
Emotional	13.5	6.20	8.75	3.5	10.94	6.38
Total	46.1	38.5	50.75	22.25	40.88	27.94

Jitter / frequency perturbation

Jitter or frequency perturbation refers to the small cycle to cycle changes of the frequency of the voice signal [4, 9]. This is due to instability of the cord during vibration and correlates with the periodicity of vocal fold vibration. The mean preoperative value of jitter was 2.056%. Jitter of 1.040% is the threshold for pathology in PRAAT. The postoperative jitter was reduced for sustained /e/ and /i/ at comfortable pitch and loudness. This was not statistically significant, however.

Shimmer / amplitude perturbation

Shimmer or amplitude perturbation refers to the small cycle to cycle changes of the amplitude of the voice signal [4, 9]. The shimmer was above the threshold for pathology (3.810%) in the pre-operative voice evaluation. Post-operative shimmer was below 3.59%. This was not statistically significant, however.

Harmonic- to- noise ratio

Harmonic -to- noise ratio is the mean amplitude of the average wave divided by mean amplitude of the isolated noise component for the train of waves. It is expressed in decibels (dB) [4]. Normal voice has a low level of noise while hoarse speakers have a harmonicity much lower than 20 dB. Harmonic-to-noise ratio was ≤ 14.9 dB pre-operatively which improved after surgery to > 15.5 dB. This was not statistically significant, however ($p=0.084$).

Voice Handicap Index

Voice handicap index showed a reduction in the total scores as well as in each of the subscales between the pre and post treatment groups (Table 3). A difference in the total score of 18 or more between pre and postoperative scores or 8 or more for the subscales is considered significant.

Voice usage and VHI

The VHI was calculated for groups divided according to the voice usage. Level I is an elite vocal performer (e.g. singer or actor), Level II is a professional voice user (e.g. priest, teacher, receptionist), Level III is a non-vocal professional (e.g. lawyer or doctor) and Level IV is a non-vocal non-professional voice user (e.g. labourer or house-wife) [10]. The Level III users had the highest perception of handicap. They had an average value of 50.75 against 46.1 and 40.88 for level II and level IV users. The level III user had a significant reduction in the total scores and in the functional and physical subscales post-operatively.

Discussion

Benign vocal cord lesions like vocal nodules, polyps and cysts cause significant dysphonia as they disrupt normal vocal fold vibratory function. Removal of lesions, restoring the vibratory function and optimizing the voice are the goals in the treatment of benign vocal fold lesions [11, 12]. Lesions not responsive to voice therapy and / or medical therapy have to be excised surgically. Objective and subjective assessment of the laryngeal functions before and after surgery help to evaluate the effectiveness of the treatment. Quantification of such results also helps to compare voice outcome using different phonosurgical techniques [5, 11].

Stroboscopic changes: Woo et al¹¹ in their study of benign lesions of larynx observed that the vocal fold edge, glottal configuration, vibratory amplitude and mucosal wave are key factors observed during stroboscopy that affect the quality of the voice. Complete glottic closure results in greater vocal fold contact because of a regular edge, with generation of a greater subglottic pressure and better amplitude of cord vibration [12]. In this series, 29 patients had complete glottic closure. The mucosal wave improved to 90% on the right and 86.9% on the left vocal cord.

Abnormal patterns of glottic and supraglottic muscle tension are seen in many patients with voice disorders. Secondary muscle tension dysphonia is caused by glottal insufficiency. This could be either due to a mass lesion or vocal cord paralysis [13]. The ventricular hyperadduction is often a compensatory gesture of the larynx to phonate at high pressures. There was an increase in muscle tension patterns noted in the post operative cases (11 patients) examined when compared to the preoperative patients (7 patients). Poor vocal habits, intrinsic hyperfunctional voice disorders and psychogenic posturing of vocal folds are the possible causes of hyperfunctional voice disorders [14].

Voice analysis: During phonation, the symmetry of the cords and amplitude of the mucosal vibrations are determined by the mass and the tension of the true cords and by the subglottic pressure. Voice analysis performed six weeks or more after surgery showed that there was a marginal decrease in the fundamental frequency. Previous studies have reported that the fundamental frequency either increased or decreased, and that the phonational range had increased but not stabilized [15]. Therefore, additional speech therapy was required. In benign vocal cord lesions, incomplete glottic closure and change in the mass results in diverse results during acoustic analysis. Jitter, shimmer and harmonics-to-noise ratio showed improvement and a trend towards normalcy though statistically the values were not significant. The improvement observed could be attributed to better vocal fold approximation and vibration.

VHI changes: An interesting observation noted during the administration of the voice handicap index was that patients were unaware of the degree of severity of their voice problem until completing the VHI⁵. In our study, the disability perceived in the emotional domain was quite high but it was rarely a presenting complaint. The unexpressed problems after the voice team-patient interview can thus be elicited from the VHI. Thus VHI can be used to study the impact of a person's voice disorder in different areas of his life.

Voice therapy: The importance of voice therapy sessions cannot be over-emphasized. Most patients are relieved to know that the mass excised in toto is benign as reported by the histopathologist. Additionally, they are happy with the improved voice and fail to understand the importance of vocal hygiene and voice therapy as preventive measures for the future. At our centre, where patients come from all over the country and spend a limited time with us, compliance with the prescribed exercises in the postoperative period is often poor and cannot be supervised. This could be the reason for the increase in MTD noted in post operative patients.

In conclusion, pre and post operative assessment of patients with benign vocal cord lesions by stroboscopy, acoustic analysis, and voice handicap index is a useful way to determine the degree of improvement following surgery. Both subjective and objective parameters are assessed. The importance of vocal hygiene and voice therapy cannot be overstated and should be emphasized at the initial consultation and incorporated in the treatment plan.

References

1. Rosen CA. (2005) Stroboscopy as a research instrument: development of a perceptual evaluation tool. *Laryngoscope* 115:423–428
2. Colton RH, Woo P, Brewer DW, Griffin B, Casper J. (1995) Stroboscopic signs associated with benign lesions of the vocal folds. *J Voice* 9:312–325
3. Bless DM, Swift E. (1996) Stroboscopy: new diagnostic techniques and applied Physiology. In: Fried MP, ed. *The Larynx a multidisciplinary approach*. 2nd ed. St. Louis. Mosby-Year Book, Inc; p. 81–100
4. Korovin GS, Rubin JS. (2003) Introduction to the laboratory diagnosis of vocal disorders. In: Rubin JS, Sataloff RT, Korovin GS, eds. *Diagnosis and treatment of voice disorders*. 2nd ed. Australia. Thomson Delmar Learning; p 183–189
5. Jacobson BH, Johnson A, Grywalski C, Silbergleit A, Jacobson G, Benninger MS, et al. (1997) The voice handicap index (VHI): development and validation. *Am J Speech Lang Pathol* 6: 66–70
6. Wilson JA, Webb A, Carding PN, Steen IN, Mackenzie K, Deary IJ (2004) Voice symptom scale and the voice handicap index (VHI): a comparison of structure and content. *Clin Otolaryngol* 29:169–174
7. Deary IJ, Webb A, MacKenzie K, Wilson JA, Carding PN. (2004) Short, self-report voice symptom scales: psychometric characteristics of the voice handicap index-10 and the vocal performance questionnaire. *Otolaryngol Head Neck Surg* 31: 232–235
8. Loughran S, Calder N, MacGregor FB, Carding P, MacKenzie K. (2005) Quality of life and voice following endoscopic resection or radiotherapy for early glottic cancer. *Clin Otolaryngol* 30:42–47
9. Colton RH, Casper FK. (1996) In: *Understanding voice problems: a physiological perspective for diagnosis and treatment*. 2nd ed. Baltimore. Williams and Wilkins; p. 186–241
10. Koufmann JA and Issacson G. (1991) The spectrum of voice dysfunction. *Otolaryngol Clin North Am* 24:985–988
11. Woo P, Casper J, Colton R, Brewer D. (1994) Aerodynamic and stroboscopic findings before and after microlaryngeal phonosurgery. *J Voice* 6:66–70
12. Noordzij Jp, Woo P. (2000) Glottal area waveform analysis of benign vocal fold lesions before and after surgery. *Ann Otol Rhinol Laryngol* 109: 441–446
13. Koufman JA. (2003) Evaluation of laryngeal biomechanics by fibreoptic laryngoscopy. In: Rubin JS, Sataloff RT, Korovin GS, eds. *Diagnosis and treatment of voice disorders*. 2nd ed. Australia. Thomson Delmar Learning; 171–189
14. Woo P. (2003) Diagnosis and management of postoperative dysphonia. In: Rubin JS, Sataloff RT, Korovin GS, eds. *Diagnosis and treatment of voice disorders*. 2nd ed. Australia. Thomson Delmar Learning; p. 701–716
15. Lim J, Choi J, Kim K, Choi H. (2000) Voice analysis of patients with diverse types of Reinke's edema and clinical use of electroglottographic measurements. *Acta Otolaryngologica* 126:62–69