ORIGINAL RESEARCH PAPER
Volume - 11 | Issue - 07 | July - 2022 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

CLINICAL IMPLICATION OF VIDEOSTROBOSCOPY, ACOUSTIC VOICE ANALYSIS AND ELECTROGLOTTOGRAPHY IN VOICE DISORDERS: AN INFORMATIVE PAPER

ENT

Dr Digvijay Singh* Assistant Professor, Department of ENT, Raipur Institute of Medical Sciences, Raipur
*Corresponding Author

ABSTRACT

The aim of this paper is to present a new technology being used to help laryngologists and voice pathologists to make a correct diagnosis of voice disorders and monitor progress in voice therapy. Such technology enables outpatient procedures to gather a wide array of information not only for laryngologists but also for voice pathologists, thus making it easier to work together. This informative paper reviews and presents the evaluation process, normative parameters, profile and clinical implications of all these armamentarium.

KEYWORDS

Videostroboscopy, Acoustic Voice Analysis, Electroglottography, Voice Disorders

INTRODUCTION

Videostroboscopy is the most important clinical tool for the evaluation of patients with voice disorders. The laryngostroboscopy allows analysis of the vocal fold vibrations during phonation. The limitation with laryngeal stroboscopy is the subjective nature of the interpretation of the video examination. The most frequently used method of diagnosing voice disorder is Videostroboscopy.

However, to facilitate objective evaluation of voice disorders, it is beneficial to implement quantitative methods of voice assessment, particularly voice acoustic analysis and electroglottography.

Acoustic analysis provides quantitative assessment of voice quality and vocal function. Acoustic measures should be used in the routine clinical examination, as substantially complements endoscopy examination and help laryngologists and voice pathologists make a correct diagnosis of voice disorders and also monitor the progress in voice therapy.

This combined technology is being introduced to help perform important diagnosis and therapy procedures for laryngeal disorders by using multimedia technology with application in endoscope. The aim of this paper is to introduce a power tool designed to enhance clinical observation of vocal fold vibration via videostroboscopy, acoustic waveform and electroglottography.

Evaluation And Normal Parametres

Evaluation process, normative parameters, profile and clinical implications of all these armamentarium in a well equipped voice clinic has been discussed below.

(a)Videostroboscopy: Subjective evaluation of vocal fold motion

Clinical experience using this technology to observe vocal fold vibration makes it easy to inspect the physiological and pathological status of the larynx and to monitor the effect of voice therapy or surgery.

Rationale of stroboscopic light [1]:
Talbot's law states that once an image is presented to the eye, it persists on the retina for 0.2 sec. (1/5 cycle/sec.).

A rapidly rotating or vibrating object cannot be seen if the speed of repetition of movements exceeds 5 per sec. Since the vocal folds are very rapidly rotating (100-300 Hz), the eyes fuse the image of successive cycles. So that the vocal folds seen during phonation in continuous light of an ordinary lamp (50 cycles/sec) seem to be standstill and blurred.

If the flashes of light are triggered after the onset of the vibratory cycle by a fixed time interval, the adjacent phases of several vibratory cycles will be illuminated successively. The perceived stroboscopic motion of the vocal fold is an optical illusion created by fusing multiple points of several successive vibratory cycles. This motion is referred to as the glottic wave.

If the flashes of light are exactly equal to and in phase with the vocal fold vibratory cycles the folds will appear motionless and still image will be observed.

Following are the different Stroboscopic features [1]:

1. Amplitude of Vibration:
It is the extent of movement of the muscular body of the vocal fold in the horizontal plane. In normal habitual phonatory conditions the extent of the horizontal excursion of the VF approximates one half the width of the visible part of the VF. Normally the amplitude of vibration decreases with raising the pitch of phonation and increases with increasing the loudness of phonation

2. Mucosal Wave:
It is the wave motion of the mucosal cover traveling along both the vertical and horizontal planes of the vocal fold. In normal habitual phonatory conditions the mucosal wave travels across the vertical plane of the vocal fold then rolls laterally across at least 50% of the width of visible part of the vocal fold. It is affected by the pliability of the covering mucosa and the presence of the natural difference in the mechanical properties between the pliable mucosal cover and stiffer muscular core.

3. Symmetry:
Is the degree to which the Vocal Folds provide mirror images to one another during vibration both in timing (phase) and in the extent of the horizontal excursion (amplitude).

In all normal phonatory conditions whether habitual or extremes of pitch or loudness the timing of both folds opening and closing patterns and the extent of the horizontal excursion of both vocal folds are equal.

4. Periodicity:
It is the degree of regularity of successive apparent glottal cycles during vibration. A periodicity between successive glottal cycles can be either in amplitude or in timing or in both. In order to evaluate this parameter we shift to the "in phase" modem of the stroboscope unit where the light flashes are executed at the same frequency of the VF vibrations. In all normal phonatory conditions with periodic successive glottal cycles this will lead to repeated illumination of the same phase of the glottal cycle resulting in a clear static laryngeal image at that certain phase of the cycle.

5. Glottic Closure Patterns:
Phase of glottic closure is the average timing of the closed phase in relation to the whole glottic cycle. In normal habitual phonatory conditions the timing of the opening phase, closing phase and, closed phase are nearly identical. The opening phase predominates with raising the pitch of phonation and with decreasing the loudness of phonation. On the other hand, the closed phase predominates with raising the loudness of phonation.

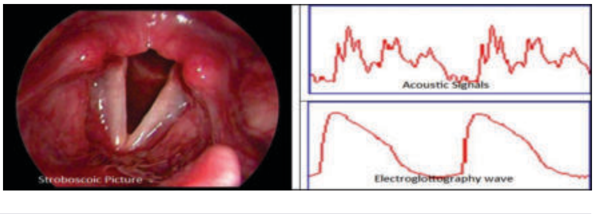

Fig. 1: Stroboscopic picture with acoustic and EGG signals simultaneously.

Configuration of glottic closure- This is the shape of the glottis at maximum closure under stroboscopic light. In normal habitual phonation there is complete closure along the vocal fold edges in males and closure along the vibrating edges with a small triangular posterior chink in females.

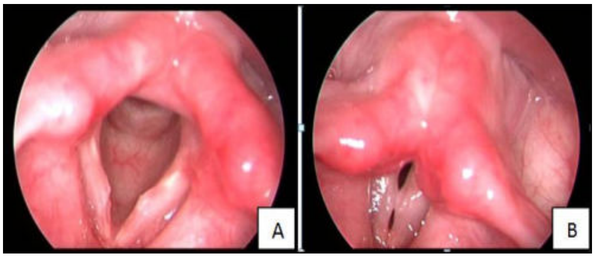

Fig.2: Stroboscopic picture of bilateral vocal nodule (A) In fully abducted position and (B) In adducted position showing hourglass shaped glottic closure

6. Non-Vibrating Portions:
Describing the site, extent and persistence of a dynamic segment of the vocal folds during vibration. This may be due to laryngeal scaring, dysplastic patches, mucosal fixation.

7. Ventricular vibrations:
Describing whether unilateral or bilateral and whether or not sharing in phonation.b) Acoustic Voice analysis: Objective assessment of vocal fold vibration

Acoustic analysis of the waveform is based on the fact that laryngeal pathology alters the normal vibratory pattern of the vocal folds; there is a relationship between the vibratory patterns at the glottal source and certain parameters of the acoustic waveform generated by this vibration.

Acoustic analysis provides following measurement. There parameters can be of considerable use in arriving at a diagnosis for evaluating the effects of surgery, or for tracking progress during voice therapy.

1. Fundamental frequency:
Fundamental frequency (F0) corresponds with the rate of oscillation of the vocal folds (expressed in Hz), and is primary factor in the perception of the pitch. Normal values: Males 112Hz (range 84-151Hz) and Females 192Hz (range 168-221Hz).

2. Frequency perturbation:
Frequency perturbation (commonly called 'jitter') is defined as the degree of cycle-to-cycle variability of the fundamental frequency. In steady vowel phonation (i.e. with constant pitch and volume) the degree of jitter may also provide an index of the stability of the phonatory mechanism.

3. Amplitude perturbation:
Amplitude perturbation ('shimmer') is a measurement of the amount of peak amplitude variability from one cycle to the next cycle. Measurements of amplitude perturbation, like frequency perturbation, are also indications of short-term variability in the vocal signal.

4. Maximum phonation duration:
Maximum phonation duration refers to the maximum time a subject can sustain a tone on one breath. Usually normal adult subjects would sustain a vowel for >15 seconds and children about >10 seconds.

5. S/Z ratio:
S/Z ratio is the ratio of maximum sustained phonation time of /s/ to maximum sustained phonation time of /z/. A normal speaker would be expected to sustain both the voiceless /s/ and the voiced /z/ for approximately equal durations, resulting in a ratio of 1. The normal range is 0.9 to 1.2.

6. Normalized noise energy (NNE):
NNE is the turbulence noise caused by the adduction insufficiency of glottis during phonation. NNE is the remainder obtained by subtracting total signal energy from inharmonic (noise) energy and hence, it is always negative. Normal value is < 12 dB.

c) Electroglottography (EGG): Objective Measure of Vocal fold Vibration
Electroglottograph or EGG is a system which gives information on the closure of vocal folds by measuring the electrical resistance between two electrodes placed around the neck. Even if the signal provides only an approximate value of the glottis surface, it gives very good information about period of vocal folds vibration, especially because we are at the source of the phonation (no influence of vocal tract) and because there is no aerodynamic noise.

EGG signal is composed of:
1. A high-frequency component which is relative to vocal folds vibration (voice)
2. A low-frequency component which is relative to low movement of larynx (ex: swallowing).

The capabilities of this software provide measures of the following parameters and are usually cited in describing normal and pathological voice [1] [2] [4]:
1. Fundamental frequency (EGG-F0) – It is a measure of the rate of quasi-periodic vibration of the vocal folds.

2. EGG-F0 Statistical Report – Standard deviation of EGG-F0 is a measure of the variability in statistical sampling of EGG-F0.

3. EGG-Jitter - It is the cycle-to-cycle variability of the fundamental pitch period (or fundamental frequency) in the EGG signal.

4. EGG-Shimmer – It is the cycle-to-cycle variability of peak-to-peak amplitude, in the EGG signal.

5. Contact Quotient (CQ) – CQ is a measure of the degree of vocal fold approximation during phonation. The calculation of CQ is defined as:

$$CQ = \frac{\text{Contact phase (CP) (Opening time + Closing time)}}{\text{Time period of one cycle of vocal fold vibration}}$$

This quotient has a normative range of 0.4 to 0.6 for males and females and is believed to indirectly reflect vocal fold adduction force.

6. Contact Index (CI) – CI is an indication of the symmetry of the EGG contact phase during vocal fold vibration. The calculation of CI is defined as:

$$CI = \frac{\text{Opening time} - \text{Closing time}}{\text{Open phase}}$$

A value of 0 is associated with perfect symmetry and is usually less than 1 for males and females. In conditions of asymmetrical vocal fold vibrations, CI is negative.

7. Contact Quotient Perturbation (CQP) – The CQP measure is the cycle-to-cycle variability of the CQ.

8. Contact Index Perturbation (CIQ) – The CIP measure is the cycle-to-cycle variability of the CI.

9. EGG-NNE- Normalized Noise Energy within the EGG signal

10. EGG-F0 Tremor & EGG- Amp Tremor

Opening time – Closing time

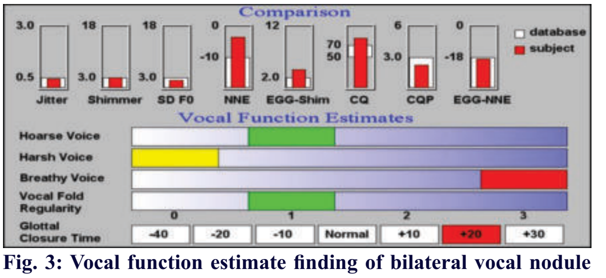

Fig. 3: Vocal function estimate finding of bilateral vocal nodule and comparison between database and subject.

Voice Data		(0.0s to 2.9s)		EGG Data			
Habitual F0 (Hz)	117.44	NNE (dB)	-3.40	Habitual F0 (Hz)	117.74	NNE (dB)	-19.05
Jitter (%)	0.48	HNR (dB)	21.45	Jitter (%)	0.96	HNR (dB)	22.86
Shimmer (%)	2.90	SNR (dB)	20.01	Shimmer (%)	3.64	SNR (dB)	20.82
F0 Tremor (Hz)	1.03	Amp Tremor (Hz)	2.11	F0 Tremor (Hz)	1.02	Amp Tremor (Hz)	2.37
Mean F0 (Hz)	118.07	MPT (s)	6.13	Mean F0 (Hz)	118.29	CQ (%)	82.26
SD F0 (Hz)	2.31	s/z ratio	0.00	SD F0 (Hz)	3.15	CI	-0.56
Max F0 (Hz)	123.53	Ratio (%)	26.00	Max F0 (Hz)	136.11	OR (%)	78.14
Min F0 (Hz)	111.93			Min F0 (Hz)	108.89	CR (%)	21.76
						CQP (%)	2.26
						CIP (%)	5.37

Fig 4: Vocal assessment and EGG data of vocal nodule obtained by speech software.

RESULTS

Clinical Implication of Videostroboscopy:

1) Detect early stages (T1) of cancer and determine the degree of cancerous infiltration.
2) Differentiate organic and functional abnormalities of the larynx.
3) Determine the changes not visible to the unaided eye such as Changes in stiffness resulting from laryngeal carcinoma, papilloma, or scar tissue.
4) The onset of any improvement can be observed in patients with vocal fold paralysis earlier and with greater accuracy.
5) For the pre and post treatment comparisons

Clinical Implication of Acoustic Voice Analysis[5]:

Acoustic analyses provide quantitative information about the voice quality. Based on an investigation between perceptual judgments and acoustic parameters [3], some conclusions are:

1) Hoarseness can be considered as a combination of breathiness and harshness
2) Jitter appears to be related primarily to harsh voice quality
3) Shimmer appears to be the primary influence on hoarse voice quality
4) The magnitude of glottal noise energy (NNE) closely corresponds to the breathy voice quality.

Clinical Implications of EGG Measures of Voice [3]:

1) EGG measures reflect the glottal condition better during the closed phase than during the open phase.
2) The presence or absence of glottal vibrations can be determined from the EGG signal.
3) Contact Quotient reveals information about degree of glottal closure; Contact Index gives information about symmetry of vocal fold vibration.
4) Contact Quotient Perturbation and Contact Index Perturbation reveal the regularity of vocal fold vibration, the cycle-to-cycle variability of vocal fold contact phase and vocal fold vibratory symmetry.
5) EGG measures obtained from connected speech context provide a better representation of age-related changes in vocal fold contact behaviors between genders.
6) Electroglottography represents one of the few noninvasive methods available for obtaining useful information about the vibratory patterns of the vocal folds.

CONCLUSION

The subjective evaluation from videostroboscopic recordings and quantitative information from acoustic signals and electroglottography are very useful for making the correct diagnosis and perform a reliable vocal assessment and therapy pre and post surgery.

REFERENCES

[1] Bless, D. M., Hirano, M., & Feder, R. J. (1987). Videostroboscopic evaluation of the larynx. Ear, Nose, and Throat Journal, 66(7), 289-296.

[2] Huang, Z., & Hu, N. (1988). Research for laryngeal cancer evaluation and diagnosis, Journal of Biomechanics, 3-2, 15-20.

[3] Huang, Z., Minifie, F., Kasuya, H., & Lin, X. (1995). Measures of vocal function during change in vocal effort level, Journal of Voice, 9(4): 429-438.

[4] Orlikoff, R. F., & Huang, Z. (1991). Influence of vowel production on acoustic and electroglottographic perturbation measures, Paper presented at American Speech-Language-Hearing Association Convention, November, Seattle.

[5] Kasuya, H., Ogawa, S. & Kikuchi, Y. (1986). An acoustic analysis of pathological voice and its application to the evaluation of laryngeal pathology, Speech Communication, 5-2.

[6] Voice Lab in Clinical Practice, Daniel Zaoming Huang, Ph.D. Tiger DRS, Inc.