ELECTROGLOTTOGRAPHIC ANALYSIS IN INDIVIDUALS WITH CHRONIC LARYNGITIS DURING SPEECH TASK

[1]Shilpashree P, [2]Yashaswini L, [3]Sunil Kumar R, & [4]Sangeetha M

Abstract

Electroglottography (EGG) is a method to monitor the vibrations of the vocal folds by measuring the varying impedance to a weak alternating current through the tissues of the neck. Non-invasive measures of vocal fold activity are useful for describing normal and disordered voice production. Measures of open, closed and speed quotient from glottal airflow and electroglottographic (EGG) waveforms have been used to describe timing events associated with vocal fold vibration. There are very few studies in western context and no Indian studies were done using speech task. The aim of the present study was to analyze the laryngeal behavior of individuals with chronic laryngitis using electroglottograph on reading voiced passage and to compare with normal individuals. 10 adults with chronic laryngitis and 10 age and gender matched normal adults in the age range of 30 – 40 years participated in the present study. All the recorded samples were analyzed for contact quotient (CQ), open quotient (OQ) and speed quotient (SQ). Results indicated that there was significant statistical difference between normal and abnormal group on all the three EGG quotients for voiced passage reading task. These results also suggested that the closed duration during vocal fold vibratory pattern was longer in individuals with chronic laryngitis and open duration was reduced thereby reducing the speed quotient which indicates the asymmetry of vocal fold vibration during reading passage task in these individuals. It also suggest that connected speech context, as in passage reading, can give better representation, due to the fact that passage is more representative to one's daily speech characteristics than sustained phonation. The laryngeal measures obtained from connected speech context offer a more accurate representation in differentiating normal versus pathological voices. Implications of the findings are discussed and topics for further exploration are identified.

Key Words: Electroglottography (EGG), contact quotient (CQ), open quotient (OQ) and speed quotient (SQ), individuals with chronic laryngitis, reading passage

Voice is the "Laryngeal modulation of pulmonary air stream, which is then further, modified by the configuration of the vocal tract" (Micheal & Wendahl, 1971). Voice is the result of breath under pressure from lungs causing the approximated vocal cords to perform the rhythmic excursions of separation and closure (Greene, 1980). The ultimate aim of the research on normality and abnormality is to enforce a procedure which will eventually bring back the voice of an individual to normal or optimum level.

Hanson, Gerratt, and Berke (1990) reported that the majority of the phonatory dysfunctions are associated with abnormal vibrations of vocal folds. Hence analysis of vibration of vocal folds in terms of different parameters constitutes an important aspect to be considered in the diagnosis and differential diagnosis of the voice disorders.

Hirano (1981) stated that, "acoustic analysis may be one of the most attractive method for assessing phonatory function or laryngeal pathology because it is non-invasive and provides objective and quantitative data. However, Hanson et al. (1990) reported that the acoustical measurements cannot necessarily have a direct physiological correspondence to abnormal glottal activity.

The study of the voice in both health and disease relies on knowledge of the vibratory pattern therefore, it is important to have techniques that permit the analysis of this pattern (Kent, 1997). There are several instruments and procedures which use either invasive or non-invasive techniques to analyze the vocal fold vibrations. They include stroboscopy, ultrasound glottography, ultra high speed photography, photoglottography, electroglottography and inverse filtering, etc.

Electroglottography (EGG) provides a non-invasive and simple measure of vocal fold contacting behaviours in phonation. The EGG waveform reflects the amount of transverse impedance at the laryngeal level. The amount of impedance decreases as vocal fold contact increases (Rothenberg & Mahshie, 1988). Therefore, an EGG waveform provides an indirect measure of the relative degree of vocal fold contact in phonation. It denotes vocal fold contacting behaviours in terms of the time and rate of glottal closure and opening (Baken & Orlikoff, 2000). The internationally recommended orientation of EGG waveform is

[1]Lecturer in Speech & Hearing, Teachers Training Centre for Hearing Handicapped (TTCHH), Mysore-21, [2]Student, All India Institute of Speech and Hearing (AIISH), Mysore-06, [3]Junior Research Fellow, AIISH, E-Mail: rsunilkumar86@gmail.com, & [4]Clinical Lecturer, AIISH, Mysore-06, E-mail: sangmahesh9@yahoo.co.in

that an upward-going waveform corresponds to an increasing vocal fold contact area. An acute rise in the EGG waveform corresponds to the quick closing of the vocal folds and is followed by a gradual decline in the waveform (Baken, 1992) which is associated with the separation of the vocal folds as the pressure below the glottis is higher than above, and the natural tendency of the vocal folds to return to their equilibrium position. EGG has been used extensively to investigate vocal fold vibratory functions in normal adults and in adults with pathological voice disorders (Childers, Smith & Moore, 1984; Dejonckere & Lebacq, 1985). The relation between the impedance of the EGG and underlying physiology of the vocal folds has been well documented by several investigators (Childers et al. 1984).

EGG does not interfere with phonation (Fourcin, 1986; Kelman, 1981). EGG certainly reflects the vibratory cycle of the vocal folds with fairly high fidelity. Irregularities of the EGG thus correspond to the irregularity in the vibratory pattern of the vocal cords. The output signals of EGG convey information regarding the contact area of the vocal folds (Koster & Smith, 1970). So, EGG could be useful for investigating the glottal condition during the closed phase.

Some authors argue that voice samples gathered from either sustained phonation or syllable repetition tasks for EGG measurements are not sufficient to represent daily, functional connected speech (Higgins & Saxman, 1993). Connected speech tasks may reveal more distinct phonatory patterns than sustained vowel phonation due to the different laryngeal mechanisms involved such as coarticulation and intonation (Hong & Kim, 1997). However, whether the use of connected speech for EGG measurements provides a better representation of normative data as sustained vowel phonation in measure of vocal fold contact has yet to be proved (Ma & Love, 2010).

Ma, and Love (2010) conducted a study to find out the age and gender effects during sustained phonation and connected speech using EGG. The authors found that there was a significant statistical main effect of speech task for fundamental frequency regardless of age and gender. Interestingly, the mean fundamental frequency obtained from passage task was significantly higher than that obtained from the phrase task (about one semitone difference). This was attributed to the nature of speech stimuli in the two tasks. The more prosodic and emotional variations involved in reading a story passage (North Wind and the Sun) than in an isolated short phrase (‘‘A baby boy’’) could have contributed to the higher mean fundamental frequency in the passage task. For contact quotient, significant age-by-gender interaction effect was found only in the passage task but not in the phrase task. The results suggest that connected speech context of longer duration, as in passage reading; can give a better representation of contact quotient measure than reading a short phrase. Therefore, these authors reported that one should make use of connected speech stimulus, preferably at passage level, in EGG evaluation for a better representation of vocal fold vibrating behaviours.

In Indian context, Balakrishna (1993) reported that good voices are characterized by high closed quotient (CQ) and low fundamental frequency (F0), low open quotient (OQ) and low speed quotient (SQ) on phonation task. These results indicated that CQ, OQ and SQ can be used as indicators of glottal efficiency. Chandrashekar (1987) compared the EGG quotients across normals and dysphonics. He found significant difference between dysphonics and normals in which, dysphonics had lower OQ and higher SQ indicating prolonged closing time. Predictive value of EGG in voice disorders was studied by Ahluwalia and Prakash (2001) and they reported overall predictability of 69.3% with high sensitivity for mass lesions and mobility disorders of vocal cord. Several studies were done to find out the normative values of EGG quotients for different age groups and also for different voice disorders using phonation task.

Attempts to document voice quality by EGG are recognised and computerized methods to obtain information about vibratory perturbations and vibratory frequency of the vocal folds have been described in literature. However, several studies measured EGG by using phonation as task. There are very few studies in Western context and no Indian studies were done using speech task. Sustained phonation or syllable repetition tasks for EGG measurements are not sufficient to represent daily, functional connected speech. Using speech task for analysis of laryngeal behaviour provides an insight into the laryngeal activity during normal conversation and in connected speech. Colton, Casper and Leonard (2005) evaluated 1,158 voice patients and reported laryngitis as one of the fifth most frequently occurring pathological condition. Therefore, there is a great need to study the laryngeal behaviour or vibratory patterns of vocal folds during speech task preferably reading passage in individuals with chronic laryngitis.

Aim of the study

The present study was conducted with the aim of analyzing the laryngeal behaviour of individuals with chronic laryngitis using electroglottograph

while reading voiced passage and to compare with normal individuals.

Method

Participants: 10 adults with chronic laryngitis diagnosed by a Speech language pathologist and otolaryngologist and 10 age and gender matched normal adults in the age range of 30 – 40 years participated in the present study. Voice evaluation of chronic laryngitis participants revealed as having moderate level of hoarseness and reduced loudness. All the subjects were native Kannada speakers had more than 12 years of formal education and they could read Kannada. All the normal participants were judged perceptually as normal vocal quality by a speech – language pathologist and they had no speech, language and hearing problems.

Instrumentation and Procedure: Electroglottographic analysis was done using Electroglottograph, Model - 6103 manufactured by Kay elemetrics. Each participant was seated comfortably in an upright position. The participant's skin over the thyroid lamina was cleaned using alcohol swab to remove any skin oil and to maximize electrode-to-skin contact. The two electrolaryngographic surface electrodes, which were attached to a neckband, were then placed externally on the participant's neck on each side of the thyroid lamina.

The neckband was sufficiently tight as to ensure adequate electrode-to-skin contact. Before the actual recording, each participant was asked to sustain the vowel /a/ for 3 seconds at his/her most comfortable pitch and loudness. The Laryngeal waveform displayed on the computer screen was then inspected until a clear waveform with the largest amplitude was captured. This procedure was performed to ensure the electrode placement was correct and the most optimal Lx signal was captured. A weak high frequency signal of 0.5 – 10MHz of low voltage of 0.5V was passed through one of the gold plates and was recorded by the other electrode.

All the participants were asked to read a Kannada passage which consists of all voiced consonants, which was developed at All India Institute of Speech and Hearing, Mysore in the year 1985. This passage was selected to avoid the effect of unvoiced consonants on laryngeal behaviour. Reading a passage with voiced consonants will give better response compared to connected speech which consists of both voiced and voiceless consonants.

Data analysis and measures: All the recorded samples were analyzed using electroglottograph for contact quotient, open quotient and speed quotient. Contact quotient (CQ), which is used to measure the degree of vocal folds approximation during reading task; open quotient (OQ), which is the proportion of the period during which the glottis is open to the total period, and speed quotient (SQ), which is used to measure the ratio of opening and closing durations.

Results and Discussion

The present study was conducted with the aim of comparing EGG quotients of normal and abnormal voice on reading passage task. For this, three comparisons were done, that is, comparison of CQ, OQ and SQ of normals with abnormal group.

1. *Comparison of contact quotient between normal and abnormal voice*

Comparison of contact quotient was done using independent samples *t* – test to find out the significant difference between the two, normal's and abnormal. Results showed that there is a significant difference [t (18) = 0.824; p<0.05] in CQ values. The mean and S.D of CQ of normal and abnormal participants is given in table 1.

Table 1: *Mean and S.D of CQ of normal and abnormal participants.*

Group	N	Mean	Standard Deviation
Normals	10	46.86	2.96
Abnormal	10	48.23	4.35

The above results show that the mean CQ is higher in abnormal voice group than in normal group. This indicates prolonged closed duration in abnormal group when compared to normal group. However, the standard deviation is more in abnormal group indicating within the group variability in individuals with chronic laryngitis. The graphical representation of mean and S.D of contact quotient of normal and abnormal participants is shown in Figure 1.

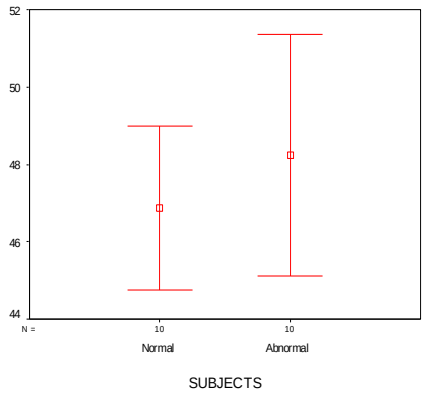

Figure 1: *Error bar graph representing mean and S.D of CQ of normal and abnormal groups.*

2. *Comparison of open quotient (OQ) between the normals and the abnormals*

Comparison of open quotient was done using independent samples *t* – test to find out the

significant difference between the two, normal's and abnormal. Results showed that there is a significant difference [t (18) = 0.896; p<0.05] in OQ values. The mean and S.D of OQ of normal and abnormal participants is given in table 2.

Table 2: *Mean and S.D of OQ of normal and abnormal participants.*

Group	N	Mean	Standard deviation
Normals	10	53.13	2.96
Abnormal	10	51.67	4.23

The above results show that the mean OQ is lower in abnormal voice group than in normal group. This indicates reduced open duration of vocal folds in abnormal group when compared to normal group. However, the standard deviation is more in abnormal group indicating within the group variability in individuals with chronic laryngitis. The graphical representation of mean and S.D of open quotient of normal and abnormal participants is shown in Figure 2.

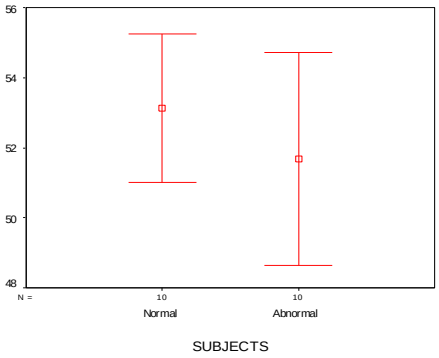

Figure 2: *Error bar graph representing mean and S.D of OQ of normal and abnormal groups.*

3. *Comparison of speed quotient between the normals and the abnormals*

Comparison of speed quotient was done using independent samples *t* – test to find out the significant difference between normals and abnormal. Results showed that there is a significant difference [t (18) = 1.707; p<0.05] in SQ values. The mean and S.D of SQ of normal and abnormal participants is given in table 3.

Table 3: *Mean and S.D of SQ of normal and abnormal participants.*

Group	N	Mean	Standard deviation
Normals	10	343.07	94.56
Abnormal	10	261.84	117.00

The above results show that the mean SQ is lower in abnormal voice group than in normal group. However, the standard deviation is more in abnormal group indicating within the group variability in individuals with chronic laryngitis. The graphical representation of mean and S.D of speed quotient of normal and abnormal participants is shown in Figure 3.

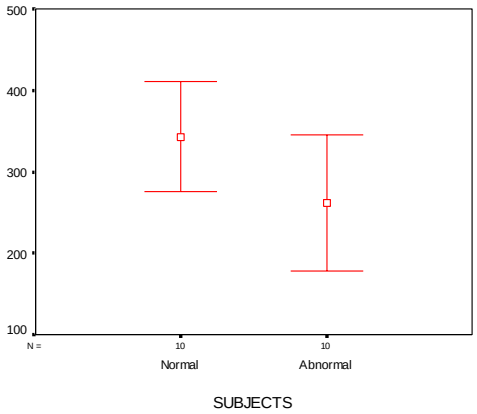

Figure 3: *Error bar graph representing mean and S.D of SQ of normal and abnormal groups.*

Discussion

EGG provides an indirect measure of vocal fold contacting behaviour in phonation and speech tasks. The main objective of the present study was to investigate the vocal fold vibratory behaviour in normals and in individuals with chronic laryngitis while reading a voiced passage. This study was also aimed to study whether reading a voiced passage task can be used during EGG analysis in clinical settings.

The present study found significant statistical difference between normal and abnormal group on all the three EGG quotients, indicating that reading voiced passage task can be used to differentiate between normal and abnormal voices. These results also suggested that the closed duration during vocal fold vibratory pattern was longer in individuals with chronic laryngitis and open duration was reduced thereby reducing the speed quotient which indicates the asymmetry of vocal fold vibration during reading passage task in these individuals.

Chronic laryngitis is a condition with thickened and dry epithelium that may lead to tissue changes such as nodules, polyps or hypertrophy of laryngeal epithelium if untreated. Hence early identification and rehabilitation is absolutely necessary. Laryngitis affects the cover of the vocal folds by increasing the stiffness, but may have little effect on the mass of the vocal folds. Colton et al. (2005) conducted stroboscopic findings in individuals with chronic laryngitis. They noted a jerk like movement of the mucosal wave, in which the wave appears to travel along part of the surface at one speed, then changes its speed for the remainder of its travel. The vocal folds showed increased asymmetry and periodicity with reduced mucosal waves and reduced amplitude. There shall be greater than

normal spectral noise in the voice of the individuals with chronic laryngitis.

The results are also possibly due to the nature of speech stimuli (voiced passage) that was used in the present study. These results suggest that connected speech context, as in passage reading, can give better representation of contact, open and speed quotient measures than sustained phonation task. The present findings offer some supports to the use of connected speech over sustained vowel prolongations as test materials in evaluating vocal fold vibratory behaviours. It also suggests that laryngeal measures obtained from connected speech are more accurate than those obtained from sustained vowel prolongation in classifying normal and abnormal voices. This may be due to the fact that connected speech is more representative to one's daily speech characteristics than sustained phonation and hence, laryngeal measures obtained from connected speech context offer a more accurate representation in differentiating normal versus abnormal voices. Ma and Love (2010) found that there is slight difference between in laryngeal behaviour on reading passage task and reading phrase tasks, as short phrase may not give adequate phonemic and prosodic representations of an individual's use of voice in connected speech. In this regard, Fourcin and Abberton (2008) recommended test materials of two minutes in duration for EGG evaluation in connected speech context. The present study support the use of connected speech, preferably at reading passage level, in electroglottographic evaluation for a better representation of vocal fold vibrating behaviours and these results also support the studies by Higgins and Saxman (1993); Hong and Kim (1997); and Ma and Love (2010) that supports the use of connected speech in electroglottographic evaluation.

Conclusion and future research

This paper is an attempt to give a state of art report of objective analysis of voice in clinical settings using speech task. Acoustic data are considered most important for patient reinforcement and assessment outcomes. Electroglottography can objectify dysphonia in individuals with chronic laryngitis and is a suitable noninvasive tool for tracking long-term progress. EGG quotients best represents the vocal-fold dysfunction in individuals with chronic laryngitis. In conclusion, this study contributed to the existing literature by further understanding the vocal fold vibratory pattern in connected speech in normals and abnormal voices. Results also encourage the use of connected speech context at passage level for more accurate and reliable evaluation of vocal fold vibratory patterns. However, the classification accuracy for measures from reading passage task was not compared with that of phonation task in the present study. Therefore, future research is warranted by including both phonation and speech tasks in the analysis and also to check the accuracy of classification by using speech stimulus with various quotients of EGG and also waveform morphology. It would also be interesting to replicate the study with other clinical voice disorders to investigate if similar findings would be generalized to all the pathological groups especially in the Indian context.

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