Electroglottography of normal voice

Thesis Submitted for the Partial Fulfillment for the Master Degree in Phoniatrics

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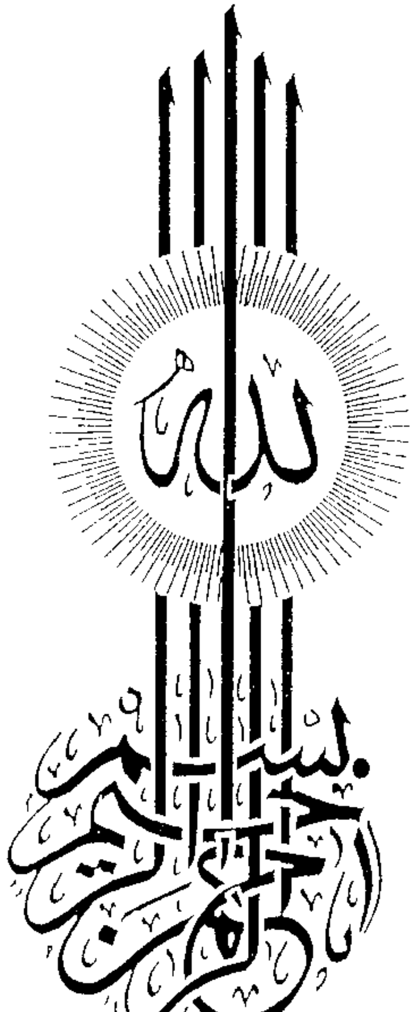
بسم الله الرحمن الرحيم

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قالوا سبحانك لا علم لنا إلا ما علمتنا،
إنك أنت العليم الحكيم

صدق الله العظيم

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INTRODUCTION AND AIM OF THE WORK

INTRODUCTION

Phonation is a term used to refer to the production of sound waves by vibration of the vocal folds. For phonation, there are several conditions that must be established prior to the initiation of sound. First, the vocal folds must be brought to a partially closed position, this maneuver creates a resistance to the exiting exhalatory air flow required for phonation. Second, the vocal folds must be tensed using the various muscles of the larynx. Again this creates a resistance to the exiting air flow. The tension and the mass of the vocal folds determine its vibrating frequency ***(Colton, 1994).***

Vibration of the vocal folds is made up of a traveling wave which moves from the lower part of the vocal folds via the free edge to the upper part of the vocal folds. This traveling wave is the essential principle of the vibration under any condition of phonation ***(Saito et al., 1981).***

Glottographic techniques have been used in speech research laboratories since the 1950s. These techniques reflect the vibrating movements of the vocal folds during phonation ***(Frokjaer-Jensen, 1969).*** Glottographic representations have included photoglottography. Ultrasonic detection, volume velocity waveform, and electroglottography (EGG). Electroglottography does not reflect a direct measure of glottal area, but rather the surface contact area of the vocal folds. It provides a non invasive means of obtaining information about vocal fold function without interfering with phonation. It measures variation of impedence to allow current flow across the neck in the vicinity of the vocal folds ***(Fourcin and Abberton, 1971).*** This is done by placing a pair of plate electrodes in firm contact on the neck on either sides of the thyroid cartilage. During phonation, a high frequency signal (the laryngograph uses 3.3 MHz) with very low non dangerous current (less than a milliamp.) is emitted by one electrode and detected by the other. The dynamic impedence between two skin electrodes changes as the vocal folds open and close ***(Hanson et al., 1988).*** As the vocal folds adduct, contact area increases and the laryngeal resistance decreases, resulting in increased current flow. As the vocal folds abduct, contact area decreases and laryngeal resistance increases resulting in decreased current flow ***(Schultz et al., 1994).***

The variation in the electrical current, caused by the difference in the electrical impedence of the tissues when the glottis is opened and closed, corresponds to the fundamental frequency of phonation ***(Fourcin, 1974, 1981).*** This is why electroglottography is being known as a non acoustic measure of fundamental frequency.

The glottal cycle can be divided into fairly distinct phases which can be related to electroglottographic waveform. As a matter of fact, most of the authors ***(Van Michael, 1967 and Lecluse et al., 1975)*** who studied such a technique tried to determine whether the glottic wave registered during sustained vowel production showed alternations from the normal in pathologic conditions. They studied glottic trace morphology (peak, form, and wave height) and measured its different tracts, like opening quotient (the duration of opening divided by the duration of entire period) and speed quotient (obtained by dividing the duration of increasing glottic area by the duration of decreasing glottic area. They distinguished a single unite responding to a complete vibratory cycle. It is composed of an ascending portion representative of the adductory phase, an apex responding to the maximum adduction point, and a descending portion graphical registration of the abductory phase ***(Motta et al., 1990).*** Briefly, in the closing phase, the folds make contact along the lower margins which close along the length of the lower edge in zipper-like fashion. Closure continues in a vertical direction toward the superior margin. The opening phase consists of the folds separating along the lower margin continuing upward in a wave-like pattern ***(Childers et al., 1983).***

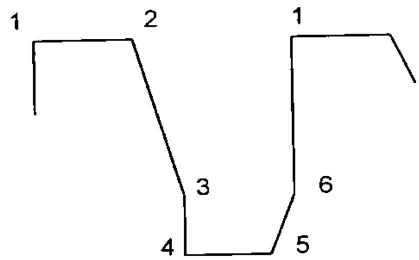

Fig. 1: Idealized electroglottographic waveform

At points 1-2, the vocal folds are at maximum contact. At points 2-3, the folds are parting from the lower margins towards the upper margins. Between 4-5, the fold are apart. At points 5-6, the folds being closing. At point 6, the folds are approximating along the lower margin. At points 6-1, there is rapid increase in vocal fold contact. Actual electroglottographic waveform taken from normal voices generally follow the pattern displayed in the idealized model.

Regarding pathological conditions ***Motta (1990)*** reported that ***Van Michael (1967)*** studying glottic wave morphology in subjects with nodules of the vocal folds, observed a notch in the portion responding to the adductory phase of the vibrating cycle. ***Abou El-Ella (1982)*** also found that in subjects with vocal fold immobility, splitting of the apex of the curve was observed. Also he noticed deformity either in the steep slope or at the apex of the electroglottograph in subjects with vocal fold polyp, vocal fold cyst and polypoid degeneration.

While most electroglottographic analysis has been generally descriptive, there have been attempt to quantify measurements on the electroglottographic waveform in order to track patient performance over time more objectively ***(Conture et al., 1986; Frokjaer-Jensen and Thyme Frokjaer, 1989; Orlikoff, 1991)***. Some of these measurements (quasi open quotient; slope measurements) have shown promise for clinical use, but as yet have not been validated on large enough population. Many of these measurements can be easily calculated using a laryngograph in conjunction with Kay's Computer-Based Waveform Display Hardware/Software Module. For example by placing a horizontal cursor across two EGG waveforms so that upper and lower trough areas are equal (called duty cycle), cursors can be placed to measure open phase duration in relation to total glottal period.