Automated Analysis of Electroglottographic Signal In Adductor Spasmodic Dysphonia

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ABSTRACT

Objectives: 1. To develop an automated computer algorithm to analyze the EGG signal in continuous dysphonic speech. 2. To identify EGG waveform features that correlate with the perceived quality of vocal strain in adductor spasmodic dysphonia (ADSD).

Methods: A computer program was created and refined in MATLAB to display and analyze EGG data via a graphical user interface (GUI). An automated peak-detection algorithm was developed using the differentiated EGG signal and used to perform simultaneous multi-parameter analysis on the EGG signal from normal speech and speech in patients with ADSD. Between-group comparisons were made using two-tailed Student's t test. Also, intra-subject comparison was made between strained and less-strained syllables in ADSD speech.

Results: A program was successfully written to allow the display and automated analysis of EGG data from samples of continuous dysphonic speech. The program was found to generate data with good internal consistency. Application to normal and ADSD subjects showed that the open quotient parameter was able to distinguish between strained and less-strained syllables with statistical significance (p=0.04).

Discussion/Conclusion: We have developed a method to analyze EGG signal from samples of continuous dysphonic speech. The numerical and graphical data obtained support the utility of EGG as an objective means to clinically highlight the speech differences between normal subjects and subjects with ADSD. Further testing to establish normative values for the analyzed EGG parameters and their subsequent comparison with patient EGG data is required to affirm their utility for routine clinical voice assessment.

INTRODUCTION

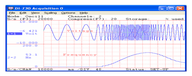
The human voice can be evaluated by a variety of methods. Electroglottographic (EGG) signal is produced when vocal fold vibrations produce cyclic fluctuation in the electrical impedance across the larynx. The EGG signal thus reflects the degree of contact between the vocal folds during voice production and provides a measure of voice quality based on phonatory physiology. However, the utility of EGG has been limited because existing methods of EGG signal analysis focus on the evaluation of 2-3 parameters in a segment of sustained vowel production, which does not reflect pathologies more apparent in conversational speech. We hypothesize that the EGG signal can capture perceptually relevant information from continuous speech in adductor spasmodic dysphonia (ADSD), an enigmatic speech disorder.

METHODS

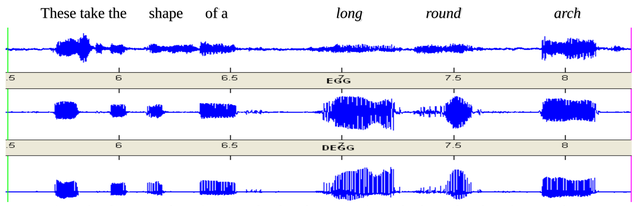
Clinical Setup:

Microphone and EGG signals are simultaneously recorded from a normal subject.

DATAQ USB data acquisition device *(top)* and WinDAQ software *(below)*.[1,2]

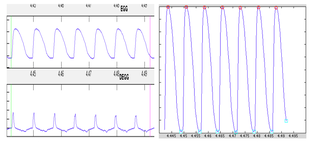


Data Acquisition:

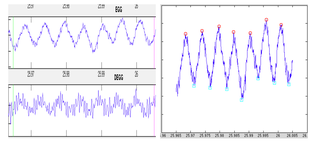


A graphical user interface (GUI) was developed in MATLAB to display and analyze the voice data.

Algorithm: An automated peak-detection algorithm was developed and applied to selected EGG cycles in order to locate their maxima and minima.

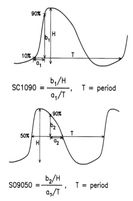


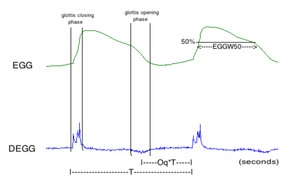
Data from a normal subject, with EGG (*top left*), DEGG (bottom left), and EGG maxima/minima (*right*).

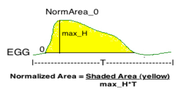


Corresponding data from an ADSD subject, with EGG (*top left*), DEGG (bottom left), and EGG maxima/minima (*right*).

Analysis: Closing slope (**SC1090**), opening slope **(SO9050)**, EGG width at 50% height **(EGGW50)**, open quotient **(Oq),** and normalized area (**NormArea**) are several parameters calculated by the computer program.

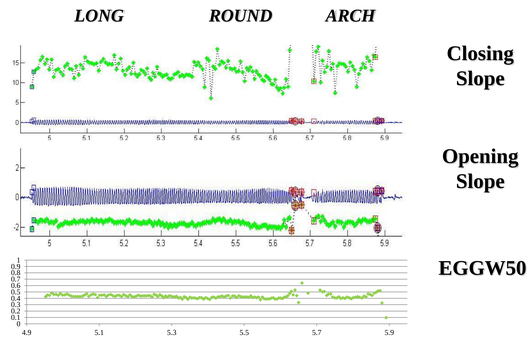




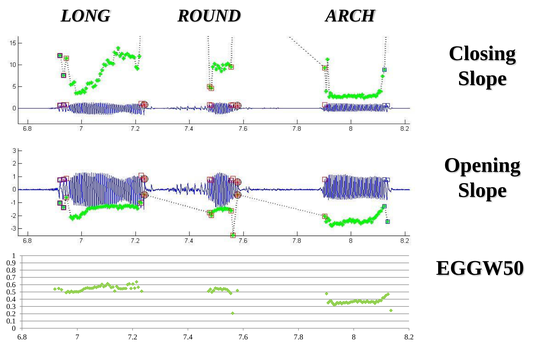


RESULTS

- The green plot in each graph below represents a parameter plotted against time. When compared to dysphonic voice, *the parameters for normal voice show significantly greater stability:*

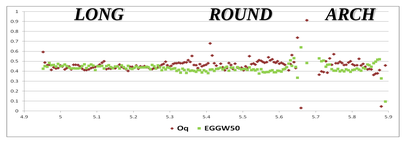


Parameter Stability – Normal Voice

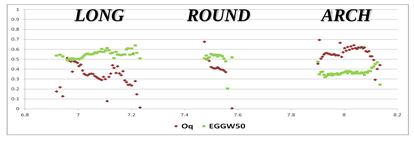


Parameter Stability – ADSD

- EGG is based on vocal fold contact. In principle, strain involves excessive vocal fold contact. This means that *EGG cycles of strained syllables theoretically should have larger widths and smaller open quotients*, which is indicated below:

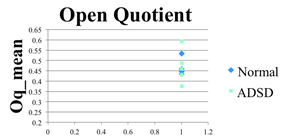


EGGW50 vs Oq – Normal Voice



EGGW50 vs Oq – ADSD

- *Open quotient (Oq) was able to distinguish between strained and less-strained syllables with statistical significance*, while *opening slope (SO9050) was able to distinguish between normal and dysphonic patients with a difference approaching statistical signifiance.*

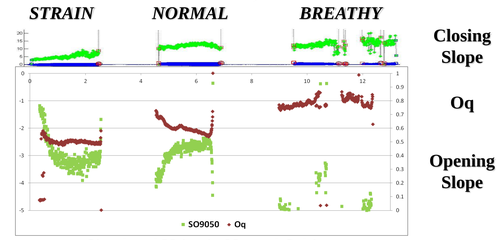


Ttest = 0.040

Ttest = 0.077

RESULTS (continued)

Notice how the open quotient parameter (in red below) gets larger as less strain is used to phonate in a normal subject:

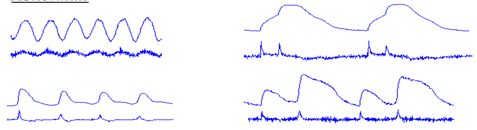


Simulated Voice in Normal Subject

Below are corresponding EGG and DEGG waveforms (all over a ~0.02s interval) from subjects with normal and abnormal voices.

Normal:

Abnormal:



DISCUSSION

- We have developed a method to analyze continuous dysphonic speech, as opposed to sustained vowel production.
- Normal and dysphonic EGG data from continuous speech present with differences in parameter stability, strain, and morphology. We have quantified these differences by measuring the aforementioned parameters, with the open quotient showing statistical significance. More patient data will be required to establish normative values for these parameters and assess their clinical utility.
- Because of the high intrinsic variability of the EGG waveform, the between-group comparison resulted in the closing slope only being able to distinguish between normal and dysphonic patients with a difference *approaching* statistical significance.

CONCLUSION

After simultaneous multi-parameter analysis, the open quotient (Oq) is able to distinguish strained and less-strained syllables with statistical significance. Based on the comparison between the normal and abnormal EGG waveforms, we believe all the parameters have the potential to graphically and numerically depict strain in continuous dysphonic speech. However, more patient data needs to be assessed in order to confirm this belief and furthermore affirm the clinical utility of these parameters.

REFERENCES

1. http://www.dataq.com/images/products/data-acquisition/720_500w.jpg
2. http://www.dataq.com/images/products/software/WinDaq-data-acquisition-large.gif
3. Fisher KV, Scherer RC, Guo CG, Owen AS. Longitudinal Phonatory Characteristics After Botulinum Toxin Type A Injection. *Journal of Speech and Hearing Research* 1996;39:968-980.

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