The Department of Communicative Sciences and Disorders and

The Department of Mechanical Engineering

Michigan State University

Ph.D. Dissertation Defense

Monday, June 19 at 9:30 a.m.

Zoom Meeting

Email sandra@msu.edu for Zoom information

ABSTRACT

LARYNGEAL MECHANISMS AND VOCAL FOLD FUNCTION IN ADDUCTOR LARYNGEAL DYSTONIA DURING CONNECTED SPEECH

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Adductor laryngeal dystonia (AdLD) is a neurological voice disorder that disrupts laryngeal muscle control during running speech. Diagnosis of AdLD is challenging because of the limited scientific consensus on accurate diagnostic criteria as it can mimic voice features of other voice disorders. The use of laryngeal high-speed videoendoscopy (HSV) as a powerful tool to capture the detailed vocal fold (VF) vibrations has been almost nonexistent to study AdLD and limited to sustained phonation, not connected speech in which AdLD’s symptoms manifest. The present dissertation aims to address the previous literature gap using HSV and provide, for the first time, quantitative analysis for the impaired vocal function in AdLD during connected speech. To accomplish this, HSV recordings were collected from vocally normal adults and AdLD patients during connected speech. Five different studies were implemented in order to analyze and extract clinically relevant information from these recordings.
The first study investigated the differences between AdLD and normal controls based on evaluating running speech durations in HSV over which VFs were visually obstructed by excessive movements of laryngeal tissues. To facilitate these analyses, a deep learning tool was developed to automatically classify HSV frames in terms of detecting visual obstructions in the VF images. The second study provided a new image segmentation tool for detecting VF edges during running speech in HSV. This tool was developed using a unique combination of the active contour modeling method and a machine-learning based method (k-means clustering) to segment VF edges in HSV kymograms. The third study developed a quantitative representation of VF dynamics in AdLD in running speech using HSV. A deep learning technique was used based on the tool developed in study two to segment the glottal area/edges and extract the glottal area waveform from the HSV recordings for analysis. The fourth study analyzed the pathological vocal function of AdLD during phonation onset and offset in connected speech using HSV. An automated approach was developed and validated with manual analysis to measure and compare the glottal attack and offset times between AdLD group and normal controls. Study five presented a one-mass lumped model that can estimate glottal area waveform and biomechanical characteristics of VFs based on HSV data.

The results of study one showed the accurate detection of the visual obstructions of the VF frames – facilitating the study of laryngeal activities in AdLD. The findings revealed that AdLD group exhibited longer durations of obstructions – making this measure a potential candidate for AdLD assessment. Also, indicating parts of connected speech that provide an unobstructed view of VFs allows for developing optimal passages for precise HSV examination and disorder-specific clinical voice assessment protocols. Study two and three demonstrated promising performance of the proposed automated tools to detect VF edges and analyze glottal area waveforms. These
accurate techniques overcame the challenges involved in HSV analysis including the poor image quality during running speech and the excessive laryngeal maneuvers of AdLD. Future research should benefit from these newly developed automated tools for HSV analysis of VF vibrations in running speech to explore diagnostically relevant information in both vocally normal adults and AdLD. The findings of the fourth study revealed the accurate measurements of the glottal attack and offset times using the developed automated technique. The measurements showed significant longer attack time in AdLD and more variability of the attack and offset times in AdLD due to the irregularity of the VF vibratory behavior in this disorder. Accordingly, glottal attack time might be a compelling measurement of the severity of AdLD, which can be further investigated in future using the developed tool with larger sample size and, even for different voice disorders. Obtaining such measures in running speech opens up new lines of research to explore the clinical significance of these measurements and address the diagnostic challenges in AdLD. In the last study on modeling, the results show the successful optimization of the developed one-mass model to closely capture the characteristics of VF vibrations observed in the HSV running speech sample. The study uncovered the potential of this simplified model to estimate biomechanical properties of VFs with minimal computational cost non-invasively– paving the path for future research to utilize this model for analyzing connected speech samples and study the impaired VF dynamics in AdLD.

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