Mucosal Waves in Self-Oscillating Synthetic Vocal Fold Models

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The objective of this research is to assess the ability of one- and two- layer self-oscillating synthetic vocal fold models to replicate physiological vocal fold motion within an experimental apparatus in the Biofluid Dynamics Laboratory. The research specifically aims to determine under what conditions a mucosal wave develops in the models. To produce speech, the initially closed vocal folds open when a critical lung pressure is reached. Air is forced through the vocal folds causing them to undergo self-sustained oscillations. When critical lung pressure is reached, the lower section of the vocal fold deforms, followed by a deformation of the upper section after a slight time delay. The lower section begins to close after the air passes over it due to the decrease in pressure and elasticity of the vocal fold. This cycle of offset deformation of the upper and lower vocal fold repeats forming the mucosal wave. The mucosal wave is an essential part of healthy voice production and visualizing it can help to diagnose speech-related disorders.

Homogeneous one- and two-layer were fabricated based on the standard M5 geometry. Materials were selected to match the properties of the different human vocal fold layers. The vocal fold models were tested using an *in vitro* vocal tract. The vocal tract has interchangeable inserts that replicate the effects of throat and mouth shape for different vowel sounds. The initial experiments were performed with the neutral (schwa) vowel tract. High-speed images were captured with an IDT NX4 high-speed camera and MotionStudio at 2500 fps to investigate vocal fold motion.

Many voice disorders can only be diagnosed by visualization. This process was traditionally done using high-speed videos played at slow speeds, which was very time-consuming. Videokymography is a technique wherein single lines in each high-speed image frame are stacked together into a single image showing the vibration at one point in the vocal fold. This process takes significantly less time than traditional methods and is equally useful in analyzing voice production.

Using a MATLAB code, the high-speed video images were converted into kymographs and analyzed to observe the mucosal wave. The kymographs did not clearly show a mucosal wave in one- or two-layer models. The mucosal was not expected in one-layer models based on previously reported studies, while previous research concerning the mucosal wave in two-layer silicone models has been inconclusive. More realistic synthetic VF models are being developed and evaluated using the techniques developed in this program to determine if a mucosal wave phenomenon is produced.