

BIOMECHANICS OF VOICE PRODUCTION

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The larynx is a delicately tuned instrument needed to produce over one half of the sounds in the English language and to create pitch contours in song and speech. Structural changes to the larynx may increase the effort needed to speak, decrease the quality of sound produced, cause pain, or eliminate the ability to speak. These symptoms can be extremely detrimental, especially if one's career relies on voice. Better understanding of the causes underlying structural changes to the larynx and of the connection between structural and functional changes has the potential to improve prevention and treatment of voice pathologies such as vocal nodules and scar.

The goal of this project is to address questions regarding the etiology and treatment of common voice pathologies. Mathematical models are ideal tools with which to achieve this goal since their variables can be systematically manipulated and controlled. Therefore finite element methods are being used to construct representations of the soft tissue vocal folds and of the airflow between them with physiologically relevant variables. The model parameters are based on laryngeal geometric and material measurements contained in the literature.

In vivo experimental measurements will be used to validate the model. Laryngeal dimensions will be estimated using a ruler in the endoscopic field. Airflow through the larynx will be estimated by applying inverse filtering techniques to airflow measurements made at the mouth during voice production. Pressure between the vocal folds both during separation and collision will be measured with a purpose designed piezoelectric film based sensor.

The validated model will be used to applied to relevant questions in the fields of speech pathology and laryngology. The role of mechanical stress and energy absorption in vocal fold pathology development will be investigated by looking for trends between vocal fold structure and mechanical stress/ energy absorption that match epidemiological trends between vocal fold structure and presence of pathology. The functional outcome of proposed surgical treatments will be predicted by examining the effect of geometric and material changes on the airflow waveform between the vocal folds, which has been shown to correlate with voice quality.

This work is being performed at the Biorobotics Laboratory at Harvard University under the supervision of R.D. Howe, Ph.D., the Voice & Speech Laboratory at Massachusetts Eye and Ear Infirmary under the supervision of R.E. Hillman, Ph.D., & the Speech Laboratory at Massachusetts Institute of Technology under the supervision of K.N. Stevens, Ph.D..

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