Effect of the paraglottic space on phonation in a MRI-based vocal fold model

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Introduction

The paraglottic space refers to the connective tissue layer that connects the vocal folds and the thyroid cartilage. This region is often neglected in computational models of phonation, in which a fixed boundary condition is often imposed on the lateral surface of the vocal fold, with the implicit assumption that the lateral surface of the vocal fold is in direct contact with the thyroid cartilage. Recent studies suggested that the presence of the paraglottic space may have important impact on voice production. The goal of this study was to investigate the effect of the paraglottic space on voice production in a MRI-based vocal fold model, and how this effect may be affected by vocal fold stiffening due to laryngeal muscle activation.

Methods

A parameter vocal fold model was developed based on MRI scanning of a cadaver hemi-larynx (57-year-old male) as described in [1]. The thyroid cartilage was directly imported from the MRI reconstructed geometry, and the paraglottic space was added by filling the gap between the vocal fold and the thyroid cartilage, as shown in Figure 1. The paraglottic space was modeled as an isotropic linear elastic material with varying Young's modulus. The vocal fold was modeled as a transversely isotropic linear elastic material as in our previous studies, with different vocal fold stiffness conditions simulating effects of laryngeal muscle activation. For each vocal fold and paraglottic space stiffness condition, voice production simulations were performed for different subglottal pressure and medial surface shape, from which the phonation threshold pressure, vocal fold vibration amplitude, and the closed quotient of vocal fold vibration were calculated.

Results

The results showed that the presence of the paraglottic space increased the mean and amplitude of the glottal area waveform, decreased the phonation frequency and closed quotient. The effect on the phonation threshold pressure was generally small. In this particular geometry with fully approximated vocal folds, the presence of the paraglottic space also reduced the occurrences of irregular vocal fold vibration. These effects of the paraglottic space generally became smaller with increasing vocal fold stiffening.

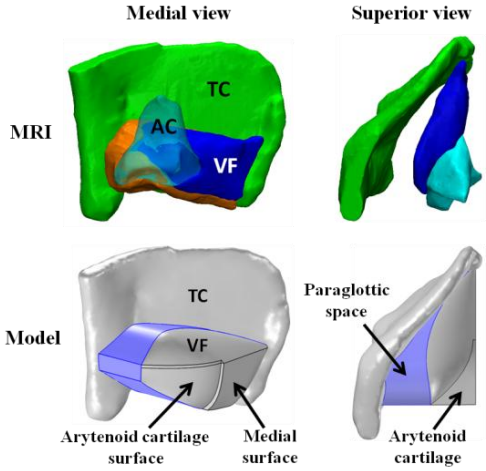

Figure 1: MRI-based vocal fold model with paraglottic space. VF: vocal fold; TC: thyroid cartilage; AC: arytenoid cartilage.

Discussion

This study showed that the stiffness condition of the paraglottic space can have important effect on vocal fold vibration and voice acoustics, and thus should receive more attention in vocal fold computational modeling, particularly in models based on realistic laryngeal geometry.

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References

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