Abstract:

Voice production is an integral component in human communication. However, the understanding of voice generation and proper treatment of communication disorders is still in its infancy. Because of the small size and inaccessibility of the vocal folds, quantitative measurement and analysis of their medial surface dynamics have been largely avoided, even though such dynamics are critical for an understanding of voice production. Because standard endoscopic techniques of laryngeal examination allow only a superior view of the vocal folds, they cannot be used to probe the medial surface dynamics, where vocal fold opening and closing take place and where sound is generated within the glottis.

Imaging the medial surface dynamics of the folds also allows quantification of the mucosal wave, which is initiated along the medial surface. While traveling up this medial surface, the mucosal wave exhibits significant amplitude excursions and interacts nonlinearly with the opposite vocal fold during collision. It also experiences possible nonlinear interactions with sub- and supraglottal systems as it modulates the glottal airflow, and produces the acoustic wave, which is later perceived as voice. If there were any region of the vocal folds that should be imaged to better understand mechanisms of voice production, propagation of the mucosal wave, and its influence on voice, it would be the medial surface of the vocal folds.

While several attempts have been made to image the medial surface dynamics of the vocal folds, only one was imaged with sufficient spatial and temporal resolution to extract the underlying modes of vibration [D. A. Berry, D. W. Montequin, and N. Tayama, J. Acoust. Soc. Am. **110**, 2539—2547 (2001)]. This former study utilized a hemilarynx procedure to image 9 fleshpoints on the medial surface of one coronal cross-section of an excised canine vocal fold. In the present study, the hemilarynx methodology was extended to both *in vivo* canine larynges and excised human larynges. Also, the entire medial surface of the vocal fold imaged, instead of just one coronal cross-section. That is, in each experiment, 25-30 fleshpoints were imaged simultaneously along the medial surface of the vocal fold (5 vertical rows of fleshpoints, with 5-6 fleshpoints per row).

Empirical eigenfunctions were exacted to examine the underlying modes of vibration, and to probe mechanisms of voice production. As in previous computational and experimental investigations, two dominant modes captured the essential dynamics of vibration (i.e., over 90% of the energy). In most cases, the primary mode was responsible for alternately shaping a convergent/divergent glottis, while the secondary mode captured the lateral in-phase movement of the vocal folds. A precise synchronization of these modes facilitated the transfer of energy from the airflow to the tissue, enabling self-oscillation. The data were also used to examine models of mucosal wave propagation. The significance of both incident and reflected waves were probed with regard to their influence on the total vibration pattern.