

## How changing the vocal fold vertical stiffness gradient changes vocal fold vibration

Sid Khosla , Liran Oren , Charles Farbos de Luzan

Department of Otolaryngology, University of Cincinnati, Cincinnati, Ohio, USA

**Keywords: vocal fold elasticity, phonation, mucosal wave**

**Introduction:** During vocal fold vibration, a coronal section of the vocal folds is convergent during opening and divergent during closing; we will refer to this vibratory pattern as the vertical mucosal wave (VMW). We also know that, as displacement increases, the superior aspect of the folds becomes less stiff than the inferior aspect; we will refer to the change in stiffness as the vertical stiffness gradient (VSG). These two facts led us to hypothesize that reduction of the vertical stiffness gradient will reduce the vertical mucosal wave.

**Methods:** 4 excised canine larynges were used. As previously described, particle imaging velocimetry of the intraglottal velocity fields was done at low and high subglottal pressures in the mid coronal plane. This was considered the baseline, and using the indentation method, stress strain curves were taken for the superior and inferior 1 mm of the fold in the mid membranous plane. Radiopaque calcium hydroxyapatite (CaHa) crystals were then injected into the very superior aspect of the fold. New stress strain curves were then obtained. PIV was then taken and intraglottal velocity fields were obtained.

**Results:** Injecting the CaHa reduced the inferior-superior stiffness gradient by over 75% in all larynges. The maximal divergence angle was also markedly reduced resulting in minimal VMW.

**Discussion:** Marked reduction of the vertical stiffness gradient also significantly reduces the vertical mucosal wave. Clinical implications will be discussed in addition to possible hypotheses for reduced VMW.