Airway reconstruction using posterior cricoid reduction for treatment of dysphonia

Elias Sundström*[1], Liran Oren[1], Alessandro de Alarcón[1,2]

[1]Department of Otolaryngology – HNS, University of Cincinnati, Cincinnati, Ohio, USA
[2]Division of Pediatric Otolaryngology– HNS, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

Keywords: Airway reconstruction, dysphonia, FSI

Introduction

Nearly 50% of children who undergo airway reconstruction for subglottic stenosis have a significant risk of developing dysphonia due to postoperative posterior glottic diastasis [1]. Many of these patients develop alternative compensatory laryngeal structures as their primary sound source for voicing (e.g., the false vocal folds).

Two of the more common surgical interventions for correcting glottic diastasis are bilateral medialization thyroplasty and posterior cricoid reduction. Both procedures reduce the diastasis by medializing the glottic region. The Bilateral medialization thyroplasty technique is slightly different than the medialization technique that is typically used for unilateral vocal fold paralysis because anterior overcorrection must be avoided, and the posterior part of the implants cannot touch the arytenoid cartilage (and affect the vocal process). In posterior cricoid reduction, a vertical line (about 2 mm thick) is removed along the posterior cricoid, which medializes the glottic region when the lateral edges of the cricoid are reattached together.

The goal for the current study is to compare the pre- and postoperative airflow dynamics in a patient subjected to posterior cricoid reduction. Our hypothesis is that posterior cricoid reduction after airway reconstruction is an effective remedy for a compensatory speech disorder.

Methods

The geometry for the model was delineated from CT scans taken pre- and post-surgery in a patient who was diagnosed with dysphonia following airway reconstruction. The patient underwent posterior cricoid reduction and there is a three year time-lapse between pre- and post-scans. The scans covered the head and neck with a 0.5 mm slice thickness and obtained while the subject sustained the /e/ sound. The airflow was predicted using the incompressible Navier-Stokes equations. Simulation of tissue dynamics was done using fluid-structure interaction (FSI) [2]. The biomechanical properties of the tissue were based on literature data. The subglottal total pressure was a set to 6 cmH20 and atmospheric pressure was assumed at the mouth opening.

Results

Prior to surgery, the false vocal fold is subjected to a major pressure drop, which coincides with the location of the smallest cross-sectional area. As a result, the jet and associated acoustic source develop at the false vocal fold. Post-surgery, undergoing cricoid reduction, the smallest cross-section was shifted to the true vocal fold. This modulates the major pressure drop to occur across the true vocal fold and the associated jet is shifted accordingly.

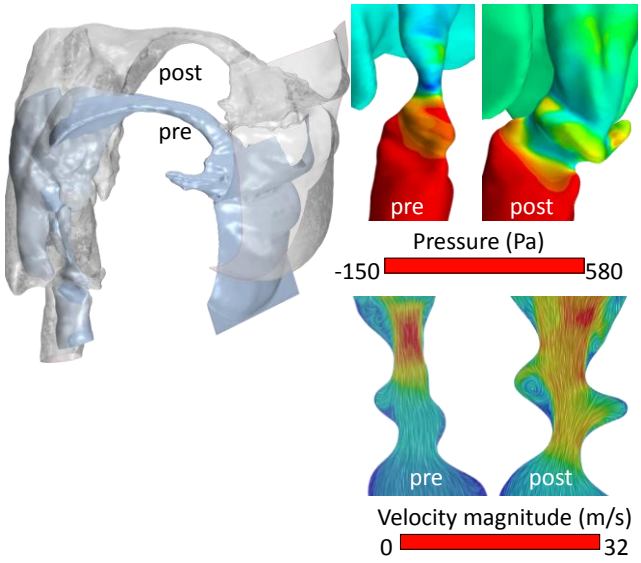

Figure 1: Isometric view of pre- and post-surgery airway reconstructions (left). Pressure and velocity distributions for pre and post inside the vocal tract (right). The flow goes from the subglottal inlet to the mouth opening.

Discussion

Prior to surgery, the patient was diagnosed with compensatory speech disorder using the false vocal folds, during phonation of the /e/ sound. With the posterior cricoid reduction, the smallest cross-sectional area was shifted to the true vocal folds. This relocates the acoustic source for phonation to the true vocal folds and correlates with a reduced compensatory speech disorder.

Acknowledgments

NA.

References

[1] de Alarcón, A., Zacharias, S., Oren, L., de Luzan, C. F., Tabangin, M. E., Cohen, A. P., Roetting, N. J., and Fleck, R. J. Endoscopic posterior cricoid reduction: A surgical method to improve posterior glottic diastasis. *The Laryngoscope*. 2019;129:S1-S9.

[2] Sundström, E., Jonnagiri, R., Gutmark-Little, I. et al. *Cardiovasc Eng Tech* (2019). https://doi.org/10.1007/s13239-019-00441-2

*corresponding author e-mail: sundstes@uc.edu

*corresponding author e-mail: sundstes@uc.edu