Numerical Simulation of Snoring in a Human Upper Airway with Dynamic Glottis

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Abstract

Snoring is a prevalent problem among adults and can significantly affect the quality of life of both the snorer and bed partner. Recent studies have shown a direct correlation between snoring and cardiovascular diseases. Up to date, the most common way to alleviate the snoring problem is still surgical intervention, which removes the tissues that are responsible for the snoring production. A critical question of the treatment plan is which part should be operated and how to find the most important noise source.

In this study, we aim to develop a computational acoustics model that can simulate the sound generation in human airways. There are four objectives in this study.

- Develop a user-define function to generate a dynamic mesh for the throat.
- Investigate the effect of the dynamic glottis on the sound generation in the upper airway.
- Simulate the whole decibel change during a 1.5 seconds breathing duration.
- Find the frequencies under which the snoring noise is the highest.

ANSYS FLUENT was used to simulate the sound generation from both a static and fluctuating glottis. The acoustic signal from individual anatomical sites such as pharynx, throat and mouth were predicted and compared to see how the acoustic pressure is distributed against the frequency. To study the effect of dynamic glottis on the sound generation, four different breathing scenarios were tested: constant speed with rigid body, constant speed with dynamic mesh, transient flow with rigid body and transient flow with dynamic mesh. The calculation data was analyzed to identify which anatomical site should be the most important noise source of snoring.

The results show that for transient flows, lung and mouth has the least decibel within the range of human's normal breathing conditions, while the larynx and pharynx has the highest decibel, especially the pharynx. However, for a constant flow speed, the larynx and pharynx has the least decibel within the range of human's normal breathing, while the mouth and lung has the highest decibel, especially the mouth. During the normal human's breathing in sleep, it is more likely to be transient during inhalation, and constant during exhalation. Clinically, this means that the pharynx is the first choice for the surgical operation for those serious snore patients considering that snoring most occurs during inhalation.

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