BIOE 451/452: Bioengineering Design

An opportunity for students to tackle and solve a design problem in bioengineering

Modification of a TEVP

April 2006

Current Standard SmartWhistle

"We aim to improve current designs of tracheoesophageal voice prostheses (TEVPs) to give female users a higher pitch than male users and to allow pitch variation within speech facilitated by a greater range of pitch for both females and males."
—Minesweeper Documentation

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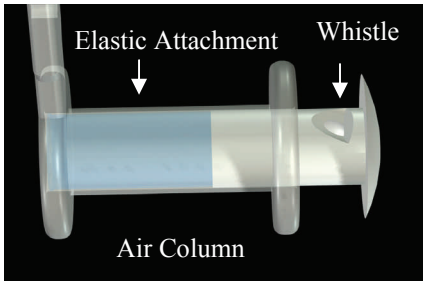
Bioengineering Design Challenge

There are currently 60,000 people in the U.S. who have had their larynxes, or voice boxes, removed. Of these, 60% use a tracheoesophageal voice prosthesis (TEVP), which relies on vibrations generated by the upper esophagus to restore the ability to speak. Although patients with TVPs report an increased quality of life, disadvantages include a monotone pitch, risk of aspiration, deterioration due to biofilm formation, and need for frequent maintenance. The biggest concern for most users is the pitch. Esophageal vibrations are lower in pitch and do not have the frequency fluctuations of normal speech. Thus, the TEVP generates a deep, monotone voice. This is especially frustrating for women due to the masculine tone the TEVP produces in all users.

Appropriate Solution

The objective of Team MimeSweeper of BIOE 451 was to design a TEVP that was able to produce pitch variation and allow for a higher pitch frequency in women. The design, the SmartWhistle, is based on the principles of musical instruments. The SmartWhistle has a sliding whistle component that is attached to the main prosthesis shell via elastic attachments. As air flows through the prosthesis, the whistle component protrudes from the prosthesis into the esophagus, increasing the length of the air column and consequently, decreasing sound frequency, or pitch. Two SmartWhistles were designed: 20 Fr. And 16 Fr.



In order to evaluate the design of the SmartWhistle, Team MimeSweeper constructed an "artificial throat" using PVC pipe. The prosthesis was placed inside the "throat" surrounded by a foam seal. Cool air from a hair dryer was blown into the "throat" at 3 different speeds. The sound produced was recorded using Praat sound software. Testing was performed on both the current standard TEVP and the SmartWhistles. In the 16 Fr. model they were able to achieve pitch elevation, while in the 20 Fr. model they were able to achieve pitch variation. Design improvements need to made to achieve both objectives in one model. Support was provided by Dr. Gregory Reece, Dr. Jan Lewin, Dr. Julia Leone, Dr. Maria Oden, Mathew Wettergreen, Kevin Bowen, Eugene Koay, Ryan McGuire, The Brown Foundation

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