SmartWhistle: A Tracheoesophageal Voice Prosthesis that Restores Pitch Variation

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Mission Statement

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.

Background

- 60,000 laryngectomees in the US currently.
- 60% laryngectomees use TEVPs.
- TEVP occupies the shunt between the esophagus and the trachea (Fig. 1).
- Sound-producing TEVPs have been shown to increase voice pitch.

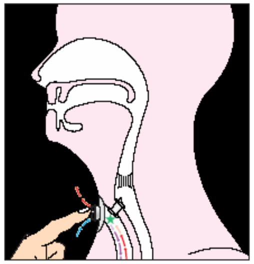


Figure 1. TEVP at work: pulmonary air is redirected through the voice prosthesis into the esophagus causing esophageal wall to vibrate, producing sound.

Limitations of Current Devices

- Female users speak with the same low pitch as male users.
  - Esophageal vibration frequency is much lower than normal female voice frequency.
- All users have a monotone pitch.

Design Objectives

Pitch	Higher fundamental frequency compared to standard
Diameter	16-22 French
Shaft length	6-28 mm
Cost	Less than $200/unit
Longevity	Greater than 3 months for disposables

All values are for the actual product, not the prototype.

SmartWhistle Prototype

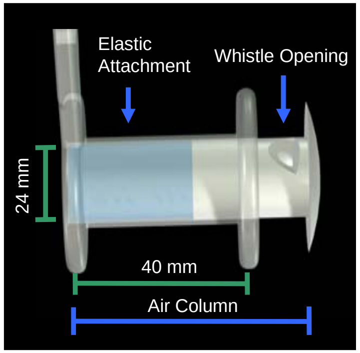


Figure 2. CAD illustration of a 20 Fr. SmartWhistle scaled up 4 to 1.

How it works:

- Air flow extends the whistle via elastic attachment (Fig. 2).
- Whistle extension elongates the air column.
- Change in air column length changes sound frequency.
- Upward diversion of air vibrates esophageal wall, producing sound (Fig. 3).

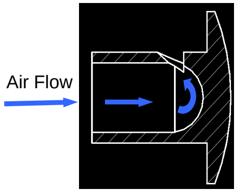


Figure 3. Air flow through the whistle opening.

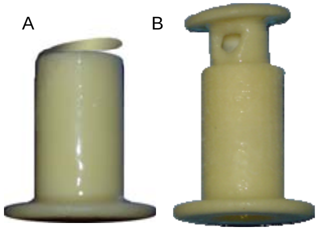
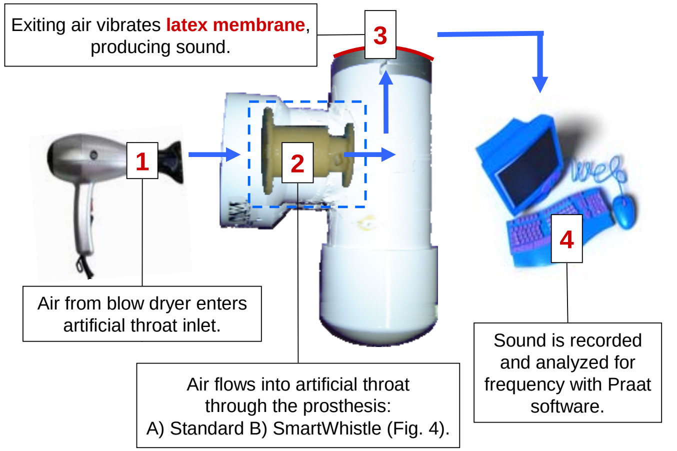


Figure 4. Prototype of A) current standard design with a flap valve and B) SmartWhistle, both made of elastomeric material.

Testing Methods

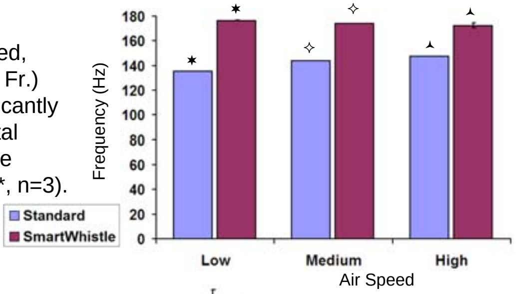


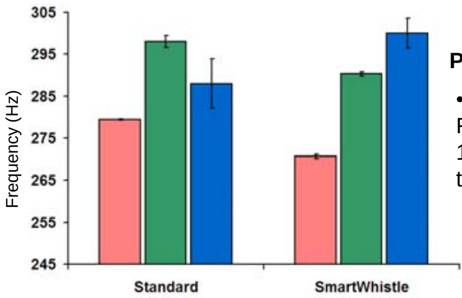
Results

Pitch Elevation

- At every air speed, SmartWhistle (16 Fr.) produces a significantly higher fundamental frequency than the standard ($p<0.05$*, n=3).

* Student's t-test, 2 tailed





Pitch Range Expansion

- SmartWhistle's (20 Fr.) frequency range is 1.5 times greater than the standard's.

Conclusion

- SmartWhistle produces a higher pitch than the current standard design, giving female users a **higher-pitched voice**.
- SmartWhistle produces a greater range of pitch than the current standard design, allowing more **pitch variation** within speech for all users.

Future Work

- Scale down the prototype and modify testing.
- Modify whistle design to produce sound in addition to changing air speed.

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