BACKGROUND/INTRODUCTION

The vocal tract (VT) measurements are typically made using medical imaging studies such as X-ray radiography, magnetic resonance imaging (MRI), and computed tomography (CT). MRI is used when detailed visualization of the soft tissue is needed, and therefore optimal for making measurements of the oral and pharyngeal regions of the VT.

Acoustic Pharyngometry (APh) is a non-invasive technique that uses the reflection of acoustic waves to calculate the cross-sectional areas (CSA) and length, and volume of the VT or upper airway. Despite its long standing clinical use to assess patency of the upper airway in sleep studies, a very limited number of studies have examined APh measurements against actual anatomic measurements; and such studies have only used select APh measurements taken in the pharyngeal region (at the level of the glottis and trachea or of the nasal cavity) to compare against anatomic measurements obtained through MRI to confirm comparability of measurements.

METHODS

Participants: Six adults (3 males, 3 females) between the age of 22 years and 30 years participated in both the APh and MRI components of this study. Participants had no health issues, specifically no pathology in the head and neck region including no history of speech/language or hearing difficulties. Also, they had no contraindications to undergoing an imaging study.

APh Protocol:

- Each participant exhaled into a mouthpiece by Eccovision® (Sleep Group Solutions)® attached to the APh wave tube in the supine body position (to simulate MRI scanner table).
- The wave tube emitted a pulsing sound into the VT as the participant exhaled. The acoustic pharyngometer then used the reflected acoustic waves to calculate and display the cross-sectional areas (CSA) of the VT as a function of distance from the glottis to the teeth (pharyngogram).
- Each participant completed eight breathing trials. Four slow exhalations (inhale through nose, exhale through mouth) and four nasal (inhale and exhale through nose). Graphs/phonygrams depicting the CSA were saved for each breathing trial.

The slow exhalation pharyngograms were used to make VT length and volume measurements:

- The nose exhale pharyngograms were used to identify the smallest CSA to mark the location of the oral-pharyngeal junction (OPJ). The pharyngometer then used the OPJ to calculate the oral and pharyngeal length and volume measurements.
- APh waveforms were analyzed for both length and volume measurements of the oral cavity, pharyngeal cavity and VT.
  - The measurement definitions are as followed:
    - Oral cavity length (OCL-APh: teeth to OPJ)
    - Pharyngeal cavity length (PCL-APh: OPJ to glottis)
    - VT length (VTL-APh: teeth to glottis)
  - The corresponding cavities’ volumetric measurements are: oral cavity volume (OCC-APh), pharyngeal cavity volume (PCV-APh), and vocal tract volume (VT-APh).

OBJECTIVE:

The purpose of this study is to determine comparability of APh measurements against MRI measurements for both the oral and pharyngeal portions of the VT.

RESULTS:

- The resulting CSA plot was then superimposed on the acoustic measurement. The path entailed establishing an oral cavity (OC) and a pharyngeal cavity (PC) path that were created based on several landmarks and user determined input, followed by manual smoothing and interpolation.
- Extracting Quantitative Measurements:
  - The VT-APh path was then used to execute a script that calculates the length and finds the orthogonal planes between each landmark and its subsequent increment. Intersection between the orthogonal plane and the 3D pharynx model was extracted as boundary vertices and edges used to obtain CSAs and volumes throughout the VT.
  - The CSAs produced were then plotted as a function of distance from the lingual aspect of the incisors/fron to the glottis, where the distance between the two points represents the APh VT.
  - The resulting CSA plot was then superimposed on the acoustic pharyngogram by having both overlap at the level of the glottis. This approach was used to infer the anatomic equivalent location for the OPJ on the mid-sagittal plane of the imaging study, and selected to divide the overall OPV into OCV and PCV.
  - In addition, the cavity length measurements are obtained from the APh:
    1) PCL: the curvilinear distance from the OPJ, as referenced by the data from APh study, to the level of the glottis.
    2) OCL: the curvilinear distance from the alveolar incisor along the palate to the OPJ.

CONCLUSION:

- APh is a non-invasive clinical tool that is being increasingly used as a research tool to gather VT measurement from typically and atypically developing individuals (who may not be imaged or cannot be imaged due to medical concerns).
- Present findings confirm that APh can be used as a research tool and can be a useful approach to study the development of the upper airway in typically and atypically developing individuals (provided the participant is able to follow APh instructions, and the pediatric APh mouthpiece fits).
- APh is a technique that may be used to gain information about the developmental changes in the oral and pharyngeal cavities. Such information may be used in VT modeling efforts to assess how changes in the oral and pharyngeal regions of the VT alter speech acoustics; also assess the role anatomic growth plays in speech intelligibility.

REFERENCES: