INTRODUCTION AND GOAL

- Glossectomy is a surgical procedure to remove the cancerous tumor of the tongue plus about 1 cm of tissue around it. After the surgery, the resection site of the tongue is sutured and closed or a flap is inserted to reconstruct the tongue volume. As a result, its speech production capability may be affected.
- Our previous studies showed that average centers of gravity in spectra of fricatives /s/ and /sh/ are significantly lower in glossectomy speakers than in normals [1] and patients will prefer to use laminal tongue shapes for /s/ due to reduced tip control [2].
- However, how speech articulation and acoustics change after glossectomy is not well understood.

Our goal is to further understand the articulation and acoustic differences in the production of fricatives /s/ and /sh/ between normal and post-glossectomy speakers.

MATERIALS AND METHODOLOGIES

- 3 male subjects: 1 control (named ‘CL’) and 2 post-glossectomy patients (named ‘PT1’ and ‘PT2’).
- PT1 has problematic /s/ productions in the context of ‘isi’, ‘asa’, ‘usu’, and ‘ese’, shown by a perceptual test discriminating /s/ and /sh/.
- PT2 has problematic /sh/ productions in ‘ush’.
- Both patients had T2 lateral lingual tumors (2-4 cm in the largest dimension) and had primary cancers after surgery.

SPEECH MATERIALS

- Vowel-consonant-vowel (VCV) words used in the perceptual test discriminating /s/ and /sh/. Vowels consist of /i/, /ah/, /uw/, /sh/, and consonants consist of /s/ and /sh/.
- PT1 has problematic /s/ productions in the context of ‘uis’, ‘uisa’, ‘uisa’.
- PT2 has problematic /sh/ productions in ‘uisu’.
- Both patients had T2 lateral lingual tumors (2-4 cm in the largest dimension) and had primary cancers after surgery.

MRI DATA

- 3.0 T Siemens Tim Trio with 8-channel Head and Neck coil.
- Cine-MRI frame rate: 26 Hz, in-plane resolution: 1.857 mm/pixel; slice thickness: 6 mm; field of view: 24 cm; 3 orthogonal image stacks (sagittal, coronal, and axial) were acquired.

DATA ANALYSIS

- Acoustic spectra were estimated using a multitaper analysis over segments of 80 ms for the /s/ and /sh/.
- A super-resolution technique [3] was applied on the 3 cine-MRI stacks to create an isotropic volume with a resolution of 1.875x1.875x1.875 mm, for vocal tract reconstructions.
- The centerline method [4] was used for determining the grid lines of area functions.

RESULTS

Fig. 1. Tongue pictures of subjects

A normal subject

Patient PT1 (tumor on his left)

Patient PT2 (tumor on his right)

The missing part of the tongue in patients makes it bend or protrude towards the left or right side depending on the location of the tumor, whereas the shape and position of a normal tongue is symmetrical. The red dashed line indicates the contralateral tongue.

Fig. 2. Mid-sagittal MR images of /s/ and /sh/

Control CL

Patient PT1

Patient PT2

The constriction for /s/ in the patients was further back than the control.

- The tongue shapes for /s/ and /sh/ are very similar in both patients, whereas the tongue shapes for /s/ and /sh/ in the control are contrasted well (apical vs. laminal /sh/).

Fig. 3. Acoustic spectra of /s/ and /sh/

Control CL

Patient PT1

Patient PT2

In PT1, the air flow bypass created by the missing tongue makes the constriction for /s/ more backward.

- In PT1, the air flow bypass created by the missing tongue makes the constriction for /s/ more backward.
- In PT2, the air flow bypass created by the missing tongue makes the constriction for /s/ more backward.

- In the control, /s/ and /sh/ have distinctive constriction locations (indicated by red dashed lines) which produce distinctive peak frequencies in the spectra.
- In each patient, /s/ and /sh/ have similar constriction locations, which causes the problems in /s/ for PT1 and in /sh/ for PT2.
- In PT1, the air flow bypass created by the missing tongue makes the constriction for /s/ more backward.

- The problems in /s/ for ‘isi’ but not in ‘asa’, for PT2 might be explained by the inability of precise tongue control and the similarity of tongue shapes between /s/ and /sh/.
- It may be easier to switch from /sh/ to /s/ than from /s/ to /sh/.

CONCLUSIONS

- A Cine-MRI-based D3 vocal tract reconstructions and the derived area function models were used effectively in this study to understand fricative /s/ and /sh/ production and interpret the observed acoustic spectra, specifically for the pathologic production in the post-glossectomy patients. This approach might potentially provide guidance on the surgery procedure to improve the speech outcome of those patients.
- Our future work will include 3-D vocal tract acoustic analysis considering the abnormality of the vocal tract for the patients.

REFERENCES


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