Variability of tongue anteriority during speech task “a shell” in glossectomy patients

Matthew Sawaged and Maureen Stone
Departments of Neural and Pain Sciences and Orthodontics, University of Maryland Dental School, Baltimore, USA

INTRODUCTION AND GOAL

Our goal is to specifically examine 4 glossectomy patients during pronunciation of “a shell” and use volumetric data to determine how tongue deformation is affected by the glossectomy compared to controls. Of the 4 glossectomy patients, 2 have surgical flaps while the other 2 do not. Previous measurements of controls help us determine any deviation from “normal” tongue deformation by the glossectomy patients.

- The Center for Disease Control and Prevention estimates more than 30,000 new cases of oral and pharyngeal cancer each year. One of the most commonly affected sites of oral cancer is the lateral border of the tongue.[1]
- During resection, a margin of clean tissue 1-1.5 cm is removed around the entire border of the tumor. Thus, the resection size will be 2-3 cm larger than the tumor size. As a result, speech production may be affected.
- Anteriority measures the percent of the tongue anterior to a tooth landmark. In this case, the percent anterior to PM2 represents the tongue tip and the percent anterior to M1 adds part of the tongue body. This measurement can help determine if the location of a glossectomy has a significant effect on speech. We feel this can reveal the way a tongue deforms when comparing similar sounds made by controls.
- **Hypothesis 1:** Glossectomy patients will achieve a less anterior tongue position than controls for “sh” and the same position for “uh”.
- Rationale: Pronunciation of the consonant “uh” does not necessitate deformation of the tongue to a more anterior position, but pronunciation of the consonant “sh” involves deformation to a more anterior-superior position of the tongue.
- **Hypothesis 2:** Flap patients will achieve a more anterior tongue position than non-flap patients for “sh” because the flap increases the tongue volume.
- Rationale: Flap patients may have to accommodate for an increase in tongue structure/volume by positioning the tongue more posteriorly than the non-flap patients.

Fig. 1. Post-Operative Pictures of Flap Patients

F1 F2

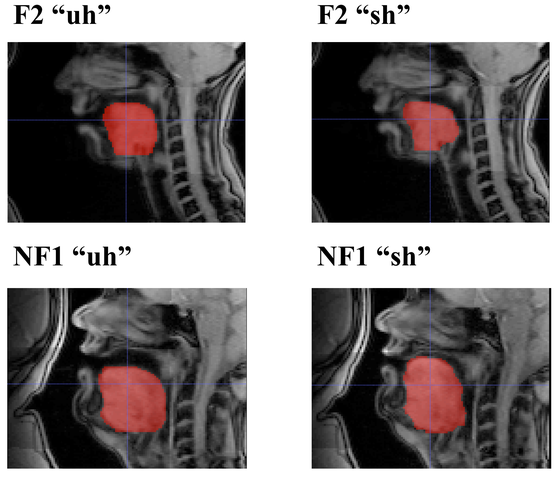
MATERIALS AND METHODOLOGIES

SUBJECTS:
22 subjects were used in this study:
- 2 Glossectomy patients with surgical flaps (F1 and F2)
  - F1 has a pedicle submental island flap on the left side
  - F2 has a radial forearm free flap on the tip of the tongue
- 2 Glossectomy patients without surgical flaps (NF1 and NF2)
- 18 Control patients (C1-C18)

MRI DATA:
- Used ITK-Snap to segment the whole tongue from 3-D MRI volumes during time frames /uh/ and /sh/ in “a shell”.
- 128 slices per time frame displayed in axial, sagittal, and coronal planes.
- Tooth roots for M1 and PM2 were extracted from high resolution MRI images and used to cut the anterior tongue regions to calculate percent anteriority.

ANTERIORITY AND VOLUME CALCULATION:
- Tongue masks were created for each patient using segmentation tools on ITK-Snap. Data for controls had been provided.
- Masks for each subject were superimposed onto downsampled high resolution supervolumes to use tooth roots to virtually cut the tongue.
- Reference points were made to create 2 planes: One that would bisect the most anterior mesial points of the maxillary first molars (M1) and midline of the palate, and the other bisecting the most posterior mesial points of the maxillary second premolars (PM2).
- Using these planes, I determined the volume of the tongue anterior to M1 and PM2 during time frame “uh” and time frame “sh” for each patient.

Fig. 2. Tongue masks for F2 and NF1 at “uh” & “sh”



RESULTS

SIGNIFICANCE OF DATA:
- Means, SDs, and Confidence Intervals were calculated for controls and test subjects.
- Volumes anterior to M1 and PM2 were divided by the whole tongue volume to determine the percentage of anteriority of the tongue for each sound and subject.

Fig. 3. Change in Anteriority at M1 and PM2

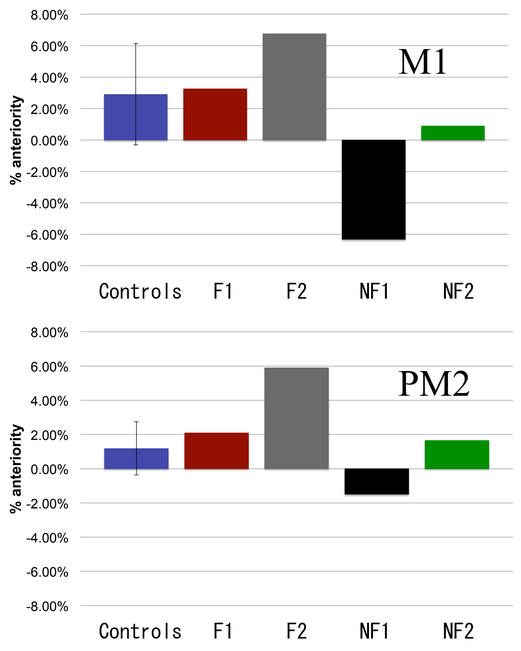


Fig. 4. Mean Anteriority Volumes of Flap Patients and Non Flap Patients

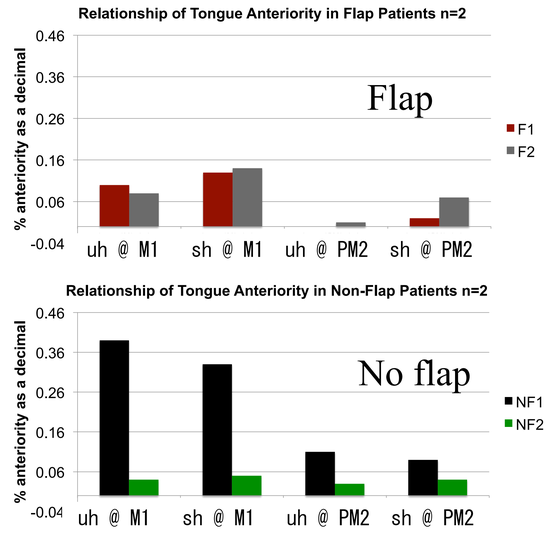
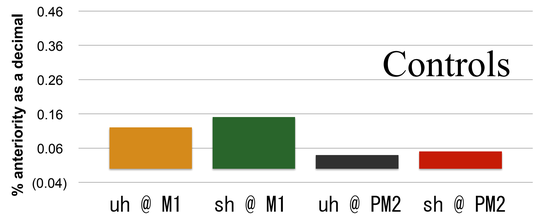


Fig. 5. Tongue Anteriority in Controls n=18



DISCUSSION

- Flap patients generally displayed a greater change in anteriority than controls during pronunciation of “sh” at M1 and PM2 (Fig. 3). Perhaps the increase in volume and fat distribution from the flap surgery actually contributed to a more anterior positioning of the tongue. Of both flap patients, F2 (gray) falls outside of the confidence interval.
- The tip of the tongue typically undergoes the most deformation during speech. Interestingly, F1 (burgundy) had the most similar change in anteriority to controls, presumably because there was no surgical involvement of the tip of the tongue (Fig. 3). Rather, F1 has a pedicle submental island flap/lateral flap.
- F2 presents with a radial forearm free flap on the tongue tip, which may increase the rigidity of the tongue and prevent it from expanding. Instead, F2 must translate the body of the tongue from “uh” to “sh”, which can explain the large change in anteriority seen in Fig. 3.
- In comparison to flap patients, non flap patients had less percent anteriority at both M1 and PM2 (Fig. 3). NF1 (black) is also outside the confidence interval but the motion is negative. It is possible that the tongue’s healing mechanism used posteriority as compensation for the resection and contributed to the tongue’s deformation during “a shell”. Posterior tongue movement from “uh” to “sh” by NF1 can be seen in Fig 2.
- Limitations to this study include small sample size and variation in tongue masking by human error.

CONCLUSIONS

- Only F1 and NF2 fell within 1.5 standard deviations of controls when measuring percent change in anteriority.
- According to the data, we can conclude that flap patients generally exhibit greater tongue anteriority during speech than non-flap patients and controls.

REFERENCES

1. Paul A. Yushkevich, Joseph Piven, Heather Cody Hazlett, Rachel Gimpel Smith, Sean Ho, James C. Gee, and Guido Gerig. User-guided 3D active contour segmentation of anatomical structures: Significantly improved efficiency and reliability. Neuroimage 2006 Jul 1;31(3):1116-28.

ACKNOWLEDGMENTS

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