Variability of anteriority relative to M1 and PM2 during speech task /uh-thing/ in glossectomy patients

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INTRODUCTION AND GOAL

This study examines how the creation of the sound "th" is related to tongue protrusion in humans. Humans demonstrate tongue protrusion as early as infancy during primitive functions such as swallowing and sucking.[5] Upon further maturation, protrusion of the tongue involves more sophisticated processes such as co-contraction of the muscles. The goal of this study is to better understand how humans may adapt motor control of the tongue to produce normal tongue protrusion following a glossectomy. "Th" is the sound in human language that requires tongue positioning most closely resembling protrusion and is therefore used in this study to replicate tongue protrusion in subjects.

- According to the American Society of Clinical Oncology, more than 53,000 people in the United States will be diagnosed with oral and oropharyngeal cancer this year, with more than 10,000 estimated deaths.[1]
- More than 32% of oral and oropharyngeal cancers are located in the tongue, with the most common treatment being a glossectomy.[4] Several factors contribute to the function of the tongue following glossectomy, including location of tumor resection and size of the lesion.[3] Damage to the muscles of the tongue and/or the hypoglossal nucleus may result in malfunctions during critical motions such as protrusion.[2]
- A radial forearm free flap (RFFF) may be used to replace excessive loss of tissue in glossectomy patients with large tumor resections, although this decision remains controversial among researchers. Previous research has indicated that preservation of speech quality is mostly reliant on preservation of the tip of the tongue during tumor resection.[3]
- This study focuses on anterior tongue displacement, further referred to as "anteriority," during the speech task /a thing/ between 2 glossectomy patients with RFFF attachments, 2 glossectomy patients without RFFF attachments, and 10 control subjects in an attempt to better understand the effects of glossectomy surgeries on tongue protrusion.

Fig. 1. Tongue pictures of subjects

A healthy subject | **Flap Patient 1 (F1)** | **Flap Patient 2 (F2)**

The pictures of patient 1 and 2 were captured after the completion of healing. F1 has a RFFF attachment replacing tissue lost from a lateral tongue tumor resection. F2 has a RFFF attachment replacing tissue loss from a tongue tip tumor resection.

MATERIALS AND METHODOLOGIES

SUBJECTS:
- 10 control patients ages 23-40
- 2 Glossectomy patients with RFFF (denoted F1 and F2)
- 2 Glossectomy patients with no RFFF (denoted NF1 and NF2)

Patient	Tumor Dimensions (cm)	Tumor Volume (mm3) using V = π/6 x L x W x H	Tumor Size
F1	6.0 x 3.5 x 2.5	27488.94	T2 N0 M0
F2	5.5 x 4.5 x 2.0	25918.14	T2 N2 MX
NF1	5.7 x 0.4 x 0.3	358.14	T3 N0 M0
NF2	3.5 x 2.6 x 2.1	10005.97	T1 N0 M0

MRI DATA:

Cine anatomical MRI data were collected for each subject in 3 orthogonal directions (sagittal, axial, and coronal) to measure the whole tongue volumes.
- Spatial resolution = 2 x 2 x 6 mm^3
- Slice thickness: 6mm

High resolution anatomical MRI data was also collected in 3 orthogonal directions to visualize the teeth and create planes to be used in measuring anteriority.
- Spatial resolution = 1 x 1 x 3 mm^3
- Slice thickness: 3mm

A super-resolution volume or "Supervolume" is created from the interpolation of intervening 3mm (6mm) slices to create an isovoxel with spatial resolution of 1 x 1 x 1 mm^3 (2 x 2 x 2 mm^3).

SEGMENTATION AND ANTERIORITY CALCULATION:

- Using cine-MRI Supervolumes, a segmented mask was created for each subject to determine whole tongue volumes (Figure 2).
- High-resolution Supervolumes were downsampled to match the spatial resolution of the masks created from cine-MRI Supervolumes, and were used to place 5 points on the following anatomical landmarks: left/right first molars, left/right second premolars, and a 5th point on the palate bisecting the first molars and second premolars (Figure 3).
- The points were used to create a vertical plane to measure the volume of the tongue anterior to the first molars. It was then shifted anterior to the points placed on the premolars (Figure 3).

Fig. 2. Whole tongue segmentation masks for F1

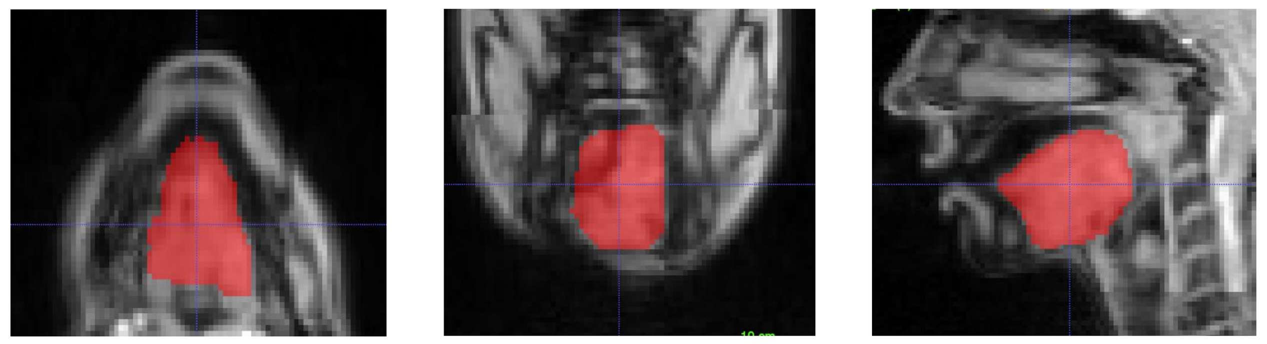
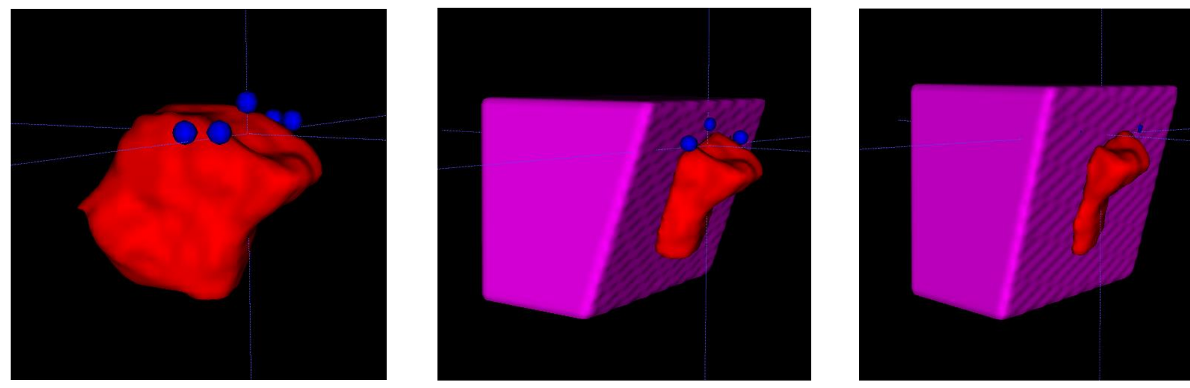


Fig. 3. Anteriority cuts for F1



RESULTS

COMPARISON WITH CONTROL SUBJECTS:

- Mean volumes with +/- SD of 1.5 were calculated for control subjects and used to create a confidence interval to compare patients' volumes.

Fig. 4. Average controls vs. patients percent total volume (mm^3) anteriority

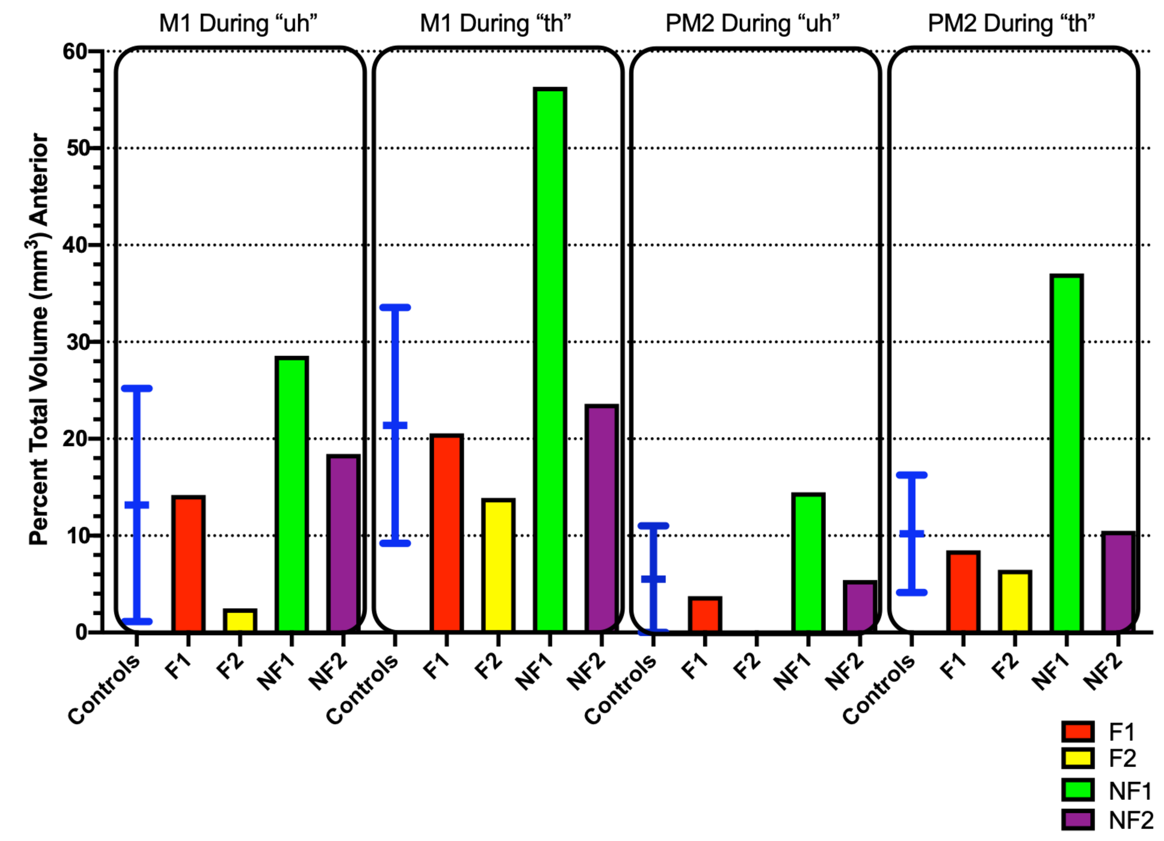


Fig. 5. Average controls vs. patients percent change in percent volume anteriority (mm^3) to M1 from "uh" frame to "th" frame

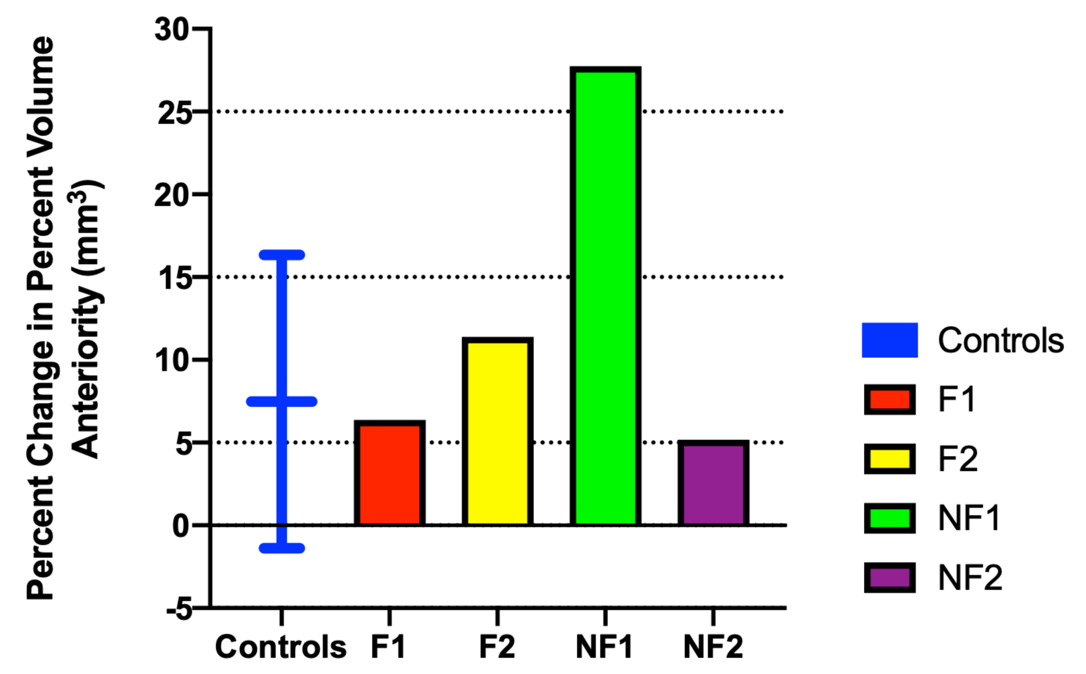
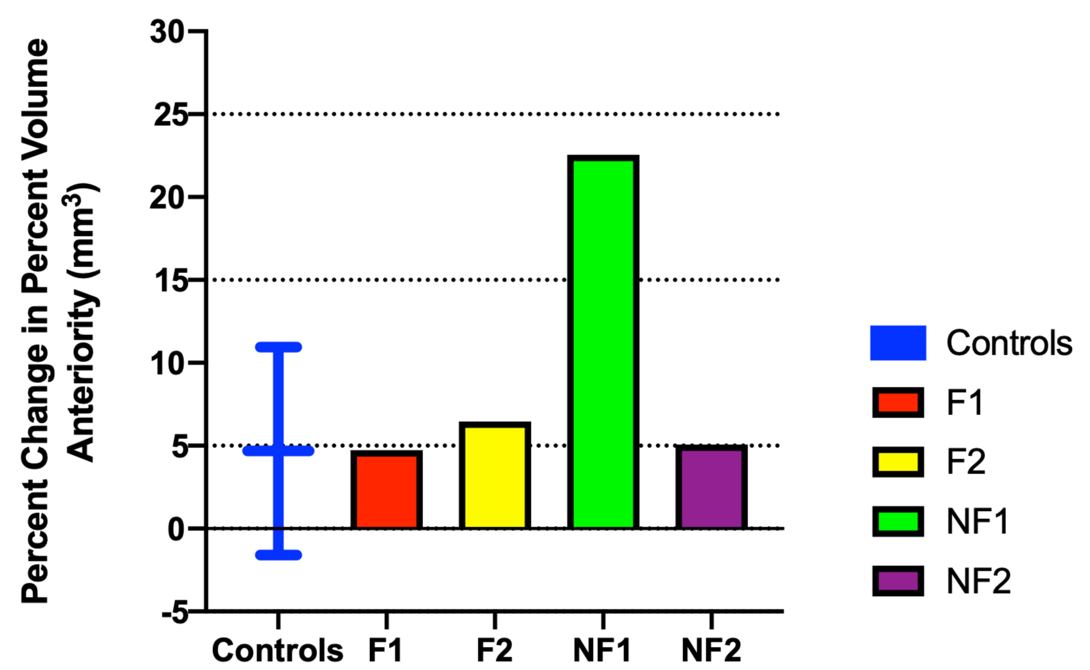


Fig. 6. Average Controls vs. Patients Percent Change in Percent Volume Anteriority (mm^3) to PM2 from "uh" frame to "th" frame



DISCUSSION

- Each glossectomy patient produced a % volume of anteriority to M1 and PM2 during both "uh" and "th" frames within +/- 1.5 standard deviations of control subjects, while NF1 consistently produced a larger % volume of anteriority to M1 and PM2 during both "uh" and "th" frames (Figure 4).
- Similarly, each glossectomy patient except NF1 demonstrated a % change in % volume anteriority to M1, as well as to PM2, between "uh" and "th" frames within 1.5 standard deviations of control subjects (Figures 5 and 6).
- These findings suggest two things:
  - There is some level of overcompensation in tongue protrusion produced by NF1 as a possible result of the patient's glossectomy.
  - F1, F2, and NF2 were able to adequately restore normal protrusive function of the tongue following their respective glossectomies.
- The size and location NF1's tumor (14x taller than wide/deep in the center of the tongue), as compared to other glossectomy patients, may have affected normal motor control of the tongue and thus contributed to this patient being an outlier.
- Limitations of this study may include human error in segmenting whole tongue masks and creating an accurate plane with which to make anteriority cuts in ITK Snap. Positioning of NF1's head during MRI data collection may have also affected the results.

CONCLUSIONS

- Even following large glossectomies, normal anterior tongue displacement in the form of protrusion can be adequately restored in patients.
- Protrusive function of the tongue following glossectomies may be largely dependent on the shape and location of the tumor resection.

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