Does asymmetry in tongue anatomy affect asymmetry in tongue position for Glossectomy and control subjects?

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UCTION

s a soft-tissue, muscular, structure that moves by As such, it is quite possible to move with left-to-right [1, 2] Unilateral tongue cancer surgery leaves patients asymmetry. In this study we examine anatomical tongue asymmetry and related motion asymmetries nd glossectomy speakers.
ight anatomical asymmetry of the tongue is expected nd glossectomy patients. Resting asymmetry occurs of the tongue rests in one side of the oral cavity. cause asymmetric muscle patterns during speech ute to patient adaptation.
pects patients to have greater anatomical and mmetry than controls, which will affect the location of mmetry.

LS AND METHODOLOGIES

nd SPEECH MATERIALS :

nd 10 glossectomy patients were studied. Five small tumors (T1N0M0) and five had larger ones

task is the motion of "uh" to "sh" in "a shell." This a complex tongue deformation the neutral "uh" and forward motion of the tongue into "sh." The s formed by the tip/blade region, which doesn't rather elevates to approximate the lateral edges of h a flat upper tongue surface. Posteriorly the tongue e groove and the root is pulled forward. One second ta (26 time frames) is collected because tags fade s.

DURES and ANALYSES:

ans are collected in 3 orientations (sag, cor, axi). For subjects hold still for 1 - 3 min per orientation. For orientation, they say 21-40 repetitions of "a shell," averaged to produce a movie of the task.
olution volumes are reconstructed. One for the high-natomy, and 26 for the tagged motion.

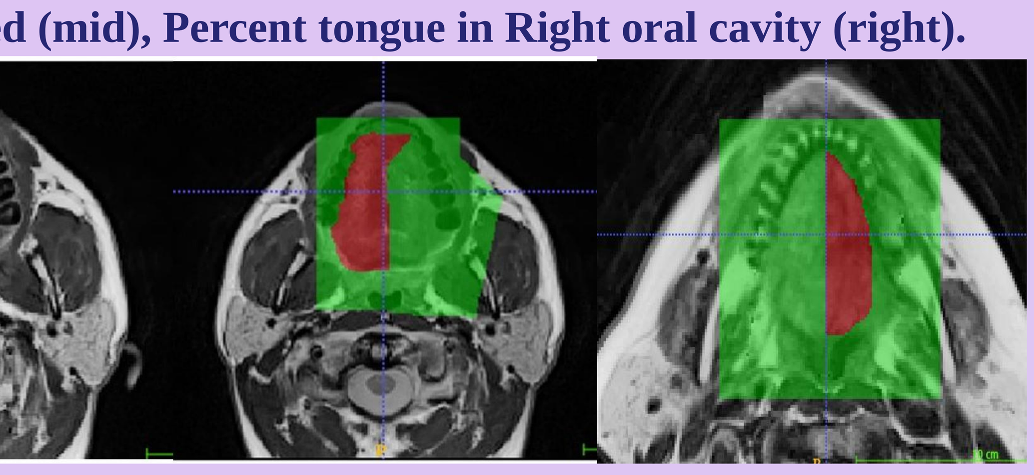
GMENTATION: Left, Right, Middle

program written in Matlab uses Random Walker to determine the tongue's boundaries.[3] Pixels within re colored red, outside pixels are green. ITK-snap[4] make two asymmetry measures.

asymmetry is determined by manually cutting the he septum, the left side, and the right side. These parts are measured separately, and the left and right compared for each subject. (see Fig 1 left, middle).

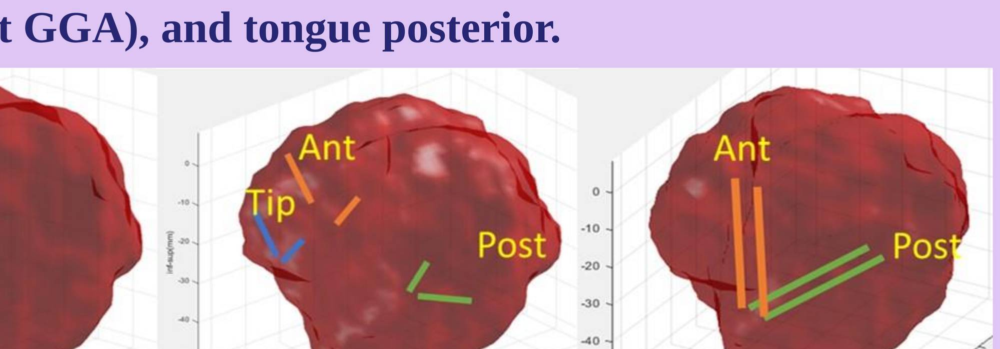
nmetry is measured by cutting a vertcal plane from the incisors to the posterior pharyngeal wall (Fig 1, ngue volume in each half of the oral cavity (OC) is espective of location of the tongue midline.

mical asymmetry: high resolution MR image (left), d (mid), Percent tongue in Right oral cavity (right).

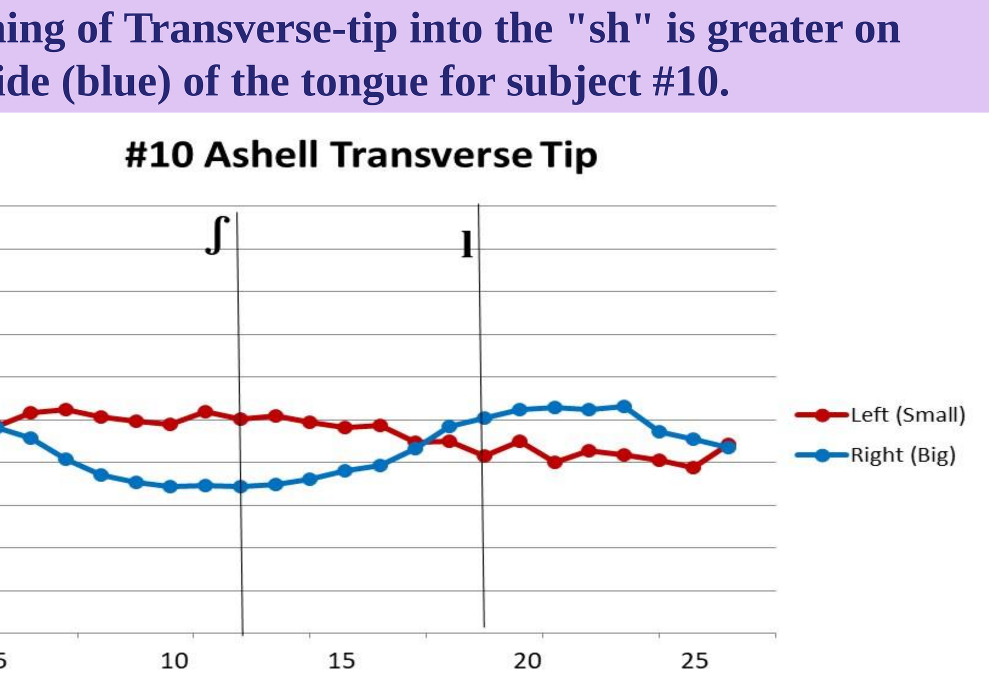


ening asymmetry is measured by comparing bilateral or Genioglossus (GGa, GGp), Verticalis (V-tip, V- Transverse (T-tip, T-at-GGa, Tp) (see Figure 2). n is measured for each time frame. (Fig. 3)

ion of muscles extracted in the tongue tip, tongue t GGA), and tongue posterior.



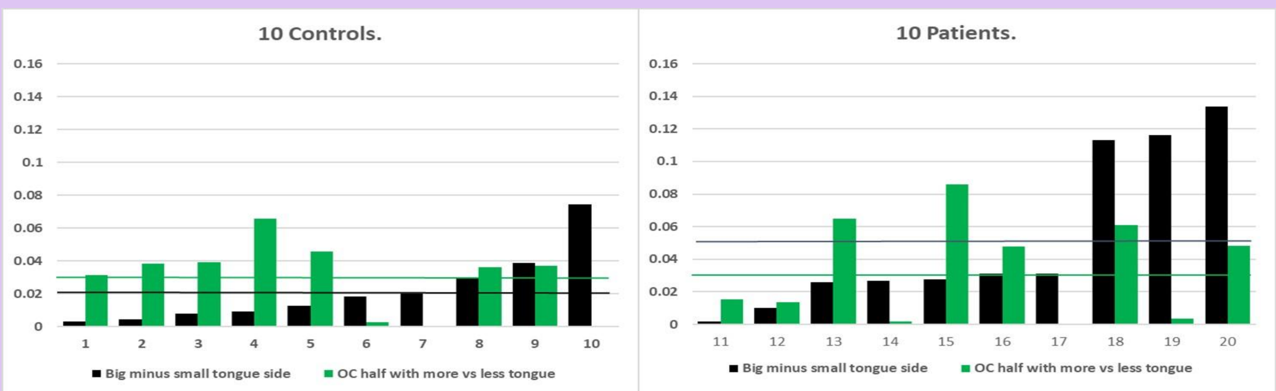
ning of Transverse-tip into the "sh" is greater on ide (blue) of the tongue for subject #10.



RESULTS

1. ANATOMICAL VS. RESTING ASYMMETRY

Figure 4. Two graphs show anatomical asymmetry (black) and resting asymmetry (green) for controls (left) and patients (right).



The black bars are ordered from small-to-large in both groups. The green bars show the resting asymmetry for the same subject.For both groups resting asymmetry is independent of anatomical asymmetry. Patients #18-20 have much more anatomical asymmetry than the others.

The horizontal black and green lines are the averages, and show that for controls (left) anatomical and resting asymmetry are similar (2% vs 3%). For patients (right) anatomical is greater than resting asymmetry (5% vs 3%) due to the glossectromy surgery. The resting asymmetry is not worse, on average, due to surgery.

2. MUSCLE SHORTENING ASYMMETRY

Table 1. Number of subjects who shortened each muscle on each side: smaller vs bigger (controls) or tumor vs non-tumor (patients). Yellow: 6-7 subjs. Orange: 8-10 subjs.

CONTROLS			PATIENTS		
N=10	Smaller	Bigger	N=10	Tumor	Non-Tumor
TRANS tip	8	9	TRANS tip	9	8
TRANS at GGA	6	9	TRANS at GGA	10	8
VERT tip	7	8	VERT tip	4	5
VERT at GGA	7	5	VERT at GGA	3	7
GGA	2	4	GGA	4	2
GGP	7	7	GGP	7	7
TRANS post	5	5	TRANS post	5	7

3. MUSCLE SHORTENING FOR FOUR EXTREME SUBJECTS.

Figure 4 above shows that control #4 and patient #15 had little anatomical asymmetry and large resting asymmetry. Control #10 and Pt #19 were the opposite, with lots of anatomical and little resting asymmetry. Patient #15 had a small (T1) tumor; Patient #19, had a larger, T2 tumor.

Table 2. Difference in shortening between tumor/non-tumor, or smaller/bigger side. Numbers are percentages.

Muscle	Control #4	Control #10	Patient #15	Patient #19
TRANS tip	10	11	5	5
TRANS at GGA		5	2	
VERT tip			8	30
VERT at GGA			6	35
GGA				4
GGP	2			
TRANS post			4	5

More shortening on: Bigger side - red.
Smaller side - blue.
Neither side >1% - white.

Salient features of motion asymmetry in Table 2.

- When there was asymmetry, subjects were more likely to shorten the larger side of the tongue to a greater extent (red) than the smaller side (blue). 11 vs 3.
- Patients had more instances of asymmetry than controls (5 each vs 2 each).
- All 4 subjects had asymmetry in Trans-tip.
- The 2 patients were also asymmetrical in Vert-tip and Vert-at-GGA. For patient #10, the shortening differences were quite large (30-35%).

DISCUSSION

1. ANATOMICAL VS. RESTING ASYMMETRY.

Figure 4 shows that resting asymmetry is not correlated wit asymmetry. Resting asymmetries were generally small, 2% The implication is that speakers tend to distribute their tong in the oral cavity irrespective of anatomical asymmetry, ev asymmetry is due to unilateral tissue loss.

2. MUSCLE SHORTENING ASYMMETRY.

Table 1 shows that the anterior portion of Transverse (Trans Trans-atGGA) was used by more subjects than any other m motion from "uh" to "sh." This suggests careful attention to narrowing and elevation of the anterior tongue during protru

Patients also were more likely to use the anterior portions o (Vert-tip and Vert-atGGA) indicating interaction of these mu forming the tongue shape at the constriction.

GGA was used by the least number of subjects. This muscl lower the midline, but can create a midline groove, which is "sh."

GGP however, was quite frequently used as it is crucial to p tongue body forward, facilitating the upward motion of the ti muscle, along with transverse post, would be unaffected by there are no differences between controls and patients. Tra antagonist to GGP, is used by some, presumably to better c via co-contraction.

3. MUSCLE SHORTENING FOR FOUR EXTREME SUBJE

More asymmetry in patients could indicate more careful con poorer L-R coordination leading to uneven activation acro both.

Control #4 had little anatomical asymmetry between sides, resting asymmetry of 6.5% (Fig 4). Only 2 muscles shorte asymmetrically, GGP had a very small difference (2%). m side of the OC with more tongue volume. This does not su effect of resting position on muscle shortening asymmetry

Control #10 had considerable anatomical asymmetry and n asymmetry (Fig 4). This subject also shortened only 2 of 7 asymmetrically, and each was on a different side (Table 2 not support any effect of anatomical asymmitry on muscle asymmetry.

Patient #15 had a small anatomical asymmetry after remov (T1) tumor (2.8%), and greater resting asymmetry (8.6%) both measurements the larger volume was on the non-tur This patient shortened 5 of 7 muscles asymmetrically, but asymmetry was not linked to one side (see Table 2). This that tissue loss may cause asymmetrical muscle usage, b predict a side..

Patient 19 had a larger (T2) tumor resulting in an 11.6% vol difference between the tongue sides. The resting asymme almost nonexistent, however (0.3%) (Fig 4). Five of the 7 showed greater shortening on the non-tumor side. Vertica especially asymmetrical (30-35% more) (Table 2). This su large tissue loss results in additional muscle usage in the side, independent of where the tongue rests when motion

CONCLUSIONS

1. Anatomical and resting asymmetry of the tongue were i of each other in 10 control and 10 patient subjects.
2. Neither anatomical nor resting asymmetry affected mus asymmetry in controls, or in patients with small tumors.
3. Patients with large tumors may depend more heavily on the non-tumor side.

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