

# ACOUSTIC AND ARTICULATORY SPACE BEFORE AND AFTER LATERAL TONGUE RESECTIONS IN ORAL CANCER PATIENTS

Orchid Rastadmehr, Tim Bressmann, Chiang-Le Heng, Jonathan C. Irish

Dept. of Speech-Language Pathology, University of Toronto, 500 University Avenue, Ontario, Canada, M5G1V7  
tim.bressmann@utoronto.ca

## 1. INTRODUCTION

Tongue cancer is relatively rare but has particularly pernicious functional consequences for affected individuals. The tongue is the main organ of speech and swallowing. Problems regarding appearance, speech ability and nutrition often decrease the quality of life of glossectomy patients. The standard treatment of tongue cancer involves resection and reconstruction, often accompanied by radiotherapy. The surgical resection and reconstruction can cause speech deficits in the glossectomy patients. It is usually assumed that the loss of tissue will be somewhat proportional to a loss of function and movement range (Rentschler & Mann, 1980). For example, Davis et al. (1987) argue that articulation errors result from a restricted range of tongue motion. Resections of the more actively moving anterior parts of the tongue dorsum and the tongue blade result in a greater loss in function than more posterior resections (Logemann et al., 1993). Obviously, the less the tongue body is modified during the surgery the less the speech production is altered. However, Savariaux et al. (2001) demonstrated that even patients with extended resections retain enough lingual motility in order to produce a differentiated range of vowels.

Despite the significant impact of tongue resections on speech and tongue motility, there have been very few studies on the relationship between the motility of the glossectomee tongue and the acoustic output. The quality of speech after a tongue resection and reconstruction is an important outcome measure for surgical success. The present research looks for an accurate description on the functional consequences of a partial glossectomy. In this paper, we investigated the impact of lateral tongue resections on midsagittal tongue movement and vowel production.

## 2. METHODS

Nine patients, male and female from 30 to 55 years of age underwent partial lateral tongue resections with different reconstructions. The patients were recruited from the Wharton Head and Neck Centre, Princess Margaret Hospital in Toronto. All participants were seen a few days before their surgery and one month postoperatively. The participants were asked to read one third of the Grandfather

passage (13-14 sec.) and repeat the syllables /aka/, /iki/, /uku/, /ata/, /iti/, and /utu/ five times each with stress on the second syllable. The patients' midsagittal tongue movement during these speech tasks was visualized using a General Electric Logiq Alpha 100 MP ultrasound scanner and a model E72 6.5MHz transducer with a 114° microconvex array. The ultrasound machine delivers a video frame rate of 30 fps. Video output of the ultrasound device was captured to digital video, together with high-quality audio. We used our Ultra-CATS software (Ultrasonographic Contour Analyzer for Tongue Surfaces) to measure the ultrasound image sequences. In this program, the distance from the ultrasound transducer to the tongue surface is measured along radiating gridlines in 5° intervals (Figure 1).

We used these measurements to establish the typical ranges of motion for the available points on the tongue before and after the operation. We calculated the average velocity of tongue movement at all available points on the tongue surface in m/sec by dividing the total distance traveled at each point by the total time of the sequence. We also evaluated the participants' vowel space by measuring the first and second formant frequencies during the steady-state phases of the second vowel in each of the VCV sequences. The measurements were made with the Kay MultiSpeech 3700 software.

## 3. RESULTS

Due to the page limitations, we only describe averaged results for the speaker group. The measurement values for the motion ranges at different grid angles demonstrated that the distance of the midsagittal tongue surface increased postoperatively. The boxplots with the average values for all 9 participants can be found in Figure 2. Multiple t-tests with a Bonferroni-adjusted alpha indicated that these postoperative increases were significant ( $p < 0.005$  in all cases). The postoperative velocities for all points on the tongue increased. A line graph with the average velocities for different points along the tongue can be found in Figure 3. We calculated mean travel speeds for all nine patients and compared the pre- and postoperative velocities using a t-test. The result indicated that the patients moved their tongues significantly faster following the operation ( $p < 0.05$ ). Finally, the formant measurements showed a slight decrease in vowel space for all speakers. These changes were most

marked for the second formants of the vowels /i/ and /a/, which dropped slightly in all speakers. When we calculated the average area for the vowel triangle for all speakers and input the results into a t-test, we found that the decrease in the vowel areas was not statistically significant.

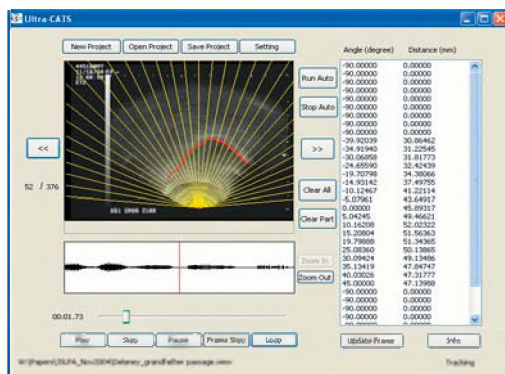


Fig. 1. Screenshot of the Ultra-CATS software with the measurement grid superimposed over a midsagittal ultrasound image with the tongue surface tracing. The anterior tongue is towards the right of the image.

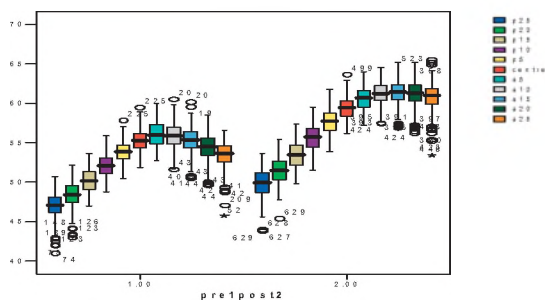


Fig. 2. Boxplots of the average movement ranges of different points on the tongue before and after the partial glossectomy surgery.

#### 4. DISCUSSION

Tongue movements of 9 patients with tongue cancer were analyzed using midsagittal ultrasound scans and parallel sound recordings. The range of tongue motion, the velocity of the tongue movement, and the vowel space were compared pre- and postoperatively. The results indicated larger ranges of motion and increases in the velocity of the tongue movement after resection. These larger and faster tongue movements are likely compensatory strategies that are employed by the patients to respond to the loss of lateral tongue tissue. As a result of this increased effort in tongue movement, almost all patients retained over 90% of their preoperative vowel space. These are interesting findings with regards to the ongoing debate among surgeons whether it is more desirable to replace as much lost tongue tissue as possible to preserve the overall volume of the tongue (Urken et al., 1994), or to opt for a reconstruction that maintains the motility of the residual tongue (Imai & Michi, 1992). Our future research about this topic will include more detailed articulatory profiles and speech intelligibility testing.

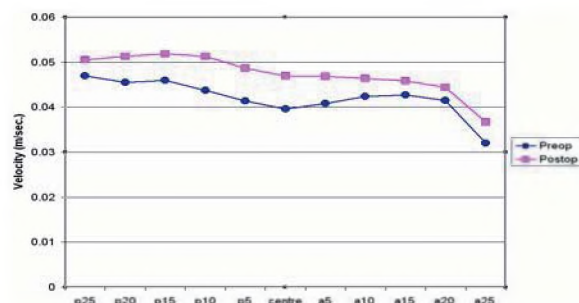


Fig. 3. Line graph of the average velocities of different points of the tongue before and after the partial glossectomy surgery.

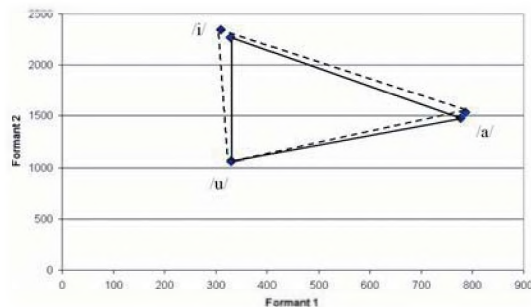


Fig. 4. Average vowel space for all patients (dashed line: preoperative vowel space; solid line: postoperative vowel space).

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