Speech after partial glossectomy: An articulatory study based on EPG data from two subjects

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INTRODUCTION

Compensatory articulation after radical glossectomy often involves employment of vocal tract structures as substitutes for the lost tongue, e.g. lips, cheek and glottis (e.g. Almé & Engstrand, 1989; Morrish, 1988) and is perceptually quite distinct, since the speech sounds deviant from normal (but still, "reasonably intelligible" (e.g., Morrish, 1988; Georgian et al. 1982)). Speech following partial glossectomy is, however, often perceptually judged as normal or near-normal. According to Heller et al.(1991), the speech evaluation of 10 partially glossectomized patients revealed that speech had returned to normal 6 months after the operation. But is the articulation back to normal, or do these speakers use compensatory strategies to produce an output that is perceptually judged as normal? To study this, direct articulatory observations are required. This paper will present some preliminary electropalatographic data on palatolingual contact of two partially glossectomized subjects, and discuss the asymmetries of the contact patterns.

METHOD

Two male speakers subjected to surgical removal of carcinoma of the oral cavity were studied. Subject G1 had undergone right hemiglossectomy and resection of the floor of the mouth. Subject G2 had undergone resection of the floor of the mouth and of the underside of the tongue, mainly on the right side, and bilateral neurotomy of the hypoglossal and the lingual nerves. In both patients the floor of the mouth had been covered by a skin flap. The recordings were made approximately three years after surgery. One normal subject served as control speaker.

The speech material consisted of 24 /CVl/-syllables, where C_2= /t,d,n,r,l,s,c,j/ and V=/i,a,u/. Each consonant occurred in each vowel context. The syllables were preceded by the carrier /ta/ to stabilize the tongue posture. The word list was read 7 times by each speaker. So far, two productions of each item have been analysed.

Speech sounds were simultaneously recorded with a DAT recorder through a microphone. One channel recorded speach, while the other recorded a synchronous pulse from a pulse generator, to facilitate speech segmentation.

The Reading EPG system was used, developed by Hardcastle (see Hardcastle (1984) and Marchal (1988) for thorough descriptions). 62 silver electrodes are embedded in the surface of the artificial palate, moulded after the subject's palate, to detect lingual contact. The electrodes are arranged in 8 horizontal rows. The frontmost row has six electrodes and the remaining seven rows have eight electrodes each. The electrodes are arranged according to anatomical and phonetic criteria permitting comparisons between data from different speakers.

To assess lingual asymmetry quantitatively, the index of asymmetry is defined as the percentage of asymmetric contacts to the total number of contacts. This index was proposed by Marchal and Espesser (1987) and was used in Farnetani's (1988) study on asymmetry in Italian. The computation is: $I_{as} = (N_a - N_b)/(N_a + N_b)$, where I_{as} is the index of asymmetry, N is the number of contacts, a is the right side and b is the left side. The EPG frame is divided into the right and left section along the longitudinal axis and into the front and back section (the first four rows vs the last four). According to physilogical criteria, the first four rows may be considered to reflect the activity of the tongue tip and blade involved in the anterior articulations, while the last four rows can be taken to reflect the tongue body activity for more posterior articulations.

The I_{as} was taken at the following articulatory points: at the point of maximum electrode activation for all consonants and at the following four points for the stops: the frame before the complete closure, the first frame of complete closure, the last frame of complete closure and the first frame after release. The analyses are based on the EPG "raw" contact data, in the form of series of individual palatal frames sampled at 100 Hz.

RESULTS AND DISCUSSION

The mean asymmetry at maximum electrode activation is shown in fig. 1a for speaker N, 1b for speaker G1 and in fig. 1c for speaker G2. Negative numbers indicate asymmetry with more contact on the left side and positive numbers more contact on the right side of the palate.

The I_{as} of /t,d,n/ shows minor differences between the speakers. For /r/ and /l/ there is slightly less asymmetry in the glossectomees' productions. The contact patterns of the fricatives, /s,c,j/, exhibit the most prominent difference between the control and the glossectomees. These sounds are normally produced by channeling the air through a groove formed by the tongue, a gesture that requieres contractions of the intrinsic muscles of the tongue, and, hence, ought to be difficult for these patients to produce. This would especially be true for /s/, where the most narrow groove has been found for normal speach (e.g. Engstrand, 1989).

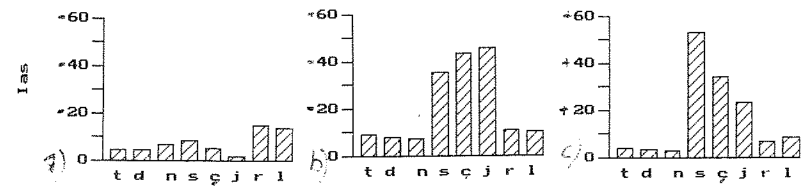

Figure 1. *Mean I_{as} at maximum constriction for a) speaker N, b) speaker G1 and c) speaker G2.*

Fricatives

In fig.2a the mean number of electrodes activated in the front and back sections of the palate is shown, and in 3a the corresponding left-right asymmetry for the normal subject's productions of /s, c, j/. The corresponding data for G1 and G2 are shown in b) and c), respectively. The I_{as} of the glossectomees shows a prominent front asymmetry. For G2, it is +100, which means that only the front right side of the palate is in contact with the tongue.

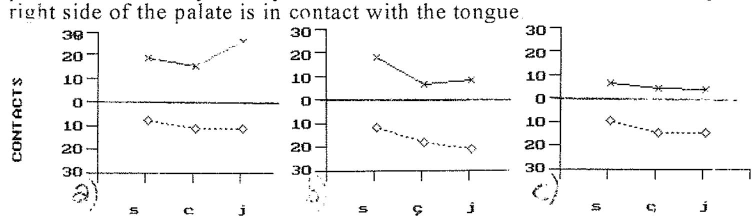

Figure 2. *Mean number of electrodes activated in the front section of the palate (above the horizontal line) and in the back section (below the line) for a) speaker N, b) speaker G1 and c) speaker G2.*

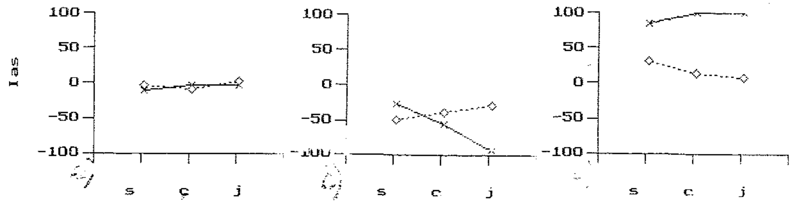

Figure 3. *Average I_{as} of the front part of the palate (solid lines) and of the back part (dotted lines) for a) speaker N, b) speaker G1 and c) speaker G2.*

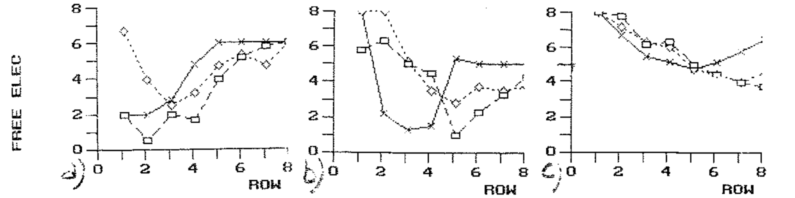

Figure 4. *Mean number of free electrodes (vertical axis) in each row (horizontal axis), where 1=the frontmost row and 8= the backmost, for /s/ (solid lines), /c/ (dotted lines) and /j/ (broken lines). Data are shown for N in fig. a), for G1 in fig. b) and for G2 in fig. c).*

In figure 4 the mean number of free electrodes (vertical axis) in each row (horizontal axis) at the point of maximum constriction of /s,c,j/ is plotted. 1 represents the frontmost row and 8 the backmost. This figure shows the place and width of the constriction. For the glossectomees, the constriction is situated more posteriorly on the palate than for the normal speaker, and for speaker G2, the groove is considerably wider. G1, on the other hand, seems to be able to produce /s/ with a narrow groove. The raw data suggest, however, that he does not form this groove by the tongue itself. Instead the air channel is situated beside the tongue on the right side, i.e. between the tongue and the teeth.

Dental stops

Figure 1 showed an insignificant asymmetry in the glossectomee's productions of /t/ and /d/ at the point of maximum constriction. The dynamic patterns of these consonants reveal, however, a pronounced asymmetry, especially in the front section of the palate. This temporal asymmetry takes the form of tongue contacts occurring earlier on one side in the approach phase, and remaining longer on that side in the release phase.

In figure 5, the mean number of electrodes activated in the front and back sections of the palate is shown, and in fig.6 the corresponding left-right asymmetry at five points in time. These are represented in the horizontal axis as follows: 1= the frame before the complete closure, 2= the first frame of complete closure, 3= the point of maximum electrode activation, 4= the last frame of complete closure and 5= the first frame after release. Figures a), b) and c) show the data for speakers N, G1 and G2, respectively.

The number of contacts in the front section is approximately equal for the three speakers at all five points in time. There is, however, a significantly increased number of contacts in the back region for the glossectomees. It can be hypothesized that these speakers are incapable of making a complete closure with the front part of the tongue only, because of a loss of control of the intrinsic muscles, but instead makes palatal contact with the entire tongue body, which can be accomplished by contraction of the extrinsic muscles.

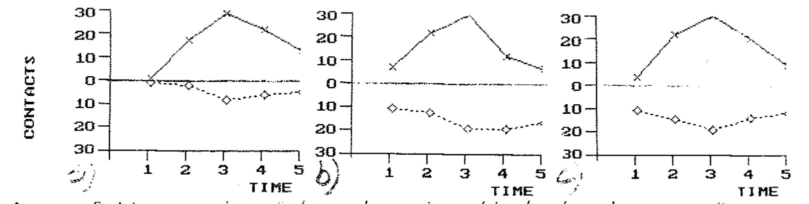

Figure 5. *Mean number of electrodes activated in the dental stops at five points in time. Data for the front section is shown above the horizontal line, and data for the back section below the line. a), b) and c) show data for speakers N, G1 and G2, respectively.*

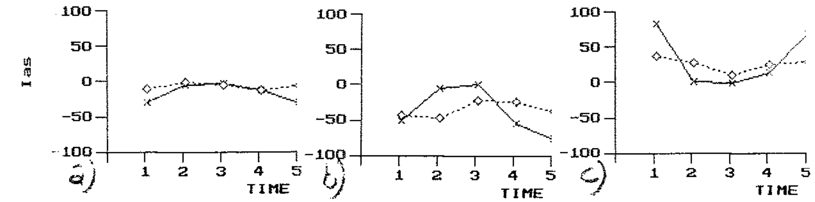

Figure 6. *Average I_{as} of the front part of the palate (solid lines) and the back part (dotted lines) at five points in time for /t/ and /d/ produced by N (fig.a), G1 (fig.b) and G2 (fig.c).*

The speech apparatus seems to have a remarkable ability to recover. Despite hemiglossectomy, G1 is able to obtain normal groove dimensions for fricatives, through compensatory reorganization of the articulation. The palato-lingual contact pattern of G2 is more deviant from normal, but not to a degree that could be expected after a loss of the 12th nerve. These results are consistent with those obtained by Almé (1991), where the severity of speech disturbance after glossectomy was perceptually judged by 30 listeners. The speech of G1 was judged as being nearly normal, and the speech of G2 to be somewhat deviant.

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