Speech After Tongue Reconstruction and Use of a Palatal Augmentation Prosthesis: An acoustic case study

La parole après la reconstruction de la langue et l'utilisation d'une prothèse palatine de suppléance : Une étude de cas en acoustique

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Abstract

In this experiment, acoustic properties of speech sounds produced by a 64-year-old Canadian English-speaking female tongue cancer patient were studied. The patient had undergone a tongue resection of the anterior two-thirds of the tongue, a tongue reconstruction with a radial forearm free flap, and treatment with a palatal augmentation prosthesis. The acoustic data included measurements of spectral characteristics analyzed from the vowels /i, I, Λ, u/ and sibilants /s, z, ʃ/ in connected speech samples produced before the tongue resection, taken one year after the resection with a free flap reconstruction and two years after the tongue reconstruction while wearing a palatal augmentation prosthesis. Acoustic changes were observed for formant frequencies ($F1$, $F2$) of the vowels and the spectral moments (mean, skewness) of the sibilants. Treatment with the augmentation prosthesis resulted in an improvement of the sibilants /s/ and /z/. The effect of the augmentation prosthesis on vowel production was less pronounced in this patient.

Abrégé

Pour cette expérience, on a étudié les propriétés acoustiques des sons de la parole produits par une Canadienne anglophone de 64 ans atteinte d'un cancer de la langue. Cette patiente a subi une exérèse des deux tiers antérieurs de la langue, une reconstruction de la langue avec du tissu de l'avant-bras innervé par le nerf radial et un traitement avec une prothèse palatine de suppléance. Les données acoustiques comprennent des mesures des caractéristiques spectrales analysées pour les voyelles /i, I, Λ, u/ et les sifflantes /s, z, ʃ/ dans des échantillons de discours continu produit avant l'exérèse, une année suivant l'exérèse et la reconstruction ainsi que deux années suivant la reconstruction de la langue, au moment où la patiente portait une prothèse palatine de suppléance. On a observé des changements acoustiques pour la fréquence des formants ($F1$, $F2$) des voyelles et des mesures spectrales (moyenne, asymétrie) des sifflantes. Le traitement avec une prothèse palatine de suppléance a eu pour effet d'améliorer les sifflantes /s/ et /z/. L'effet de la prothèse sur la production des voyelles a été moins marqué chez cette patiente.

Key words: acoustics, radial forearm free flap, oral cancer, palatal augmentation prosthesis, sibilants, speech, tongue reconstruction, vowels

Patients with head and neck cancer face many functional challenges (e.g., deficits in their ability to speak) as they progress through their treatment and rehabilitation. While disease control is the primary goal in the treatment of head and neck cancer, maintenance of function also drives treatment interventions. This is particularly pertinent in treatments for oral cancer, which may be associated with functional morbidity because of involvement of structures that are essential for speech production. Surgical reconstruction and prosthetic treatment methods may offer the potential for restoration of patients' speech production. For example, surgical techniques, such as radial forearm free flaps, and prosthetic reconstructive techniques, such as palatal augmentation prostheses, hold the promise of restoring intelligible and acceptable speech in oral cancer patients (de Carvalho-Teles, Sennes, & Gielow, 2008; Matsui, Shirota, Yamashita, & Ohno, 2009).

The objective evaluation of speech articulation following glossectomy is essential for directing treatment aimed at the restoration of speech intelligibility. One of the most common methods for evaluating postoperative speech is the perceptual evaluation of tape-recorded speech samples (e.g., sounds, syllables, sentences, conversational speech) using standardized intelligibility and articulation tests (Furia et al., 2001; Korpijaakko-Huuhka, Söderholm, & Lehtihalmes, 1999; Sun, Weng, Li, Wang, & Zhang, 2007; Terai & Shimahara, 2004). Other objective methods used to evaluate glossectomy speech and tongue function include ultrasound (Rastadmehr, Bressmann, Smyth, & Irish, 2008), videofluoroscopy (Georgian, Logemann, & Fischer, 1982), electropalatography (Imai, Michi, Yamashita, & Suzuki, 1991), and magnetic resonance imaging (Kimata et al., 2003).

Acoustic Outcomes of Tongue Reconstruction

While the effects of oral cancer surgery on speech have been examined in a number of studies, few studies have looked at acoustic outcomes of speech function after microvascular and prosthetic reconstruction. The study of speech acoustics is important because acoustic analysis provides valuable information about the physical properties of the speech output, which carry the phonetic information understood by a listener as a meaningful message. In one acoustic study that used a Fast Fourier Transform method, Knuuttila, Pukander, Määttä, Pakarinen, and Vikman (1999) found just minor effects on formant frequencies of Finnish vowels produced by patients with partial glossectomy and pectoralis major myocutaneous flap reconstruction. The only significant changes were the increase of $F1$ in /i/ and lowering of $F2$ in /a/. Using a Linear Predictive Coding method, Whitehill, Ciocca, Chan, and Samman (2006) observed restricted ranges of $F2$ for Chinese (Cantonese) patients with partial glossectomies after reconstruction. This was interpreted as a sign for reduced tongue mobility for anterior–posterior movements of the tongue. In addition, the vowel space area was found to be smaller (i.e., centralized) than that in the control group, indicating reduced capacity to produce intelligible speech. Also using linear predictive coding, Kazi et al. (2007) found differences in formant frequency between females and males with partial glossectomy compared to a control group. In that study, only a sustained /i/ vowel was analyzed.

Speech Outcomes with Palatal Augmentation Prosthesis

One of the potential outcomes of tongue resection and reconstruction is limited bulk and movement of the reconstructed tongue, resulting in reduced tongue–palate contact. When this occurs, a palatal augmentation prosthesis (PAP) can be constructed for the patient. The primary benefit of a PAP for oral cancer patients with reduced tongue volume and movement is that the artificial lowering of the palatal vault improves tongue–palate contact.

Only a few studies about the effects of PAPs on the speech of oral cancer patients have been published thus far. Cantor, Curtis, Shipp, Beumer, and Vogel (1969) discovered that patients with severe restriction of tongue movement had the best prognosis for benefiting from a PAP, whereas patients with moderate restrictions had unfavourable outcomes with a PAP. Some investigators have argued that the bulky palatal augmentation may hinder articulatory movements of the residual tongue, decreasing speech intelligibility (Wheeler, Logemann, & Rosen, 1980). Shimodaira, Yoshida, Yusa, and Kanazawa (1998) reported that a PAP provides the patient with effective tongue–palate contact, resulting in increased speech intelligibility and a more effective ability to communicate. In a review of nine published studies, the functional efficacy of PAP was supported for individuals who had severe restrictions in tongue–palate contact after tongue resection (Marunick & Tselios, 2004).

The speech outcomes of rehabilitation with a PAP have been investigated in different acoustic studies. Based on spectrographic analysis, Leonard and Gillis (1990) found a speech improvement of 9% to 23% for oral cancer patients after wearing a PAP. Using speech oscillograms, Ichikawa, Komoda, Horiuchi, and Matsumoto (1995) found that the noise duration of /s/ increased significantly in three out of four palatal augmentation cases. In addition, voice onset time (the time interval between the release of a plosive and the onset of the following vowel) had a tendency to increase with a PAP both in the palatal stop /c/ and the velar stop /k/ produced by Japanese males. De Carvalho-Teles et al. (2008) used spectrography to analyze Brazilian Portuguese vowel sounds in glossectomy patients who had a PAP and who had undergone speech therapy. Female and male patients were grouped together. The prosthesis was reported to bring the formant values ($F1$, $F2$, $F3$) closer to normal in many vowels.

Purpose

The present case study aimed to describe longitudinal changes in speech function related to a PAP. A patient who had undergone primary reconstruction with a radial forearm free flap and secondary rehabilitation with a PAP was recorded at different times during a 2-year time frame (pre-operative, 1 year postoperative, and 2 years postoperative with a PAP).

The study employed acoustic analyses that had not been used concurrently in previous studies. The main focus was on changes of acoustic characteristics such as vowel formant frequencies and spectral moments of fricatives. Based on the results of previous studies, it was hypothesized that speech would become poorer after primary surgical treatment with a radial forearm free flap (RFFF) at the 1-year post-operative visit and that it would improve at the 2-year assessment time while wearing a PAP. It was expected that the vowel space area would be smaller after the RFFF reconstruction because of reduced tongue function (Whitehill et al., 2006). For sibilants, changes were expected in the spectral moments of sibilant sounds because of changes in the place, degree, and length of constriction. After the PAP, formant values would be higher because of a smaller vocal tract size. As PAPs have been observed to improve the function of the residual tongue and the tongue–palate contact (Shimodaira et al., 1998, de Carvalho-Teles et al., 2008), it was assumed that with the use of a PAP, the acoustic features would return to the pre-operative level or at least approach it.

Methods

The protocol for this study was approved by the Health Research Ethics Board of the University of Alberta in Edmonton. The patient was a 64-year-old English-speaking Canadian female who had undergone resection of a portion of the anterior two-thirds of the tongue and a reconstruction with a RFFF. The resection included the total removal of the right styloglossus, the anterior portion of the inferior and superior longitudinal muscles, the anterior portion of the transverse and vertical muscles, and the right hyoglossus. In addition, a portion of the right genioglossus was removed. The patient underwent adjuvant chemo-radiation therapy. Due to persistent difficulty with swallowing one year after the surgery, she received eight sessions of therapy that included tongue manometry feedback. Little progress was made with conventional therapy; thus, 15 months after surgery, a PAP was custom-made to assist with speech and swallowing. Following delivery of the PAP, the patient underwent two blocks of speech therapy that included 16 sessions each during a four month period. These sessions consisted of articulation therapy with electropalatography biofeedback.

The speech recordings were completed during clinical visits before the tongue resection, both 1 year after the tongue resection and reconstruction and 2 years after the surgery while wearing a PAP. Speech utterances were collected via a head-mounted unidirectional microphone and recorded using a digital audiotape recorder with a sampling rate of 48 kHz. For the acoustic analyses, three different sets of phrases were read by the patient at all assessments. The phrases consisted of a series of "say hVd again" with four different vowels, six stimulus sentences (Weismer, Jeng, Laures, Kent & Kent, 2001), and the *Zoo Passage* (Fletcher, 1978; see Appendix 1). The stimulus sentences and the *Zoo Passage* were read once at each visit. The hVd phrases were read once at the pre-operative visit, and five times at both the 1-year postoperative visit with RFFF and the 2-year postoperative visit with the PAP.

Acoustic analysis

Vowels

Recordings were digitized at 48 kHz and analyzed using the Computerized Speech Laboratory (CSL; Model 4400, KayPentax, Lincoln Park, NJ). The signal was down-sampled to 16 kHz. Frequencies of the first and second formants ($F1$, $F2$) of the vowels /i/, /Λ/, and /u/ were analyzed from samples of the hVd phrases and the stimulus sentences (see Appendix 1). The vowels /i/, /Λ/, and /u/ were chosen because they are suitably distinct with regards to their articulatory, acoustical, and perceptual properties. The vowel /I/ was also analyzed because it is qualitatively quite similar to the vowel /i/. These vowels are also used to calculate the vowel space area. The formant frequencies were obtained using linear predictive coding (frame length 20 ms; filter order 12; pre-emphasis 0.9; pitch-synchronicity applied; Blackman window). The linear predictive coding analysis was performed by placing the cursor at the temporal midpoint of the vowel segment taken from the waveform and the broadband spectrogram display (analysis size 100 points; pre-emphasis 0.9; display 0-4,000 Hz, Blackman window). The vowel midpoint was chosen in order to eliminate the contextual effects of adjacent segments and to approximate the point where the articulatory target is presumed to be reached (Lindblom, 1963). The numerical values of the formant frequencies were exported in a table. In doubtful cases when the formant was weak, the measured formant values were double-checked and hand-measured using a spectrogram and/or a 512-point fast Fourier tracking analysis (20 ms Hamming window; low smoothing level).

The averaged $F1$ and $F2$ values of the four vowels were used to calculate acoustic vowel space areas, using the mathematical formula presented by Liu, Kuhl, and Feng-Ming (2003). The vowel quadrilaterals were divided into two triangles, and the acoustic spaces of these two triangles were calculated (in Hz^2) and summed (Turner, Tjaden, & Weismer, 1995).

Sibilants

Spectral moments of the long-term average spectrum, i.e., the mean (1st moment) and skewness (3rd moment), were analyzed from the speech samples of the stimulus sentences and the *Zoo Passage* using the Computerized Speech Laboratory (CSL; Model 4400, KayPentax, Lincoln Park, NJ). The signal was down-sampled to 24 kHz. The spectrum was computed using the fast Fourier transform (analysis window 512-points, 20-ms Hamming window, analysis range 0–10,000 Hz). The long-term average spectrum was measured over the entire frication by manually placing the initial cursor at the onset of the frication and the final cursor at the end of the frication. The numerical values of the spectral moments were obtained from the *Long-Term Average Fast Fourier Transform Statistics* table that was generated. The two spectral characteristics were selected because these parameters are suitable for qualifying the overall shape of the spectrum (Flipsen, Shriberg, Weismer, Karlsson, & McSweeny, 1999) and can summarize the concentration (mean) and asymmetry (skewness) of the energy distribution.

Statistical analyses

Statistical comparisons across time were not calculated because of the single-subject experimental design. The results were instead summarized in descriptive statistics.

Results

Vowels

For the hVd phrases (Figure 1, upper diagram), *F*1 increased for the high vowels /i/ and /u/ with the PAP, indicating a lower tongue position and a narrower pharyngeal area. Less pronounced increases in *F*1 were noted after the RFFF procedure. Decreases in *F*2 were observed for all vowels after the RFFF reconstruction. After treatment with the PAP, the *F*2 values for all vowels moved closer to the pre-operative level. For the stimulus sentences (Figure 1, lower diagram), a decrease of *F*2 was observed after the RFFF. With the PAP, *F*2 values approached the pre-operative level, similar to the results for the hVd phrases. The *F*1 increased for the high vowel /i/ after the RFFF reconstruction, but returned to the pre-operative level after the PAP.

The area size of the vowel space (Figure 1) decreased systematically over time, in both the hVd phrases and the stimulus sentences (hVd: pre-op = 39,8472 Hz²; post-RFFF = 27,2055 Hz²; post-PAP = 25,4426 Hz². Stimulus sentences: pre-op = 29,5467 Hz²; post-RFFF = 25,7013 Hz²; post-PAP = 24,0456 Hz²). The percentage changes of the vowel space areas were as follows: for the hVd phrases, pre-op vs. 1-year postoperative = decrease of 32%, 1-year post-operative vs. 2-year post-operative with PAP = decrease of 6%, and pre-operative vs. 2-year postoperative with PAP = decrease of 38%; for the stimulus sentences, pre-operative vs. 1-year postoperative = decrease of 13%, 1-year postoperative vs. 2-year postoperative with PAP = decrease of 6%, and pre-operative vs. 2-year postoperative with PAP = decrease of 19%.

Sibilants

Regarding the stimulus sentences, changes were found in the spectral mean (1st spectral moment) for /s/ and /z/ (Figure 2, lower diagram). The spectral mean decreased after reconstruction (pre-operative vs. 1-year postoperative: mean decrease of 2,448 Hz), but increased after treatment with the PAP (1-year postoperative vs. 2-year postoperative with PAP: mean increase of 1,186 Hz). Thus, spectral mean approached the quantitative level of the pre-operative state (pre-operative vs. 2-year postoperative with PAP: mean decrease of 1,262 Hz). The skewness values returned to the pre-operative level over time (Figure 3, lower diagram). For /ʃ/, effects were found in skewness (3rd moment), which decreased systematically over time (pre-operative 1.54 vs. 2-year postoperative with PAP 0.55, mean decrease 0.99).

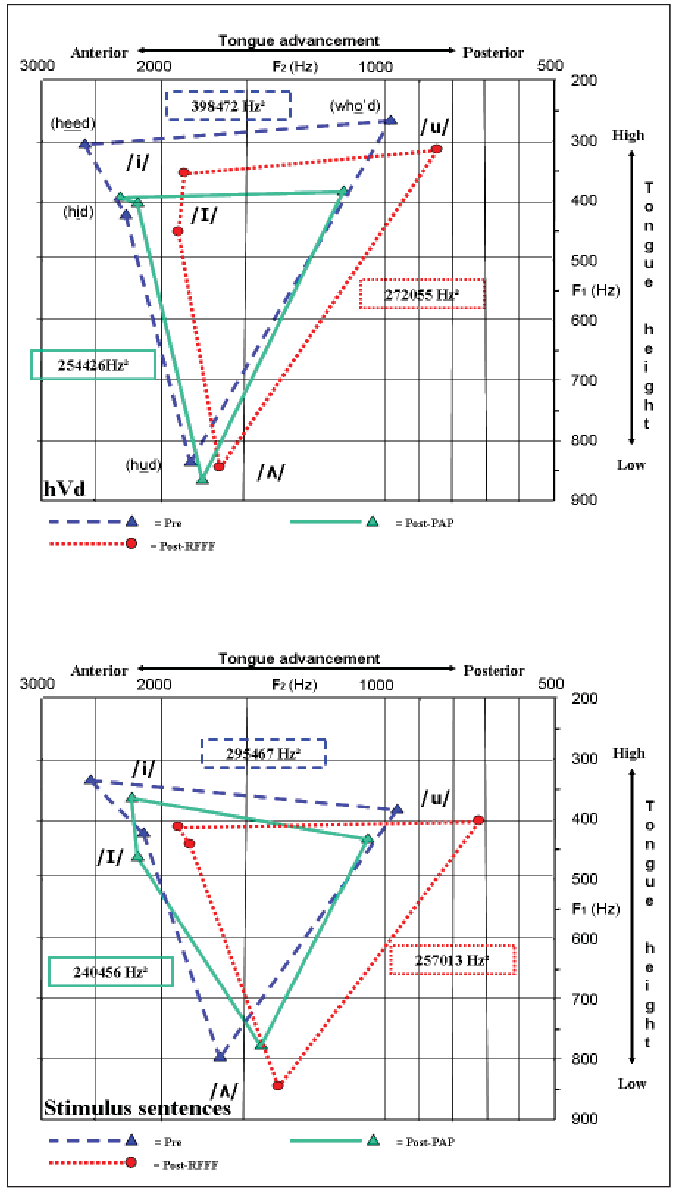

Figure 1. The vowels /i, ɪ, ʌ, u/ produced by the subject in hVd phrases (upper diagram) and stimulus sentences (lower diagram) are plotted on an acoustic plane according to the mean values of *F*1 and *F*2 (in Hz). The vowel sounds produced before the resection (Pre) are marked by triangles connected by dashed lines; the vowels produced 1 year after the resection with RFFF reconstruction (Post-RFFF) are marked by solid circles connected by dotted lines; the vowels produced 2 years after the RFFF reconstruction while wearing a PAP (Post-PAP) are marked by triangles connected by solid lines.

Effects also were found in the spectral mean (pre-operative 4,358 Hz vs. 2-year postoperative with PAP 5,058 Hz, mean increase 700 Hz).

For the *Zoo Passage*, effects were found in the spectral mean (Figure 2, upper diagram) and skewness (Figure 3, upper diagram) for /s/ and /z/. As in the stimulus sentences, the spectral mean decreased after the RFFF (pre-operative vs. 1-year postoperative: mean decrease of 2,240 Hz), and increased after treatment with a PAP (1-year postoperative vs. 2-year postoperative with PAP: mean increase of 814 Hz). The spectral mean approached the qualitative level of the pre-operative state, but did not achieve the pre-operative quality (pre-operative vs. 2-year postoperative with PAP: mean decrease of 1,426 Hz). Skewness increased at the 1-year postoperative time (mean increase of 0.09), but treatment with the PAP resulted in decrease of skewness (mean decrease of0.53). The change in skewness between the pre-operative assessment and the 2-year postoperative assessment was notable (mean increase of 0.77). For /ʃ/, the same pattern of decrease followed by increase as observed for /s/ and /z/ was found in the data for the spectral mean (pre-operative 4418 Hz vs. 2-year postoperative with PAP 4,769 Hz, mean increase of 351 Hz). This observation was in agreement with observations from the stimulus sentences.

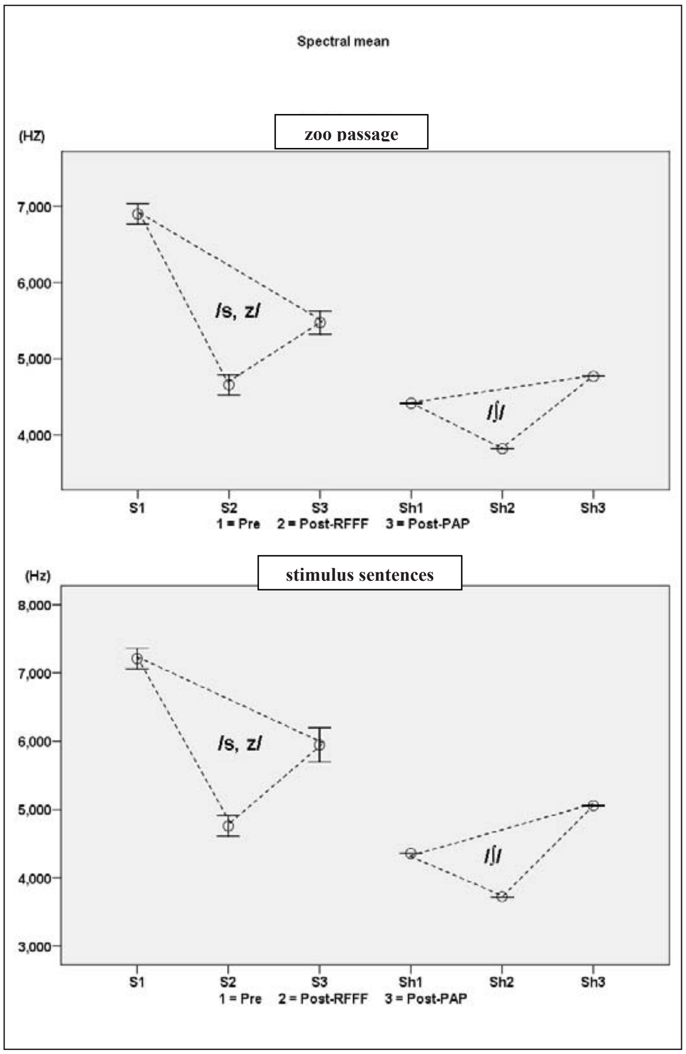

Figure 2. Averaged data of spectral mean of sibilants /s, z/ (= s) and /ʃ/ (= sh) produced in the *Zoo Passage* (upper diagram) and in stimulus sentences (lower diagram) by the subject. The mean and standard error of mean are shown. For both /s, z/ and /ʃ/, data from three sessions are connected by dotted lines (Pre = sounds produced before the resection; Post-RFFF = sounds produced 1 year after the resection with RFFF reconstruction; Post-PAP = sounds produced 2 years after the RFFF reconstruction while wearing a PAP).

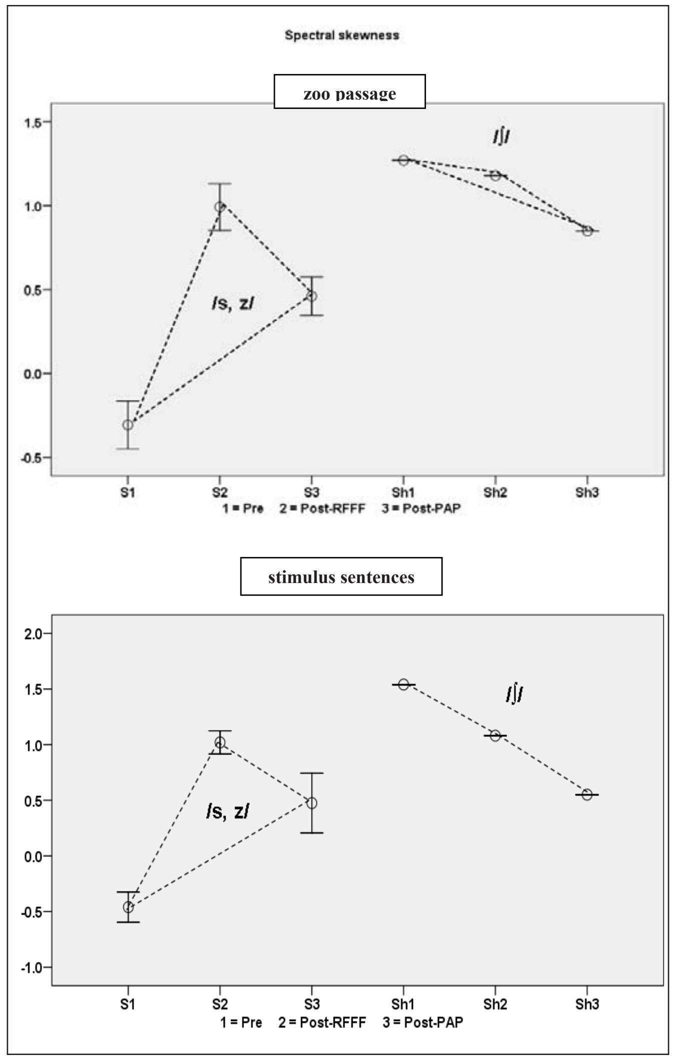

Figure 3. Averaged data of spectral skewness of sibilants /s, z/ (= s) and /ʃ/ (= sh) produced in the *Zoo Passage* (upper diagram) and in stimulus sentences (lower diagram) by the subject. The mean and standard error of mean are shown. For both /s, z/ and /ʃ/, data from three sessions are connected by dotted lines (Pre = sounds produced before the resection; Post-RFFF = sounds produced 1 year after the resection with RFFF reconstruction; Post-PAP = sounds produced 2 years after the RFFF reconstruction while wearing a PAP).

The results for skewness showed the same overall decrease observed in the stimulus sentences (pre-operative 1.54 vs. 2-year postoperative with PAP 0.55, mean decrease 0.99).

Discussion

In this experiment, acoustic properties of speech sounds produced by a female patient with tongue cancer were studied. Acoustic changes were observed for formant frequencies ($F1$, $F2$) and spectral moments (mean, skewness), showing that the tongue resection and reconstruction with the RFFF and the use of the PAP changed the articulatory output. Rehabilitation with the PAP was found to lead to acoustic measures that were moderately similar to the preoperative state.

Vowels

The observed increase of $F1$ after the rehabilitation with the PAP suggests the use of a lower tongue position, resulting in a more open oral cavity and a narrower pharyngeal space. The changes in $F1$ were found only during speech produced with the PAP, suggesting that the prosthesis changed the vocal tract configuration. It may have been the case that the patient used a lower position of the mandible to compensate for the lowered palate. In turn, this may have constrained the tongue and decreased the vocal tract space. Such a change would be most obvious in high vowels. The changes in $F2$ indicated that RFFF had an effect on the forward–backward movement of the tongue. The decreased $F2$ suggests a more posterior tongue position after surgical reconstruction. After treatment with a PAP, the $F2$s were closer to the pre-operative levels, indicating that the PAP may have been helpful for the patient with regards to restoring pre-operative formant ranges.

In addition to changes in formant frequencies, changes in the size of vowel space area were studied. The vowel space area has been found to correlate both with the precision of articulation and with the clarity of speech (Weismer et al., 2001). In this study, vowel space area was found to decrease over time. After rehabilitation with the PAP, the vowel areas were found to be even smaller than after the resection and RFFF reconstruction (see Figure 1). However, the quantitative change was relatively small and should not be overstated. Therefore, the results may support the view that a PAP does not have a significant effect on vowel production.

Sibilants

Sibilant sounds /s/, /z/, and /ʃ/ are the most complex speech sounds to produce because they require fine motor control of the tongue. Therefore, these sounds are particularly prone to be affected by a glossectomy.

Spectral moments have been found to reflect characteristics of the cavities anterior to constriction and at the constriction itself; however, the precise relationship between the spectral moments and the articulatory function is still unclear. Increasing the length of the cavity anterior to the constriction, increasing of the length of the constriction, or increasing of the degree of the constriction have been found to lower the energy mean, i.e., 1st spectral moment (Nittrouer, 1995). Positive skewness (3rd moment) indicates a spectral tilt with an energy concentration in low frequencies, while negative skewness suggests a spectral tilt with an energy concentration in higher frequencies (Jongman, Wayland, & Wong, 2000).

For sibilant sounds in this study, significant changes in spectral moments were found after the RFFF reconstruction and rehabilitation with a PAP, both in the stimulus sentences and in the *Zoo Passage* samples. Changes were observed in both the mean and the skewness values of the energy distributions. For the alveolars /s, z/, the lower energy mean and higher skewness coefficient after the tongue resection and reconstruction with the RFFF indicated that the patient was unable to produce an appropriate constriction. According to the model by Nittrouer (1995), the causative factors may have been a larger or longer constriction than before the reconstruction. The place of the constriction may have been more posterior than normal. One of the possible reasons for lower energy mean and higher skewness can be lateral emission where the airstream escapes across the lateral part of the tongue. After treatment with the PAP, mean energy increased and skewness decreased, but they were not restored to pre-operative levels. This suggests that the PAP had a moderately positive effect on the production of alveolar sibilants. Palatal augmentation prostheses are designed to improve tongue–palate contact. Tongue–palate contact is important in the production of stop sounds (/t/, /d/, /k/, and /g/). However, sibilants require delicate grooving of the tongue. Previous research has reported negative effects of a PAP. Stops were found to have a longer closure phase and the sibilant /s/ was found to have a longer duration after treatment with a PAP (Ichikawa et al., 1995). The PAP also reduced the tactile feedback from the palate which may interfere with the patient's fine motor control of the tongue. In the present case, the energy distribution for /s/ and /z/ increased to higher frequencies; however, the acoustic distance to /ʃ/ still remained small, indicating that the perceptual distinction of these sounds was not clear.

For the palato-alveolar /ʃ/, the trend of the results was similar to /s/ and /z/. Higher frequency components after treatment with the PAP compared to the pre-operative"production suggest that the patient may have used a smaller constriction or a more anterior constriction placement, resulting in higher mean energy and lower skewness. However, the changes were very small and should not be overstated. In the present case, the conservative conclusion has to be that neither the resection and the RFFF reconstruction nor the PAP had an effect on /ʃ/.

Thus, in spite of the fact that the acoustic parameters can qualify spectral shape (Forrest, Weismer, Milenkovic, & Dougall, 1988), they are relatively crude representations of the sibilant spectrum. The acoustic properties of sibilants can be sensitive to small modifications of articulatory movements, but relatively small spectral changes can be associated with significant changes in the perception of these sounds (Stevens, 2000).

Conclusion

The acoustic analyses used in this study documented the effects of a tongue resection and RFFF reconstruction and a PAP. Like other investigations of glossectomy speech, the present study demonstrates the complexity of speech rehabilitation in these patients. The results of the acoustic analysis demonstrated that the patient in the present study benefitted from the PAP, but also that these benefits were moderate. According to the research by Marunick & Tselios (2004), it is currently difficult to demonstrate consistent and systematic benefits of PAPs. A PAP can be a blessing or a curse for the patient. Designing a good PAP is particularly difficult because glossectomy patients may use atypical and asymmetrical compensatory articulation patterns (Bowers, Tobey, & Shaye, 1985). Even normal speakers use distinctive idiosyncratic strategies when trying to compensate for the effects of deteriorated speech function (McFarland, Baum, & Chabot, 1996). The use of the same surgical procedure across patients may produce speaker-specific effects. It is essential to understand the individual variability in speech function, as well as the contributions of underlying anatomical, physiological, and perceptual factors to this variability.

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Appendix 1

hVd phrases (analyzed vowel sounds in brackets):

Say heed again (/i/ in heed)
Say hid again (/ɪ/ in hid)
Say who'd again (/u/ in who'd)
Say hud again (/ʌ/ in hud)

Stimulus sentences (analyzed vowel sounds in brackets; analyzed sibilant sounds underlined)

I took a spoon and a dish (/u/ in spoon, /ɪ/ in dish)
A new seed will grow fast (/i/ in seed)
A high stack of cards is on the table (no vowels analyzed)
Buy Bobby a puppy (/i/ in Bobby, /ʌ/ in puppy, /i/ in puppy)
The potato stew is in the pot (no vowels analyzed)
I saw you hit the cat (/ɪ/ in hit)

Zoo Passage (analyzed sibilant sounds underlined):

Look at this book with us. It's a story about a zoo. That is where bears go. Today it's very cold out of doors, but we see a cloud overhead that's a pretty, white fluffy shape. We hear that straw covers the floor of cages to keep the chill away: yet a deer walks through the trees with her head held high. They feed seeds to birds so they're able to fly.