Denture Influence on Resonance Balance in Speech

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Introduction

Normal resonance of the voice begins when the sound waves produced by vocal fold vibration interact with resonating tubes and chambers in the throat, mouth, nose and cranium. Normally, this vibrating airstream is selectively resonated and filtered within the vocal tract and, as it moves headward, is directed primarily through the oral cavity for non-nasal sounds and through the nasal cavity for nasal sounds. Disordered resonance, revealing itself as either hyponasality or hypernasality, is detrimental to the acceptability and intelligibility of speech and thus constitutes a major clinical problem in speech-language pathology.

In the past, clinical assessment and management of disordered resonance have depended on perceptual judgments which are subjective in nature and are influenced by many different speaking variables. However, oral/nasal resonance balance now can be measured instrumentally with the Nasometer (Kay Elemetrics Corporation, Lincoln Park, New Jersey, USA), a computer-based tool that calculates nasalance based on acoustical information received from both oral and nasal microphones. Nasalance, the ratio of nasal acoustic energy (N) to nasal-plus-oral acoustic energy (N+O) expressed as a percentage [(N)/(N+O) x 100], is a correlate of the human perception of resonance balance (Hardin, Van Demark, Morris, & Payne, 1992; Dalston, Warren, & Dalston, 1991a, 1991b). The Nasometer is useful, therefore, in complementing clinical judgments of resonance disorders (Dalston, Neiman, & Gonzalez-Landa, 1993; Dalston, Warren, & Dalston, 1991a, 1991b; Hardin et al., 1992).

As normal reference data for nasalance have accumulated, small but reliable differences in nasalance values have emerged across age groups; that is, older speakers tend to obtain higher nasalance scores than younger speakers. Explanations for the trend toward increased nasalance with age include naturally-occurring physiological and structural changes of the speech mechanism. In addition, with advancing age, individuals meet with a greater probability of requiring dentures. Conceivably, dentures have the potential to impose artificial structural changes that could influence nasalance scores. Therefore, the possibility exists that the presence of an upper denture may act as an intervening variable in the measurement of nasalance.

The passive acoustic effects on oral/nasal resonance balance related to the presence of dentures are not understood. In theory, the presence of an upper denture may increase or decrease nasalance according to one of the two following hypotheses. The first hypothesis suggests that the baseplate of the upper denture, which covers the entire hard palate and extends onto the soft palate, could impede the passive transmission of sound waves through the palate and into the nasal cavities. Thus, a reduction in the overall nasal energy in the nasalance ratio would result in decreased nasalance. Alternatively, it may be argued that a denture would decrease the volume of the oral cavity and increase oral impedance thereby reducing the oral energy component of the nasalance equation, resulting in increased nasalance. Thus, the presence of an upper denture appears to have the potential to alter resonance, however the passive acoustic effects on the oral/nasal resonance balance related to the denture are not fully understood.

The purpose of this study was to investigate the effects of upper dentures on nasalance values in normal elders. Specifically, the experimental question posed was "Is there a difference between nasalance obtained with and without full upper dentures for the same speaker reading the same passage aloud?"

Method

Participants

Twenty women between the ages of 61 and 81 years (mean = 71 years) participated in this study. All had been residents of western Canada for at least 45 years and were fluent in the English language. All participants had worn upper or upper and lower dentures for at least 1 year prior to data collection. In addition, all participants were satisfied with the speech function of their dentures. Histories of respiratory, neurological, laryngeal, velopharyngeal, or craniofacial disorders were criteria for exclusion of potential participants. In addition, all participants were free of upper respiratory infections at the time of recording.

Instrumentation and Materials

A Nasometer (model 6200) was used to collect nasalance data. Reading stimuli included three English language passages used routinely in clinical practice and in the collection of nasalance data in North America. Use of these passages ensured that the speech samples obtained would vary with respect to the presence of nasal consonants.

Procedure

Denture-speaking status was randomly counterbalanced across participants' performances: half of the women read all passages first with their upper denture in place and then with it removed. This order was reversed for the remaining participants. The three passages also were presented in random order, and each participant read each passage three times. After reading all passages in the first condition, the upper denture was either removed or inserted, depending upon the initial condition which had been assigned. The participant then read each passage three times again, in random order.

Data Analysis

The nasalance data were submitted to a three-factor (2 x 3 x 3) (denture condition; passage; trial) within-subjects factorial Analysis of Variance (ANOVA). An alpha level of .05 was used for all statistical tests.

Results

Significant main effects were revealed for denture condition, $F(1,19) = 8.18$, $p<.01$, and passage, $F(2,38) = 5.21$, $p<.01$, but not for trial, $F(2,38) = 3.25$, $p>.05$. A significant interaction was found between denture status and trial, $F(2,38) = 3.25$, $p<.05$. All remaining two-way and three-way interactions were not significant. With respect to the main effect for denture status, participants displayed significantly lower nasalance scores without their upper dentures than with them. This finding was consistent across the group means for all three reading passages, $F(3,76) = 4.04$, $p<.01$.

Discussion

The purpose of this study was to determine if the presence of an upper denture affects nasalance values. Two hypotheses regarding the effects of dentures on nasalance values were offered. The first hypothesis proposed that the baseplate of an upper denture may impede the passive transmission of sound waves into the nasal cavities thereby reducing nasalance values. This hypothesis was not supported in this study. Nasalance values were higher with an upper denture in place than without one. The second hypothesis proposed that an upper denture would change the dimensions and the relative acoustical impedance of the oral cavity in a manner that would result in an increase in nasalance values. This hypothesis was supported by the results of the present study. An explanation for this finding may be found by considering it in relation to the acoustical theory of vowel production (Fant, 1960) and in the context of the equation used to compute nasalance (Fletcher et al., 1989).

When considering both the oral and nasal channels of the vocal tract, the one with less acoustical impedance will transmit a greater proportion of sound energy through it. Specific to this experiment, an upper denture may decrease the volume and length of the oral cavity relative to those same dimensions with no denture in place. Additionally, an increase in oral impedance may result from increased contact of the tongue with the palate that has been found when speaking with dentures versus without (Ylppo and Sovijarvi, 1962; Wictorin and Agnello, 1970). The result of a decrease in oral resonating volume and an increase in oral acoustical impedance with dentures in could result in a decrease in oral energy received by the Nasometer's oral microphone compared to oral energy values with dentures out. Likewise, with dentures removed: oral volume would increase; oral impedance would decrease and oral resonance received by the Nasometer's oral microphone would increase. Because the oral component of the nasalance ratio is increased, the nasal component would be relatively weaker thereby decreasing the nasalance value.

This hypothesis could be tested through first and second formant frequency analyses and second formant (F2) loci comparisons across denture conditions. The frequency of all formants will decrease as vocal tract volume increases (Lindblom & Sundberg, 1971; Murry & Bone, 1989). With respect to dentures, one would expect that speech produced without a denture (increased vocal tract length and volume) would be characterized by oropharyngeal formants which were lower in frequency than those obtained for speech produced with a denture (decreased vocal tract length and volume). Because the behavior of F2 responds to changes of dimension within the anterior oral cavity, F2 loci comparisons might be sensitive to differences in oral cavity constriction and increased impedance associated with the presence of a denture. F2 is higher in frequency when the anterior oral space becomes constricted and lower in frequency when the oral cavity is elongated or more open (Lindblom & Sundberg, 1971). One would expect that speech produced with dentures would be characterized by higher F2 values than speech produced without dentures.

Conclusion

The nasalance values obtained from the speakers in this study differed significantly between denture and edentulous conditions. The small yet significant differences were explained by considering them as a function of the nasalance ratio in the context of the acoustical theory of vowel production. That is, higher nasalance values obtained with dentures in place were attributed to a decrease in the dimensions of the oral cavity and an increase in oral acoustical impedance resulting in a reduction in the amount of acoustical energy transmitted to the Nasometer's oral microphone.

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