Effect of Prosthetic Speech Bulb Reduction on Articulation

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Modification of prosthetic speech appliances has served as the independent variable in a number of studies where the dependent variable included movements and relationships of the articulators, acoustic parameters of the speech signal, and perceptual data obtained through listener judgment. Methodologies have included studying subjects with their appliances in place and again removed (*1, 17*), varying type and position of the speech bulb (*11, 13*), fitting the speech bulb with apertures that couple the nasopharynx and oropharynx (*12*), and removal of acrylic from the margins of the speech bulb (*2, 3*). Clinically, bulb reduction may be necessitated by increase in the amount of movement of palatopharyngeal muscles (*8–10*). Rosen and Bzoch (*14*) attributed this increase in movement to resistance provided by the speech appliance, and Blakeley (*2, 3*) recommended gradual speech bulb reduction as a treatment to increase pharyngeal movement preparatory to pharyngeal flap surgery.

The investigation is part of a project designed to study the effects of speech bulb reduction on articulation scores, on cinefluorographically observed articulatory movements, and on oral and nasal sound pressure levels. The basic purpose was to determine whether speech bulb reduction in gradual decrements resulted in either forward movement of the posterior wall of the pharynx or elevation and retraction of the tongue during speech. The amount of acrylic could be reduced in various quantities and on different schedules; therefore, speech bulb fitting procedures and bulb reduction procedures were planned to

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meet the following two specifications. First, the speech bulb was to be fitted so that it prevented nasal escape of air during speech and yet contained little or no acrylic noncontributory to the separation of the oropharynx from the nasopharynx. Secondly, the speech bulb reduction was to involve removal of small amounts of acrylic that did contribute to separation of the nasopharynx from the oropharynx.

The report will describe the procedures for bulb fitting and bulb reduction, and data will be reported to compare the articulation of prosthetically managed persons having an open cleft with that of persons with surgically-repaired cleft palate who wear prostheses because of palatal insufficiency. Measures describing the dimension of well-fitting speech bulbs will be presented. The following questions will be given special consideration. a) Did the bulb reduction procedure involve removal of acrylic contributory to separation of the oropharynx from the nasopharynx? b) Did pre-reduction articulation scores differ from postreduction scores?

Procedure

To be included in the bulb reduction phase of the study, a subject had to wear a speech bulb and to be free of articulation errors involving lack of oral pressure or nasal escape of air. No subject had a standard score lower than 80 on the Peabody Picture Vocabulary Test nor a hearing loss greater than 20 dB (ASA) for the frequencies 500, 1000, 2000, 4000, and 8000 Hz in the better ear at the time tested. The subjects also made scores on the Boston University Speech Sound Discrimination Test and on a digit memory span subtest from the Illinois Test of Psycholinguistic Abilities that were in the average range or higher for the standardization groups. Since the subjects tended to be older than the standardization groups, those test results served only to provide a gross screening of auditory perceptual skills.

Twenty-five persons were considered as subjects; however, six were deleted because of audible nasal escape on the articulation test and because of failure on the fitting tasks. They tended to produce measurable nasal escape of air even when their speech bulbs were temporarily enlarged with paste. Thus, nineteen subjects participated in the bulb reduction. Ten wore bulbs positioned behind the palate by a carrier and support wire. Nine of these ten had received surgical treatment for congenital cleft palate. The tenth had a submucous cleft that had not been surgically treated. The other nine subjects had open palate clefts. Data will be reported for the open cleft and the closed palate groups separately and for the two groups combined. The open cleft group consisted of eight females and one male. They ranged in age from 6-7 to 13-7. The closed palate group consisted of eight males and two females, and they ranged in age from 8-9 to 18-6 years.

Obturator Fitting. The speech bulb for each subject was fitted to meet the following criteria: a) The subject was able to articulate /p, b, t, d, s, z, ʃ/ with oral breath pressure that was judged acceptable to the speech pathologist and without audible nasal escape of air. b) With one naris closed and the other coupled to a U-tube water manometer, the subject was able to produce the above phonemes with no more than 1 cm of water displacement in one wing of the manometer. c) Quotients based on oral blowing pressure with nares open and again closed were approximately 1.00. An average of three sets of readings made with a Hunter manometer with its bleed valve open was used as the criterion measure. d) The appliance was comfortable for the wearer. e) When the subject spoke and changed head posture while wearing pliable paste on the speech bulb, the paste was displaced from the bulb, but the bulb was not wiped clean.

Clinical fitting of speech bulbs often terminates at this point; however, removal of any excess acrylic was important if the bulb reduction phase of the study was to involve acrylic contributory to closure of the nasopharynx (*7, 15*). Therefore, after the fitting criteria were met, still x-ray pictures were made of each subject phonating /ɑ/ and again at rest. These films and additional paste displacement observations were used to guide removal of acrylic not essential to closure of the nasopharynx. Following this removal, all fitting observations described above were repeated.

All but one of the subjects wore speech bulbs prior to the initiation of this study, and for most of the subjects fitting involved removal of excess acrylic. Fitting of the subject new to obturation involved building up the bulb that had been provided approximately five months earlier. The bulb of one other subject had to be built up as part of the fitting process, and the bulbs of three subjects had to be rebuilt after too much acrylic was removed as excess.

Each speech bulb was measured and weighed before and after removal of excess acrylic during the bulb fitting and before and after each reduction. Maximum width, length, and height of the pharyngeal portion were measured in millimeters with a caliper, and the volume of the total appliance was determined by weighing the appliance suspended in air and then suspended in distilled water. The difference between the two weight measures was recorded as the obturator volume in milliliters. Length was measured as the maximum distance between the anterior and the posterior margins of the bulb portion of the appliance or, for the subjects with an open cleft, between the posterior margin of the appliance and a prominent anterior feature.

Articulation. Following the fitting of the appliance, the articulation of each subject was evaluated by use of a 223-item task that included 65 words elicited by picture, and 67 words in isolation, 67 words in sentences, and 24 isolated phonemes, all imitated after the examiner. The word and sentence portions of the task each sampled the various single phonemes of English other than /h/ as they appeared at the beginning, middle, and end of words. No phoneme was tested in the same word twice. For the isolated phoneme task, the subject was given three attempts to produce each sound. If none of the three efforts was correct, the sound was scored as being defective. Articulation was judged on a right-wrong basis as in a previous study (*16*). Judge reliability for articulation skill was examined by use of Pearson correlation coefficients and by computation of percentages of agreement. The correlations for different judge pairs ranged from .86 to .99, and the percentages of agreement ranged from 77 to 90.

CINEFLUOROGRAPHY. A cinefluorographic film (24 frames per second) was obtained after satisfactory bulb fit was established. The films involved phonation of /a/, /u/, /s/, /sɑs/, *I see Lee sleeping by the seat, and The cars are parked on the arcade.* Adhesive tinfoil was affixed to the midline portion of each bulb during filming to increase margin contrasts in the film.

BULB REDUCTION. As indicated earlier, the procedure was planned to give the subjects opportunity to develop forward movement of the posterior pharyngeal wall during speech. Starting with a speech bulb that permitted articulation free from nasal escape and from which excess acrylic had been removed, each subject's obturator was to be reduced in small decrements. The criteria or tasks used to fit the bulbs were also used to guide reduction. If the results of the fitting tasks showed no decrease in the level of performance or if with time the subject adapted to the reduction, second and third reductions were scheduled. Intervals between reductions ranged from four to fifteen weeks. Limitations of time forced termination after three reductions; however, most subjects were terminated after only one or two reductions because of performance on the fitting tasks. Follow-up observations were made on eight of the ten subjects whose bulbs were reduced either two or three times. Provision of the opportunity for more than one reduction increased the likelihood that removal of acrylic contributory to closure of the nasopharynx would occur, thus giving each subject opportunity to develop compensatory movements. The amounts of acrylic removed were kept small on the assumption that subjects would be more likely to adapt to small rather than to large modifications of bulb size. For each subject, articulation was retested and a second cinefluorographic film was made after his reductions were terminated.

Results

SPEECH BULB DIMENSIONS AND AMOUNT OF ACRYLIC REMOVED. Nine subjects received one reduction, six had two reductions, and four had three reductions. Number of subjects receiving one, two, and three

TABLE 1. Medians and ranges for speech bulb width and height and for appliance length (all in mm) and for volume (in ml) taken at three intervals. Measures for the cleft and closed palate subgroups are compared by use of the Mann-Whitney U test. Group differences significant at the 10% level of confidence are asterisked.

	open cleft			*closed plate*			*U*
	N	*median*	*range*	*N*	*median*	*range*	
mid-fit (prior to removal of excess acrylic)							
width	9	29.74	22.50–33.14	10	27.52	23.40–41.55	42
height	8	24.12	19.34–36.25	10	25.55	20.17–34.91	31.5
length		not measured			21.57	14.53–35.00	—
volume	9	18.77	8.89–27.38	10	12.92	8.38–22.33	21*
pre-experimental reduction							
width	9	29.51	22.36–35.30	10	28.02	23.39–41.68	44
height	7	21.61	13.86–30.86	10	24.00	18.31–33.92	32.5
length	7	68.93	60.34–74.52	10	20.52	14.77–25.00	0*
volume	9	14.71	8.31–27.35	10	12.62	7.66–21.45	25
after last reduction							
width	9	24.69	19.51–33.06	10	25.35	18.26–36.51	40
height	7	19.60	13.86–29.44	10	21.00	16.34–29.39	36
length	9	67.61	58.81–78.59	10	18.42	13.56–23.69	0*
volume	9	13.97	7.21–25.54	10	11.15	6.41–16.44	22*

reductions respectively were five, two, and three for the closed palate group and four, four, and one for the open palate group.

Medians and ranges for speech bulb width, height, length, and volume during the fitting process (before removal of excess acrylic), prior to the first reduction, and following the last reduction, are reported in Table 1. Table 1 also compares the open and closed palate groups for each of these measures by use of the Mann-Whitney U test. Speech bulb width and height did not differ for the two groups. The appliances of the open-cleft subjects tended to be of greater volume than those of the subjects with closed palates. This difference might have been more marked had the two groups been more nearly equal in terms of sex and age distribution. The greater length of the open cleft subjects' appliances simply reflects the fact that the measurement reference points for two groups were different.

Medians and ranges for total reduction in width, height, length, and volume are reported in Table 2. These figures do not include the reduction involved in the removal of acrylic defined as excess. Table 2 also compares the open and closed groups for these amounts removed. Obturator length for the closed palate group was reduced more than was obturator length for the open cleft group; otherwise, differences in the reduction provided members of the two groups were not statistically significant. To check the reliability of these measures, speech bulbs

TABLE 2. Medians and ranges for reduction in width, height, length (all in mm), and for volume (in ml). Measures for the cleft and closed palate subgroups are compared by use of the Mann-Whitney U test. Figures are for the total of one, two, or three reductions. Group differences significant at the 10% level of confidence are asterisked.

	open cleft			*closed palate*			*U*
	N	*median*	*range*	*N*	*median*	*range*	
width	9	2.96	.03 to 7.28	10	2.95	.21 to 7.44	43
height	8	.58	−.26 to 3.23	10	.22	−.27 to 6.02	29
length	7	1.44	−.13 to 1.96	10	2.17	.51 to 3.31	16*
volume	9	1.12	.40 to 2.94	10	1.55	.36 to 5.01	43

were measured twice with no intervening modification. A Pearson correlation coefficient of .99 was obtained for each measure. *t* ratios obtained in comparing each set of measures were 1.38 or less and not significant at the .10% level. While the speech bulb measures were highly reliable, occasionally a dimension was measured as slightly larger after a reduction than before. This error occurred when the dimension involved underwent little or no change.

REDUCTION EFFECT ON CLOSURE OF THE NASOPHARYNX. The tasks used to guide bulb reduction served to prevent removal of too much acrylic at one time. Nevertheless, as shown in Table 3, the U tube manometer measures tended to be greater after reduction than during bulb fitting or prior to the first reduction. Water displacement scores were obtained on the schedule described earlier. The score for each administration was obtained by determining the median measure for the seven phonemes tested. Table 3 contains the medians and ranges for these scores and

TABLE 3. Central tendency and variability for U tube water manometer measures of nasal escape of air. The unit of measurement was cm of water in one wing of the U tube.

	open cleft				*closed palate*			
	N	*median*	*range*	*phoneme range*	*N*	*median*	*range*	*phoneme range*
during fitting	9	.15	−.05– .64	0– .5	10	.11	0– .88	0–1.5
after removal of excess	7	.15	0– .64	0–1.0	8	.08	0– .25	0– .5
pre first reduction	7	.25	0– .59	0–1.5	9	.02	0– .04	0– .5
post first reduction	9	.19	0–2.08	0–4.0	10	.22	0–1.82	0–4.0
pre second reduction	9	.19	0–1.08	0–3.0	10	.58	0–2.0	0–4.0
post 2nd or 3rd reduction	5	.91	.08–2.25	0–4.4	5	.39	0– .75	0–1.0
follow-up	5	1.50	.42–1.58	0–3.0	3	.97	.05–1.25	0–4.0

also the highest and lowest readings obtained for individual phonemes. The open cleft and closed palate subgroups obtained similar readings throughout the study. With one exception, readings for each subject were higher at the end of the study than at the beginning.

The pre- and postreduction cinefluorographic films were examined to determine whether contact between the speech bulb and the posterior pharyngeal wall was continuous or inconsistent. The one subject who had a gap between the bulb and the posterior wall of the pharynx prior to reduction later underwent surgical removal of a nasal obstruction. Following the operation, the speech bulb had to be rebuilt. For six other subjects, bulb contact with the posterior wall of the pharynx was inconsistent after reduction. The six included four of the open cleft subjects and two with closed palates. The person whose final water manometer test showed no nasal escape of air was among these six subjects.

Articulation Scores. One subject in the open cleft subgroup was not included in the articulation analysis because he underwent surgical removal of a nasal obstruction between the time of his final bulb reduction and his final articulation test. He was the only subject whose speech bulb had to be refitted at the termination of the study. Table 4 reports pre- and postreduction articulation error scores for both subgroups for the total articulation test and for two subtests (sibilants and plosives).

Results of statistical analyses indicated that the open cleft and closed palate subgroups did not differ before reduction or after reduction on any articulation subtest, on total test scores, or on number of errors made on sibilants or plosives.

Difference scores reflecting change in articulation were determined for the spontaneous words, the imitated words, and the imitated words in sentences by subtracting postreduction scores from pre-

TABLE 4. Means and standard deviations for number of articulation errors made by members of each subgroup on the total articulation test and on subtests. None of the differences is significant.

	prereduction				*postreduction*			
	open cleft		*closed palate*		*open cleft*		*closed palate*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
spontaneous words	6.77	3.99	7.11	3.95	5.55	2.60	8.22	3.07
imitated words	5.00	2.92	4.33	3.28	3.44	2.38	5.44	3.05
imitated sounds	.55	—	.67	—	.55	—	.75	—
imitated sentences	6.33	4.06	5.11	3.79	5.33	2.96	7.78	5.63
total test	18.67	10.02	17.22	11.10	14.89	7.52	22.78	14.90
sibilants	10.88	6.35	8.33	6.98	10.11	6.81	12.33	9.01
plosives	4.11	3.06	3.77	3.27	3.33	3.32	3.67	3.28

reduction scores. The resulting scores were submitted to a 2 × 3 analysis of variance with repeated measures on one factor (*19*). The analysis tested for differences in articulation change between the subgroups and among the three articulation tests. It also tested for interaction between groups and subtests. The *F*s obtained were not statistically significant. These results show that the open cleft and closed palate groups did not differ from one another in articulation change.

For the eighteen subjects combined, the mean number of articulation errors after their bulbs were fitted was 17.94 (SD, 10.29). Following reductions, the mean number of errors was 18.78 (SD, 12.15). The difference between the two means is not significant. Nor were the differences in number of sibilant errors and in number of plosive errors before and after reduction significant.

For the six subjects whose cinefluorographic films showed a change from continuous to inconsistent contact between speech bulb and posterior wall of the pharynx, the prereduction mean number of articulation errors was 15.50 (SD, 5.89) compared with 14.67 (SD, 7.74) postreduction errors; the difference between the two means is not significant.

Discussion

In this study, removal of moderate amounts of acrylic contributory to closure of the nasopharynx did not adversely influence articulation. The stability of articulation under the bulb reduction conditions of this study may be compared with the effects of speech bulb removal described by Arndt and others (*1*) and by Subtelny and others (*17*). We postulate that closure is more critical for articulation acquisition than for articulation maintenance and that bulb reduction in younger subjects or in persons with greater numbers of articulation errors might impair articulation development. Further reduction in the absence of effective compensation would result in audible nasal escape of air accompanying good oral articulation, and then in distortion of phonemes because of their emission through the nose. Lack of sufficient oral pressure might result because of increased opening into the nasopharynx or because the subject decreased the amount of pressure produced in an effort to decrease the amount of the nasal escape (*4, 5, 18*). A good obturator fit might involve some inaudible nasal escape of air measurable by manometer but no audible nasal escape or lack of oral pressure.

If a speech bulb is larger than necessary, the wearer may fail to use desirable movements that would tend to decrease his dependency on the appliance. Thus removal of excess acrylic and consideration of later removal of additional acrylic are clinically important. However, consideration must also be given to the danger of developing undesirable movements. Temporary use of a bulb fit to prevent passage of air through the nose might be used for diagnostic purposes (*6*) or to facilitate speech therapy directed to accomplishment of oral emission of sounds.

Bulb reduction for some individuals with an intact palate, surgically repaired or noncleft, might result in compensations that eliminate need for the appliance (*2*, *3*), but such advantage is not expected for subjects with open cleft palate. Repeated reductions for persons who do not adapt and for persons with open clefts would eventually result in articulation distortion. The first effect would probably be development of inaudible nasal escape of air.

Summary

This investigation is part of a project designed to study the effects of speech bulb reduction on articulation scores and on articulatory movements cinefluorographically observed. The bulb fitting and bulb reduction procedures used and the amount of acrylic removed are described. Data are reported which indicate that bulb reduction involved acrylic contributory to separation of nasopharynx from oropharynx, and articulation scores before and after reduction are compared.

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