Effect of Speech Bulb Reduction on Movement of the Posterior Wall of the Pharynx and Posture of the Tongue

RALPH L. SHELTON, Ph.D.
ARTHUR F. LINDQUIST, D.D.S.
WILLIAM B. ARNDT, Ph.D.
MARY ELBERT, M.A.
KARL A. YOUNGSTROM, Ph.D., M.D.
Tucson, Arizona 85721

This article is part of a series of reports concerned with the influence that speech therapy or speech bulb reduction may have on articulation phenomena in persons with palate problems. The variables of interest are movement of the posterior pharyngeal wall and tongue position. Increase in forward movement of the posterior pharyngeal wall could contribute to improved palatopharyngeal closure and thus to speech production. Blakeley (*2*) reported that speech bulb reduction can result in such movements.

Persons with poor palatopharyngeal closure may use the tongue to support the palate. This may interfere with articulation. Brooks, Shelton, and Youngstrom (*3, 4*) reported that unobturated palate defective subjects who contacted the posterior wall of the pharynx with the tongue during speech were inferior in palatopharyngeal closure and articulation to persons who did not make such contacts. Subtelny, Sakuda, and Subtelny (*15*) observed that during articulation of /u/ the tongue is higher in the mouth and further back with reference to the posterior pharyngeal wall when the obturator is removed than when it is in place. This phenomenon, illustrated in Figure 1, was observed in three of four patients filmed by the authors during utterance of /ɑ/ in each of several contexts. Perhaps a lingual compensation similar in direction to that illustrated sometimes accompanies removal of speech bulb acrylic contributory to closure of the airway into the nasal passages.

The first purpose of the present study was to describe and compare movements of the posterior wall of the pharynx during speech before and after speech bulb reduction. The measurements and observations used for this purpose were made from cinefluorographic films. The second purpose

Dr. Shelton and Mrs. Elbert are with the Hearing and Speech Department and Dr. Youngstrom with the Radiology Department of the University of Kansas Medical Center. Dr. Lindquist is in private practice, and Dr. Arndt is with the Psychology Department of the University of Missouri at Kansas City.

This study was supported by PHS Research Grant DE02004 and Research Career Development Award DE 31, 669, National Institute of Dental Research.

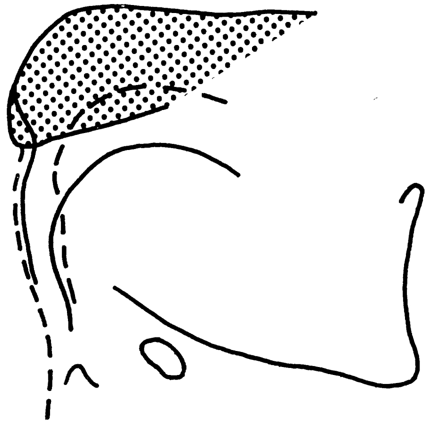

FIGURE 1. Tongue position during [a]. The tracings were made from cinefluorographic film frames. Solid lines show structural positions with the speech bulb in place; dashed lines show positions with the appliance removed.

was to describe and compare the position of the posterior pharyngeal wall at rest before and after speech bulb reduction. An increase in the distance between the atlas and pharyngeal wall at rest would suggest presence of a pharyngeal wall adjustment that was perhaps maintained at all times. Prephonation cinefluorographic film frames were used for this purpose. The third purpose was to compare tongue position during specified utterances before and after reduction. Again, cinefluorography was used. Articulation data obtained as part of this study have been published (*12*). In another companion study (*13*) certain articulation therapy methods were found not to influence movement of the posterior pharyngeal wall or distance between the tongue and the atlas. Nevertheless, articulation was improved. Current findings will be compared with those reported in the therapy study (*13*). As described in 1968 (*12*), persons who wore speech bulbs positioned behind the palate (closed palate group) were considered separately from individuals whose palates had not been closed surgically (open cleft group).

Procedure

Subject selection, speech bulb fitting, and bulb reduction procedures were reported by Shelton *et al* (*12*). However, one closed palate subject included in the previous report was excluded from the current data analyses. He had undergone removal of a nasal obstruction during the time of our study. Briefly then, nine persons served in the closed palate group and nine in the open cleft group.

Prior to the first bulb reduction, acrylic not contributory to separation of the nasopharynx from the oropharynx was removed, and adequacy of bulb fit was determined from articulation judgments and use of a water manometer to measure nasal air pressure during production of test utterances. Later each subject underwent from one to three bulb reductions at intervals of four to six weeks (*14*). Articulation test results and water manometer measurements determined the number of reductions. At the first reduction approximately 2 mm of acrylic was to be removed from the posterior margin of the bulb and .5 mm from each lateral margin. The amount removed varied from subject to subject depending on the extent of contact between the appliance and the posterior pharyngeal wall as shown in the cinefluorographic film. Information gained from a still x-ray made during the first reduction session and from manometer data was used to guide further reductions. Less acrylic was removed during second and third reductions than during the first reduction.

Cinefluorographic Filming. After the excess acrylic was removed, cinefluorographic films were made at 24 frames per second. Later these were analyzed with stop frame projectors and tracing cabinets (*7, 10*). Adhesive tinfoil was affixed to the speech bulbs during filming to increase contrast. The speech sample used included /ɑ/, /s/, /sɑs/, and two sentences, *I see Lee sleeping by the seat* and *The cars are parked on the arcade.* Observers' judgments were used to evaluate movement of the posterior wall, and caliper measurements were used to evaluate position of the posterior wall and tongue.

Judging Forward Movement of the Posterior Wall of the Pharynx. Each film was projected twice at 12 frames per second for study by three observers. Each observer was to indicate on a score sheet whether or not movement of the pharyngeal wall occurred for each of the five utterances described above, and if so, whether it was of sufficient magnitude that caliper measurement might be possible. Observations were restricted to the region of the soft palate and the atlas. This procedure was described in more detail previously (*13*).

Caliper Measurement of Least Distance Between the Anterior Tubercle of the Atlas and Both Posterior Wall of the Pharynx and the Tongue. The least distance between the atlas and the posterior pharyngeal wall was measured at life size in prephonation frames. This measure was not used during the speech contexts of interest because of the small movements observed during the judging procedure described above. During projection stopped on a single frame, mandible margins are easily confused with pharyngeal wall margins in some films. Also, as Moll (*11*) pointed out, the complex contours found among posterior pharyngeal walls make it difficult to describe pharyngeal wall movement by specific measures.

Tongue placement was studied by measuring the least distance between the tongue and the most anterior portion of the anterior tubercle of the atlas. This measurement was made in the following contexts: /ɑ/ out of context, in the syllable /sɑs/, and in the words cars, parked, and arcade; /p/ as it occurred in the words sleeping and parked; /b/ in by; and /k/ in cars. These contexts were thought to be physiologically compatible with tongue retraction (Brooks et al, *3, 4*). Identification of film frames associated with each of these sounds was described previously (*13*).

For these x-ray measurements each frame was independently identified and measured by two observers. Discrepancies 3 mm or greater were resolved by remeasurement of the frame by a third observer. Measurements made by all observers were then averaged. When a discrepancy involved the selection of a frame for measurement, the third observer reviewed the frame selection criteria and selected the frame he thought to be appropriate. His measurement was averaged with that of the other judge who had selected the same frame.

Results

Forward Movement of the Posterior Wall of the Pharynx. The number of utterances in which a subject showed movement of the posterior wall of the pharynx was used as a score. Since there were five utterances, a subject could make a score from zero through five. For both the open cleft palate and the closed palate groups, the median number of utterances showing posterior pharyngeal wall movement before and after reduction was zero. Only three of the nine open cleft subjects displayed movements either in the pre- or post-treatment films. Of these three, one subject showed an increase in number of movements and two showed a decrease from pre- to post. Of the nine closed group subjects, none showed movement pre- but four showed movement post. The movements observed were considered to be too small in magnitude for caliper measurement. Application of the sign test to these two sets of data indicated that neither the open nor the closed group made a statistically significant change in number of movements. The number of movements observed in this study even after treatment was less than that in non-obturated subjects with palate problems (*13*). We would conclude that our bulb reduction was not an effective means of developing posterior pharyngeal wall movements.

Prephonation Distance Between the Atlas and the Posterior Pharyngeal Wall. Means and standard deviations for the prephonation distance between the anterior tubercle of the atlas and posterior pharyngeal wall are reported in Table 1. Pre- and post-reduction measures are reported for the open cleft and closed palate groups. Study of these data by analysis of variance showed no difference significant at the .05 level between groups (F = 2.57), between pre- and post-treatment measures (F = 4.05), and

TABLE 1. Means and standard deviations for the distance between the anterior tubercle of the atlas and the posterior pharyngeal wall. Measures were made in frames prior to onset of speech movement.

open ($N = 9$)				*closed* ($N = 9$)			
pre		*post*		*pre*		*Post*	
$\bar{X}$	*S.D.*	$\bar{X}$	*S.D.*	$\bar{X}$	*S.D.*	$\bar{X}$	*S.D.*
3.76	.85	4.36	1.64	2.99	.91	3.83	1.13

TABLE 2. Means and standard deviations for cinefluorographic measures of the distance between the tongue and the atlas.

	open cleft ($N = 9$)				*closed palate* ($N = 9$)			
	pre-reduction		*post-reduction*		*pre-reduction*		*post-reduction*	
	$\bar{X}$	*S.D.*	$\bar{X}$	*S.D.*	$\bar{X}$	*S.D.*	$\bar{X}$	*SD.*
X̄ /ɑ/	17.13	3.92	17.64	3.89	18.33	3.25	20.07	3.76
slee*p*ing	24.48	3.69	24.48	3.70	24.11	3.31	25.23	4.80
*p*arked	16.99	3.70	18.11	3.62	18.72	3.76	19.81	3.92
*b*y	19.89	3.39	20.31	3.31	19.91	2.50	21.13	3.55
*c*ars	17.37	2.18	16.69	3.19	19.23	3.86	19.38	4.23
Mean	19.20	3.40	19.45	3.55	20.06	3.34	21.12	4.05

no interaction between the two variables ($F < 1$). If the subjects tended to position their posterior pharyngeal walls in a more forward position after the bulb reduction than before, our measurement error obscured the identification of that phenomenon.

Distance Between the Tongue and the Anterior Tubercle of the Atlas. The means and standard deviations for the cinefluorographic measures of the distance between the tongue and the anterior tubercle of the atlas are reported in Table 2. A three way analysis of variance with repeated measures on two factors showed that the open cleft and closed palate groups did not differ in tongue to atlas measure ($F < 1.0$, $p > .10$). The difference between pre-reduction measures and post-reduction measures was not statistically significant ($F = 3.89$, $p > .05$). A significant difference was found among the contexts ($F = 27.35$, $p < .01$). None of the interaction effects were statistically significant. Further analysis of the context data by use of the Newman Keuls test showed that the /p/ in sleeping differed from all of the other contexts ($p < .01$) but that none of the other contexts differed from one another. Since the various /ɑ/'s did not differ from one another, they were averaged for one entry in Table 2.

Discussion

Following completion of the analysis reported above, we undertook qualitative study of the films. Three observers re-examined the subjects' films. Pre- and post-treatment films were threaded in projectors placed side by side and were studied sequentially. The observers, however, did not know which film was pre and which was post. The observers were to indicate whether a gap ever could be seen between speech bulb and posterior pharyngeal wall, whether the speech bulb was displaced, whether the tongue contacted the bulb or the wire that carried it, whether cranio-cervical posture changed, and whether the posterior pharyngeal wall moved.

Each film was projected once for each of these judgments. One open cleft subject (C129) was observed in her post reduction film to produce a pharyngeal wall movement that contributed to closure during each utterance whereas in her pre treatment film no pharyngeal wall movement was observed. This subject was 14 years of age. One subject (C122) in the closed palate group produced more extensive movements in his post treatment films than were observed in the pre films. Variables other than speech bulb reduction could have contributed to these changes or to those reported in the next paragraph.

At times closure seemed to be obtained when a subject changed his cranio-cervical posture or when he displaced his speech bulb while maintaining posture. A subject or two may have adapted to reduction by use of these compensations, but several subjects demonstrated these maneuvers in their first film. The availability of these maneuvers may decrease the probability of pharyngeal wall movement in a given person. Several subjects showed pharyngeal movement that was unskilled in that it occurred irregularly or lacked range of motion. This movement was often present before as well as after treatment. Perhaps greater reduction decrements and longer adaptation times would have resulted in more substantial pharyngeal wall movement in more subjects. However, it is also possible that patients whose obturation provides closure adequate for speech tend to develop less pharyngeal wall movement than do other persons with palate problems. It is also possible that with closely fitted bulbs in place, patients do not produce pharyngeal wall movements that would be used in speech without the bulbs. This is not to say those movements would provide adequate closure.

Just how the speech bulb might contribute to increase in movement of the pharyngeal walls is not known. Spontaneously occurring forms of compensation for poor closure such as nares constriction and tongue retraction are thought to be established through reinforcement. That is, acts associated with rewards for even modest speech improvement become established as part of the speech pattern. We would think that use of the speech bulb would not be necessary to development of pharyngeal wall movements in this manner—indeed it may be less effective than direct training—but perhaps it serves as a stimulus that helps to establish the response. Fletcher, Haskins and Bosma (*8*) observed that stimulation of superior portion of the pharyngeal wall results in reflex forward movement of that part of their posterior pharyngeal wall. Perhaps the bulb helps some people to use that same movement in their automatic speech. However, we did not see this pharyngeal reflex in our films. An alternate explanation is that the bulb provides resistance to muscle movement and thus leads to greater muscle strength and consequent increase in range of motion (*5*). Of course, this hypothesis requires that the muscles work against the bulb in the first place. At this time, we're still working to understand the conditions whereby pharyngeal wall movements can be developed for use in speech. Our viewpoint has been that the speech clinician should teach speech and rely on the dentist or the surgeon to place the mechanism in good working condition. However, it is certainly in order to test the use of therapeutic exercise techniques for the establishment of pharyngeal wall movements if adequate procedures are available. We know that some persons can learn to move their pharyngeal walls voluntarily and to use those movements as they talk. We don't know the conditions under which those movements will provide needed closure adequacy or whether they will function well in automatic speech under stressful conditions. Unwanted side effects may also occur.

The prosthetic speech bulb is used to facilitate speech by separating the nasopharynx from the oropharynx. However, the device may be applied in several ways to accomplish that goal. It may be used as a permanent treatment in persons with gross defects of closure; it may be used as a stimulus intended to increase movements of the pharyngeal walls and of the palate; or it may be used as a temporary device to help in the evaluation of palatopharyngeal closure adequacy (*1, 6*).

Diagnosis of palatopharyngeal closure adequacy for speech production is complicated in that several variables may interact with closure to influence speech. For example, closure may be more critical for speech acquisition than for speech maintenance (*9, 12*). The speech bulb may permit a young child with questionable closure to develop good articulation—perhaps without speech therapy. If removal of the bulb results in speech distortion associated with nasal escape, then the diagnosis of palatopharyngeal insufficiency would appear to be confirmed. Gradual reduction rather than abrupt removal would give the patient the opportunity to adapt to the loss, but it would confound the diagnosis. That is, if the child continues to speak well after the reduction and removal, we don't know whether closure was adequate initially or whether the gradual reduction contributed to increased movement of the pharyngeal walls or other compensation.

We recommend use of speech bulbs for diagnostic-therapeutic purposes in young children with questionable closure. Use is especially warranted where no speech therapy is available or where the child produces some speech distortion by nasal escape of air despite speech therapy and despite nearly normal speech. While we have reduced only one patient to the point where he could speak as well without as with his appliance, a number of our young children after obturation have developed good speech without speech therapy.

Summary

Cinefluorographic films were made of subjects before and again after their prosthetic speech bulbs were reduced. Subjects were divided into two groups: those with open clefts and those whose palates were closed. The treatment had little or no effect on movement of the posterior wall of the pharynx. Lingual compensation for the bulb reduction in the form of tongue elevation and retraction was not observed. Various uses of the speech bulb contributory to articulation development are discussed.

reprints: *Dr. Ralph L. Shelton*
Speech Dept.
University of Arizona
Tucson, Arizona 85721

Acknowledgment: The following persons have contributed to this study: David W. Robinson, Frank W. Masters, Lynn D. Ketchum, Linda Chisum, Donna Brahl, Beverly Shelton and Earlene Tash.

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