Selective Movement of the Lateral Aspects of the Pharyngeal Walls during Velopharyngeal Closure for Speech, Blowing, and Whistling in Normals

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In a study of five normal adult subjects performing speech, blowing, whistling, swallowing, and gagging tasks in both frontal and lateral cinefluorographic projections, Shprintzen, et al. (*6*) found evidence of two different velopharyngeal closure mechanisms, and possibly a third. Speech, blowing, and whistling were found to share a common closure mechanism (labelled the pneumatic closure mechanism) which involved a characteristic velar height and configuration of the lateral aspects of the pharyngeal walls (LAPW). No approximation of the LAPW was evident in any of the five subjects during the pneumatic activities. Gagging and dry swallowing were found to share a common closure mechanism (labelled the nonpneumatic closure mechanism) which showed a greater velar height and total or near total LAPW approximation in all five subjects. Reflexive swallowing also showed LAPW approximation, but the degree of medial movement of the LAPW and velar elevations was less than that for the dry swallow. Other investigators (*1*, *3*) have also noted differences between types of velopharyngeal closure for various activities. The question arises as to the basis of these different patterns of velopharyngeal closure.

Shprintzen, et al. (*6*) found that the general LAPW configuration as

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This paper was presented at the annual meeting of the American Cleft Palate Association in Boston, April, 1974, as part of a presentation titled "A Three Dimensional Cinefluoroscopic Analysis of Velopharyngeal Closure During Speech and Nonspeech Activities in Normals." This study was derived from the first author's doctoral dissertation done at Syracuse University, completed in July, 1973, directly supervised by Dr. Ruth Lencione and in co-operation with Dr. Gerald McCall and Dr. Leon Skolnick.

observed in frontal view fluoroscopy during speech, blowing, and whistling involved a specific level of marked medial excursion in the superior portion of the oropharynx for all five subjects. Though there was some individual variation in LAPW pattern, all five subjects exhibited this selective movement resembling shelves in the pharyngeal walls. This shelving pattern becomes an important factor when one considers that not only is velar elevation to the posterior aspect of the pharyngeal walls (PAPW) necessary to closure, but also LAPW approximation to the lateral edges of the velum (*5*). This paper reports some kinesiological observations regarding the characteristic shelving pattern observed during the pneumatic activities of speech, blowing, and whistling and the relationship of this frontal view configuration to the movement of the velum as observed in lateral view.

Method and Procedures

SUBJECTS. Five normal adult subjects, four female, one male, ranging in age from 33 to 45 with a mean age of 38.2 were studied in frontal and lateral videofluoroscopic projections while performing speech, blowing, and whistling tasks. Subjects were judged as normal if they had no history of oral or pharyngeal surgery, no history of speech therapy or speech disorder, no evidence of nasal speech, and no structural anomalies of the oral and pharyngeal cavities.

EXPERIMENTAL PROCEDURE. The radiographic technique for evaluating the velopharyngeal portal in lateral and frontal projections has been described in detail elsewhere (*5*). Prior to the videofluoroscopic examination, the pharynx and velum of each subject was heavily coated with barium intranasally to define the LAPW and the margin of the velum. Each subject sat in a specially constructed chair with a head immobilization device positioned so that the subject's hard palate was parallel to the horizontal.

Three repetitions of each of the three experimental tasks were selected from both frontal and lateral views for the synchronization procedure. The tasks, presented in random order to each subject, were:

Speech: Production of the following syllables in the carrier sentence "Say _____ again."
/sup/, /sæp/, /tup/, /tæp/, /lup/, /læp/

Blowing: Each subject was instructed to blow a sustained air stream out of the mouth. The instructions were to "blow as if you are blowing on hot soup for a couple of seconds."

Whistling: Each subject was instructed to whistle a sustained note for a one second duration.

The videofluoroscopic examinations were recorded on one inch video tape (SONY model EV210) and later converted to 16 mm motion picture film. Each frame of the film was numbered to provide an accurate record for referral to any frame for repeated observation. In order to explore the relationship between the shelving in the LAPW and the movements of the velum, a method of synchronizing the frontal and lateral views was performed.

SYNCHRONIZATION PROCEDURE. The frontal films for each of the five subjects performing the speech, blowing, and whistling tasks were viewed first. A line was drawn on the viewing surface connecting the points of maximum medial excursion in the shelved area of the LAPW. Another line was drawn marking the superior margin of the velum visible in frontal view. These lines were drawn during maximum medial excursion of the LAPW and maximum velar elevation. The lateral films for the same activity were then viewed with the lines remaining on the viewing surface. Since the specially constructed chair held the head immobile, the placement of the lines on the frontal view marking the points of maximum medial excursion of the LAPW would represent where the shelving was occurring in relation to the structures observed in lateral view. Similarly, the line marking the superior margin of the velum visible in frontal view would show its relationship to the velum as seen in lateral view.

Results and Discussion

The lines marking the superior margin of the velum visible in frontal view corresponded with the levator eminance as observed in lateral view for each of the five subjects (Figures 1–5). Thus, the portion of the velum visible in frontal views marks the levator eminance which is helpful in determining the relation of the levator muscle to the pattern of velopharyngeal closure. In addition, the coincidence of the point of maximum velar elevation observed in frontal view with that observed in lateral view served as an indicator that the patient's head was immobile, therefore making the synchronization procedure accurate.

The results of the synchronization procedure revealed that the line con-

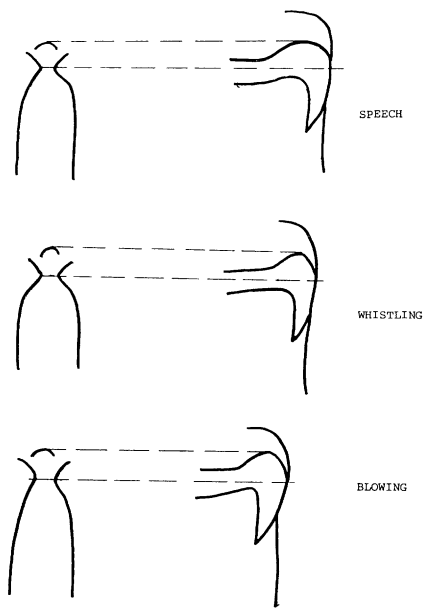


FIGURE 1. Synchronization of frontal and lateral views for Subject I during speech, whistling, and blowing.

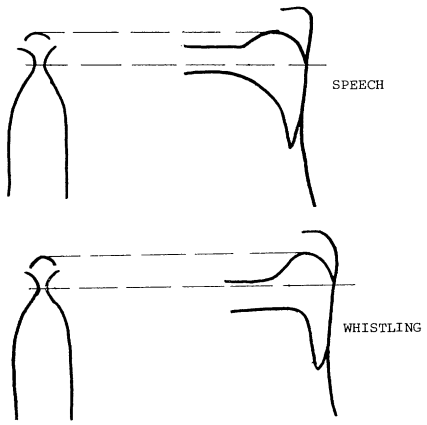


FIGURE 2. Synchronization of frontal and lateral views for Subject II during speech, whistling, and blowing.

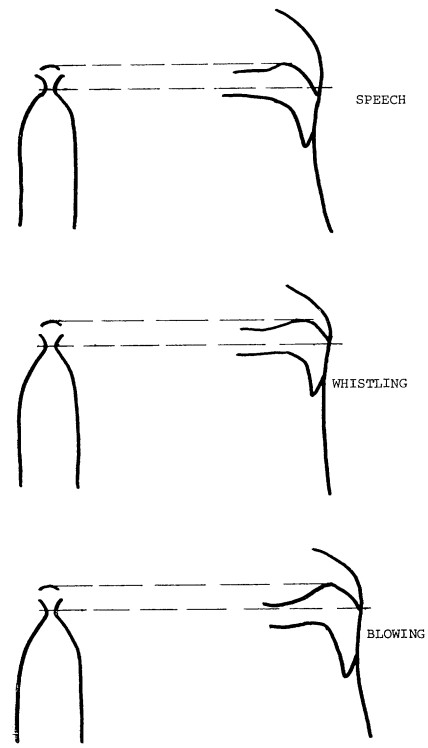
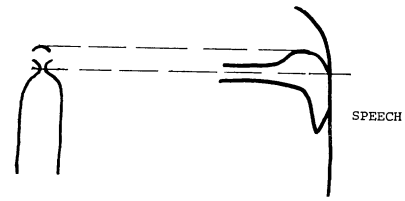


FIGURE 3. Synchronization of frontal and lateral views for Subject III during speech, whistling, and blowing.



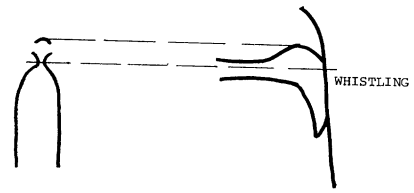
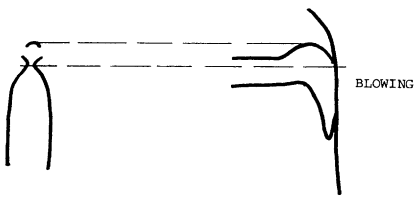
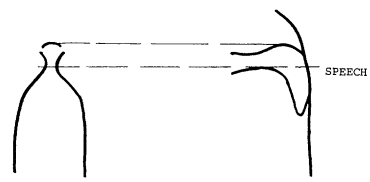
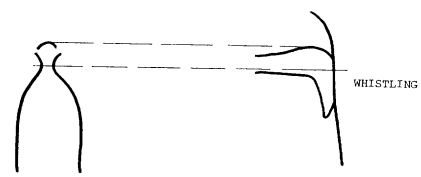


FIGURE 4. Synchronization of frontal and lateral views for Subject IV during speech, whistling, and blowing.







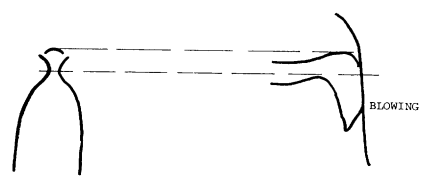


FIGURE 5. Synchronization of frontal and lateral views for Subject V during speech, whistling, and blowing.

necting the shelves in frontal view intersected the full length of the velum and hard palate generally within several millimeters of its superior point of contact with the PAPW for each of the five subjects (see Figures 1–5). This is in agreement with Skolnick's (1969) findings which stress the importance of the LAPW approximating with the lateral edges of the velum as a component of velopharyngeal closure. It therefore appears that this facet of closure occurs at the level of the shelves observed in frontal view. Thus, the results of this study indicate that the specificity of function in the LAPW serves a definite function.

The shelves in the LAPW observed during speech, whistling, and blowing occur at the level of the full length of the velum and hard palate, not at the levator eminance, and represent a narrowing of the pharynx at a specific level during the pneumatic activities. It may be hypothesized that this narrowing is the result of the selective contraction of the uppermost fibers of the superior constrictor muscle; that is, those entering the velum through the lateral walls of the pharynx and possibly those attached to the pterygoid plates. While there is also medial excursion of the LAPW at lower levels in the oropharynx for all five subjects, indicating possible activity throughout the superior constrictor, the greatest amount of medial movement is in the area of the velopharyngeal portal. In synchronizing the frontal and lateral views for these pneumatic activities, it appears that closure consists of the elevation and posterior movement of the velum plus the medial movement of the LAPW around the lateral edges of the velum. It may be hypothesized that the muscles primarily responsible for this observed interaction are the levator and uppermost fibers of the superior constrictor. While this contention does not disagree with the EMG data of Fritzell (*3*), it is not in agreement with the suggestions of Dickson (*2*). Dickson hypothesized, based on dissection alone, that the sole muscle of velopharyngeal closure is the levator palatini. While the results of this study are not absolutely definitive concerning the actual physiology of velopharyngeal activity, the kinesiological observations of this study would seem to indicate that both the levator and superior constrictor are necessary to closure.

It seems evident from the tracings in Figures 1–5 that the levator eminance is not the portion of the velum where closure occurs in the pneumatic activities. It is above both the point of contact between the velum and PAPW and the area of the maximum medial excursion of the LAPW which represents the area of contact with the velum laterally. It therefore seems that closure is occurring at the portal between the posterior third of the velum and the pharyngeal walls. Dissectional data indicates that the levator arises superior to the palate from where it courses in an antero-inferior direction to enter the velum through the lateral walls of the pharynx (4). Therefore, the fibers of the levator which enter the velum represent the most inferior level of that muscle. It becomes evident from the anatomical location of the levator and from the results of this study that the levator

acts as a sling when contracted to pull the velum in a postero-superior direction. The levator eminance, which moves in this manner, clearly represents the bottom of this sling, or the most inferior fibers of the levator. However, the medial movement of the LAPW occurs below the levator eminance. This would seem to indicate that there is an active contraction of some muscle other than the levator which would cause medial movement of the LAPW, which is a necessary component of closure. Considering the location of the superior constrictor and the level at which the movement occurs, it seems likely that select fibers of the superior constrictor actively contribute to velopharyngeal closure. Data shown by Shprintzen et al. (*6*) would seem to indicate that during dry swallowing and gagging, the superior constrictor muscle is in total contraction. The LAPW are in total approximation with no specific level of the lateral walls showing any selective contraction or decontraction. However, the reflexive swallow shows a Y-shaped configuration indicating that the LAPW are not in approximation in the upper portions of the oropharynx. It may be speculated that what is occurring to account for the Y-shaped LAPW is a selective decontraction of those uppermost fibers of the superior constrictor which enter the velum and attach to the pterygoid plates.

The kinesiological synchronization of the frontal and lateral views in this study have made it possible to observe the interaction between the levator eminance and the pharyngeal walls. This information, coupled with dissectional findings, make it possible to draw suppositions, not conclusions, concerning physiology. Since neither the data from dissection alone nor videofluoroscopy alone constitute proof positive of physiological activity, it may be suggested that the addition of electromyographic data to simultaneous kinesiological observation would help to definitely isolate the physiological aspects of closure.

Summary

The frontal and lateral cinefluorographic views of five normal subjects performing speech, blowing, and whistling tasks were synchronized in order to observe where the greatest degree of medial movement in the lateral aspects of the pharyngeal walls was occurring in relation to structures observed in lateral view. The results of the synchronization procedure indicates that for all five subjects, maximum medial excursion in the lateral walls of the pharynx occurred at the level of the full length of the velum and hard palate, well below the levator eminance. It is hypothesized that this observed interaction may be due to the select contraction of those fibers of the superior constrictor muscle which enter the velum via the lateral walls and those fibers attached to the pterygoid plates as well as levator muscle activity. It is also suggested that definitive physiological data must be obtained from further study of combined EMG and fluoroscopic procedures.

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