Pharyngeal Wall Motion in Prosthetically Managed Cleft Palate Adults

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Fiberoptic nasoendoscopy was used to evaluate the activity in the lateral and posterior pharyngeal walls of five adults with cleft palate, each of whom had worn a prosthetic speech appliance for more than 20 years. Activity during speech was greatest in the area of the levator veli palatini muscle and Passavant's ridge, while no gross activity was observed in the area of the auditory tube superiorly. Activity was variable within and between subjects. Apparent medial movement of the auditory tube seemed to be secondary to the influence of the levator muscle on the pharyngeal wall soft tissues.

During the past several decades the function of the velopharyngeal mechanism in individuals with cleft palates has been the subject of much clinical observation because of the importance of this mechanism in the production of speech. Two major areas of concern have been focused upon: furthering our understanding of the function of the musculature in the lateral and posterior pharyngeal walls and developing clinical methods for evaluation of the system.

In both normal and cleft palate individuals, movements of the posterior and lateral walls of the nasopharynx are important in velopharyngeal closure during speech and swallowing, and for the opening of the auditory (Eustachian) tube (AT). Located in the lateral walls are the levator veli palatini, the tensor veli palatini, the salpingopharyngeus, and the superior constrictor muscles. The levator veli palatini muscle has been reported to be the most active muscle in elevating the palate for velopharyngeal closure. The locus of activity of this muscle as observed by nasoendoscopy occurs below the level of the torus tubarius (Lavorato and Lindholm, 1977). In individuals with cleft palates, compensatory activity has been observed in the lateral walls at the level of the superior constrictor muscle (Glaser et al., 1979; Shprintzen et al., 1977) and possibly in the palatopharyngeus muscle (Luschka, 1868; Rueckert, 1882). Shprintzen et al. (1977) in their evaluation of pharyngeal wall activity have described "incongruous" motion in some cleft palate subjects. Nasoendoscopic observations have suggested that the movement of the levator during velopharyngeal closure produces passive movement of the torus tubarius superiorly (Shprintzen and Croft, 1981), as well as passive movement of the floor of the orifice of the AT (Lavorato and Lindholm, 1977). This movement may or may not be accompanied by constriction of the lumen of the AT. The major variable in determining whether or not constriction of the AT occurs appears to be the task employed (Shprintzen et al., 1977). According to Shprintzen et al. (1977), speech in normal
individuals produces movement of the torus which during swallowing and blowing is accompanied by a narrowing of the lumen of the tube. Rood and Doyle (1982) present yet another interpretation of the apparent movement of the levator during velopharyngeal closure: they feel that the movement observed may actually be that of the heavy coat of soft tissue overlaying the torus tubarius.

A number of clinical tools, including videofluoroscopy and nasoendoscopy, have been used to examine the structure and function of the velopharyngeal apparatus. Videofluoroscopy has become a standard clinical procedure for the evaluation of patients with hypernasal speech. It is recommended that basal, frontal, and lateral views of the valving mechanism be obtained, and that the dynamics of the system be evaluated according to standardized rating scales (Skolnick et al., 1975; McWilliams and Bradley, 1965). Oral endoscopy has been used to define activity of the velopharyngeal port (Shelton et al., 1975; Taub, 1966; Zwitman et al., 1974) but gives limited information since it interferes with normal speech production. Transnasal fiberoptic endoscopy has been demonstrated to be an effective method of evaluating lateral and posterior pharyngeal wall motion and of viewing the nasopharyngeal orifice of the AT (Lavorato and Lindholm, 1977; Shprintzen and Croft, 1981; Jaumann et al., 1980; Pigott et al., 1969; Matsuya et al., 1974, 1979; Miyazaki et al., 1975).

The purpose of this investigation was to describe and evaluate pharyngeal wall motion in a group of adults with unrepaired cleft palates which had been managed prosthetically.

### Methods

#### Subjects

Five adult subjects with unrepaired cleft palates were evaluated using nasoendoscopy and lateral-view videofluoroscopy. The patients ranged in age from 37 to 59 years with a mean age of 51 years. Four patients had clefts of the hard and soft palates. One patient had a velar cleft only. All patients had been wearing prosthetic speech appliances for from 26 to 37 years and none had undergone surgery for treatment of the cleft palate (Table 1).

Each subject first removed his speech appliance. Then the nasal vestibule and floor of the nose were anesthetized by inserting cotton pledgets soaked with 4% Xylocaine into the nose. The pledgets were removed after several minutes, and the Storz* rigid fiberoptic nasopharyngeal telescope (70° viewing angle) with Xenon light source (Figure 1) was inserted into the nasal passage. The telescope was coupled to a fiberoptic teaching arm** and then to a 1/2-inch videotape recorder which stored the image.

Following endoscopy, each patient underwent standard lateral and frontal view videofluoroscopy of the velopharyngeal mechanism during speech with and without a radiopaque medium and without the speech appliance. During both procedures, each patient was asked to produce the following speech sample: (1) /a/ ("ah"), (2) /i/ ("ee"), (3) "Sissy sees papa", and (4) prolonged /s/.

#### Table 1. Subject Information: Pharyngeal Wall Motion in Cleft Palate Adults

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Age (Yrs.)</th>
<th>Sex</th>
<th>Type of Cleft and Repair</th>
<th>No. Years With Speech Prosthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52</td>
<td>F</td>
<td>Hard and Soft Palate Unrepaired Soft Palate</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>37</td>
<td>M</td>
<td>Bilateral Lip and Palate Unrepaired Hard and Soft Palate</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>59</td>
<td>M</td>
<td>Left Unilateral Lip and Palate Unrepaired Hard and Soft Palate</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>56</td>
<td>M</td>
<td>Left Unilateral Lip and Palate Unrepaired Hard and Soft Palate</td>
<td>37</td>
</tr>
<tr>
<td>5</td>
<td>53</td>
<td>M</td>
<td>Left Unilateral Lip and Palate Unrepaired Hard and Soft Palate</td>
<td>29</td>
</tr>
</tbody>
</table>

* Karl Storz Endoscopy—America, Inc., Los Angeles, California.

** Teaching arm F08910; American Cytoscope Makers, Inc., Pelham Manor, New York.
A rating scale was developed by two of the investigators (QB and SR) to assess the activity of several structures within the nasopharynx. Each rater was experienced in evaluating velopharyngeal structures using videofluoroscopy. The movement of each structure (torus tubarius, levator veli palatini, salpingopharyngeal fold, and Passavant’s ridge) was evaluated according to a five-point scale with equal-appearing intervals. Each structure was defined, and the points on each scale were discussed prior to the evaluation of the videotapes (see footnote, Table 2). The videotapes were evaluated by each judge independently. Each study was reviewed as many times as needed for each rater to complete the rating.

**Results**

**Nasendoscopy**

Lateral Pharyngeal Walls: The mean ratings of movement of the structures of the lateral walls of the nasopharynx are shown in Table 2. The structures as viewed obliquely are shown in Figures 2 and 3. The orifice of the AT and the area of the torus tubarius were easily identified bilaterally in all subjects. During speech activities, no gross movements in the area of the tori were observed. Sphrintzen and Croft (1981), who also studied cleft palate adults by nasoendoscopy, reported that in their subjects the orifice of the AT was small and often unidentifiable and the AT cartilage was hypoplastic. In contrast, the AT orifice of the individuals we studied were easily identifiable and the protrusion of the AT into the nasopharynx was no different from the torus pictured by Shprintzen and Croft (1981) as representing the normal “tori” or observed in a series of normal subjects by two of the investigators (QB and SR). However, the presence of the palate in the normal subjects made the lower portion of the AT orifice difficult to distinguish. The differences between this study and that of Shprintzen and Croft (1981) as to AT protrusion cannot be explained at this time.

Speech activities which required palatal elevation were seen to produce a bulking of the soft tissue in an area immediately inferior to the nasopharyngeal orifice of the AT. This is the area through which the levator veli palatini is thought to course (Lavorato and Lindholm, 1977; Rood and Doyle, 1978). Thus, the tissue bulking was thought to indicate levator activity. All subjects showed at least some movement bilaterally with considerable inter-subject variability. These findings are consistent with those of Jaumann and co-workers (1980) who reported that 70 percent of cleft palate patients have a hyperplastic levator veli palatini muscle.

Three subjects had prominent lateral velar tags. In one patient, the tags were pulled cephalad and laterally, with the greatest movement occurring during the production of...
of a prolonged /s/. A second patient demonstrated minimal movement bilaterally, while a third showed marked asymmetry in the amount of bilateral movement observed. In the other two subjects no remnants of the velum were seen. Instead the posterior margin of the hard palate merged with the lateral walls anterior to the salpingopharyngeal fold.

The salpingopharyngeal fold, a vertical elevation of the lateral pharyngeal wall coursing caudally from the inferior tip of the AT, was not usually evident at rest (see Figures 2 and 3). The fold became evident bilaterally in all patients during activities in which pharyngeal wall motion was noted. The movement ranged from slight to moderate with the activity being the same bilaterally in most subjects. Whether the fold results from di-
FIGURE 3. Nasoendoscopic view of the left lateral wall of an adult with a cleft palate (A) at rest, (B) during phonation, and (C) schematically during phonation, showing the torus tubarius (TT), the orifice of the auditory tube (AT), the salpingopharyngeal fold (SP), Passevant's ridge (PR), and the levator veli palatini (LVP) muscle. The nasal telescope is placed in the right nostril.

rected muscular activity (salpingopharyngeal muscle) or is merely a soft tissue fold produced by pharyngeal wall activity cannot be determined by endoscopy alone. The small size of the salpingopharyngeus muscle (Dickson et al., 1975) suggests that this bulking of tissue may not be caused by action of this muscle. Instead, the fold may be caused by action of the levator veli palatini upon the torus tubarius or the torus tubarius salpingopharyngeal complex (Lavorato and Lindholm, 1977).

Some investigators have studied the anatomy of the palatopharyngeus muscle and have suggested that, in addition to the vertical component, the muscle may have a circumferential component that may assist in velo-
pharyngeal closure (Luschka, 1868; Rueckert, 1882). On the basis of anatomical dissections, Dickson (1975) observed that the palatopharyngeus is anatomically positioned as an oropharyngeal elevator-constrictor.

**Posterior Pharyngeal Wall.** The posterior pharyngeal wall was defined as that part of the pharynx which lies between the lateral fossae of Rosemüller. All five subjects demonstrated varying degrees of anterior projection of the posterior wall during speech and swallowing. In three subjects a distinct horizontal bulge in the posterior pharyngeal wall (Passavant’s ridge) was observed at the level of the palatal plane. The bulge occurred during speech where velopharyngeal closure was expected. Figure 4 shows the posterior wall at rest and during phonation. Movement in the

![Figure 4](image-url)
posterior wall was observed on both sides of the midline. In a fourth subject, Passavant’s ridge was definitely asymmetrical in appearance, one side of midline showing greater movement than the other. The fifth subject demonstrated Passavant’s ridge during swallowing, during production of the isolated sustained /s/, and on a single occurrence on /s/ in continuous speech. In addition, the anterior projection of the posterior wall was greater on the isolated /s/ than during swallowing. These observations of changes in Passavant’s ridge with various speech and nonspeech activities are in agreement with those made using multiview videofluoroscopy (Glaser et al., 1979; Glaser, 1980).

**VELOPHARYNGEAL ORIFICE.** When viewed from above through the rigid fiberoptic nasopharyngoscope, the shape of the velopharyngeal port demonstrated a significant amount of inter- and intra-subject variation. The shape of the port at rest and during production of sustained /s/ is shown schematically in Figure 5. There was little similarity in the shape of the orifice among subjects. The lack of similarity could have been due to variation in the shape of the orifice, to positioning of the telescope, to tongue posturing, or to variation in degree of head flexion during the examination. As only soft tissues are observed when visualizing the nasopharynx by endoscopy, it is difficult to locate a point of reference for consistent positioning of the telescope in all subjects.

The velopharyngeal port was defined as the perimeter of the pharyngeal lumen at the level of the palatal plane anteriorly and Passavant’s ridge posteriorly. In all subjects the movements of the walls of the port were quasicircumferential; that is, resembling the action of a drawstring. The posterior wall moved anteriorly and the lateral walls medially. The activity appeared to be synchronous. Passavant’s ridge was continuous from the posterior wall into the lateral walls of the pharynx and ended in the region of the cleft in the hard palate. This is consistent with the observation of Glaser et al. (1979) that Passavant’s ridge is not just a midline structure but is continuous over three walls of the pharynx at the level of the hard palate. Figure 6 shows the velopharyngeal port at rest and the circumferential activity in the walls of the pharynx during phonation. Two subjects had prominent velar tags which elevated simultaneously with pharyngeal wall activity, thus completing a projected circumferential motion. One subject had greater over-all motion of the posterior and lateral walls on the right side than the left. The two remaining subjects had more prominent posterior pharyngeal wall movement than lateral wall movement.

**VIDEOFLUOROSCOPY**

Videofluoroscopy in the lateral and frontal view was evaluated in three of the five subjects (videotapes were not available for the other two subjects because of technical difficulties). The process and results of instilling the barium through one nostril were observed through the nasopharyngoscope which had been inserted through the contralateral nos-
Unilateral instillation of the radiopaque medium did not provide an even coating of the nasopharynx. The barium flowed down the side of the pharynx into which it had been instilled and did not coat the other side even when there was considerable pharyngeal wall activity bilaterally, as in swallowing. Video-fluoroscopy in the frontal projection reflected this unilateral coating. Lateral videofluoroscopy revealed active movement of Passavant's ridge (Figure 7).

The results of the unilateral instillation of radiopaque medium indicate the necessity of instilling barium bilaterally in order to obtain
valid frontal and lateral videofluoroscopic views in patients with unrepaired cleft palates or with incomplete velopharyngeal closure. This would be true for basal views as well. Passavant's ridge was observed in the lateral view and was clearly outlined by the barium. The nasoendoscopic evidence of unilateral variation in activity in the same subject sug-

FIGURE 7. Lateral videofluoroscopic image of the velopharyngeal mechanism in an adult with a cleft palate (A) at rest, (B) during phonation, and (C) schematically during phonation, showing the protrusion of Passavant's ridge (PR) from the posterior pharyngeal wall (PPW).
gests that unilateral instillation of barium may not yield a true evaluation of lateral and posterior wall function using multiview video-fluoroscopy.

Discussion

All subjects in this study were adults with unrepaired cleft palates who had used prosthetic speech appliances for a long time. The time factor, as well as the shape and contour of the speech appliance, may account for the degree and asymmetry of movement of the pharyngeal walls. The use of obturators has been advocated to stimulate increased movement of the lateral and posterior pharyngeal walls in the presence of an incompetent velopharyngeal mechanism (Harkins, 1947; Peterson, 1974; Dalston, 1977). It has been proposed that by increasing sensory stimulation, the motor function of the pharyngeal muscles may be facilitated (Dalston, 1977). The wearing of an appliance for a long time—more than 20 years—may have had an influence on the muscle function in the adults in our study. However, we cannot be certain that the high degree of pharyngeal wall activity noted in the subjects in this study was in part or wholly due to the long-term use of an appliance. Previous studies which evaluated the efficacy of a prosthetic speech bulb in improving posterior wall action found that when the bulb was used for four to six weeks there was no significant increase in movement of the posterior wall (Shelton et al., 1971). Longitudinal studies of patients with unrepaired cleft palates who have been managed with prostheses for more than six weeks would provide further insight into the effect of the prosthetic appliance on the activity of the musculature in the walls of the pharynx.

Transnasal fiberoptic endoscopy is a unique method for studying oral pharyngeal function, even though the technique is limited because of the variability in landmarks in the nasopharynx, which restricts the analysis of information to subjective assessment. The mechanism of closure is complex and may not be limited to one anatomical plane but may occur at several planes along the vertical axis through the pharynx. In attempting to assess function in the patient suspected of velopharyngeal insufficiency when the palate is intact, it may be difficult to determine the activity present in the lateral walls at the level of the palate because the palatal activity may obscure the view through the telescope. However, nasopharyngoscopy is a useful technique which can provide valuable information on the functioning of the oropharynx.

Conclusions

The following observations were reported in this study of prosthetically managed adult cleft palate subjects.

1. The mobility of structures of the lateral walls of the nasopharynx is generally equal bilaterally. However, some variability is evident in laterality and degree of movement.

2. The AT superiorly appears stationary during speech, but slight movement may be observed along the inferior medial border of the AT. This movement may be due to the levator veli palatini pushing medially or to the soft tissue overlying the cartilaginous tube being displaced by levator veli palatini activity.

3. Passavant’s ridge extends bilaterally and anteriorly at approximately the level of the hard palate.

4. Nasoendoscopy is a technique applicable for studying pharyngeal wall motion in individuals with unrepaired cleft palates. Its value in evaluating the function of the velopharyngeal valve needs to be investigated further, particularly in patients managed by prosthodontics.

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