Nasopharyngoscopy of The Normal Velopharyngeal Sphincter: An Experiment of Biofeedback

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In a single normal subject, nasopharyngoscopy was used as an instrument for visual biofeedback of the velopharyngeal sphincter during speech. The goal of the experiment was for the subject to alter the velopharyngeal valving pattern observed during spontaneous speech by manipulating the relative contributions of the velum and pharyngeal walls. After six sessions, each lasting twenty minutes, the subject was able to change velopharyngeal valving pattern at will during short samples of connected speech. This implies the role of learning in velopharyngeal valving and a degree of physiologic plasticity in the velopharyngeal sphincter. The procedure is felt to have possible application to a variety of conditions which have velopharyngeal insufficiency as a symptom.

KEY WORDS: Biofeedback, nasopharyngoscopy, velopharyngeal function

Traditionally, the treatment of velopharyngeal insufficiency has been surgical or prosthetic (Schneider and Shprintzen, 1980). Several recent reports have explored the use of various biofeedback techniques to manipulate the velopharyngeal mechanism (Curle, 1979; Flack, 1979; Selley, 1970; Shelton et al., 1975; Shelton et al., 1978; Shprintzen et al., 1975; Tudor and Selley, 1974; Warren, 1979). Each of these studies relied upon instrumentation which did not allow direct visualization of the velopharyngeal sphincter during unimpeded connected speech. Miyazaki et al. (1975) did mention the use of flexible fiberoptic nasopharyngoscopy as a tool for biofeedback in patients with repaired clefts of the palate, but no specific data were provided on the outcome.

Several studies have reported on the heterogeneity of patterns of velopharyngeal closure in both normal and cleft palate populations (Croft et al., 1981; Skolnick et al., 1973; Zweitman et al., 1976). It has been noted that the relative degree of movement of the velum, lateral pharyngeal walls, and posterior pharyngeal wall varies from individual to individual. Most recently, Croft et al. (1981) hypothesized that the presence of multiple patterns of velopharyngeal valving in the normal population implies that velopharyngeal closure is influenced by learning amongst other factors including anatomical variability. If the velopharyngeal sphincter is influenced by learning, is it possible for an individual to learn to alter their velopharyngeal closure pattern?

Nasopharyngoscopy allows a direct view of the movements of the velopharyngeal sphincter from above during connected speech.
(Croft et al., 1981; Pigott, 1977; Shprintzen et al., 1980). As such, it is a technique well-suited to velopharyngeal biofeedback. It has the added advantages of being easily tolerated and it may be repeated as frequently as necessary. There is no exposure to radiation as in fluoroscopic techniques and there is no interference with the normal flow of speech as in oral endoscopy (Taub, 1966; Zwitman et al., 1976).

This is a report on an experiment using flexible fiberoptic nasopharyngoscopy as an instrument for visual biofeedback of velopharyngeal valving in a single normal adult subject.

Subject

The subject for this study was the first author. Peroral examination of the subject was unremarkable with no evidence of bifid uvula, muscular diastasis of the velum, or notching of the hard palate. There was no history of speech disorders or hypernasality. Adenotonsillectomy was performed at age 9 without complication or sequelae.

Method

An end-viewing flexible fiberoptic nasopharyngoscope (Machida ENT-25 II R) with a diameter of 3.5 mm at the distal tip and an up-and-down bending radius of 210° one centimeter from the tip was used. A high intensity xenon cold light source (Pentax LX-75F) provided sufficient illumination for videotaping. The examinations were recorded on a ½ inch videocassette machine (Sony 5400) through a special endoscopic television system (SynOptics). The video system enabled the examiner to view the velopharyngeal mechanism through a beam splitter while the subject observed the same image on the color television monitor placed behind the examiner (Figure 1).

All endoscopic examinations were done with the subject sitting upright in a comfortable chair. The details of anesthetizing the nose have been described elsewhere (Croft et al., 1981; Shprintzen et al., 1980). The endoscope was passed through the middle meatus of the subject’s left nostril until the velopharyngeal orifice was visualized. At that point, both the examiner and subject observed the anatomical structures at rest and during phonation until both agreed the maximal view had been obtained.

Velopharyngeal Valving Pattern

As has been described in previous reports (Croft et al., 1981; Skolnick et al., 1973), there is considerable variation in velopharyngeal valving patterns. The velum, lateral pharyngeal walls, and posterior pharyngeal wall contribute varying amounts of motion to the closure process from person to person (Croft et al., 1981). Though the closure patterns are not actually discrete, for convenience sake, Skolnick et al. (1973) categorized velopharyngeal valving into four patterns which was later reinforced by Croft et al. (1981). These patterns are exemplified in Figure 2:

Coronal pattern: The majority of valving is palatal with the full width of the velum contacting the posterior pharyngeal wall. The lateral walls move medially to the lateral edges of the velum. There is no motion in the posterior wall.

Sagittal pattern: The majority of valving is pharyngeal. The lateral walls move to midline and approximate each other. The soft palate does not contact the posterior pharyngeal wall, but instead abuts up against the approximated lateral pharyngeal walls, thus completing the closure pattern.
Circular pattern: There is essentially equal contribution from the velum and lateral pharyngeal walls with the bulk of the musculus uvulae acting as the focal point. The dorsum of the musculus uvulae contacts the posterior wall (which does not move). The lateral walls squeeze around the bulk of the musculus uvulae.

Passavant’s ridge pattern: As in the circular pattern, there is essentially equal contribution from the velum and lateral pharyngeal walls, but in addition, the posterior pharynx moves forward. The musculus uvulae also serves as the focal point for closure in this pattern.

During the first experimental session, it was found that the subject used a circular closure pattern (Figure 3).

Results

By prior agreement the experiment continued until the subject was able to change valving pattern at will during short samples of connected speech. This required six sessions, each approximately 20 minutes in length, as outlined below:

Session 1—During this first session, initial observations of the subject’s normal valving pattern were made and recorded. Because of the excellent lateral pharyngeal wall movement seen in the circular valving pattern, it was mutually agreed that the first attempts would be made to inhibit lateral wall motion, thus producing a coronal pattern. It was observed that during the phonation of nasal phonemes (/n/, /m/, /ŋ/), lateral wall movement was
decreased though velar elevation was not as markedly reduced. Therefore, by manipulating phonemic context, the subject attempted to denasalize the nasal CV /no/ to /go/ to /do/ and in the process, to increase velar motion while maintaining limited lateral wall motion. These attempts met with some limited success. The subject was able to diminish lateral wall movement, but was not able to maintain contact of the velum to the posterior pharyngeal wall.

Session 2—Attempts to change from a circular to a coronal pattern were continued. After approximately 5 minutes of attempts to manipulate the pattern, the subject performed a nonspeech maneuver, a tongue click, during which the lateral pharyngeal walls approximated in midline and the velum abutted up against them forming a sagittal closure pattern (Figure 4). The subject was able to repeat this maneuver without difficulty. The subject was then able to phonate while maintaining the sagittal pattern and attempts to change to a coronal pattern were abandoned. With repeated practice, the subject was able to produce CV combinations (/ga/, /ta/) in a sagittal pattern with slight difficulty and a mildly strained vocal quality.

Session 3—The subject was able to easily produce CV combinations in sagittal pattern with normal voice quality after only several minutes of trial. The CV combinations (/go/, /pa/, /ka/) were then expanded into CVC combinations (/kik/, /gat/) and words. Session 4—The subject was able to produce short phrases in sagittal pattern and normal voice quality with some difficulty at the beginning of the session, but by the end of the session, two short phrases ("got to go", "go away") were produced without effort.

Session 5—This was the last session where the subject observed her own valving pattern on the television system. She was able to produce a variety of short phrases (such as "stop the bus", "catch a fish", and "Suzie sees Sally") utilizing both the circular and sagittal closure patterns, switching from one to the other at will with no change in vocal quality though the rate of her speech was slightly slower in the sagittal pattern.

Session 6—This last session was recorded on motion picture film rather than videotape so that the subject could not see the valving process. Only the examiner was able to view the valving mechanism. Still longer phrases were obtained using a variety of phonemic contexts in sagittal pattern. At this point, the experiment was concluded.

Following the conclusion of the experiment, ten segments of the videotaped speech were shown without sound to two observers experienced with nasopharyngoscopy and familiar
with the concept of multiple valving patterns as described by Skolnick et al. (1973) and Croft et al. (1981), but not familiar with the purpose of the experiment. The ten segments consisted of five matching utterances in both circular and sagittal pattern ("stop the bus" in both patterns, etc.). The two judges were asked to categorize the closure pattern according to Skolnick et al. (1973) and Croft et al. (1981). They were not told that the pattern would be either circular or sagittal, but rather were asked to classify the pattern according to the four categories. In all ten instances the judges agreed with the categorizations of the authors.

Discussion

This experiment shows that in a brief period of time and under the appropriate conditions, a normal individual can alter the contributions of the various components of velopharyngeal valving. In this case, lateral wall motion was increased and velar motion inhibited to change from a circular pattern to a sagittal pattern.

The movements of the velopharyngeal mechanism have typically been regarded as basically uniform from individual to individual in the normal population. This gave rise to numerous publications discussing the "normal" mechanism of velopharyngeal closure (Dickson, 1972; Moll, 1965; Shprintzen et al., 1974). However, more recent studies suggest that variations in velopharyngeal closure from person to person are the rule rather than the exception (Croft et al., 1981; Daniller et al., 1982; Shprintzen et al., 1982). Data collected from 100 nasopharyngoscopic studies on normal subjects indicate both anatomical and physiological variation in the velopharyngeal sphincter across subjects (Daniller et al., 1982; Shprintzen et al., 1982). It was found that certain anatomical features seemed to influence velopharyngeal closure patterns, but that there was not a direct relationship between structure and function. These studies also hypothesized that learning was a variable that could influence a person's chosen valving pattern. However, in our opinion, the ability of an individual to "learn" velopharyngeal closure could not be conclusively inferred until it was determined that the velopharyngeal valving pattern could be changed at will (i.e. that the mechanism was capable of more than a single response). This would then imply that the valve is capable of performing the same task (closure) in several different ways which would further imply voluntary control over the mechanism.

Previous attempts at velopharyngeal biofeedback have been in pathologic populations (Miyazaki et al., 1975; Shprintzen et al., 1975) and other than Miyazaki's report, all other
investigations have relied on instrumentation which monitored the consequences of velopharyngeal valving (such as air flow) rather than the valve itself. Shelton et al. (1978) indicated that visual biofeedback of the velopharyngeal mechanism was a technique worth pursuing. However, though the subjects in Shelton’s study experienced improvement in velopharyngeal closure during visual panendoscopic biofeedback, the authors did not feel that this constituted an improved performance on an “automatic” level during spontaneous speech. In our opinion, however, it cannot be assumed that oral endoscopy provides a view of velopharyngeal valving free from physiologic distortion. In an unpublished study, Shprintzen et al. (1976) noted that gaps in the velopharyngeal sphincter tended to be exaggerated by oral panendoscopy when compared to nasopharyngoscopy or multiview videofluoroscopy. Even more important, the presence of the panendoscope within the oral cavity does not allow the subject to produce “automatic” spontaneous speech. Therefore, any conclusions concerning carry-over from panendoscopic observations to judgements of spontaneous speech cannot be considered valid.

On the other hand, nasopharyngoscopy provides an excellent method for biofeedback because it allows close observation of the velopharyngeal sphincter during free connected speech. In fact, it was the first author’s experience that the repeated pairing of the visual stimulus and the speech task allowed her to voluntarily “switch” into the alternative closure pattern as if the visual stimulus prompted a heightened awareness in the pharynx thus facilitating voluntary manipulation of the musculature.

The ability of a normal subject to learn to use a new velopharyngeal valving pattern has been demonstrated. Following similar experiments with more normal subjects, it may be suggested that the next step is to apply the same procedure to a population of subjects with velopharyngeal insufficiency. The possibility exists that nasopharyngoscopic biofeedback technique could improve inadequate velopharyngeal valving in a pathologic population including patients with cleft palate, failed pharyngeal flaps, or neurologic disorders. This contention is supported by the findings of Croft et al. (1981) who found a similar distribution of closure patterns amongst subjects with cleft palate as compared to normals, thus implying the role of learning in the cleft population, as well. Therefore, it may be possible to increase lateral pharyngeal wall motion prior to pharyngeal flap surgery in patients with gross velopharyngeal insufficiency, thereby improving the prognosis of surgery and perhaps removing the necessity of an overly obstructive flap. Though nasopharyngoscopy has the drawbacks of expense and the need for the presence of a physician, these objections would appear to be of relative minor consequence if surgery can be eliminated or if the prognosis of intended surgery can be improved.

References


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