The Role Of The Soft Palate In Cleft Palate Speech

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Introduction

A controversy exists at the present time concerning the etiology of defective cleft palate speech. Defective cleft palate speech is characterized by a harsh nasal quality which is often termed nasality. There is a tendency for defective cleft palate speakers to exhibit abnormal nasal emission of air when they attempt to build up and maintain air pressure for the production of speech sounds. There are two contradicting theories which attempt to explain the factors responsible for nasality and nasal emission in cleft palate speech.

Most observers seem to feel that nasal emission and nasality are the symptoms of an inadequate soft palate incapable of properly shutting off the nasopharynx from the oropharynx. The general tenets of this concept were first proposed by Passavant[1] in 1865.

Passavant felt that normal speech was impossible for an individual whose soft palate could not completely close off the nasal pharynx from the oral pharynx. He believed this closure was accomplished by the upward and backward movement of the soft palate against the bulging area on the posterior wall of the pharynx which is now called Passavant's pad, and by the medial movement of the lateral pharyngeal walls (Fig. 1 and 2).

Since Passavant's time, until very recently, most workers concerned with cleft palate rehabilitation have accepted the importance of an adequate nasopharyngeal closure to normal speech. Recently the validity of this entire concept has been challenged.

In 1951 McDonald and Baker[2] presented a new concept to explain defective cleft palate speech. They stated the ratio between the opening of the nasal and the oral port was the most important consideration determining the degree of nasality and nasal emission during speech in cleft palate individuals. They felt the competence of the velopharyngeal valve to be of secondary importance. They emphasized the importance of the size of the oral port which, they believed, was habitually reduced during speech in cleft palate individuals by the use of abnormally high lingual and mandibular positions.

Theoretically it should be very simple to test the validity of these two concepts. Measurements for nasality or nasal emission in a sample of cleft palate individuals could be plotted against measurements of soft palate function during nasopharyngeal closure. If Passavant was correct, the coordinates should approach a straight line indicating a high correlation between nasality or nasal emission and nasopharyngeal closure. If McDonald and Baker were correct, the coordinates should approach a random arrangement. Practically, this procedure is hampered by the difficulty of quantitatively measuring the variables involved.

Since nasality is an acoustic phenomenon, it must be measured by some device capable of quantitatively measuring the quality of speech sounds. In

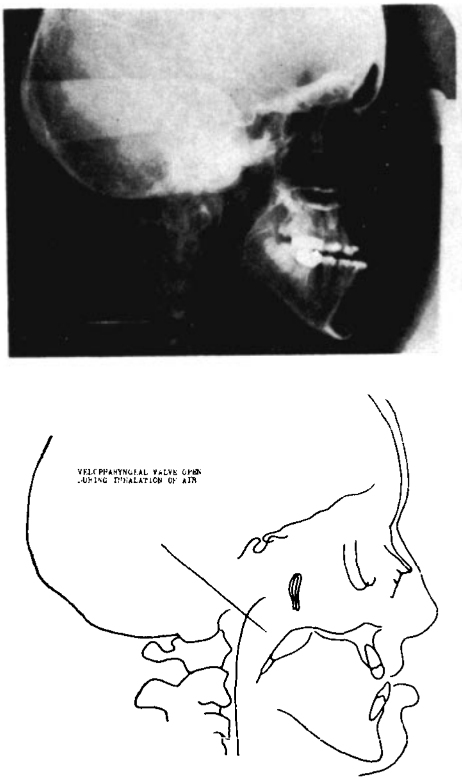

Fig. 1 Above: Lateral cephalometric radiograph of cleft palate individual taken during inhalation of air.

Below: Tracing of radiograph above. Note that the velopharyngeal valving mechanism is open.

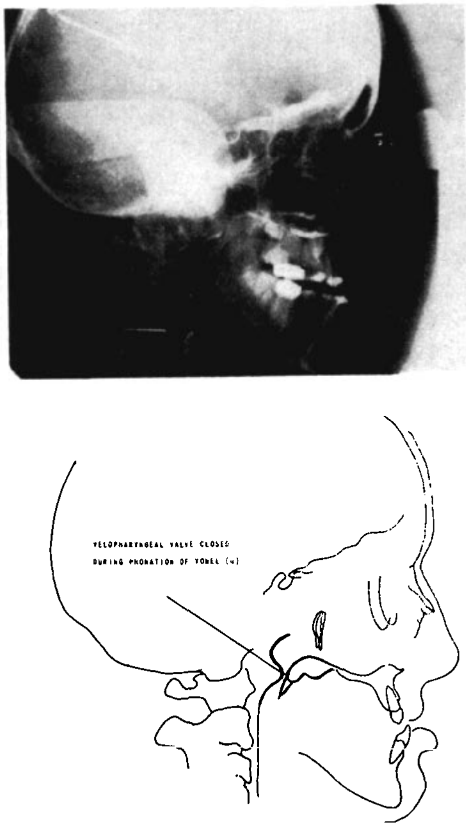

Fig. 2 Above: Lateral cephalometric radiograph of cleft palate individual taken during phonation of the vowel *u*.

Below: Tracing of radiograph shown above. Note that the velopharyngeal valving mechanism is in closed position.

1948 Kanter[3] stated that there were many devices which show nasality which were valuable as teaching aids. He warned that none of these was accurate enough to be of diagnostic value. At that time Kanter felt the human ear was still the most reliable instrument for measuring nasality. Quantitative measurement of nasality would probably be very difficult with equipment now available.

Nasal emission is a matter of air escaping from an orifice which theoretically can be measured in terms of air pressure. A number of devices have been used to measure nasal emission but none of them has been very satisfactory. One of the most encouraging attempts was made by Nusbaum, Foley and Wills.[4] They used a system of manometers to measure the pressure necessary to break down the velopharyngeal valve during the production of certain vowels. Their method was not suitable for measurement of nasal emission during the production of consonants. In 1955 Doubek[5] reported using new manometric methods to measure nasal emission. Since there are many simple air pressure measuring devices, it should not be too difficult to devise a satisfactory method of measuring nasal emission.

The positions of the soft palate can be adequately measured by cephalometric radiological techniques. A number of investigators have used cephalometric radiographs to study the position of the soft palate during the production of vowel sounds.

Although it might be very difficult to measure nasality, it seems that it should be possible to measure nasal emission and palatal movement during the production of speech sounds. A study designed to determine the correlation between nasal emission and palatal movement should shed much light on the etiology of defective cleft palate speech.

Purpose

The purpose of this study was to determine the relation between nasal emission and the movements of the soft palate during speech in a group of cleft palate individuals. Since an adequate instrument for measuring nasal emission was not available, it was necessary to adapt existing air pressure measuring devices for that purpose.

Method of Measuring Nasal Emission

Nasal emission was measured during the production of plosive and fricative consonants. Clinical experience indicates the greatest tendency toward nasal emission occurs when a cleft palate individual attempts to build up or maintain air pressure for the production of fricative or plosive consonants. The plosive sounds chosen for measurement were *pa, ta* and *ka*. The fricative sounds were *sa, sha* and *tcha*. The instrument developed to measure nasal emission in this study was called a nasometer, for lack of a better name, and was essentially a Marey tambour fitted with nasal olives and positioned to write on the smoked drum of a kymograph (Fig.3). Since the tambour readings were curvo-linear and were subject to changes in degree according to the condition of the rubber diaphragm, a U tube water manometer was used to calibrate the tambour before and after each test. The nasometer was operated in two phases. During the calibrating phase the end of the tambour connected with nasal olives was shut off and a column of air of given value was introduced into the tambour. This activated the tambour needle which produced a mark on the drum

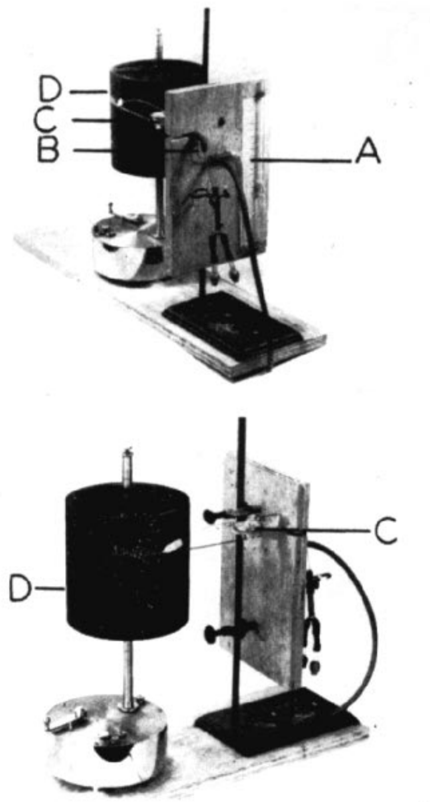

Fig. 3. The nasometer used to measure nasal emission of air.
A. The manometer in the calibrating system.
B. The hollow shunt from the calibrating system which delivers blasts of air of known force to calibrate the tambour.
C. Tambour.
D. Kymograph.

which represented a given air pressure. Four marks were made on the drum which represented one, two, three and four units of air pressure.

During the testing phase, the clamp between the nasal olives and the tambour was opened. The nasal olives were carefully fitted into the subject's nose and the subject was asked to repeat the consonant test sounds. Nasal emission of air accompanying the production of the speech sounds activated the tambour which produced test marks on the kymograph.

A microphone positioned three inches from the subject's mouth and connected to the volume control of the recording machine was used to control the sound level. Test sounds not produced on the standard level were discarded.

Nasal emission for each test sound was expressed in terms of the known calibrating units of air pressure in the following formula:

> Nasal emission in units equals the number of units represented by the largest calibrating mark equal to or immediately smaller than the test mark.

If the test mark in question was not exactly equal to a calibrating mark, then the fraction of the test mark was converted to units by the following formula:

> The length of the test mark minus the length of the calibration mark immediately smaller than the test mark divided by the length of the calibration mark immediately larger than the test mark minus the length of the calibration mark immediately smaller than the test mark.

The accuracy of the nasometer was tested by determining the ability of the instrument to produce the same readings in units of nasal emission for the same control test sounds produced by the same patient in two different tests. The machine was calibrated before each of the tests in the manner previously described. In each of the tests records were made by the previously described methods while the subject produced the sound *ta*. The nasometer was readjusted, the diaphragm of the tambour was changed and the machine was again calibrated in the interim between the two tests.

The mean for group one was 23.5 units and the mean for group two was 22.0 units. When the T ratio was calculated, it was found $T = 1.378$, which indicated there was no significant difference in the two samples at the 5% level.

Method of Measuring Functional Movements of the Soft Palate

Cephalometric radiology lends itself ideally to the study of functional movements of the soft palate and associated structures. Oriented cephalometric radiographs are taken with the aid of a head-positioning device which holds the patient in either a labial or anterior position at a fixed distance from the x-ray tube. Since the position of the x-ray tube and subject is fixed, it is possible to produce comparable radiographs at desired intervals of time. A number of workers have used lateral cephalometric radiographs successfully to study the movements of the soft palate. A radiopaque disclosing solution is often used to define the soft palate and associated soft tissue structures of the pharynx.

Ideally, a lateral cephalometric radiograph should have been taken during each of the consonant sounds for which a score for nasal emission was obtained. However, the movements of the palate are rapid enough during the production of consonants to make the production of good radiographs difficult. On the other hand, during the production of vowels the palate moves to its position of function and stays in that position over some period of time. Most investigators agree that the soft palate is relatively open during the production of such vowels as *a* but closed during the production of *i* and *u*. Williams[6] and Carpenter[7] used cephalometric radiographs of the palate at rest and during phonation of the vowel *u* to measure velar function. That was the technique decided upon for this study.

Iodo-chlorol, a radiopaque disclosing solution, was used to facilitate the visualization of the soft tissues of the velopharyngeal valving mechanism in the lateral headplates.

Superimposed tracings were made for each patient from lateral cephalometric headplates taken during the phonation of the vowel *u* and during the inhalation of air into the lungs. The tracing of the headplate taken during inhalation, which represented the resting position of the palate, was done first. That tracing was then superimposed on the headplate of the same subject taken during the phonation of the vowel *u*, which represented the palate in the closing state, and the soft palate was traced on as a broken line. The composite tracing represented the palate functioning in velopharyngeal closure and in the resting position (Fig. 4).

A reference line was drawn on the composite tracing through the area where the velum and the palate most nearly approximated during valving. The following reference points were established:

- W—The point at which the reference line bisected the posterior wall of the pharynx in the resting position.
- X—The point at which the reference line bisected the posterior wall of the pharynx during function.

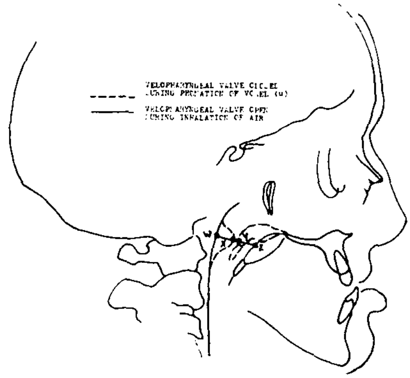

Fig. 4. Composite lateral cephalometric tracing showing velopharyngeal valving. YZ represents soft palate movement during velopharyngeal valving. WX represents postpharyngeal movement.

- Y—The point at which the reference line bisected the line of the functioning velum.
- Z—The point at which the reference line bisected the line of the resting velum.

The length of the lines WZ, WX and YZ were measured in mm. with the aid of fine line dividers and a mm. rule. The following ratios were computed for each case: YZ:WZ and WX:WZ. The ratio YZ:WZ was said to indicate the contribution of the posterior movement of the velum to closure of the velopharyngeal valve aperture. The ratio WX:WZ was said to indicate the contribution of the anterior wall of the pharynx to closure of the velopharyngeal valve aperture. The line WZ was said to represent the antero-posterior aperture of the velopharyngeal valve.

Data

The data were arranged to show the relation between nasal emission and velopharyngeal closure in the group studies.

Linear correlation coefficients were determined between the scores for nasal emission and the scores obtained by measuring the velopharyngeal closure by three different methods.

In Figure 5, above, the mean values for nasal emission recorded during the production of the speech sounds *pa, ta, ka, sa, sha* and *tcha* were compared to the degree of movement of the velum toward the posterior wall of the pharynx during phonation of the vowel *u*. The value for r was —0.753. The linear correlation of the two groups was significant at the 1% level. The strong negative relation indicated that the subjects whose velums accomplished the greatest percentage closure of the velopharyngeal aperture during the phonation of the vowel *u* showed the least degree of nasal emission during the production of the sounds *pa, ta, ka, sa, sha* and *tcha*.

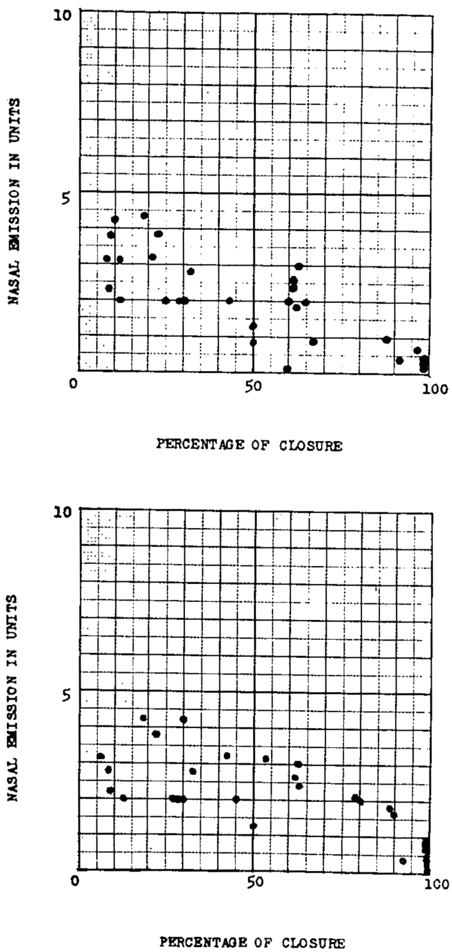

Fig. 5. Above: Scattergraph showing strong correlation between nasal emission and the amount of palatal movement during velopharyngeal closure.

Below: Scattergraph showing the strong correlation between nasal emission and the amount of palatal and post-pharyngeal movement during velopharyngeal closure.

Figure 5, below, shows the relation between the mean nasal emission recorded during the production of the sounds *pa, ta, ka, sa, sha* and *tcha* and the combined contribution to velopharyngeal valving of the movement of the velum toward the posterior wall of the pharynx, and the movement of the posterior wall of the pharynx toward the velum, during the phonation of the vowel *u*. The value of —0.775 for the linear correlation coefficient indicated a negative linear correlation significant at the 1% probability level. The strong negative relation indicated the subjects whose velopharyngeal apertures were closed to the greatest percent by the movement of the posterior wall of the pharynx and the velum during the phonation of the vowel *u* showed the least nasal emission during the production of the sounds *pa, ta, ka, sa, sha* and *tcha*.

Figure 6 shows the relation between the mean nasal emission recorded during the production of the sounds *pa, ta, ka, sa, sha* and *tcha* and the distance between the velum and the posterior pharyngeal wall measured at the narrowest part of the velopharyngeal aperture during the phonation of the vowel *u*. The value for the linear correlation coefficient is +0.743 which is significant at the 1% probability level. The strong positive correlation indicates the subjects with the smallest measurements of the velopharyngeal valve aperture showed the least degree

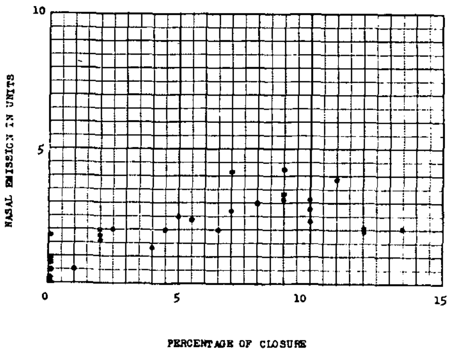

Fig. 6. Scattergraph showing strong correlation between the degree of nasal emission and the size of the aperture between the soft palate and post-pharyngeal wall during velopharyngeal closure.

of nasal emission during the production of the sounds *pa, ta, ka, sa, sha* and *tcha*.

Discussion

The data show an extremely high degree of correlation between nasal emission and velopharyngeal closure. Those individuals with the most efficient velopharyngeal valving mechanisms showed the least tendency toward nasal emission.

These findings support Passavant's contention that a mobile soft palate capable of shutting off the nasopharynx from the oropharynx is essential to normal speech for cleft palate individuals. The data do not support McDonald's and Baker's belief that the amount of nasal emission in cleft palate speech is related only secondarily to the degree of patency of the nasopharyngeal port.

The very high degree of correlation found in this study between nasal emission and velopharyngeal valving efficiency indicates the method of testing these variables was accurate. If inaccurate measurements approaching a random sample were obtained for either nasal emission or velopharyngeal function, then it would have been impossible to show such a high degree of linear correlation between these two variables. The cephalometric techniques for measuring palatal function and the nasometer appear to be accurate.

One of the diagnostic criteria of velopharyngeal valving efficiency used today is the position of the soft palate shown in lateral cephalometric radiographs during the phonation of the vowel *u*. The successful use of this technique to measure palatal function in this study should encourage clinicians working with cleft palate cases to use cephalometric radiology in diagnosis with increased confidence. The use of cephalometric radiology to follow cleft palate cases by surgeons, speech therapists and other members of cleft palate teams seems to be justified.

Clinical methods of measuring nasal emission have in the past been very unsatisfactory. The nasometer used in this study proved to be a sensitive and reliable research tool and should be valuable as a clinical method of measuring nasal emission. One obvious clinical application of the nasometer would be its use to follow the progress of cleft palate patients. Measurements could be taken before and after staphylorrhaphy to determine any immediate improvement in the patient's ability to control nasal emission. Measurements could then be taken with the nasometer at regular intervals during the progress of speech therapy to determine how successfully the patient was learning to control nasal emission.

Diagnosis and treatment of defective cleft palate speech is complicated at best. Perhaps in time we will have an adequate armamentarium of accurate instruments and a solid base of theoretical knowledge to help us meet the challenge by cleft palate patients who need our help.

Summary and Conclusions

This study was designed to determine the relation between nasal emission of air during speech and the efficiency of the velopharyngeal valving mechanism in cleft palate individuals. The group used in this study consisted of thirty male and female cleft palate patients, of an age range from ten to twenty years, from Northwestern University's Cleft Palate Institute. Nasal emission was measured during the phonation of the consonants *pa, ta, ka, sa, sha* and *tcha* by an instrument called a nasometer which was developed for this study. The movements of the soft palate and posterior wall of the pharynx were measured from tracings of lateral cephalometric radiographs taken during inhalation and during phonation of the vowel *u*. Evaluation of the results suggested the following interpretations and conclusions.

1. The linear correlation between the scores for nasal emission and the scores for velopharyngeal valving were significant at a level well below the 1% probability level. This evidence indicates that the soft palate plays an important role in the control of nasal emission by the cleft palate individual.
2. The nasometer developed for this study proved to be a reliable research instrument. Clinicians may find the nasometer a valuable clinical tool for evaluating and following cleft palate cases.
3. The use of lateral cephalometric radiographs as a diagnostic criteria to determine the efficiency of the velopharyngeal valving mechanisms seems to be justified.

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