Objective Measurement of Nasality in Cleft Palate Patients: A Preliminary Report

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The prime objective of cleft palate surgery is purely a functional one, aimed at achieving acceptable speech. Whereas the basic principle underlying the surgery—that of providing a competent velopharyngeal valve—has remained unchanged, several modifications to the classical Von Langenbeck procedure have been introduced in recent years (*5*, *7*). In addition, controversy exists about whether surgery should be attempted at all at an early age, or whether a program of graduated obturators should be initiated, with surgery at a later date. The ultimate results of such varied methods of treatment, and differing surgical procedures, remain at present largely undetermined.

Methods of evaluating the effects of treatment for cleft palate vary even more widely than the therapeutic programs in use. The simplest and most direct is a subjective assessment of the patient's speech defect. A good example is that used at the Cleft Lip and Palate Clinic at the Toronto Hospital for Sick Children (*6*). Patients' speech is rated as: (a) Class I, normal speech; (b) Class II, intelligible with minor imperfections; (c) Class III, intelligible with gross imperfections; and (d) Class IV, unintelligible.

This method, however, carries inherent limitations. The classification is quite gross, as fine degrees of speech variation are difficult to assess subjectively, and considerable variations are evident between individual observers. More important from an investigative standpoint is that comparison between speech evaluated at different centers is not possible on a subjective basis. No conclusions, then, can be drawn concerning the relative merit of different approaches to the cleft palate problem.

Objective methods of studying the competence of the repaired palate as a velopharyngeal valve are many. These, in general, do not involve the variable of human assessment. Oral manometry (*4*) will define the pres-

Presented at the 1963 Convention of the American Cleft Palate Association, Washington, D. C.

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This investigation was completed while the senior author was affiliated with the Surgical Service, Children's Hospital in Denver.

ence of "nasal escape," a phenomenon indirectly related to speech function, as specific features of articulation depend on an air column of adequate pressure. However, it is known that the ability to achieve closure for a limited time span is not always related to sustained intelligibility.

Cineradiography with frame analysis yields detailed information concerning the activity of the palate (*1, 2*). This information deals with "anatomy in motion" rather than "function," if the term function is restricted to speech production. While it is an exciting and useful technique, the results do not always correlate precisely with the degree of speech impairment noted clinically.

The most accurate method of objectively assessing speech competence is by means of the spectrographic tracing (*3*). The sound spectrograph, developed by the Bell Telephone Laboratories some 20 years ago, displays the power components of speech, translating the sound into a visible pattern. The pattern is extremely complex, requiring either considerable interpretation on the part of the investigator, or the use of a digital computer to reduce the redundancy of the information obtained. This technique is therefore not suited for use in the average clinic, nor for a broad survey involving large numbers of recordings.

Recognizing the need for a simple and reliable method of assessing speech impairment objectively, an attempt has been made to design an instrument to perform this function. As nasality is not only one of the principal stigmata of cleft palate speech, but also the hardest feature to define, the initial work has been directed toward the calibration of nasality.

This new Nasality Meter represents a departure from the frequency analysis method typified by the Vocoder, developed by Bell Telephone Laboratories in the same period as the sound spectrograph. No frequency filters whatever are used in the Nasality Meter but instead, analysis is made of the *time relationships*, or phase, of the frequencies in the speech. Whereas the frequency differences between normal and nasal voiced sounds are subtle, the phase differences in terms of positive and negative asymmetry are very distinct. A curious fact is that the phase shift phenomenon in a complex wave such as speech is indiscernible to a human ear, and perhaps this accounts for the elapse of a century between the discovery and use of the phase phenomenon.

In the voice recognition machines of Voice Systems, the degree of nasality is used to identify certain words to be recognized. In speech defect analysis, the process is reversed, and the degree of nasality is used to measure the quality of specified test words and pharses. Voice recognition machines basically "hear" phonetically what the person actually said (not what he thought he said) and so lack the flexibility of a human listener, who hears on the linguistic level. Humans continually get the right linguistic message from phonetically incorrect building blocks. It is this flexibility that makes it difficult if not impossible for a human to judge speech consistently on the phonetic level. Analytically, the human enjoys a linguistic advantage, and the machine the phonetic advantage. The objective analysis of speech obviously must be done on the phonetic level.

Calibration

The test results with normal and cleft palate speakers were calibrated against the nasal component difference in the pronunciation of the digit *nine* and the word *oh* spoken by a typically normal male person, on the assumption of more nasality in the *nine*. Although this calibration is crude, it is very effective. Further, we recorded engineering data so that the calibration was reproducible.

Test Procedure

The patient speaks a test phrase of about 10 seconds duration into the microphone. This is then fed into the circuit diagrammed in Figure 1.

The output meter records the aggregate polarity of envelope asymmetry, either positive or negative according to whether the swicth is activated to left or right. To normalize speaking volume effect, the ratio of the two values is used as the score. This ratio is then multiplied by a convenient constant scale factor for plotting purposes, and a Unit of Palatal Competence derived. The Nasality Meter is battery powered for convenience, and portable enough to be used in a clinical setting.

Results

Ten children have to date been studied by means of the Voice Systems Nasality Meter described. Five of the children were post-operative cleft palate patients, and five were convalescing in Denver Children's Hospital from surgical procedures unrelated to the palate. Each child was required to repeat the word *oh,* and to count from *one* through *nine* as a sustained sentence of approximately ten seconds duration. The voicing was recorded on Ampex tape by means of an Ampex PR-10 recorder and an Electrovoice 664 microphone at 7½ feet per second tape speed. It was felt that this

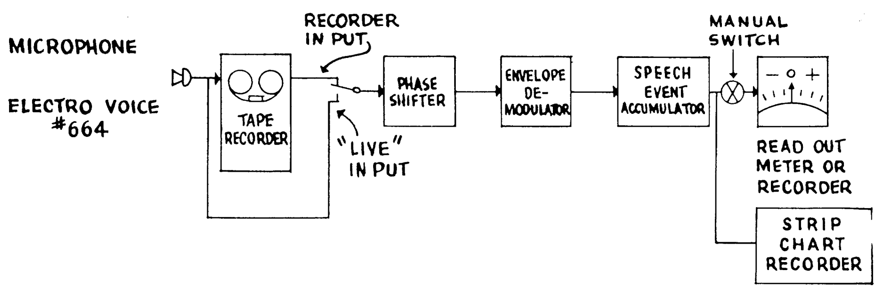

FIGURE 1. Block diagram of Voice Systems Nasal Meter.

technique provided an adequate spectrum of nasal and non-nasal vowels for valid comparison between individuals. Although care was taken to keep the microphone at a constant distance from the child's mouth, and to keep the gain at a predetermined level, considerable variation in volume was encountered due to the age differences and difficulty some of the children had in trying to cooperate. Each child's recording was then fed into the Nasality Meter and the aggregate peaks of positive and nega-

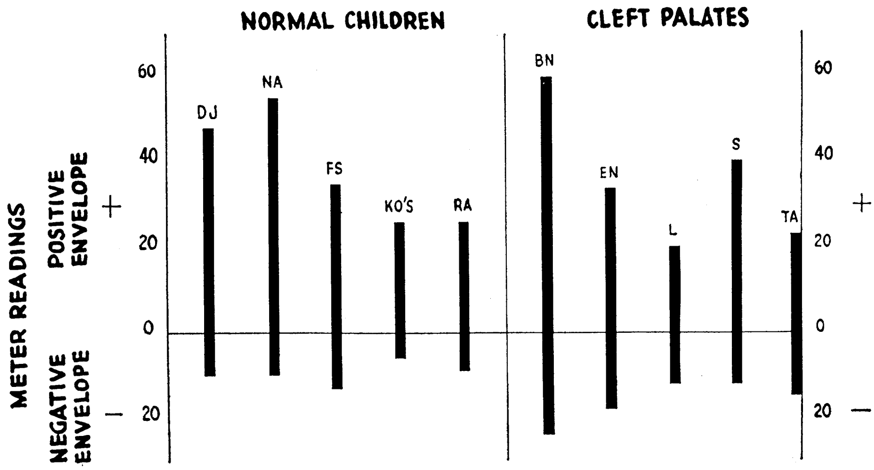

FIGURE 2. Aggregate peak of positive and negative meter readings.

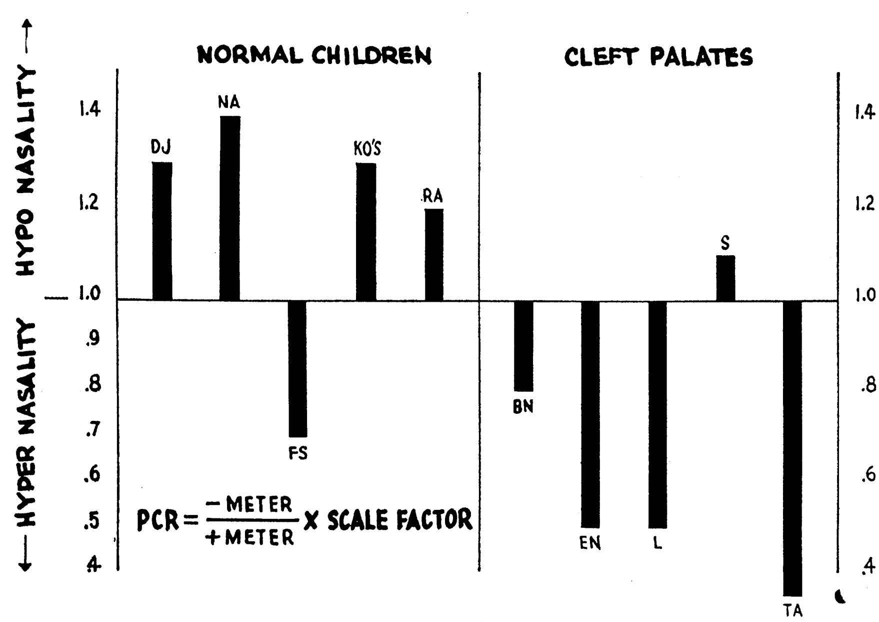

FIGURE 3. Ratios of positive to negative values after scale corrections, for 10 subjects.

tive asymmetry recorded (Figure 2). The ratio of positive to negative values for each individual, after scale correction, is shown in Figure 3.

A higher ratio score or higher unit of palatal competence in normal children represented a trend away from excessive nasality, and the lower ratio score in cleft palate patients a trend toward excessive nasality. Of interest were the two individuals whose values varied the greatest from the mean of their respective groups. Subject F. S., a normal child with a rating of .97 units, had a moderate cold at the time of his recording. Speech was consequently nasal in character. Subject Steve, of the cleft palate group, was wearing a prosthetic device and had virtually normal speech. These variations serve to reinforce the concept that the instrument will detect and record objective differences in nasality.

These early tests are exciting and encouraging. Work is proceeding with the big task of more refined calibration techniques, test sentences, and data interpretation, all based on a greater number of patients.

Summary

It has been stated that certain inadequacies exist concerning the ability to assess objectively the degree of speech impairment in cleft palate patients. Consequently, up to now, it has been hard if not impossible to evaluate critically the relative success of differing modes of treatment. It is hoped that the Voice Systems Nasality Meter described in the foregoing paragraphs is a first step toward the remedying of this deficit.

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Acknowledgments

The authors would like to thank Doctors D. W. Macomber, S. E. Blandford, Jr., and F. A. Garcia for graciously allowing their patients to be recorded.

References

1. Björk, L., Velopharyngeal function in connected speech. *Acta Radiol.*, Suppl. 202, 1961.
2. Nylen, B. O., Cleft palate and speech. *Acta Radiol.*, Suppl. 203, 1961.
3. Potter, R. K., Kopp, G. A., and Green, H. C., *Visible Speech.* Princeton, N. J.: Van Nostrand Co., Inc. 1947.
4. Spriestersbach, D. C., and Powers, G. R., Articulation skills, velopharyngeal closure, and oral breath pressure of children with cleft palates. *J. speech hearing Res.*, *2*, 318–325, 1959.
5. Stark, R. B., and DeHaan, C. R., The addition of a pharyngeal flap to primary palatoplasty. *Plastic reconstr. Surg.*, *26*, 378–387, 1960.
6. *The Cleft Lip and Cleft Palate Research and Treatment Center. A Five Year Report 1955–1959.* The Research Institute, The Hospital for Sick Children, Toronto, Canada.
7. Wardill. W. E., Cleft palate. *Brit. J. Surg.*, *21*, 347–369, 1933.