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Assessment of Velopharyngeal Function: Comparison of Various Methods

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Abstract

Precise estimation of velopharyngeal function is the essential first step in treating cleft palate speech either by surgery or by speech therapy. The methods in use at our daily clinic include judgement of speech, oral-inspection, rhinometric mirror, pneumotachography, velopharyngeal radiography, videonasoendofiberscopy, videofluororadiography and computerized tomography.

Evaluation of velopharyngeal function on the basis of auditory impression, especially of nasality, is clinically important but requires accumulated experiences. This paper emphasizes the usefulness of 3 methods in particular: videonasoendofiberscopy, videofluororadiography and computerized tomography.

Videonasoendofiberscopy provides direct visual information on the velopharyngeal closure during speech activity but quantitative analysis is impossible. There is also a problem in reproducibility and reliability due to possible different position of the fiberscope on each test.

Videofluororadiography permits dynamic and quantitative assessment of velopharyngeal closure when the video-images are repeatedly displayed for measurement. Two directional projections—lateral and antero-posterior—are recommended for full understanding of the velopharyngeal function. It is also advantageous in that the relation between velopharyngeal function and articulatory lingual movement can be well visualized.

A most modern computerized tomography can demonstrate the velopharyngeal aperature on a calibrated scale.

Introduction

From the view point of genesis, cleft palate speech generally consists of two factors, velopharyngeal incompetence and faulty habits of articulation. When a patient has speech disorder after primary operation of cleft palate, the first thing we

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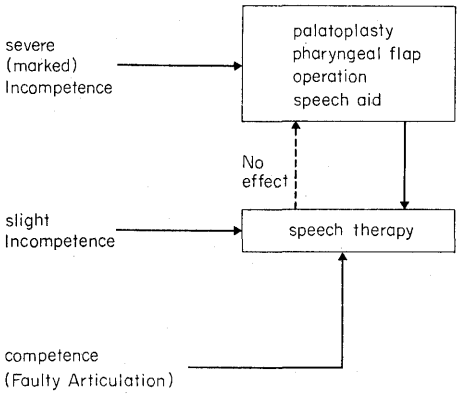

Fig. 1. Therapeutic policy at our clinic.

have to do is the differentiation between velopharyngeal incompetence and faulty habits of articulation.

Velopharyngeal incompetence is primarily to be corrected by secondary surgery (mainly pharyngeal flap operation)[3)5)9)] or speech prosthesis, while the faulty habits of articulation should be treated solely by speech therapy.

It is often difficult to decide either secondary palatopharyngoplasty or speech therapy to be employed for patients with marginal velopharyngeal closure. It appears that speech therapy has been utilized for correcting the slight velopharyngeal incompetence as the first treatment. (Fig. 1)

A marked incompetence is the indication for surgery but a mild case is usually placed on a tentative speech training program for 2–3 months[1)2)]. If it fails, the patient is then sent to plastic surgeon for pharyngeal flap operation, for instance.

EVALUATION OF VELOPHARYNGEAL FUNCTION

Differential diagnosis between velopharyngeal incompetence and faulty habits of articulation is the essential first step. In other words, correct assessment of the dynamic velopharyngeal function is a prerequisite to any treatment, either secondary surgery or speech therapy. The information we need regarding the velopharyngeal function is 1) what extent the velopharyngeal incompetence is, if any. 2) What factors are contributive to the incompetence?: velar mobility or length, velopharyn-

Table 1. Evaluation of Velopharyngeal Function

① Assessment of Velopharyngeal Closure competence, slight incompetence, incompetence
② Dynamic Aspect of Velopharyngeal Closure elevation of soft palate, inward movement of lateral pharyngeal wall, posterior pharyngeal wall (Passavant's ridge)

geal distance, or mobility of the lateral pharyngeal wall, just for a few examples. 3) Relation between velopharyngeal function and articulation. (Table 1) Whether velopharyngeal function is complete or not can roughly be judged first by listening to speech of the patients, nasal or nonnasal in other words. But, judgement of nasality is difficult when mixed with articulatory disorders. A simple rhinometric mirror, or a stainless plate which is placed below the nostril during plosive or fricative production, is simple and useful for detecting velopharyngeal incompetence. Lateral still X-ray picture of the velopharynx during respiration, vowel/a/, or/s/production, gives a sharp contour of the velopharynx but can not provide any information about dynamic aspect during running speech. Pneumotachography is simple to

Fig. 2. Pneumotachography

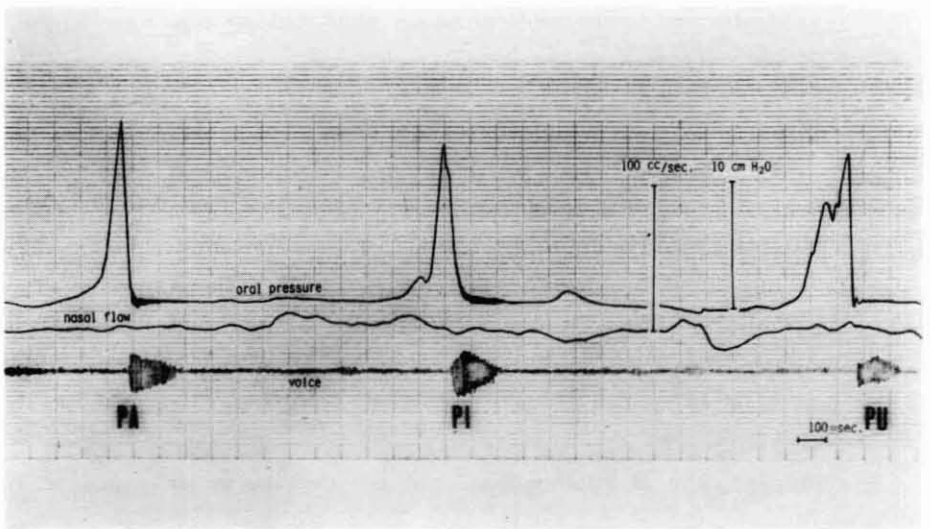

Fig. 3. Result for simultaneous measurements of nasal-air-flow rate and oral-breath-pressure, voice.

Table 2. Diagnostic means and Criteria for Velopharyngeal function

	Diagnostic means	Incompetence	Slight Incompetence	Competence
1	Auditory Analysis (hypernasality)	apparent	slight	none
2	Rhinometric mirror (Stainless plate)	above scale 3	1–3	below 1
3	Pneumotachograph (V-P resistance) dyne sec/cm^5	below 50	51–100	above 101
4	Video-nasoendoscopy (fiberscopy)	no closure	imperfect closure	closure
5	Videofluoroscopy	no closure	imperfect closure	closure
6	Computerized Tomography	no closure	imperfect closure	closure
7	Inspection			
	V-P distance	long	fairly long	normal
	Velar movement	poor	moderate	good
	Lateral wall movement	poor	moderate	good

1–6 cardinal criteria 7 reference findings

perform without pain, yielding objective quantitative data about velopharyngeal resistance, but is limited in the syllable sounds to be tested/p/or/b/. (Fig. 2, 3)

Recent progress in the instrumentations enabled us to assess the velopharyngeal function without much experience in speech. They are fiberscopy and various radiographic examinations. The diagnostic criteria for velopharyngeal incompetence can be summarized as follows: hypernasality on perceptive judgement of speech, velopharyngeal resistance below 50 dyne sec/cm^5 as measured by pneumotachograph, above scale 3 in the rhinometric mirror, and a significant gap in the velopharynx as observed by nasoendofiberscopy, fluororadiography, and computerized tomography. (Table 2)

Video-nasoendofiberscopy

The fiberscope we most frequently use is a flexible one, 4.4 mm or 3.7 mm in diameter, which is always connected to a videotape recorder in order to allow repeated observation by both speech therapists and surgeons. Generally, a flexible one is preferred to a rigid one, but the latter has an advantage of providing a sharper image and is often used for adult patients. (Fig. 4, 5) The fiberscopy is reliable in confirming the incompetence by direct vision but quantitative measurements are technically impossible so far and the images obtained vary on each trial with the position and direction of the fiberscope inserted. (Fig. 6)

Videofluororadiography

Fluororadiography in combination with a videotape is performed in two directions, antero-posterior and lateral. (Fig. 7) It has been extremely useful for analysisof the velopharyngeal dynamics and for obtaining information about velo-

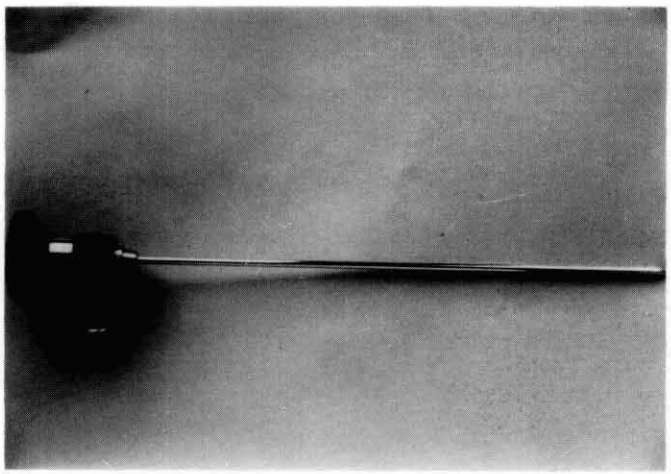

Fig. 4. rigid Nasoendoscope

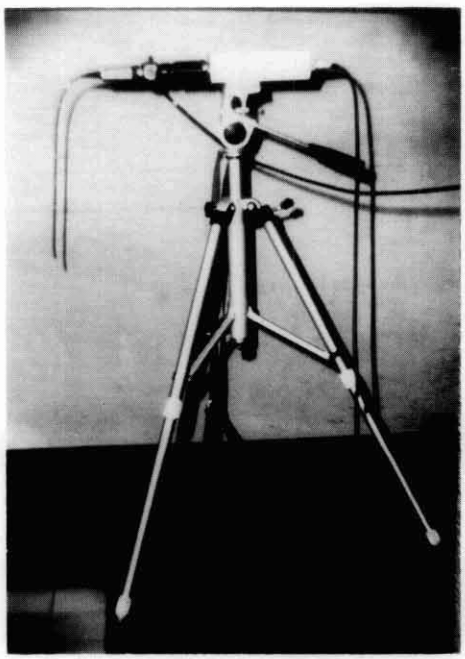

Fig. 5. flexible Nasendo-fiberscope

lingual interaction.

An antero-posterior image shows the lateral wall movement and the extent of mobility and asymmetry if any are examined. On a lateral image, besides the velar movement or velopharyngeal closure, of particular importance is the interrelation between the velopharyngeal function and the other articulatory organs such as the mouth or tongue. (Fig. 8 a, b, c)

Above all, we would like to emphasize that the lateral wall movement as demon-

strated by the antero-posterior fluororadiography is an essential information for deciding the indication, the size, and the prognosis of pharyngeal flap operation. In some cases, asymmetry in the extent of the lateral wall movement was revealed

Fig. 6. Videonasoendofiberscopy

Fig. 7. Videofluororadiography (lateral view)

Fig. 8a. Videofluororadiography lateral view, at rest.

Fig. 8b. /ʃ/ production. The velopharynx is closed.

Fig. 8c. Antero-posterior view. (⬆ lateral pharyngeal wall)

and flap was produced so as to match the particular condition.

Analysis of velopharyngeal movements can only be made with the use of fiberscopy or two-directional dynamic fluororadiography recorded on videotape.

Repeated observation of videotape facilities the exchange of opinion among different specialities.

Computerized tomography

The most recent model of computerized tomography permits sharp delineation of velopharyngeal aperture on a calibrated scale. (Fig. 9a, 9b) The area of velopharyngeal aperture during respiration and speech sound can also be calculated,

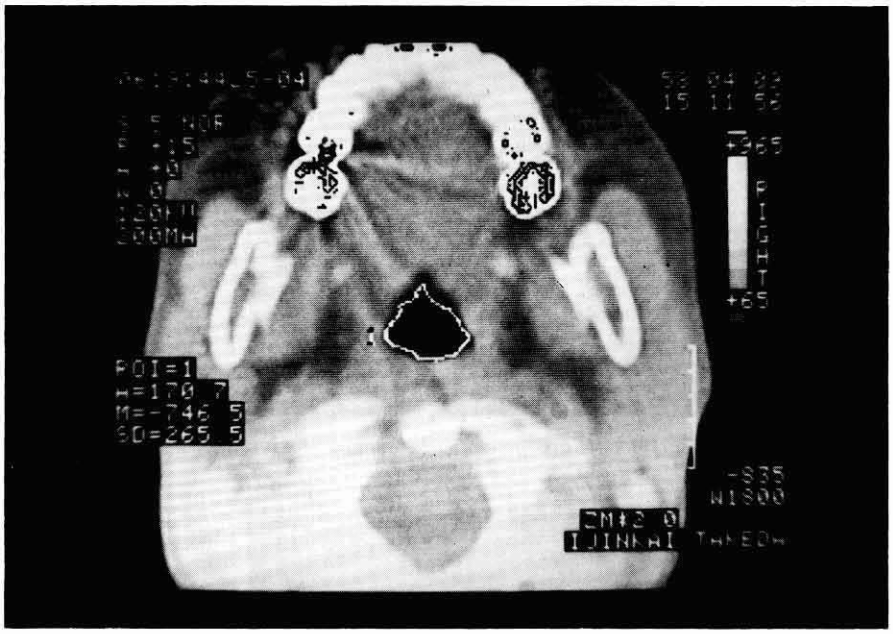

Fig. 9a. Computerized Tomography of velopharynx with calibrated scale, at rest.

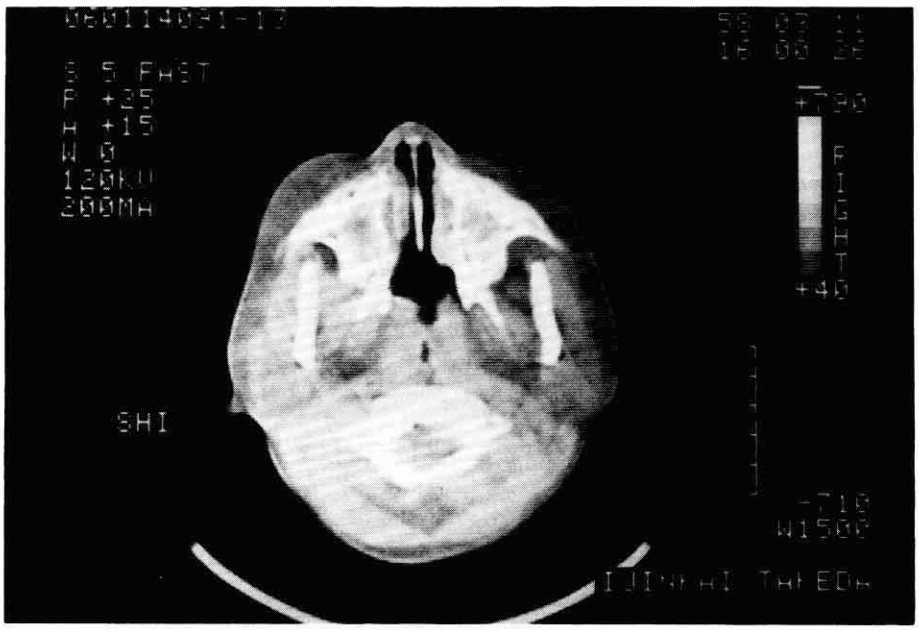

Fig. 9b. /ʃ/ production. The velopharynx is closed.

thus leading to objective expression of mobility. Computerized tomography describes a sharp image of velopharyngeal closure in a horizontal section on one rentogen film. The radiation dosis needed for this examination is about 1.5–2.0 rad[6].

Table 3. Advantages and Disadvantages of Various Diagnostic means of Velopharygeal function

Means	Advantages	Disadvantages
Auditory assessment	most important, comprehensive, any instrument unnecessary	subjective, needs experiences
Per oral Inspection	directly visible	limited to /a/ phonation
Pneumotachography	painless, instantaneous closure quantitative	for /p/, /b/ only
Videonasoendoscopy	direct observation during speech	difficult in children, painful, angle-dependent
Videofluororadiography	objective, reproduceable relation to articulation	two directions required, radiation dosis
Computerized tomography	painless, calibrated	static

Discussion

A number of instrumentations are now available for testing velopharyngeal function and each of them has its advantage as well as disadvantage. (Table 3) A sufficient intra-oral air-pressure required for plosive or fricative production during speech can be produced only with competent velopharyngeal function[4].

Pneumotachography measures the intra-oral pressure and nasal air flow objectively, and the velopharyngeal resistance can be calculated[4]. Despite the advantages of being painless and quantitative, this method, however, can not be applied to running speech, and is limited to/p/, /b/production.

Velopharyngeal closure in cleft palate patients consists of velar elevation, inward movement of the lateral pharyngeal wall, and, in some, anterior bulging of the posterior pharyngeal wall, that is Passavant's ridge[7)8)10)12)13)16)17].

Correct evaluation of dynamic velopharyngeal closure in velopharyngeal incompetence is essential to decide a therapeutic policy. Fluororadiography using two directional projections appears necessary for evaluation of the dynamic velopharyngeal closure[7)8)10)11)16)17]. This examination is applied to the patients over 4 years of age in our clinic. In normal subjects, the velopharynx comes into complete closure on producing plosive or fricative consonants. In cleft palate speech, however, this gesture tends to be very inconsistent. The extent of velopharyngeal incompetence greatly varries with the kinds of consonants, for example it may close for/p/, but may not for/s/. Such velar-lingual interaction can be clearly observed by a videotaped fluororadiography.

The radiation dosis during fluororadiography is less than 1 rad. But repeated examinations particularly in younger patients should be avoided. Recently, endoscopic examination of the velopharynx was first developed in 1969 by Pigott in

normal adult subjects[13)14)15)]. The nasoendofiberscopy enables direct visualization of velopharyngeal closure during speech. But, it can hardly be applied to the children under 4 years of age. The most important disadvantage is that the images obtained vary with the way it was inserted on each examination trial. So, the fiberscopic findings should carefully be evaluated with the condition of insertion always taken into account.

Although the computerized tomography per se can not reveal a dynamic velopharyngeal function, comparison of the area of velopharynx on respiration with that on phonation provides some useful information about this aspect. This method is advantageous for being painless and applicable to younger children[6)].

In short, there is no single method capable of assessing every aspect of velopharyngeal function, and multiple approaches to the problem are recommended.

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