Assessing VP Function: The Lateral Still Technique vs. Cinefluorography

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Thirty consecutive patients with clinical manifestations of velopharyngeal insufficiency were evaluated by the radiographic techniques of 70 mm lateral stills and lateral cinefluorography. The purpose of this study was to make retrospective comparisons between the actual decisions on velopharyngeal competency or incompetency which were originally made on the basis of cinefluorographic findings with those which we believe would have been made from that information obtained from lateral stills alone had the lateral stills been the only radiographic information available. The results of the comparison between the two techniques suggests that one is apt to misdiagnose the presence or absence of velopharyngeal insufficiency on the order of 30% of the time when relying on the lateral still X-ray technique alone. We attribute this potential error rate to the very limited speech sample that can be employed with the lateral still technique.

With the increasing number of secondary procedures available for treating VP dysfunction it is our opinion that cine- or videofluoroscopy allows the clinician to examine additional aspects of the patient's palatal function that are as important in the final management decision as simply the identification of closure or the lack of closure of the velopharyngeal sphincter.

Introduction

The use of radiography in the study of the speech mechanism and in particular for the assessment of velopharyngeal function began with the single lateral still X-ray technique. The "speech" sample employed with the lateral still X-ray is typically the prolongation of isolated sounds such as vowels or sibilants. Inherent in the lateral still X-ray technique is the fact that the diagnostician is presented with a static piece of momentary information about a dynamic ongoing physiological process—speech.

It would seem that the rationale for using the lateral still X-ray during sustained speech sounds must include, in part, that velar function during this type of activity is similar to or predictive of velar function during connected speech. However, this does not appear to be the case. In fact, there exists a large body of evidence indicating that, for many normal speaking individuals, complete velopharyngeal closure is *not* always effected during the production of certain sustained nonnasal speech sounds (Moll, 1962; Bjork and Nylen, 1963; Shelton et al., 1964; Benson, 1972). Moll (1962), using a lateral cinefluorographic procedure, reported the following percentages of velopharyngeal openings for his normal speaking subjects: /u/ 11%, /i/ 14%, /a/ 37%, and /æ/ 38%. Bjork and Nylen (1963), using the combined techniques of cinefluorography and sound spectrography, found that " . . . in many persons with normal speech, there was an appreciable opening of the velopharynx during the production of consonants such as k, v, s, t, b, and d." Benson (1972), in a roentgenographic study, also found that frequent openings occurred during the production of sustained vowels (/a/, /i/, /u/) for his normal subjects. This literature tends to confirm that complete closure of the velopharyngeal sphincter is not necessarily to be expected during the production of isolated sounds by normal speakers.

Shelton et al. (1964), using cinefluorogra-

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phy, noted that, in their clinical sample of 30 subjects, two individuals failed to make closure during sustained /s/ and /s/ syllables even though closure was demonstrated on other utterances. These authors reported that " . . . reliance on /s/ or /s/ plus a vowel might result in an underestimation of some individual's closure movements. Observations of closure on a single sound does not tell the clinician how the individual client uses his palate in other contexts." The experienced clinician knows that many individuals with velopharyngeal incompetency (VPI) have serious articulation problems. For example, an /s/ sound is often produced in a compensatory manner by pulling the back of the tongue against the posterior pharyngeal wall and constricting the airway to create a fricative-like sound known as a pharyngeal fricative. It has been our experience that many patients who have developed this compensatory pharyngeal fricative, not only for the /s/ but for other fricative and affricative consonants as well, will not necessarily show any simultaneous movement of the soft palate. Glaser et al. (1979), in a recent multiview videofluoroscopic study of the dynamics of Passavant's Ridge in a clinical sample, noted that one of their subjects demonstrated complete lack of palatal movement in a defectively articulated /s/. In a clinical population, it is to be expected that defective and/or compensatory articulation might exist. This fact, in addition to the almost universal findings that velopharyngeal closure does not always occur for normal speakers during sustained vowel production, makes it difficult to advance a rationale for using sustained speech sounds as a predictor of velopharyngeal competency for speech.

In an attempt to improve on the limitations of isolated speech sounds Bzoch (1968a) conducted a lateral cinefluorographic study to determine the functioning of the velopharyngeal port while his subjects repeated the consonant-vowel (CV) syllables /pi/, /pa/ and /pu/. Each syllable was repeated seven times at the subject's normal speaking rate. His results indicated that complete closure of the velopharyngeal sphincter *is* typical of normal speakers during the production of these repeated oral CV syllables. His findings are in agreement with the earlier findings of Graber et al. (1959), who, using lateral still X-rays, observed that complete closure of the velopharyngeal sphincter occurred while their normal speakers produced repeated oral syllables. One clinical implication of these findings is that, when only the lateral still X-ray technique is available for assessing velopharyngeal closure, syllable production might provide a better "speech sample" than sustained isolated sounds. However, this has not been demonstrated on a clinical population.

During the past decade, numerous studies dealing with a variety of topics about the velopharyngeal sphincter including the assessment of velopharyngeal function and the outcome of treatment strategies, have employed isolated sounds as viewed laterally (Musgrave, 1971; Benson, 1972; Van Demark, 1974; Witzel and Munro, 1977; Kuehn and Van Demark, 1978; Bowman and Shanks, 1978). For example, Bowman and Shanks (1978) have stated that " . . . the use of static lateral cephalmetric radiographs is a generally acceptable method adopted clinically to confirm or reject the perceptual suspicion of VP incompetence." They further note that such X-ray studies are often made during production of sustained /i/ and /s/. In response to this article, Glaser et al. (1979) state that using the static X-ray approach is " . . . totally unacceptable for clinical purposes." In defense of their original article, Bowman and Shanks (1979) responded to this charge by noting that there are no available data reported on the existence of differences between X-ray techniques used for assessing velopharyngeal function.

We feel that it is important to note that, certainly, by the time the patient is seen for a radiographic evaluation, a clinical impression has been made based upon the individual's speech and voice characteristics that velopharyngeal incompetency exists. We believe that a radiographic assessment of the velopharyngeal mechanism should include both lateral and frontal views using fluoroscopy while the individual produces a sample of connected speech. Skolnick et al. (1973), using a multiview radiographic approach including lateral, frontal, and basal views, found that velopharyngeal closure is sphincteric in nature. However, we don't routinely use the basal view and concur with Shelton and Trier (1976)

that there are difficulties in interpreting velar function from this view. On the other hand, it should be noted that McWilliams et al. (1968) found that hyperextension of the neck as is typically employed in filming the basal view may provide additional diagnostic information about velopharyngeal function. We believe that lateral and frontal fluoroscopic views taken while the individual produces a sample of connected speech permits an accurate analysis of velopharyngeal functioning and provides information necessary to answer the following questions: 1) Is the soft palate mobile? 2) If the palate is mobile, is the pattern of movement appropriate to the speech samples? 3) Is there a gap? 4) If a gap exists, what is its size? 5) Where, on the posterior pharyngeal wall, in relation to the palatal plane, is the best attempt at closure observed? 6) Is there lateral wall movement and if so, at what level is maximal mesial excursion observed? If one accepts the foregoing questions as indicative of the minimum body of information necessary for describing velopharyngeal function or dysfunction, it is apparent that observations of the velopharyngeal sphincter must be made while the individual is producing a sample of connected speech. At this time it appears that answers to these questions can be obtained only through the use of cine- or videofluoroscopy.

The purpose of this study was to make retrospective comparisons between velopharyngeal competency or incompetency as seen on lateral cinefluoroscopy during connected speech with velopharyngeal competency or incompetency as seen on lateral still X-rays during the production of the sustained vowel /i/ and the repeated CV syllable /pi/.

Procedure

Thirty consecutive clinical patients with the symptoms of hypernasal speech and inappropriate nasal emission were evaluated radiographically. The subjects consisted of 17 males and 13 females ranging in age from four to 18 years with a mean age of 10 years. Subjects were seated in a normal upright position, and immobilization of the head was achieved by an adjustable lucite head positioner equipped with ear rods and a nasion bar. A solution of 50% barium sulfate mixed to the consistency of thick cream was introduced into the subject's nasal passageways with a bulb syringe in order to coat the superior surface of the velum and the lateral pharyngeal walls. A Philips fluoroscopic unit with a six-inch image intensifier mounting a 70 mm spot camera and a modified 16 mm Eastman Cine II sound camera were used. Lateral 70 mm spots were obtained during the production of the sustained vowel /i/, as in the word *sea*, and during the middle of a series of repeated productions of the syllable /pi/, as in the word *pea*. Lateral cinefluorographic film was obtained while each subject produced a one-minute sample of connected speech. Although the speech sample consisted of several sentences, the sentence, "In the evening Connie watches T.V. with me," is routinely used for analysis on the lateral view at our Center because normative data on palatal functioning during the production of this sentence have been obtained on 100 normal speakers (Bzoch, 1968b). This sentence contains five nasal phonemes and ten oral phonemes requiring the rapid opening and closing of the velopharyngeal sphincter for normal production.

The 70 mm spots and the fluoroscopic filming were done by a radiologist. Monitoring of the subject's production of the speech protocol was conducted by a speech pathologist. During the taking of the 70 mm spot films, the speech pathologist signaled the radiologist to take the radiograph when the patient's production of the vowel or repetitive syllable was judged to be optimal. If there was any question that the timing of the radiograph with the individual's sound production was off, additional radiographs were taken. This procedure resulted in localized radiation exposure to the patient of no more than 0.46 Rads per 70 mm spot and 4.9 Rads for the one-minute fluoroscopic film.

At the time that these clinical subjects were evaluated, treatment decisions were made by the cleft palate team after reviewing the interpretations of the cine films done by one or both of the authors.

Because of the continued use of the lateral still with its limited "speech sample" as a predictor of palatal function for connected speech, we elected to compare the competency or incompetency of the velopharyngeal sphincter as seen on the lateral still X-rays

during the production of /i/ and /pi/ to the decisions about competency or incompetency made from the lateral cinefluorographic films of connected speech. Retrospectively, from the lateral stills, assessment of velopharyngeal "function" was made on the basis of whether or not a gap was observed during production of /i/ or /pi/. The presence of a gap constituted the basis for a retrospective classification of velopharyngeal incompetency. Conversely, if closure was observed on the lateral still, the patient was retrospectively classified as having velopharyngeal competency. These retrospective decisions based on the lateral stills were then compared to the actual decisions on velopharyngeal function made from our interpretations of the lateral cinefluorographic films.

Results

Decisions about competency or incompetency made from the lateral stills for /i/ and the repetitive syllable /pi/ are compared with the observations of competency or incompetency that were made from the cine analysis of connected speech in Tables 1 and 2.

Sustained vowel /i/. As can be seen in Table 1, six patients appeared to demonstrate competency, that is closure of the velopharyngeal sphincter, while producing the sustained vowel /i/ on the lateral still X-ray. However, lateral cine analysis revealed that only four of the six had velopharyngeal competency for the connected speech sample. Had treatment decisions been made only on the basis of the sustained vowel, treatment would not have been recommended for two of the six patients or 33% of this sub-sample when, in fact, treatment was necessary. Further, 24 of the patients appeared to have velopharyngeal incompetency, that is no closure, on the lateral still X-ray. Cine analysis, however, revealed that only 18 of these 24 failed to demonstrate velopharyngeal closure for connected speech. Thus, there was an error of six "false negatives" or 25% of the sub-sample. Had decisions been based on the lateral still only, treatment would have been recommended when it was not necessary in one-fourth of the cases. If clinical decisions on this group of 30 patients had been made on the basis of lateral still X-rays using the sustained vowel /i/ as the "speech sample," the total error rate would have been eight out of 30 or 27%.

TABLE 1. Error Rate of Predicting VP Function from Lateral Stills During Sustained Vowel /i/ (N = 30)

Technique	*VP Closure*	*No VP Closure*
Lateral Still /i/	6	24
Cine (connected speech)	4 Confirmed	18 Confirmed
Errors	2 False Positives	6 False Negatives
Sub-Sample Error Rate	33%	25%
Total Error Rate: 8/30 or 27%		

Repeated CV syllable /pi/. As seen in Table 2, 13 patients demonstrated competency, that is closure, of the velopharyngeal sphincter during repetitive CV syllable production on the lateral still X-ray. However, lateral cine analysis revealed that only seven of the 13 had velopharyngeal competency for connected speech. Had treatment decisions been made only on the basis of the repeated CV syllable, six of the 13 patients or 46% of the sub-sample would not have been recommended for treatment (six false positives) when, in fact, treatment was necessary. The remaining 17 patients appeared to have velopharyngeal incompetency, that is no closure, on the lateral still X-ray. Cine analysis, however, revealed that only 14 of the 17 failed to demonstrate velopharyngeal closure for connected speech. This difference of three false negatives or 18% of the sub-sample is the error that could have resulted from recommending treatment when none was necessary if decisions had been based on the lateral still only. In summary, had clinical decisions on this sample of 30 patients been made on the basis of lateral still X-rays using the repeated CV syllable /pi/ as the "speech sample," the total error rate would have been nine out of 30 or 30%.

Discussion

The results of this study suggest that decisions made relative to both velopharyngeal competency or incompetency, and subsequent decisions for treatment will differ appreciably depending upon the speech sample used and in turn, by the radiographic technique employed. With either the sustained vowel or the repetitive CV syllable as viewed on the 70

TABLE 2. Error Rate of Predicting VP Function from Lateral Stills During Repeated CV Syllable /pi/ Production (N = 30)

Technique	*VP Closure*	*No VP Closure*
Lateral Still /pi/	13	17
Cine (connected speech)	7 Confirmed	14 Confirmed
Error	6 False Positives	3 False Negatives
Sub-Sample Error Rate	46%	18%
Total Error Rate: 9/30 or 30%		

mm lateral X-rays, we found that errors could be made in two directions. First, the appearance of velopharyngeal incompetency when no incompetency was evident during connected speech on lateral cinefluorography could have led to a recommendation for treatment when no treatment was necessary. Secondly, the appearance of closure when, in fact, velopharyngeal incompetency was seen during connected speech on lateral cinefluorography could have resulted in the decision not to undertake treatment when treatment was necessary.

When a patient is referred for a radiographic evaluation of his or her velopharyngeal sphincter because of the clinical symptoms of hypernasality and nasal emission, it is the speech sample to be employed that is of critical importance. The subjects in this study were similar to normals in that velopharyngeal closure was not necessarily seen during the production of a sustained vowel. In contrast to the findings of Bzoch (1968a) in which complete closure was observed in normal speakers for repetitive oral CV syllables, this group of subjects demonstrated that closure or lack of closure during repetitive CV syllables as seen on lateral still X-rays was not a valid predictor of velopharyngeal integrity during connected speech. Some patients may be able to achieve velopharyngeal closure for such isolated tasks as sustained vowels and repetitive CV syllables but not during connected speech. The "false positives" may occur because the demands on velopharyngeal function can be met in the limited context of the speech sample required.

As noted earlier, many reports in the literature continue to use information obtained from the lateral still technique as an aid to the clinician in determining whether the velopharyngeal mechanism is competent for speech and in making treatment decisions. In a clinical population with suspected velopharyngeal incompetency, the information gained from radiographs is often used as an aid in deciding which patients will be referred for physical management, which is most often a secondary surgical procedure. However, regardless of which management decisions are made, it is clear that errors are likely to be made when the "speech sample" is limited to vowels and/or syllables of the type included in this study. If speech pathology and radiology are to combine their talents in the assessment of velopharyngeal function for speech, as Skolnick (1977) has strongly advocated, it is clear that the task and the technique must be combined to provide the most reliable and valid information possible.

Summary

This study compared the decisions of the competency of the velopharyngeal mechanism, as determined from a sample of connected speech obtained cinefluorographically, to decisions made from lateral still X-rays taken during the production of the sustained vowel /i/ and the repetitive oral CV syllable /pi/. We found that misdiagnosis of the competency or incompetency of the velopharyngeal sphincter as viewed during the production of the sustained vowel /i/ would have occurred on 27% of the cases and 30% of the cases during the production of the CV syllable /pi/.

Most referrals of patients with VPI for radiographic assessment are made in order to obtain additional information needed for planning treatment. Since viewing the velopharyngeal sphincter on lateral still x-rays taken during the production of vowels or CV syllables can lead to a significant number of errors, it is not a clinically valid technique.

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