Cineradiography in Research and Clinical Studies of the Velopharyngeal Mechanism

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Within the past decade, cineradiographic procedures have come into wide use in research investigations of the velopharyngeal mechanism and in the clinical diagnosis of velopharyngeal inadequacy (*2–6*). During this period, instrumentation and techniques have been constantly improved in order to obtain films with better structural definition and at higher film rates. The considerations involved in obtaining films of good quality have been covered by the previous speakers; however, there are other methodological issues besides those already discussed which also should be considered. Today, I wish to direct my remarks to some of these other considerations and to point up some of the basic philosophies and principles which would appear to be of prime importance in the efficient utilization of cineradiography for the study of velopharyngeal function.

Research versus Clinical Purposes

For the purposes of this discussion, it will be helpful to make a distinction between the use of cineradiography for research and its use in clinical diagnosis of velopharyngeal incompetence. Although it is recognized that research and clinical diagnosis have some aspects in common, the distinction is being made to emphasize the fact that these two activities are basically different. The most obvious difference is that research must involve observations of more than one subject to be meaningful, whereas clinical diagnosis is restricted to observation of one patient. The basic purpose of research is to answer variants of the question: In general, how does the velopharyngeal mechanism operate? There may be almost an infinite number of answers to this question depending on the conditions under which the observations are made. The end result is a description of the operation of the mechanism. On the other hand, the basic question posed in clinical evaluations is: Does this individual possess the potential to achieve adequate velopharyngeal closure for

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speech? We may need to describe the operation of the mechanism under different conditions in order to answer this question, but more than a description is necessary; a decision must be reached. The number of alternative decisions which are available depend, to some degree, on the particular clinical setting, but the number is usually quite small. In our clinic, there actually are only four possible answers: a) the patient has adequate velopharyngeal closure; b) he exhibits the potential for adequate closure with training; c) he does not exhibit the potential for adequate closure; and d) we can't decide whether he has the potential or not. Recommendations for further physical or speech management will depend on which of these decisions is reached.

Thus, research and clinical diagnosis have different basic purposes, research leading primarily to descriptions and the establishing of relationships, diagnosis to one of a small number of alternative decisions concerning velopharyngeal adequacy. As a result of this difference, the considerations involved in the use of cineradiography for research may be quite different than those involved when this technique is utilized for clinical diagnosis.

Research Considerations

Let us first consider the use of cineradiography for research investigations of the velopharyngeal mechanism. Undoubtedly the most important principle involved in any type of research is that it should be carefully designed and carried out in the most controlled, systematic manner possible. Although this principle appears to be obvious, it often has been ignored in cineradiographic studies. Because of the advantages of this technique, many investigators rushed to obtain films on various types of subjects producing various types of speech utterances and performing a wide range of non-speech activities. In many instances an attempt was made to take films of as much connected speech as was safely possible without much thought given to standardization and careful control of other aspects of the speech productions.

The frequent lack of careful planning and control appears to be related to a number of factors. In the first place, many of the cineradiographic studies carried out in the past have been too broad in scope. It appears that many investigators attempted to design studies which would completely describe all of the variations and interrelationships of velopharyngeal functioning. In most instances, long samples of connected speech were used, despite the fact that variables such as phonetic composition are much more difficult to control in such samples than in words or syllables. It is true that we are interested in velopharyngeal function during connected speech, but is this where we should start? Is it not more reasonable to start with the study of this mechanism under specific conditions than to try to describe everything about the mechanism in one enormous study? It is from a large number of small studies, designed to answer specific questions, followed by investigations of relationships

between specific variables that a body of knowledge about velopharyngeal functioning will be obtained.

Another factor which is pertinent to this discussion is that much of the research on velopharyngeal function has been based on information derived, almost incidentally, from films taken primarily for clinical evaluations. There is no objection to this if it can be assumed that the procedures are as carefully planned and controlled for clinical films as they should be for research studies. Undoubtedly, however, this often is not the case. Careful, pre-observation planning of the study, in which consideration is given to the variables which might affect the activities being studied, and in which the specific purposes of the observations are explicitly stated, would appear to be an important prerequisite of any research.

Besides the necessity for careful planning and control, there is another basic consideration, one which involves the methods utilized to extract information from cineradiographic films. In many studies, one or more individuals have observed the films in motion and have described their observations, usually in very general terms. Although such descriptions are interesting and often informative, they have several disadvantages. How can they be combined to describe velopharyngeal function in a group of subjects? They cannot be averaged. How can statistical procedures be applied to such observations in order to make comparisons? How free from observer bias are these observations? Obviously, such descriptive procedures have severe limitations when considered in relation to any of these questions. Moreover, it is almost impossible to observe some systematic variations in velopharyngeal function by simply viewing the films in motion. It would appear that, if cineradiography is to be a really useful tool in studying the velopharyngeal mechanism, it is necessary to somehow reliably quantify the information contained on the films. Although the reliability of measurements made from individual movie frames has been demonstrated by a number of investigators, (*3*, *4*, *6*) many studies still are carried out without the use of data quantification. It is true that such analysis methods are time-consuming and that often good criteria are not readily available for deciding on the particular measurements to be utilized. Moreover, some individuals contend that measurements from single frames show only structural positions and not movements; however, it should be pointed out that a series of still pictures of structural positions is all that is contained on a cineradiographic film. The study of positions as a function of time is a study of movement. Thus, it appears that some sort of quantification methods along with careful planning and control are very important in any cineradiographic study of velopharyngeal function.

Considerations in Clinical Diagnosis

Let us now consider some of the issues involved in the use of cineradiography for clinical evaluations of velopharyngeal competence.

Again, it should be emphasized that the purpose of clinical diagnosis is to choose between a small number of alternative decisions. It also should be recognized that cineradiography is only one of various diagnostic procedures which provide information concerning velopharyngeal adequacy; various articulation tests, air pressure or flow measures, and single-exposure x-ray films also can be used to arrive at a diagnosis (*5*). What is not often realized is that, in some instances, the use of all of these procedures, including cineradiography, may not be necessary. For example, in the case of a patient who has essentially normal speech and demonstrates the ability to impound intraoral breath pressure on manometer tasks, the use of cineradiographic observations may not be necessary in reaching a decision concerning velopharyngeal adequacy. There may be a need to determine whether closure is being obtained against an adenoidal pad or not; however, this can be done with single-exposure x-ray procedures. In evaluating closure of the nasal port in a patient with a posterior pharyngeal flap, x-ray procedures usually contribute nothing. The posterior pharyngeal wall and the velum are now connected; spaces on the sides of the flap cannot be evaluated from lateral x-ray films. It may be interesting to see if there is movement of the velar-flap structure, but this may contribute little to reaching a diagnostic decision. In this instance, other types of observations are necessary. It is recognized that cineradiography is often helpful in corroborating other findings and is often necessary in clinical evaluations; however, it is not always an essential technique.

When cineradiography is used to evaluate velopharyngeal closure, another question which should be considered is: What activities should be sampled? If it is accepted that we are interested basically in evaluating this function for the production of connected speech, then it can be concluded that samples of connected speech should be utilized. Preferably, such samples should include a number of plosive and fricative sounds which presumably require more precise velopharyngeal closure than do other speech sounds. Although isolated, sustained consonant or vowel sounds also may be utilized, it should be recognized that the adequacy of closure on such sounds may be quite different from that exhibited in connected speech. In general, it appears that closure is more likely to be obtained on such sustained sounds than in connected speech. Observation of sustained sounds may provide some information on the potential of this patient to achieve closure under optimal conditions; however, there is as yet no evidence to indicate that this potential, when exhibited only on sustained sounds, is a valid predictor of the potential for achieving closure during speech.

Non-speech activities such as swallowing, blowing, sucking, and gagging also have been utilized frequently for cineradiographic evaluations of velopharyngeal function. For such observations to be useful, they must aid in predicting the potential for velopharyngeal closure during

speech. In many instances, they are not valid predictors. For example, the closure mechanism for swallowing may be much different than that utilized in speech. Figure 1 shows tracings of structural positions during speech and during swallowing for an individual with a repaired cleft palate. These tracings were made from a cinefluorographic film taken at 24 frames per second. Although this patient exhibits a large velopharyngeal opening during speech (solid lines), a contact between the velum and posterior pharyngeal wall is obtained for swallowing (broken lines). A number of investigators (*1*, *2*) have reported similar observations; that is, closure is usually obtained during swallowing even in individuals who cannot achieve closure for speech. Inspection of Figure 1 suggests that this difference may be related to increased anterior movement of the pharyngeal wall in swallowing and to the use of the tongue, which appears to push the velum backward and upward to contact the wall. It also appears that the effective palatal length utilized to close the nasopharyngeal port is greater for swallowing. In this patient the tip of the velum makes contact with the wall on swallowing. For speech, it has been consistently observed (*2*, *6*) that the middle third of the velum, not the tip, makes contact with the posterior pharyngeal wall.

Another activity which has often been utilized to evaluate velopharyngeal function is sucking. Figure 2 shows tracings from cinefluorographic films taken while a noncleft subject with normal speech performed sucking tasks under two conditions. It can be noted that when the subject produces negative pressure on an oral manometer without an air leak

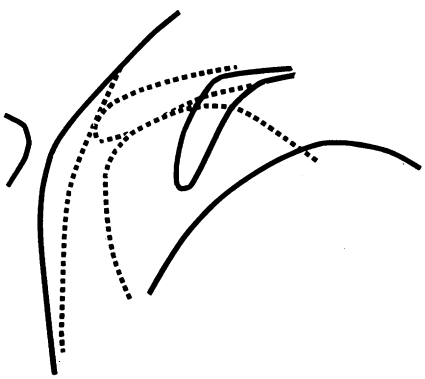

FIGURE 1

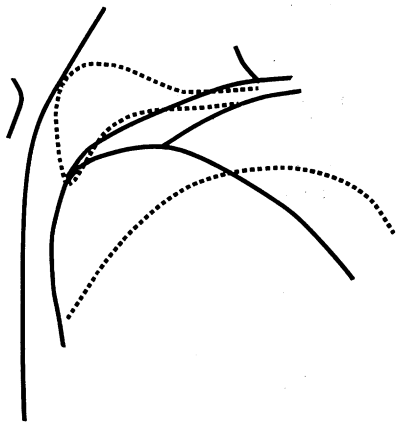

FIGURE 2

FIGURE 1. Tracings of cinefluorographic frames showing velar and pharyngeal positions in an individual with a repaired cleft palate during speech production (solid lines) and during swallowing (broken lines).

FIGURE 2. Tracings of cinefluorographic frames showing velar and pharyngeal positions in a normal, adult individual during two activities: sucking on an oral manometer without an air leak in the system (solid lines) and with air leak introduced (broken lines).

in the system (solid lines), tongue-palate contact is utilized rather than velopharyngeal closure. When a leak is introduced in the system, however, velopharyngeal closure is utilized (broken lines). The sucking activity without an air leak is analagous to drinking liquid through a straw. For this task, closure obviously is not necessary. As a result, such a task does not provide a valid observation of the adequacy of velopharyngeal closure. Parenthetically, it might be pointed out that sucking exercises have been utilized in speech therapy for many years to improve velopharyngeal functioning. At present, a number of studies are in progress in our laboratory which are designed to provide more definitive comparisons of velopharyngeal closure in speech and nonspeech activities for both cleft and noncleft subjects.

The final point that I wish to discuss concerns methods for evaluating cineradiographic films in clinical diagnosis. It has been emphasized previously that data quantification is necessary in research. However, it should be recognized that quantification may not be necessary in arriving at a diagnostic decision concerning velopharyngeal function. In the future we may have normative data to which to compare measurements, but at this point we do not. Even when such data become available it is quite likely that measurements may be superfluous. In most instances a decision concerning velopharyngeal closure can be made by viewing the film in motion; however, such evaluations are often complicated by two factors. In the first place, there are large gaps in existing knowledge concerning the degree of closure which is necessary for normal speech. Secondly, a decision as to the potential for closure, not just the status of closure, is necessary. Decisions concerning patients who consistently obtain closure and those who obviously can never obtain it are fairly simple to make. However, there is a borderline area. Some patients may exhibit inconsistent closure; some may exhibit only very small openings of the port. In these instances, decisions are difficult. As more experience in the clinical use of cineradiography is achieved, and as our knowledge concerning the basic functioning of the velopharyngeal mechanism increases, we should have much better bases for making diagnostic decisions than we have at present.

Summary

An attempt has been made to discuss some of the primary issues that appear to be involved in the application of cineradiography to research and clinical studies of the velopharyngeal mechanism. In research we must strive for controlled experimentation with results that can be quantified. To do this, we must design experiments carefully toward a particular purpose. In clinical evaluations of velopharyngeal closure, it appears that observations during connected speech result in the most valid decisions and that extensive samples and quantification methods may not be necessary to reach one of a small number of alter-

native decisions. It would appear that these considerations, and others not discussed, must be recognized if we are to make full and effective use of cineradiography in research and clinical evaluations of velopharyngeal function.

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