Comparison of Methods for Measuring Velar Position from Lateral-View Cineradiography

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The purpose of this experiment was to compare methods of measuring *velar position* during *speech* movements from *lateral-view cineradiographic films.* Specifically, correlations were calculated between measurements from a radiopaque marker sutured to the oral surface of the velum and three velar measurements that do not involve a radiopaque marker. As the correlations with the marker measurements were relatively high, it is concluded that experimenters may be free to choose any of the measurement procedures. The attachment of radiopaque markers to the velum does not appear necessary for obtaining a reliable and valid estimate of velar movements during speech.

It is well-known that abberations in the timing of velar movements may contribute to velopharyngeal incompetency during speech (Kuehn, 1976, and others). Because of the need for greater understanding of velar timing in both normal and disordered populations, methods of measuring the movement of the velum are important considerations. In earlier work, Moll (1960) described two cineradiographic measurements that may be taken to represent the changes in velar position. One measurement, "velum-pharynx distance," was the distance from the posterior border of the velum to the posterior pharyngeal wall. The other measurement, "velopharyngeal contact," was the length of vertical contact between the velum and the posterior pharynx during closure. In other studies, a third measurement has been employed that is termed "velar height" (Hagerty et al., 1958; Graber et al., 1959; Moll, 1962; Kent and Moll, 1969). Velar height was defined as the vertical distance between the most superior point on the nasal surface of the velum and a horizontal reference line. Finally, a fourth method called "velar movement" (VM) has been calculated by measuring the point at which the nasal surface of the velum crosses a reference line (Moll and Shriner, 1967; Moll and Daniloff, 1971). The latter measurement is explained in more detail below. Although the choice of velar measurements must depend on the purposes of the experiment, Moll and Daniloff (1971) felt that VM would give the best representation of the movement patterns of the velum during speech.

In 1967, Houde attached small radiopaque markers to the lips and tongue prior to cineradiographic filming. As noted by Kent (1972), this simplifies film analysis as it is necessary to measure only the change in position of the radiopaque markers from frame to frame. This analysis technique is often referred to as "point parametization." The technique not only simplifies measurement but also insures that the same flesh points are measured from frame to frame. Although the radiopaque markers are relatively easy to attach to the lips and tongue with dental adhesive, it is difficult to get the velar mucosa dry enough for the dental adhesive to hold a marker to the velum. For this reason many cineradiographic studies have not used a velar marker (Kent and Moll, 1972; Kuehn and Moll, 1976). However, Kent et al. (1974) and Kuehn (1976) managed to attach a radiopaque marker to the identation ("dimple") on the oral surface of the velum by suturing the marker to the mucosa. Because suturing a marker to the velum is unpleasant for the subjects, it is desirable to utilize a less invasive technique if possible. This may be of concern

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especially when dealing with disordered subjects who may be more apprehensive than normals in an experimental situation.

If one does not wish to suture a marker on the velum, there are a number of measurement procedures that might be adopted. One alternative might be to simulate the point parametization technique as closely as possible. In this case, the experimenter might attempt to determine the position of the dimple on the oral surface of the velum for every frame. This is the point where a marker would be positioned if one were present. A point parametization technique using the velar dimple (VD) could be successful only to the extent that the dimple could be located accurately in all velar positions. Another alternative to suturing the marker would be to revert to the VM measurement advocated prior to development of point parametization. However, VM is based on movement of the nasal surface of the velum, and radiopaque markers have been placed on the oral surface. The extent to which the two procedures would provide similar information is not clear. A third alternative, a compromise between VM and VD used by Seaver (1978), measures the intersection between the oral surface of the velum and a reference line. The reference line could be placed so that the intersection would occur in the area of the velar dimple or knee. We will refer to this measurement as the velar knee (VK) and distinguish it from the velar dimple (VD) measurement that does not involve a reference line.

The purpose of the present experiment was to measure VM, VD, and VK during speech and to compare these data to the velar positions obtained by measuring the position of a radiopaque marker.

Procedure

SUBJECT. The subject was a young adult female. She was a normal speaker of American English with no history of orofacial anomalies.

FILMING PROCEDURE. The cineradiographic equipment and procedures used in this study are described in detail by Kent and Moll (1969). The filming speed was 100 frames per second.

In the first half of the film, the subject produced [næsæn] and [nisin] in the carrier phrase "say__again." Each sample was produced four times with a brief pause between each replication. The subject was then removed from the filming apparatus, and a radiopaque marker was attached to the oral surface of the velum. A small amount of local anesthetic agent was injected at the point of attachment, and then a hemispherical lead marker 3.5 mm at the base was sutured in place. The marker was positioned along the midline as close as possible to the dimple appearing in the raised velum. After 15 minutes, the subject was repositioned in the x-ray apparatus and the eight phrases were produced as the second half of the film was exposed. The total radiation dosage was 2.1 R.

FILM ANALYSIS. Four different measurements were made. For the "marker" measurement, the x-y coordinates of the velar marker were measured as described by Kent (1972). The y coordinate corresponds to the inferior-superior dimension, and the x coordinate corresponds to the anterior-posterior dimension.

The other three measurements were taken from the first half of the film in which no velar marker was used. The measurements were velar dimple (VD), velar movement (VM), and velar knee (VK). The VD dimension was obtained by measuring the point on the oral surface of the velum where an experimenter estimated a marker might appear if one had been attached at the angle formed in the elevated velum. As illustrated in Figure 1, the VM measurement was obtained by first constructing a reference line from the most superior point on the elevated velum through the shortest distance to the nasal surface of the velum at rest (Moll and Daniloff, 1970). The values for VM were taken at the point where the nasal surface of the velum intersected with the reference line. The VK measurement also involved a reference line. The VK line was drawn through the dimple in the maximally elevated velum and the nearest point on the oral surface of the velum at rest. The VK reference line is also shown in Figure 1. The VK measurements were taken at the intersection between the oral surface of the velum and the VK reference line. As illustrated in Figure 1, the hard palate was taken as representing the horizontal plane. The hard palate and dental fillings were used to insure the same alignment of all frames.

In each phrase, measurements made on the frames included maximum velar elevation, maximum velar lowering, and four intermediate frames. Tracings of the entire velum were used to designate the frames with maximum velar positions. The intermediate frames were taken at points occurring one-third and two-thirds through the movements between the open and closed positions. All measurements were made to the nearest millimeter. The entire measurement procedure was repeated on a second day to assess reliability.

Results

As shown in Table 1, the anterior-posterior (x) and inferior-superior (y) coordinates obtained for the VD, VM, and VK measurements were each correlated with the coordinates obtained for the marker. All of the correlations are relatively high, and no one combination has appreciably higher correlations than the others.

As explained above, all measurements were made twice to compare the reliability of the four measurement procedures. The correlations between the first and second measurements ranged from 0.83 to 0.98 with a mean of 0.92 for the eight correlations. The standard errors between the first and second measurements ranged between 0.44 mm and 0.83 mm with a mean of 0.69 mm. No one procedure stood out as substantially more reliable than the others.

The reliability of the VD measurements is of special interest as this measurement has not been used previously. However, it showed high correlations between the first and second measurements—0.92 and 0.89 for the x and y dimensions respectively. Since the velar dimple is defined better when the velum is elevated, it might be hypothesized that VD is more accurate at the elevated positions. We analyzed the data with the velum maximally elevated separately from the data obtained when the velum was maximally lowered. The standard errors of measurement for VD were 0.61 mm and 0.71 mm for the x and y coordinates in the maximally elevated position and 0.64 mm and 0.77 mm in the maximally lowered position. Therefore, the VD measurement was not appreciably less accurate in the lowered position. None of the other measurements showed large differences in the standard error of measurement in the maximally elevated versus the maximally lowered position.

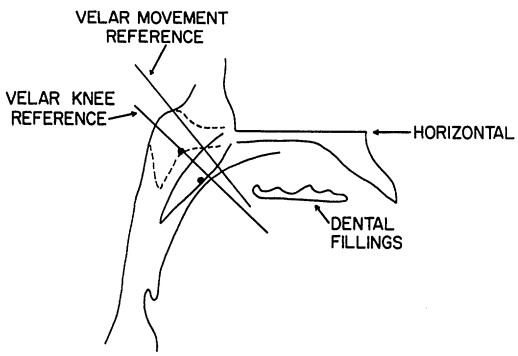

FIGURE 1. Tracing of two superimposed cineradiographic frames showing the position of the velum at rest and at maximum elevation (dotted lines). The radiopaque marker is illustrated in both positions in addition to the velar movement (VM) and velar knee (VK) reference lines. However, the marker was not present when measurements employing the reference lines were made.

Discussion

The results indicate that all three measures (VM, VD, and VK) correlate highly with the measurements taken from the radiopaque marker. It should be pointed out that it was necessary to make these measurements and those using the marker on different productions of the speech sample. As the subject could not be expected to repeat the phrases with precisely the same movements, the correlations found in the present study are underestimates of the true correspondence between measurement schemes.

TABLE 1. Pearson product-moment correlations between the velar marker and velar dimple (VD), velar movement (VM), and velar knee (VK). The *x* coordinates represent posterior movement, and the *y* coordinates represent superior movement.

		Velar Dimple		*Velar Movement*		*Velar Knee*	
		x	*y*	*x*	*y*	*x*	*y*
Velar Marker	*x*	0.81		0.75		0.74	
	y		0.84		0.85		0.84

In general, the choice of velar measurement procedures must be dictated by the goals of any particular experiment. Understanding velar movement as opposed to the size of the velopharyngeal gap is an example. However, when the choice of schemes involves these four procedures, all of which can be used to determine the position of the velum, it does not appear to make much difference which measurement is used. As the results can be expected to correlate highly, the choice of measurement technique might be dictated by convenience rather than by questions of data interpretation. It appears that the data derived from the nonmarker conditions are sufficiently similar to the data obtained when a radiopaque marker is used to suggest that suturing a radiopaque marker to the velum is not worth the inconvenience or the discomfort experienced by the subject. The VD measurement is the easiest to do because it does not require a preanalysis of the data to construct a reference line. However, as mentioned above, the dimple may be more difficult to measure when the velum is lowered so that, although it can be estimated accurately, determination of the VD coordinates might take more time than the other procedures. The dimple may also be more difficult to locate in some subjects, especially in children and in subjects with extensively scarred clefts. The implications of the present study are limited by the use of only one subject.

Several research and clinical centers have accumulated large numbers of cineradiographic films from normal as well as disordered populations. As there is now great concern about subject risk associated with radiation exposure, future cineradiographic experimentation may become more limited. However, the existing cineradiographic films may possibly be analyzed retrospectively for a number of purposes. Although the majority of existing cineradiographic films do not have a radiopaque marker attached to the velum, the results of this study suggest that this is not a necessary prerequisite for accurate measurement of velar position. It is hoped that, when the opportunity arises, experimenters will be able to apply either VM, VD, or VK measurements to existing cineradiographic films rather than exposing additional subjects to radiation for the sake of obtaining films with a radiopaque marker.

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