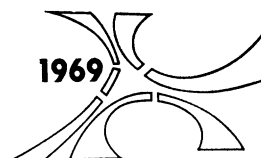


A Cinefluorographic Study of the Pharyngeal Flap Mechanism



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The posterior pharyngeal flap operation was first described in 1875. A similar technique was used by Rosenthal (20) and was introduced to the United States by Padgett (17), who resorted to the flap after other methods proved unsatisfactory in improving velopharyngeal closure.

In recent years, as the pharyngeal flap operation has come into wide use with individuals who have velopharyngeal incompetence, a number of research investigations of the flap technique has been reported. These studies may be divided into two groups: those in which the general success of the flap procedures was evaluated and those in which the nature of the resulting velar-flap mechanism was considered.

Within the first category, investigators have evaluated success of pharyngeal flap procedures in various ways. Some (4, 12, 18, 22) have assessed success by judgments of nasality and report varying amounts of reduced nasality postoperatively. In none of these studies was an attempt made to control the effects of pre- or postoperative speech therapy.

More recently, oral breath pressure ratios have been utilized as a criterion of flap success (1, 5, 21, 23).

Several groups of investigators (8, 16, 19) have evaluated flap procedures by assessing the general speech characteristics of their subjects in relation to normal speech. Their results showed a definite improvement in speech postoperatively for many subjects. In addition, Hamlen (8) reported that although there was no spontaneous improvement in nearly half the subjects, they did exhibit an ability to produce speech sounds either directly upon stimulation or with training. However, the validity of utilizing normal speech as a standard in the evaluation of flap success may be questioned. Smith and associates (21) point out that the flap technique "... is designed to correct only the condition of velopharyngeal inadequacy ...", whereas

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This paper was presented at the 1969 International Congress on Cleft Palate, Houston, and is based upon a thesis completed under the direction of Kenneth L. Moll, Ph.D., The University of Iowa.

The investigation was supported in part by PHS Research Grant DE-00853, National Institute of Dental Research.

the acquisition of normal speech also depends upon such factors as age, hearing ability and intelligence. Thus, the presence of deviant speech may not reflect a failure of the pharyngeal flap procedure in providing a competent velopharyngeal mechanism.

As the nature of the pharyngeal flap mechanism has been explored, two basic theories have been suggested to explain the physiological factors involved in the operation of the flap mechanism: the flap as a living obturator and the flap as a dynamic mechanism. The "living obturator" theory suggests that its very existence serves to narrow the velopharyngeal aperture; hence, no flap movement is necessary for success. Dunn (6) and Moran (12) modified this theory to suggest that the presence of the flap serves to pull the velum backward toward the pharyngeal wall. On the other hand, several investigators (7, 9) have reported increased velar movement postoperatively, suggesting a dynamic mechanism. Broadbent and Swinyard (3) utilized electromyography and reported "normal muscular activity" in the flap. None of these three investigations related velar-flap movement to speech skills.

Since the purpose of the flap is to correct velopharyngeal incompetence, an important consideration is whether movement of the flap is necessary for closure of the velopharyngeal port. Bradley and associates (2) examined the relation of flap movement to the degree of hypernasality. A study of the relationship between flap movement and various speech and non-speech activities has also been reported (1).

Regardless of the manner in which flap success has been evaluated, it appears from previous research that the pharyngeal flap technique is highly successful in the reduction of nasal voice quality, in improving general speech skills, and in increasing the potential for closure of the velopharyngeal port. Less definitive observations have been made concerning the nature of the flap mechanism. Although it appears, according to Bradley and associates (2), that subjects with "less mobile" velar-flap structures exhibit greater degrees of hypernasality, it also has been reported that the amount of velar-flap movement is not related to speech sound articulation (1). Morris and Spriestersbach (14) also concluded that good articulation is possible without observable velar-flap movement. There is contradictory evidence concerning the general theories of flap functioning, and no observations have been made of flap movements in relation to preoperative velar movements. Such information might help in determining if preoperative velar movements are reliable predictors of postoperative flap movements.

Statement of the Problem

This study was designed to provide further information concerning the nature and functioning of the pharyngeal flap mechanism by utilizing cinefluorographic observations of flap movements. The following specific questions were posed: a) What is the relationship between pharyngeal flap movements and preoperative velar movements? b) What is the relationship

between flap movements and success of the operative procedure? c) How do flap movements vary among different speech and non-speech activities?

Procedures

SUBJECTS. The subjects utilized were seven male and four female children who had undergone superiorly based pharyngeal flap surgery between the ages of five and 14 years. Preoperative cinefluorographic films had been obtained for eight subjects and postoperative films were available for all subjects.

Descriptive information on the subjects is shown in Table 1. Evaluation of velopharyngeal functioning was based on various observations described previously by Morris and Smith (13). These included still and motion-picture x-ray observations, measures of the ability to impound intraoral breath pressure on manometer tasks, and assessments of speech articulation skills. It can be noted in Table 1 that few of the subjects articulated more than 50% of the articulation test items correctly and that, in general, the breath pressure ratios are considerably less than 1.00. All subjects had normal hearing for the frequencies of 500, 1000, and 2000 Hz. Intelligence quotients, as determined from the Wechsler Intelligence Scale for Children, ranged from 71 to 124 with a mean IQ of 94.

FILM SAMPLES AND ANALYSIS. The activities which were recorded on film are described in Figure 1. Subjects read or repeated the sentences.

The analytical and tracing procedures used in this study and the equipment for the identification and tracing of cinefluorographic frames have been described by Moll (10). For both pre- and postoperative films, all frames associated with production of the following words were traced: see,

TABLE 1. Descriptive information about the subjects utilized in this study. The Iowa Pressure Articulation Test Scores and the manometer ratios shown were obtained prior to pharyngeal flap surgery. Maximum articulation test score is 43; maximal manometer ratio is 1.00.

<i>subject</i>	<i>type of cleft</i>	<i>age at time of flap surg. yrs. mo.</i>	<i>pressure artic. score (no. correct)</i>	<i>manometer ratios</i>	
				<i>without bleed</i>	<i>with bleed</i>
1	bilateral complete	8-5	0	0.30	0.40
2	unilateral complete	13-2	23	0.42	0.42
3	non-cleft	12-6	23	0.94	0.94
4	palate only	14-3	8	1.00	0.80
5	soft palate only	7-3	0	0.67	0.80
6	soft palate only	6-2	2	0.50	0.55
7	bilateral complete	11-9	0	0.25	0.25
8	unilateral complete	6-6	20	0.74	0.70
9	unilateral complete	6-8	—	—	—
10	bilateral complete	5-8	—	—	—
11	bilateral complete	7-5	6	0.40	0.40

- I. Speech activities
 - A. Children can see many animals at the zoo. They have camels, and some fish, and a large black bear. I think they even have a pig.
 - B. Production of sustained /u/ and /s/.
- II. Non-speech activities
 - A. Physiologic rest.
 - B. Swallowing.
 - C. Oral manometer tasks.

FIGURE 1. Activities for film samples.

many, fish, black, and pig. The following sounds were then selected from these tracings for analysis: /s/ in see, /m/ in many, /f/ in fish, /p/ in pig, and /g/ in pig. For the sustained productions of /u/ and /s/ and for each of the non-speech activities, the three frames showing greatest movement of the velum or flap were traced.

DATA ANALYSIS. The frames exhibiting the greatest velar or velar-flap movement on each of the speech sounds traced and on each of the non-speech activities were selected for data analysis. The selected frames were then handled as follows: a) For both pre- and postoperative tracings, the selected frame for each activity was superimposed on the frame representing rest position for each subject. b) The selected frame for blowing without air bleed was superimposed on the frame for blowing with bleed for each subject. c) The frame showing greatest flap movement during swallowing was superimposed on frames of selected speech and blowing activities. d) The frame showing the greatest flap movement during speech activities was superimposed on the two conditions for blowing.

Preliminary analysis of these superimposed tracings led to the establishment of a three-category classification of pharyngeal flap and velar movement. Figure 2 provides graphic examples of the three categories. For the purposes of this study, "no movement" was defined as lack of parallel upward movement by the superior and inferior surfaces from the flap position at rest. "Marked movement" was defined as definite upward and backward movement of the flap mechanism.

ADDITIONAL MEASURES. Available postoperative oral breath pressure ratios and scores on the Iowa Pressure Articulation Test were utilized to make comparisons among flap movements, ability to impound oral breath pressure, and articulation performance.

Results

The results of this study will be discussed in relation to three general topics: the relationship of flap movements to preoperative velar movements, comparisons of flap movements among various speech and non-speech activities, and variations of movements among postoperative measures of velopharyngeal competency.

FLAP MOVEMENTS AND PREOPERATIVE VELAR MOVEMENTS. Analyses were made of preoperative velar movements for speech and non-speech

activities as compared to flap movements for the same activities. The data show a) no change from preoperative to postoperative movements for three subjects, b) a change from no movement preoperatively to slight movement postoperatively for three subjects, and c) a reduction in movement postoperatively for two subjects. These three types of changes are illustrated in Figure 3. Illustration (A) shows marked movement for production of /u/ both pre- and postoperatively; illustration (B) shows essentially no velar movement preoperatively but slight movement postoperatively for production of /p/; and illustration (C) shows marked movement preoperatively but no movement postoperatively for production of /g/. It appears, therefore, that there is a general relationship between preoperative and postoperative movements; that is, individuals with no preoperative movement of the velum were more likely to exhibit no postoperative movement than those who showed marked degrees of velar movements preoperatively. It should be noted, however, that this trend is not completely consistent, since two subjects showed a postoperative reduction in movement.

Comparison of preoperative velar and postoperative flap movements for blowing activities revealed a tendency for postoperative movements to remain the same or increase slightly.

The results of pre- and postoperative flap movements, comparing /m/ with the non-nasal sounds utilized in this study for eight subjects, are shown in Table 2. It appears from these findings that movement is more likely to increase postoperatively on non-nasal sounds than on nasal sounds.

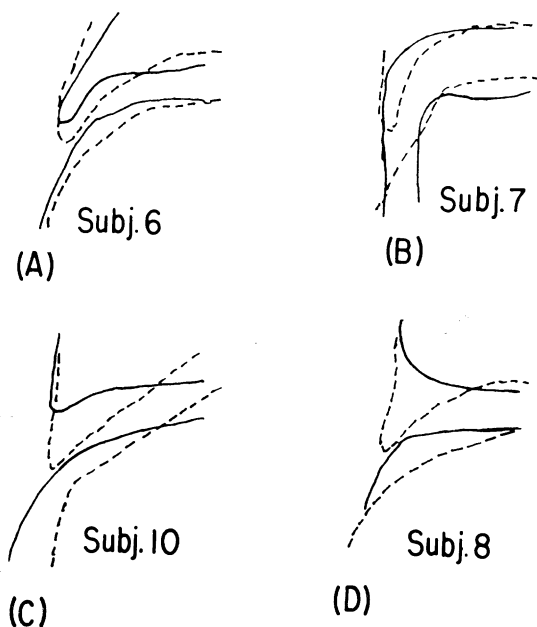


FIGURE 2. Examples of the three categories of flap movement used in this study. Rest position is indicated by dotted lines.

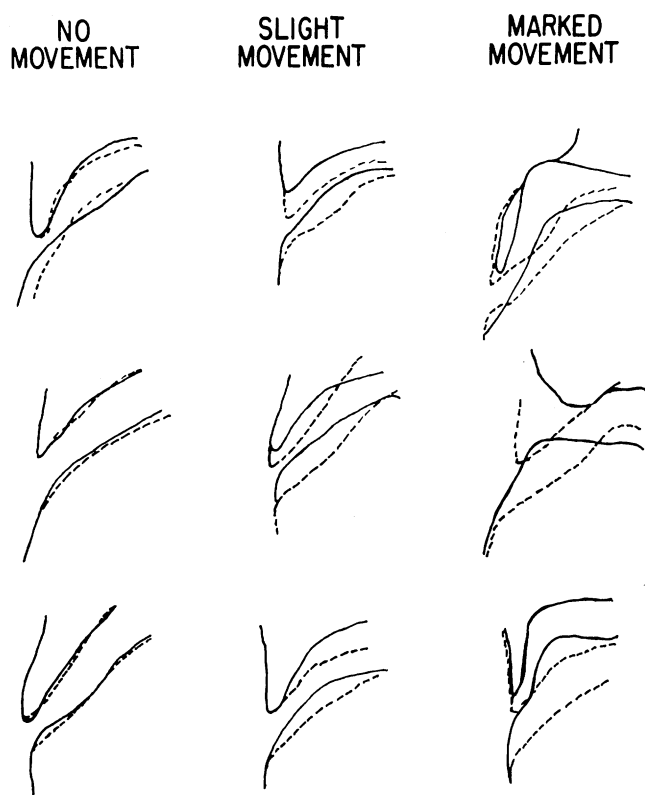


FIGURE 3. Positions of velar or velar-flap structures on speech activities as compared to the positions on physiologic rest (represented by dotted lines) for preoperative and postoperative films.

TABLE 2. Amounts of preoperative and postoperative velar or velar-flap movements for the nasal sound /m/ and for the non-nasal sounds utilized in this study. None: no movement; slight: slight velar or velar-flap movement; marked: marked velar or velar-flap movement.

<i>subject</i>	<i>/m/ pre/post</i>	<i>non-nasals pre/post</i>
1	none/slight	none/none
2	marked/none	slight/slight
3	marked/marked	marked/marked
4	none/none	none/none
5	marked/none	marked/none
6	none/none	none/slight
7	none/none	none/slight
8	none/none	none/slight

TABLE 3. Preoperative and postoperative scores (number correct) on the 43-item Iowa Pressure Articulation Test and the 25-item Sound Stimulation Test, and breath pressure ratios obtained on a manometer with an air bleed.

<i>flap movement category</i>	<i>subject</i>	<i>press. artic. scores pre/post</i>	<i>stim. test scores pre/post</i>	<i>pressure ratios pre/post</i>
none	1	0/0	10/9	0.40/1.00
	4	8/41	13/25	1.00/1.00
	5	0/31	20/24	0.80/0.60
slight	2	23/38	25/25	0.42/1.00
	6	2/34	9/25	0.55/1.00
	7	0/38	9/22	0.25/1.00
	8	20/39	19/24	0.70/1.00
	10	—/18	—/22	—/1.00
marked	11	6/8	12/21	0.30/1.00
	3	23/42	25/25	0.93/0.93

FLAP MOVEMENTS, SPEECH, AND NON-SPEECH ACTIVITIES. The relationship between general pharyngeal flap movements and three measures utilized to assess the success of the operative procedure are presented in Table 3. The results indicate that seven of nine subjects showed considerable improvement in Pressure Articulation scores, that eight of nine subjects either obtained perfect scores or made improved scores postoperatively on the Sound Stimulation Test, and that breath pressure ratios increased markedly or remained high in all but one instance (subject 5) regardless of general velar-flap movement. There is no trend in Table 3 for any of the three measures to be related to the amount of flap movement.

VARIATIONS OF MOVEMENTS AMONG ACTIVITIES. Comparing the greatest flap movement among all speech activities to the greatest flap movement for both conditions of blowing, seven of the 11 subjects had more pronounced movements for blowing than for speech. These differences are illustrated in Figure 4.

Comparisons of flap movements among swallowing, blowing, and speech, for six subjects showed greater flap movement during swallowing than for the other two conditions in all cases.

Finally, comparisons between flap movements and nasal and non-nasal sounds were made. Except for the fact that greatest flap movement occurred for non-nasal sounds, there appears to be no trend for the greatest movement to occur consistently for one particular sound or sound type.

Discussion

The major finding of this study is that there appears to be little, if any, relationship between movements of the velar-flap structure and the success of the operative procedure as assessed by articulation tests and breath pressure ratios. These results are not consistent with those of Bradley and

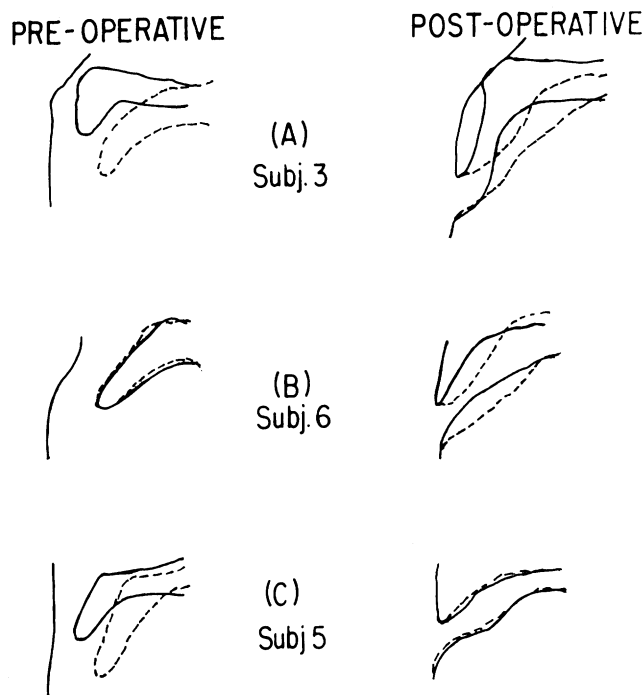


FIGURE 4. Illustrations comparing greatest flap movements among all speech activities and blowing with air bleed for four subjects. The flap and pharyngeal wall during speech activities are indicated by dotted lines.

associates (2), who interpreted their findings as showing a positive relationship between flap movements and the reduction in nasal voice postoperatively. There were not enough subjects with inadequate postoperative performances in the present study to define this relationship fully. Even if such a relationship exists, however, it cannot be a strong one, since the present results demonstrate that the operative procedure can be quite successful, even in the complete absence of velar-flap movements. Thus, the flap mechanism does not necessarily have to be "dynamic" as suggested by Broadbent and Swinyard (3), for it to be successful.

The findings discussed above add support to the suggestion of Morris and Spriestersbach (14) that the method of flap functioning may vary among different individuals.

It should be emphasized that the use of the term "flap movement" does not imply that such movement results necessarily from contraction of muscle fibers within the flap itself, as has been suggested by Broadbent and Swinyard (3). In most instances in this study, the movements observed appeared to be relatable to velar elevation which pulled the flap along with it.

In addition to noting the greater extent of movement for blowing than for speech, it also appeared that for some subjects such movement was not

due to velar elevation. Rather, a more general backward and upward movement was noted for the entire flap structure, without a definite levator eminence. The finding of more movement on blowing is consistent with Bradley's (1) results. More flap movement was noted for swallowing than on either speech or blowing tasks. Thus, it probably is not valid to assess movement on blowing or swallowing and then attempt to predict movements on speech activities from such observations. This finding is in agreement with Moll (11), who reported that speech and non-speech tasks in normal subjects appear to involve different velar activities. It appears that further investigations should be carried out in an attempt to identify other variables which can be assessed preoperatively and which are more closely related to success than are velar-flap movements. It is possible that, indeed, there are no preoperative characteristics which are related to operative success. Instead it may be that factors such as the maximum flap width which can be achieved and maintained are the determining variables of a successful result.

Little support was found for the hypothesis of Longacre and DeStefano (9) that the presence of a flap results in increased velar movement.

Because of the relatively small number of subjects utilized, generalization from the results of this study to larger groups should be done with caution. In addition, the usefulness of cinefluorographic techniques might be questioned in examining flap dynamics, since openings at the lateral edges of the flap and movements of the lateral pharyngeal walls may be important to the operation of this mechanism.

Summary

This study was designed to investigate the functioning of the pharyngeal flap mechanism in relation to preoperative velar movements and measures of operative success and to assess differences in such functioning among various speech and non-speech activities. Cinefluorographic films were utilized for 11 subjects who had undergone pharyngeal flap surgery between the ages of five and 14 years. The major findings were: a) There appeared to be a relationship between preoperative velar movements and postoperative flap movements for speech activities. b) Movement was more likely to increase postoperatively on non-nasal sounds than on nasal sounds. c) No trend was found for postoperative articulation measures or breath pressure ratios to be related to the amount of flap movement. d) Movement was found to be more pronounced for blowing than for speech. There was consistently more movement for swallowing than for either blowing or speech. Indication is made that the flap mechanism need not be "dynamic" in order to achieve velopharyngeal closure. It appears, rather, that speech status may be relatively independent of the degree of flap movement.

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Acknowledgment. The author is indebted to Dr. Kenneth L. Moll for his invaluable direction and encouragement.

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