Patterns of Swallow in Cleft Palate Children

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Some persons involved in the habilitation of cleft palate individuals have expressed concern that palate defects cause difficulty with swallowing. Best and Taylor (*2*) write that defects in the soft palate or paralysis of the palatal muscles result in entrance of food into the nasopharynx and difficulty with swallowing. However, from studying cinefluorographic films of a number of normal persons and persons with palatal incompetency, Sloan and associates (*16*) state, 'Very few differences can be noted by the viewer between the normal deglutition pattern and that of the patient with palatal incompetency deglutition pattern.' They discuss briefly a deglutition mechanism in which, 'The posterior aspect of the tongue is depressed to allow the bolus to move, seemingly by taking advantage of gravity. . . .' They consider this swallow pattern to be compensatory for poor palatopharyngeal closure, and they also comment on the minimal amount of nasopharyngeal regurgitation which occurs.

Two features of swallow acts by normal individuals are especially important in considering deglutition by individuals with defective palates. First, only the first part of the swallow act is voluntary behavior. Deglutition is often described as involving three stages: the oral stage, the pharyngeal stage, and the esophageal stage (*3, 8, 9, 10*). Best and Taylor (*2*) write that a large part of the second stage and all of the third stage of swallowing are entirely involuntary.

A second important feature of swallow by normal persons involves the displacement of the bolus from the front of the mouth into the pharynx. This is described as involving pressing the tongue against the roof of the mouth progressively from front to back (*1*). From his review of the literature, Fletcher (*7*) concluded that 'The bolus is moved through the mesopharynx as a result of a stripping action of the tongue dorsum against the hard palate, followed by tongue root against the soft palate and finally compression by the pharyngeal constrictors which forces the bolus through the hypopharynx and into the esophagus.'

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The purposes of this study are: a) to determine the percentage of a group of palate defective subjects who displace barium bolus into the nasopharynx during swallow; b) to describe variability in swallow in persons with palate defects; c) to contrast the swallowing acts of three cleft palate subjects as they swallow with their obturators in place and again with the obturators removed; d) to compare the articulation and also the mean palatopharyngeal gaps of palate defective persons who swallow by means of tongue-palate press with those who swallow by 'free fall' of the bolus into the hypopharynx. The term *free fall* is defined with the report of results for the second purpose.

Procedure

Thirty-two children between the ages of 6 years 5 months and 12 years 11 months served as subjects in this study. Seventeen subjects had surgically repaired clefts of the palate or palate and lip, four had unrepaired palatal inadequacy (hereafter abbreviated as PI), one subject had an unrepaired cleft of the soft palate only, and 10 subjects had clefts which were prosthetically managed. Cineradiographic film was available of all subjects swallowing in an upright, seated position. Three of the 10 subjects with prosthesis were filmed swallowing with obturator in place and then again with it removed.

For the filming, subjects were seated in a dental chair with a head holder attached. This head holder restricts lateral rotation or tilting of the head and helps maintain erect posture. Some flexion and extension movement of the neck is possible. A mixture of barium and water was provided for each subject to swallow. The bolus consisted of approximately one teaspoon of this material. Further detail of general filming procedures and equipment is described in a previous paper (*14*).

Film of the swallowing act of each subject was projected by use of a Perceptoscope projector to a tracing surface of a tracing cabinet. Film was viewed in slow motion and at full speed of 24 frames per second. Each film was viewed by an investigator, who then made a decision whether nasal surge of bolus material was evident during the swallow. For purposes of this study, nasal surge was defined as consisting of movement of the barium at any time during the swallow, in an upward direction into the nasopharynx above the level of the horizontal plane of the hard palate or above the inferior portion of the speech bulb. In addition, each film was observed by an investigator at varying speeds, and on a frame-by-frame basis, and successive aspects of the swallow were described. Detailed tracings were made of the three subjects swallowing with obturator in and out, and from the tracings and observations, the two swallows for each subject were described and contrasted.

An additional comment regarding measurement of velopharyngeal opening is required. The criterion measure for velopharyngeal opening for each subject was the mean measurements of the gap for all frames for that

subject. When reporting group data for velopharyngeal opening, the mean of those subject means was computed, or the *mean mean* gap.

Articulation scores were available from previous work for 31 of the 32 subjects. Mean palatopharyngeal gap measurements were also available for 20 of the 22 nonobturated subjects. The articulation scores ranged from 43.2% correct to 98.5% correct with a mean of 77.4%; the mean palatopharyngeal gap measurements for subjects ranged from .04 mm to 9.4 mm with a mean for the group of 1.65 mm. Seven of the 10 obturated subjects in this study were earlier described by Werth (*17*) as having continual contact between the obturator bulb and the posterior wall of the pharynx, as shown by cinefluorographic film. She described the other three as occasionally showing a bulb-wall gap of approximately 1.0 mm during rest frames.

The group consisting of the 17 surgically repaired cleft palate subjects, the four PI subjects, and the one unrepaired cleft palate subject was divided into two subgroups, one showing tongue-palate press swallow pattern and the other showing free fall of the bolus during swallow. The significance of the differences in articulation scores and in mean palatopharyngeal gap measurements between these groups was tested by use of the Mann Whitney U test (*15*). Measurement of mean palatopharyngeal gap and of articulation was described in an earlier paper (*12*).

Results

Incidence of Nasal Surge. None of the 32 subjects was observed to show nasal surge during swallow, not even the subject with unrepaired palatal defect nor the three subjects who were filmed with their obturators out.

Patterns of Swallowing. Three patterns of swallowing were observed in this study which deviate from the description of normal swallowing discussed above. A consistent feature of each of these deviations was a period of 'free fall' of the bolus. This phenomena is characterized by an interruption of the progressive 'stripping action' of the tongue against the roof of the mouth. The bolus is lifted to the alveolar ridge by the tip of the tongue and forced back to approximately the middle of the hard palate by occlusion of the tongue against the hard palate. At this point, tongue movement ceases for varying periods of time (depending on the individual) and the bolus flows, apparently by gravity, over the posterior slope of the tongue into the valecula or past the tip of the epiglottis with little or no observable tongue movement. In several instances, during the period of free fall, barium is observed to flow over the tip of the epiglottis while it is still in an upright position. After the free fall, the bolus is moved into the esophagus by tongue press against the posterior pharyngeal wall. The soft palate or speech bulb may or may not be contacted by the tongue in this movement.

The three deviations from normal swallowing found in this study are described as follows.

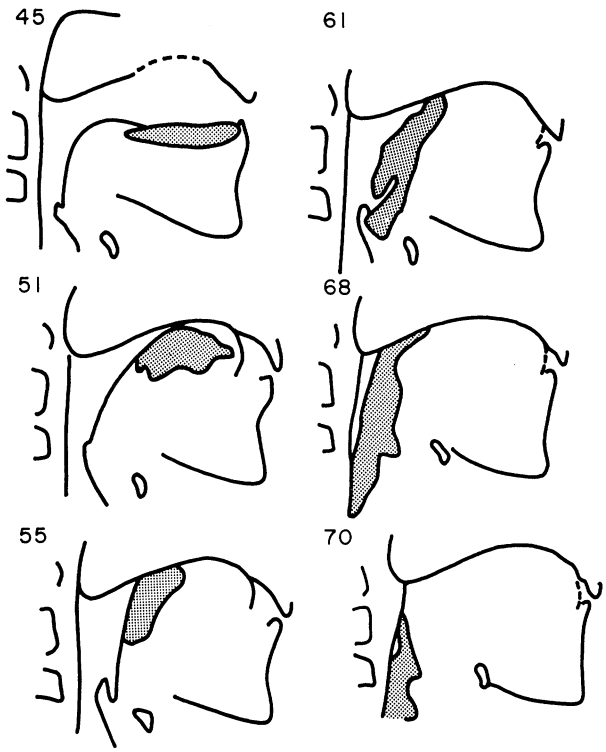

FIGURE 1. Tracings from cinefluorographic film illustrating swallowing pattern ⅋1. The subject is wearing an obturator in this illustration. The stippled areas in the illustration indicate bolus material. The interrupted line was used in tracing some areas where the film image was relatively unclear. Frame 45: The subject is in a preparatory position with the barium bolus pooled in the front of the mouth prior to initiation of the swallow. Frame 51: The tongue is elevated and there is occlusion between the tongue and the anterior portion of the palate. Frame 55: Posterior movement of the tongue along the palate ceases; barium bolus free fall begins. The base of the tongue has moved forward from the position shown in Frame 51. Frame 61: The bolus continues free fall descent into the hypopharynx without change in tongue position. Frame 68: The tongue resumes motion and occludes against the posterior portion of the palate. Frame 70: The oral passage is completely sealed by tongue-bulb-posterior pharyngeal wall occlusion.

Pattern ⅋1. Swallowing is initiated with elevation of the bolus to the alveolar ridge by the tongue tip. The bolus is then moved to the middle of the hard palate region by press of the tongue dorsum against the anterior portion of the hard palate. Tongue movement ceases at this point and the bolus cascades over the posterior portion of the tongue into the hypopharynx. Following this period of free fall, progressive tongue-speech bulb-posterior pharyngeal wall occlusion continues in a normal appearing manner. The tongue and the posterior pharyngeal wall make contact opposite the interspace between the first and second cervical vertebrae. Figure 1 shows a series of tracings of selected frames of cinefluorographic film showing parts of the swallowing pattern described above.

Pattern #2. Swallowing is again initiated with the bolus being carried to the region of the mid-section of the hard palate by a tongue-hard palate press. As the tongue ceases movement at this point, a period of bolus free fall ensues. After the free fall period, occlusion between the tongue and the anterior portion of the palate is released before the posterior portion of the tongue moves back to effect a tongue-posterior pharyngeal wall press. Marked movement of the posterior pharyngeal wall contributes to this press, which again occurs opposite the interspace between the first and second cervical vertebrae. Hemi-palates may also be involved in this press. Figure 2 shows a series of tracings illustrating this swallowing pattern.

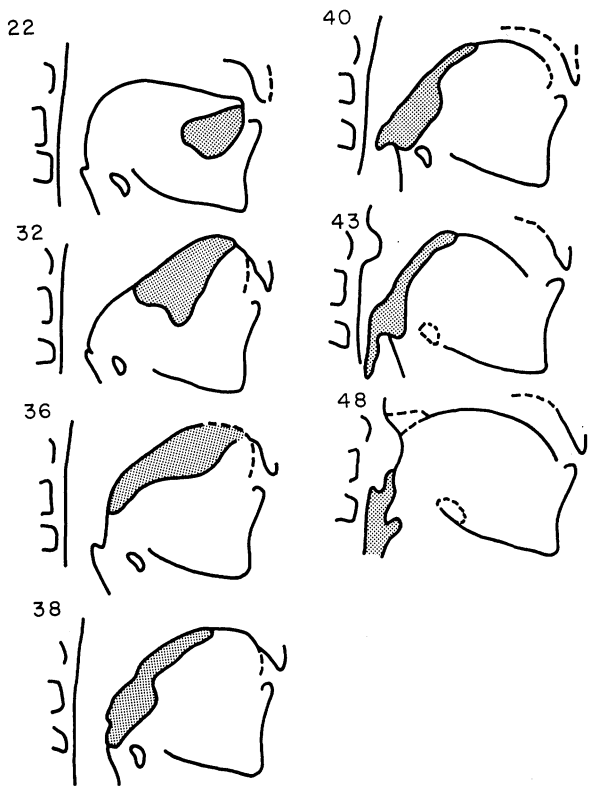

FIGURE 2. Tracings from cinefluorographic film illustrating swallowing pattern #2. The subject shown in this illustration is prosthetically repaired but is shown swallowing here with the obturator removed. Frame 22: The subject is in a preparatory position with the bolus pooled in the front of the mouth prior to initiation of the swallow. Frame 32: The tongue is raised and in contact with the anterior portion of the palate. Frame 36: Bolus free fall begins; the base of the tongue has moved slightly forward. Frame 38: Free fall of bolus into the hypopharynx continues without change in tongue position. Frame 40: The tongue moves away from the palate; the bolus continues descent. Frame 43: The pharyngeal portion of the tongue has moved superiorly toward the extended Passavant's ridge on the pharyngeal wall. Frame 48: The tongue is in contact with the posterior pharyngeal wall and with hemi-palate tissue. Tongue-pharyngeal wall occlusion is opposite the interspace between C1 and C2.

Pattern ⅋3. The bolus is carried to the mid-section of the hard palate by tongue-hard palate occlusion. A period of free fall then occurs followed by release of contact between the tongue and the anterior section of the palate. Finally, the tongue moves posteriorly and the posterior pharyngeal wall moves forward to occlude opposite the interspace between the second and third cervical vertebrae. In this pattern, there is no contact at any point between the tongue and the posterior section of the hard palate or the speech bulb (the example illustrated being an obturated subject). Tongue-posterior pharyngeal wall contact is also at a lower cervical level than in the preceding examples. This pattern of swallow is illustrated by a series of tracings shown in Figure 3. It will be noticed that this subject has divided the bolus into two parts. The succeeding swallow of the remaining bolus material was accomplished by a second free flow of barium followed by a second tongue-posterior pharyngeal wall occlusion. No tongue contact with the roof of the mouth or the speech appliance took place after the free fall in the second swallow.

Differences among the three patterns of swallow described above may be summarized as follows: Instances of pattern ⅋1 were identified on the basis of a period of bolus free fall occurring roughly at midpoint of the oral stage of the swallow; the preceding and succeeding swallowing movements in these instances appeared to be normal. In pattern ⅋2, occlusion between the tongue and the anterior palate is present preceding bolus free fall but is not resumed following it. In these instances, tongue-palate (or prosthesis) contact after the free fall is effected by the posterior portion of the tongue. Pattern ⅋3 is distinguished from the preceding two patterns by the fact that after the period of bolus free fall there is no further tongue-palate contact. In this swallowing pattern, the tongue moves back to contact the pharyngeal wall after the free fall without resumption of tongue-palate or tongue-bulb contact.

No attempt was made in this study to categorize subjects into one of the three swallow patterns described above. However, it was noted that 18 subjects showed some period of free fall during the swallowing act. Film of swallow by three normal subjects was reviewed. One showed free fall. Descriptions made from observation of swallowing of the remaining 14 pathological subjects closely followed that described as normal swallowing in the literature.

Comparison of Swallowing with Obturator In and Out. Description of the swallowing act of three subjects first with obturator in and then out is as follows.

Subject No. 1 (C72). The swallowing pattern of this subject with obturator in place was used for the illustration in Figure 1 and is described above. With the obturator removed, the swallow pattern is similar to that illustrated in Figure 3. In both swallows free fall was present. However, with the obturator in, tongue-anterior palate contact is maintained throughout. Tongue-obturator-pharyngeal wall occlusion is opposite the top of the second cervical vertebra. With the obturator out, tongue-ante-

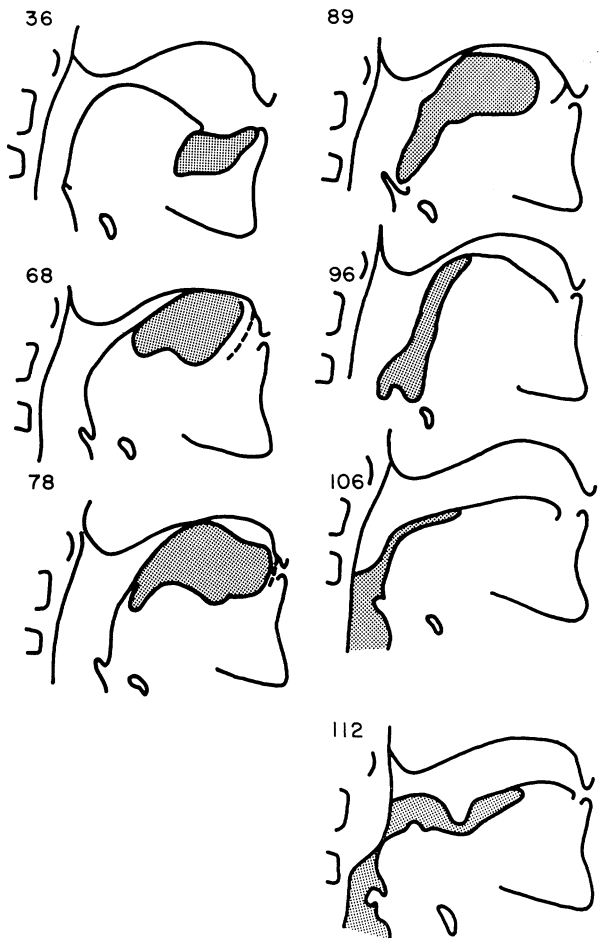

FIGURE 3. Tracings from cinefluorographic film illustrating swallowing pattern #3. The subject is wearing an obturator in this illustration. Frame 36: The subject is in a preparatory position with the barium bolus pooled in the front of the mouth prior to the initiation of the swallow. Frame 68: The tongue makes contact with the anterior portion of the palate. Frame 78: Bolus free fall begins; the base of the tongue has moved slightly forward. Frame 89: Free fall of bolus into the hypopharynx continues without change in tongue position. Frame 96: The tongue moves away from the palate; the bolus continues to descend. Frame 106: The tongue begins to move posteriorly toward the posterior pharyngeal wall. Frame 112: Tongue-pharyngeal wall occlusion occurs opposite the interspace between C2 and C3.

rior palate occlusion is lost after the free fall and tongue-pharyngeal wall occlusion is made opposite the middle of the second cervical vertebra.

Subject No. 2 (C68). The swallowing pattern of this subject with obturator removed was used for the illustration in Figure 2. Swallowing of this subject was essentially the same with obturator out and in. That is, the bolus was moved to the mid-palatal area by tongue-palate press; a period of free fall occurred; tongue-anterior palate contact was lost;

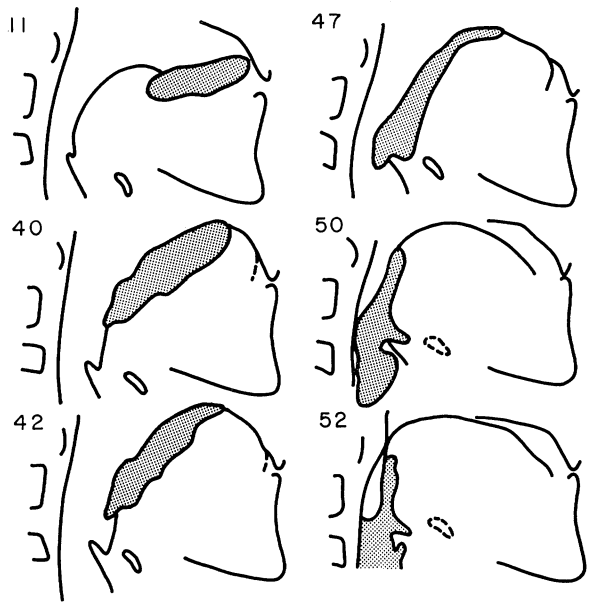

FIGURE 4. Tracings from cinefluorographic film illustrating the swallowing pattern of subject No. 3 with his obturator removed. Frame 11: The subject is in a preparatory position with the bolus pooled in the front of the mouth prior to initiation of the swallow. Frame 40: The tongue is elevated and there is occlusion between the tongue and the anterior portion of the palate. Frame 42: A period of bolus free fall begins; the base of the tongue has moved slightly forward. Frame 47: Bolus free fall continues without change of tongue position. Frame 50: The tongue loses contact with the anterior portion of the palate and begins moving toward the pharyngeal wall. Frame 52: Tongue-posterior pharyngeal wall occlusion is accomplished at the level of C1.

and finally, tongue-obturator-pharyngeal wall occlusion (or soft palate tissue when the obturator was removed) was effected opposite the first cervical vertebra (C1). With the obturator in, tongue-pharyngeal wall contact following free fall was first observed below the obturator level and then extended upward to include obturator contact. Formation of a ridge on the posterior wall was observed both with the obturator in and out. It contributed to the tongue-posterior wall contact.

Subject No. 3 (C101). The swallowing pattern of this subject with obturator in place was used for the illustration in Figure 3 and is described above. With the obturator removed, the swallow is similar to that described as pattern ⅋2. Thus, in both swallows, free fall was present and tongue-anterior palate contact is lost after free fall. However, with the obturator out, the tongue press is near C1 and involves the hemi-palate tissue as well as the posterior pharyngeal wall (Figure 4), while with the obturator in, tongue-pharyngeal wall occlusion is opposite the interspace between C2 and C3 and does not involve the obturator.

SUBGROUP COMPARISONS FOR ARTICULATION AND MEAN PALATOPHARYNGEAL GAP. The significance of the difference in articulation scores of sub-

jects in this study who swallow normally and those who use a free fall swallow pattern was tested by use of the Mann Whitney U test. The mean articulation score of subjects showing normal swallow was 75.1% correct with a range of 46.2% to 98.5% correct articulation; the mean articulation score of subjects with free fall swallow pattern was 79.3% correct with a range of 43.2% to 94.02% correct. A Mann Whitney U of 109.5 was obtained, indicating no significant difference in articulation between the two groups.

Subjects with surgical repair of palate defect or unrepaired PI (obturated subjects not included) were also divided into a group showing normal swallow and a second group showing a free fall swallow pattern as described above and tested for difference in mean palatopharyngeal gap measurements. The group showing normal swallow had a mean mean palatopharyngeal gap of 1.59 mm with a range of .04 to 9.4 mm; the group showing free fall swallowing had a mean mean palatopharyngeal gap of 1.72 mm with a range of .35 to 6.3 mm. A Mann Whitney U of 68.5 was obtained, indicating no significant difference between the two groups in mean palatopharyngeal gap.

Discussion

Swallowing, under the conditions existing in this study, does not seem to be a problem for persons with cleft palate or palatal inadequacy, even when palatopharyngeal closure is poor for speech or when the defect is unrepaired. In no instance was nasal surge of bolus observed during the swallows filmed. The authors realize, however, that given individuals with palate defects may have difficulty in swallowing as, for example, with the head down.

The three patterns of swallow described in this paper which differ from literature descriptions of 'normal' swallow are not viewed by the authors as representing exclusive categories and no attempt was made to categorize all subjects as either normal or fitting into one or another of these patterns. Rather, the three deviant patterns of swallow described are presented as examples of variability. In each instance a period of bolus free fall was part of the pattern. This free fall occurs during what is described in the literature as the oral stage of swallowing (*1*). The oral stage of swallowing has been reported to be the only aspect of swallowing which is under voluntary control of the subject. Since literature descriptions of normal swallow do not include mention of free fall, its frequent presence in a sample of persons with palatal problems suggests that it is probably a learned compensation for poor palatopharyngeal closure. Its use may be continued even after the palate has been adequately repaired. However, free fall was observed in film of one of three normal subjects reviewed by the authors. Free fall of the bolus does serve a compensatory function in that the bolus moves lower into the hypopharynx before tongue-pharyngeal wall contact occurs, causing downward propul-

sion of the bolus into the esophagus. Thus, the bolus is further removed from a palate which may provide insufficient palatopharyngeal valving, and thus the bolus is not so likely to be squeezed upward into the nasal cavity by tongue-palate-pharyngeal wall press.

The study of three persons swallowing with obturator in and out suggests that presence or absence of the obturator in the mouth may influence the swallowing pattern; only in one of three instances was the swallowing pattern of the subject similar with obturator in and out. However, the design of this study does not preclude the possibility that variability in swallow is typical of persons studied regardless of obturation. Shelton (*11*) commented on and illustrated variability among movements of the tongue and palate of the normal speaker in moving the bolus from the front of the mouth into the pharynx and esophagus.

Summary

This study reports results of a cineradiographic investigation of swallowing in 27 cleft palate children with surgical or prosthetic management, one child with an unrepaired cleft, and four children with unrepaired palatal inadequacy. No child was observed in this investigation to show bolus passage into the nasopharynx during swallow. Eighteen subjects are identified as having swallowing patterns which deviate from descriptions of normal swallow found in the literature. Three swallow paterns which deviate from normal are described and illustrated as examples of variation in the swallow patterns of cleft palate children. Three subjects were photographed swallowing with obturator in and then out. Swallow patterns with obturator in and out are described and contrasted for each of these subjects. Statistical analyses indicate that the presence or absence of bolus 'free fall', as dichotomized in this study, is not significantly related to articulation proficiency or adequacy of palatopharyngeal closure as measured by mean palatopharyngeal wall gap measurements.

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