A Longitudinal Study of Maxillary Growth Following Pharyngeal-Flap Surgery

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The purpose of this study was to examine the *effects* of *pharyngeal-flap* surgery on *maxillary growth* in cleft palate individuals. Longitudinal cephalometric radiographs obtained on three separate populations were analyzed. One group of 24 cleft palate individuals had had pharyngeal-flap surgery performed prior to the prepubertal growth period. A subdivision of this group included five subjects with congenital palatal insufficiency who were additionally analysed separately. Two control groups were analyzed for comparative purposes. One consisted of 28 non-cleft individuals and one of 18 cleft palate individuals who had had surgical repair but no pharyngeal-flap surgery. *Longitudinal* cephalometric *records,* matched according to age, were available on all *three groups.*

It was found that pharyngeal-flap surgery has an effect on maxillary growth. When compared with the normal sample, both cleft samples, those with and those without pharyngeal-flaps, showed some reduction in forward maxillary growth. When compared with the normal sample, both cleft samples, those with and those without pharyngeal-flaps, showed some reduction in forward maxillary growth. However, the pharyngeal-flap group showed significantly greater *reduction* in maxillary *forward* growth. The pharyngeal-flap group showed normal vertical maxillary dimensions with growth whereas the non-flap cleft group exhibited some reduction in vertical growth of the maxillary complex. Localized effects ascribed to the pharyngeal-flap were noted.

Introduction

Clinically, not all patients with surgically repaired clefts of the palate achieve acceptable speech after the initial repair of the palate. In recent years, pharyngeal-flap surgery has become generally accepted as a desirable secondary surgical procedure to correct many of those cases where residual palatopharyngeal incompetence is evident. Pharyngeal-flap surgery is also frequently recommended as the initial operative procedure in patients with congenital palatopharyngeal incompetence resulting from submucous cleft or excessive depth of the nasopharynx. Recent studies (Curtin et al., 1973; Bzoch, 1964) have shown that a very high percentage of subjects can have near normal voice quality following pharyngeal-flap surgery. Although investigators have generally agreed that this surgical procedure is effective in reducing hypernasality in individuals with palatopharyngeal inadequacy, information has been sparse relative to the effects, if any, of pharyngeal-flap surgery upon facial growth and development.

There are several potentially influential factors that could conceivably have an effect on maxillary growth incident to this surgical procedure. First, whether the pharyngeal-flap is superiorly or inferiorly based, it involves the forward positioning of musculature from the posterior aspect of the pharynx and its subsequent addition to the soft palate, creating the possibility of increased muscular activity in the velopharyngeal area. Secondly, whether the donor site is closed or not, one must conjecture that there is the development

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of some scar tissue incident to healing. The cicatricious tissue, in addition to the functional activity of the repositioned musculature, could create a backward directed tension on the posterior aspect of the osseous palate via the soft palate musculature and the flap. Finally, the creation of a pharyngeal-flap mechanism does cause some obturation of the nasopharyngeal cavity, which is not normally present when the soft palate is in its resting posture. It is true that openings are maintained lateral to the flap to permit nasal respiration and mucous drainage. However, the physical presence of the flap may possibly reduce the capacity for full and adequate nasal respiration. Changes in the functional capacities of the oral-nasal-pharyngeal cavities could conceivably have an influence on facial development (Moss, 1964). The question arises as to whether these aforementioned factors might have some effect on the growth, the architecture, and the spatial relationships of the maxillary skeleton as well as on the rest of the facial complex.

Sample and Procedures

Obviously, answers to the aforementioned questions are contingent upon an evaluation of a sample with longitudinal records of sufficient duration to span an active growth period. Longitudinal cephalometric radiographs were obtained on 24 cleft palate individuals who had pharyngeal-flap surgery performed prior to the approximate time of the pubertal growth spurt. These serial cephalometric films were obtained from the files of the Orthodontic Department of the Eastman Dental Center and the Center for Craniofacial Anomalies of the University of Illinois. This group included 14 males and 10 females upon whom flap surgery had been performed between seven and 11 years of age. Serial x-ray films were available from the time of flap surgery until late adolescence or early adulthood. A sub-division of this included five subjects with congenital palatal insufficiency. This sub-division was partially analyzed separately since they represented a group with no prior palatal surgery and presented a unique opportunity to assess the effects of the flap procedure. Two control groups with longitudinal cephalometric records were analyzed for comparative purposes. One control group consisted of 28 non-cleft individuals, 15 males and 13 females; the records for this group were obtained from the Bolton Study of the Face of the Growing Child at Western Reserve University. The second control group consisted of 18 cleft palate individuals, 13 males and five females, with surgical repair of the palate, but no pharyngeal-flap surgery. Longitudinal cephalometric records on this group were available from the files of the Eastman Dental Center. The records on all three groups were matched according to age.

To make the best possible use of the avail-

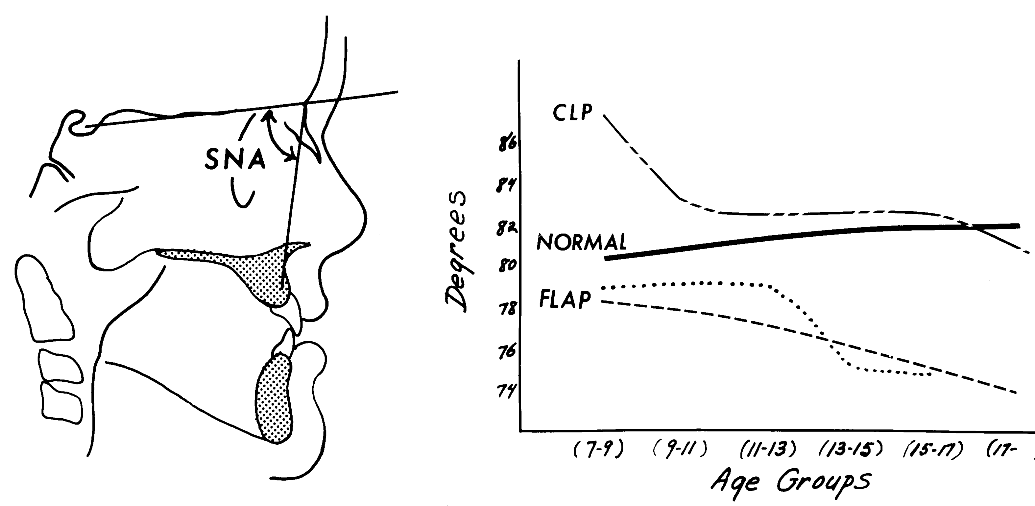

FIGURE 1. Cephalometric tracing to illustrate the angular measurement SNA used to evaluate the spatial relationship of the anterior aspect of the maxilla to the forehead region and mean changes with age. The dotted line indicates the changes in the small submucous cleft (subdivision) group. CLP represent the means of the cleft palate non-flap group.

able data, initially a mixed longitudinal approach was used. Every pharyngeal-flap series started at the time of surgery, and attempts were made to duplicate these ages as closely as possible with comparable records from the control groups whose serial records started at approximately seven years of age and extended until approximately 18 years of age. Cephalometric x-ray films in each series were not necessarily available for each succeeding year. For analysis purposes, the records were divided into three-year age gradients, starting from seven to nine years as the first group and ending with 17 to 19 years as the last group. For comparative purposes, means and standard deviations were obtained for each age grouping and were statistically analyzed. Thus, a somewhat cross-sectional, longitudinal approach was used. However, it was recognized that the variation existent within

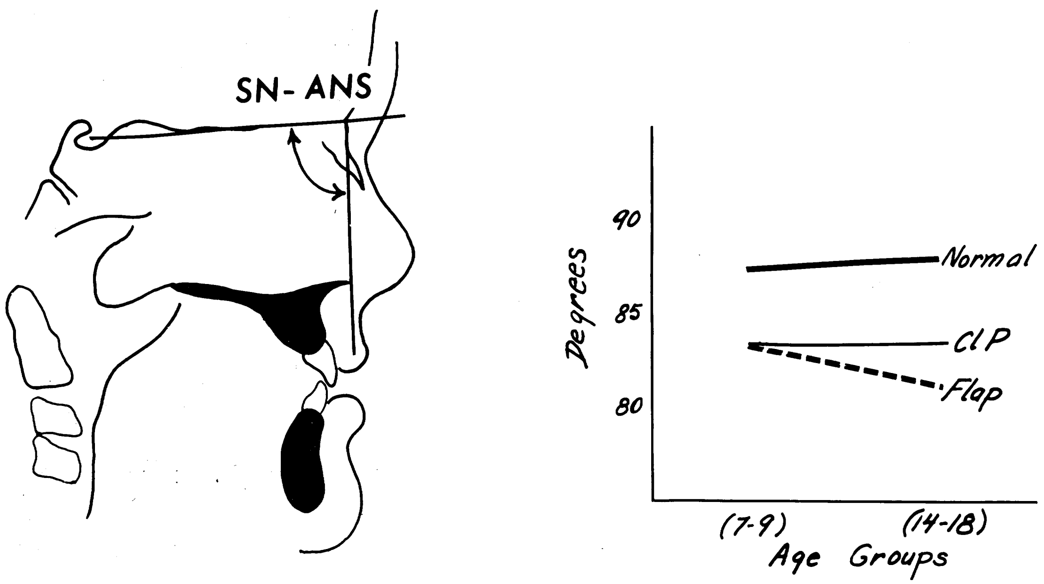

FIGURE 2. Cephalometric tracing to illustrate the angular measurement S-N-ANS used to evaluate the changing position of the anterior nasal spine relative to the anterior aspect of the cranium. Means were based on the paired statistical analysis.

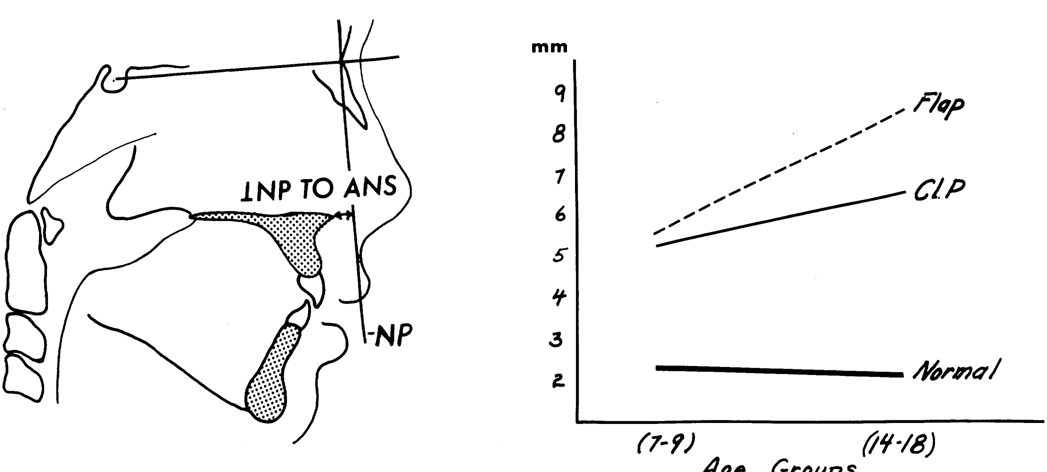

FIGURE 3. Cephalometric tracing to illustrate the linear dimension from the anterior nasal spine to the perpendicular to the sella-nasion plane registered at nasion. Using the paired statistical analysis, it was noted that this dimension increased between the early and late age groups in the flap subjects.

groups could reduce the value of longitudinal material when it was incorporated into a mixed longitudinal approach. Therefore, a further study was initiated selectively choosing 16 longitudinal series in each group (Toothman, 1977). These series were studied using a paired statistical analysis approach. Records were chosen based on comparable records available at an early and a late age level. The limiting factor, of course, was the age at the time of pharyngeal-flap surgery. Trends were statistically analyzed by evaluating changes from the early age grouping, seven to nine years, to the late age grouping, 14 to 18 years of age. Added credibility was extended to the observations when the two analytical approaches confirmed each other, and those observed trends will be reported. The analyses will be used interchangably for each in presentation and to illustrate the pertinent findings. As an added confirmation, observations were further corroborated by superimposing longitudinal cephalometric tracings in individual series.

For measurement purposes, an anterior cranial base line, from Sella (center of the pituitary fossa) to Nasion (junction of the frontal and nasal bones) was established as the primary base line. Angular measurements were made relative to this cranial base plane (Figures 1, 2, 7); vertical linear measurements were made at a perpendicular to this base line (Figure 5). For purposes of attaining horizontal measurements, a coordinate system was set up by a perpendicular to the Sella Nasion plane at Sella; perpendiculars to the vertical coordinate were established from various landmarks to attain desired measurements (Figure 4). A secondary vertical coordinate to the cranial base plane was established at Nasion (Figure 3). The Sella-Nasion base line was also used for superimpositioning purposes of the longitudinal tracings, registering at Sella (Figures 6, 8).

THE SPATIAL RELATIONSHIP OF THE SKELETAL MAXILLA TO THE CRANIUM. Since the primary focus of this investigation was to study changes in the spatial relation-

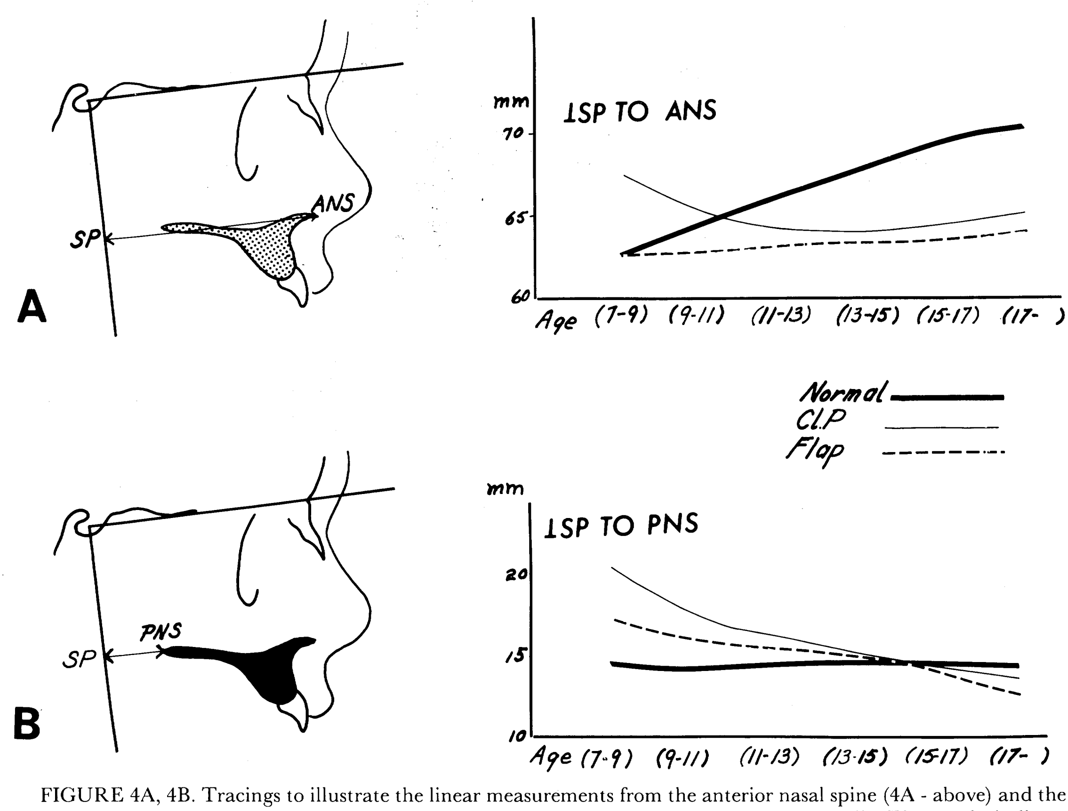

FIGURE 4A, 4B. Tracings to illustrate the linear measurements from the anterior nasal spine (4A - above) and the posterior nasal spine (4B - below) to the perpendicular to the sella-nasion plane registered at sella. The graphs indicate mean changes with age in the different subjects studied.

ship of the maxilla with growth and time, its position relative to the anterior aspect of the cranium was first evaluated. The angle (SNA), formed between the cranial base line and a line from Nasion to the skeletal maxillary Point A was used to indicate changes, incident to time and growth, in the relative anteroposterior position of the maxillary complex in reference to the forehead. In the normal group, the average angular reading increased moderately from the early age level to approximately 82 degrees by early adolescence and tended to be relatively stable through the later growth periods (Table 1). This observation has been previously reported in other studies (Lande, 1952; Reidel, 1952). Thus, with growth, the forepart of the maxilla was generally maintaining a relatively stable anteroposterior relationship with the anterior aspect of the cranium in its forward growth. The comparable measurement was significantly different for the group in which the subjects had undergone pharyngeal-flap surgery. The initial mean value was somewhat less at the early age level, but with increasing age there was a progressive decrease in the mean to approximately 74 degrees. Thus, in the pharyngeal-flap group, the anterior aspect of the maxilla was progressively falling back in its spatial relationship to the anterior aspect of the cranium which was growing forward. When they were analyzed as a separate group, similar observations were noted for the five subjects with congenital palatal insufficiency who had had pharyngeal-flap surgery but no previous surgery. In the non-flap cleft group, a tendency for this angle to decrease somewhat was noted, i.e. the mean value was smaller than that observed for normals at the later age levels, indicating that, in this group, the maxillary complex was also falling back relative to the forehead. However, it was not comparable to that observed for the pharyngeal-flap group.

Because landmark, Point A, is many times affected by the position of unerupted incisors, especially in cleft palate individuals, it was decided to further substantiate the aforementioned observations. Paried statistical analysis was employed to evaluate the relative anteroposterior position of the Anterior Nasal Spine relative to Nasion in the three groups at the early and the late age levels (Toothman,

TABLE 1. Antero-posterior position of the skeletal maxilla to the cranium

measurement	age groups	7–9		9–11		11–13		13–15		15–17		17–	
	subjects	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.
Angle S-N-A	1. Normal	80.40	0.4	80.80	0.4	82.10	0.8	81.30	0.3	82.10	0.8	82.00	0.6
	2. Cleft Palate (Non-Flap)	87.75	2.01	82.66	1.96	82.88	2.29	81.91	1.14	83.50	3.86	81.14	2.65
	3. Pharyngeal Flap	78.37	1.35	77.16	1.27	77.45	1.69	76.00	1.22	74.77	1.12	73.95	1.52
	4. Submucous and Pharyngeal Flap	78.8 ± 3.3				79.3 ± 5.7		75.0 ± 1.4		75.0			

1977). An angular reading, similar to SNA, was undertaken except for a projection from Nasion to the Anterior Nasal Spine rather than Point A (Figure 2). The same general trend was noted. The mean value increased slightly in the normal group over the approximate ten-year age span but decreased significantly for the pharyngeal-flap group over the same period. The non-flap cleft group showed comparable mean values at both age levels. Thus, in the pharyngeal-flap group the maxilla seemed to be progressively falling back relative to the forehead more than in the non-flap group and significantly more than in the normal group.

An additional linear measurement was used to corroborate the impression that the forepart of the maxilla was not moving forward with growth as rapidly as the forehead area and to ascertain, if possible, what was happening to the postural relationship of the maxillary complex. Utilizing a perpendicular to the cranial base, registered at Nasion, changes in the distance of the Anterior Nasal Spine from this plane were measured. In the normal population, this dimension decreased slightly with age (Figure 3). This indicated that, with age, the Anterior Nasal Spine was progressively coming forward in relation to the forehead plane. The same trend was not evident in either the pharyngeal-flap group or the cleft palate non-flap group. Over the period studied, in the latter two groups, the average dimension increased with time. This

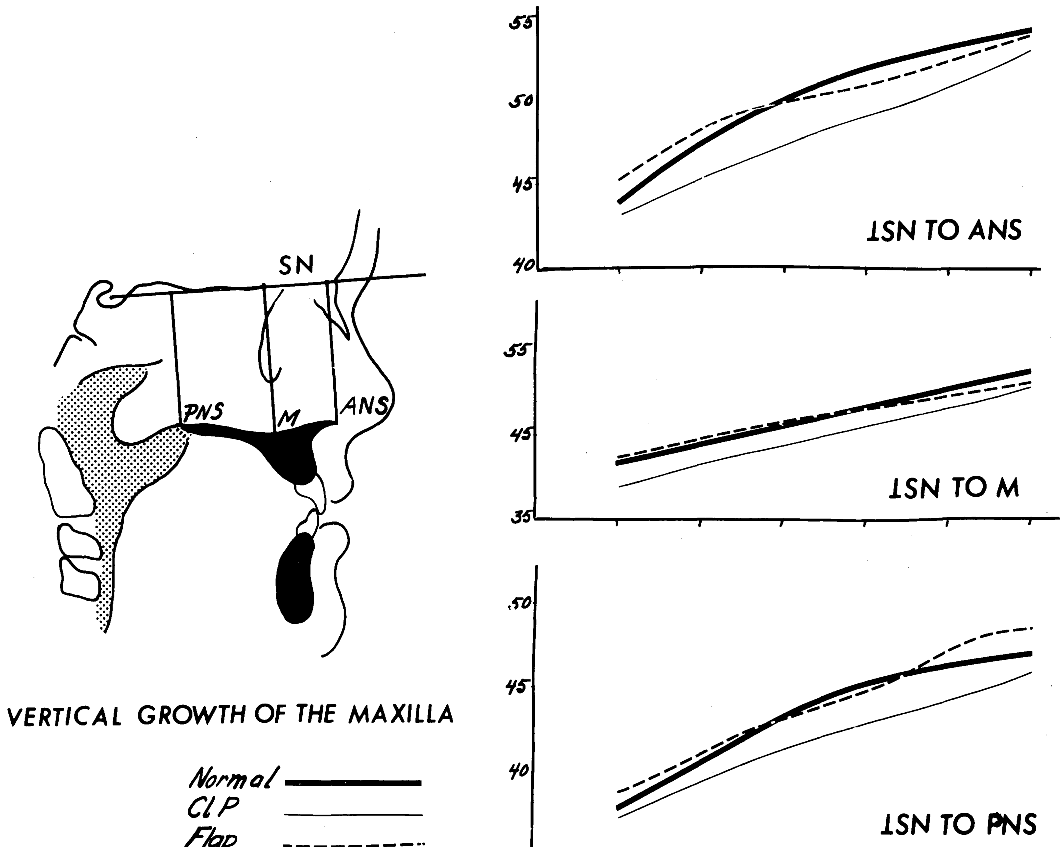

FIGURE 5. Measurements to evaluate vertical development of the maxillary complex. Perpendicular from the sella-nasion plane to the anterior nasal spine (SN to ANS) indicates anterior verticle development. The perpendicular through the inferior aspect of the left orbit (SN to M) indicates intermediate maxillary vertical development. The perpendicular to the posterior nasal spine indicates posterior vertical development (SN to PNS). Graphs indicate mean changes with age. Dots on the horizontal abscissa indicate (7–9), (9–11), (11–13), (13–15), (15–17), (17–up) age in years.

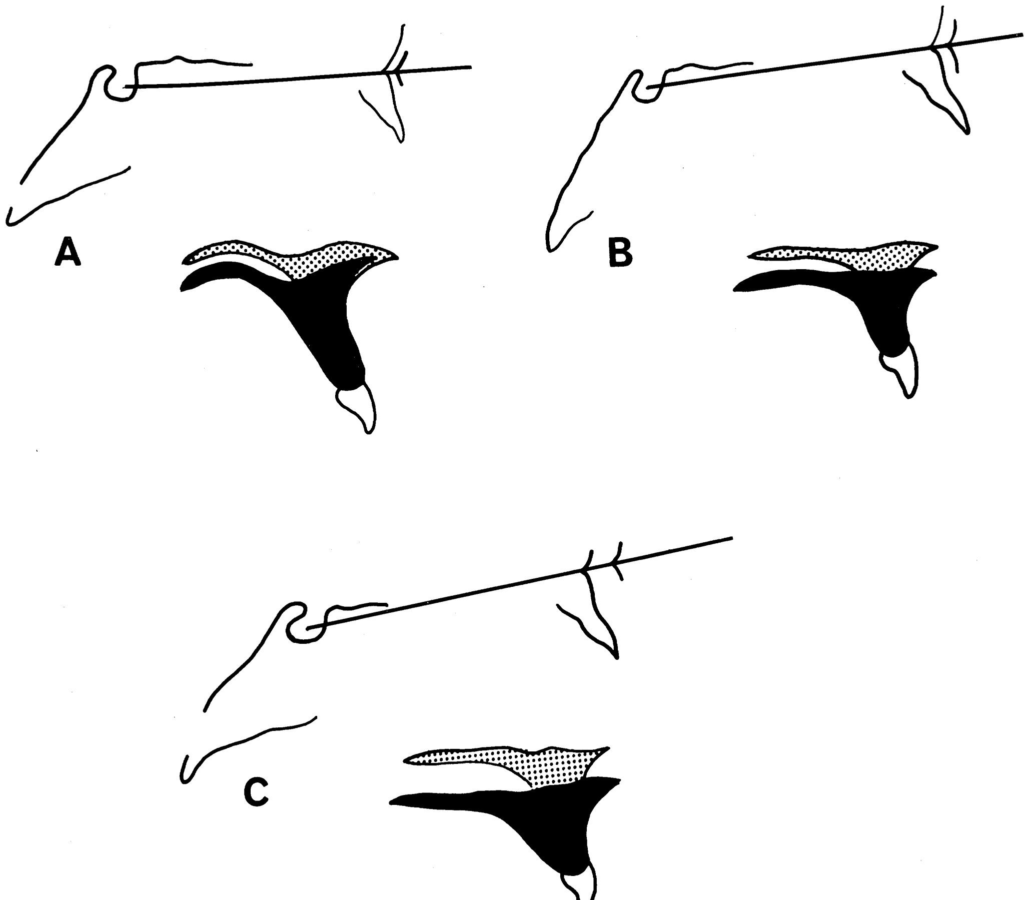

FIGURE 6. Superimposed tracings of three of the pharyngeal-flap subjects to indicate greater downward and backward movement of the posterior aspect of the hard palate in comparison with the anterior aspect of the hard palate. Superimpositions were on the sella-nasion plane registered on sella.

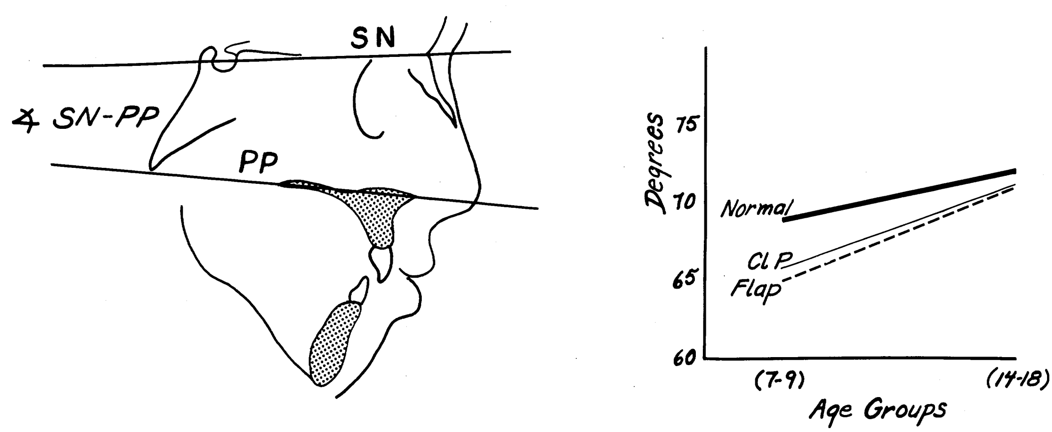

FIGURE 7. Tracing to illustrate the angular measurement between the anterior cranial base plane (SN) and the palatal plane (PP)—Angle SN-PP. Graph, based on the paired statistical analysis, indicates changes between the early and later age levels in the tracings.

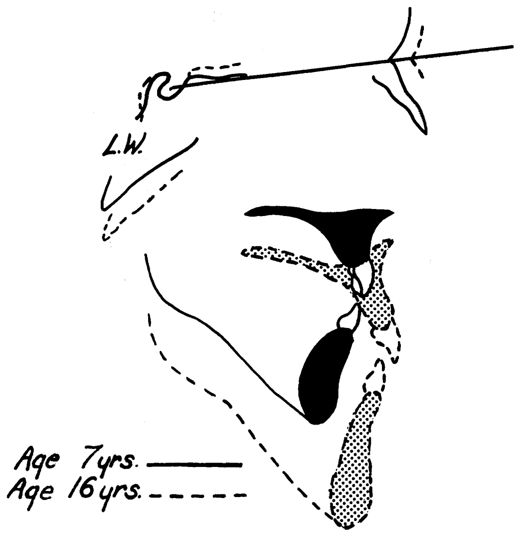

FIGURE 8. Superimposed tracings of the cephalometric x-rays taken on the same individual at two different age levels after pharyngeal-flap surgery. Greater downward than forward development of the mandible is noted.

was particularly evident in the pharyngeal-flap group where the increase was quite pronounced and was statistically significant. Thus, a further corroboration that in the pharyngeal-flap group the forepart of the maxilla is not keeping pace with the forward movement of the forehead and with increasing age is gradually falling back relative to the anterior aspect of the cranium.

In light of this observation, it was decided to determine what was occurring in the postural relationship of the maxilla, with age, in reference to a more posteriorly located landmark and baseline. Utilizing the posteriorly located vertical coordinate, linear measurements were made to the anterior (ANS) (Figure 4A) and posterior, (PNS) aspects of the hard palate (Figure 4B). As one might anticipate, the distance from the posterior plane to the Anterior Nasal Spine increased with growth in all groups. However, differences were noted between the groups. The normal population exhibited the greatest increase in this dimension as the Anterior Nasal Spine was moving progressively forward. In the cleft palate non-flap group, there was greater variation but smaller increment when compared with the normal group. Noteworthy was the pharyngeal-flap group where the increase in this dimension was the smallest of all three groups and markedly less than that observed for the normal population. Thus, in the pharyngeal-flap group, as the anterior nasal spine was gradually falling back and not keeping pace with the forward movement of the anterior aspect of the cranium, the anterior maxillary skeletal area was not moving forward relative to the posterior cranial area to the same degree as observed in the normals (Figure 4A). Continued evaluation with the addition of the next measurement (SP-PNS, Figure 4B) added some insight into an understanding of the observed difference. In the three groups, differences in the distance between the posterior nasal spine and the vertical posterior plane were not statistically significant. However, trends were recognizable and worthy of note. In the normal group, the average distance from Sella Plant (SP) to the Posterior Nasal Spine tended to remain approximately the same. This is in accordance with the findings of King (1952) and Brodie (1941). In the non-flap group, greater variability was evident, but there was a tendency toward a decrease in this dimension between the early and the later ages. Less variability was recorded in the pharyngeal-flap group, but of particular note was the greater difference in trend observed in this group. Initially, at the early age level, the average dimension was considerably greater than that observed for the normal population and greater, though less marked, than that observed in the non-flap cleft palate group. The trend for a progressive decrease in this dimension was noted in the pharyngeal-flap population until, at the later age level, the average dimension was less than that observed for both the normal and the non-flap cleft populations (Figure 4B). The observation to be emphasized is that, in the pharyngeal-flap group, the posterior aspect of the maxillary complex, as represented by the posterior border of the hard palate (PNS), was progressively positioning closer to the vertical reference plane (SP).

To summarize, in the subjects who have had pharyngeal-flap surgery, one attains the impression that small, but definite changes tend to take place in the position of the maxillary complex. The anterior aspect of the maxilla showed a tendency to recede relative to the forehead. Further, the posterior aspect of the maxillary complex, as represented by the posterior border of the palate, seemed to be drawn closer to the posterior vertical reference plane (SP). This inter-relation is not conventionally observed in normal growth studies. In the subjects who had had pharyngeal-flap surgery, it seemed as though the maxillary complex, or at least the hard palate, was being pulled posteriorly as the growth of the craniofacial complex progressed. The question now arises as to whether or not the pattern and extent of growth of the maxilla, both in the vertical and horizontal directions, are the same in the pharyngeal-flap subjects as in the other subjects, and how this relates to the observation that, in the flap subjects, there may be a posteriorly directed force on maxillary growth.

HORIZONTAL GROWTH OF THE MAXILLA. To a degree, some aspects of horizontal growth have been discussed in the preceding section. It was pointed out that the Anterior Nasal Spine, in relation to the forepart of the cranium and the posterior aspect of the cranial base, did not progress as far forward in the cleft palate groups as in the normal group. The next step was to determine if there were any differences, on an increasing age basis, in the antero-posterior depth of the maxilla as measured along the length of the palate from the posterior border to the Anterior Nasal Spine. Additionally, since the Posterior Nasal Spine area is deficient in many cleft palate cases, maxillary depth was also measured along the Palatal Plane from the Pterygomaxillary Fissure, representing the maxillary tuberosities, to the Anterior Nasal Spine. In the normal group, there was a definite and progressive increase in the average length of the hard palate with age. The average length in the seven to nine year age group was 47.5 millimeters, and this dimension increased to an average of 55.3 millimeters by late adolescence (Table 2). Over the age span studied, in the normals, the average increment approximated 8 millimeters for the ten-year period. When compared to the normal group, mean palatal length was smaller in the pharyngeal-flap group at the younger age levels (averaging 46.3 millimeters) and remained smaller with increasing age (averaging 51.7 millimeters) at the later age levels. For the pharyngeal-flap group, the average increment in palatal length was a little over five millimeters for the ten-year period. Thus, the average anteroposterior dimension of the hard palate in the pharyngeal-flap group was shorter at the start and never reached a dimension comparable to the normal group.

TABLE 2. Horizontal growth of the maxilla (in millimeters)

measurement	age groups / subjects	7–9 mean	9–11 mean	11–13 mean	13–15 mean	15–17 mean	17– mean
A. Palatal Length Anterior Nasal Spine to Posterior Nasal Spine	1. Normal	47.5	50.0	52.2	53.8	55.1	55.3
	2. Cleft Palate (Non-Flap)	47.5	47.8	48.0	49.1	49.2	53.7
	3. Pharyngeal Flap	46.3	46.3	48.0	49.5	50.1	51.7
B. Pterygomaxillary Fissure to Anterior Nasal Spine PTM-ANS	1. Normal	49.9	51.8	53.8	55.3	57.1	57.2
	2. Cleft Palate (Non-Flap)	54.8	54.4	51.1	51.3	53.0	53.7
	3. Pharyngeal Flap	52.1	51.4	52.0	53.0	50.6	54.4
C. Perpendicular from Sella Vertical to Anterior Nasal Spine	1. Normal	62.4	64.2	67.0	67.5	69.7	70.1
	2. Cleft Palate (non-Flap)	67.5	63.8	64.1	63.0	67.0	65.1
	3. Pharyngeal Flap	62.6	62.7	63.2	64.1	66.7	64.0

Growth in length was evident, but it was also observed that the degree of increment at each successive age level was not the same as that observed in the normals. That is to say that there was proportionate increase in length with progressive age but that the proportional increment was smaller when compared to the normal group. Once again, variability was noted in the cleft non-flap group. The initial mean value at the early age levels was similar to that observed for the normal population and greater than that observed for the pharyngeal-flap group. However, the progressive increments were less than that observed in the other groups so that the curve became more closely associated with that of the flap group until the later age level, when a pronounced increment caused the curve to approach more closely the curve for the normal population. Hard palate length was initially smaller in the phraryngeal-flap group and, despite growth in length, remained smaller in this group. This was true in comparison to the normals and generally true, although to a lesser degree, in comparison to the non-flap cleft group.

When the anteroposterior dimensions of the maxillary complex from the region of the tuberosities to the anterior nasal spine were evaluated, the results generally led to somewhat similar interpretations. Whereas progressive increment in this dimension was noted for the normal group, comparable increment was not observed for the two cleft groups (Table 2). At the early age levels, in both cleft groups, this dimension, on the average, tended to be longer than observed in the normal population. Perhaps this finding may be related to the inclusion of bilateral cleft cases with forward positioning of the premaxillary region. However, in both groups, the average dimensions eventually fell below those observed for the normal population at approximately the 10- to 12-year age levels. Subsequent to this age level, despite continued growth, the average dimensions in both groups tended to fall behind progressively to a greater extent than was observed for the normal population. The composite of the observations leads one to suspect that the somewhat reduced horizontal dimensions in the flap group is not a result of the pharyngeal-flap because both the cleft palate non-flap group and the pharyngeal-flap group were less than the normal. At the later age levels, the trends in development were similar. Thus, the observed differences are probably inherent in the cleft and/or its correction. In both cleft palate groups, these dimensions were smaller and exhibited less increment in age when compared to the normals.

VERTICAL GROWTH OF THE MAXILLARY COMPLEX. Measurements were taken in three regions to evaluate vertical growth of the maxillary complex (Figure 5). Perpendiculars from the Anterior Nasal Spine and the posterior border of the palate were projected to the Sella-Nasion (cranial base) plane. In an effort to attain a more intermediate measurement, a third perpendicular was erected, passing through Orbitale, or the lowest aspect of the left bony orbit. In both the anterior and the intermediate vertical measurements, the normal and pharyngeal-flap groups were very comparable. Although fluctuation was evident, these dimensions showed closely comparable increment with the progression in age. This was also true for the cleft palate non-flap group except that these dimensions were somewhat smaller during the early age levels and although, with progressive age, these vertical dimensions seemed to increase at a slightly greater pace. However, at the later age level, the mean values never fully reached the mean values observed for the normal group (Table 3). The posterior vertical dimension involved the erection of a perpendicular from the posterior border of the hard palate to the cranial base plane. Once again, the cleft palate non-flap group exhibited mean values that were shorter during the early age levels. Although increment in this dimension was evident in the non-flap group, it seemed not to achieve a comparable dimension when compared to the other groups and ended up as a shorter mean vertical posterior dimension at the later age levels. It was surmised that, in the cleft palate non-flap group, posterior vertical maxillary height was not increasing as much with growth when compared with the normal and flap groups, and, in fact, did not seem to increase as much as was evident in the anterior maxillary regions. The non-flap cleft group tended to exhibit some reduction in vertical growth of the maxillary complex in the more posterior regions. The same did not seem to be true for the pharyngeal-flap group.

TABLE 3. Vertical development of the maxillary complex (in millimeters)

measurement	age groups	7–9		9–11		11–13		13–15		15–17		17–	
	subjects	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.
A. Anterior Vertical (Perpendicular SN to ANS)	1. Normal	44.22	0.53	47.86	0.57	51.33	1.09	51.36	0.65	53.83	1.57	54.40	1.08
	2. Cleft Palate (Non-Flap)	43.00	0.70	45.23	1.28	48.00	1.41	49.66	2.10	47.87	2.94	53.85	1.45
	3. Pharyngeal Flap	45.37	0.68	48.75	0.70	49.60	1.09	50.50	1.03	52.44	1.05	54.05	1.37
B. Intermediate Vertical (Perpendicular through Orbitale)	1. Normal	41.70	0.4	45.20	0.5	48.60	0.9	48.40	0.6	51.00	1.5	51.50	0.9
	2. Cleft Palate (Non-Flap)	38.50	1.75	42.58	1.05	43.77	1.26	47.00	1.34	46.75	2.05	51.00	1.61
	3. Pharyngeal Flap	42.20	0.61	44.66	0.55	47.40	1.13	47.50	0.86	50.77	0.97	50.30	0.98
C. Posterior Vertical (Perpendicular SN to Posterior Border of Palate)	1. Normal	37.70	0.4	40.90	0.4	44.00	0.8	44.10	0.7	46.40	1.4	46.80	0.7
	2. Cleft Palate (Non-Flap)	37.00	1.22	40.00	1.00	39.50	1.59	43.00	1.34	43.50	2.39	46.00	1.13
	3. Pharyngeal Flap	38.75	1.18	40.83	1.62	43.20	1.39	43.80	1.11	47.77	1.01	48.10	0.62

Although not statistically significant, the posterior vertical dimension seemed to increase to a greater average dimension when compared to the cleft non-flap group. Furthermore, although again not statistically significant, at some age levels, particularly at the later age levels, some of the mean posterior vertical dimensions slightly exceeded those observed for the normal group as well. An explanation for this observation was found by evaluating superimposed serial cephalometric tracings of individual patients. Variation, of course, was noted when one individual series was compared with another. However, in some of the series, it became evident that the posterior aspect of the hard palate was progressing vertically away from the cranial base more extensively than the more anteriorly located landmarks. In some instances, it appeared that the posterior aspect of the hard palate was bending downward as well as developing posteriorly with growth (Figure 6). This was also observed, although on a non-significant basis, when the angulation of the palate was measured in reference to the cranial base line (Figure 7). When measured at the early age level and compared with the late age level, it was found in both the normal group and the cleft non-flap group that the average angular value increased slightly by the later age level. An increase or opening of the average angle would indicate that the forepart was progressing vertically, to varying degrees, to a somewhat greater extent than was the posterior part of the palate. In the pharyngeal-flap group, the average reading decreased slightly by the later age level. This led to the interpretation that, in some of the cases, the posterior aspect of the hard palate was descending a little more than the anterior region of the maxillary complex leading to a decrease or closing of the average angular relationship. . Additionally, the impression was that the posterior aspect of the hard palate was being pulled in a downward as well as backward direction as growth progressed following the time of pharyngeal-flap surgery. From the cephalometric x-rays, it is virtually impossible to ascertain whether this observation represents an actual movement of the palate or some deformity of the posterior aspect of the hard palate because of the increased muscle forces incident to the introduction of pharyngeal muscle to the velum. The fact remains that the change is evident on a number of the serial cephalometric x-rays.

Discussion

The findings indicate that pharyngeal-flap surgery can have an influence on growth of the maxillary complex. In essence, it might be best characterized as a redirecting of maxillary growth and should not necessarily be characterized as a retardation of maxillary growth. It is true that the individuals who had undergone pharyngeal-flap surgery showed greater reduction in forward maxillary growth than the non-flap cleft group and an even greater reduction when compared to the normal group. However, in the pharyngeal-flap cases, it is conceptualized that the whole maxillary complex is being repositioned posteriorly as the forehead progresses anteriorly with growth. This does not mean that the maxilla is not growing, nor that it is not being positioned forward with growth, but it indicates that it is positioning forward with growth to a lesser degree than in the normal since it is also being positioned posteriorly with growth, which is not observed in a normal population. Additionally, some localized effects which can be attributed to the pharyngeal-flap have been observed in the posterior region of the maxillary complex. With growth, in a number of subjects, the posterior aspects of the hard palate were either being pulled or were being distorted inferiorly under the influence of muscle forces and the resultant cicatricious tissue incident to the pharyngeal-flap surgery.

The fact that the pharyngeal-flap seems to have some effect on the forward positioning of the maxillary complex should not, and does not, negate its value as a desirable rehabilitative procedure. In the first place, non-nasal speech is a major concern and an optimal goal in cleft palate habilitation. The pharyngeal-flap has proven itself to be a desirable secondary procedure where improvement in nasalized speech production is being sought. Furthermore, it seems to be a general clinical observation that its probable effect on maxillary forward positioning, during growth, does not generally lead to adverse facial disfigurement. This leads to the interpretation that either the retropositioning of the midface complex in the flap patients is not of such great magnitude as to adversely affect facial appearance or that growth patterns in the rest of the facial complex may be compensating sufficiently to permit continued satisfactory facial aesthetics with growth. To determine if there might be some compensating postural relationships, it was decided to evaluate changes in the position of the mandible, with growth, in the pharyngeal-flap group in comparison to the normal group, sixteen of the longitudinal series were evaluated (Ramsay, 1977). For this discussion, only a few of the salient findings will be mentioned. It was found that, in the pharyngeal-flap group, the chin was becoming more retrusive with age when compared to the normals. In other words, the chin was not coming forward to the same degree as in the normal group. Upon analysis, it was determined that the mandibles in both groups, in fact, in all three groups, were growing to the same extent; overall mandibular length, body length, and ramal height were similar in dimension and growth increments. The mean ramal heights were shortest in the pharyngeal-flap group, but the differences were not significant. Further analysis revealed that, while the chin in relation to the forehead was falling back to a greater degree in the pharyngeal-flap group when compared to the normals and non-flap subjects, it was also progressing further downward, vertically, away from the forehead (Figure 8). On an average, with age, the flap group showed a greater proportional increase in lower facial height (the anterior nasal spine to the lower border of the mandibular symphysis) relative to the total facial height. In other words, with growth, in the pharyngeal-flap subjects, the position of the chin relative to the rest of the facial complex was assuming a more downward and backward position than was noted for the other groups resulting in a proportionately greater lower facial height. This would tend to maintain satisfactory facial relationships despite the fact that the maxilla was being positioned somewhat posteriorly in the pharyngeal-flap subjects. The fact that the lower facial height was increasing proportionately while the chin was assuming a more downward and backward position within the facial profile would also explain the clinical impression that acceptable facial appearance seems to maintain itself with growth in the pharyngeal-flap group.

One might speculate why, in the flap group, mandibular chin position grew more downward and backward when compared to the normal group while the mandible itself was growing to the same extent and size. First, the attachment of a pharyngeal-flap to the soft palate reduces the orifice for air passage from the nasopharynx to the oropharynx while the subject is at rest. Normally, at rest, the soft palate usually closely approximates the dorsum of the tongue leaving an open passage for naso-respiratory purposes (Subtelny, 1954). The flap creates some physical obturation to this airflow, and it has been shown that there is less nasal airflow following pharyngeal-flap surgery (Subtelny et al., 1970; Warren et al, 1974). With the possible reduction in nasal airflow, there may be an increased need for oral air flow resulting in a compensatory depression in mandibular posture to increase the size of the oropharyngeal space. In cases with limited nasal respiration and with the necessity for increased oral respiration, it has been shown that the mandible may grow more vertically, resulting in an increase in the height of the face below the level of the palate (Linder-Aronson, 1970; Linder-Aronson and Backstron, 1960). In individuals with pharyngeal-flaps, , this pattern could be instrumental in helping to maintain good facial relationships and esthetics despite the fact that the pharyngeal-flap seems to have some retropositioning effect on the midfacial region. It would seem that compensatory adjustments to the pharyngeal-flap may change the postural relationships of growing parts to permit the advantageous development of an acceptable facial profile. Additionally, the retropositioning of the maxillary complex, as well as the potential for increased posterior vertical dimension, may have a "counterclockwise" rotational effect on the developing maxilla. This too would enhance the possibility of the mandible positioning in a downward and backward direction and again would help to maintain acceptable facial relationships. It should be pointed out that oral respiration and the resultant mandibular posture may lead to an open bite malocclusion and possibly long vertical facial dimension in the noncleft individual. In this instance, it may be to the detriment of the developing occlusion.

However, in the instance of the individual with pharyngeal-flap surgery, the change in mandibular posture may possibly aid in maintaining satisfactory facial appearance. Finally, it is suggested that scarring incident to pharyngeal-flap surgery should be kept as minimal as possible. While the retropositioning influence of the pharyngeal flap does not appear to alter good facial aesthetics markedly, the flap does appear to have an effect on the facial complex during growth, and excessive scar contracture could alter the delicate balance.

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