Nasopharyngeal Growth

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Variations in height and depth of the nasopharynx are quite apparent from birth throughout the early years of growth and development. However, many controversial opinions with regard to the comparative size of the nasopharynx in normal and cleft palate persons have been expressed (*9–18*).

Since horizontal and vertical dimensions of the nasopharynx in cleft palate children are intimately associated with the execution of basic and important functions, such as speech and respiration, it was considered important to undertake the present study, which was designed to answer the following questions: a) What are the vertical and horizontal dimensions of the nasopharynx in children with clefts of the palate from birth through 7 years of age? b) What is the pattern of growth in height and depth of the nasopharynx in cleft palate children from birth to 7 years of age? c) Do vertical and horizontal dimensions of the nasopharynx in cleft palate children differ from those recorded for children without a palatal defect?

The technique of cephalometric roentgenography introduced in 1931 by Broadbent (*2*) permitted Rosenberger (*11*) to make a longitudinal study of the naso-respiratory area in children from three months to five years of age. It was his opinion that an enlargement of the naso-respiratory area was achieved by growth in the body and the great wing of the sphenoid as well as by a forward drift of the hard palate. Brodie (*3*) demonstrated that the hard palate moves away from the base of the skull in a parallel manner with increment in age, and that this results in a progressive increase in the height of the nasal and nasopharyngeal areas.

In a study of the growth of the pharynx, King (*6*) concluded that there is a considerable increase in the vertical dimension of the pharynx resulting from the descent of the hard palate, the mandible, and the hyoid bone as well as from an increase in the height of the cervical vertebrae. He also concluded that there is no appreciable increase in the anteroposterior dimension of the pharynx after an early age.

According to Scott (*13*), growth in height of the pharyngeal area is

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regulated by the cartilages of the cervical vertebrae. He, as well as Todd (*16*), attributed growth in the anteroposterior dimension of the nasopharynx to growth at the spheno-occipital synchrondrosis.

Subtelny (*14*) studied vertical growth of the nasopharynx and observed a steady rate of increase until 15 years of age. Using a measurement from the posterior nasal spine to the soft tissue of the posterior wall of the pharynx, he observed a general increase in depth of the nasopharynx at the level of the palatal plane.

Several investigators studying cleft palate subjects have been concerned with skeletal structures closely related to the nasopharynx. Ricketts (*10*) found that the basilar portion of the occipital bone varied in its position when related to the anterior cranial base and that these variations can influence the anteroposterior dimension of the nasopharynx. Brader (*1*) reported significantly smaller anteroposterior and vertical nasopharyngeal dimensions in cleft palate subjects than in normals and noted that his cleft palate subjects had larger masses of adenoid tissue within the nasopharynx. He also observed no significant difference in the angularity of the cranial case for cleft palate individuals when compared with normal individuals.

Moss (*7*) studied malformations of the skull base associated with cleft palate deformities and indicated that a flexion of the cranial base places the basioccipital bone "... more anteriorly relative to the sphenoid bone as a whole..."; thus creating a smaller anteroposterior nasopharyngeal dimension. Subtelny (*15*) showed the width of the skeletal nasopharynx to be larger for cleft palate persons compared to normal cases.

The primary purpose of the present study was to investigate nasopharyngeal dimensions in height and depth for cleft palate children during their early years of growth and development.

Procedure

The data selected for this investigation were derived from the serial growth study in progress at the Cleft Palate Clinic of the University of Illinois.

In general, serial cephalometric x-rays obtained on the 57 cleft lip and palate subjects were taken every three months during the first year of life, every six months during the second and the third years of life, and annually thereafter until seven years of age.

The composition of the subjects with clefts is shown in Table 1. Eleven subjects had cleft lip only and were used here as a kind of control group. Forty-six subjects had a cleft palate, either with or without a cleft lip. The extent of the cleft in the 15 subjects with posterior cleft palate ranged from a cleft of the soft palate to a cleft of both hard and soft palate.

It should be pointed out that x-ray records were not available for

TABLE 1. Distribution of cleft type for the 57 subjects with clefts, according to sex.

sex	*cleft lip*			*lip and palate*			*cleft palate*
	right	*left*	*bilateral*	*right*	*left*	*bilateral*	
male	3	3	2	7	6	6	7
female	1	1	1	3	5	4	8
total	4	4	3	10	11	10	15

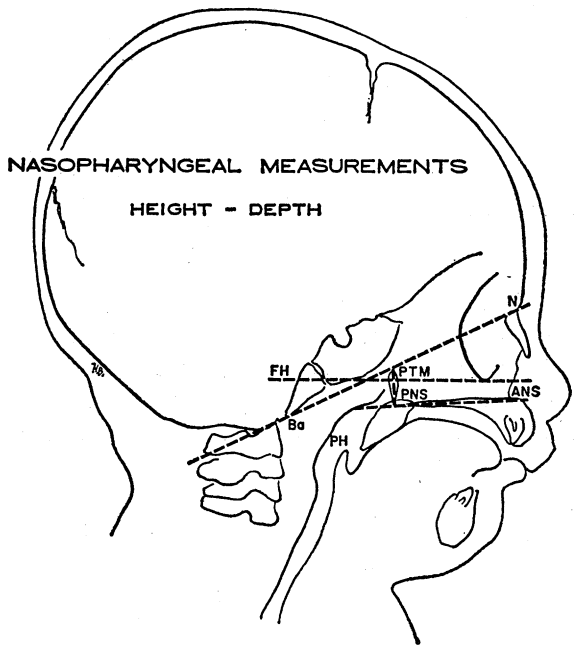

FIGURE 1. Landmarks and measures used in the investigation.

every subject at every age level. As a consequence, although they were obtained on the same individuals, the number of x-ray records varies from group to group. The technique employed on obtaining these films has been described elsewhere by Pruzansky and Lis (*8*). Palatal surgery had been performed on 72% of the patients studied. The age range at which surgery was performed was 1.2 years to 6.6 years.

Comparisons were made with normative data for growth of the nasopharynx, reported by Subtelny (*14*). He studied thirty subjects with serial cephalometric x-ray records from infancy to early adulthood.

LANDMARKS. The following anatomical structures were traced (Figure 1). Nasion (N) was defined as the most anterior point of the naso-frontal suture at the junction of the frontal and nasal bones. Basion (Ba) was defined as the median point of the anterior margin of the foramen mag-

num. Anterior nasal spine (ANS) was defined as the most anterior point of the hard palate. ANS was difficult to visualize in bilateral cleft palate cases; therefore, when necessary a point was taken on the anterior margin of the premaxilla at the level of the inferior posterior angle of the ala cartilage. Posterior nasal spine (PNS) was defined as the most posterior border of the hard palate. In certain unilateral and bilateral cleft palate cases there is an identifiable anatomical counterpart of PNS (*17*). In posterior clefts, however, no definitive posterior nasal spine is visible. In these cases the most posterior margin of the hard palate was traced. Outlining the inferior aspect of the pterygomaxillary fissure permitted the delineation of the maxilla. Posterior pharynx (PH) was defined as the most anterior limit of the soft tissue of the posterior wall of the pharynx at the level of the hard palate. A line was constructed connecting the anterior nasal spine with the posterior nasal spine (the palatal plane). This line was continued distally until it intersected the posterior pharyngeal wall. Pterygomaxillary fissure (PTM) was defined as the point where the anterior margin of the pterygoid process meets the posterior margin of the tuberosity of the maxilla.

For the purposes of measurement, two base lines were constructed: a cranial base plane (NBa), which was defined by a line connecting nasion and basion, and a palatal plane (PP), which was defined by a line connecting the anterior nasal spine and the posterior nasal spine of the hard palate. Linear measurements were employed to determine increments in the vertical and horizontal dimensions of the nasopharynx incident to growth. All measurements were read with correctional scales.

MEASUREMENTS. To investigate the increase in height of the nasopharynx as a result of growth, the linear distance from the point of intersection of the palatal plane with the pterygomaxillary fissure to the cranial base plane was measured. This line was constructed perpendicular to the cant of the Frankfort horizontal plane and was projected to intersect the cranial base line.

Horizontal changes of growth in depth of the nasopharynx were evaluated by measuring the linear distance along the palatal plane, from the point of intersection of the palatal plane with the pterygomaxillary fissure to the soft tissue of the posterior wall of the pharynx. An additional measurement was obtained to assess growth in depth of nasopharynx, using PNS instead of PTM.

Results

VERTICAL CHANGES. As indicated in Table 2, measurements of vertical changes at specified age intervals revealed that the cleft palate group showed slightly smaller nasopharyngeal height measurements than did the normal group. The difference was significant at age levels up to three years but was not significant for the older age levels. Thus, although the cleft palate group started out with significantly shorter ver-

TABLE 2. Mean values, in mm, for nasopharyngeal height and standard deviations for all cleft palate subjects combined and for normal and cleft lip control groups according to age. (Sexes are combined.)

cleft palate				*normal*				*cleft lip*			
age	*N*	*PTM-NBa*		*age*	*N*	*PNS-NBa*		*age*	*N*	*PTM-NBa*	
		M	*SD*			*M*	*SD*			*M*	*SD*
months				*months*				*months*			
3	31	10.8	1.58	3	10	13.3	1.52	3	5	10.2	1.27
6	37	11.4	1.52	6	14	13.7	1.23	6	4	13.2	1.00
9	28	12.0	1.61	9	15	15.2	1.33	9	7	13.8	1.84
years				*years*				*years*			
1	41	13.0	1.61	1	17	16.0	1.07	1	9	15.4	1.48
1.6	38	14.0	1.61	1.6	16	16.9	1.13	1.6	8	16.8	.71
2	39	14.6	2.10	2	20	17.4	1.27	2	10	17.5	.89
2.6	39	15.4	2.03	2.6	21	18.1	1.36	2.6	8	18.3	1.64
3	44	16.2	1.67	3	28	18.3	1.29	3	8	17.8	1.73
4	43	17.1	2.00	4	28	19.5	1.52	4	11	19.1	.71
5	32	17.8	1.61	5	28	19.9	1.36	5	10	20.4	2.03
6	19	18.4	3.05	6	24	21.0	1.73	6	6	21.3	2.03
7	10	20.4	1.76	7	28	21.5	1.63	7	3	22.2	2.74

tical measurements of the nasopharynx, the deviation from the normative standards appears to diminish with growth.

For the total age range, the cleft palate group showed an average increment of 9.6 mm, while the normal group had an average increment of 8.2 mm.

Increments in the vertical dimension of the nasopharynx, shown in Table 3, was proportionately greatest for all three groups during the earliest age level (from three months to one and one-half years). Approximately one-half of the total dimensional increase which occurred from three months to seven years of age in the normal and in the cleft lip control groups was demonstrated by the age of one and one-half years. A somewhat lesser proportional increment (one-third) was observed in the cleft palate group by that age, but the deficit was compensated for by a slightly greater-than-normal proportional increment in the cleft palate group one and one-half to three year age interval.

The essential parallelism of the pattern of change in the vertical dimensions of the nasopharynx is underscored by the fact that by three years of age, all three groups (normal, cleft lip, and cleft palate) had attained approximately 60% of their respective increase in nasopharyngeal height. The three-to-five-year and the five-to-seven-year intervals showed somewhat similar percentage increments in the vertical dimensions of the nasopharynx in both control groups. In the five-to-seven-

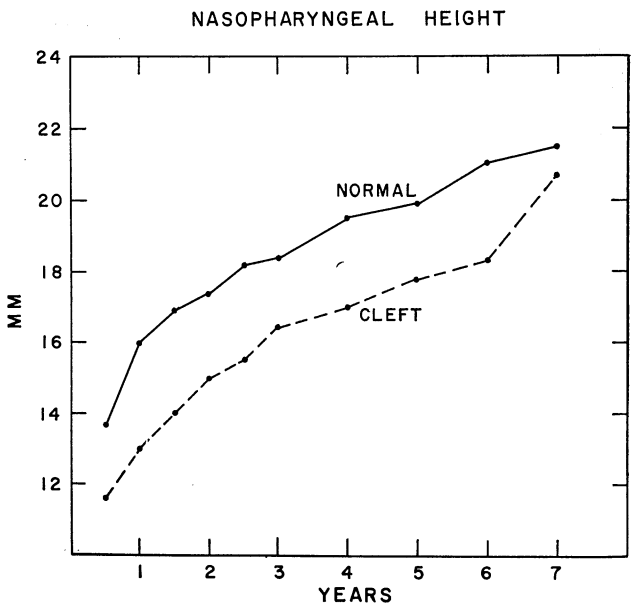

FIGURE 2. Rate and pattern of change in nasopharyngeal height with age, for the cleft palate and the normal control group.

TABLE 3. Nasopharyngeal height, expressed in millimeters and in percentage of total increment, for the cleft palate group and for the normal and cleft lip control groups, according to age level.

groups	*age groups*								
	3 mos. to 1½ yrs.		*1½ to 3 yrs.*		*3 to 5 yrs.*		*5 to 7 yrs.*		*total*
	mm	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	*mm*
cleft palate	3.2	33.3	2.2	22.9	1.6	16.6	2.6	27	9.6
cleft lip	6.6	55.0	1.0	8.3	2.6	21.6	1.8	15	12.0
normal	3.6	43.8	1.4	17.0	1.6	19.5	1.6	19.5	8.2

year age interval the cleft palate group showed a discernible increment in nasopharyngeal height compared to the other two groups.

HORIZONTAL CHANGES. Means and standard deviations for the anteroposterior measurements of the nasopharynx (PTM-PH for cleft palate subjects and PNS-PH for normal subjects) are presented in Table 4. Comparison of means for the cleft palate group at three months (12.0 mm) and at seven years (18.8 mm) reveals a total increase in the anteroposterior dimension of the nasopharynx of 6.8 mm. The same means for the normal at three months (14.7 mm) and at seven years (19 mm) shows an increment of only 4.3 mm. Thus, the cleft palate group was

TABLE 4. Mean values, in mm, for nasopharyngeal depth and standard deviations for all cleft palate subjects combined and for normal and cleft lip control groups according to age. (Sexes are combined.)

cleft palate						*normal*				*cleft lip*			
age	*N*	*PNS-PH*		*PTM-PH*		*age*	*N*	*PNS-PH*		*age*	*N*	*PTM-PH*	
		M	*SD*	*M*	*SD*			*M*	*SD*			*M*	*SD*
months						*months*				*months*			
3	31	14.0	3.11	12.0	2.93	3	10	14.7	2.97	3	5	14.4	2.07
6	36	13.3	2.57	11.2	3.86	6	14	13.9	2.26	6	4	14.7	2.86
9	26	13.1	2.57	10.8	3.00	9	15	14.6	1.81	9	7	15.1	2.28
years						*years*				*years*			
1	38	13.9	3.15	11.7	3.16	1	17	15.4	3.49	1	9	16.8	2.61
1.6	38	14.8	2.95	12.8	2.61	1.6	16	14.9	3.20	1.6	8	19.7	1.82
2	38	16.0	3.18	13.5	3.02	2	21	16.3	3.26	2	6	17.5	2.63
2.6	41	15.9	2.76	13.4	2.76	2.6	21	14.8	2.55	2.6	9	18.6	2.47
3	41	16.1	3.15	13.7	3.45	3	30	16.3	3.19	3	8	18.7	1.23
4	41	18.3	3.49	15.4	3.65	4	29	16.8	3.89	4	10	19.3	2.65
5	32	17.6	4.18	14.8	3.51	5	27	18.1	2.78	5	10	18.2	1.14
6	21	20.9	4.57	17.2	4.42	6	25	17.7	4.36	6	6	20.3	1.30
7	10	21.3	4.52	18.8	3.78	7	28	19.0	4.13	7	3	20.3	1.30

TABLE 5. Nasopharyngeal depth, expressed in millimeters and in percentage of total increment, for the cleft palate group, using PTM and PNS landmarks, and for the normal control group, according to age level.

Groups	*3 mos. to 1½ yrs.*		*1½ to 3 yrs.*		*3 to 5 yrs.*		*5 to 7 yrs.*		*Total mm*
	mm	*%*	*mm*	*%*	*mm*	*%*	*mm*	*%*	
cleft palate (PTM-PH)	0.8	11.8	.9	13.9	1.1	16.1	4	58.8	6.8
cleft palate (PNS-PH)	0.8	10.9	1.3	17.9	1.5	20.5	3.7	50.6	7.5
normal (PNS-PH)	0.2	4.6	1.4	32.5	1.8	41.8	0.9	20.9	4.3

found to increase a slightly greater amount than the normal group during the specified time interval. The difference between the cleft palate group and the normal was statistically significant for only the nine-month and the six-year levels.

Also reported in Table 4 are data for nasopharyngeal depth for the cleft palate subjects, using PNS-PH as the measure. The increment observed for PNS-PH from age 3 months to 7 years is 7.3 mm.

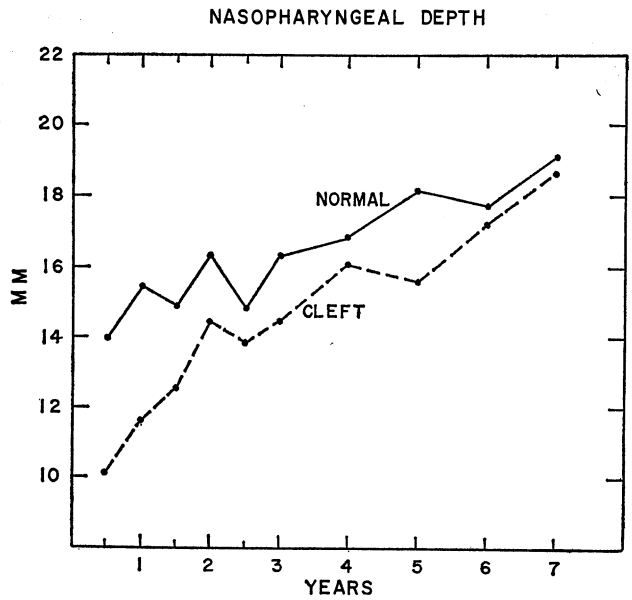

FIGURE 3. Rate and pattern of change in nasopharyngeal depth with age, for the cleft palate and the normal control group.

Percentages of total increment in the horizontal dimension of the nasopharynx are presented for the cleft palate and normal control group in Table 5. For the age intervals of three months to one and one-half years of age, and five to seven years of age, the cleft palate group showed a greater percentage of increase in the horizontal dimension of the nasopharynx than was observed for the normal group. The reverse was true for the one and one-half to three and the three-to-five-year intervals. It is interesting to note that by the end of five years of age the cleft palate group realized approximately one-half of the total increment in the horizontal dimension of the nasopharynx; the normal group, however, for the same period, achieved more than three-fourths of the total increment in this dimension. It would appear from these data that the cleft palate group attained a greater proportional increment in the horizontal dimensions of the nasopharynx between five and seven years of age (about 50% of the total). The rate and pattern of increases in the horizontal dimension of the nasopharynx for the cleft palate and normal group is illustrated in Figure 3.

As shown in Table 5, nasopharyngeal depth increases in cleft palate subjects were comparable for the three months to one and one-half years age level regardless of whether PTM or PNS was used. The normal group showed a much smaller increment (4.6%) for the same age interval. For the one and one-half to three years age level, increments in nasopharyngeal depth were greater when PNS was used (17.9%) than when PTM

was used (13.9%). Similar trends were observed for the three-to-five-year period. For the cleft palate subjects, greatest increment in nasopharyngeal depth occurred during the five-to-seven-year age interval, based on measurements using either PTM (58.8%) or PNS (50.6%). By comparison, it is noted that the normal group showed the greatest percentage increase in nasopharyngeal depth in the three-to-five-year age interval. A percentage increase of 20.9% was noted for the normal group during the five-to-seven-year age level.

Discussion

Continued velopharyngeal adequacy with increase in age is strongly dependent upon a close coordination in growth of the anatomical parts involved in velopharyngeal closure (that is, the soft palate and the contiguous pharyngeal structures). Results from the present study emphasize the important changes in height and depth of the nasopharynx, occurring over time, for cleft palate children. While the cleft palate group demonstrated an increase in nasopharyngeal height with age, the dimension was shorter than the normal at most of the age levels studied. That shortness could be due in part to either a deficiency and/or a displacement of the maxilla. Brader (*1*) stated that cleft palate individuals manifest a superior position of the posterior margin of the hard palate as compared to control subjects, while Graber (*5*) is of the opinion that the maxilla in cleft palate patients is deficient in vertical growth.

The shorter vertical measurements in cleft palate subjects may be interpreted as indicating that the posterior limits of the hard palate are closer to the cranial base (Figure 4). Thus, the posterior aspect of the hard palate would be located closer to the roof of the nasopharynx. The posterior pharyngeal wall slants in a downward and backward direction away from the base of the skull before it becomes more vertical in its posture relative to the skull. Less vertical growth of the maxilla would keep the soft palate more closely related to that aspect of the nasopharynx which curves downward and ventrally, facilitating velopharyngeal closure (Figure 5). However, it should be mentioned that between five and seven years of age, it was observed that the increase in the nasopharyngeal vertical dimensions was greater in the cleft palate group than for the normal group. At the older age levels, the soft palate was carried away from the superior direction to the more vertical aspect of the nasopharynx at a more rapid rate than that observed for the normal, increasing the dimension in which the soft palate must function.

Increases in the anteroposterior dimension (the depth of the nasopharynx) in the cleft palate subjects were noted for all age levels studied. During the early stages of development, the cleft palate group showed shorter anteroposterior dimensions of the nasopharynx than did the normal subjects, but, during the later stages of development (five to seven years of age), the cleft palate group showed anteroposterior di-

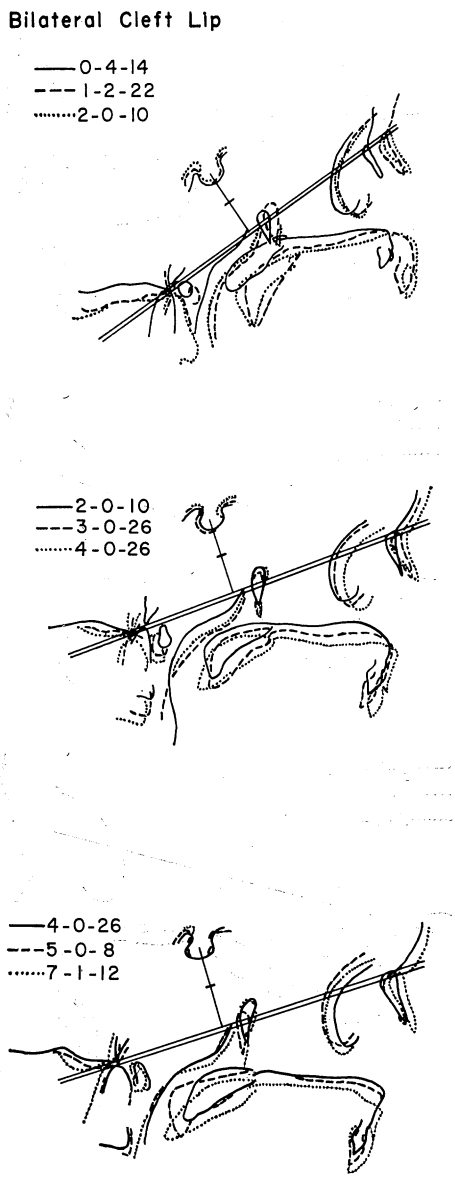

FIGURE 4. Superimposed tracings of cephalometric x-ray films for a cleft lip only subject, indicating changes with growth in dimensions of the nasopharynx. (Information regarding age is in years-months-days.)

mensions which were closer to those observed for the normal group. The cleft palate group demonstrated the greatest gains in nasopharyngeal depth during the five-to-seven-year age interval, suggesting that, at the older age levels, the vertical descent of the hard palate places the posterior aspect of the hard palate farther away from the superior and pos-

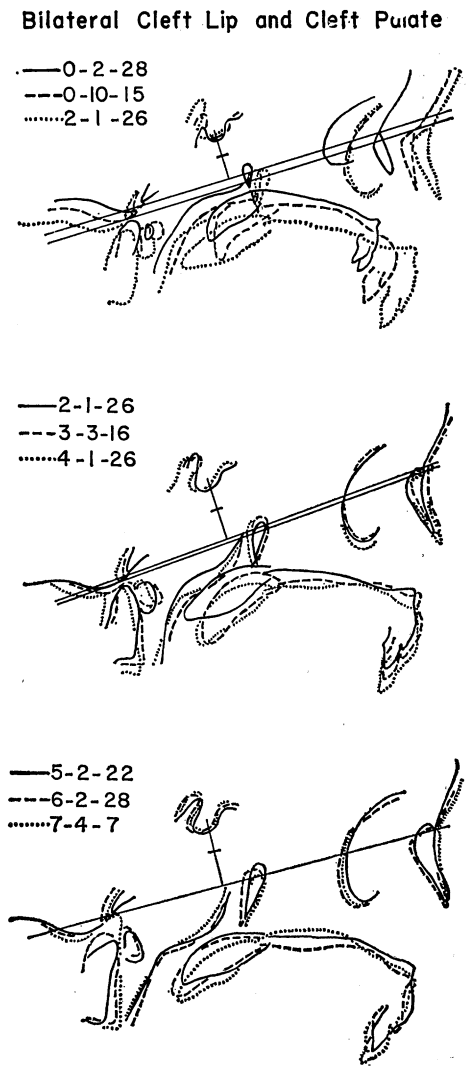

FIGURE 5. Superimposed tracings of cephalometric x-ray films for a cleft palate subject, indicating changes with growth in the dimensions of the nasopharynx. (Information regarding age is in years-months-days.)

terior walls of the nasopharynx. This is important in evaluating potential velopharyngeal activity in cleft palate subjects.

The soft palate, by virtue of its attachment to the hard palate, is also being spatially repositioned with growth and must grow to overcome the increased nasopharyngeal dimensions if normal function is to be maintained. In some of the cleft palate subjects, the posterior margin of the hard palate, presumably as a consequence of the cleft, was considerably forward in its relation to the anterior limits of the nasopharynx. This observation was substantiated by the larger distances for PNS-PH

than for PTM-PH. Therefore, because of a relatively more ventral attachment of the velum in many cleft palate patients, the soft palate must move a greater than normal distance in order to contact the posterior pharyngeal wall. This observation seems particularly pertinent since a previous study (*4*) showed that the cleft palate group tended to have shorter velar lengths when compared to noncleft subjects. Velar length has been demonstrated to be an important variable related to velopharyngeal opening (*12*).

The comparatively shorter velar length and the comparatively greater dimension through which the soft palate must move to contact the posterior pharyngeal wall could explain the development of inadequate velopharyngeal closure for some cleft palate individuals as a consequence of growth.

Although notable increases in nasopharyngeal depth were discernible for all groups, the measurements were shorter for the cleft palate group than for the control group. The trend was apparent for most of the age levels studied. An explanation for this finding may be the failure of the maxilla to descend and to move forward sufficiently to a nasopharyngeal depth which is similar to that in the control group. It may also be that adenoid tissue may have been greater in quantity for cleft palate patients than in the normals as suggested by Brader (*1*).

The greatest proportional increments in horizontal dimensions of the nasopharynx were demonstrated for the cleft palate group between the ages of five and seven years. Fifty percent of the total increment in nasopharyngeal depth in the cleft palate group occurred during this two-year period. This finding may be significant with respect to speech. Ricketts (*10*) postulated that postoperative cleft palate patients frequently experience increased nasal emission after age six to eight years of life. Such speech difficulties could be attributed to changes associated with growth in the nasopharyngeal region, which results in positioning the soft palate at such a distance from the nasopharyngeal wall that contact between the two structures is not possible. Subtelny (*14*) suggests that this new level of velopharyngeal function could explain why a patient with a repaired cleft palate has good speech at an early age and poor speech at a later age. He maintains that the dimension of the nasopharyngeal space, as well as changes in configuration of this area resulting from growth, could be an added contributing factor.

Summary

A serial cephalometric study of the growth of the nasopharynx in cleft palate children was undertaken to determine incremental changes in height and depth from birth to seven years of age. Fifty-seven children with varying degrees of cleft lip and/or palate were selected for this study. Cephalometric records were taken from birth through seven years of age. The data obtained on the cleft palate subjects were compared

with cleft lip only and normal control groups. The following findings were obtained. a) Steady and consistent increase in nasopharyngeal height was noted throughout the periods studied. Shorter nasopharyngeal vertical measurements were observed for the cleft palate group than for the normal group, at most of the age levels studied. b) Little increase in the anteroposterior measurement of the nasopharynx was recorded from birth through the first year of life. Thereafter, there was an increase in the anteroposterior dimensions of the nasopharynx until the seventh year of life. c) Shorter nasopharyngeal horizontal measurements were noted for the cleft palate group than for the normal group, for most of the age levels studied. Greater proportional increments in the horizontal dimensions of the nasopharynx were noted between five and seven years of age in the cleft palate group.

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