Longitudinal Analysis of Growth of the Soft Palate and Nasopharynx from Six Months to Six Years

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Between the ages of six months and six years, *longitudinal lateral headfilms* were taken on 54 patients with *palatal clefts* or with unilateral and bilateral clefts of the lip and palate. They were measured and were compared to data on both *normals* and subjects with clefts of the lip only. The objectives of the study were:

1. To study the effects of *palatal surgery* on the *growth* of the *soft palate*.
2. To compare the growth of the soft palate and *nasopharynx* among the patients with various types of clefts and normals.
3. To study the *growth acceleration* or so-called *catch-up growth* after palatal surgery at various ages. (Anterior palatal surgery at 14 months ± 2 months. Posterior palatal surgery at 16 months ± 2 months.)
4. To evaluate the relationship between *velopharyngeal growth* in cleft groups and *voice quality*.

Introduction

This longitudinal study was designed to investigate the effect of two-stage palatal repair on growth of the soft palate and nasopharynx.

The investigation was undertaken to obtain the following specific information:

1. Growth of the soft palate and nasopharynx in three cleft groups (CP, UCLP and BCLP) aged six months to six years.
2. Effects of surgical repair of the hard and soft palates on growth of the velopharyngeal structures.
3. Correlation between velopharyngeal growth in cleft groups and voice quality.

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Subjects

The sample consisted of 20 children with unilateral complete clefts of the lip and palate (UCLP) (14 male, 6 female); 10 with bilateral clefts of the lip and palate (BCLP) (8 male, 2 female); 13 with clefts of the palate only (CP) (6 male, 7 female); and 15 controls (7 male, 8 female). The sexes were pooled. The normal control information used by Subtelny (1956, 1957) was utilized as a second control sample.

Material and Methods

Longitudinal growth data were obtained from lateral x-ray headfilms of children taken from six months to six years of age. All records were complete since there were no missed appointments by any of the subjects during the period of the study. Hence, this is a "pure" rather than a "mixed" longitudinal study. Recall was made on the birthday of the patient, at six-month intervals during the first two postnatal years, and annually thereafter.

The normal control group included two samples:

1. The Lancaster Cleft Palate Clinic sample consisted of 15 subjects, eight of whom had clefts of the lip with no palatal defects. Seven subjects were the normal twin siblings of cleft subjects participating in the study.
2. A second sample consisted of the normative data on the growth of the soft palate and nasopharynx reported by Subtelny (1956, 1957).

The cephalometric roentgenograms were traced and digitized by an experienced operator (Figure 1). An OSCAR Unit Model F scanning device recorded designated points from the traced cephalometric films as x-y coordinates. These coordinates were produced at various voltage levels and were automatically fed into a decimal converter. The converter changes the voltage levels into integer numbers and feeds these numbers into an 026 card punch which in turn produces a punched data card. By the application of appropriate programs, data were analyzed and the results printed on read-out paper.

Ratings of oral-nasal resonance balance (nasality) were made from tape recordings of each patient's speech. They were made by one of the authors (RTM) who has had extensive experience in the evaluation of nasality disturbances associated with cleft palate. Each patient was judged as nasal or as of socially acceptable voice quality during a conversational speech sample. Each patient's nasality was rated at three years of age and again at six years.

Results

VELAR LENGTH. The mean velar length (PTM-U and PNS-U) for various cleft types was compared to the control group (Tables 1, 2). At six months of age, prior to the palatal surgery, the mean velar length for all cleft types was significantly shorter than that of the controls. There was no significant difference in this respect among the cleft types at six

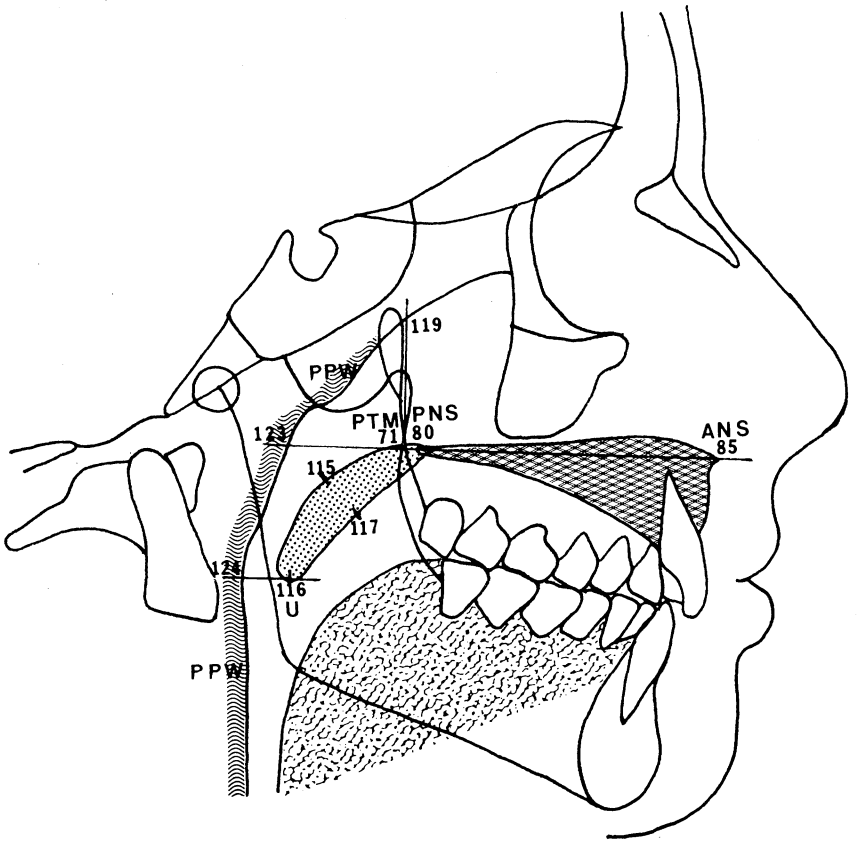

FIGURE 1. Digitized cephalometric tracing of the velopharyngeal region. Soft palate length, PNS (posterior nasal spine)—U (tip of uvula). 80–116 or PTM (pterygomaxillary fissure)—U, 71–116. Thickness of the soft palate, 115–117. Height of the nasal pharynx (71–119), measured along a perpendicular line to the palatal plane (superior pharyngeal wall SPW-PTM). Depth of nasal pharynx, PTM-PPW (71–123 posterior pharyngeal wall) or PNS-PPW (80–123).

months. The amount of difference at six years for cleft patients and the controls was less marked, suggesting that the soft palate grew relatively more in the cleft palate group than in the controls and indicating that there was catch-up growth. Interestingly, there was no growth lag noted among the cleft types after palatal surgery. From birth to six years the absolute amount of velar length growth was greater than in the controls. More than half of the velar growth was attained from six months to one-and-a-half years in both the control and the cleft groups. The only variation noted occurred among the cleft palate only (CP) group, i.e., the velar length was relatively greater from one-and-a-half years to six years than from six months to one-and-a-half years. Even though no significant difference is noted in the velar length among the cleft types, the cleft palate only (CP) group showed consistently longer soft palates after the age of two years. There was no noticeable difference between

TABLE 1. Length of the soft palate, 80–116 (PNS–U)

age	*c.p.* *m.6 f.7* *m.*	*tot.13* *s.d.*	*u.c.l.p.* *m.14 f.6* *m.*	*tot.20* *s.d.*	*b.c.l.p.* *m.8 f.2* *m.*	*tot.10* *s.d.*	*control* *m.7 f.8* *m.*	*tot.15* *s.d.*	*n*	*normal "Subtelny"* *m.*	*s.d.*
6 mos.	18.64	1.59	19.68	2.15	18.30	1.16	23.30	2.73	18	21.3	1.42
1 yr.	20.73	1.46	20.62	2.28	21.11	2.22	25.99	2.93	17	22.6	1.36
1½ yr.	22.10	2.99	22.96	2.08	22.92	2.08	26.20	2.07	19	24.1	1.66
2 yr.	24.06	2.94	23.79	2.26	22.93	1.47	26.49	4.08	21	24.3	1.44
3 yr.	24.33	3.06	23.78	1.57	24.35	2.31	26.30	2.52	28	24.8	1.51
4 yr.	24.63	2.91	24.53	2.01	23.91	1.56	26.90	2.22	29	25.7	1.51
5 yr.	27.13	2.64	25.69	2.24	25.16	1.95	27.97	2.59	29	26.5	1.86
6 yr.	27.20	2.62	26.03	2.11	25.80	2.49	28.36	2.64	25	27.4	2.18

* Measurements in millimeter.

Means and standard deviations for soft palate length in three types of clefts, controls (cleft lip or normal twins), and normals by Subtelny.

TABLE 2. Length of the soft palate, 71–116 (PTM–U)

age	c.p. m.6 f.7 m	tot.13 s.d.	u.c.l.p. m.14 f.6 m.	tot.20 s.d.	b.c.l.p. m.8 f.2 m.	tot.10 s.d.	control m.7 f.8 m.	tot.15 s.d.
6 mos.	17.57	1.73	18.42	2.08	17.23	1.07	21.35	3.20
1 yr.	19.43	1.38	19.25	2.13	19.91	2.17	23.98	2.44
1½ yr.	20.83	2.76	21.55	2.03	21.63	2.24	24.45	2.34
2 yr.	22.74	2.93	22.31	2.19	21.75	1.43	24.46	3.48
3 yr.	22.93	2.80	22.33	1.48	22.90	1.89	23.81	2.13
4 yr.	23.31	2.76	23.11	1.95	22.74	1.78	25.57	3.30
5 yr.	25.43	2.58	24.13	2.18	23.51	1.86	26.01	2.54
6 yr.	25.74	2.59	24.49	2.23	24.31	2.82	25.98	2.32

Note that the soft palate growth pattern is the same regardless of PTM or PNS skeletal landmarks used as reference point for measurements. Note also linear measurements of the velar length when PTM is more posteriorly placed and closer to U than PNS-U. There was no significant difference in velar length between our control and Subtelny's normative data.

the unilateral (UCLP) and bilateral (BCLP) cleft lip and palate groups.

Velar Thickness (Nasal to Oral Sides). The growth of velar thickness (the maximum dimension in the velum between its oral and nasal surfaces) occurred most rapidly between six months and a year-and-a-half in all cleft types and in the controls (Table 3). Slight reduction in thickness was noted between one-and-a-half and three years. There was no significant difference among the cleft types nor between the cleft and control groups. A slight reduction in thickness was noted in the cleft palate only (CP) group at all ages.

Vertical Heights (PTM-SWP). The height of the nasopharynx was measured along a perpendicular line to the palatal plane at PTM, intersecting the superior wall of the nasopharynx. The vertical height changes at various ages among the cleft types and between the cleft group and the control sample revealed no significant differences (Table 4). At the ages of five and six years, the cleft groups had a slightly greater nasopharyngeal height than the controls. Fifty percent of the total increase in the vertical height of the nasopharynx occurred between the ages of six months and a year-and-a-half in the control group. However, the three cleft types showed a relatively greater increment from one-and-a-half years to six years. There were no significant differences in the mean of nasopharyngeal height among the cleft types at the ages of three, four, and five years.

Depth of the Nasopharynx. Nasopharynx depth was measured along the palatal plane from PTM-PPW and PNS-PPW. There was a significant difference between the mean depth of the nasopharynx in the control and cleft groups at six months of age, i.e., the control group had a greater anteroposterior dimension (Tables 5 and 6). The depth increment from six months to six years for the control was 3 mm; unilateral cleft lip and palate (UCLP), 4.16 mm; bilateral cleft lip and palate (BCLP), 4.67 mm; and cleft palate only (CP), 1.34 mm. Thus, the cleft

TABLE 3. Thickness of the soft palate at mid-level, 115–117 (MN-MO)

age	*c.p.* *m.6 f.7* *m.*	*tot.13* *s.d.*	*u.c.l.p.* *m.14 f.6* *m.*	*tot.20* *s.d.*	*b.c.l.p.* *m.8 f.2* *m.*	*tot.10* *s.d.*	*control* *m.7 f.8* *m.*	*tot.15* *s.d.*	*normal "Subtelny"* *m.*	*s.d.*
6 mos.	5.51	0.67	6.21	0.83	5.11	0.92	7.16	1.26	7.2	0.40
1 yr.	5.75	0.73	6.63	0.82	6.21	1.23	7.55	1.02	7.5	0.66
1½ yr.	6.23	0.61	7.50	0.82	7.27	1.51	8.36	1.54	7.2	0.58
2 yr.	6.77	1.07	7.84	1.27	7.27	1.28	8.01	1.62	7.4	0.46
3 yr.	6.09	1.07	7.14	0.72	7.05	1.16	7.14	0.75	7.8	0.39
4 yr.	5.96	0.54	7.32	0.96	6.84	1.05	7.56	1.10	7.7	0.42
5 yr.	6.55	1.24	7.57	0.98	6.94	0.77	7.90	0.99	7.7	0.54
6 yr.	6.66	1.65	7.51	0.99	6.71	0.87	7.80	1.10	7.9	0.56

Means and standard deviations for soft palate thickness for all cleft types and two control groups.

TABLE 4. Height of nasopharynx, 71–119 (PTM-SPM)

age	c.p. m.6 f.7 m.	tot.13 s.d.	u.c.l.p. m.14 f.6 m.	tot.20 s.d.	b.c.l.p. m.8 f.2 m.	tot.10 s.d.	control m.7 f.8 m.	tot.15 s.d.
6 mos.	10.36	1.52	9.67	1.28	9.61	0.38	10.48	2.02
1 yr.	12.61	1.95	11.39	1.80	11.37	1.16	12.83	1.40
1½ yr.	13.63	1.14	13.72	1.61	13.16	1.38	13.90	1.88
2 yr.	14.48	1.74	14.82	1.72	14.58	1.84	15.56	2.12
3 yr.	16.26	1.32	16.01	1.80	15.86	1.64	16.21	1.98
4 yr.	17.63	1.53	16.99	1.67	16.70	2.07	16.91	2.27
5 yr.	18.80	1.36	18.00	2.10	18.12	2.13	17.24	2.32
6 yr.	19.42	1.66	19.10	2.32	18.35	1.91	17.33	2.95

Means and standard deviations for height of nasal pharynx in three cleft groups and control subjects for the ages recorded.

palate only group had a smaller increment than the other three groups. Nasopharynx depth was slightly greater at six years in the control group than in UCLP and BCLP. A significant difference was found in the nasopharyngeal depth between the control and cleft palate only (CP) groups at six years. Approximately one-third of the nasopharyngeal depth increment was attained in the cleft only (CL) group and in the control between six months and one-and-a-half years. The cleft palate only group routinely demonstrated a relatively greater increment in nasopharyngeal depth from six months to six years.

NASALITY RATING. For the purpose of this study, nasality judgments were analyzed only at three and six years. The results are presented in Table 7. As the table illustrates, we observed a general decrease in nasality from three to six years of age. The greatest amount of improvement was observed in the UCLP group. At three years of age, 75 per cent of the twenty patients in this group had nasality. By age six, only 30 per cent had nasality, a decrease of 45 per cent. The CP group showed an improvement of 25 per cent (44 per cent nasal at three years, 19 per cent at six years). Eighty per cent of the BCLP group were nasal at three years and 50 per cent at six years, a 30 per cent improvement. Overall, the BCLP group had the poorest ratings at each age.

Discussion and Summary

The length and function of the soft palate, the depth and width of the nasopharynx, and posterior and lateral pharyngeal wall activity are factors which affect velopharyngeal competency. Whether surgery affects these parameters is an important consideration.

The question of whether shortness of the soft palate is the result of prenatal velar underdevelopment (Veau & Forel, 1931), of palatal bony deficiency, or of nonfunctional atrophy (Coccaro, Subtelny, and Pruzansky, 1962) may be raised. Our data reveal a continuous relative growth rate of the soft palate from six months to six years and do not indicate nonfunctional velar atrophy.

The finding that velar length appears to be affected more in the

TABLE 5. Depth of nasopharynx, 80–123 (PNS-PPW)

age	*c.p.* *m.6 f.7* *m.*	*tot.13* *s.d.*	*u.c.l.p.* *m.14 f.6* *m.*	*tot.20* *s.d.*	*b.c.l.p.* *m.8 f.2* *m.*	*tot.10* *s.d.*	*control* *m.7 f.8* *m.*	*tot.15* *s.d.*	*n*	*normal "Subtelny"* *m.*	*s.d.*
6 mos.	13.50	2.97	13.36	3.34	11.67	2.20	16.17	4.24	14	13.9	2.26
1 yr.	13.17	3.71	14.01	3.20	11.53	1.85	16.99	4.67	17	15.4	3.49
1 1/2 yr.	13.03	1.58	15.99	4.40	13.38	1.70	16.66	3.69	16	14.9	3.20
2 yr.	13.15	2.37	16.48	3.06	13.11	3.28	18.15	4.91	21	16.3	3.26
3 yr.	12.69	3.51	16.74	3.28	15.25	3.24	17.05	5.77	30	16.3	3.19
4 yr.	14.12	2.80	17.87	3.41	16.80	3.94	20.20	7.08	29	16.8	3.89
5 yr.	15.70	2.98	18.15	3.88	16.34	5.09	19.75	6.61	27	18.1	2.78
6 yr.	15.33	4.44	18.42	4.22	17.44	5.02	19.40	6.54	25	17.9	4.36

The depth of the nasal pharynx in the three cleft groups, control and normal by Subtelny. The lesser nasopharyngeal depth in cleft groups than control could be related to increase in the size of the adenoid.

TABLE 6. Depth of the nasopharynx, 71–123 (PTM-PPW)

age	c.p. m.6 f.7 m.	tot.13 s.d.	u.c.l.p. m.14 f.6 m.	tot.20 s.d.	b.c.l.p. m.8 f.2 m.	tot.10 s.d.	control m.7 f.8 m.	tot.15 s.d.
6 mos.	11.91	3.00	11.73	3.25	10.34	2.08	13.59	3.59
1 yr.	11.53	3.41	12.05	3.04	9.70	1.65	14.47	4.79
1½ yr.	11.20	1.60	13.90	4.03	11.27	1.72	14.53	4.02
2 yr.	11.26	2.23	14.28	3.06	11.18	3.18	16.31	4.90
3 yr.	10.73	3.52	14.60	3.07	12.96	3.62	15.48	4.83
4 yr.	12.09	2.91	15.45	3.33	14.75	3.94	17.32	5.47
5 yr.	13.36	2.92	15.55	3.58	13.94	5.28	17.10	5.59
6 yr.	13.26	4.61	15.89	4.24	15.00	4.81	16.54	6.74

Means and standard deviations of the nasopharyngeal depth in millimeters in cleft subjects and control gruop. Please note a similar growth pattern between PNS-PPW and PTM-PPW, regardless of the two skeletal landmarks used as reference points for measurement.

TABLE 7. Percent of cleft subjects with socially acceptable voice quality

cleft type	n	age	
		three years	six years
Cleft palate only	16	56%	81%
Unilateral cleft lip and palate	20	25%	70%
Bilateral cleft lip and palate	10	20%	50%

UCLP and BCLP groups than in the CP only group suggests that intrauterine underdevelopment and palatal bony deficiency may contribute to velar deficiency at birth.

These data, from birth to six years, do not support the concept of the posterior border of thehard palate being superiorly positioned (Brader, 1957), nor do the data suggest a deficiency in vertical growth of the maxilla (Graber, 1949).

However, it should be reemphasized that the accelerated growth of the pre- and circumpubertal period is not considered in the present data and in time a differential rate of maxillary growth may occur between the cleft and normal individual. This might involve a latent growth aberrancy that we have not noticed up to the age of six years. We, therefore, do not anticipate diminished growth in this dimension of the nasopharynx, and posterior and lateral pharyngeal wall activity are factors which affect velopharyngeal competency. Whether surgery affects these parameters is an important consideration.

The question whether shortness of the soft palate is the result of prenatal velar underdevelopment (Veau & Forel, 1931), palatal bony deficiency, or of nonfunctional atrophy (Coccaro, Subtelny, Pruzansky, 1962) may be raised. These data reveal the continuous relative growth rate of the soft palate from six months to six years and do not indicate nonfunctional velar atrophy.

The finding that velar length appears to be affected more in the UCLP and BCLP groups than in the CP group suggests that intrauterine underdevelopment and palatal bony deficiency may contribute to velar deficiency at birth.

These data, from birth to six years, do not support the concept of the posterior border of the hard palate being superiorly positioned (Brader, 1957), nor do the data suggest a deficiency in vertical growth of the maxilla (Graber, 1949).

However, it should be reemphasized that the accelerated growth of the pre- and circumpubertal period is not considered in these data and in time a differential rate of maxillary growth may occur between the cleft and normal individual. This would involve a latent growth aberrancy that we have not noticed up to the age of six years. We, therefore, do not anticipate diminished growth in this dimension at a later age. Obviously, final answers can come only as the present subjects studied from birth to six years grow older.

We are also aware of the involution of tonsillar and adenoid tissues at puberty; hence, we expect changes in tonsillar-velopharyngeal relationships. However, the extent and its effect on the data cannot presently be estimated.

The presence of an adenoid mass certainly is an important variable in the determination of nasopharyngeal depth and height. The variability in height and depth measurements might possibly be related to variation in the size of the adenoids and adenoidal health conditions at various ages when tests were made.

Ricketts (1954) and Subtelny (1957) have stated that postoperative cleft palate patients frequently experience an increase in nasal emission after the age of six. They suggested that this difficulty might be attributed to the growth of the nasal pharyngeal region as well as to changes in configuration of this area resulting in lack of velopharyngeal seal. The data do not support the concept of the cleft groups as having better voice quality at an earlier age than at a later age because of an increase in the size of the nasopharynx. On the contrary, we have found that nasality decreases from the age of three to six years without intervention of secondary surgery. The CP only group had the least nasality at each age and the UCLP group showed the greatest decrease in nasality from three to six years of age. The results suggest that the relatively less nasality observed in the CP and UCLP groups may be related to a longer soft palate and shorter nasopharynx. The results similarly suggest that the relatively greater nasality observed in the BCLP group may be related to a shorter soft palate and a deeper nasopharynx.

We have also noted that the type of surgery performed has the least effect on the function of the soft palate. All patients with good speech quality demonstrated proper velopharyngeal closure (the details of speech performance and cineradiographic evaluation of the velopharyngeal region of these patients will be published in a subsequent paper).

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