Growth and Changes in Maxillary Arch Form in Complete Unilateral Cleft Lip and Cleft Palate Children

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The inhibition of maxillary growth resulting from arch collapse after surgical closure was described by Harvold (*1*), Subtelny (*2*), and others (*3, 4, 5*). Recently, for the prevention and/or the improvement of secondary deformities such as maxillary arch collapse, segmental displacement and cross bite, pre-operative or post-operative orthopedics and bone grafting have been suggested (*6, 7, 8*).

In order to understand the rationale of this treatment, it is essential to study the maxillary growth process during infancy and to understand the changes of the deformed parts. To enable a comparison of the maxillary growth process between normal and malformed subjects, it is necessary to measure the maxillary arch form tri-dimensionally. At the Department of Maxillo-facial Surgery of Osaka University Dental School, such a method has been developed by the authors (*9*).

The present study compares the growth changes of the maxillary arch of 62 normals and 87 complete unilateral cleft lip and cleft palate patients by the measurement of maxillo-facial models. This will help answer such questions as: when and where maxillary growth will occur, and the nature of the growth changes.

Procedure

Patients with complete unilateral cleft lip and cleft palate were classified into four age-groups:

1. 6 months old, before lip and palate surgery.
2. 2 years old, lip repair at 6 months.
3. 3 years old, lip repair at 6 months, palate closure at 2 years.
4. 4 years old, lip repair and palatal closure as in 3.

For the lip repair, Millard's rotation-advancement method and for the palatal closure, push-back operation procedures, were performed by one of

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TABLE 1. Distribution of the subjects.

stage	*normal group*					*cleft group*				
	number	*weight (kg)*		*age (Y–M)*		*number*	*weight (kg)*		*age (Y–M)*	
		mean	*SD*	*mean*	*SD*		*mean*	*SD*	*mean*	*SD*
1	16	7.1	0.3	0–6	0.6	29	7.1	0.5	0–6	0.5
2	11	11.2	0.6	2–0	0.6	30	11.1	1.0	2–0	1.2
3	21	13.4	0.7	3–2	1.8	14	13.4	0.8	3–2	1.6
4	14	15.3	1.1	4–3	1.7	14	15.2	0.9	4–2	2.1
Total	62					87				

the authors (T.M.). Normal subjects were also classified into four age-groups to match the cleft group by age and body weight (Table 1). Impressions were taken of each patient's upper jaw and upper face simultaneously, using alginate impression material under general anesthesia. The maxillo-facial model was then made.

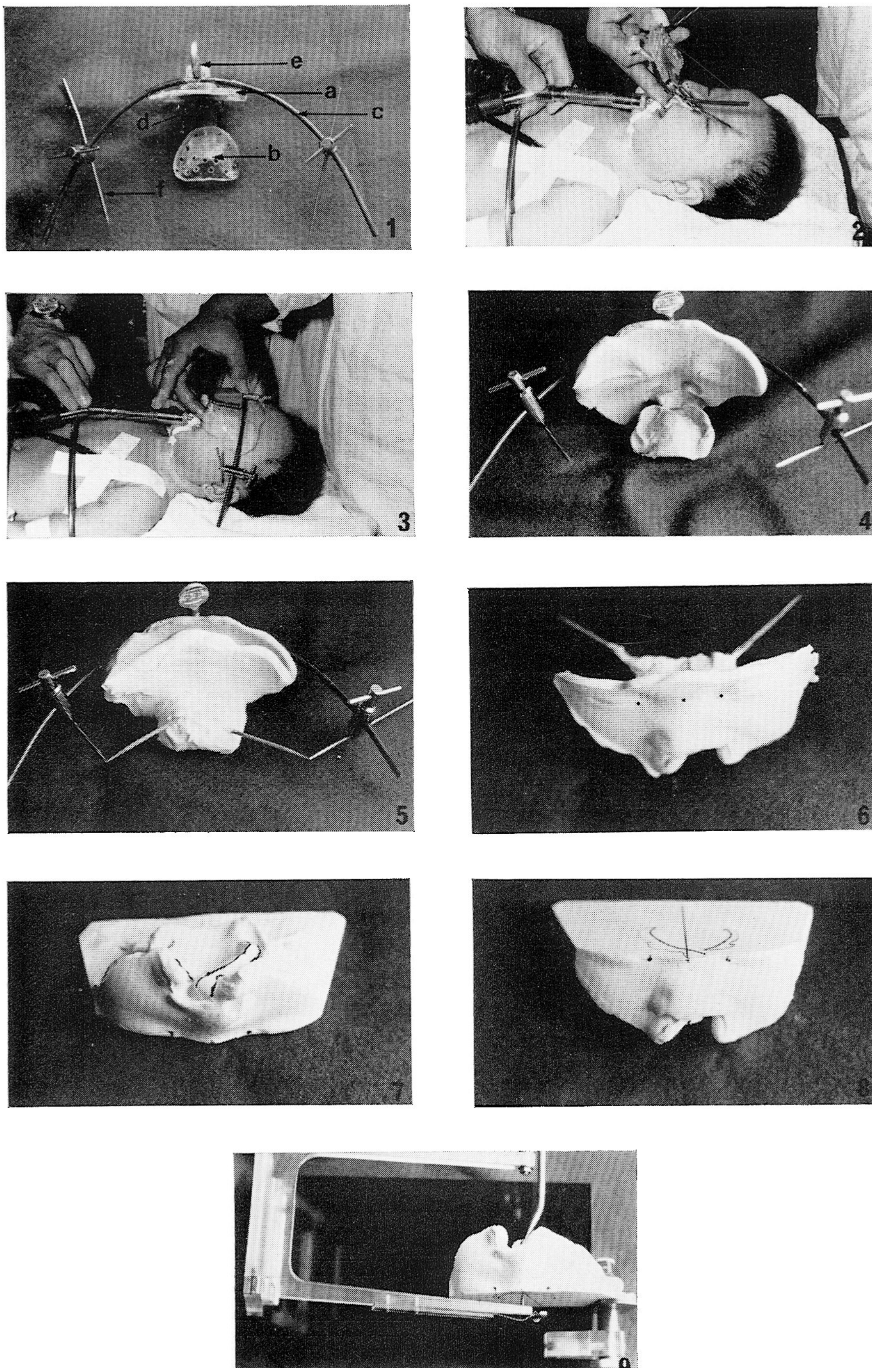
Techniques

In the study of the maxillary growth of the cleft lip and cleft palate patients, it is essential to evaluate the segmental displacements and the changes of the alveolar arch tri-dimensionally. This is not possible via the usual roentgen cephalometry or the dental models; the cephalograms lack three dimensions, and the dental models cannot be measured in relation to the other structures.

The model devised by the authors (*9*) which shows the details of the maxillo-facial relationship in three dimensions, makes it possible to relate the dental model to the cephalogram. The following illustrates the technique of making and measuring the model.

Figure 1 shows the method of taking the impression and the creation of the maxillo-facial model. The apparatus for impression-taking is composed of the facial tray (a), palatal tray (b), and face bow (c). The palatal tray and the facial tray are connected by a hinge (d) and an adjustive screw (e) to provide for ease of movement and stabilization at the proper position. The face bow is attached to the facial tray with index rods (f) on both sides in order to locate tragion* (Figure 1–1). Figures 1–2 and 1–3 show the impression procedure. After filling the trays with the impression material, the palatal tray is put into the mouth: the facial tray is then quickly placed on the face, involving upper lip, nose and eyes without pressing and distorting soft tissues. The palatal and facial trays are then set at the proper position by the adjustive screw. At the same time the index rods are adjusted to the tragia. The finished impression of the face and palate

* Tragion is at the base of the tragus of the ear. It is acceptably the external counterpart of porion.



FIGURES 1-1 to 1-9. Procedure of making the maxillo-facial model.

is shown in Figure 1–4. When impression-taking is completed, the maxillo-facial model is made so that the tips of the index rods are at tragion (Figure 1–5). The mid point of right and left endocanthion (inner corner of the eye) is marked. The cast excess above this point is trimmed (Figure 1–6). A thin layer of dental plaster is poured on a flat glass and the model is placed on it upside down. This establishes a horizontal plane which includes mid-endocanthion and the right and left tragia (Figures 1–7, 1–8, 1–9).

Model Analysis. To facilitate the measurement of the maxillary arch form in three dimensions, three bases of measurements were provided on the maxillo-facial model, i.e., horizontal plane, midline plane and tragion line (Figure 2). The horizontal plane is made up of the three upper facial points, i.e., mid point of right and left endcanthion and the right and left tragia. The midline plane is at the mid-endocanthion point and the mid-point of right and left tragion, and is perpendicular to the horizontal plane. The tragion line is established by connecting the right and left tragia.

Nishiki (*10*) has discussed the location of the mid-endocanthion: The nasion in the living subject is difficult to locate precisely. He concluded that the mid-endocanthion point was the equivalent of nasion. In a recent study, Tsuji (*11*) stated that tragion is not influenced by lip and/or palate clefting.

To ascertain the precision of the location of these upper facial points all subjects were examined. Since no significant differences were found between the normal and the cleft group related to age, weight, and upper facial dimensions, it was concluded that the horizontal plane was acceptable as a basis of measurement.

In measuring and analyzing maxillary arch form the following alveolar points are marked on the model (Figure 3): point A, where a line connecting the incisal papilla and the labial frenum crosses the crest of the alveolar ridge (this corresponds to the top of the interdental papilla between cen-

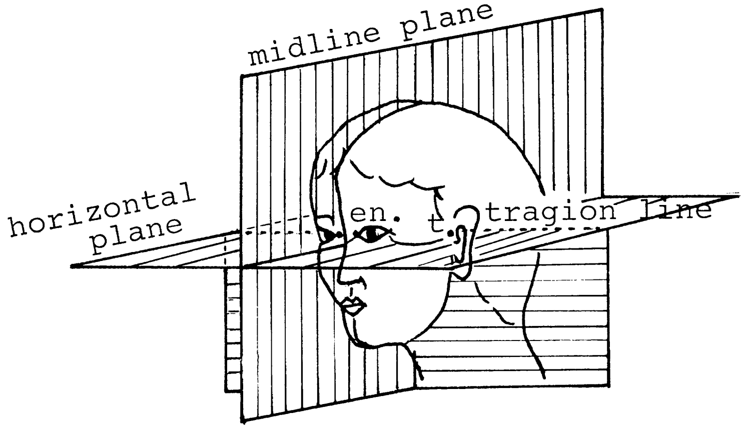


FIGURE 2. Basis of measurement.

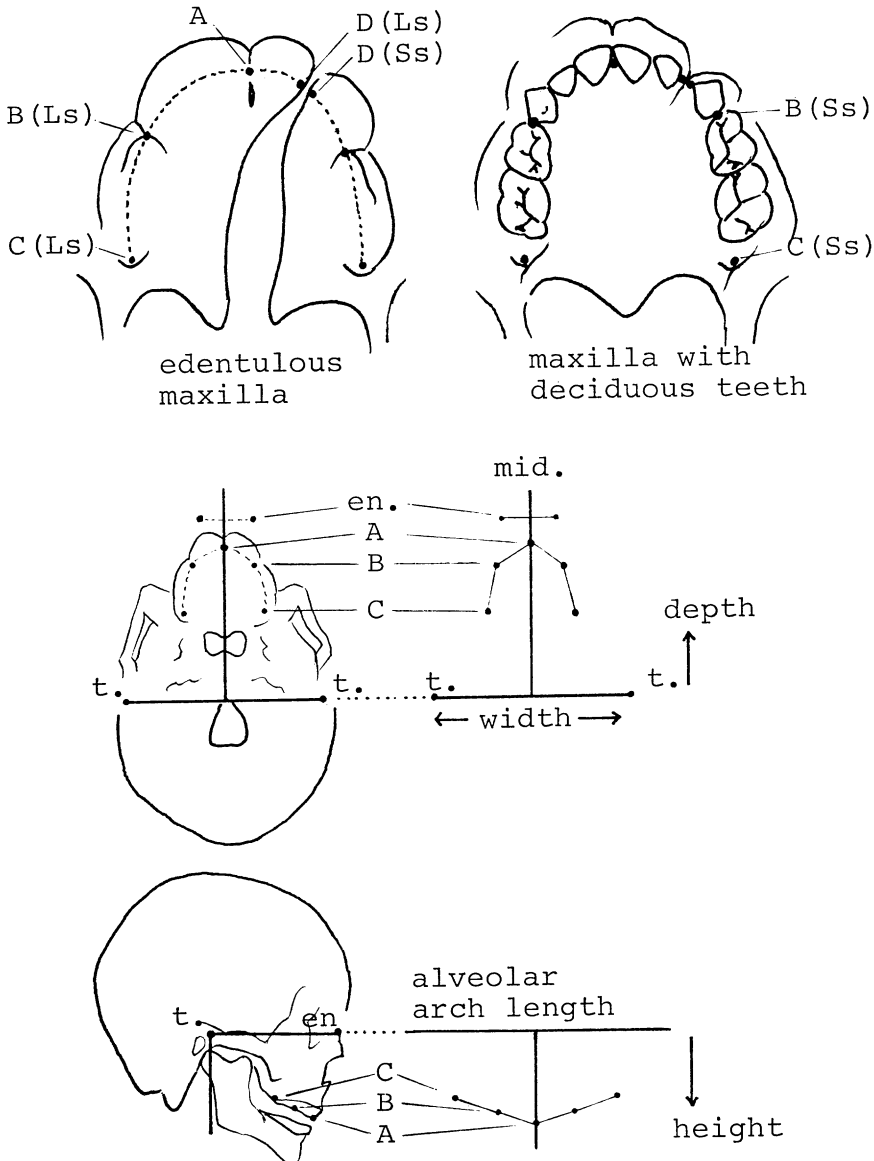


FIGURE 3. Measuring technique.

tral incisors in the deciduous dentition); point B, where a lateral sulcus crosses the crest of the alveolar ridge (this corresponds to the top of the interdental papilla between canine and first molar in the deciduous dentition); point C, the retromolar point; point D, where a line of the alveolar crest turns from the oral side to the nasal side at the anterior end of each segment in the cleft group. The B, C, and D points on the larger segment in the cleft group are given as B(Ls), C(Ls) and D(Ls), and the corresponding points on the smaller segment are B(Ss), C(Ss) and D(Ss). These alveolar points were comparable to those in studies by Sillman (12) and Tsuji (11).

All these points are projected on to the horizontal plane (Figure 1–9). The following *lengths* were measured on the horizontal plane: distance of each point from the bi-tragal line: *widths* of anterior palatal region (B-B), and of posterior palatal region (C-C): width of the cleft (D(Ls)-D(Ss)): *heights* from the horizontal plane to each point of the alveolar crest: alveolar arch length, i.e., a line connecting these alveolar points along the crest of alveolar ridge.

Error of the Model Measurement. All markings on the model and all measurements of length were taken by T. Wada. The average of three sets of measurements was taken to the nearest $\frac{1}{10}$ mm. Measurements on the dental models were checked with those on the living subject. The mean, standard deviation, and coefficient of variation of the alveolar points ranged less than 1.5%. No significant difference was found between the two measuring techniques.

It is difficult to determine the midline of the alveolar region because of the segmental displacement and the alveolar malformation. Nevertheless, a midline plane was established based on the upper facial points previously mentioned. The test of reliability of the midline plane established it as acceptable for it ran through the center of the alveolar region.

Findings

1). Normal group: 62 normal subjects were classified into four stages (Table 1). The results are shown in Table 2. Means and standard deviations were calculated for the measurements of the depths, widths, heights of alveolar points and the length of alveolar arch at each stage in the normal group. Significances of these factors were tested between each of the stages. A difference found to be significant ($P < 0.05$) was indicated by an asterisk (Table 2).

Depths of alveolar points. A high rate of increase occurred between stages 1 and 2 and stages 3 and 4.

Widths of alveolar points. The width of the anterior palatal region showed no significant change through the four stages. The width of the posterior palatal region increased gradually between each successive pair of stages.

Heights of alveolar points. Each alveolar point increased in each of the stages except point A in stages 2 and 3.

Alveolar arch length. The length of (A–B) increased between stages 1 and 2. There were no significant change between stages 2 and 3 and 3 and 4.

The mean patterns of the maxillary arch for each stage were constructed by connecting points A, B and C (Figure 4). The mean for each length was used as between stages, which aids in the analysis of the relative mean dimensional and morphologic changes between stage-linked arches.

Forward and downward growth of the anterior alveolar region increased between stages 1 and 2, and stages 3 and 4. There was little growth at the anterior alveolar

TABLE 2. Results in the normal group.

(1) Depths of the alveolar points.

stage	A		sig.				B		sig.				C		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	50.9	1.9		*	*	*	42.1	2.6		*	*	*	31.1	1.3		*	*	*
2	62.0	1.5			—	*	50.5	3.8			—	*	33.7	2.8			—	*
3	62.2	2.7				*	52.7	2.7				*	33.7	2.9				*
4	66.1	4.7					54.5	3.4					37.0	2.8				

(2) Widths of alveolar points.

stage	B(L)-B(R)		sig.				C(L)-C(R)		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	28.5	3.0		—	—	—	32.9	1.9		*	*	*
2	27.4	0.9			—	—	36.5	0.6			*	*
3	27.8	1.9				—	38.8	1.7				*
4	29.0	1.4					41.8	2.3				

(3) Heights of alveolar points.

stage	A		sig				B		sig.				C		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	36.6	1.8		*	*	*	34.0	1.9		*	*	*	30.2	1.8		*	*	*
2	45.1	1.6			—	*	42.6	1.5			*	*	34.7	2.2			*	*
3	46.6	2.9				*	44.4	2.5				*	36.5	3.1				*
4	48.7	2.5					46.9	2.9					39.7	3.3				

(4) Alveolar arch length.

stage	A-B		sig.				B-C		sig.				total arch length		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	16.5	2.3	*	*	*	*	12.8	1.9		*	*	*	57.6	4.9		*	*	*
2	18.9	1.1			—	—	17.2	2.1			*	*	72.3	3.6			*	*
3	18.9	1.2				—	19.7	2.2				—	78.5	5.1				—
4	20.0	1.8					19.5	1.4					79.2	4.4				

L, left side; R, right side; sig., significance by t test of mean difference (* = significant $P < 0.05$, — = not significant).

region during all stages. Depths and widths of point C increased gradually during all stages which demonstrated the growth of the posterior alveolar region, the area back of point C.

2). Cleft group: 87 patients with complete unilateral cleft lip and cleft palate were classified into four stages (Table 1). The results are shown in Table 3.

Depths of alveolar points. On the larger segment, points A and B showed a significant increase between stages 1 and 2 and stages 3 and 4. Point D(Ls) showed no significant change between stages 1 and 2 and stages 2 and 3, but increased significantly between stages 3 and 4. On the smaller segment the point B(Ss) showed a significant increase between stages 1 and 2 and stages 3 and 4.

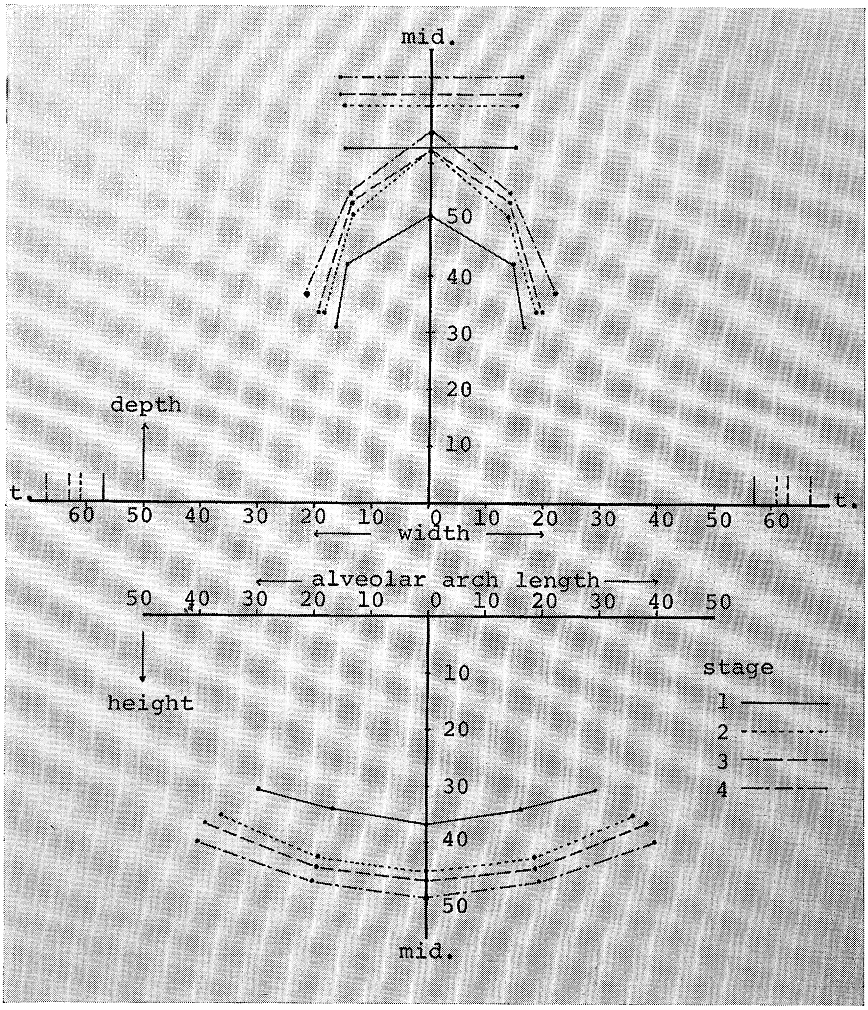


FIGURE 4. Mean pattern of the maxilla in the normal group.

Width of alveolar point. A great rate of decrease occurred between stages 1 and 2 at the anterior palatal region (B(Ls)-B(Ss)) and the cleft region (D(Ls)-D(Ss)). In the same period an increase occurred in the posterior palatal region of (C(Ls)-C(Ss)), and these lengths were thereafter similar. Consequently, a maxillary downward growth insufficiency was seen in this stage.

The maxillary arch form of stage 2, after lip repair, showed approximation of the alveolar segments with narrowing of the width of the anterior palatal region and of cleft width. The depths of points D(Ls), C(Ls) and C(Ss) remained about the same in stages 1 and 2, exhibiting an arch form with point A as the extreme point. The mean heights of the anterior alveolar points were in the relation of D(Ss) $\fallingdotseq$ D(Ls) $<$ B(Ss) $<$ A $<$ B(Ls), and the asymmetry in the heights of the alveolar region were still seen in stage 2.

In stage 3 about one year after palatal closure, the decrease in the depths of each alveolar point was noted as evidence of maxillary retrusion; however, changes were not as significant as in stage 2. The great rate of increase in the heights of alveolar points occurred between stages 2 and 3, and exhibited a symmetric arch form in the alveolar segments. Point A was positioned in approximation to the midline. Alveolar arch collapse was slight in stages 3 and 4.

Heights of alveolar points. Each of the alveolar points A, B(Ls). B(Ss), C(Ls) and C(Ss) showed a continuous increase between stages 1 and 2 and stages 3 and 4, but that between stages 3 and 4 was not significant.

Alveolar arch length. On the larger segment, the length of (A-D(Ls)) and (B(Ls)-C(Ls)) showed increases between stages 1 and 2, but the length of (A-B(Ls)) showed no significant changes up to stage 4. On the smaller segment the length of (D-(Ss)-B(Ss)) showed no significant change up to stage 4, but the length of (B(Ss)-C(Ss)) showed increases between stages 1 and 2. After this there was no significant change up to stage 4.

Symmetry of bilateral alveolar points in a stage. Point A showed a deviation toward the normal side in stage 1, but after this the deviation shifted toward the affected side. The depths and widths of point B and point C showed no significant bilateral changes in stage 1; however, the heights of point B(Ls) was larger than that of the point B(Ss) at stages 1 and 2.

Figure 5 shows the composite mean pattern of the cleft group. The maxillary arch form of stage 1 showed assymmetry in each dimension. Point D(Ls), the anterior end of the larger segment, was protruded and point A showed a lateral displacement toward the normal side. The widths of the anterior palatal region and cleft width were larger in stage 1 than in subsequent stages. The mean heights of anterior alveolar points were in the relation of D(Ls) $\doteqdot$ D(Ss) $<$ B(Ss) $<$ A $<$ B(Ls). Thus, the lateral segmental displacements and the segmental inclination upward appeared as if both alveolar segments in the anterior region were rotated to the cleft side.

Discussion

In an effort to compare maxillary growth in cleft subjects 62 normal subjects were studied at each stage, and were further classified by weight and age categories. Mean, standard deviation and significance of differences ($P < 0.05$) for each dimension were presented (Table 2). The mean pattern of the maxillary arch was then presented to render possible an evaluation of relative mean dimensional and morphological changes (Fig. 4).

The investigations undertaken by Hellman (*13*) and Krogman (*14*) via roentgen cephalometry, indicated that at birth face breadths were 55% of adult value, face depths 30–35%, and face heights 40–45%. At the age of two years the values were 80%, 75%, and 68%, resp. Thus postnatal facial growth differs in each set of dimensions, and indicates that the growth rate in depths and heights is greatest in early life. Further investigations of Scott (*15*) indicated that the facial and maxillary growth in depths and heights depended principally on the growth of the nasomaxillary complex and at the maxillary suture. For maxillary arch form Yoshioka (*16*) stated dimensional growth is not continuous, but showed step-like periods of slower and faster growth.

The present study confirms the views of earlier workers that the depths and heights of the maxillary arch increased significantly between stages 1 and 2 and stages 3 and 4, and that the increase of point A and point B, which coincided with the growth direction of the nasomaxillary complex, were greater than that of point C. Our findings also agreed with the explanation of maxillary dimensional growth by a synchronous apposition of bone to the posterior alveolar region and the posterior tuberosity.

It is evident that the malformation of cleft lip and palate must have some degrees of effect on the growth of the maxilla and the face. Clinical experience has shown an apparent maxillary retrusion, or underdevelopment in cleft patients. It is difficult to demonstrate when, how, and by what kind of factors the deformities develop.

Graber (*19*) and Harvold (*1*) pointed out via roentgen cephalometry that the major part of the deformity is localized in the area of the maxilla which lies below the anterior nasal spine and the nasal floor, i.e., the alveolar process and its immediate surroundings. Tsuji (*11*) reported in 1965 via dental models of cleft adult subjects that there was a growth inhibition in the area of the anterior alveolar region, especially in the premaxillary region. While it is possible that cause of this growth inhibition is related to a cleft lip and palate, it is unknown whether this is due to a deficiency of tissue, to a segmental displacement, or to a lack or arrest of growth potential.

Peyton (*20*), who compared the depths, widths, and heights of the alveolar arch on maxillary dental models, between normal and cleft patients, concluded that there was no evidence of significant difference between both groups at one year of age. However, an apparent difference in tissue deficiency in the cleft patient was noted at the age of three years. Coupé and Subtelny (*21*) made a cephalometric observation of cleft lip and alveolus, complete cleft lip and palate, and cleft of soft palate patients, and stated that there was a tendency to tissue deficiency in the cleft patients, and that the extent of the deficiency was related to cleft type. Huddart (*22*) measured the angle and the area at the posterior end on the maxillary dental model, and came to the conclusion that both tissue deficiency and segmental displacements were noted in complete unilateral cleft lip and palate patients, and the tissue deficiency was approximately 13.7% of neonatal normal subjects.

However, these studies on tissue deficiency, although including linear and angular measurements, do not deal with the quantitative difference of tissue.

As regards segmental displacements, Harvold (*1*) found no significant asymmetry beyond the maxillary complex, and attributed the major part of the cleft palate deformity to the change in position and shape of the maxillary segments. Innes (*23*) (living) and Atherton (*24*) (skulls) also observed that in the untreated cleft lip and palate, a medial palatal collapse of the lateral alveolar segments was associated with diminished downward growth of the alveolus, resulting in cross bite, lateral open bite, and anterior open bite. Hama (*25*) made a cephalometric study of the profile of 55 treated cleft lip and palate patients, and indicated that the maxilla of the complete cleft lip and palate patients revealed a superior location in height and in posterior depth in reference to the anterior cranial base.

Concerning other aspects of the maxillary growth aberrations, Van Limborgh (*26*) studied cleft skulls of different ages and types, and concluded that in individuals with cleft the growth process is slower than in normal individuals but that the growth potentials are essentially the same, except in the region of the cleft. However, it is not known whether this was a temporary or permanent retardation in growth, and whether this would be compensated for by a prolonged period of growth or by an increased rate of growth at a later age. Pruzansky (*27*) stated that the child with a cleft palate is endowed with inherent potentialities for growth and development that reflect his genetic heritage and the metabolic climate in which he thrives. Subtelny (*28*), quoting this, continued as follows, "Thus, it must be appreciated that some have a potential for attaining a favorable facial appearance, whereas some right from the time of birth, do not have this potential."

The present investigation showed growth changes in dimensions and form of the maxilla with complete unilateral cleft lip and palate (Fig. 4, 5).

At stage 1, prior to lip repair, the anterior end of the larger setment is prominently forward, and the bilateral alveolar segments, especially in the anterior alveolar region, are deflected laterally. The heights of the anterior alveolar region were considerably less than those of the normal group. It is apparent from these findings that the lack of tension due to the cleft may be a reason for the protrusion of the anterior end of the larger segment and the lateral segmental displacement. However, the segmental feature, such as segmental rotation at the anterior alveolar region, must be responsible for the reduced downward growth.

At stage 2, after lip repair and just prior to palatal closure, growth disturbance in depths and heights was noted in all the alveolar points in the anterior alveolar region in comparison with the normal group. The nature of this growth deviation was explained by Hama (25) and Tsuji (11) who stated that the maxilla was located in a superior and posterior position.

It is commonly stated after lip repair that the lip molds the segments toward the midline and reduces the transverse diameter of the cleft (*27*). The present investigation revealed that the width of the anterior palatal region (B(Ls)-B(Ss)) was reduced significantly in stage 2, i.e., the abnormally deflected lateral segments were depressed (Table 3). Furthermore, it is revealed that the form of the anterior alveolar region changed into an arch form with the point A as the extreme point. The lateral segmental displacements seen between stage 1 and stage 2 is probably responsible for the deviations in other structures. This must have influenced, along with the morphological change at the anterior alveolar region, the lower part of the nasal septum, which has an important role in the deviation of maxillary growth. As a result of this, growth direction and amount are changed.

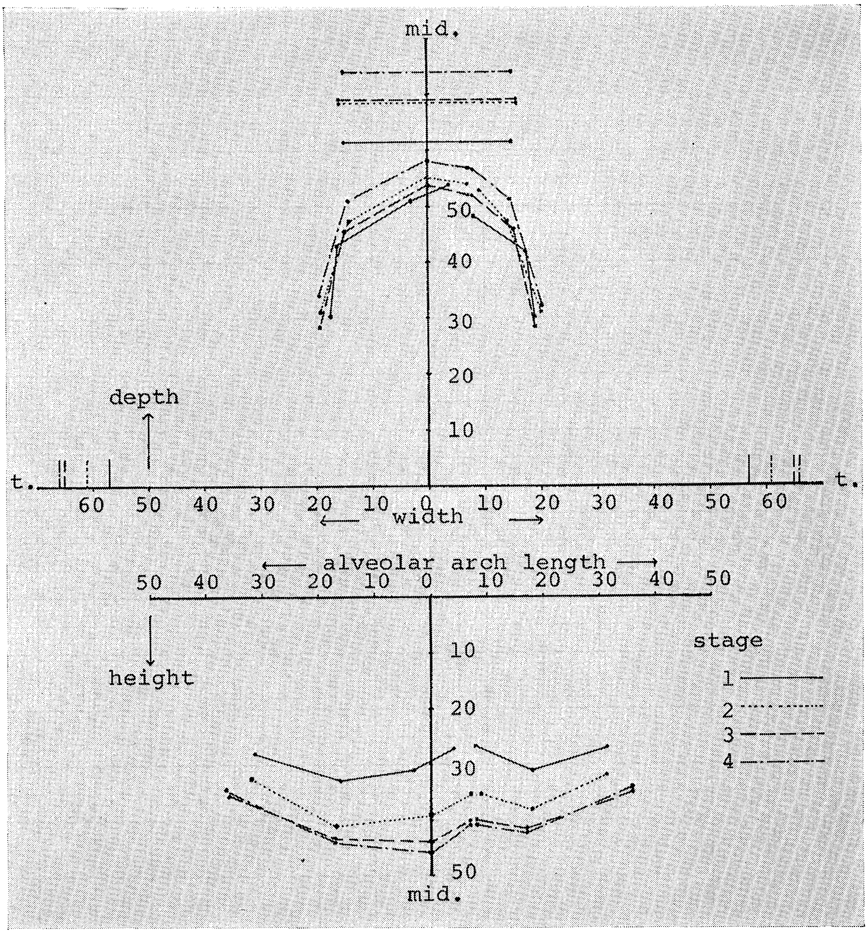


FIGURE 5. Mean pattern of the maxilla in the cleft group.

At stage 3, one year after palatal surgery, the depths in all alveolar points diminished, but not significantly compared to stage 2.

At stage 4 the depths and heights in all alveolar points increased, but height increase was slight. The total increase of each alveolar point in depth from stage 2 to stage 4 was similar to that of the normal group.

The push back operation performed in patients in this study may give a temporary growth inhibition in depth as seen in stage 3. However, the underdevelopment in the forward growth seen in stage 2 is largely responsible for that seen in stage 4.

Our study has shown that the major part of the growth disturbance was in the anterior alveolar region and was characterized as antero-posterior growth insufficiency after lip repair. The orthopedics after lip repair which will stabilize the segments should be planned for the diminished cleft

TABLE 3. Results in the cleft group.

(1) Depths of alveolar points.

stage	A		sig.				B(Ls)		sig.				B(Ss)		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	51.0	3.0		*	*	*	42.9	3.5		*	*	*	41.6	4.1		*	*	*
2	55.3	3.9			—	*	47.4	4.3			—	*	46.8	4.1			—	*
3	53.6	4.2				*	45.5	4.9				*	46.5	5.5				*
4	58.1	3.3					51.5	3.0					51.1	2.6				

stage	C(Ls)		sig.				C(Ss)		sig.				D(Ls)		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	30.1	3.9		—	—	*	29.7	4.2		—	—	—	53.7	3.0		—	—	*
2	30.8	2.9			*	*	31.0	3.1			*	—	53.7	4.2			—	*
3	28.1	5.9				*	28.1	4.1				*	52.3	4.5				*
4	33.5	3.4					31.9	1.9					56.9	2.9				

stage	D(Ss)		sig.			
	mean	SD	1	2	3	4
1	48.2	3.0		*	*	*
2	52.8	3.3			—	*
3	52.2	4.5				*
4	56.4	2.7				

(2) Width of alveolar points.

stage	B(Ls)-B(Ss)		sig.				C(Ls)-C(Ss)		sig.				D(Ls)-D(Ss)		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	33.1	3.1		*	*	*	36.4	2.3		*	*	*	9.4	3.9		*	*	*
2	27.8	3.0			—	—	39.3	2.5			—	—	2.5	1.7			—	—
3	29.9	4.0				—	39.2	6.3				—	1.8	1.7				—
4	29.0	2.3					39.4	3.8					1.2	1.5				

(3) Heights of the alveolar points.

stage	A		sig.				B(Ls)		sig.				B(Ss)		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	31.2	2.6		*	*	*	33.4	2.5		*	*	*	30.5	2.5		*	*	*
2	39.6	3.1			*	*	40.1	2.3			*	*	37.4	2.2			*	*
3	43.6	2.5				—	43.5	3.4				—	41.8	2.9				—
4	45.5	4.0					43.9	4.7					42.3	4.9				

stage	C(Ls)		sig.				C(Ss)		sig.				D(Ls)		sig.			
	mean	SD	1	2	3	4	mean	SD	1	2	3	4	mean	SD	1	2	3	4
1	28.0	3.2		*	*	*	27.0	2.9		*	*	*	27.4	2.0		*	*	*
2	32.4	2.7			*	*	31.9	0.9			*	*	35.3	2.1			*	*
3	35.3	3.8				—	34.9	3.8				—	40.1	2.5				—
4	34.5	3.3					34.4	2.4					40.9	4.8				

Ls, larger segment; Ss, smaller segment; sig., significance by t test of mean difference between stages (* = significant $P < 0.05$, — = not significant).

TABLE 3. *Continued*

stage	D(Ss) mean	D(Ss) SD	sig. 1	sig. 2	sig. 3	sig. 4
1	26.8	2.1		*	*	*
2	35.3	2.1			*	*
3	40.2	2.4				—
4	40.8	4.8				

(4) Alveolar arch length.

stage	A-D(Ls) mean	A-D(Ls) SD	sig. 1	sig. 2	sig. 3	sig. 4	A-B(Ls) mean	A-B(Ls) SD	sig. 1	sig. 2	sig. 3	sig. 4	B(Ls)-C(Ls) mean	B(Ls)-C(Ls) SD	sig. 1	sig. 2	sig. 3	sig. 4
1	6.3	2.3		—	—	—	14.5	3.4		*	*	*	14.5	3.0		*	*	*
2	7.1	1.9			—	—	18.3	3.2			—	—	18.6	4.1			—	*
3	7.1	1.7				—	17.3	3.6				—	18.5	1.6				*
4	6.7	2.8					17.7	2.0					20.3	1.8				

stage	B(Ss)-D(Ss) mean	B(Ss)-D(Ss) SD	sig. 1	sig. 2	sig. 3	sig. 4	B(Ss)-C(Ss) mean	B(Ss)-C(Ss) SD	sig. 1	sig. 2	sig. 3	sig. 4	total arch length mean	total arch length SD	sig 1	sig 2	sig 3	sig 4
1	10.4	2.0		—	—	*	13.3	3.2		*	*	*	58.9	6.6		*	*	*
2	9.1	2.3			—	—	17.8	2.5			—	*	71.3	5.1			—	—
3	9.2	3.0				—	19.4	3.3				—	71.8	6.8				—
4	8.0	2.5					19.9	2.4					71.8	4.1				

(5) Symmetry of the alveolar points.

stage	B(Ls) depth mean	B(Ls) depth SD	B(Ss) depth mean	B(Ss) depth SD	C(Ls) depth mean	C(Ls) depth SD	C(Ss) depth mean	C(Ss) depth SD
1	42.9	3.5	41.6	4.1	30.1	3.9	29.7	4.2
2	47.4	4.3	46.8	4.1	30.8	2.9	31.0	3.1
3	45.5	4.9	46.5	5.6	28.2	5.9	28.1	4.1
4	51.5	3.0	51.1	2.7	33.5	3.4	31.9	1.9

stage	A distortion mean	A distortion SD	B(Ls)-mid. width mean	B(Ls)-mid. width SD	B(Ss)-mid. width mean	B(Ss)-mid. width SD	C(Ls)-mid. width mean	C(Ls)-mid. width SD	C(Ss)-mid. width mean	C(Ss)-mid. width SD
1	N 3.0	3.0	15.7	2.4	17.3	3.0	17.5	1.8	18.9	2.0
2	A 2.0	2.0	13.7	2.4	14.1	2.4	19.6	2.5	19.7	2.3
3	A 0.4	0.8	15.1	2.5	15.1	2.5	19.5	2.3	18.9	3.0
4	A 0.5	4.0	14.3	1.3	14.0	1.5	19.5	1.7	19.9	2.5

stage	B(Ls) height mean	B(Ls) height SD	B(Ss) height mean	B(Ss) height SD	C(Ls) height mean	C(Ls) height SD	C(Ss) height mean	C(Ss) height SD
1	33.4*	2.5	30.5	2.5	28.0	3.2	27.0	2.9
2	40.1*	2.3	37.4	2.2	32.4	2.7	31.9	3.2
3	43.6	4.2	41.8	2.9	35.3	3.8	34.9	3.8
4	43.9	4.2	42.3	4.9	33.8	3.3	34.4	2.4

Ls, larger segment; Ss, smaller segment; N, normal side; A, affected side; *, significant by t test of mean difference between the points of larger and smaller segments in a stage.

width after lip repair to be compensated not by segmental displacement but by the growth of the segments themselves.

Summary

This study aims at the comparison of growth changes of the maxillary arch of 62 normals and 87 complete unilateral cleft lip and cleft palate subjects. This is achieved by measuring their maxillo-facial models, which will aid in clarifying such questions as: when and where the maxillary growth inhibition will occur, and the several aspects of growth-change.

Patients with complete unilateral cleft lip and cleft palate were classified into four stages: 1) six month old infants before lip and palatal closure; 2) two year old children, lip repair at six months of age; 3) three year old children, lip repair at six months and palatal closure at two years; 4) four year old children, with repairs as in stage 3. Normal subjects were also classified into four stages, to match the cleft group by age and body weight. Impressions were taken for each patient's upper jaw and upper face simultaneously under general anesthesia, and the maxillo-facial model was made.

Results obtained were as follows:

(1) In the normal group, the forward and downward growth of the anterior alveolar region increased considerably between stages 1 and 2 and stages 3 and 4. The growth of the anterior alveolar arch was slight during all four stages. The depth and width of the retromolar point increased gradually through all four stages, and measured the growth of the posterior alveolar region.

(2) In the cleft group: at stage 1 the anterior end of the larger segment was protruded and both the larger and smaller segments, especially in the anterior region, were laterally dislocated. The height of the anterior alveolar region was found to be noticeably less than that of the normal group. At stage 2 the growth inhibition in depth and height was noted in all the alveolar points of the cleft group, especially in the anterior alveolar region, in comparison to the normal group. At stage 3 the depths in all alveolar points decreased, but no significant difference was found when compared to stage 2. However, the increase in heights was marked. At stage 4 the depths and heights of alveolar points in the cleft group were found to be smaller than those of the normal group.

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