Craniofacial Growth in Complete Unilateral Cleft Lip and Palate: A Roentgeno-cephalometric Study

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This study investigated craniofacial growth in unilateral complete clefts using lateral roentgenographic cephalograms. The cleft sample was composed of 135 males and 120 females aged four, six, eight, ten, twelve and eighteen years. Control subjects included 120 non-cleft males and 120 non-cleft females of similar age to the cleft subjects.

The cleft group differed from the control group in several major respects: (1) Their over-all growth trend showed a more downward or vertical direction; (2) The cranial base angle was more flattened; (3) The maxilla was smaller and was located in a more posterior and upward position; (4) Ramal height was shorter and the gonial angle was more obtuse. Chin position was generally retrognathic; (5) Skeletal profile showed less convexity; (6) Upper face height was less and lower face height was greater; (7) Both upper and lower central incisors showed a marked lingual inclination; (8) Females in both groups matured about two years earlier than did males. Underdevelopment in both the maxilla and the mandible was more pronounced in cleft females than in cleft males.

Introduction

Patients with cleft lips and palates are generally characterized by abnormalities of the dental arch form, malocclusions, facial deformity, and masticatory dysfunction.

Orthodontic treatment is imperative for the improvement of these abnormalities. For orthodontic diagnosis, planning of treatment, and prognosticating, it is important to understand the growth and development of cleft lip and palate patients. This matter is also of interest to other specialists who treat such patients.

Since Graber (1949a, 1949b) reported on the craniofacial morphology of cleft

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lip and palate deformities, many studies have been undertaken (Bjork, 1961; Blaine, 1969; Borden, 1957; Brader, 1957; Coup and Subtelny, 1960; Dahl, 1970; Engman, 1965; Hama, 1964; Harvold, 1954; Ishikawa, et al., 1970; Levin, 1963; Mazaheri, et al., 1967; Nakago, 1964; Nakamura, 1972; Sekiguchi, 1971). Most of these, however, have combined several types of clefts with a limited age span. Some recent studies of craniofacial development in cleft subjects have specifically delineated the type of cleft. Friede and Pruzansky (1972) dealt longitudinally with bilateral, complete clefts beginning prior to primary lip repair and continuing through 20 years of age. Narula and Ross (1970) followed their patients from six to 16 years of age. Shibasaki and Ross (1969) studied isolated cleft palate cases from six to 15 years. Concerning unilateral complete cleft lip and palate, Coccaro and Pruzansky (1965) conducted longitudinal research on children with unilateral complete clefts from age six months to seven years. Aduss (1971) also reported longitudinal data from four to 14 years. Minaba (1972) studied the growth of the craniofacial skeleton in three types of clefts. He used a cross-sectional design in which the subjects, ranging in age from five to 25 years, were grouped at five-year intervals. Quite recently, Krogman, et al., (1975) studied longitudinally children with cleft palate and cleft lip and palate from birth to six years. However, growth features of the craniofacial skeleton from childhood to young adulthood are not yet fully clarified.

The present study was a cross-sectional investigation of craniofacial development in children with complete unilateral clefts over the age span of four to 18 years. Roentgenographic cephalograms were employed.

Materials and methods

Tracings of lateral roentgenographic cephalograms of 255 Japanese patients with unilateral cleft lips and palates were obtained from records prior to orthodontic treatment at Osaka University Dental School Hospital. The cleft sample, divided into six age groups, was composed of 135 males and 120 females. All patients had received cheiloplasty and palatoplasty. The mean age of primary lip repair was 2.3 months with a range from a few days after birth to six months. Not all of the primary lip surgery had been performed at our hospital, but the lip repair carried out in the Oral and Maxillofacial Surgery Department of the hospital included variations of the Von Langenbeck, Millard, and Tennison techniques. Palatoplasty (push-back method) for all of the patients had been carried out at our hospital at about two-and-a half years of age. None of the patients had had bone grafts or pharyngeal flaps.

As a control, data on 240 non-cleft Japanese children (120 males and 120 females) of the same ages were obtained from the Orthodontic Department, Osaka University Dental School. Table 1 shows the sample size of both cleft and control groups at each age for males and females.

In the analysis of the cephalograms, 14 traditional landmarks were employed as shown in Figure 1. Profilograms were drawn showing the depth and height of 12 landmarks on the co-ordinates made by the S-N line and a line perpendicular to the S-N line intersecting at S and so superimposed.

TABLE 1. Age and Sex Distribution of 255 Cleft Subjects and 240 Controls.

Male

Age group			4	6	8	10	12	18
Cleft group (N 135)		N	17	21	26	27	25	19
	Age	Mean	4y 3m	6y 8m	8y 5m	10y 4m	12y 7m	18y 4m
		Range	3y 6m 5y 2m	6y 1m 7y 2m	7y10m 9y 2m	9y10m 11y 1m	12y 0m 13y 1m	15y10m 21y 2m
Control group (N 120)		N	20	20	20	20	20	20
	Age	Mean	4y 5m	6y 6m	8y 6m	10y 6m	12y 7m	18y 7m
		Range	3y11m 4y11m	6y 2m 6y11m	8y 2m 8y11m	10y 2m 10y11m	12y 2m 12y11m	16y 3m 20y11m

Female

Age group			4	6	8	10	12	18
Cleft group (N 120)		N	17	21	25	19	18	20
	Age	Mean	4y 5m	6y 6m	8y 6m	10y 4m	12y 4m	18y 1m
		Range	3y 6m 5y 2m	5y10m 7y 2m	7y10m 9y 2m	9y10m 11y 2m	11y10m 13y 2m	16y 0m 20y 3m
Control group (N 120)		N	20	20	20	20	20	20
	Age	Mean	4y 4m	6y 6m	8y 6m	10y 6m	12y 7m	18y 7m
		Range	3y 7m 4y11m	6y 2m 6y11m	8y 2m 8y10m	10y 2m 10y10m	12y 2m 12y11m	16y 2m 20y11m

N : Sample size

Besides the analysis of profilograms, eight linear and eleven angular measures, which were shown in Figures 2 and 3, were made. Linear measurements were made of the anterior cranial base length (S-N), maxillary depth (A'-Ptm'), mandibular ramal height (Ar-Go), mandibular length (Ar-Me), mandibular body length (Go-Me), upper face height (N-NF), lower face height (NF-Me), and total face height (N-Me). Angular measurements were made of the cranial base angle (NSBa), angle SNA, angle SNB, mandibular plane angle to the S-N plane, ramus angle, gonial angle, angle NAP, U1 (non-cleft side) to the S-N plane, L1 to mandibular plane, and interincisal angle.

In addition to these measures, the heights (stature) of the cleft and control children were recorded when the cephalograms were taken and were employed as an index of general somatic development.

When the mean linear measures and the mean body height at 18 years of age were calculated in terms of 100, the growth rate at each of the younger ages was obtained. The residual growth rate was calculated by subtracting the ratio from 100.

Results

1. Body height (Table 2, Figure 4).

Body height of cleft males was less than that of the controls, especially at four and 18 years of age. For females, height in both groups was almost the same up to 10 years of age. After 12 years, the cleft females were shorter in stature than their non-cleft peers.

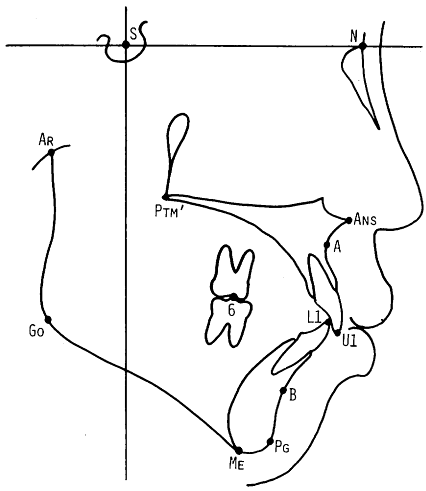


FIGURE 1. Landmarks and the co-ordinates employed in this study.

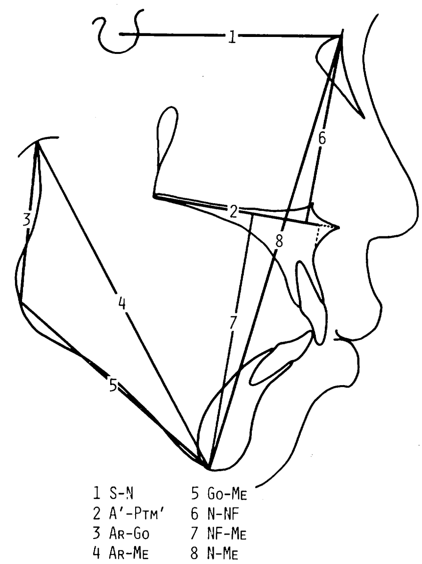


FIGURE 2. Eight linear measures employed in this study.

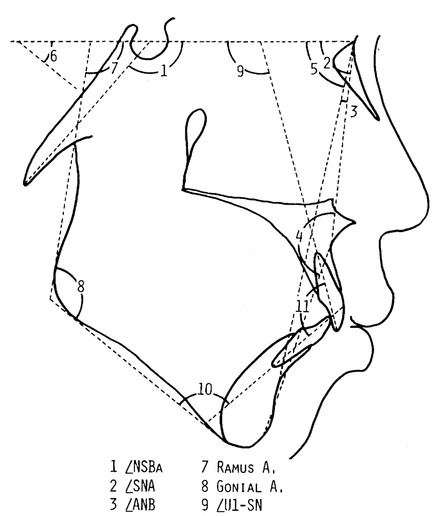


FIGURE 3. Eleven angular measures employed in this study.

Residual growth rate for body height in the cleft and control groups was similar in both sexes. However, the rate for females was less than for males.

2. Profilograms (Figures 5 and 6).

As shown in Figure 5, the superimposed profilograms demonstrate that the anterior portion of the maxillofacial skeleton of the cleft group grew downward or vertically in both sexes while the control group showed downward and forward growth.

TABLE 2. The mean, standard deviation and standard error of the body height of cleft and control groups. (* or ** represents significant difference between the two adjacent age groups at the 5% and 1% levels respectively.)

Male

Age group		4	6	8	10	12	18
Cleft group	x	100.1	112.0	122.7	132.1	145.8	165.5
	s.d.	5.1	3.5	6.6	5.1	7.8	4.2
	s.e.	1.3	0.9	1.5	1.1	1.6	1.2
	sig.	**	**	**	**	**	
Control group	x	105.8	113.5	124.4	135.0	150.3	170.0
	s.d.	3.9	3.8	4.1	4.7	8.0	4.5
	s.e.	0.9	0.8	0.9	1.1	1.8	1.0
	sig.	**	**	**	**	**	

Female

Age group		4	6	8	10	12	18
Cleft group	x	101.6	111.6	122.3	135.8	145.2	154.3
	s.d.	4.7	3.8	5.1	6.4	5.1	4.5
	s.e.	1.2	1.1	1.3	1.9	1.6	1.2
	sig.	**	**	**	**	**	
Control group	x	102.0	111.7	123.0	136.4	150.7	156.0
	s.d.	4.1	5.1	5.8	7.5	4.7	3.7
	s.e.	0.9	1.1	1.3	1.7	1.0	0.8
	sig.	**	**	**	**	**	

(unit : cm)

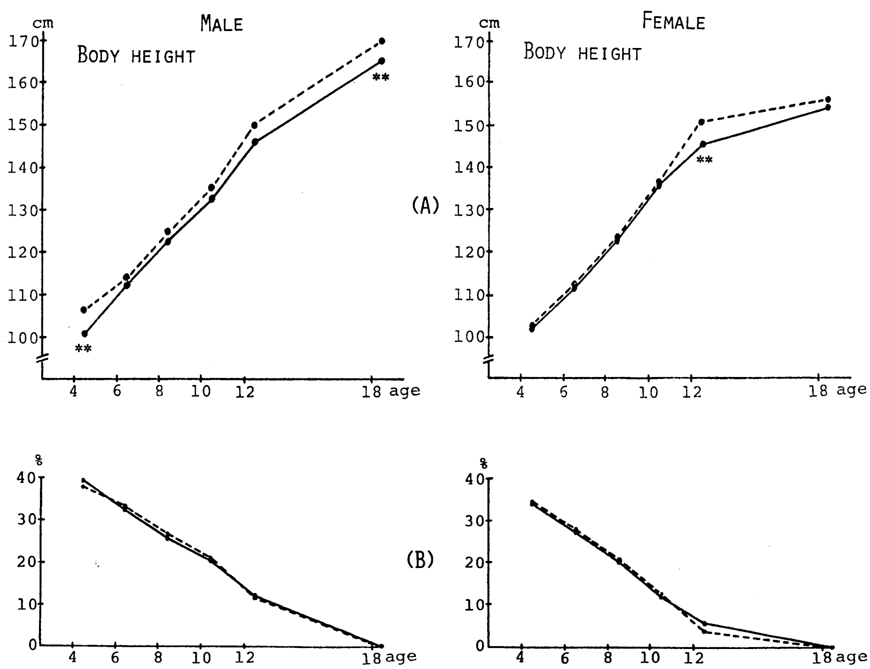


FIGURE 4. Mean growth curve (A) and residual growth rate curve (B) of the body height of the cleft (●——●) and control (●---●) groups for males and females. (** represents significant difference at the 1% level.)

FIGURE 5-1

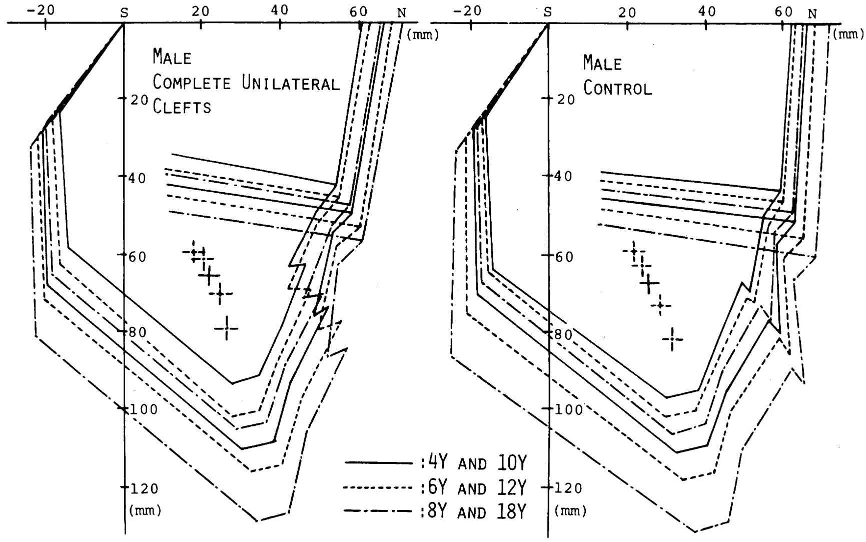
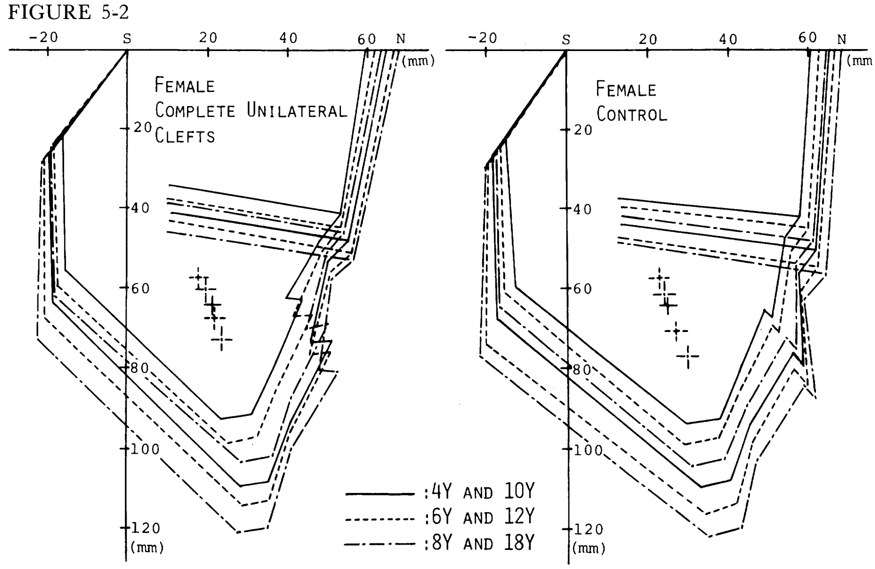


FIGURE 5-2



FIGURES 5-1 and 5-2. Over-all growth trends as shown by superimposed profilograms for cleft and control males (5-1) and females (5-2).

Figure 6 depicts the superimposition of profilograms of both cleft and control groups at each age. The length of the anterior cranial base of the cleft group was similar to that of the controls, regardless of age, for both sexes. The palatal plane was located in an upward and backward position in the cleft group, a tendency more marked in the posterior area of the palatal line (Ptm′) than in the anterior area (Ans) at younger ages. With increase in age the palatal line of the cleft group became parallel with that of the controls. These characteristics were observed in both males and females.

FIGURE 6-1

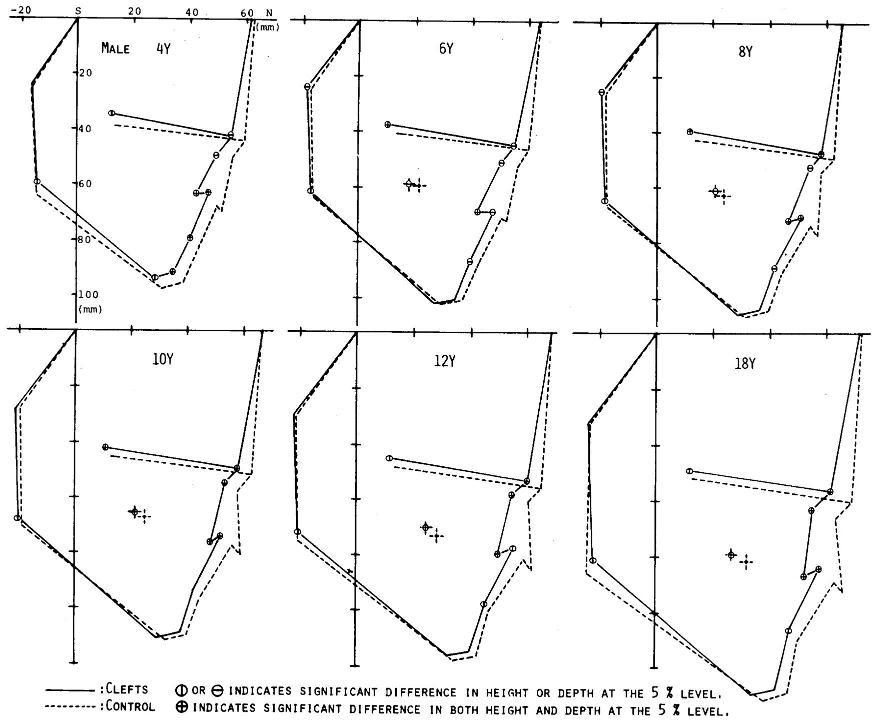
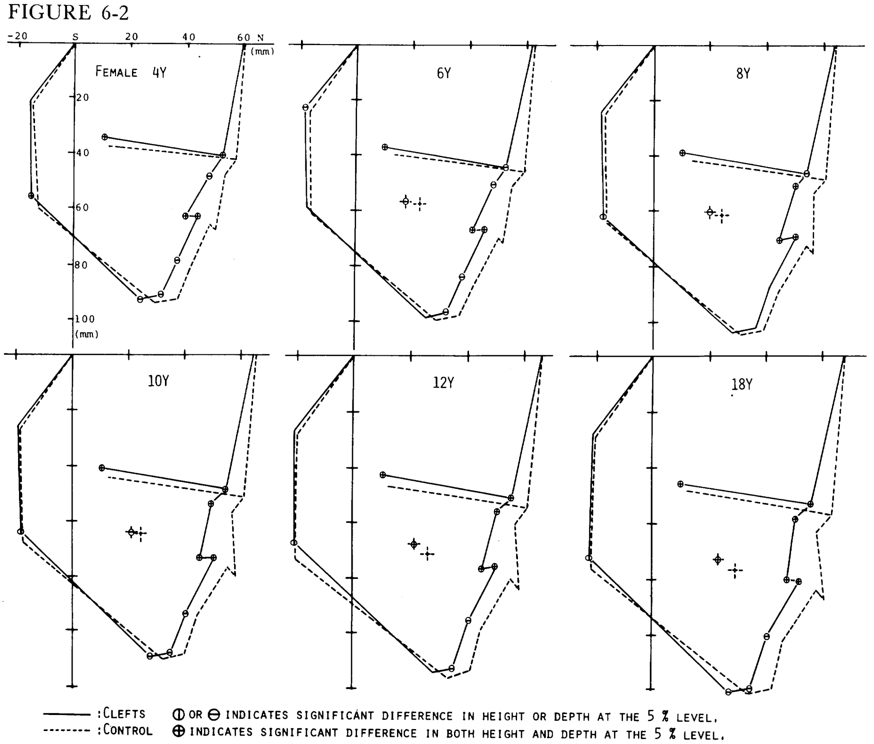


FIGURE 6-2



FIGURES 6-1 and 6-2. Comparison of the cleft and control groups by superimposed profilograms (S-N at S) at each age for males (6-1) and females (6-2).

In addition, the cleft group, regardless of age or sex, differed from the controls in that the chin occupied a more backward position although cross-bite in the incisor area was observed in most cases; gonion was located in a more upward position; upper and lower incisors were in a more upward and backward position; the first molar was in a more posterior position.

3. Linear and angular measures.

1) Cranial base (Tables 3, 4, and 5, Figure 7).

No statistically significant differences were found between the cleft and control groups at any age or for either sex in the length of the anterior cranial base. Residual growth rates were also similar.

The cranial base angle of the cleft group was more flattened than the controls. However, the cranial base angle seemed to be stable during the age periods under investigation.

2) Maxillary complex (Tables 3, 4, and 5, Figure 8).

Maxillary depth of the cleft group was significantly shorter than the controls by four years of age for both males and females. When the mean value of the maxillary depth of the adjacent age groups was statistically compared, no significant differences were observed in the cleft group. On the other hand, in the control group, a significant increment in maxillary depth was found as is shown in Table 3. Therefore, with increase in age, differences in maxillary depth between the cleft and control groups became greater.

It is interesting that the residual growth rate of maxillary depth in the cleft group was smaller than in the control group. At four years of age, the residual growth rate for males was 11 per cent in the cleft group in contrast to 17 per cent in the control group. In females, it was six per cent in the cleft group in contrast to 11 per cent in the control group. When the residual growth rate at 12 years of age was evaluated, only 2 per cent was found in cleft males in contrast to 6 per cent in control males. Zero per cent was found in cleft females in contrast to 3 per cent in control females. These rates indicate that the cleft group shows little maxillary growth after 12 years of age. The maxillary depth of the cleft group at 12 years of age in both sexes is almost equivalent to the size achieved by seven years by male controls and by four years by female controls.

The angle SNA was significantly smaller in the cleft group than in the controls at all ages and for both sexes. The tendency for the SNA angle to decrease with age seems more apparent in the cleft group than in the controls.

3) Mandible (Tables 3, 4, and 5, Figure 9).

Ar-Go was shorter in the cleft group, and significant differences were found at four, 10, 12, and 18 years of age for both sexes. The growth features of Ar-Me and Go-Me were quite similar. That is, the mean values for both cleft and control groups were almost the same until 12 years of age for males and until 10 years of age for females. After these ages, the differences between the cleft and control groups became apparent.

Residual growth rates of these mandibular measures at four years of age were almost the same in both groups for both sexes. However, the cleft group demonstrated lesser rates than did the controls between four and 18 years of age in both sexes. Figure 9 also shows that females attained their growth at an earlier

TABLES 3-1 and 3-2. Mean, standard deviation, and standard error of linear measures of cleft and control groups in each age group for males (3-1) and females (3-2). (* or ** represents significant difference between the two adjacent age groups at the 5% and 1% levels respectively.)

TABLE 3-1

Male		Cleft group						Control group					
Age group		4	6	8	10	12	18	4	6	8	10	12	18
S-N	x	61.1	63.4	65.9	66.6	68.8	71.5	62.7	63.6	65.5	66.5	68.8	72.8
	s.d.	2.9	2.6	3.6	3.2	2.7	3.1	3.0	2.3	2.4	2.4	3.0	3.3
	s.e.	0.7	0.6	0.7	0.6	0.5	0.7	0.7	0.5	0.5	0.5	0.7	0.7
	sig.		*	**		*	**			*	*	**	**
A'-Ptm'	x	39.9	42.0	43.8	43.5	44.4	45.1	43.2	43.9	45.3	46.0	49.1	52.3
	s.d.	3.9	3.5	3.6	3.0	2.5	3.8	3.0	2.0	1.9	2.2	3.0	3.8
	s.e.	1.0	0.8	0.7	0.6	0.5	0.9	0.7	0.5	0.4	0.5	0.7	0.8
	sig.									*		**	**
Ar-Go	x	35.7	37.7	39.5	40.1	42.4	49.3	39.3	39.4	40.6	42.9	45.0	54.0
	s.d.	2.8	3.7	2.8	3.1	3.7	4.0	2.7	2.7	2.2	2.5	3.7	5.9
	s.e.	0.7	0.8	0.6	0.6	0.7	0.9	0.6	0.6	0.5	0.6	0.8	1.3
	sig.					*	**				**	*	**
Ar-Me	x	82.6	90.0	93.0	96.7	102.4	113.4	85.8	88.9	93.7	98.3	103.6	116.7
	s.d.	4.5	4.2	3.7	4.5	5.7	4.1	3.9	3.6	3.3	3.1	5.9	6.9
	s.e.	1.1	0.9	0.7	0.9	1.1	0.9	0.9	0.8	0.7	0.7	1.3	1.6
	sig.		**	*	**	**	**		*	**	**	**	**
Go-Me	x	54.1	59.3	61.7	65.5	69.7	74.5	55.3	58.6	62.2	65.1	69.1	77.4
	s.d.	3.8	3.7	4.4	3.7	4.0	2.9	3.2	3.2	2.8	2.8	4.4	4.3
	s.e.	0.9	0.8	0.9	0.7	0.8	0.7	0.7	0.7	0.6	0.6	1.0	1.0
	sig.		**		**	**	**		**	**	**	**	**
N-NF	x	42.7	45.7	48.5	50.2	53.9	57.6	44.0	46.6	49.3	51.6	55.7	60.8
	s.d.	3.0	2.4	3.4	2.9	4.5	2.4	1.7	1.6	1.9	1.9	2.4	1.8
	s.e.	0.7	0.4	0.7	0.5	0.9	0.6	0.4	0.4	0.4	0.4	0.5	0.4
	sig.		**	**	*	**	**		**	**	**	**	**
NF-Me	x	55.6	60.9	61.8	64.4	67.2	76.3	56.4	58.8	60.7	63.5	66.8	75.3
	s.d.	3.0	3.5	3.3	4.2	5.4	5.7	3.4	3.1	3.2	3.5	3.3	3.1
	s.e.	0.7	0.8	0.7	0.8	1.1	1.3	0.8	0.7	0.7	0.8	0.7	0.7
	sig.		**		*	*	**		*		*	**	**
N-Me	x	99.6	108.6	111.7	116.1	122.3	135.5	102.7	107.7	111.9	116.7	123.5	136.8
	s.d.	5.3	5.2	5.8	5.5	8.1	8.1	4.6	4.0	4.1	4.2	4.8	4.0
	s.e.	1.3	1.2	1.1	1.1	1.6	1.9	1.0	0.9	0.9	0.9	1.1	0.9
	sig.		**		**	**	**		**	**	**	**	**

(unit : mm)

TABLE 3-2

Female		Cleft group						Control group					
Age group		4	6	8	10	12	18	4	6	8	10	12	18
S-N	x	59.6	62.0	63.2	64.4	66.6	67.3	60.6	63.0	64.5	65.5	66.7	68.3
	s.d.	2.5	2.3	3.1	3.1	3.6	3.1	2.2	2.6	2.5	2.7	3.3	3.7
	s.e.	0.6	0.5	0.6	0.7	0.8	0.7	0.5	0.6	0.6	0.6	0.7	0.8
	sig.		**	*		*			**	*	*	*	*
A'-Ptm'	x	39.4	40.5	41.4	40.6	42.2	41.9	42.5	42.9	44.2	45.3	46.6	48.1
	s.d.	2.1	3.0	3.1	2.4	3.7	4.1	2.2	1.8	1.8	2.5	2.4	2.9
	s.e.	0.5	0.7	0.6	0.6	0.9	0.9	0.5	0.4	0.4	0.6	0.5	0.7
	sig.									*			
Ar-Go	x	34.0	36.0	37.6	37.3	40.1	44.0	37.2	36.7	39.2	40.5	44.2	47.6
	s.d.	3.1	3.0	3.5	2.9	4.1	4.6	2.5	2.3	3.2	3.1	3.1	3.3
	s.e.	0.7	0.7	0.7	0.7	1.0	1.0	0.6	0.5	0.7	0.7	0.7	0.7
	sig.		*		*	**				**		**	**
Ar-Me	x	81.4	86.8	92.1	95.2	99.3	104.5	83.8	87.3	92.8	97.3	102.9	107.8
	s.d.	3.4	3.5	5.1	4.4	5.1	5.7	2.8	3.6	4.3	5.0	4.7	5.6
	s.e.	0.8	0.8	1.0	1.0	1.2	1.3	0.6	0.8	1.0	1.1	1.0	1.3
	sig.		**	**	*	*	**		**	**	**	**	**
Go-Me	x	53.9	57.9	62.5	65.0	67.4	69.5	54.0	58.0	61.9	66.0	70.0	71.9
	s.d.	3.1	2.1	4.4	2.6	4.3	3.9	2.8	3.7	3.7	3.9	3.6	4.2
	s.e.	0.7	0.5	0.9	0.6	1.0	0.9	0.6	0.8	0.8	0.9	0.8	0.9
	sig.		**	**	*	*			**	**	**	**	
N-NF	x	41.2	45.4	47.3	49.5	52.3	53.9	42.2	45.1	48.3	51.0	55.7	56.6
	s.d.	2.1	2.1	3.0	2.5	2.8	4.4	1.6	1.9	2.4	2.5	3.9	2.6
	s.e.	0.5	0.5	0.6	0.6	0.7	1.0	0.4	0.4	0.5	0.6	0.9	0.6
	sig.		**	*	*	**			**	**	**	**	
NF-Me	x	55.8	58.1	60.7	64.4	67.0	71.8	54.7	57.6	59.7	62.3	64.9	69.1
	s.d.	2.7	3.0	4.2	4.8	3.8	5.3	2.3	3.1	2.8	3.6	3.5	3.7
	s.e.	0.7	0.7	0.8	1.1	0.9	1.2	0.5	0.7	0.6	0.8	0.8	0.8
	sig.		*	*	*		**		**	*	*	*	**
N-Me	x	99.2	105.5	108.9	115.4	120.8	127.8	99.0	105.0	109.5	114.5	121.1	126.5
	s.d.	3.5	3.2	5.3	7.2	5.8	7.8	3.2	3.8	4.0	4.9	4.5	5.0
	s.e.	0.9	0.7	1.1	1.6	1.4	1.7	0.7	0.8	0.9	1.1	1.0	1.1
	sig.		**	*	**	*	**		**	**	**	**	**

(unit : mm)

TABLES 4-1 and 4-2. Mean, standard deviation, and standard error of the angular measures of cleft and control groups in each age group for males (Table 4-1) and females (Table 4-2). (* or ** represents significant difference between the two adjacent age groups at the 5% and 1% level respectively.)

TABLE 4-1

Male		Cleft group						Control group					
Age group		4	6	8	10	12	18	4	6	8	10	12	18
∠NSBa	x	131.3	132.3	132.4	130.9	131.5	131.7	128.5	130.1	129.7	129.6	130.2	130.1
	s.d.	2.8	3.1	4.2	4.6	4.7	5.0	4.2	3.6	4.1	4.4	4.5	4.4
	s.e.	0.7	0.7	0.8	0.9	0.9	1.2	0.9	0.8	0.9	1.0	1.0	1.0
	sig.												
∠SNA	x	77.4	75.4	76.4	76.2	76.1	75.3	81.1	81.8	81.9	82.0	81.8	81.5
	s.d.	3.6	4.4	3.9	3.4	3.6	4.7	2.2	3.2	3.8	3.3	3.6	3.3
	s.e.	0.9	1.0	0.8	0.6	0.7	1.1	0.5	0.7	0.9	0.7	0.8	0.7
	sig.												
∠SNB	x	75.8	74.9	74.3	75.6	76.6	76.9	76.6	76.7	76.9	77.5	77.3	78.3
	s.d.	3.1	3.1	3.1	3.2	4.0	4.0	2.1	2.9	3.4	3.2	3.8	4.0
	s.e.	0.8	0.7	0.6	0.6	0.8	0.9	0.5	0.6	0.8	0.7	0.9	0.9
	sig.												
∠SN-Mp	x	38.4	41.5	39.4	39.0	39.0	39.6	36.2	39.1	37.8	37.2	36.7	34.9
	s.d.	3.7	5.5	4.4	5.4	6.4	7.1	3.1	4.0	4.2	3.9	4.1	5.9
	s.e.	0.9	1.2	0.9	1.0	1.3	1.6	0.7	0.9	0.9	0.9	0.9	1.3
	sig.		*						*				
Ramus angle	x	88.6	89.5	89.9	91.6	90.5	91.3	89.2	90.5	90.6	90.8	91.7	93.5
	s.d.	5.7	4.7	4.8	5.0	5.8	5.0	2.9	2.8	4.2	4.4	4.9	5.4
	s.e.	1.4	1.0	0.9	1.0	1.2	1.1	0.6	0.6	0.9	1.0	1.1	1.2
	sig.												
Gonial angle	x	129.6	131.8	129.2	127.5	128.4	128.5	126.5	128.5	126.8	126.2	124.6	120.8
	s.d.	4.2	6.5	6.4	5.2	7.5	7.1	4.6	4.4	5.1	5.3	6.0	6.3
	s.e.	1.0	1.4	1.3	1.0	1.5	1.6	1.0	1.0	1.1	1.2	1.3	1.4
	sig.												*
∠ANB	x	1.7	0.5	2.1	0.6	-0.5	-1.6	4.5	5.1	5.0	4.5	4.4	3.3
	s.d.	2.9	3.3	3.2	2.8	2.9	3.4	1.4	1.6	2.1	1.8	2.3	2.4
	s.e.	0.7	0.7	0.6	0.5	0.6	0.8	0.3	0.4	0.5	0.3	0.5	0.5
	sig.												
∠NAP	x	174.0	177.0	175.1	178.4	180.1	183.8	168.0	170.0	168.2	169.3	170.2	173.2
	s.d.	6.0	6.6	6.1	5.7	6.0	7.6	3.7	3.4	4.0	4.1	5.1	5.4
	s.e.	1.5	1.4	1.2	1.1	1.2	1.8	0.8	0.8	0.9	0.9	1.1	1.2
	sig.				*								
∠U1-SN	x	75.2	81.5	85.7	92.3	91.8	94.7	89.7	89.9	100.7	104.9	105.1	106.4
	s.d.	5.5	9.1	11.2	7.6	0.8	9.7	4.8	4.9	4.9	6.3	7.0	7.9
	s.e.	1.3	2.0	2.2	1.5	1.4	2.2	1.1	1.1	1.1	1.4	1.6	1.8
	sig.		*		*					**	*		
∠L1-Mp	x	80.9	81.4	88.4	86.9	86.2	82.6	86.7	86.0	90.9	92.8	96.0	95.3
	s.d.	3.8	7.5	6.9	6.3	8.4	9.0	4.6	6.5	7.1	6.4	5.3	6.2
	s.e.	0.9	1.6	1.4	1.2	1.7	2.1	1.0	1.5	1.6	1.4	1.2	1.4
	sig.			**						**			
Interincisal angle	x	165.4	157.6	146.3	142.0	142.3	143.1	148.0	145.8	129.8	125.5	122.2	124.5
	s.d.	7.1	11.2	14.0	9.8	10.2	15.2	6.9	8.8	10.0	11.4	8.9	8.8
	s.e.	2.7	2.4	2.7	1.9	2.0	3.5	1.5	2.0	2.2	2.6	2.0	2.0
	sig.		*	**						**			

(unit : degree)

age than did males and that the residual growth rate in the mandible was generally larger than that in the maxilla at the same age level.

The gonial angle and the angle created by the mandibular line and the S-N line in the cleft group were larger than in the control group. These angles did not seem to change with age in the cleft subjects but had a tendency to decrease with age in the controls. Very little difference was found between the two groups in the angle created by the ramus and the S-N lines. There was a slight increase in the mean with age in each group. The angle SNB in the cleft group was smaller than in the controls regardless of age or sex.

4) Intermaxillary relation (Table 4, Figure 10).

The angle ANB was smaller for clefts than for controls with a significant difference at all ages. The angle NAP was larger in clefts than in controls with a significant difference throughout the age range for both sexes. NAP became larger in both groups with increase in age, but this was especially so in the cleft group in whom the NAP angle exceeded 180° after 12 years of age for males and after eight years of age for females.

TABLE 4-2

Female		Cleft group						Control group					
Age group		4	6	8	10	12	18	4	6	8	10	12	18
∠NSBa	x	132.3	133.2	132.9	130.9	131.2	131.8	130.6	130.4	130.4	130.2	129.9	130.0
	s.d.	4.3	4.0	5.1	4.2	4.1	4.3	3.4	4.9	4.8	4.1	6.1	6.0
	s.e.	1.1	0.9	1.0	1.0	1.0	1.0	0.8	1.1	1.1	0.9	1.4	1.3
	sig.												
∠SNA	x	76.3	74.9	75.4	74.8	73.6	73.6	81.6	81.5	81.1	80.8	80.8	80.8
	s.d.	3.4	4.9	3.4	4.3	4.7	4.4	2.9	2.5	2.8	3.2	3.5	3.7
	s.e.	0.8	1.1	0.7	1.0	1.1	1.0	0.6	0.6	0.6	0.7	0.8	0.8
	sig.												
∠SNB	x	74.0	73.8	75.8	75.4	74.7	75.0	77.5	76.4	77.0	77.4	77.5	77.8
	s.d.	3.0	4.0	3.5	2.7	5.1	3.7	3.1	2.5	2.5	2.6	4.3	4.6
	s.e.	0.7	0.9	0.7	0.6	1.2	0.8	0.7	0.6	0.6	0.6	1.0	1.0
	sig.												
∠SN-Mp	x	42.5	41.2	40.4	43.6	42.7	44.0	38.7	40.4	39.0	38.4	36.9	36.8
	s.d.	4.1	4.4	3.6	5.5	6.5	7.1	3.4	4.1	3.7	3.7	4.8	4.6
	s.e.	1.0	1.0	0.7	1.3	1.5	1.6	0.8	0.9	0.8	0.8	1.1	1.0
	sig.				*								
Ramus angle	x	90.8	90.9	91.5	92.0	91.8	94.1	87.9	90.4	90.8	91.1	94.0	95.0
	s.d.	4.8	5.8	4.7	5.3	3.9	5.7	3.4	4.1	3.9	4.0	4.0	5.5
	s.e.	1.6	1.3	0.9	1.2	0.9	1.3	0.8	0.9	0.9	0.9	0.9	1.2
	sig.								*			*	
Gonial angle	x	131.6	130.5	128.6	131.1	130.9	129.4	130.4	129.4	128.0	127.2	122.6	121.9
	s.d.	4.4	6.2	5.1	7.7	7.4	6.2	4.5	4.8	5.2	5.2	4.3	5.2
	s.e.	1.1	1.4	1.0	1.8	1.8	1.4	1.0	1.1	1.2	1.2	1.0	1.2
	sig.											**	
∠ANB	x	2.3	1.1	-0.9	-0.7	-1.1	-1.4	4.7	5.1	4.1	3.3	3.3	2.9
	s.d.	3.7	3.3	3.4	2.8	3.6	4.3	2.2	1.9	2.0	2.7	2.1	2.4
	s.e.	0.9	0.7	0.7	0.6	0.9	1.0	0.5	0.4	0.4	0.6	0.5	0.5
	sig.			*									
∠NAP	x	172.4	176.1	179.5	180.4	181.8	182.2	168.3	166.2	169.3	171.1	173.1	173.3
	s.d.	7.7	7.3	7.5	6.3	8.0	9.8	4.4	4.6	5.4	7.2	5.4	5.4
	s.e.	1.9	1.6	1.5	1.5	1.9	2.2	1.0	1.0	1.2	1.6	1.2	1.2
	sig.												
∠U1-SN	x	73.7	80.7	86.9	89.4	88.8	91.8	89.0	93.1	103.9	106.8	106.1	106.9
	s.d.	5.2	10.6	9.1	8.7	7.9	11.7	4.6	6.3	5.9	5.1	8.8	8.9
	s.e.	1.3	2.3	1.8	2.1	1.9	2.6	1.0	1.4	1.3	1.2	2.0	2.0
	sig.		*	*					*	**			
∠L1-Mp	x	76.7	84.0	85.4	81.4	81.2	84.3	83.8	85.6	92.2	91.8	93.1	93.7
	s.d.	4.5	4.9	7.3	7.6	5.9	7.8	4.7	6.3	5.6	6.8	5.4	6.7
	s.e.	1.1	1.1	1.5	1.7	1.4	1.7	1.1	1.4	1.2	1.5	1.2	1.5
	sig.		**							**			
Interincisal angle	x	166.1	153.7	147.6	145.8	148.3	135.5	148.8	140.4	125.3	123.3	125.5	123.1
	s.d.	7.3	11.5	9.9	11.1	11.4	14.0	7.0	9.2	6.0	4.7	10.1	11.0
	s.e.	1.8	2.5	2.0	2.7	2.8	3.1	1.6	2.1	1.3	1.1	2.3	2.5
	sig.		**				**		**	**			

(unit : degree)

TABLE 5. Mean linear measures and mean body height of cleft and control groups at each age level for males and females.

Male	Cleft group						Control group					
Age group	4	6	8	10	12	18	4	6	8	10	12	18
S-N	85.5	88.7	92.2	93.1	96.2	100.0	86.1	87.4	90.0	91.3	94.5	100.0
A'-Ptm'	88.5	93.1	97.1	96.5	98.4	100.0	82.6	83.9	86.6	88.0	93.9	100.0
Ar-Go	72.4	76.5	80.1	81.3	86.0	100.0	72.8	73.0	75.2	79.4	83.3	100.0
Ar-Me	72.8	79.4	82.0	85.3	90.3	100.0	73.5	76.2	80.3	84.2	88.8	100.0
Go-Me	72.6	79.6	82.8	87.9	93.6	100.0	71.4	75.7	80.4	84.1	89.3	100.0
N-NF	74.1	79.3	84.2	87.2	93.6	100.0	72.4	76.6	81.1	84.9	91.6	100.0
NF-Me	72.9	79.8	81.0	84.4	88.1	100.0	74.9	78.1	80.6	84.3	88.7	100.0
N-Me	73.5	80.1	82.4	85.7	90.3	100.0	75.1	78.7	81.8	85.3	90.3	100.0
Body height	60.5	67.7	74.1	79.8	88.1	100.0	62.2	66.8	73.2	79.4	88.4	100.0

Female	Cleft group						Control group					
Age group	4	6	8	10	12	18	4	6	8	10	12	18
S-N	88.6	92.1	93.9	95.7	99.0	100.0	88.7	92.2	94.4	95.9	97.7	100.0
A'-Ptm'	94.0	96.7	98.8	96.9	100.7	100.0	88.4	89.2	91.9	94.2	96.9	100.0
Ar-Go	77.3	81.8	85.5	84.8	91.1	100.0	78.2	77.1	82.4	85.1	92.9	100.0
Ar-Me	77.9	83.1	88.1	91.1	95.0	100.0	77.7	81.0	86.1	90.3	95.5	100.0
Go-Me	77.6	83.3	89.9	93.5	97.0	100.0	75.1	80.7	86.1	91.8	97.4	100.0
N-NF	76.4	84.2	87.8	91.8	97.0	100.0	74.6	79.7	85.3	90.1	98.4	100.0
NF-Me	77.7	80.9	84.5	89.7	93.3	100.0	79.2	83.4	86.4	90.2	93.9	100.0
N-Me	77.7	82.6	85.2	90.3	94.5	100.0	78.3	83.0	86.6	90.5	95.7	100.0
Body height	65.8	72.3	79.3	88.0	94.1	100.0	65.4	71.6	78.8	87.4	96.6	100.0

(unit : %)

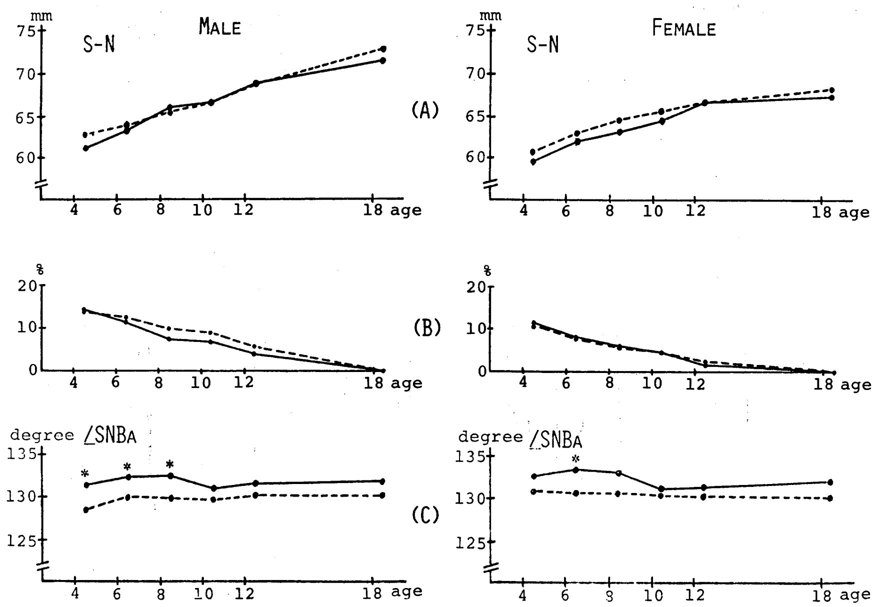


FIGURE 7. The cranial base: mean growth curve (A), residual growth rate curve (B) of anterior cranial base length and mean cranial base angle (C) of cleft (●——●) and control (●--- ●) groups. (* represents significant difference at the 5% level between the two groups.)

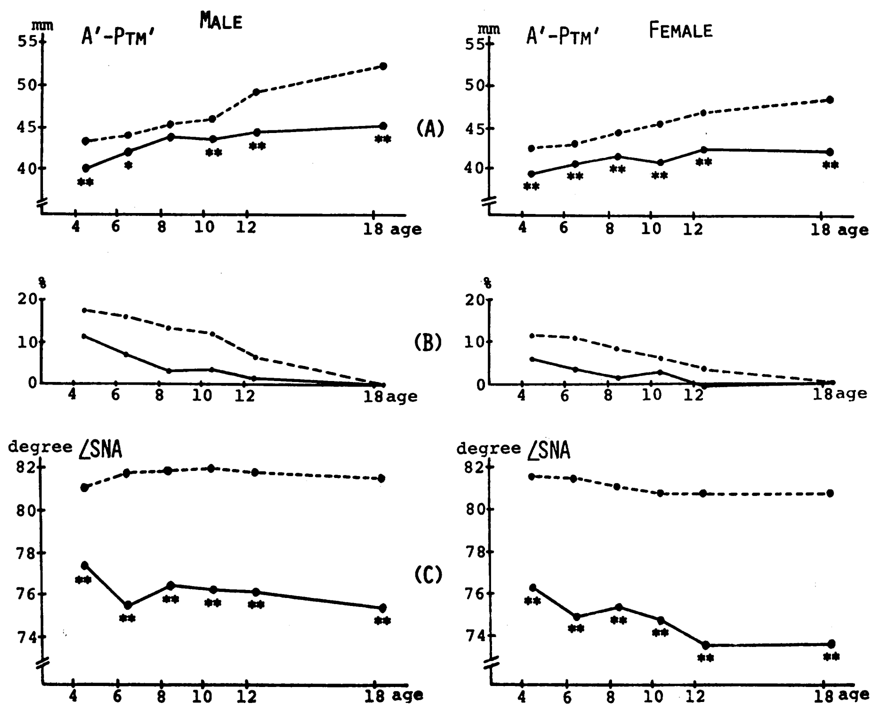


FIGURE 8. The maxilla: mean growth curve (A), residual growth rate curve (B) of maxillary depth, and mean angle SNA (C) of cleft (●——●) and control (●--- ●) groups. (* or ** represents significant difference at the 5% and 1% levels respectively.)

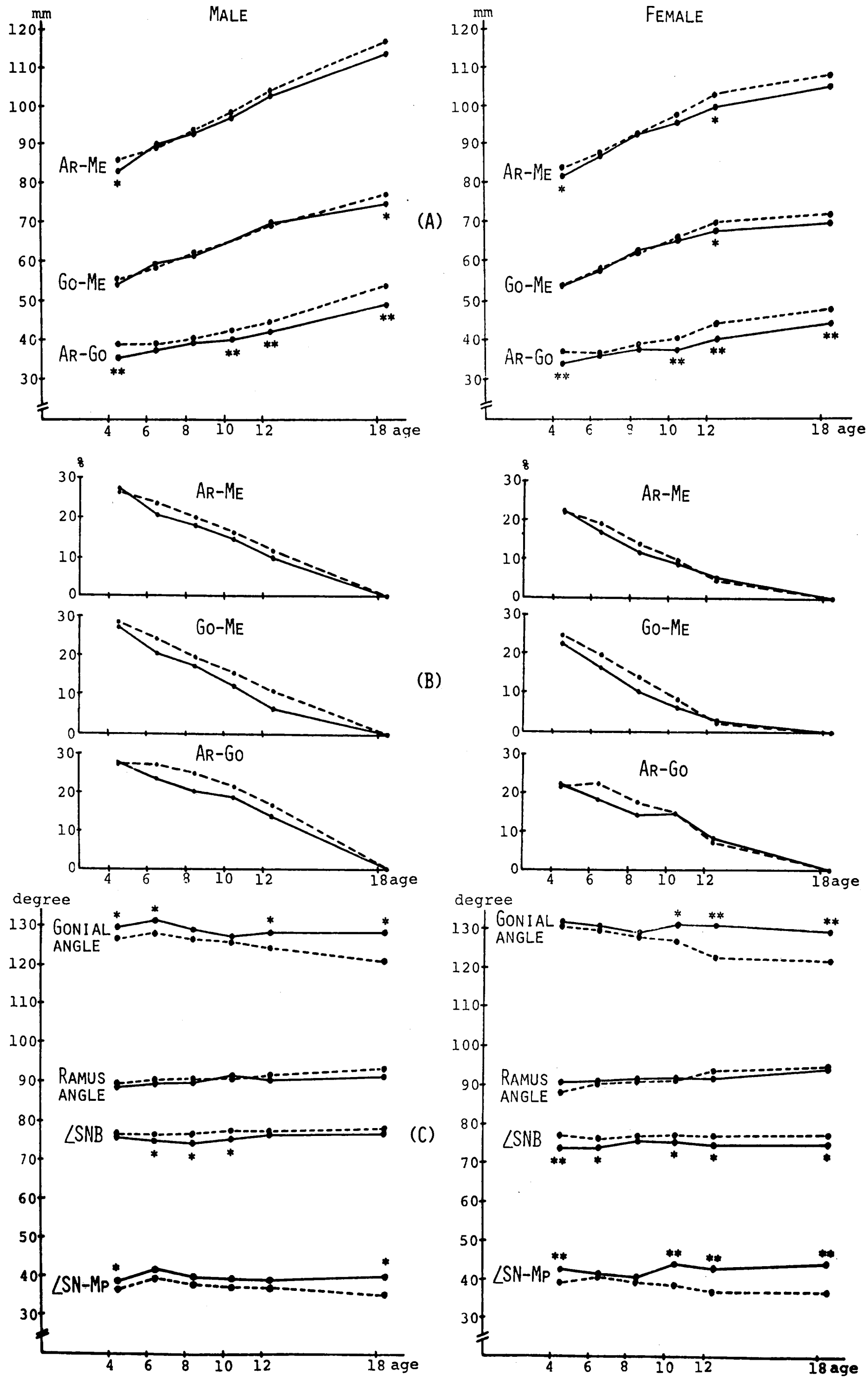


FIGURE 9. The mandible: mean growth curve (A), residual growth rate curve (B) of linear measures, and mean of the angular measures (C) of cleft (●——●) and control (●---●) groups. (* or ** represents significant difference at the 5% and 1% levels respectively.)

5) Face height (Tables 3 and 5, Figure 11).

The mean of the upper face height of the cleft group was slightly smaller than that of the controls at younger ages and for both sexes. This difference increased with age, and cleft subjects evidenced shorter upper face heights as they grew older. This coincides with the change in the inclination of the palatal plane already mentioned in connection with the findings from the profilograms (Figures 5 and 6). On the other hand, the mean height of the lower face of both males and females in the cleft group was slightly larger than that of the controls for all ages studied. Consequently, there was very little difference in total face height between the two groups.

Concerning residual growth rate, upper face height in the cleft group seemed to reach the projected value at 18 years earlier than in the controls. The growth rates for lower face height and total face height were very similar for both groups.

6) Upper and lower central incisors (Table 4, Figure 12).

Both upper and lower central incisors of the cleft group showed a marked lingual inclination as compared to the controls. The interincisal angle of the cleft group was, therefore, larger than that of the controls, and the difference was significant in all age groups.

4. Sex differences (Tables 5 and 6).

The growth rate of linear measures and body height for males from six to 12 years of age was quite similar to the rate for females from four to 10 years of age. At 18 years of age, all of the linear and body height measures for males were larger than for females, and the sex difference was significant in both the cleft and the control groups. However, during the growing period, both males and females in the cleft group appeared, on some measures, to be developing in a different manner from those in the control group.

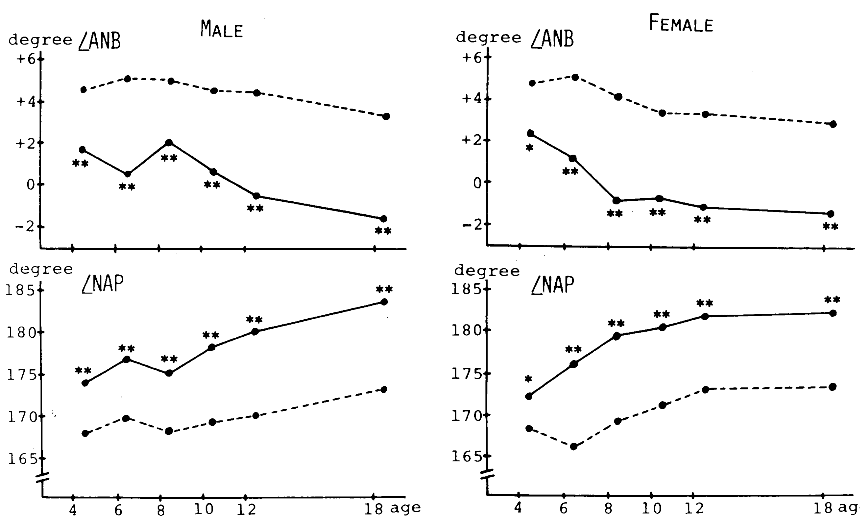


FIGURE 10. Intermaxillary relationships: mean of the angular measures of cleft (●——●) and control (●- - -●) groups (* or ** represents significant difference at the 5% and 1% levels respectively.)

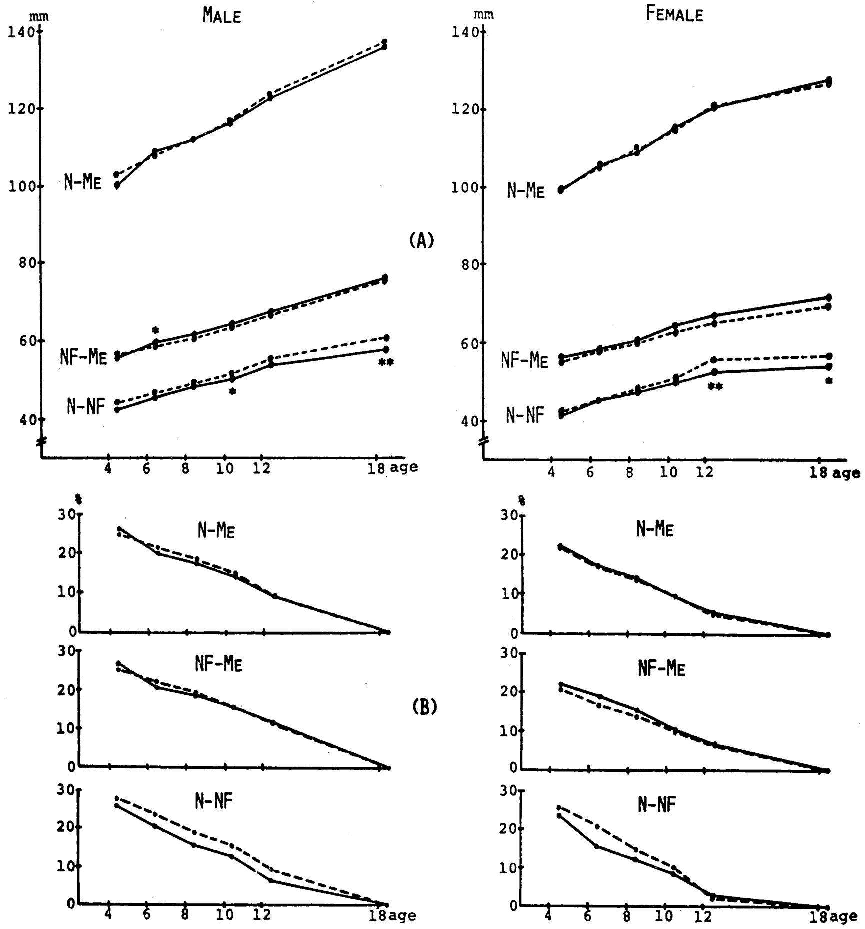


FIGURE 11. Face height: mean growth curve (A), residual growth rate curve (B) of cleft (●——●) and control (●---●) groups (* or ** represents significant difference at the 5% and 1% levels respectively.)

On measures of the maxilla, A′-Ptm′ of cleft males was significantly larger than that of cleft females above eight years of age, but significant differences did not appear until 12 years of age in the controls. The angle SNA in cleft males was also larger than in females for all ages. This sex difference was less marked in the controls.

In the mandible, the mean of the angle SNB in cleft females was less than that of cleft males at almost all ages, and the angle created by the mandibular and the S-N lines was significantly larger in cleft females than in cleft males after 10 years of age. These sex differences were less notable in the controls.

Discussion

Recent studies have tended to investigate longitudinally the growth of the craniofacial skeleton on the basis of cleft type. However, it is not possible to deny orthodontic treatment to cleft patients in order to obtain longitudinal cephalo-

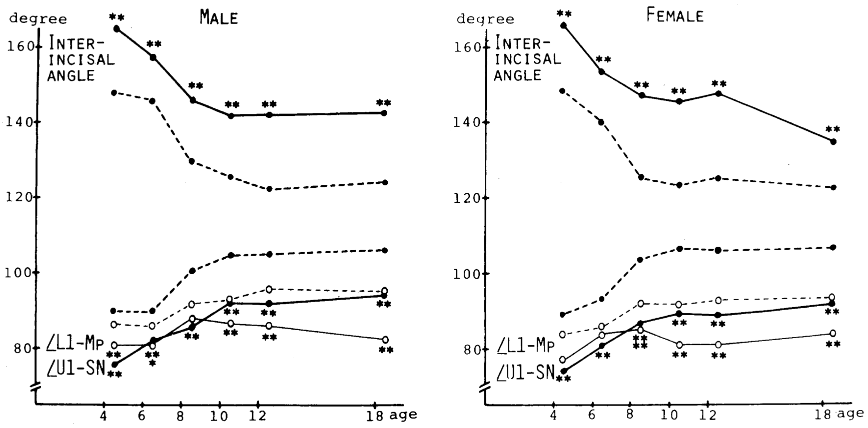


FIGURE 12. Mean of angular measures relating to inclination of upper and lower central incisors in each age group of cleft (●——●, ○——○) and control (●---●, ○---○) males and females. (* or ** represents significant difference at the 5% and 1% levels respectively.)

grams free from the influences of intervention. Moreover, recent studies (Aduss, 1971; Coccaro and Pruzansky, 1965; Krogman, et al., 1975) have reported good longitudinal facial growth and have concluded that plastic surgery actually encourages rather than inhibits growth. This may be true in some series of cleft samples. However, it is also true that there are still many cases showing the concave profile. Thus, in order to study a larger number of cases than would have been possible had we used only longitudinal data, cross-sectional data were collected and analyzed for both clefts and their controls. It is recognized that longitudinal information on a wide variety of cleft subjects managed in known ways would provide additional needed knowledge which might have greater predictive value than we can presently claim.

BODY HEIGHT. Many studies have been undertaken to investigate the relationship between the growth of the craniofacial skeleton and general skeletal development. However, only a few papers have mentioned the body height of cleft subjects.

Dahl (1970) studied the craniofacial morphology of young adult males and reported that the average standing height of cleft subjects was less than that of the controls. In an investigation of the anterior and posterior cranial base length of cleft lip and palate children, Ross (1965) stated that the smaller cranial base is probably due to the smaller size of the children. On the other hand, Krogman, in a personal communication (1975), pointed out that Renalli and Mazaheri at the Lancaster Cleft Palate Clinic have found that both male and female cleft subjects are a bit shorter than their normal controls but not significantly so. Since this work has not been published, it is difficult to use for comparison purposes.

The average height of the cleft group in the present study was less than that of the control group after the period of the pubertal growth spurt in both sexes. The findings suggest, however, that the pubertal growth spurt appears at about the same age in cleft and control subjects.

TABLES 6-1 and 6-2. Sex differences in linear (6-1) and angular (6-2) measures of cleft and control groups at each age level. (Sex differences are calculated by subtracting the mean of the females from that of the males with * or ** representing significant difference between males and females at the 5% and 1% levels respectively.)

TABLE 6-1

Sex difference		Cleft group						Control group					
Age group		4	6	8	10	12	18	4	6	8	10	12	18
S-N	diff.	1.5	1.4	2.7	2.2	2.2	4.2	2.1	0.6	1.0	1.0	2.1	4.5
	sig.			**	*	*	**	*				*	**
A'-Ptm'	diff.	0.5	1.5	2.4	2.9	2.2	3.2	0.7	1.0	1.1	0.7	2.5	4.2
	sig.			*	**	*	*					**	**
Ar-Go	diff.	1.7	1.7	1.9	2.8	2.3	5.3	2.1	2.7	1.4	2.4	0.8	6.4
	sig.			*	**		**	*	**		**		**
Ar-Me	diff.	1.2	3.2	0.9	1.5	3.1	8.9	2.0	1.6	0.9	1.0	0.7	8.9
	sig.		*				**						**
Go-Me	diff.	0.2	1.4	-0.8	0.5	2.3	5.0	1.3	0.6	0.3	-0.9	-0.9	5.5
	sig.						**						**
N-NF	diff.	1.5	0.3	1.2	0.7	1.6	3.7	1.8	1.5	1.0	0.6	0	4.2
	sig.						**	**	*				**
NF-Me	diff.	-0.2	2.8	1.1	0	0.2	4.5	1.7	1.2	1.0	1.2	1.9	6.2
	sig.		**				*						**
N-Me	diff.	0.4	3.1	2.8	0.7	1.5	7.7	3.7	2.7	2.4	2.2	2.4	10.3
	sig.		*				**	**	*				**
Body height	diff.	-1.5	0.4	0.4	-3.7	0.6	11.2	3.8	1.8	1.4	-1.4	-0.4	14.0
(cm)	sig.				*		**	**					**

(unit : mm)

TABLE 6-2

Sex difference		Cleft group						Control group					
Age group		4	6	8	10	12	18	4	6	8	10	12	18
∠NSBa	diff.	-1.0	-0.9	-0.5	0	0.3	-0.1	-2.1	-0.3	-0.7	-0.6	0.3	0.1
	sig.												
∠SNA	diff.	1.1	0.5	1.0	1.4	2.5	1.7	-0.5	0.3	0.8	1.2	1.0	0.7
	sig.					*							
∠SNB	diff.	1.8	1.1	-1.5	0.2	1.9	1.9	-0.9	0.3	-0.1	0.1	-0.2	0.5
	sig.												
∠SN-Mp	diff.	-4.1	0.3	-1.0	-4.6	-3.7	-4.4	-2.5	-1.3	-1.2	-1.2	-0.2	-1.9
	sig.	**			**	*	*	*					
Ramus angle	diff.	-2.2	-1.4	-0.6	-0.4	-1.3	-2.8	-1.3	0.1	-0.2	-0.3	-2.3	-1.5
	sig.												
Gonial angle	diff.	-2.0	1.3	0.6	-3.6	-2.5	-0.9	-3.9	-0.9	-1.2	-1.0	2.0	-1.1
	sig.							*					
∠ANB	diff.	-0.6	-0.6	3.0	1.3	0.6	-0.2	-0.2	0	0.9	1.2	1.1	0.4
	sig.			*									
∠NAP	diff.	1.6	0.9	-4.4	-2.0	-1.7	0.6	-0.3	3.8	-1.1	-1.8	-2.9	-0.1
	sig.			*					**				
∠U1-SN	diff.	1.5	0.8	-1.2	2.9	3.0	2.9	0.7	-3.2	-3.2	-1.9	-1.0	-0.5
	sig.												
∠L1-Mp	diff.	4.2	-2.6	3.0	5.5	5.0	-1.7	2.9	0.4	-0.3	1.0	2.9	1.6
	sig.	**			*	*							
Interincisal angle	diff.	-0.7	3.9	-1.3	-3.8	-6.0	7.6	-0.8	5.4	4.5	2.2	-3.3	1.4
	sig.					*	*		*	*			

(unit : degree)

Cranial Base. Sekiguchi (1971) and Shibasaki (1973) both measured the distance between nasion and sella on operated complete unilateral clefts. Levin (1963) measured the N-Ba distance on the extended S-N line in cleft palate children. These authors reported that no differences were found between cleft subjects and their controls. On the other hand, Dahl (1970) stated that the anterior cranial base length (N-S) was shorter in clefts than in their controls. Ross (1965) reported similar findings on the total cranial base length. Aduss (1971) found that only girls with clefts revealed shorter cranial base length.

In this study, no difference was found in length or growth rate of the anterior cranial base at any age regardless of sex (Figure 7). The anterior cranial base in cleft subjects seems to grow in the same manner as in non-cleft subjects.

Some writers have reported no differences between cleft and control subjects in the cranial base angle measured by N-S-Ba (Aduss, 1963; Ross, 1965; Sekiguchi, 1971). However, others (Blaine, 1969; Dahl, 1970; Hama, 1964; Shibasaki, 1973) have noted a larger cranial base angle in the cleft group. Bjork (1961) stated that, when the elongation and the lowering of the median fossae are proportional in magnitude, the shape of the cranial base is unchanged from childhood to adulthood. However, when the posterior lengthening of the base is greater than the lowering, the base flattens out with growth.

In the present study, cranial base angle changed very little with increase in age in either cleft or control subjects. However, the angle of the cleft group was larger than for the controls (Figure 7). This difference may be related to the greater angulation of the medial pterygoid plates in all cleft types as reported by Subtelny (1955). This is assumed to have occurred before four years of age, probably in an early embryonic stage. It may be related to the dysostosis sphenoidalis reported by Moss (1956).

MAXILLA. It has been widely accepted that the maxillary complex grows downward and forward in relation to the cranial base by sutural, appositional, and remodeling growth (Bjork, 1961; Enlow, 1971). In clefts, however, many studies have shown that the maxilla is located in a more backward position relative to the anterior cranial base in comparison to controls (Blaine, 1969; Dahl, 1970; Foster, 1970; Hama, 1964; Sekiguchi, 1971; Shibasaki, 1973).

The backward and upward position of the maxilla in the cleft group may be discussed from the view points of depth and height. The anteroposterior dimension of the maxilla in clefts has been shown to be smaller than in noncleft populations by many investigators (Dahl, 1970; Foster, 1970; Graber, 1949; Levin, 1963; Minaba, 1972; Shibasaki, 1969). However, Hama (1964) and Sekiguchi (1971) did not find the smaller maxilla. They observed retroposition of the maxilla in cleft patients. Atherton (1967) reported a shorter length of the maxilla on the cleft side and a slightly distal position on the noncleft side in the unoperated, unilateral cleft palate skulls which he studied.

Appositional growth at the maxillary tuberosity and sutural growth is considered to play an important role in increasing maxillary depth. Bjork (1966) stated that sutural growth continues up until 17 years of age, while Latham and Burton (1966) said up to only two years of age and Scott (1956) up to seven years of age. Asai (1973) found that the maxillary depth as measured by A′-Ptm′ increased up to 17 years of age for both sexes.

In the present study, the increment in growth of the maxilla from one age to another was smaller in the cleft group than in the controls, especially after eight years of age, for both sexes. The residual growth rate of the maxillary depth of the cleft group was less than that of the controls at four years of age (Figure 8). This may suggest either lower maxillary growth potential in the cleft group or the effects of the maxillary ankylosis suggested by Ross (1970) on the appositional growth at the tuberosity.

The distance from the anterior and posterior regions of the nasal floor to the anterior cranial base was measured to evaluate increment in the height of the nasal floor between four and 18 years. This analysis revealed that the downward growth of the anterior region was less in the cleft group than in the controls for both sexes but that growth in the posterior region was almost the same in both groups.

Brodie (1941; 1951) stated that the nasal floor of noncleft subjects did not change its inclination until one year of age. Ans descended more than Pns thereafter up to 17 years of age. The same tendency was confirmed in the control group in the present study.

The downward growth of the maxillary arch consists of inferior alveolar elongation, a composite of downward palatal growth with upward growth at the frontomaxillary sutures and downward growth at the pterygopalatine sutures (Bjork, 1961; Bjork, 1966). Moreover, Scott (1953) and Sarnat (1963) pointed to the role of endochondral growth of the nasal septum in the downward and forward growth of the maxillary complex.

Therefore, alteration of the resorptive and appositional process of nasal floor, the deviated nasal septum (Aduss and Pruzansky, 1963; Latham, 1969), and reduced sutural growth may be considered as causes of underdevelopment of the maxilla in a downward direction in cleft patients.

Change of the angle SNA with increase in age was small in the control group as has been reported previously (Asai, 1973; Iizuka, 1958; Ohnishi, 1969; Susami, 1967). In the cleft group, however, the angle SNA showed a tendency to decrease with age (Figure 8). This may be caused by tight lip musculature and scar tissue on the alveolus as Shibasaki and Ross (1969) have pointed out.

The retroclination of the maxillary incisor may result from the insertion into scar tissue of periodontal fibers from the teeth as Ross (1970) has suggested. Maxillary incisors on the non-cleft side in the cleft group were labially inclined between six and 10 years in males and between four and eight years in females.

MANDIBLE. Retrognathic mandibles in cleft subjects have been reported by a number of investigators (Coccaro and Pruzansky, 1965; Graber, 1954; Hama, 1964; Minaba, 1972; Shibasaki, 1969).

In the present study it was noted that the positional change with age of the anterior region of the mandible (point B, Pogonion and Menton) was less in the cleft group than in the controls especially after 12 years for males and 10 years for females. That is, the forward undergrowth of the mandible became evident with increasing age.

The mandibular ramus is considered to be the major site of posterior and upward growth of the mandible (Enlow, 1961). In the cleft group, which we studied, however, the shorter ramus was apparent as has been reported elsewhere (Dahl, 1970; Levin, 1963; Nakamura et al., 1972; Sekiguchi, 1971; Shibasaki 1973). Go-Me became shorter at 18 years of age for males and after 12 years of age for females. This tendency coincided with the results of Dahl (1970), Hama (1964), and Shibasaki (1973) on adult cleft males.

Mandibular prognathism, measured by the angle SNB, was also smaller in the cleft group than in the controls. Although the retrognathic mandible was evident in the cleft group, it is interesting to note that anterior cross-bite was found in 93 per cent of the 255 cleft samples studied. However, Susami (1967), who studied the growth of the dento-facial complex of noncleft Japanese with anterior teeth in cross-bite from deciduous dentition to adult age, found the mandible to be larger than in the controls in both effective and body length. This resulted in a marked increase of the angle SNP and SNB in the mixed dentition stage. Thus, growth of noncleft subjects with anterior cross-bite was quite different from that of the cleft group.

Although the mandible in the cleft group had some shape characteristics already mentioned, the ramus angle, interestingly, differed very little from the controls in both sexes. Change with age was not marked. The ramus angle seems to be characterized by a stable factor in the cephalometric measures.

Morphologic and positional changes of the mandible in the cleft group seem to be caused by a number of factors which are discussed below.

Borden (1957) stated that intra-uterine factors, postnatal feeding difficulties, or surgical procedures could influence mandibular growth in cleft palate infants. Asai (1973), in a roentgeno-cephalometric study on noncleft Japanese, reported that the pronounced downward movement of gonion was observed in males after 12 years of age. In the present study, the downward movement of gonion was observed also from 12 to 18 years of age for male controls and from 10 to 12 years of age for female controls. Scott (1954) stated that muscle function determined the ultimate form of the mandible at the gonial angle and that reduced muscle activity would account for the flattening in this area. Therefore, the obtuse gonial angle and the inclined mandibular plane of the cleft group were considered to be partly the result of the reduced surface bone apposition in the gonial area.

Ross (1970) discussed many factors which might contribute to alteration in mandibular posture in cleft lip and palate patients. Frequent respiratory infections and nasal septal deviations were possible causes of mouth breathing and habitual open mouth. These, together with the contracted maxillary arch and the low palatal vault, caused the tongue to drop; and, as a result, the mandible also dropped. McKee (1956) has also reported on tongue position in cleft lip and palate subjects. He observed that the tongue, at physiological rest, in occlusion, and during phonation of the vowel /u/, was generally carried much higher in relation to the occlusal plane in non-cleft subjects than in cleft subjects. Shibasaki (1973) explained that the morphologic characteristics of the mandible were the result of morphologic adaptations made in oral function as responses to small oral and pharyngeal cavities.

It is obvious that additional studies of the growth and function of the mandible in cleft samples are required in order to clarify these problems.

Intermaxillary Relation and Face Height. The smaller ANB angle of the cleft group in comparison with the controls idicated the retrusion of the maxilla in relation to the mandible. With increase in age, both cleft and control groups showed a decrease of the angle ANB. The angle SNB became larger than the angle SNA at 10 to 12 years of age for male clefts and at six to eight years of age for female clefts. Thereafter, as Sakuda (1971) mentioned, the intermaxillary relationship changed into a more severe skeletal III relationship. These findings were similar to the growth changes in the cases of mandibular protrusion studied by Susami (1967). The convexity of the skeletal profile measured by the angle NAP was significantly less in the cleft group than in the controls in the present study. On the other hand, Coccaro, et al., (1965) reported that the convexity of the skeletal profile in unilateral clefts was greater than for the normal population. The difference between their study and ours may be the result of the racially characteristic Japanese retrognathism of the noncleft subjects as reported previously (Iizuka and Ishikawa, 1957; Miura, et al., 1965; Sakamoto, 1959) or the more backward position of point A in our cleft group than in theirs.

From eight to 18 years of age for males and from six to 12 years of age for females, there was a straightening of the skeletal profile in the control group, while the cleft group went from straight to concave.

Upper face height in clefts has been reported to be less when measured from nasion to spinal point (Dahl, 1970) and to be shorter when measured from nasion to the anterior boundary of the maxillary base (Levin, 1963). Upper face height of the cleft group in this study, as measured from nasion to the nasal floor, was less than that of the controls especially in older subjects. This may be related to the deceleration of the downward development of the anterior part of the nasal floor. On the other hand, the greater lower face height of the cleft group is probably due to the upward position of the nasal floor and the backward rotation of the mandible.

SEX DIFFERENCES. When linear measures of growth were compared to body height in males and females, it was observed that females in both cleft and control groups had a tendency to mature two years earlier than did the males (Table 5).

Foster (1970) investigated sex differences in unilateral cleft lip and palate subjects and reported that the length of the maxilla was reduced more in females than in male subjects in comparison with matched, normal controls. Meskin, et al., (1968), in their epidemiologic investigation, mentioned that the female with a facial cleft appeared to have a greater likelihood of demonstrating a complete cleft than had her male counterpart.

As shown previously in Table 6, this study shows that underdevelopment in the maxilla and in the mandible as well was more pronounced in females than in males.

Concerning orthodontic treatment for patients with cleft lip and palate, Ross and Johnston (1967) concluded that, for most children with unilateral clefts, orthodontic treatment prior to the presence of permanent dentition had no appreciable effect on the facial growth pattern. Subtelny (1966; 1967) on the other hand, stated that the advantages of early treatment may be the encouragement of more normal growth and development with a resulting improvement in soft tissue relationships and the provision of a more harmonious intraoral environment for the development of highly complex speech patterns.

In the present study, the smaller maxilla and mandible were found as early as four years of age. These findings seem to verify the necessity of orthodontic treatment at an early age for the encouragement of residual growth potentiality.

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