Sex Differences in Craniofacial Growth from One Month to Ten Years in Cleft Lip and Palate

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This study is based on serial lateral X-ray headfilms from one month to ten years for 64 children with unilateral cleft of lip and palate (UCLP), 32 children with bilateral cleft lip and palate (BCLP), and 78 children with cleft palate only (CPO). Measurements for eleven dimensions and three angles were obtained. These included measurements for the cranial base, facial heights, midfacial depths, and the mandible. The 10-year period was divided into infancy, i.e., birth to one year; early childhood, i.e., one to six years; and mid childhood, i.e., six to ten years. All measurements were evaluated on the basis of growth time and growth velocity. The shape of the cranial base as seen in the sellar angle was influenced by clefting whereas the size, i.e., the clival length and the anterior cranial base length were affected by sex. No sex differences were observed for the angle S-N-A. Face heights, midfacial depths, and mandibular body length were all found to be larger for males.

KEY WORDS: Growth, sex differences, cephalometrics, cranial base, facial heights, midfacial depths, mandible, cleft lip, cleft palate

Introduction

This study is an extension of an earlier one (Krogman *et al.* (1975)) on children with unilateral cleft lip and palate (UCLP), bilateral cleft lip and palate (BCLP) and cleft palate only (CPO). The age and sample size have been increased, and males and females are considered separately. Thus, this report is in greater depth and provides increased perspective on growth as it relates to age and sex within the three cleft-types.

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Materials and Methods

Serial radiographs were measured of 174 children, 64 with unilateral cleft lip and palate (UCLP), 32 with bilateral cleft lip and palate (BCLP), and 78 with cleft palate only (CPO). Table 1 presents summary information for this sample.

Data on the lateral roentgenographic headfilms with respect to several major growth or morphological areas are presented. Three angular relationships and 11 dimensions were measured: Ba-S, the clival length; S-N, the anterior cranial base length; Ba-S-N, the sellar angle; N-ANS; N-Ids, upper face heights; Idi-Gn, lower face height or the mandibular symphyseal height; S-N-A, the angular relationship of the profile of N-A in the upper face to S-N; Ptm'-ANS, the palatal length; Ptm'-A; Ptm'-KR, the posterior half of the

TABLE 1. Sample Sizes*

Age	*UCLP*			*BCLP*			*CPO*		
	Male	*Female*	*Total*	*Male*	*Female*	*Total*	*Male*	*Female*	*Total*
0:1	18	9	27	9	6	15	7	8	15
0:3	8	5	13	8	3	11	10	7	17
0:6	26	14	40	10	9	19	16	19	35
1:0	30	22	52	14	9	23	27	33	60
1:6	25	18	43	15	11	26	27	31	58
2:0	33	23	56	16	11	27	30	35	65
3:0	36	23	59	20	12	32	30	42	72
4:0	37	26	63	19	11	30	28	39	67
5:0	37	26	63	18	11	29	30	43	73
6:0	37	26	63	20	11	31	31	41	72
7:0	35	24	59	16	9	25	27	41	68
8:0	32	22	54	15	5	20	23	38	61
9:0	25	20	45	15	7	22	19	31	50
10:0	24	16	40	11	3	14	11	28	39

* 64 UCLP, 32 BCLP, 78 CPO; total 174 case histories.

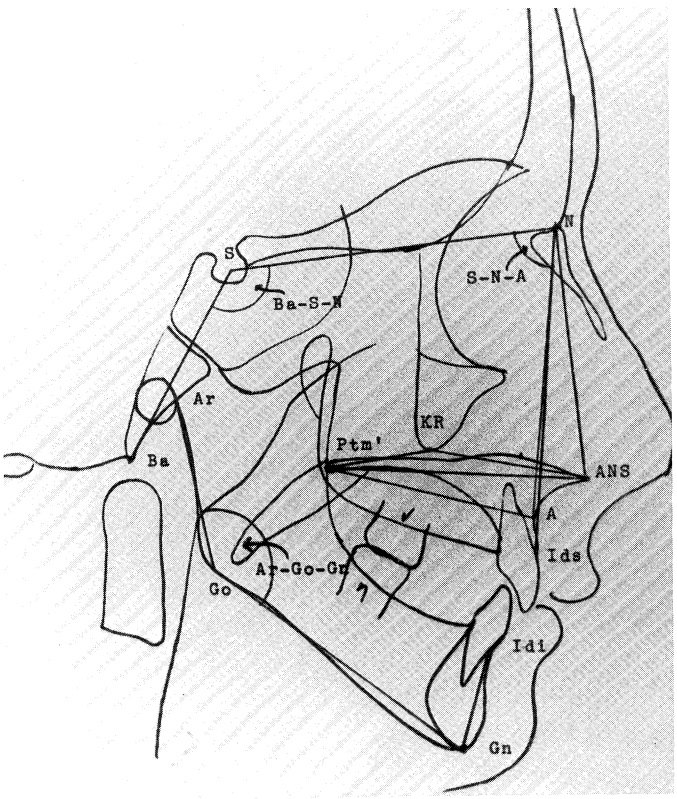

FIGURE 1. Cephalometric endpoints, dimensions, and angles.

palatal length; KR-ANS, the anterior half of the palatal length; Ar-Go, the ramal height; Go-Gn, the body length; and Ar-Go-Gn, the gonial angle. All these dimensions and angles are shown in Figure 1. The detailed definitions are given in Krogman *et al.* (1975).

FINDINGS

Possible sex differences were ascertained by using the t-test. The differences found to be statistically significant are given in Table 2. In Tables 3 through 9, the means and stan-

TABLE 2. Significant Sex Differences for Different Cleft Types Discovered by t – Test at $\alpha = .05$*

Variable	*Group*	*Age*													
		0:1	*0:3*	*0:6*	*1:0*	*1:6*	*2:0*	*3:0*	*4:0*	*5:0*	*6:0*	*7:0*	*8:0*	*9:0*	*10:0*
Dimension	UCLP			^1X	^1X		^1X	^1X							
Ba–S	BCLP	^1X								^1X					^1X
	CPO			^1X	^1X	^1X	^1X		^1X	^1X	^1X		^1X	^1X	
Dimension	UCLP			^1X	^1X			^1X	^1X	^1X	^1X	^1X	^1X	^1X	^1X
S–N	BCLP											^1X		^1X	^1X
	CPO				^1X	^1X	^1X	^1X	^1X	^1X	^1X	^1X	^1X	^1X	
Angle	UCLP					^2X									
Ba–S–N	BCLP			^2X	^2X	^2X	^2X	^2X	^2X	^2X	^2X	^2X		^2X	
	CPO														
Dimension	UCLP			^1X				^1X							
N–ANS	BCLP														
	CPO				^1X		^1X	^1X	^1X	^1X		^1X			
Dimension	UCLP			^1X											
N–Ids	BCLP														
	CPO			^1X			^1X	^1X	^1X	^1X		^1X			
Dimension	UCLP							^1X							
Idi–Gn	BCLP	^1X						^1X		^1X					
	CPO								^1X	^1X	^1X	^1X		^1X	
Angle	UCLP														
S–N–A	BCLP						^1X		^1X						
	CPO														
Dimension	UCLP														
Ptm′–ANS	BCLP														
	CPO						^1X			^1X		^1X	^1X	^1X	
Dimension	UCLP														
Ptm′–A	BCLP														
	CPO				^1X		^1X	^1X	^1X	^1X		^1X	^1X	^1X	
Dimension	UCLP										^1X				
Ptm′–KR	BCLP				^2X								^2X		
	CPO								^1X						
Dimension	UCLP														
KR–ANS	BCLP														
	CPO											^1X		^1X	
Dimension	UCLP			^1X											
Go–Gn	BCLP				^2X										
	CPO			^1X					^1X	^1X	^1X	^1X	^1X		
Dimension	UCLP							^1X				^1X			
Ar–Go	BCLP														
	CPO														^2X
Angle	UCLP														
Ar–Go–Gn	BCLP				^1X			^1X	^1X		^1X				
	CPO														

* An X indicates a significant difference. The superscript in front of X indicates the index of the group having the larger mean (1 = males, 2 = females).

dard deviations for selected dimensions and angles are presented. The detailed tables for other measurements can be obtained from the authors. However, in Table 10, the total growth that occurred during the 10 year period covered in this study for all measurements is given.

Results and Discussion

A. Cranial Base

Table 2 shows that for clival length (Ba-S) sex is a factor in CPO and possibly in UCLP but not in BCLP. The clival length for UCLP for the pooled data presented here agrees very

TABLE 3. Means and Standard Deviations of Dimension Ba-S (in MMs.)

Age yr:mo	Males UCLP $\bar{X}$	Males UCLP S.D.	Males BCLP $\bar{X}$	Males BCLP S.D.	Males CPO $\bar{X}$	Males CPO S.D.	Females UCLP $\bar{X}$	Females UCLP S.D.	Females BCLP $\bar{X}$	Females BCLP S.D.	Females CPO $\bar{X}$	Females CPO S.D.	Pooled UCLP $\bar{X}$	Pooled UCLP S.D.	Pooled BCLP $\bar{X}$	Pooled BCLP S.D.	Pooled CPO $\bar{X}$	Pooled CPO S.D.
0:1	26.3	1.74	28.0	2.12	26.7	1.50	26.4	2.74	25.7	0.82	26.5	1.62	26.3	2.08	27.1	2.05	26.6	1.50
0:3	28.0	2.20	30.9	3.76	28.7	3.09	27.0	2.74	30.0	1.73	27.0	2.00	27.6	2.36	30.6	3.26	28.0	2.76
0:6	32.3	2.24	31.2	2.15	31.9	3.11	29.8	3.24	30.8	2.39	29.9	1.82	31.4	2.85	31.0	2.21	30.8	2.66
1:0	34.3	2.70	34.0	3.19	34.0	2.03	31.9	2.29	33.4	1.74	32.6	2.56	33.3	2.78	33.8	2.68	33.2	2.43
1:6	35.4	2.66	35.1	2.89	35.1	2.38	34.1	2.22	34.2	2.32	33.5	2.55	34.8	2.53	34.7	2.65	34.2	2.59
2:0	36.5	2.50	35.9	3.14	36.5	1.80	34.2	2.30	35.0	2.86	34.4	2.40	35.6	2.66	35.5	3.00	35.4	2.37
3:0	37.4	2.75	37.3	2.58	36.9	2.57	35.7	2.72	36.2	2.86	36.0	2.48	36.7	2.85	36.9	2.70	36.4	2.54
4:0	38.0	3.00	38.2	3.58	37.9	3.01	37.1	2.69	35.8	2.04	36.3	2.54	37.7	2.89	37.3	3.28	37.0	2.83
5:0	38.8	2.93	39.3	2.24	39.0	2.67	38.0	3.32	37.0	2.45	37.1	2.24	38.5	3.10	38.4	2.54	37.5	2.58
6:0	39.8	3.47	39.4	3.36	40.2	2.83	39.0	3.07	37.4	3.32	38.0	2.32	39.5	3.31	38.7	3.44	38.9	2.75
7:0	40.2	3.51	40.9	2.44	40.0	2.82	39.6	3.43	39.4	2.92	38.6	2.76	40.0	3.46	40.4	3.66	39.1	2.85
8:0	41.3	3.27	41.9	2.42	40.3	1.86	40.9	2.76	39.8	3.11	38.7	2.25	41.1	3.05	41.4	2.68	39.3	2.24
9:0	41.2	3.56	42.7	2.43	41.3	2.06	40.8	2.89	40.9	2.79	39.4	2.92	41.0	3.25	42.1	2.64	40.1	2.77
10:0	42.1	3.31	43.1	2.43	42.8	2.23	41.9	2.74	44.0	5.29	40.1	3.31	42.1	3.06	43.3	3.00	40.9	3.25

closely with the data of Aduss (1971) and McNeill (1962). Males have a larger S-N dimension (Table 2) especially in UCLP and CPO.

Over and beyond cleft-type and sex, a possible cranial shape factor may be operative. Thomson (1903) found a high positive correlation between total cranial length as measured from glabella to opisthocranion and anterior cranial base length as measured from sella to nasion. Long-headed crania were classed as dolichocranic, and short- or broad-headed crania were classed as brachycranic. Hence, the dolichos have a larger S-N than the brachys. During 1947–1971 at the Growth Center in Philadelphia, several thousand heads of children from the "Greater Delaware Valley" area were measured. Long-headedness was the major tendency in this sample. Our cleft-palate sample does not differ significantly in ethnic origin from the Philadelphia sample. Thus, the tendency to long-headedness is apparent in the present data. An additional observation is that males, in general, tend to long-headedness and females to broad-headedness. The greater male S-N length, perhaps, is a true sex and ethnic factor, wholly unrelated to clefting.

The sex difference in angle Ba-S-N (Table 2) seems to exist in relationship to clefting, rather than to male-female differences. The sellar angle is definitely an indication of greater cranial flexion in the females, particularly in BCLP. It seems logical that the more severe the cleft type in females, the greater the sellar angle of basicranial flexion. This situation almost certainly is a carry-over of differential embryogenesis in the females. Burdi and Silvey (1969) provide a possible explanation when they state that the timing of the elevation and medianward movement of the palatal shelves occurs later in the females. Since, at the same time-interval, cranial flexion, cerebral flexion, and pontine flexion, in that order, are occurring, it is possible that the *extent* of such flexion in the females over a longer period of time will be greater. This permits the conclusion that the larger sellar angle in the females, the most marked in BCLP, is an early and real sex-cleft occurrence which persists into the first decade of postnatal life.

An over-all interpretation of a possible sex

TABLE 4. Means and Standard Deviations of Dimension S-N (in MMs)

Age yr:mo	Males						Females						Pooled					
	UCLP		BCLP		CPO		UCLP		BCLP		CPO		UCLP		BCLP		CPO	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
0:1	47.3	1.53	47.0	2.12	44.7	2.21	46.2	3.19	45.8	1.60	44.9	2.85	47.0	2.23	46.5	2.62	44.8	2.48
0:3	49.1	3.72	52.0	2.51	51.1	3.21	49.6	2.97	51.7	2.52	48.9	4.67	49.3	3.33	51.9	2.39	50.2	3.91
0:6	56.3	2.01	54.2	2.90	54.1	5.38	53.6	2.77	54.8	2.49	52.6	3.20	55.3	2.61	54.5	2.65	53.3	4.33
1:0	60.2	3.22	59.0	3.84	59.5	2.46	58.0	3.27	59.8	1.86	57.1	3.66	59.3	3.40	59.3	3.18	58.2	3.38
1:6	62.4	3.34	61.1	3.69	61.6	2.64	60.7	2.87	60.4	2.94	59.1	3.64	61.7	3.23	60.8	3.35	60.3	3.41
2:0	62.9	3.26	62.8	2.76	63.4	2.53	61.5	2.57	61.6	2.94	60.6	2.80	62.3	3.06	62.3	2.84	61.9	3.00
3:0	64.4	3.22	64.3	2.94	64.1	2.35	62.3	2.43	62.6	2.27	61.7	2.98	63.6	3.11	63.6	2.79	62.7	2.96
4:0	66.2	2.92	65.4	2.83	65.2	3.15	64.0	2.78	64.0	2.28	62.8	2.70	65.3	3.04	64.9	2.69	63.8	3.10
5:0	66.9	2.99	66.6	3.38	66.6	3.25	64.7	2.62	65.2	2.23	63.7	3.13	66.0	3.02	66.1	3.03	64.9	3.46
6:0	68.0	3.07	67.6	2.96	66.8	3.23	64.5	2.85	66.2	2.36	64.4	3.32	67.0	3.20	67.1	2.80	65.4	3.47
7:0	68.5	3.21	69.4	2.60	68.1	3.63	66.6	2.84	66.9	1.54	64.4	3.39	68.8	3.19	68.5	2.55	65.9	3.91
8:0	69.7	3.42	69.7	3.73	68.7	3.57	67.0	2.44	68.6	2.79	66.3	3.39	68.6	3.32	69.5	3.49	67.2	3.62
9:0	70.5	3.86	70.9	2.46	69.8	2.25	67.5	2.98	68.4	2.57	67.1	3.26	69.1	3.78	70.1	2.71	68.1	3.50
10:0	71.3	4.11	71.9	2.21	69.2	3.12	68.3	2.59	67.7	2.08	67.7	3.07	70.1	3.86	71.0	2.77	68.1	3.11

factor in the cranial base in clefting is that the sex differences are a blend of cleft type and a male-female size dichotomy. The cleft-type shows up in an angular relationship (Ba-S-N) and the sex-size factor appears in a dimensional relationship (Ba-S, S-N). It is possible, therefore, to conclude that cranial base *shape* is influenced by clefting, while cranial base *size* is a manifestation of a male dominance factor.

The growth of the cranial base is quite complex, for it involves two different types of growth velocity, i.e., Scammon's *neural* curve and his *general* or *somatic* curve (Harris *et al.*, 1929). The former has a high velocity and reaches 95% of its value by about seven years. The latter has high initial velocity (to about 5:0), then slow (to about 10:0), then rapid to 15:0, declining by 18:0 to 20:0. Ba-S, with the spheno-occipital synchondrosis about halfway between Ba and S, follows a somatic curve; S-N is a blend of both curves, neural from S to the foramen caecum, somatic from there to N (Keith and Campion, 1922; Ford, 1958; Brodie, Jr., 1955; Zuckerman, 1955). Bjork (1955) maintains that it is differential growth at the spheno-occipital synchondrosis that gives rise to changes in the sellar angle. On the other hand Brodie (1941) demonstrated that at 0:3 S-N was longer than Ba-S and that the proportion established at 0:3 was maintained by equal rates of growth in each dimension. Brodie, Jr. (1955) demonstrated via angular measurements that each part of the cranial base complex was a growth constant up to 18 years of age. In a more sweeping generalization Elmajian (1959) stated that the plane of the sphenoid, the cribriform plate of the ethmoid, and the curve of the great wing of the sphenoid hold a steady relationship to one another.

The foregoing data emphasize our own findings of the stability of cranial base dimensions in the three cleft types in the first postnatal decade. Our findings also affirm that cranial base flexion has its transverse axis through the body of the sphenoid (Moss and Greenberg, 1955). Like Ross (1965) we did not find the "dyostosis sphenoidalis" reported by Moss (1956). Nakamura *et al.* (1972) found no significant differences in the cranial base in clefting. Hayashi *et al.* (1976) found the cranial base "flatter", a possible tendency to platybasia not discovered in our cranial base

TABLE 5. Means and Standard Deviations of Angle Ba–S–N (in Degrees)

Age yr:mo	Males						Females						Pooled					
	UCLP		BCLP		CPO		UCLP		BCLP		CPO		UCLP		BCLP		CPO	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
0:1	135.4	5.77	135.0	4.53	133.0	3.74	135.2	4.66	138.7	5.39	132.8	3.65	135.4	6.05	136.5	5.05	132.9	3.56
0:3	133.6	3.70	133.6	6.84	135.0	3.50	136.6	5.50	139.0	5.29	134.9	5.01	134.8	5.41	135.1	6.69	134.9	4.04
0:6	131.2	5.21	131.7	3.23	131.7	4.19	133.6	8.04	137.6	5.13	131.4	4.76	132.0	6.34	134.5	5.09	131.5	4.45
1:0	130.6	4.75	129.0	4.82	130.5	4.15	131.5	6.63	137.3	5.79	130.0	4.76	131.0	5.58	132.3	6.57	130.2	4.46
1:6	128.5	5.40	129.2	5.66	129.2	4.06	131.9	5.03	134.1	5.28	130.5	5.16	129.9	5.45	131.3	5.43	129.9	4.68
2:0	128.8	4.86	127.8	4.23	129.1	4.27	129.7	6.52	133.5	6.70	128.5	4.74	129.2	5.56	130.1	6.00	128.8	4.51
3:0	129.1	4.93	127.8	4.05	128.1	5.12	130.4	5.71	134.1	6.33	128.4	5.91	129.6	5.24	130.1	5.82	128.3	5.56
4:0	128.9	4.69	127.7	4.61	129.0	4.47	129.8	5.84	134.0	5.14	128.9	6.15	129.3	5.18	130.0	5.64	128.9	5.47
5:0	129.4	4.48	128.8	4.99	128.9	4.29	130.3	5.61	134.5	6.11	129.2	5.14	129.8	4.95	130.9	6.02	129.1	4.78
6:0	129.3	4.31	129.9	5.31	129.5	6.39	129.9	5.67	134.8	4.45	129.7	5.59	129.6	4.88	131.6	5.49	129.6	5.90
7:0	130.3	4.66	129.7	4.94	130.1	6.37	130.6	5.53	135.4	6.31	130.2	5.75	130.4	4.99	130.8	6.04	130.2	6.00
8:0	130.1	4.30	129.4	4.44	130.0	6.62	131.1	4.78	133.8	4.09	131.1	4.96	130.5	4.49	130.5	4.67	130.7	5.61
9:0	130.5	4.17	129.7	4.37	129.8	7.47	130.8	5.43	133.7	3.35	130.5	5.67	130.6	4.72	131.0	4.43	130.2	6.32
10:0	131.0	4.22	129.7	5.46	130.6	9.03	131.2	5.90	131.0	1.73	130.6	5.51	131.1	4.89	130.0	4.87	130.6	6.56

TABLE 6. Means and Standard Deviations for Dimension N–ANS (in MMs)

Age yr:mo	Males						Females						Pooled					
	UCLP		BCLP		CPO		UCLP		BCLP		CPO		UCLP		BCLP		CPO	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
0:1	24.2	1.76	28.2	3.11	25.7	1.50	25.2	2.22	26.3	4.50	25.8	2.96	24.5	1.95	27.5	3.70	25.7	2.31
0:3	27.9	3.36	32.8	2.87	29.3	2.31	29.0	3.54	34.0	0.00	27.7	2.56	28.3	3.33	33.1	2.47	28.6	2.47
0:6	31.6	1.72	33.8	3.85	32.2	2.74	29.9	2.59	32.2	2.59	30.5	2.04	31.0	2.19	33.1	3.32	31.3	2.49
1:0	33.7	3.13	34.9	4.25	34.6	2.64	32.7	3.20	35.3	3.00	32.8	2.67	33.3	3.17	35.1	3.74	33.6	2.78
1:6	34.8	2.50	35.3	3.15	35.8	2.45	35.2	2.71	36.5	3.62	35.2	2.84	34.9	2.57	35.8	3.35	35.4	2.66
2:0	36.6	2.22	36.6	3.38	38.3	2.45	35.5	3.48	37.2	4.12	35.6	2.31	36.1	2.83	36.9	3.63	36.8	2.71
3:0	39.1	2.72	39.5	2.54	39.6	2.16	37.7	2.42	40.3	3.11	38.5	2.07	38.6	2.67	39.8	2.76	38.9	2.17
4:0	41.0	2.94	41.5	2.80	41.8	2.59	39.9	2.90	41.6	2.58	40.2	2.45	40.5	2.95	41.6	2.67	40.9	2.61
5:0	42.4	2.27	42.9	3.02	43.4	3.48	42.0	3.08	43.5	2.07	41.8	2.48	42.2	2.62	43.2	2.67	42.4	3.01
6:0	43.7	3.26	45.5	3.43	44.2	2.54	43.2	3.18	45.8	2.27	43.8	2.83	43.5	3.21	45.6	3.03	44.0	2.70
7:0	45.7	2.97	47.5	3.03	47.6	4.11	44.8	4.00	48.2	2.22	44.9	3.65	45.3	3.41	47.8	2.74	45.9	4.03
8:0	47.5	3.02	48.9	3.90	48.3	3.75	46.7	4.00	48.8	3.35	47.6	3.74	47.2	3.44	48.9	3.68	47.9	3.72
9:0	48.8	3.24	50.0	3.36	49.4	3.22	47.8	3.21	49.3	2.29	48.4	3.19	48.3	3.23	49.8	3.02	48.8	3.20
10:0	50.1	3.51	52.3	2.05	50.3	3.95	49.4	3.20	51.7	3.79	50.1	4.36	49.8	3.37	52.1	2.35	50.1	4.20

TABLE 7. Means and Standard Deviations of Dimension Idi–Gn (in MMs)

Age yr:mo	Males						Females						Pooled					
	UCLP		BCLP		CPO		UCLP		BCLP		CPO		UCLP		BCLP		CPO	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
0:1	15.8	1.48	16.9	1.90	14.4	1.81	15.9	1.76	14.3	0.52	15.1	2.10	15.8	1.55	15.9	1.96	14.8	1.93
0:3	17.4	3.02	18.6	3.07	17.5	1.96	17.8	2.59	17.0	1.73	16.4	2.07	17.5	2.76	18.2	2.79	17.1	2.01
0:6	18.8	2.41	19.1	2.42	19.1	1.71	17.8	2.08	18.6	0.73	18.6	1.67	18.5	2.33	18.8	1.80	18.9	1.68
1:0	21.0	2.58	21.8	2.04	21.6	1.93	20.2	3.10	21.2	3.38	20.8	1.89	20.7	2.81	21.6	2.59	21.2	1.93
1:6	23.2	2.47	23.3	1.87	22.8	2.32	22.4	1.97	22.2	2.18	22.2	2.36	22.9	2.28	22.8	2.04	22.5	2.34
2:0	23.5	2.17	24.3	1.99	24.2	1.74	22.9	2.18	23.7	1.49	23.3	1.71	23.2	2.17	24.1	1.80	23.7	1.76
3:0	24.8	2.42	25.8	1.67	25.2	2.01	23.5	2.29	23.8	1.71	24.3	1.97	24.3	2.44	25.0	1.94	24.7	2.02
4:0	26.1	2.35	26.9	1.70	26.6	2.57	24.9	2.34	25.7	1.49	25.1	1.95	25.6	2.40	26.5	1.70	25.7	2.34
5:0	26.3	2.35	27.3	1.97	27.0	2.53	25.5	2.66	25.8	1.17	25.5	1.98	26.0	2.49	26.8	1.85	26.1	2.33
6:0	26.1	2.53	28.1	2.46	26.9	2.51	25.3	2.59	26.5	1.29	25.4	3.20	25.7	2.57	27.5	2.22	26.0	3.00
7:0	25.7	2.29	26.8	1.91	27.1	3.60	24.8	2.93	26.7	1.80	25.2	2.73	25.4	2.59	26.8	1.83	26.0	3.22
8:0	26.3	2.74	27.7	1.87	26.7	2.43	25.3	2.10	27.4	1.67	25.5	2.31	25.9	2.52	27.7	1.79	26.0	2.41
9:0	26.7	2.25	28.1	2.33	27.4	2.29	26.0	2.50	27.7	2.14	25.8	2.39	26.4	2.37	28.0	2.23	26.4	2.46
10:0	27.3	2.37	29.0	3.63	26.8	3.19	27.0	3.14	26.0	2.65	26.8	2.23	27.2	2.67	28.4	3.59	26.8	2.49

TABLE 8. Means and Standard Deviations of Dimension Ptm′–ANS (in MMs)

Age yr:mo	Males						Females						Pooled					
	UCLP		BCLP		CPO		UCLP		BCLP		CPO		UCLP		BCLP		CPO	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
0:1	34.9	2.98	39.7	5.00	31.4	4.16	35.1	3.72	39.2	6.46	32.6	2.56	35.0	3.17	39.5	5.41	32.1	3.33
0:3	35.9	3.87	45.6	4.47	35.0	3.40	38.4	5.59	45.0	7.00	36.0	3.65	36.8	4.56	45.5	4.89	35.4	3.06
0:6	40.6	2.86	43.6	3.81	39.1	2.79	39.3	3.05	44.2	2.64	38.4	2.39	40.2	2.95	43.9	3.23	38.7	2.56
1:0	43.8	3.60	46.7	3.47	40.8	2.72	42.5	2.79	45.9	2.37	39.6	3.33	43.3	3.32	46.4	3.06	40.1	3.11
1:6	44.9	3.05	48.2	3.30	42.3	3.45	44.8	3.42	45.8	2.96	40.9	3.39	44.9	3.17	47.2	3.32	41.6	3.46
2:0	45.6	3.32	49.0	3.10	43.0	3.25	44.6	3.46	46.7	5.08	41.4	3.20	45.2	3.39	48.1	4.09	42.2	3.30
3:0	46.3	2.61	51.3	4.20	43.8	3.02	46.2	2.29	49.6	5.78	42.9	3.10	46.3	2.47	50.6	4.83	43.3	3.08
4:0	47.9	2.87	51.6	3.86	45.5	3.80	47.2	2.68	49.3	4.20	43.9	2.95	47.6	2.79	50.8	4.08	44.6	3.39
5:0	48.9	3.33	53.3	3.71	46.9	3.01	48.3	2.94	51.5	3.27	45.2	2.87	48.6	3.16	52.6	3.60	45.9	3.03
6:0	50.5	3.54	54.5	3.50	47.7	3.38	42.9	2.86	52.7	2.87	46.3	3.03	50.0	3.32	53.8	3.35	46.9	3.23
7:0	51.1	3.72	54.7	3.14	48.9	2.59	50.4	2.67	53.1	3.55	47.1	2.99	50.8	3.32	54.1	3.31	47.8	2.96
8:0	52.3	3.36	55.5	3.23	50.3	3.50	51.0	3.00	53.2	3.35	48.0	3.30	51.8	3.25	55.0	3.33	48.9	3.54
9:0	52.9	3.93	57.1	3.73	51.3	3.50	51.3	2.72	56.0	3.42	48.4	3.97	52.2	3.50	56.7	3.59	49.5	4.02
10:0	53.3	3.57	58.1	3.75	51.3	3.50	52.7	3.28	57.0	5.00	50.6	3.74	53.0	3.42	57.9	3.86	50.8	3.64

TABLE 9. Means and Standard Deviations of Dimension Go-Gn (in MMs)

Age yr:mo	Males UCLP $\bar{X}$	Males UCLP S.D.	Males BCLP $\bar{X}$	Males BCLP S.D.	Males CPO $\bar{X}$	Males CPO S.D.	Females UCLP $\bar{X}$	Females UCLP S.D.	Females BCLP $\bar{X}$	Females BCLP S.D.	Females CPO $\bar{X}$	Females CPO S.D.	Pooled UCLP $\bar{X}$	Pooled UCLP S.D.	Pooled BCLP $\bar{X}$	Pooled BCLP S.D.	Pooled CPO $\bar{X}$	Pooled CPO S.D.
0:1	34.2	3.70	36.2	3.15	31.9	1.95	33.7	3.24	32.5	5.39	33.3	4.07	34.0	3.50	34.7	4.43	32.7	3.26
0:3	35.4	4.17	39.1	3.44	35.9	4.36	35.4	2.79	37.7	2.08	35.0	2.58	35.4	3.57	38.7	3.10	35.5	3.66
0:6	41.9	3.43	42.9	3.21	40.6	3.38	39.4	3.08	41.0	3.20	38.3	2.13	41.0	3.50	42.0	3.27	39.3	2.48
1:0	45.9	3.88	46.1	3.88	44.2	2.90	44.0	4.28	47.3	2.35	43.9	3.40	45.1	4.13	46.6	3.35	44.1	3.16
1:6	48.2	3.77	49.5	4.63	46.9	3.01	47.1	3.94	47.9	3.30	46.3	4.01	47.8	3.83	48.8	4.12	46.6	3.56
2:0	50.0	3.49	51.0	4.21	49.5	3.62	49.0	3.38	49.6	5.05	48.5	3.75	49.6	3.45	50.4	4.53	49.0	3.70
3:0	53.1	4.22	53.3	4.13	52.7	2.88	52.3	3.27	52.9	3.70	51.2	3.83	52.8	3.87	53.1	3.92	51.8	3.53
4:0	56.2	4.06	55.9	4.18	56.2	3.46	55.2	3.45	55.1	4.44	53.3	4.82	55.7	3.82	55.6	4.21	54.5	4.51
5:0	58.4	4.30	59.0	4.19	59.2	4.54	57.4	3.28	58.5	3.83	56.3	4.05	58.0	3.91	58.8	3.99	57.5	4.46
6:0	61.1	4.20	61.4	3.86	60.7	4.69	60.0	3.86	61.4	4.18	58.4	4.18	60.6	4.07	61.4	3.90	59.4	4.52
7:0	62.6	5.02	64.0	4.34	62.9	4.83	62.4	3.81	63.7	4.12	60.1	3.94	62.5	4.53	63.9	4.18	61.2	4.49
8:0	64.6	4.77	66.6	3.83	64.8	5.55	63.9	3.41	67.0	4.00	61.9	4.04	64.3	4.25	66.7	3.77	63.0	4.83
9:0	65.9	5.23	68.3	3.98	66.3	5.70	65.1	4.18	67.9	6.12	64.2	4.10	65.5	4.76	68.2	4.62	65.0	4.82
10:0	67.3	4.73	69.6	4.78	65.9	4.04	66.2	6.09	67.7	7.57	65.9	4.35	66.9	5.27	69.2	5.21	65.9	4.21

data. Brader (1957) discovered significant differences in the sellar angle between cleft and non-cleft samples.

B. Facial Heights

In the more severe cleft types, UCLP and BCLP, where the premaxillary area is involved, it seems that the more severe the clefting, the more the leveling-off of a possible sex factor, and the more the equating of a male-female similarity in facial heights. It may be that in CPO, the least severe cleft-type, the transition from deciduous to permanent incisors is recorded by slightly greater alveolar growth in the males (possibly longer-rooted permanent central incisors).

In a broader sense, it becomes relevant to relate the profile of the upper face to the anterior cranial base, a basifacial relationship. This can be achieved via an angular relationship, the S-N-A angle.

The decrease in the S-N-A angle, the magnitude of which (in the decreasing order) is in the order of BCLP, UCLP, and CPO, points to a moderate increase in midfacial retrusiveness, which is apparently related to severity of clefting. The data, do in fact, warrant the conclusion that with growth, i.e., with age change, there is a slightly more retrusive midface, but this retrusion is *not* to the degree of so-called "growth failure" or "midfacial concavity". What may be involved is the re-positioning of Point A on the anterior aspect of the maxillary complex. Since the age-linked decrease in the angle is greater in BCLP and UCLP than in CPO, it is possible that the premaxillary segment (upon which A is located) is post-operatively stabilized so that it is increasingly relatively less protrusive. As can be seen from Table 2, no significant sex differences were observed.

C. Midfacial Depths

With these dimensions we come to the veritable center of the manifestation of the palatal cleft, for the measurements are at palatal level, antero-posteriorly. Here there is a focus upon two aspects of palatal morphology: (i) clefting, per se, whether singly midline or unilaterally or bilaterally involved; (ii) their growth behavior in the first postnatal decade, as a whole or considered in terms of anterior

TABLE 10. Growth from Age One Month to Ten Years

Measurement	Males			Females			Pooled		
	UCLP	BCLP	CPO	UCLP	BCLP	CPO	UCLP	BCLP	CPO
Ba–S (mms.)	15.8	15.1	16.1	15.5	18.3	13.6	15.8	15.2	14.3
S–N (mms.)	23.8	24.9	24.5	22.1	21.9	22.8	23.1	25.5	24.3
Ba–S–N (deg.)	−4.4	−5.3	−2.4	−4.0	−7.7	−2.2	−4.3	−6.5	−2.3
N–ANS (mms.)	25.9	24.1	24.6	24.2	25.4	24.3	25.3	24.6	24.4
N–Ids (mms.)	29.9	29.5	30.6	27.1	30.2	26.6	28.9	29.9	27.1
Idi–Gn (mms.)	11.5	12.1	12.4	11.1	11.7	11.7	11.4	12.5	12.0
S–N–A (deg.)	−9.0	−13.2	−6.3	−7.7	−12.3	−5.4	−8.4	−13.0	−5.7
Ptm′–ÅNS (mms.)	18.9	18.4	19.9	17.6	17.8	18.0	18.0	18.4	18.7
Ptm′–A (mms.)	16.6	15.0	17.5	15.7	13.4	15.5	16.3	14.7	16.3
Ptm′–KR (mms.)	8.9	7.9	8.2	8.9	11.3	9.0	8.9	9.1	8.9
KR–ANS (mms.)	10.0	10.3	11.4	8.8	6.2	9.0	9.6	9.1	9.8
Go–Gn (mms.)	33.1	33.4	34.0	32.5	35.2	32.6	32.9	34.5	33.2
Ar–Go (mms.)	20.4	19.9	17.2	19.6	18.7	21.4	20.2	19.6	20.1
Ar–Go–Gn (deg.)	−8.8	−7.7	−4.9	−15.5	1.5	−9.8	−11.2	−4.5	−7.9

and posterior segments with KR as the dividing point.

The only statistically significant differences observed for Ptm'-ANS and Ptm'-A are for CPO in which case males have significantly larger dimensions than females sporadically in early childhood and more concentratedly in later mid-childhood. Apart from this, sex or clefting seems to have played a minor role in over-all dimensionality of Ptm'-ANS and Ptm'-A.

D. Mandible

For the ten year postnatal period studied, the growth seems to be relatively uniform across cleft types and sexes, and only in CPO, the males were found to have significantly larger body length than females during late early childhood and early midchildhood. Body length is, as it were, the dental counterpart of alveolo-based length, Ptm'-A.

The data on male size dominance in both Ptm'-A and Go-Gn in CPO show its occurrence at about the same time period, i.e., late early childhood and late mid-childhood. Both maxillary alveolo-basal and mandibular body length are functionally and structurally related to dental arch length, so that there may be a male dental arch length factor which is greater (more significant) in the later growth-period in CPO; but, one may reflect, why not in UCLP and BCLP? Is it possible that in the more severe and hence complex cleft-types dental calcification and eruption (and therefore, alveolo-basal growth) are moderately retarded in both sexes, so that possible sex differences are inhibited or repressed?

Gonial angle does not seem to exhibit any real sex differences. This is probably related to two circumstances, viz., (i) the synchronous growth of Ar-Go and Go-Gn, and (ii) the fact that the two compartments of the angle, Ar-Go and Go-Gn, themselves show a relatively weak sex factor.

Conclusion

In the *cranial base* there is a male size factor only in dimensions Ba-S and S-N. In UCLP the male factor operates early in Ba-S, later in S-N. In BCLP it operates only in later mid-childhood. In CPO for both Ba-S and S-N it is the force over most of the 10-year period. The sellar angle, Ba-S-N, is ruled by a female size-factor, seen only in BCLP, which, as we pointed out, may be a postnatal holdover of a very early (embryonic) cleft and cranial flexion non-synchrony. The presence of a male size-factor in late mid-childhood may betoken the fact that growth in S-N, the anterior cranial base, is such a dominant dimension in cranial base growth that it over-rides the female component registered in angularity.

In *facial heights* we may, for practical purposes, negate a sex size-factor in UCLP and BCLP for dimensions, and also for the S-N-A angle (basifacial angularity). It appears that

maleness and femaleness are subordinate to the more extensive and severe clefts; it is as though UCLP and BCLP "masked" any possible sex differences. This does not hold for the facial height dimensions in CPO, since all three height dimensions grow synchronously over most of the 10-year period, with N-Ids and Idi-Gn later than N-ANS, for both the former involve a factor of alveolar growth, probably time for the replacement of the deciduous incisors by their permanent successors. In CPO there is no sex-size factor for the S-N-A angle.

In *facial depths* the complete absence of a sex-size factor in UCLP and BCLP parallels the similar condition seen in facial heights. One may ponder the possibility that cleft-mediated facial growth as a whole—*both* heights and depths—triumphs over sex-mediated patterns of total facial growth. Once more we envision the philosophy of the "masking" phenomenon. In CPO this concept does not hold since a male size factor seems to be operative in early and mid-childhood in palatal length (Ptm'-ANS) and possibly in late mid-childhood in KR-ANS. This situation suggests that the posterior segment of palatal length is less affected by clefting so that a male size factor comes to significance. This holds for CPO only, for it is the least severe and complex of the three cleft-types.

The *mandible* parallels facial heights and depths in the presence of a male size factor in CPO only, but for a single dimension, viz., body length. The fact that the size factor shows up in late early childhood and early mid-childhood points to a dentally-mediated age-period, i.e., the time of the beginning of the transition from the deciduous dentition to the permanent, i.e., the beginning of the mixed dentition. Ramal height shows no significant male factor and the gonial angle only doubtfully (its irregular presence in late early childhood in BCLP may be due to sample size).

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