Craniofacial Growth in Different Cleft Types from One Month to Ten Years

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This study is based on serial cephalometric radiographs from one month to ten years of 64 children with unilateral cleft lip and palate (UCLP), 32 children with bilateral cleft lip and palate (BCLP), and 78 children with cleft palate only (CPO). Eleven dimensions and three angles were measured in the cranial base, the midface, and the mandible. The 10-year period was divided into infancy (birth to one year), early childhood (one to six years), and mid childhood (six to ten years). Growth differences for each measurement at each age for the three cleft pairs (UCLP/BCLP, UCLP/CPO, and BCLP/CPO) were evaluated by analysis of variance. Cranial base was not affected by cleft-type in males, although sellar angle was found to be significantly larger in BCLP females. Upper face heights in BCLP were different from UCLP and CPO in both sexes. Midfacial depths Ptm'-ANS, Ptm'-A, and anterior segment of palatal length KR-ANS were different for each cleft type. The same was true for the basifacial angle S-N-A. The mandible was relatively unaffected by cleft-types.

KEY WORDS: Craniofacial Growth, cranial base, unilateral cleft lip and palate, bilateral cleft lip and palate, cleft palate, midface, mandible

Sample

A sample of 174 cases with good appointment records was chosen from our Research Series of approximately 350 case-histories. There are 64 cases with unilateral cleft lip and palate (UCLP), 32 cases with bilateral cleft lip and palate (BCLP), and 78 cases with cleft palate only (CPO). Serial lateral and pa X-ray headfilms were available at the following ages: 0:1, 0:3, 0:6, 1:0, 1:6, and annually to age 10:0. All visits were within one week up to 1:6, and within two weeks of the birthday thereafter.

Method

The end-points, dimensions and angles used for this study are depicted in Figure 1. The definitions of all these mensurational data are given in Krogman *et al.*, (1975). The dat was analyzed for significant differences via methods of group comparison for each of the three cleft-type pairs, i.e., UCLP/BCLP, BCLP/CPO, and UCLP/CPO.

It is our experience (Krogman et al., 1975) that palatal clefting is not an isolated osteological phenomenon. Its occurrence in embryogenesis is synchronous with the growth of other—usually contiguous—structures or areas in the cranial and facial skeleton. Therefore, the analysis shall be presented in terms of four related craniofacial components: I. Cranial Base; II. Facial Heights; III. Midfacial Depths and the Basifacial Angle; and IV. the Mandible.

There is another factor, that of growth-time

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(Krogman, 1972) that shall be considered in the age-period under consideration. During this ten-year period there are three growthstages, characterized chiefly by differing growth-rates: Infancy, from birth to one year, is a time of very great growth velocity; Early Childhood, from one to six years, is a time of initial high velocity which gradually decelerates; and Mid Childhood, from six to ten years, is a time of rather slow, even growth. We set up a structural scale of severity and/ or complexity of cleft-involvement. In the comparisons we shall accept BCLP as the most severe cleft-type, UCLP as a less severe or moderate cleft-type, and CPO as the least severe cleft-type.

Statistical Methods. For each of the 14 variables considered, one way analysis of variance F statistic was computed for each age to ascertain significant differences among UCLP, BCLP, and CPO for males and females separately and for males and females pooled. The sample sizes for each age are given in Table 1. Multiple group comparisons were made by using the Fisher's LSD procedure. The groups found to be significantly different at $\alpha = .05$ are given in Tables 2–3. The means and the standard deviations for each sex and for the pooled sample (males + females) for each cleft-type and for each age considered, are given in Krogman *et al.*, (1982).

Results and Discussion

I. The Cranial Base. The cranial base is a structural demarcation between cranial vault (above and behind) and facial skeleton (below and in front). In this sense the basifacial axis represented by Ba-N is the "hafting" zone between cranial skeleton and facial skeleton. In general, the measurements of the cranial base have about 90% of their adult value by early mid-childhood (approximately 7:0); Ba-S is an exception, for the dimension includes the spheno-occipital synchondrosis, a cartilag-inous growth site that does not cease until 17–20 years.

The angle Ba-S-N was found to be larger

208 Cleft Palate Journal, July 1982, Vol. 19 No. 3

TAB	LE	1.	Sample	Sizes*
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Age		UCLP			BCLP		СРО					
	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	4 1	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.

in females, smaller in males in the more severe cleft-type. Significant differences were only obtained for pairs involving BCLP at some ages and only in females (Table 2).

It is of import to note that the size-dominance in cranial base flexion by the female is in the more severe clefting, BCLP and UCLP, in both of which the lip is involved. This leads to the possibility that a larger Ba-S-N angle may be part of a greater syndrome, for these two cleft-types, as opposed to CPO, are considered to have a genetic basis. The larger sellar angle in the two more severe or complex cleft-types suggests that clefting and cranial flexion, which occur almost simulataneously in embryogenesis, are linked not only to structural organismictime, but also by a polygenic mechanism.

There is no clear-cut pattern in the dimensions Ba-S and S-N as related to clefting. Virtually no significant differences were obtained.

In summary, the cranial base paired clefttypes differ significantly only in the female Ba-S-N angle; they do not differ significantly in the dimensions Ba-S and S-N (Tables 2–3). In other words, size, and to a larger extent, growth-timing, are uninfluenced by clefttype.

II. Face Heights. In terms of growth-timing the three facial heights measured evince a focal growth-change in infancy (essentially tooth calcification) and at the early childhood—mid childhood transition (beginning deciduous-permanent teeth replacement). There was an interesting over-all dichotomy for the dimension N-ANS. There is a size dominance in both the most severe and the least severe of the cleft-types: BCLP over UCLP and BCLP over CPO (but unevenly in the male); CPO over UCLP. Krogman *et al.* (1975), using the pooled sample, showed N-ANS to be uniformly larger in CPO in comparison to UCLP. Significant differences were obtained exclusively in the pairings involving the BCLP during infancy for males, and during infancy and at the early childhood—mid childhood transition for females.

Statistically significant differences for N-Ids were obtained for pairs involving BCLP only during infancy for males. For females, BCLP was found to be significantly larger than UCLP and CPO in late infancy and early early childhood. Krogman *et al.* (1975), found CPO to be larger than UCLP for ages 0:1 through 3:0 but smaller for ages 4:0 through 6:0. No statistically significant differences were observed for Idi-Gn.

III. Midfacial Depths and the Basifacial Angle. The dimensions Ptm'-ANS, Ptm'-A, KR-ANS, and the angle S-N-A were significantly larger for the more severe of the paired cleft-types. Similar results were obtained by Krogman *et al.* (1975) for the pooled samples. For Ptm'-KR, almost no significant differences were observed.

IV. The Mandible. For the corporal length Go-Gn, except for BCLP/CPO pair in females, almost no significant differences were observed. For BCLP/CPO pair in females,

								Ag	e						
Variable	Group	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
Angle	UCLP, BCLP														
Ba-S-N	BCLP, CPO														
	UCLP, CPO														
Dimension	UCLP, BCLP	₂ X*													
Ba-S	BCLP, CPO														
	UCLP, CPO														
Dimension	UCLP, BCLP														
S-N	BCLP, CPO	$_{2}X$													
	UCLP, CPO	$_{1}X$													
Dimension	UCLP, BCLP	$_{2}X$	$_{2}X$	$_{2}X$							$_{2}X$				
N-ANS	BCLP, CPO	$_{2}X$	$_{2}X$				$_{3}X$								
	UCLP, CPO						$_{3}\mathrm{X}$					$_{3}X$			
Dimension	UCLP, BCLP	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$						$_{2}X$			$_{2}X$	
N-Ids	BCLP, CPO	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$								$_{2}X$		
	UCLP, CPO									$_{3}X$					
Dimension	UCLP, BCLP										$_{2}X$				
Idi-Gn	BCLP, CPO	$_{2}X$													
	UCLP, CPO														
Dimension	UCLP, BCLP	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$
Ptm'-ANS	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$
	UCLP, CPO	$_{1}X$			ıΧ	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}\mathrm{X}$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$		
Dimension	UCLP, BCLP	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$
Ptm'-A	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$
	UCLP, CPO	${}_{1}X$		$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$
Dimension	UCLP, BCLP		$_{2}X$												
Ptm'-KR	BCLP, CPO		$_{2}X$									$_{2}X$			
	UCLP, CPO		$_{3}X$									$_{1}X$			
Dimension	UCLP, BCLP	$_{2}X$	$_{2}\mathrm{X}$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}\mathrm{X}$
KR-ANS	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$
	UCLP, CPO			$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$				
Angle	UCLP, BCLP	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$		$_{2}X$		$_{2}\mathrm{X}$
S-N-A	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	- ₂ X	$_{2}X$	$_{2}X$	$_{2}X$
	UCLP, CPO		$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$			•
Dimension	UCLP, BCLP														
Go-Gn	BCLP, CPO	$_{2}X$				$_{2}\mathrm{X}$									
	UCLP, CPO														
Dimension	UCLP, BCLP			$_{1}X$		$_{1}X$									
Ar-Go	BCLP, CPO											$_{2}X$			$_{2}X$
	UCLP, CPO			$_{1}X$				$_{1}X$	$_{1}X$	$_{1}X$		$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$
Angle	UCLP, BCLP														
Ar-Go-Gn	BCLP, CPO			$_{3}X$											
	UCLP, CPO				$_{3}X$										

TABLE 2. Significantly Different Groups by Variable by Age at $\alpha = .05$ for Males.

* An "X" in a given row and column indicates significance at $\alpha = .05$. The subscript in front of "X" indicates the index of the group having the larger mean (1 = UCLP, 2 = BCLP, 3 = CPO).

BCLP had significantly larger corporal length at 0:6, 1:0, 6:0 to 8:0. The same was true for the ramal height, Ar-Go, but except for the UCLP/CPO pair in males, no significant differences were observed. For UCLP/CPO pair in males, the UCLP had significantly larger ramal height at 0:6, 3:0–5:0, 7:0–10:0. For BCLP/CPO pair in females, CPO had significantly larger gonial angle Ar-Go-Gn from 1:0–6:0. Thus, in contrast to the other skeletal complexes analyzed, i.e., cranial base and midface, the mandible is relatively unaffected by clefting.

Conclusions

In an over-view of the foregoing data we offer a final statement of paired cleft-type differentiation of the four major structural areas and/or units that we set up.

210 Cleft Palate Journal, July 1982, Vol. 19 No. 3

TABLE 3. Significantly Different Groups by Variable by Age at $\alpha = .05$ for Females

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Variable	Group	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
Angle	UCLP, BCLP				$_{2}X^{*}$					$_{2}X$	$_{2}X$	$_{2}X$			
Ba-S-N	BCLP, CPO	$_{2}X$		$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$			
	UCLP, CPO														
Dimension	UCLP, BCLP														
Ba-S	BCLP, CPO														
	UCLP, CPO												$_{1}X$		
Dimension	UCLP, BCLP														
S-N	BCLP, CPO				$_{2}X$							$_{2}\mathrm{X}$			
	UCLP, CPO											$_{1}\mathrm{X}$			
Dimension	UCLP, BCLP		$_{2}X$	$_{2}X$	$_{2}X$			$_{2}X$			$_{2}X$	$_{2}X$			
N-ANS	BCLP, CPO		$_{2}X$		$_{2}X$			$_{2}X$		$_{2}X$	$_{2}X$	$_{2}X$			
	UCLP, CPO														
Dimension	UCLP, BCLP			$_{2}X$	$_{2}X$		$_{2}X$					$_{2}X$			
N-Ids	BCLP, CPO			$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$					$_{2}X$			
	UCLP, CPO														
Dimension	UCLP, BCLP														
Idi-Gn	BCLP, CPO														
	UCLP, CPO														
Dimension	UCLP, BCLP			$_{2}X$	$_{2}X$			$_{2}X$		$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$		$_{2}X$	
Ptm'-ANS	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$
	UCLP, CPO				ıΧ	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	
Dimension	UCLP, BCLP	$_{2}X$	$_{2}X$		$_{2}X$		$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$		$_{2}X$	
Ptm'-A	BCLP, CPO	$_{2}X$	$_{1}X$		$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$
	UCLP, CPO	$_{1}X$			$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}\mathrm{X}$	$_{1}X$	$_{1}X$	$_{1}\mathrm{X}$
Dimension	UCLP, BCLP			$_{2}X$	$_{2}X$										
Ptm'-KR	BCLP, CPO			$_{2}X$	$_{2}X$										
	UCLP, CPO														
Dimension	UCLP, BCLP	$_{2}X$		$_{2}X$			$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$		$_{2}X$	
KR-ANS	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$
	UCLP, CPO				$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}\mathrm{X}$	$_{1}X$	$_{1}X$	$_{1}X$
Angle	UCLP, BCLP	$_{2}X$													
S-N-A	BCLP, CPO	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}X$	$_{2}\mathrm{X}$	$_{2}X$			$_{2}X$	-
	UCLP, CPO			$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$	$_{1}X$			$_{1}\mathrm{X}$	
Dimension	UCLP, BCLP				$_{2}X$										
Go-Gn	BCLP, CPO			$_{2}X$	$_{2}X$						$_{2}X$	$_2X$	$_{2}X$		
	UCLP, CPO											$_{1}X$			
Dimension	UCLP, BCLP														
Ar-Go	BCLP, CPO														
	UCLP, CPO				$_{1}X$										
Angle	UCLP, BCLP	$_{1}X$			$_{1}X$										
Ar-Go-Gn	BCLP, CPO UCLP, CPO				₃ X	3Х	₃ X	₃ Х	$_{3}\mathrm{X}$	$_{3}X$	3Х				

* An "X" in a given row and column indicates significance at $\alpha = .05$. The subscript in front of "X" indicates the index of the group having the larger mean (1 = UCLP, 2 = BCLP, 3 = CPO).

- 1. In the cranial base the only difference between paired cleft-types is found in the angular relationship and not in dimensions. Furthermore, only females are involved, and it is BCLP that is set apart from both UCLP and CPO. Severity of the cleft-type in the female sellar angle stands out as a determining measurement of differences.
- 2. In facial heights, BCLP is set apart from UCLP and CPO in males and females, but only in the upper face. Severity of cleft-type is a determining factor of dimensional difference in upper face but not in lower face (mandibular symphyseal height).
- 3. In midfacial depths and the basifacial angle in each cleft-type pair, it is the

more severe of the two that has significantly larger dimensions in both sexes. There is one notable exception, Ptm'-KR, the posterior segment of the palate, shows no cleft-type difference whatsoever.

4. The mandible, interestingly enough, shows only one pairing where the gonial angle, Ar-Go-Gn, is a differentiating measurement: CPO female in the BCLP/CPO pair. An analogous but reversed situation was found in the sellar or cranial base angle, Ba-S-N, where the BCLP female stands out in the BCLP/ CPO pair. It is possible that in clefting these angles are of a compensatory adjustive nature in each of the two areas or structures concerned, viz., cranial base and mandible.

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