Cephalometric Comparisons on the Cranial Base and Face in Individuals with Isolated Clefts of the Palate

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Introduction

The literature is replete with references to cleft palate individuals and their facial growth when compared to non-cleft individuals. Confusing evidence has been presented regarding the effects of surgery, with some authors contending that all the observed differences are a direct result of the surgery. The question that arises is whether the defect is confined to the maxilla and/or mandible or if it is part of an aberrant cranial growth pattern which affects the facial growth and profile.

Objectives

The purposes of this study are:

1. To determine linear and angular measures of the cranial base and the relative positions of the maxilla and the mandible to the cranial base in two samples of cleft palate only (CPO) female individuals at two different ages (before and after the pubertal growth spurt).
2. To compare these cleft palate only samples with randomly selected samples of normal (non-cleft) individuals of the same age and sex.
3. To describe any differences that may exist.

Literature Review

The purpose of this review is to analyze the literature regarding roentgenographic cephalometric findings and differences observed in the craniofacial morphology of individuals with isolated clefts of the palate (CPO) in comparison to the non-cleft individuals.

Results of studies on the craniofacial complex of the CPO individual will be presented under three headings: cranial base, maxilla and mandible.

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CRANIAL BASE. The cranial base of the CPO individual has not been adequately studied and few investigations on this subject can be found in the literature.

Moss (*9*) contends the cranial base of all cleft lip and/or palate individuals differs from the non-cleft individual. He has termed this malformation of the cranial base "dyostosis sphenoidalis", and hypothesized that early embryonic stages of fetal development may be responsible for this difference.

Ross (*12*) in a study which included 103 CPO individuals (38 males and 65 females) from ages four to adulthood, could find no difference in the clivus-planum cranial base flexure in the CPO individual when compared to the non-cleft sample.

Dahl (*4*) found the cranial base of the CPO individual to differ on the average from the control in both size and shape. The total linear measures (N-Ba), as well as the anterior (N-S) and posterior (S-Ba) segmental measures, were significantly shorter in the CPO group. Changes in shape of the cranial base were manifested in a general tendency toward flattening of the base.

In summary, the review of the literature reveals few studies of the cranial base in the CPO individual. Dahl (*4*) found that the midline cranial base flexure tends toward flattening, while Moss (*9*) reported an increased flexure. Dahl (*4*) and Ross (*12*) reported significant differences in the absolute linear measures of the cranial base between the CPO and normal non-cleft sample. Ross (*12*) reported no difference in the relative linear measures between the two groups and tends to regard the smaller overall stature of the CPO individual as the contributing factor to any differences in the absolute cranial base linear measures.

MAXILLA. Many investigators have presented data to show that the maxilla of the CPO individual, on the average, is shorter anteroposteriorly and more retrusive in relation to the cranial base when compared to the non-cleft individual (*1, 4, 14*). Some have indicated that the cleft has retarded the growth potential of the maxilla and is responsible for the retrusive maxilla (*3, 6, 9, 12*).

In more recent literature, investigators have shown that skeletal maxillary growth in antero-posterior and lateral dimensions in the CPO individual does not differ significantly between the operated or obturated CPO individual (*1, 4, 10*).

Bishara (*1*) compared 20 CPO Caucasian females (12 operated and 8 obturated) with a matched control sample of 32 normal non-cleft Caucasian females. The mean age of the cleft sample was 18.2 years with a range of 15.9 years to 21.5 years. The mean age of the normal non-cleft sample was 19.4 years with a range of 18.2 to 23.4 years. Comparative data between the non-cleft and the total CPO sample revealed that the maxilla was positioned more posterior in relation to the anterior cranial

base (SNA), and the maxillary length measured from anterior nasal spine (ANS) to pterygomaxillary fissure (PTM) was significantly shorter in the CPO group. A comparison was then made between two subgroups; operated and obturated. The data revealed no significant differences in the angular or linear dimensions measured between the two CPO subgroups.

Dahl (*4*) compared 57 CPO Danish males (41 operated and 16 non-operated) with a matched control sample of 102 normal non-cleft Danish males. The CPO sample age range was 18 to 33 years, while the non-cleft control was 20 to 30 years. Comparative data between the non-cleft and the total CPO sample of 94 craniofacial parameters measured, revealed differences in the maxillary length measures and in the sagittal position of the upper face. Indicating that in the CPO individuals the maxilla was retrusive in relation to the anterior part of the cranial base.

A comparison of the same measures between the two subgroups (CPO operated and CPO non-operated) revealed no significant difference in most of the angular or linear craniofacial measurements examined. Dahl found that in the obturated group the mandibular plane is steeper and the total face height is larger. Posterior maxillary height (S-PTM) was smaller in the operated group. In his discussion he stated that he does not believe that in the operated group the clefts were of lesser extent.

The findings of Bishara (*1*) and Dahl (*4*) agree that the maxillary relation and depth in operated and non-operated (obturated) CPO individuals are not significantly different. When the maxilla of the CPO individual is compared to the non-cleft control, the maxilla is found to be shorter (ANS-PTM) and positioned relatively posterior in relation to the cranial base (SNA).

Mandible. The mandible of the CPO individual has been the subject of much controversy. The findings in the literature indicate that many varied opinions have been presented. Pinkerton et al. (*11*), in a review and critical analysis of the literature regarding size and position of the mandible in subjects with clefts of the lip and/or palate concluded that many of the purported findings were clinical impressions and/or based on non-homogeneous samples. In a number of studies it has been reported that the mandibular plane angle (MP-SN) is larger and the mandible is more retrusive (S-N-Pg) in CPO subjects when compared to non-cleft individuals (*1, 4, 5, 13, 14*).

Shibasaki and Ross (14) reported the mandible is of normal length but retropositioned. This was postulated as a functional response of the mandible to the altered maxilla. They also found the retruded face to become more retruded with age but that the facial profile of the CPO individual was clinically acceptable due to the functional positional changes in the mandible.

In summary, the literature reveals that the mandible in the CPO individual differs from the non-cleft individual. These differences are centered around a more obtuse gonial angle which creates a steeper MP-SN angle,

and/or a more posterior position of the mandible in relation to the cranial base in the CPO individual.

Materials and Methods

The present study will be concerned with a population of CPO individuals who will be compared to a control non-cleft group matched regarding race, age, and sex. Differences (if any exist) can be more meaningfully reported and analyzed.

The subjects for this study are American-born Caucasian females predominantly of northwest European ancestry. A study of females only is considered more pertinent because of the predominant distribution of females in the CPO population (*12*). Moreover individuals with typical Pierre Robins Syndrome were excluded from the study. Data characterizing the subjects are found in Table 1.

CONTROL SAMPLE. *Group I.* The subjects for this group are 30 normal (non-cleft) Caucasian females between 6.9 to 9.7 years of age. *Group III,* the subjects for this group are 30 normal (non-cleft) Caucasian females between 18.2 to 23.4 years of age.

CLEFT SAMPLE. *Group II.* The subjects for this group are 27 CPO Caucasian females between 7.0 to 9.7 years of age. *Group IV,* the subjects for this group are 27 CPO Caucasian females between 14.0 to 21.5 years of age.

There are eight individuals who are common to both the young and old CPO groups and longitudinal data will be presented on these subjects.

The data was derived from norma lateralis roentgenograms of subjects whose heads were positioned in a cephalostat and oriented to Frankfort horizontal plane.

TABLE 1. Subjects utilized in the investigation.

subjects	*I young normal*	*II young CPO*	*III old normal*	*IV old CPO*
sample size	30	27	30	27
mean age and range at observation in years	8.2 (6.9–9.7)	8.0 (7.0–9.7)	19.4 (18.2–23.4)	17.6 (14.0–21.5)
cleft sub-type*				
1		1		0
2		12		8
3		13		16
4		1		3

* Cleft sub-type:
1. Cleft of the uvula only
2. Cleft of the soft palate but not involving the hard palate
3. Cleft of the hard palate not extending to the incisive foramen
4. Cleft of the hard and soft palate extending to the incisive foramen

Duplicates of all original films were used in this study. Since the original and duplicate films are in contact during processing, the duplicate is an exact copy of the original. All of the measured rectilinear distances were corrected by using the appropriate correction factors.

LANDMARKS. The following anatomic landmarks and points (*7, 8*) were located and pricked on the duplicate head films (Figure 1).

1. Point A (A): the deepest midline point between anterior nasal spine and prosthion. 2. Point B (B): the deepest midline point between infradentale and pogonion. 3. Sella (S): the midpoint of sella turcica determined by inspection. 4. Nasion (N): the most anterior portion of the naso-frontal suture located on the frontal bone. 5. Sphenoid Wing Point (W): the point located by inspection midway between intersections of the two greater wings of the sphenoid bone with the sphenoid

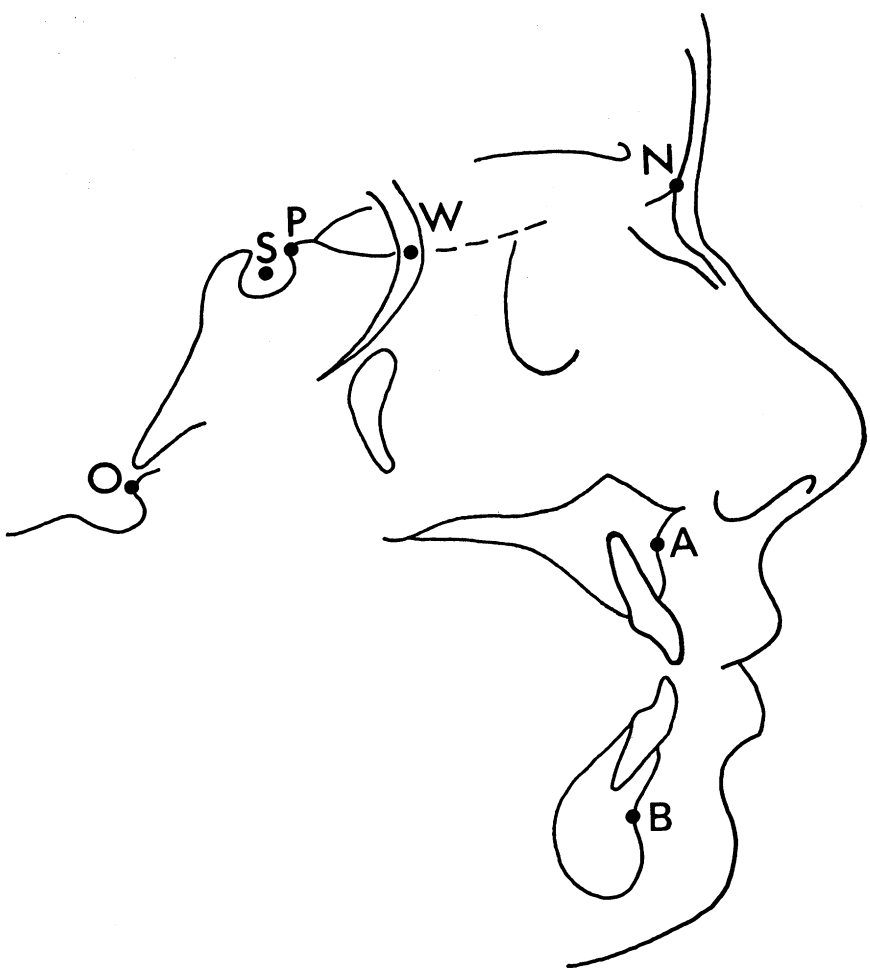

FIGURE 1. Landmark points used in the investigation.

plane. 6. Pituitary Point (P): the point of greatest convexity between the anterior contour of sella turcica and the sphenoid plane. 7. Anterior-most point of occipital condyle (O): the point demarcating the junction of the anterior margin of the condyle with the precondylar portion of the occipital bone.

These landmarks allow segmenting of the cranial base into three sections: two dimensions between nasion and pituitary point, and a posterior dimension. Linear and angular measures of the cranial base were recorded for the four groups of subjects.

MEASUREMENTS. Using the previously described landmarks, the following measurements were recorded from each of the duplicate cephalographs.

Cranial Base Linear Measures (*7*). 1. N-W: representative of the sinus and ethmoid segments of the anterior cranial base. 2. W-P: representative of the presphenoid segment of the anterior cranial base. 3. N-P: representative of the anterior cranial base. 4. P-O: representative of the postsphenoid segment of the cranial base. 5. N-O: representative of the anterior and posterior cranial base length.

Cranial Base Angular Measure NPO: representative of the cranial base flexure.

Craniofacial Angular Measures (*8*). 1. SNA: Representative of the relative anteroposterior relation of the maxilla to the cranial base. 2. SNB: representative of the relative anteroposterior relation of the mandible to the cranial base. 3. ANB: the difference between the angles SNA and SNB representing the relative position of the maxilla to the mandible.

STATISTICAL METHODS. The mean ($\bar{X}$), standard deviation (S.D.), t value, correlation coefficient (r), and multiple correlation (R) from a step-wise regression were calculated for the normal and CPO groups. The student's t-test was used to test the null hypothesis of no significant difference between means. Statistical significance was predetermined at the .05 and .01 level of confidence.

The correlation coefficient (r) and the multiple correlation (R) from a step-wise regression were calculated to determine if any significant relations of practical value between the angle SNA (as the dependent variable) and the other cranial base linear and angular measures existed.

Intra- and inter-investigator measurement reliability were calculated and revealed no significant difference at the .05 level of confidence.

Findings

Detailed findings are presented in Tables 2–6. Comparative data between the groups are presented in a similar manner in each table. The tables include the measure of study, the mean and standard deviation of the measure, and the t-value. Table 7 presents longitudinal data on the 8 CPO individuals who are common to the young and old CPO samples.

TABLE 2. Young normal vs. young CPO.

measures	*young normal (N = 30)*		*young CPO (N = 27)*		*t value*
	mean	*s.d.*	*mean*	*s.d.*	
linear					
N-W mm	40.34	2.51	37.57	3.02	3.84**
W-P mm	17.44	2.01	17.71	1.98	−0.53
N-P mm	57.66	1.99	55.36	3.39	3.19**
P-O mm	40.77	2.70	39.85	2.68	1.31
N-O mm	88.95	3.52	85.60	4.92	3.02**
angular					
NPO°	128.97	4.61	127.58	6.62	0.94
SNA°	80.48	2.17	78.52	4.46	2.16*
SNB°	76.98	2.87	75.60	4.03	1.52
ANB°	3.48	1.75	3.10	2.91	0.61
relative proportions					
NP % NO	64.86	1.65	64.95	2.45	−0.15
PO % NO	45.83	2.17	46.74	2.39	−1.54

Levels of significance * alpha = .05
** alpha = .01

In the text, for the sake of brevity, only the significant findings will be reported.

Young Normal vs. Young CPO (Table 2). In this comparison the total cranial base length (N-O), the anterior cranial base length (N-P) and the ethmoid segment of the anterior cranial base length (N-W) of the CPO individual are on the average significantly shorter than the young normal individual ($P \leqq .01$). The angle SNA of the young CPO individual is on the average 1.96° smaller than the young normal individual ($P \leqq .05$).

Old Normal vs. Old CPO (Table 3). In this comparison the total cranial base length (N-O) and the posterior cranial base length (P-O) of the old CPO individual are on the average significantly smaller than the old normal individual ($P \leqq .01$).

Old CPO Obturated vs. Operated (Table 4). The data revealed no significant difference on any of the measurements at the .05 level of confidence.

Old Normal vs. Young Normal (Table 5). The total cranial base length (N-O), the ethmoid segment of the anterior cranial base length (N-W) and the posterior cranial base length (P-O) of the old normal individual are on the average significantly larger than the young normal individual ($P \leqq .01$). The angle ANB of the old normal individual is on the average 1.39° smaller than the young normal individual ($P \leqq .05$). The relative length of the anterior cranial base to the total cranial base length (N-P % N-O) and the relative length of the posterior cranial base to the total cranial base (P-O % N-O) of the old normal individual are significantly larger than the young normal individual ($P \leqq .01$).

TABLE 3. Old normals vs. old CPO.

measures	*old normal (N = 30)*		*old CPO (N = 27)*		*t value*
	mean	*s.d.*	*mean*	*s.d.*	
linear					
N-W mm	42.29	2.94	42.25	3.89	0.04
W-P mm	17.73	2.35	16.96	2.90	1.12
N-P mm	59.87	1.84	59.73	4.08	0.18
P-O mm	44.85	2.59	43.16	2.53	2.52*
N-O mm	94.87	3.80	91.71	4.48	2.90**
angular					
NPO°	129.42	4.52	127.53	7.52	1.17
SNA°	79.92	3.03	77.18	4.48	2.74**
SNB°	77.84	2.58	75.90	5.05	1.86
ANB°	2.09	2.43	1.56	3.40	0.69
relative proportions					
NP % NO	63.16	1.94	63.54	2.01	−1.66
PO % NO	47.27	1.97	47.10	2.53	0.29

Levels of significance * alpha = .05
** alpha = .01

Old CPO vs. Young CPO (Table 6). The total cranial base length (N-O), the anterior cranial base length (N-P), the ethmoid segment of the anterior cranial base length (N-W) and the posterior cranial base length (P-O) of the old CPO individual are on the average significantly larger than the young CPO individual ($P \leqq .01$).

TABLE 4. Old CPO-operated vs. non-operated.

measures	*old CPO operated (N = 16)*		*old CPO non-operated (N = 7)*		*t value*
	mean	*s.d.*	*mean*	*s.d.*	
linear					
N-W mm	42.56	3.19	41.05	5.21	−0.86
W-P mm	17.00	2.10	17.42	3.94	0.33
N-P mm	59.58	2.50	60.63	7.05	0.53
P-O mm	43.87	1.54	42.65	2.84	−1.35
N-O mm	92.79	3.24	89.59	5.08	−1.83
angular					
NPO°	127.73	6.59	124.57	5.06	−1.13
SNA°	77.30	4.79	76.68	2.57	−0.32
SNB°	75.56	5.70	75.82	4.55	0.11
ANB°	1.73	3.46	0.86	3.33	−0.56
relative proportions					
NP % NO	64.25	1.92	65.12	2.13	0.96
PO % NO	47.33	2.23	47.65	2.57	0.30

Levels of significance * alpha = .05
** alpha = .01

TABLE 5. Young normal vs. old normal.

measures	*young normal (N = 30)*		*old normal (N = 30)*		*t value*
	mean	*s.d.*	*mean*	*s.d.*	
linear					
N-W mm	40.34	2.51	42.29	2.94	−2.77**
W-P mm	17.44	2.01	17.73	2.35	−0.52
N-P mm	57.66	1.99	59.87	1.84	−4.48**
P-O mm	40.77	2.70	44.85	2.59	−5.97**
N-O mm	88.95	3.52	94.87	3.80	−6.26**
angular					
NPO°	128.97	4.61	129.42	4.52	−0.38
SNA°	80.48	2.17	79.92	3.03	0.83
SNB°	76.98	2.87	77.84	2.58	−1.22
ANB°	3.48	1.75	2.09	2.43	2.54**
relative proportions					
NP % NO	64.86	1.65	63.16	1.94	3.65**
PO % NO	45.83	2.17	47.27	1.97	−2.70**

Levels of significance * alpha = .05
** alpha = .01

Old CPO vs. Young (Matched Set). The detailed finding of the longitudinal data on the matched set of eight CPO individuals is found in Table 7. The total cranial base length (N-O), the anterior cranial base length (N-P), the ethmoid segment of the anterior cranial base (N-W) and the

TABLE 6. Young CPO vs. old CPO.

measures	*young CPO (N = 27)*		*old CPO (N = 27)*		*t value*
	mean	*s.d.*	*mean*	*s.d.*	
linear					
N-W mm	37.57	3.02	42.25	3.89	−5.09**
W-P mm	17.71	1.98	16.96	2.90	1.15
N-P mm	55.36	3.39	59.73	4.08	−4.40**
P-O mm	39.85	2.68	43.16	2.53	−4.79**
N-O mm	85.60	4.92	91.71	4.48	−4.89**
angular					
NPO°	127.58	6.62	127.53	7.52	0.03
SNA°	78.52	4.46	77.18	4.48	1.13
SNB°	75.60	4.03	75.90	5.05	−0.25
ANB°	3.10	2.91	1.56	3.40	1.84
relative proportions					
NP % NO	64.95	2.45	64.54	2.01	0.68
PO % NO	46.74	2.39	47.10	2.53	−0.55

Levels of significance * alpha = .05
** alpha = .01

TABLE 7. Longitudinal data on the matched set of CPO individuals.

measures	*young CPO (N = 8)*		*old CPO (N = 8)*		*t value*
	mean	*s.d.*	*mean*	*s.d.*	
linear					
N-W mm	37.84	4.10	41.68	3.34	−4.85**
W-P mm	18.42	2.33	18.27	2.84	0.21
N-P mm	56.14	4.67	59.84	2.36	−3.88**
P-O mm	40.39	2.78	43.58	1.55	−3.90**
N-O mm	87.11	5.53	93.06	2.36	−3.63**
angular					
NPO°	129.00	6.56	128.03	5.07	0.52
SNA°	77.91	4.76	75.50	6.39	1.36
SNB°	74.75	3.07	74.47	4.67	0.17
ANB°	3.22	3.24	2.03	2.18	1.19
relative proportions					
NP % NO	64.40	1.93	64.35	2.21	0.07
PO % NO	46.42	2.77	46.84	1.45	−0.66

Levels of significance * alpha = .05
** alpha = .01

posterior cranial base (P-O) of the old CPO individual are on the average significantly larger than the young CPO individual ($P \leqq .01$).

CORRELATIONS. Correlation coefficients were computed on all of the measured variables for the total normal ($N = 60$) and the total CPO ($N = 54$) groups, as well as for the young and old groups separately. The data revealed statistically significant correlations at the .05 level of confidence, but these correlations are very small and therefore have little practical value. These findings are consistent in both the normal and CPO groups.

STEP-WISE MULTIPLE REGRESSION. A step-wise multiple regression was computed on all the measured variables for the total normal ($N = 60$) and the total CPO ($N = 54$) groups, as well as for the young and old groups separately. In the step-wise multiple regression angle SNA is the dependent variable with the remaining measures as the independent variables. The only measures that were highly related to SNA were SNB and ANB, and these were expected.

Discussion

The review of the literature regarding the comparisons between the normal and CPO individuals revealed the following:

1. Absolute cranial base linear measures on CPO individuals are on the average shorter when compared to non-cleft individuals.

2. The cranial base flexure angle in CPO individuals as compared to non-cleft individuals has been reported as smaller (*9*), larger (*4*), and normal (*12*).

3. The maxilla and mandible of the CPO individual as compared to the

non-cleft individual are more retrusive in their relation to the anterior cranial base as evidenced by a smaller SNA and SNB angle (*1, 4*). However, the relative position of the maxilla to the mandible appears to be normal as evidenced by the ANB angle (*1, 4, 14*).

4. The CPO operated and CPO non-operated individual are not significantly different in linear and angular measures of the cranial base (*14*) and its associated facial structures (*1, 4*). It has therefore been suggested that the CPO and normal faces are different and that such a difference is not necessarily the result of the palatoplasty performed (*1*).

Comparisons of the data in this investigation to that of other studies reveal the following:

Cranial Base. 1. The normal non-cleft individuals in both the old and young age groups are larger in terms of the absolute dimensions of the cranial base (N-O, N-P, P-O) when compared to the corresponding CPO groups. However, there were no significant differences found in the relative measures (NP % NO, PO % NO) of the cranial base between the corresponding normal and CPO groups.

2. The cranial base flexure angle (NPO) in the CPO individual is not significantly different from the normal individual in either the young or old age group.

3. The longitudinal data presented on the 8 matched CPO individuals, reveals significant differences of similar magnitude on the same measures, as does the previously discussed cross sectional data. This information reveals that linear proportional growth has occurred in the cranial base from the younger to the older age group.

Maxilla and Mandible in Relation to the Cranial Base. Maxilla. The maxilla of the CPO individual is on the average more retrusive in relation to the anterior cranial base (SNA) than in the corresponding non-cleft individual in both age groups. These findings were previously reported (*1, 4, 14*). The maxilla in the CPO individual tends to become more retrusive with age, but not significantly different from the same tendency recorded in the normal individual.

Mandible. In this investigation the SNB angle of the CPO individual was not significantly different from the corresponding normal group. Bishara (*1*) and Dahl (*4*) previously reported significant differences between the CPO and non-cleft subjects.

Maxillary-Mandibular Relations: The CPO individual appears to have a relatively normal anteroposterior jaw relation as indicated by the ANB angle. In both the young and old CPO groups the ANB angle is slightly but not significantly smaller when compared to the corresponding normal groups. Similar findings were previously reported (*1, 4*).

Operated vs. Non-Operated (Obturated). The CPO sample was divided into operated and non-operated individuals to detect differences in the cranial base and the relation of the maxilla and mandible to each other. No significant differences were noted between the two subgroups.

Similar findings on other parameters were previously reported by Bishara (*1*) and Dahl (*4*).

The findings in this study are generally in support of the work by Bishara (*1*), Dahl (*4*), Ross (*14*) in that the CPO individual is smaller on the average in most cranial linear measures, yet proportionately the same when compared to the normal individual. The maxilla of the CPO individual is on the average more retrusive to the cranial base than in the normal individual. The maxillo-mandibular relations of the CPO individual should afford him/her an acceptable profile.

It can be hypothesized that the differences in the facial relations between the CPO individual and the normal individual may be due to any one or combination of the following factors:

1. Surgical intervention (palatoplasty).
2. Differences in the cranial base morphology.
3. Morphogenetic facial pattern of the CPO individual associated with the presence of the cleft (i.e., part of a cleft palate syndrome).
4. Mechanically compensatory due to the mechanical presence of the cleft itself (i.e., due to absence of the proper parts).

The comparative results of the CPO operated vs. CPO non-operated individual in this study and the support of work by Bishara (*1*) and Dahl (*4*) would tend to confirm to a certain extent the assumption that palatoplasty is not the only (or major) factor affecting the anteroposterior and vertical craniofacial skeletal relations. It must be stressed on the other hand that palatoplasty does affect the dental relations.

Comparative results between CPO and normal individuals showed no significant differences in cranial base flexure. Significant differences in linear dimensions are absolute rather than relative. These findings are similar to those of Dahl (*4*) and Ross (*12*) and together would tend to minimize the role of the cranial base morphology as one of the explanations for the differences between the CPO and normal individuals.

It is, therefore, suggested that part of the explanation for the observed differences between the CPO and the normal groups can be related to either morphogenetic differences in facial patterns or mechanically compensatory changes associated with the presence of the local defect in the maxilla.

Chierichi et al. (*2*) in a recent experiment, surgically induced a complete cleft of the bony palate and constricted the maxilla on 21 Rhesus monkeys and used another 21 monkeys as controls. At the end of one year they found no significant differences in the length of the mandible or in face height, yet significant differences were found in the gonial angle, inclination and intrusion of the incisors, mandibular intra-molar width and arch length. This study tends to indicate that at least in the mandible there are compensatory changes related to the presence of the cleft and/or the constriction of the maxilla in the Rhesus monkeys.

Conclusion

The cranial base of the CPO individual on the average is smaller than the non-cleft individual in absolute linear measures, however, the relative measures are not significantly different in the two groups. The cranial base of the CPO individual on the average must be considered normal in relative dimensions yet smaller in over-all size when compared to the non-cleft individual.

The CPO operated and CPO non-operated individuals are not significantly different in any of the parameters measured in this study.

The retrusive relation of the maxilla in the CPO individual compared to normal individuals does not appear to be a function of the cranial base. No correlation coefficients of any significance could be ascertained between the angle SNA and any of the cranial base measured.

It is suggested that part of the explanation for the observed differences between the CPO and normal groups can be related to either morphogenetic differences in facial patterns or mechanically compensatory changes associated with the local defect in the maxilla.

The effects of palatoplasty (or other acquired factors) are thought to be superimposed on an existing facial pattern. To better answer the questions at hand, more studies on unoperated individuals using larger samples are needed.

Cross-sectional studies of a large sample of unoperated individuals at maturity are possible although such a sample may be hard to find in any one institute. A collaborative effort on the other hand can make such a study possible.

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