A Cephalometric Analysis Of Cleft Palate Deficiencies In The Middle Third Of The Face

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Early opinions regarding cleft palate procedures were based on observation rather than measurement and are readily divisible into two groups of thought completely at variance with one another. One group believed that all palatal tissue was present at birth, while the other group felt that there was an actual deficiency of palatal tissue due to deficient development, arrested growth, or atrophy. Brophy[1] felt that there was not a deficiency of tissue in the median line, but that there had been a failure of union and that the bones had been crowded in utero by action of the lower jaw. He advocated early surgery with complete approximation of parts feeling that subsequent growth would correct the deformity. On the other hand, Case[2] was of the opinion that only in rare cases of cleft palate was there sufficient soft tissue for surgical closure.

There have been many studies dealing with growth and development in cleft palate patients. Borden[3] and Williams[4] have demonstrated a similarity in growth of the cranial base in cleft and noncleft children. Brader[5] and Konishi[6] observed a superior position of the palate in cleft palate individuals. Subtelny[7] found wider and more laterally inclined pterygoid plates in patients afflicted with a cleft palate.

In an extensive study of cleft palate patients Graber[8] observed a definite correlation between delayed surgical procedures and normal development. He advocated postponement of surgical correction until at least the end of the fourth year of life when five-sixths of total maxillary width is usually achieved. This concept of delayed surgical intervention was endorsed by Slaughter and Brodie.[9] A recent study in Puerto Rico by Mestre, et al.,[10] presented further evidence to this effect by reporting a conspicuous absence of deficiencies in unoperated cleft palate adults. Ricketts[11] was of the opinion that it would be erroneous to assume that a concave profile in a cleft palate patient is always the result of surgical interference with growth, inasmuch as a variation in the facial skeleton of noncleft individuals also may manifest itself as a concave profile.

The cleft palate patients used in this study were grouped according to the modified Veau classification, as presented by Bzoch,[12] and as used at the Northwestern University Cleft Lip and Palate Institute. The following is a brief description of this classification:

Class I: clefts involving only the soft palate.

Class II: clefts involving all of the soft palate and some of the hard palate up to the incisive foramen.

Class III: a midline cleft through the hard and soft palates plus a complete or incomplete fissure through the alveolar ridge, to either the left or the right of the premaxillary segment.

Class IV: clefts of the hard and soft palates and a bilateral fissure, one on each side of the premaxillary region. A unilateral or bilateral cleft of the lip

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structure usually accompanies the alveolar ridge clefts and is designated as either complete or incomplete, and as right, left, or midline in this classification.

Problem

It has been observed that some cleft palate patients present a deficiency in the maxillary region of the face in profile. With this thought in mind an attempt was made to measure the various craniofacial components of cleft palate individuals exhibiting a middle-third deficiency of the face by means of cephalometric radiographs and to compare these measurements with those of noncleft individuals as determined in a previous study by Coben[13] at the University of Illinois in 1952.

Materials and Methods

The materials used in this investigation were obtained from the Northwestern University Cleft Lip and Palate Institute. The lateral cephalometric radiographs of 900 patients were examined visually to determine if a deficiency in the middle one-third of the face existed. A deficiency was considered to be present when the SNB angle was as large, or larger, than the SNA angle. In those cases in which a deficiency could not definitely be established by a visual examination, measurements were taken to confirm the presence, or absence, of a deficiency. The teeth were in occlusion in all the radiographs used. Two hundred fifty-one cases displayed deficiencies in the middle one-third of the face. Each case was then grouped appropriately within the cleft classification previously described.

In a study of craniofacial form and growth Coben[13] established standard measurements for various components of the facial skeleton. He employed a random sample of noncleft children 8 years of age ± 1 year. Therefore, legible cephalometric radiographs of 8 year olds ± 1 year, taken in occlusion and displaying anteroposterior deficiencies, were the criterion for the selection of the material used in this study. Fifty-three radiographs were obtained; 2 were Class I, 8 were Class II, 24 were Class III, 17 were Class IV, and 3 were prepalate. The total cleft sample, as well as each of the four cleft groups, was analyzed and compared with values established by Coben for noncleft individuals.

Each radiograph was traced twice and, when a discrepancy occurred in the two measurements, the mean value was used. When bilateral structures cast two images, the average of the two was traced. All linear measurements were read to the nearest 0.5 millimeter. Angular measurements were obtained with a standard protractor and read to the nearest 0.5 degree.

Inasmuch as we were dealing with individuals presenting deficiencies in the middle third of the face, it was necessary to redefine some landmarks, namely, anterior nasal spine and Point A. Sassouni[14] defines anterior nasal spine as "the tip of the maxilla on the mid-sagittal plane." The radiographs used in this investigation, by nature of their deficiency, were obscure in the region of the anterior nasal spine. The definite maxillary incurvature between the anterior nasal spine and the crest of the maxillary alveolar process was also lacking. Instead, the bony outlines were either that of an everted curvature with a continued rounded prominence from the crest of the maxillary alveolar process to the nasal floor, or that of a more nearly vertical image of the bony plate. This was also observed by Konishi in his study of cleft palate infants.

In this study Point L was used in lieu of anterior nasal spine and is defined as the most anterior bony limit of the floor of the nasal cavity. When an everted curvature was noted between the nasal floor and the crest of the maxillary alveolar process, Point A, by definition, was also missing. Coben used Point A to express the anterior boundary of the maxillary base; therefore, when no incurvature was present, it was felt that Point L also expressed the anterior boundary of the maxillary base. When an incurvature was present, its deepest point was used to demarcate the anterior limit of the maxillary base and was designated as Point I.

In studies utilizing cephalometric radiographs, one must be cognizant of the variability in the interpretation of landmarks. To reduce this variable to a minimum, each radiograph used in this study was traced twice and measured each time to test the reliability of the landmarks. When a discrepancy occurred between two measurements the average was used. The constancy with which the landmarks were selected was verified by the fact that most of the measurements varied within one millimeter and none more than two.

Each tracing was divided by a coordinate system of lines with the Frankfort horizontal plane as the abscissa. Horizontal measurements of craniofacial depth were taken parallel to the abscissa. Vertical height was measured along ordinate lines.

The depth of the cranial base was recorded as the length between points basion (Ba) and nasion (N). All subsequent measurements of craniofacial depth were expressed as proportions of the cranial base depth, basion-nasion (Figure 1).

The vertical height of the face was analyzed by measurements taken along lines drawn perpendicular to the Frankfort horizontal plane. The height of the anterior face was recorded as the vertical distance between points nasion (N) and menton (M). All subsequent measurements of craniofacial height were expressed as proportions of anterior face height (Figure 2).

To illustrate graphically the comparison of cleft with noncleft subjects a standard deviation polygon was constructed for the cleft palate groups.

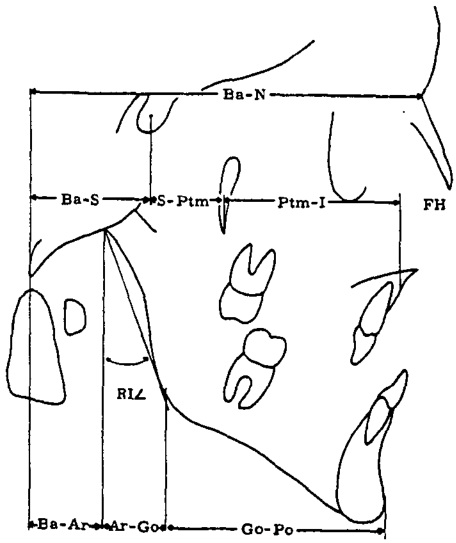

Fig. 1 Method of analysis of craniofacial depth.

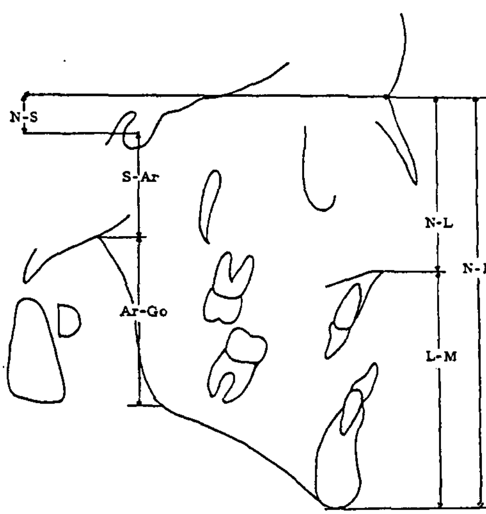

Fig. 2 Method of analysis of craniofacial height.

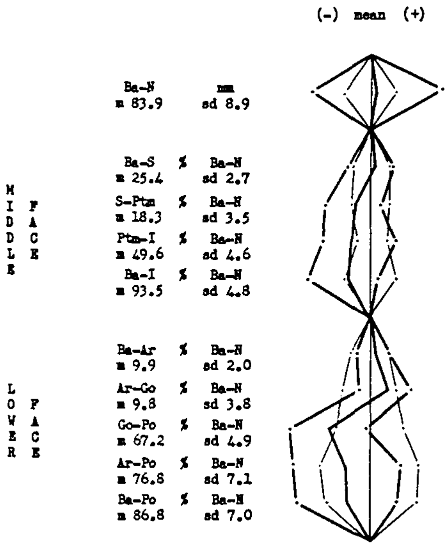

Fig. 3 Diagram comparing craniofacial depth of total cleft sample with noncleft standards.

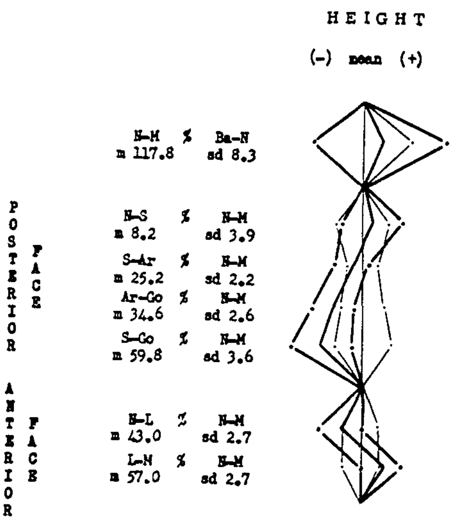

Fig. 4 Diagram comparing craniofacial height of total cleft sample with noncleft standards.

This polygon represents the average craniofacial proportions, together with their variability, within a limit of one standard deviation. A comparison was made with a similar diagram presented by Coben[13] for noncleft individuals. In this manner the contribution of each facet of facial depth and facial height in cleft palate patients was compared with noncleft values (Figures 3 and 4). Means, standard deviation, and ranges were determined by standard statistical procedures.

Discussion

The literature presents no evidence of previous investigations dealing solely with cleft palate individuals who demonstrate anteroposterior deficiencies in the middle third of the face in profile. This study has been based on the premise that such a deficiency exists.

An attempt has been made to determine the number of individuals exhibiting anteroposterior deficiencies in the middle third of the face, and to assess the maxillary and mandibular contributions to these deficiencies. Components contributing to craniofacial height and depth in the cleft palate sample were compared with noncleft values obtained by Coben to determine, if possible, the area responsible for the deficiency. The method of analysis used by Coben was followed as closely as possible in the evaluation of cleft individuals.

Inasmuch as Coben had employed the Frankfort horizontal plane as the plane of reference, all measurements used were related to this plane. Many authors have criticized the use of the Frankfort horizontal plane in lateral cephalometric radiographs because of the variability of porion. A method was devised to confirm the reliability of porion in this investigation. The longest measurement in the horizontal plane was basion-nasion (Ba-N). Constructing

TABLE I

Type	Number of Cases	Number Possessing Deficiencies	Percentages
Class I	68	8	11.7%
Class II	244	48	19.7%
Class III	314	112	35.7%
Class IV	126	66	52.4%
Prepalate	59	9	15.3%
Others	36	8	28.6%
Total	847	251	29.6%

a new porion two millimeters above the original porion, another basion-nasion was measured through the constructed point. The two basion-nasion lengths disclosed a difference of less than one millimeter; therefore, it would be safe to assume that the selection of porion, within a four millimeter range (± 2 millimeters), would have little effect on the measurements obtained. This is an extreme range in the selection of this landmark and all the porions used in this study were well within this range. In defense of the Frankfort horizontal plane, Krogman[15] stated: "Regardless of the foregoing, we still feel that the Frankfort horizontal, for purposes of orienting the head in a roentgenographic apparatus, is the best single plane of reference. It is in wide and current use; therefore, it makes possible comparative analysis when several series of data are to be compared."

Obscurity in the region of the premaxilla necessitated redefinition of landmarks in the cleft palate radiographs. The typical contour of the anterior nasal spine (ANS) and Point A was lacking in many of the radiographs. If deficient populations are to be studied radiographically, we feel that standard definitions of these ambiguous landmarks should be presented for further studies. These definitions were presented previously in the section, "Materials and Methods."

Table I indicates that the number of cases exhibiting anteroposterior deficiencies in the middle third of the face represents 29.6% of the total population of the Northwestern University Cleft Lip and Palate Institute. Deficiencies in this area of the face are most prevalent in the Class IV type cleft (52.4%).

Clinical observation reveals that the presence of attenuated growth, as seen in profile, is not an uncommon occurrence in postoperative cases of clefts involving the ridge and lip. Early surgical intervention to establish lip closure has been a popular procedure in these cases. All alveolar ridge clefts measured in this study presented a history of cheiloplasty prior to six months of age. The timing of palatal surgery varied from six months to three years of age. Many investigators have felt that there is a definite correlation between early palatal surgery and the presence of a maxillary deficiency. Sicher[16] has stated that growth in unoperated cleft palate individuals closely parallels the growth observed in noncleft children. The findings of a recent study in Puerto Rico,[10] mentioned earlier, support this point of view. It might be of significant value that, of the fifty-three cases comprising the sample in this investigation all but two (both Class II cleft) revealed a history of palatal and/or lip surgery.

In order to see more clearly the comparison of cleft and noncleft individuals, and the extent of variance within the groups, the contributions of maxillary

TABLE II

SIGNIFICANT MEASUREMENTS OF THE COMPONENTS CONTRIBUTING TO MIDDLE FACE DEPTH AS COMPARED WITH VALUES FOR NONCLEFT INDIVIDUALS.

	Total	Class II	Class III	Class IV
Basion-sella	n. s.	n. s.	n. s.	n. s.
Sella-Ptm	.01*	n. s.	.01*	.01*
Ptm-Point I	.01*	n. s.	.01*	n. s.
Basion-Point I	.01*	.01*	.01*	.01*

n. s. Not significant (P> .05)
* Significantly smaller (P< .01)

and mandibular components to facial depth and height were studied.

The horizontal length basion to nasion, representative of the depth of the cranial base, showed no significant difference in the groups studied. This confirms reports by Borden[3] and Williams[4] of a similarity in cranial growth between cleft and noncleft palate children. Clinically, however, we had observed the presence of anteroposterior deficiencies in the population studied; therefore, one might have anticipated a deficiency in the cranial base depth. The absence of a deficiency in this area suggests that cranial structures are not affected by the presence of a cleft palate and that one should look elsewhere in accounting for this deficiency. The horizontal length, sella-pterygomaxillary fissure, was significantly shorter in the cleft palate individuals (Table II). Brodie[17] described this measurement as the most stable in the facial area. The discrepancy in this horizontal length may be correlated with the findings of Subtelny[7] in which he described the pterygoid plates in cleft palate patients as wider and more laterally inclined. He attributed this to the lack of balance between the tensor palati and the external pterygoid muscles, which act on the pterygoid plates prior to closure of the sutures between the body and the greater wings of the sphenoid bone. If this explanation is accepted, the backward and upward direction of the external pterygoid muscle, in addition to its lateral course, would result in a posterior positioning of the pterygoid plates. The result would be a decrease in the horizontal length, sella-pterygomaxillary fissure.

The horizontal contribution of the maxillary base (pterygomaxillary fissure-point I) also presented a significant deficiency in the total cleft sample measured Table II). The Class II and Class IV cleft groups, individually, also showed a decrease in this measurement, though it was not statistically significant. Inasmuch as the clinical observation showed that Class IV type clefts exhibited the largest percentage of anteroposterior deficiencies, one would anticipate a significant deficiency in the maxillary base in this group. Sample size or the fact that other areas are at fault in the deficiency may account for the lack of statistical significance.

In the Class IV cleft the only significant deficiency observed in the middle face components occurred in the sella-pterygomaxillary fissure region. Since the over-all middle face depth also was significantly shorter in this group, one might conclude that, in the Class IV sample used in this study, the area at fault may be the sella-pterygomaxillary fissure.

The values for components contributing to middle face depth in the Class II cleft sample were smaller than mean values derived for the noncleft sample,

TABLE III

SIGNIFICANT MEASUREMENTS OF THE COMPONENTS CONTRIBUTING TO LOWER FACE DEPTH AS COMPARED WITH VALUES FOR NONCLEFT INDIVIDUALS.

	Total	Class II	Class III	Class IV
Ramus width (Ar-Go)	.01*+	n. s.	.01*+	n. s.
Body Length (Go-Po)	.01*—	n. s.	.01*—	.01*—
Mandibular length (Ar-Po)	.01*—	n. s.	n. s.	.01*—
Lower face depth (Ba-Po)	.01*—	n. s.	n. s.	.01*—

n. s. not significant (P> .05)
*+ significantly larger (P< .01)
*— significantly smaller (P< .01)

although these measurements were not statistically significant. Inasmuch as the total middle face depth in this group was significantly shorter, one might assume that the deficiency seen in each component, although not significant, contributes to the significant decrease seen in the over-all middle face depth.

Table II demonstrates the significant measurements obtained in the evaluation of middle face depth in the cleft palate group as compared with the values for noncleft individuals, and Table III shows the significant measurements obtained in the evaluation of lower face depth.

The mandibular contribution to lower face depth was analyzed by dividing the mandible into that segment contributed by the ramus (articulare-gonion) and that by the body (gonion-pogonion). The effective ramus width showed a significant increase in the Class III and the total cleft sample. The Class II and Class IV groups, individually, showed no significant increase in this measurement. Overclosure of the mandible from rest position to occlusion, in the Class III clefts, may be a factor in this excessive ramus proportion. As a result of this overclosure, gonion would describe a larger arc than usual, thereby increasing the horizontal measurement, articulare-gonion. Graber[8] observed a larger freeway space in his cleft palate subjects and an excessive intermaxillary clearance in those cleft cases that had been surgically corrected. He felt that mandibular overclosure was a consequence of the maxillary deficiency usually seen in the surgically corrected cases.

The larger contribution of the mandibular ramus to lower face depth also would be affected by the angle of ramus inclination. This angle is defined as the deviation of the ramus plane from a true vertical relation to the Frankfort horizontal plane; the greater the angle of inclination, the more the contribution of the mandibular ramus to the depth of the lower face; the smaller the angle, the more the contribution of the ramus to posterior face height. There was no significant difference in the angles of ramus inclination.

The contribution to facial depth by the body of the mandible (gonion-pogonion) was significantly smaller in all the cleft groups studied with the exception of the Class II cleft group; Graber[8] found that the SNB angle was significantly smaller in cleft palate patients. He interpreted this as an indication of a deficiency in, or a retruded position of, the mandible.

The vertical distance sella to gonion, representative of posterior face height, was significantly shorter in the cleft palate groups analyzed. Measurements expressing the vertical positioning of the mandible (sella-articulare) and the height contribution of the mandibular ramus (articulare-gonion) also were found to be significantly shorter in the cleft palate sample. Overclosure of the mandible, which accompanies an excessive freeway space, may account for these observations. It would be interesting to evaluate the condylar movements from rest position to occlusion in cleft palate cases, particularly in those cases demonstrating an excessive freeway space. Translatory movement, in addition to the hinge movement, may be a contributing factor to some of the deficiencies observed in the vertical plane.

In the assessment of anterior face height it is interesting to note that upper face height (nasion-point I) presented a significant deficiency in the cleft palate group, while lower face height (point I-menton) showed a significantly larger measurement in the same group. Subtelny has shown that the normal rate of downward and forward growth in the maxilla is retarded in the repaired cleft resulting in a superior position of the palate. Konishi and Brader have substantiated the superior position of the palate in cleft palate individuals. This elevated position of the palate would result in a superior positioning of Point L, thereby reducing the proportion of upper face height (N-L) and increasing lower face height (L-M).

The variability observed in the behavior of the various cleft groups studied would seem to indicate that the cleft palate condition should never be analyzed as a single entity. Since the type and severity of the cleft seem to affect the behavior of the facial growth pattern, each type of cleft should be analyzed individually.

It should be recognized that in studies involving growth of cleft palate individuals, a broader concept could be obtained by serial cephalometric methods. Using this study as a basis for analyzing deficient cleft palate subjects at an eight year level, future investigations, using older age groups, may reveal changes which occur in the growth patterns of these individuals.

Conclusion

An attempt has been made to determine the number of individuals exhibiting anteroposterior deficiencies in the middle one-third of the face in profile. A deficiency was considered to be present when the SNB angle was as large, or larger, than the SNA angle. Various craniofacial measurements of deficient cleft palate individuals were compared with mean values derived from noncleft individuals in an attempt to assess the maxillary and mandibular contributions to these deficiencies. The findings in this investigation seem to warrant the following conclusions:

1. An anteroposterior deficiency in the middle third of the face was observed in 29.6% of the total population at the Northwestern University Cleft Lip and Palate Institute.

2. The Class IV type of cleft yielded the largest percentage (52.4%) of patients displaying anteroposterior deficiencies.

3. There was no significant difference in the length of the cranial base (basion-nasion) between the cleft palate and noncleft palate values compared in this study.

4. A comparison of the components contributing to middle face depth showed the following significant differences:

a) Sella-pterygomaxillary fissure was deficient in the Class III and Class IV cleft groups and in the total cleft sample.

b) Pterygomaxillary fissure-Point I was deficient in the Class III cleft group and in the total cleft sample.

5. A comparison of the components contributing to lower face depth showed the following significant differences:

a) The body of the mandible (gonion-pogonion) was shorter in the Class III and Class IV cleft groups and in the total cleft sample.

b) Lower face depth (basion-pogonion) was deficient in the Class IV cleft group and in the total cleft sample.

6. A comparison of the components contributing to posterior face height showed the following significant differences:

a) The vertical positioning of the mandible (sella-articulare) was more superior in all cleft groups studied.

b) The mandibular ramus (articulare-gonion) was shorter in all cleft groups studied.

c) Posterior face height (sella-gonion) was shorter in all cleft groups studied.

7. A comparison of the components contributing to anterior face height showed the following significant differences:

a) Upper face height (nasion-point L) was shorter in all cleft groups studied.

b) Lower face height (point L-menton) was longer in all cleft groups studied.

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