A Serial Cephalometric Analysis Of Facial Growth In Adolescent Cleft Palate Subjects

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Review of the Literature

Noncleft Palate Growth

Head and facial structure and development in the "normal child" have been the subject of much study in the past. Early studies used anthropologic measurements and were designed mainly to establish racial skeletal types.

Broadbent[1] in 1931 introduced radiographic cephalometry which has made possible a wealth of knowledge concerning the growth of the head and face. Cephalometric studies are mainly of two types. They may make use of the cross-sectional or the longitudinal method of study. Using the latter method, the individual's development is followed by radiographs taken at intervals in his growth making possible the assessment of individual growth patterns. Early longitudinal studies by Broadbent[2] and Brodie[3] stressed the uniformity of growth and introduced the pattern concept. In the years following these studies, many investigators have attempted to establish "normal" facial proportions. Methods of analysis were devised and, as a result, the concept of facial norms arose.

Recent studies have resulted in greater emphasis being placed upon individual variation rather than average characteristics. Statistical methods have helped demonstrate that individual variation in human growth is often more prevalent than conformity.

Cleft Palate Growth

The cause of the cleft palate deformity has been attributed to many factors. Early literature cited by Graber[4] lists geographical locations, malnutrition, maternal impressions, and climate as possible causes. Grace[5] was able to find no correlation of occurrence with length of pregnancy, age of the mother, number of siblings, or birthplace of the mother. Fogh-Andersen[6] found heredity to be the most important factor.

The frequency of cleft palate births has been reported differently by various investigators. Fogh-Andersen[6] has reported one cleft palate birth in 665 live births in Denmark. More conservative estimates by Davis[7] and Vaughan[8] have placed the occurrence of a cleft palate at one in approximately 1225 births.

Various methods of classification of the different types of cleft lip and palate have been established. A simplified classification of the four major cleft types has been listed by Levin.[9]

Cleft palate and cleft lip deformities result as an aberration of the normal developmental pattern. In order to understand this abnormal growth, it is necessary to be familiar with the normal development of the oral and nasal structures. This subject has been well covered by Sicher[10] who states, ". . . defects such as harelip and cleft palate are in all probability not localized to the immediately involved area but wider regions of the head may be also affected."

One of the earlier cross-sectional studies was conducted by Gilley.[11] Using patients in a broad age range, he found the interocclusal clearance to average larger than the noncleft group. He

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attributed this to a reduced maxillary height. Gilley also felt the cleft sample exhibited an inclination of the lower border of the mandible which was abnormally small due to the large interocclusal clearance. He reported an angular measurement of facial convexity of —4.7 degrees, showing that on the average his sample displayed a concave profile.

Substantiating Gilley, Graber[12] found a mean interocclusal clearance of 6.4 millimeters, as opposed to the usual 2.5 to 3.0 millimeters established by Thompson.[13] The typical concave facial profile, described by Bzoch[14] as "dished in" and later classified by Levin[9] as an anteroposterior deficiency in the middle one-third of the face, was observed by Graber. He concluded that the maxilla of a cleft palate patient exhibited deficient maxillary development, not only in the anteroposterior and lateral dimensions, but also in a vertical direction. Mandibular development, however, appeared to be within the realm of normality. His results were a severe indictment of early traumatic palatal surgery suggesting its devastating effect upon facial growth.

The reason for the lack of anteroposterior maxillary development was investigated by Harvold,[15] who concluded that the medial collapse of the maxillary alveolar processes was due to a rotation which occurred in the paired maxillary bones. This observation supported somewhat the findings of Subtelny,[16] who noted that the maxillary tuberosities were placed farther apart in the cleft than in the noncleft group; thus, the cleft palate patient would appear to have an abnormally wide nasopharynx. Harvold also observed that the deformities may not be due to a reduced growth potential. He felt that perhaps the forward growth of the maxilla was inhibited by he tightness of the upper lip.

Swanson, MacCollum, and Richardson[17] surveyed cephalometric radiographs of cleft palate children at eight years of age using the Downs' method of analysis. Their measurements of the convexity of the skeletal profile disclosed that, even if profound anterior growth of the mandible occurred at adolescence, the angle of convexity was sufficient to insure balanced faces when these children reached adulthood.

By comparing early cleft palate growth serially with the growth of noncleft infants, certain investigators felt it would be possible to observe the initial disharmonies uncomplicated by later years of growth. The studies of Williams,[18] Borden,[19] and Konishi[20] have contributed knowledge concerning growth patterns in infants.

In a serial study Williams compared maxillary growth in the cleft palate group with that previously reported for noncleft individuals. In general, he found that the vertical and horizontal growth vectors of the pterygomaxillary fissure, orbital rim, anterior nasal spine, and palate paralleled those of the noncleft population.

Borden showed statistically that the mandible was smaller by linear measurements in cleft palate infants than in a noncleft group. However, he found the patterns and rates of growth to be similar in both groups.

Konishi was able to demonstrate a superior positioning of the posterior margin of the hard palate among cleft palate infants.

Levin[9] limited his study to those patients having anteroposterior deficiencies in the middle one-third of the face. Using an eight-year-old group, he compared his sample with the noncleft figures established by Coben.[21] In surveying the files of the Northwestern University Cleft Lip and Palate Institute, he found 29.6 per cent of the cases had

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a deficiency as he defined it. He discovered the posterior face height (measured vertically from sella turcica to gonion) and the upper face height (measured from nasion to his equivalent of the anterior nasal spine) were less than those reported by Coben. However, Levin's figure of 43 per cent, although less than that of Coben (45.8 per cent), is similar to the values obtained by certain other investigators of noncleft individuals. Pawliuk,[22] studying a similar age group of less seriously involved cleft palate patients, obtained a figure of 44.5 per cent for upper face height.

In discussing morphogenetic growth patterns, Slaughter and Brodie[23] pointed out that longitudinal studies have shown that both cleft palate and noncleft palate individuals exhibit the same stability in their growth patterns. The initial insult of a cleft palate is seen early in intrauterine life and is of short duration. After recovery has occurred, according to Slaughter and Brodie, the parts seem to follow their normal paths of development at normal rates of growth. However, Graber,[4] Dupertuis,[24] and Olin[25] have reported that surgery can inhibit growth — either by a diminution of the blood supply to a part or by permanent damage to a growth center. These two considerations show the difficulty involved in drawing conclusions from any small segment of so diversified a group as the cleft palate population.

Adolescent Growth

Adolescence is defined as "the state or process of growing up from childhood to manhood or womanhood." During the adolescent period profound changes take place in the physical, physiological, emotional, and mental development of an individual. Although many changes occur, one of the most obvious expressions of maturity is growth.

The adolescent period usually extends from twelve to twenty-one years of age in the female and from fourteen to twenty-five years of age in the male. This rather long period of development has been divided by Stolz and Stolz[26] into phases — the second phase (usually between thirteen and sixteen years of age in the male) being the phase in which most bodily growth occurs.

Davenport[27] noted that an "adolescent spurt of growth" is characteristic of this developmental period. Describing the adolescent growth spurt, Stuart[28] stated that the growth increments throughout life constantly diminish in magnitude with each succeeding year of development. The change from a decelerating rate of growth to an accelerating one marks the beginning of the adolescent growth spurt.

Numerous facial growth studies have shown the characteristic facial changes which are associated with the growth spurt seen at adolescence. Barnes[29] studied children between twelve and fifteen years of age and found the males were growing more rapidly during this period than the females. The males exhibited a significant increase of length in both the maxilla and the mandible. In the female the mandible increased in length significantly, while the maxilla did not. Barnes concluded that the mandible became more protrusive with adolescent growth resulting in a decrease in the convexity of the facial profile.

From studies of lateral cephalometric radiographs Björk[31,30] concluded that the rate of decrease of facial convexity was greatest during the later years of adolescence. He felt this was because the development of the cranial base was concluded earlier than was the growth of the mandible. He observed an increase in the height of the mandibular ramus due to growth at the condyle. This height increase caused the mandi-

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ble to be shifted forward in relation to the maxilla — the growth of which was complete, or very slight, at that time.

Coben[21] felt that during the adolescent period the anterior growth of the middle portion of the face was only slight, while the anterior movement of the lower portion was substantial. He was able to see few sexual differences. Seal,[32] however, reported that by eighteen years of age the female was more prognathic than the male.

From the literature cited, it is apparent that the study of the cleft palate individual's adolescent growth can be little more than a study of variables. The differences in adolescent growth, superimposed upon the results of surgical treatment, cleft palate type, and individual variation, should make for a composite of enormous variability.

Statement of the Problem

This investigation was undertaken to assess the effect of adolescent growth upon certain facial structures of the cleft palate individuals.

Using the serial method of study, typical patterns of growth were evaluated by following the movements of facial areas in a vertical and horizontal manner.

The data were analyzed in an attempt to determine the ages at which changes occurred in the male and in the female.

Methods and Materials

The materials for this study consisted of serial lateral cephalometric radiographs of cleft palate individuals. The radiographs were obtained from the Cleft Lip and Palate Institute of Northwestern University. The sample was composed of twenty-five persons — eleven females and fourteen males. Films were obtained for each age of study — twelve, fourteen, and sixteen years, plus or minus six months. At all ages the mean age fell within .077 years of the year represented. The sample consisted of seven subjects with clefts of the hard and soft palates up to the incisive foramen, nine subjects with unilateral clefts of the hard and soft palates involving the alveolar ridge, and nine subjects with clefts involving all of the hard and soft palates and a bilateral involvement of the alveolar ridge.

Tracings were made using standard tracing techniques. Various films were retraced as a check on tracing and measuring exactness. The resulting accuracy was within 0.5 millimeters for linear measurements and 0.5 degrees for angular measurements. The Frankfort horizontal plane of the twelve-year-old films was transferred to subsequent films by superimposing the lines sella turcica to nasion (SN) and registering at sella turcica. Thus, the Frankfort horizontal planes of the films of a series were parallel. Lines were then drawn perpendicular and parallel to the Frankfort horizontal plane to be used for linear measurements. This method of measurement was used in an attempt to secure purely horizontal and vertical measurements, rather than a resultant of the two. In addition to the linear measurements used, certain angular measurements were also included in this study. Figures 1 and 2 may be used to clarify certain measurements as they are discussed in the material to follow.

The data obtained from the various measurements were recorded in separate age groups and in male and female subgroups. The arithmetic means of the subgroups were obtained. The incremental growth values were found by algebraic subtraction of the values of the individual measurements. The arithmetic means of the growth increments were obtained for each growth period. Using the incremental data, graphs were constructed to disclose growth patterns or trends. The analysis of vari-

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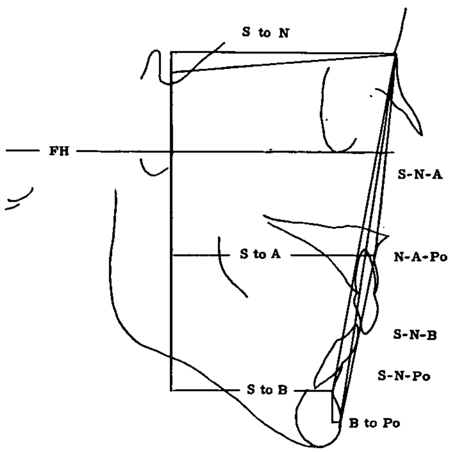
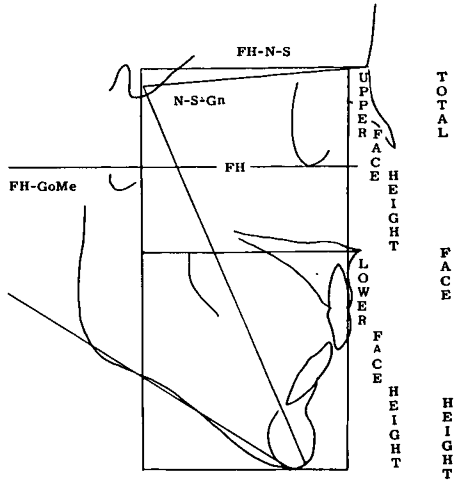


HORIZONTAL FACIAL MEASUREMENTS

Fig. 1



VERTICAL FACIAL MEASUREMENTS

Fig. 2

ance was applied to seventeen of the eighteen measurements, again considering the male and female separately. The analysis of variance was used to verify statistically the trends which had been observed in the graphed material.

Results

It is not practical to include here the numerous graphs and tables constructed for each measurement. However, Table I presents a summary of the measurement changes. The numerical changes with age are rated as "Not Significant", "Significant", or "Very Significant" as determined by the analyses of variance. An explanation of these terms, as used in Table I and in the Discussion, may be necessary. "Very Significant" ($P<.01$) indicates a statistical probability of less than .01 which means the changes noted could occur by chance once in one hundred times. "Significant" ($P<.05$) indicates a statistical probability of less than .05 which means the changes seen could occur by chance five times in one hundred. "Not Significant" ($P>.05$) indicates a probability greater than .05 which means the changes observed could occur more than five times in one hundred cases. The direction of the changes is shown by using a plus (+) sign when the value increases and a minus (—) sign when the value decreases in the period from twelve to sixteen years.

Discussion

The objective of this study was the evaluation of typical patterns of growth for a sample of cleft palate individuals during the adolescent growth period.

Numerous methods of skeletal facial analysis have been used by other investigators. The measurements selected for this study were particularly effective in assessing horizontal or vertical growth of the facial parts. Several of the measurements selected are in widespread use, making up segments of either the Downs[33] or Riedel[34] analyses. The selection of a well-established method of measurement had the advantage of being readily understood by a large percentage of readers. The popularity of such measurements as NAPo and SNA may be attributed in part to the ease

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MEASUREMENTS TO ASSESS HORIZONTAL GROWTH

			Not Significant[1]	Significant[2]	Very Significant[3]
ANGULAR					
	S-N-Po	F	+		
		M			+
	S-N-A	F	-		
		M			-
	S-N-B	F	+		
		M			+
	A-N-B	F		-	
		M			-
	N-A-Po	F			-
		M			-
LINEAR					
	S to N	F			+
		M			+
	S to A	F	+		
		M	+		
	S to B	F		+	
		M			+
	A to B	F	-		
		M		-	
	B to Po	F			+
		M			+

MEASUREMENTS TO ASSESS VERTICAL GROWTH

			Not Significant[1]	Significant[2]	Very Significant[3]
ANGULAR					
	N-S-Gn	F	-		
		M	-		
	FH-GoMe	F	-		
		M		-	
LINEAR					
	N to ANS	F			+
		M			+
	ANS to Me	F			+
		M			+
	N to Me	F			+
		M			+
	N to ANS % N to Me	F	-		
		M	o		
	ANS to Me % N to Me	F	+		
		M	o		

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with which the landmarks involved can be observed on a radiographic film.

Using angular measurements, it was possible to relate three points by a measurement expressed in degrees. With growth, the change was recorded as degrees of change. The use of angular measurements made possible the comparison of individuals irrespective of size differences. Although angular measurements have become well established, they are characterized by certain disadvantages. These measurements are often described as expressing the location or growth movement of a certain area. It must be remembered that the other two points involved in the angle may also be undergoing growth changes.

In order to substantiate the angular measurements used in this study, certain linear measurements were also selected. All linear measurements were made along lines constructed either parallel or perpendicular to the Frankfort horizontal plane.

The use of the SN line for superimposition has a disadvantage in that nasion, in its anterior growth, may also exhibit vertical movement. Upon superimposition, the vertical growth of nasion would result in the entire second tracing being rotated, with sella acting as the center of rotation. Oliver[35] has investigated the vertical movement of nasion with growth. From his observation of twenty-five cases he found nasion to ascend in fifteen instances, to descend in four, and to remain unchanged in the remaining six. Thus, it may be seen that certain variables were introduced by the selection of the SN line as a basis of superimposition.

Certain angular measurements in this study made use of the SN line as one side of a constructed angle. Angles will be affected by movement of any of the three points involved. Oliver stated that sella typically moves slightly downward with growth and, as noted above, nasion growth movement is inconsistent.

Angular measurements involving the SN line also will be influenced by the anterior growth of nasion. As will be cited later in specific cases, the anterior growth of nasion will act to decrease the angular values. On the other hand, during this growth period, if nasion does not move forward as more inferior points do or if the inferior points overshadow the anterior growth of nasion, the angles will be increased with age.

So that angular measurements could be more accurately interpreted, the horizontal forward growth of nasion was measured. From a perpendicular line passing through sella, the measurement extended along a line parallel to the Frankfort horizontal plane to nasion. Anterior movement of nasion was seen in all but two cases. The change was very significant statistically ($P<.01$) in both sexes. The female group, from age fourteen to sixteen years, exhibited only slight anterior growth, while the male sample experienced almost four times as large a mean increment in the same time period. Similar values were obtained for the male and female groups, age twelve to fourteen years.

Having established the limitations of interpretation imposed by the use of the SN line, we may proceed to discuss the measurements utilizing this line.

Horizontal Growth

To assess horizontal forward growth of the mandible, the angular measurement SNPo was constructed. The great-

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Table 1 [1]Probability greater than .05; [2]probability less than .05; [3]probability less than .01; + = value increased; — = value decreased; 0 = value unchanged.

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est angular increase was made by the male sample between the ages of twelve to fourteen years. The female was dominant in the period from fourteen to sixteen years as shown by the mean increase for this period. However, the male mean determination was affected by one individual's marked deviation from the typical pattern. The trend, however, as shown in the graphed material, demonstrated the male angular increase to be of greater magnitude than the female in almost every case over the total period of study. The changes with age in the male values were found to be very significant ($P<.01$) statistically, and the female changes were found to be not significant. It is interesting to note that if the male data had been compiled excluding the one deviating member, the total mean increase of angulation would have been 2.08 degrees — a figure more in keeping with the general trend of the graphed material.

We may conclude that point Po moved forward in relation to the cranial base line during this growth period. Although male movement was very significant ($P<.01$), female movement was not.

The angle SNB was used to record anterior growth of the mandible at point B. The angular changes seen in this measurement were small in the female sample and statistically not significant. Most changes were within one degree and could be attributed to inaccuracies of tracing or measuring. The male angular changes, particularly between the age of twelve and fourteen years, were consistent and increased in all but one case. For the same period the female changes were varied. During the period from fourteen to sixteen years both male and female growth increments seemed rather inconsistent. However, during the total period the mean increase of the male group was twice that of the female group and was shown to be very significant ($P<.01$) by the analysis of variance.

These measurements suggested similar findings as demonstrated by the angle SNPo, as the anterior portion of the mandible was positioned more anteriorly with adolescent growth. It should be noted that the total incremental values of the angular measurement SNB were of less magnitude than were those for the measurement SNPo. Since both points B and Po were midline structures on the anterior surface of the mandibular symphysis, growth occurred more at Po than at B.

In order to measure the differing effect of growth on points B and Po, the linear distance separating the two points was measured on a line parallel with the Frankfort horizontal plane. Growth in this area was small, but very consistent and seemed to be similar in both sexes. The female sample showed a tendency to continue its growth to sixteen years of age with little sign of early cessation as seen elsewhere. Growth here was found to be very significant ($P<.01$) statistically in both sexes. Thus, it may be concluded that point Po moves anteriorly to a greater extent than does point B during adolescent growth. At this time appositional bone growth may occur at Po and not at B. This would explain in part the difference seen between the growth of the two points.

It has been shown that during the adolescent growth period there was forward movement of the mandible in response to growth. One would expect a similar pattern to be followed in the maxilla. Riedel[34] used the angular measurement SNA to determine the anteroposterior placement of point A (the maxilla). He found his adult "normal occlusion" group to have a mean value slightly higher than his "normal" child group, although statistically this

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had no significance. This increase would suggest adolescent anterior growth of the maxilla as measured angularly.

The same angular measurement, SNA, was used in this study to follow maxillary horizontal growth during the adolescent period. Measured in this manner, the cleft palate sample exhibited no anterior maxillary movement during adolescence; rather the maxilla appeared to have moved posteriorly as related to nasion. The magnitude of the change seen here was small, particularly in the female in whom no statistical significance could be demonstrated. In the male, a greater change was seen showing an apparent reduction of maxillary prominence. The male change was statistically very significant ($P<.01$).

It is obvious that the anterior surface of the maxilla cannot grow to a more posterior position than it originally held. Therefore, we may say only that with adolescent growth point A became more posteriorly placed as related to the anteroposterior position of nasion. The greater changes seen in the male sample were caused by continued growth of nasion either forward, or upward and forward, thus reducing the angular relationship with sella and point A. Whether or not actual anterior maxillary growth occurred during this period may be more fully established by the linear measurement S to A which will be discussed later.

It will be remembered that the other angular measurements involving sella and nasion (SNPo and SNB) demonstrated anterior movement of the mandible. Thus, anterior growth movement of the mandible must be of such extent as to overcome the anterior growth of nasion, thereby increasing the angular measurement. In the SNA angular measurement, maxillary anterior growth occurred to such a limited extent that the growth seen at nasion obscured the maxillary movement, thereby reducing the angular value with age.

We have seen that during this period of adolescent growth the maxillary measurement (SNA) decreased as the mandibular measurement (SNB) increased; therefore, with growth the degrees of difference between the two measurements were reduced.

The angle ANB was used to show the difference in the values of SNA and SNB. Riedel listed this measurement as 2.77 degrees in his child "normal occlusion" group (seven to eleven years of age) and 2.00 degrees in his adult "normal occlusion" sample (eighteen to thirty-six years of age). These figures indicated a convex facial profile with point A placed anteriorly to point B.

In the cleft palate sample using the ANB measurement, a convex profile was seen in both the male and female groups at twelve years of age. However, with adolescent growth the mandible moved forward increasing its angular relation to the SN line. The limited maxillary growth resulted in a reduction of the maxillary angular measurement; thus, the ANB angle was reduced with age. This reduction of facial convexity was very significant ($P<.01$) statistically in the male sample and significant ($P<.05$) in the female sample. The extent of the change was twice as great in the male mean incremental determination as in the female. At sixteen years of age, both male and the female mean measurements were within .6 degrees of zero; thus, by Riedel's standards, each then possessed a concave facial profile.

The NAPo angle was used as a second method of measuring facial convexity. Graber[4] has stated that the NAPo angle exhibited a concave reading of —6.2 degrees in his cleft palate population. In this study the mean measurement of facial convexity was —.1 degrees for the female sample at

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twelve years of age. The male sample, which probably had not as yet undergone many adolescent growth changes, showed a mean value of 3.58 degrees. The convex profile seen at this time was not maintained throughout the study. The mean value of NAPo at sixteen years of age indicated a marked concave profile in both sexes (—4 degrees and —3.3 degrees respectively). As was noted in other measurements involving the point Po (B to Po and SNPo), little tendency was seen here toward a cessation of growth changes in either sex. The analysis of variance showed the angular changes to be very significant ($P<.01$) in both sexes. Although the magnitude of the changes differed in the sexes, the consistency of the changes allows one to say that during adolescent growth the skeletal facial profile becomes less convex or more concave as the case may be.

Linear millimetric measurements were used in this study to further analyze horizontal growth. These measurements, being linear rather than angular, eliminated the influence of the anterior growth of nasion. However, as mentioned earlier, vertical movement of nasion, if present, would have affected these measurements.

In the linear measurement S to A, the mean values showed only slight increases in both sexes. However, the graphs disclosed that maxillary anterior growth of some degree occurred. The analysis of variance demonstrated no statistical significance in the changes seen with age in either sex.

As would be expected from the changes seen in the angular measurements NAPo and ANB, the changes seen in the linear measurement S to B were substantially greater than the increases seen in the measurement S to A during adolescent growth. In both sexes the increments of the S to B measurement were twice those seen in the S to A measurement. More consistency was also seen in the S to B measurement changes as demonstrated by the "F" ratio being very significant ($P<.01$) in the male and significant ($P<.05$) in the female.

The measurement A to B was used as an expression of the mathematical difference between the linear measurements S to A and S to B. This measurement is comparable to NAPo and ANB angular measurements. The numerical values had little worth here. However, the consistent reduction of the value again demonstrated the trend toward a less convex face during this growth period. The analysis of variance disclosed no significance in the female sample, but showed significance ($P<.05$) in the male changes.

Vertical Growth

Certain angular and linear measurements were included in this study to assess the changes in the vertical dimension during adolescent growth.

The angular measurement NSGn has been called an expression of the downward and forward direction of the growth of the mandible. This measurement showed little change during the period of study. The changes of the individual angular measurements were of such a nature that the resulting arithmetic means showed that almost no change occurred.

The angular measurement FH-GoMe expressed the inclination of the lower border of the mandible to the Frankfort horizontal plane. This inclination was affected by vertical growth of the mandible. Lande[36] stated that this angular measurement decreased with growth. Brodie[37] reported that such a change was seen in only fifty per cent of the cases he studied. The sample under study demonstrated a reduction of this angular measurement. Although the

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changes were slight, they were shown to be statistically significant ($P<.05$) in the male group. Reduction of this measurement could have been caused by several factors: inferior growth of nasion, superior movement of menton, and inferior growth of gonion.

Vertical growth of nasion has been shown to be rather inconsistent. Oliver[35] observed the vertical descent of nasion in only sixteen per cent of his cases. Thus, it could be assumed that this movement was not a factor in the FH-GoMe angular reduction. Although artificial movement of menton may be accomplished by orthodontic means, such a condition would result most often in an inferior movement of menton or a movement opposite that which was suggested here. The reduction of the angular measurement may be associated with the downward growth of the mandibular ramus, causing gonion to be placed more inferiorly as related to menton and the Frankfort horizontal plane. This reduction of the FH-GoMe angle results in a more horizontal placement of the lower border of the mandible.

The effect of adolescent growth upon anterior face height was measured millimetrically along a line perpendicular to the Frankfort plane. The total face height (N to Me) was divided into a measurement of the upper face height (N to ANS) and the lower face height (ANS to Me). The male sample showed a great increase in the total measurement, particularly between fourteen and sixteen years of age. As little tendency toward a cessation of growth was seen, it could be assumed that vertical facial growth might continue after sixteen years of age in the male. The female sample showed a markedly reduced rate of growth in the second time period.

The changes seen in the upper and lower face height measurements were similar to the changes seen in the total face height measurement. However, the incremental changes seen in these two measurements seemed to suggest a tendency; it was suspected that the growth increments were somewhat larger in the lower face height than in the upper face height. Larger growth increments in the lower face height would have resulted in a change with growth in the percentage contribution of the parts to the total face height.

Brodie[38] has stated that the percentage contribution of the face of an individual will remain constant with growth. In order to evaluate this question, the values for the upper and lower face heights for each member of the sample were expressed as percentages of the total face height. The values obtained were graphed, the means established, and an analysis of variance run. The resulting means showed little or no change with growth. The "F" ratios were very small, showing no significant changes with age.

Summary

This study was designed to evaluate typical growth patterns for a sample of cleft palate individuals during adolescent growth. Serial tracings of eleven female and fourteen male cleft palate subjects were obtained from the Northwestern University Cleft Lip and Palate Institute. Seventeen angular and linear measurements were used in an analysis of growth. The linear measurements were so constructed as to follow the growth changes in a purely horizontal or vertical direction. From the measures obtained, the incremental values were computed, graphed and subjected to an analysis of variance.

As a result of this study, certain conclusions may be drawn; however, these should be prefaced with this reservation. Since these conclusions were in part based upon arithmetic means of incremental changes, we wish to stress

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that the mean values expressed no more than a typical indication of the actual situation. In reporting mean figures, many individual considerations were obscured. The graphed material was perhaps the best method of demonstrating the individual as he underwent or deviated from the typical group movements.

1. In the male, growth typically continued during the complete period of study. The anterior portion of the mandible moved anteriorly both angularly and millimetrically as a result of growth. Maxillary anterior movement was noted, using linear measurements, with no statistical significance. Angular measurements demonstrated the maxilla became relatively less prominent with age. As a result of the profound mandibular movement and little maxillary change, the average facial convexity seen at twelve years of age in the males was reduced during adolescence; in other words, the skeletal facial profile became less convex or more concave as the case dictated. These movements were all statistically significant ($P<.05$) except the linear measurement of maxillary movement.

2. In the female, growth seemed to be mainly completed during the twelve-to-fourteen-year age period. During the period from twelve to sixteen years of age the anterior portion of the mandible typically moved forward as did the maxilla when measured linearly. However, when measured angularly, the maxilla became relatively less prominent with age. In the female sample these movements were not statistically significant. However, the result of these two movements was significant ($P<.05$). The facial contour was, on the average, rather straight at twelve years of age. As a result of adolescent growth, by sixteen years of age the typical female face has assumed a concave skeletal profile.

3. Anterior vertical facial growth was substantial in the male during the entire period studied. In the female sample most anterior vertical facial growth had ceased during the fourteen-to-sixteen-year period.

4. In both sexes the point Po exhibited more anterior growth than point B. In most areas growth was virtually completed during the period of study in the female. However, Po seemed to continue its forward growth throughout the whole period.

5. In both sexes the mandible tended to assume a slightly more horizontal position during adolescent growth.

6. The percentage contribution of the upper and lower face height to the total face height tended to remain the same during the growth period.

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