Anterior Vertical Incremental Facial Growth: Its Effects in Class II Treatment

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The orthodontist knows the importance of attempting orthopedic correction in certain malocclusions. However, the reaction of the facial complex to orthopedic forces has not been well-defined when related to yearly increments of facial growth. Accurate prediction of periods of rapid circumpuberal facial growth increments for each individual would be desirable in treatment planning. Various indicators, such as chronologic age, height and weight gain, and the onset of puberty by use of the hand-wrist radiographs have been studied, but disagreements among investigators as to the relative value of these maturational indicators can be found in the literature. The purpose of this paper was to study one of these indicators, the utilization of the hand-wrist radiograph, in predicting the timing of vertical facial growth. The clinical reactions of the maxilla to orthopedic forces during these periods of growth and the concurrent mandibular growth response will be demonstrated.

LITERATURE REVIEW

Graber[11] has reported that most of the orthodontic problems seen for correction are Class II malocclusions. One of the main characteristics of these problems is the excessive anteroposterior apical base difference. In severe Class II malocclusions it has been suggested that therapy be started early, even in the deciduous dentition. Some believed therapy should be initiated in the mixed dentition, preferably after full eruption of the four maxillary incisors and after their roots have been fully formed. This is usually around eight and one-half years of age. Others advocated waiting until ten and one-half to twelve years of age in girls and twelve and one-half to seventeen years of age in boys, or during the height of pubertal growth spurt. It was felt that by using orthopedic forces to restrict horizontal maxillary growth increments while mandibular adjustment growth occurred, orthodontic correction could be accomplished. When patient cooperation occurred, and proper applications of extraoral forces were used, good results could be and have been achieved in Class II malocclusion corrections.

Numerous growth studies have been recorded in the literature. In 1759 Count Philbert Gueneau de Montbeillard[20] began the earliest known longitudinal growth study using his son's yearly incremental growth records. From thirteen and one-half to fifteen years of age, a period of accelerated growth was recorded, followed by a period of slower terminal growth. This period of accelerated growth is now known as the adolescent or circumpuberal growth period.

Correlation of a facial growth spurt at the same time as the circumpuberal growth spurt was a question needed to be answered for the orthodontist. Hunter,[15] Singh, Savara and Miller,[25] Björk,[4] and Nanda[21] agreed with Bergersen[3] who concluded that "a significant correlation existed between the onset of the male adolescent spurt of all facial dimensions studied and standing height." Only Nanda and Bambha and Van Natta[2] felt that the

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peak of facial growth usually occurred later. However, most researchers seem to support the view that both growth spurts occurred at the same time.

Having found correlations of body and facial growth periods, chronologic age, dental age and skeletal age relationships needed study. Using chronologic age as a means of predicting growth was soon found to be inconsistent. In a recent report by the National Center for Health Statistics[22] a secular trend of ever-increasing size and earlier maturation required a re-evaluation of growth charts for the U.S. child population of like age and sex. Björk,[4] Bambha and Van Natta,[1] Lewis and Garn,[18] and Green[12] reported studies on tooth formation, calcification, and eruption with skeletal maturation. Again the majority agreed that dental age could not be used accurately to estimate skeletal maturation.

According to Krogman,[17] the basic intrinsic biologic age of the child is his skeletal age. He believes positive and significant correlations occur between craniofacial dimensions, dimensional proportional growth and the skeletal age. Crampton[7] first described the principles of skeletal maturation in 1908. Buehl and Pyle,[6] Todd,[27] and Greulich and Pyle[13] helped develop the present system of using hand and wrist radiographs to determine skeletal maturity. More recently, Tanner et al.[26] published *Assessment of Skeletal Maturity and Prediction of Adult Height* to aid in the practice of pediatrics. These backgrounds were the basis of more recent studies by graduate students at The Ohio State University.[5,8,10,14] The appearance of the sesamoid bone and the closure of the distal epiphysis of the second digit were related to the incremental changes of body, mandibular and maxillary heights. Some of the conclusions drawn were: 1. The earlier appearance of the sesamoid than previously reported (girls—10.6 years and boys—12.3 years). 2. Significant acceleration in body height began the year of and peaked the year after sesamoid ossification. 3. Maximum body height rate never occurred after closure of the distal epiphysis of the second digit. 4. Mandibular growth peaked the same time as body growth and decelerated thereafter. 5. Vertical growth of Point "A" followed the same pattern as body growth.

The use of orthopedic forces was popularized by Kloehn,[16] who stated that the correct time to initiate treatment was early, thus providing the best facial balance and stability. On the other hand, Newcomb[23] was disappointed with extraoral therapy; would the lack of unfavorable incremental growth in his Class II cases have been the reason? Marschner and Harris[19] suggested that the growth potential of untreated Class II cases was never realized, and further, a favorable mandibular growth rate was found in some Class II patients undergoing therapy, particularly in the nine to ten age level, regardless of the mechanics used.

Ryan's[24] unpublished master's thesis at Northwestern related incremental growth; he found yearly increments of upper and lower face height for males and females from nine through seventeen. Two observations became obvious from his figures. The upper face seemed to spurt before the lower face and females spurted before males.

Dermaut and O'Reilly[9] studied twenty-four females and related upper and lower face height growth to the menarche. The upper face-height peak velocity occurred most often at eleven and twelve. The lower face-height peak velocity occurred at twelve and thirteen. Significant growth was found prior to and after menarche, but the amount *before* was usually greater.

This study hopes to add to the subject of incremental vertical growth of the upper and lower face, related to the skeletal age as assessed by the presence of the sesamoid bone of the thumb and the closure of the distal epiphysis of the second digit. The reaction of the maxilla to applied orthopedic forces and the concomitant changes of the mandible at different times during vertical facial growth will be demonstrated.

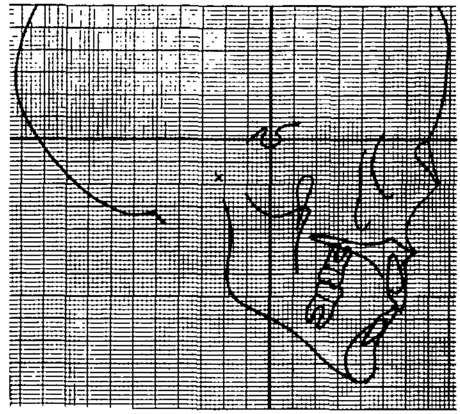

Fig. 1 Orientation of the tracings on graph paper that is divided by two axes of reference, X and Y. SN is laid on the X axis with S superposed at the intersection of the X and Y axes.

Methods and Materials

The materials used in this investigation were derived from the files of the Department of Orthodontics, The Ohio State University. Thirty-eight patients were selected who had not received orthodontic treatment and were in normal or Class I occlusion. Of these, twenty-one were females and seventeen, males. Because incremental changes of facial height were our main interest, a series of ten films was utilized. The first was taken four years before the presence of the adductor sesamoid and the last, two years after the closure of the distal epiphysis of the second digit. The mean age for the appearance of the sesamoid was 10.60 years in the female and 12.30 years in males. The mean age for closure of the distal epiphysis of the second digit was 12.92 years in the females and 15.20 years in the males.

Tracings of the lateral head plates were made in the usual manner and the anatomical points of interest were located. The tracings were then laid on millimeter graph paper as follows: the graph paper was divided into four equal quadrants by two coordinates or axes of reference; one horizontal (X), and one vertical (Y); the SN plane was chosen as the plane of reference and was laid on the X axis with S superposed at the intersection of the X and Y axes (Fig. 1). Positions for each anatomical point could be established to the X and Y axes for all age groups. These were defined as distances in millimeters from the respective axes. The factor of size distortion introduced by the distance of the film from the midsagittal plane required consideration. Corrective magnification factors were used for all measurements.

The distance from the X axis to ANS and the distance from ANS to Gn measured perpendicular to the X axis were recorded. To find the amount for any one year, the distance recorded for the previous year was subtracted from the amount recorded for that year. These results were tabulated from three years before the presence of the sesamoid bone to two years after the closure of the distal epiphysis of the second digit and recorded in tables.

Findings

The means and standard errors for each year for upper face height, lower face height, and for males and females

TABLE I

The mean and S.E. of the incremental vertical growth amounts per year of upper face height and lower face height for males and females as related to the skeletal age and the presence of the sesamoid bone and the closure of the distal epiphysis of the second digit.

Females							*Males*					
		Upper Face		*Lower Face*					*Upper Face*		*Lower Face*	
S.A.	*No.*	*Mean*	*S.E.*	*Mean*	*S.E.*		*S.A.*	*No.*	*Mean*	*S.E.*	*Mean*	*S.E.*
8	18	1.33	.150	1.59	.165		10	15	0.87	.117	1.03	.260
9	21	1.17	.160	1.06	.159		11	17	1.15	.131	0.87	.137
10	21	1.05	.096	1.00	.174		12	17	0.75	.164	0.94	.143
11	21	1.02	.136	0.90	.147		13	17	1.01	.122	1.36	.168
12	21	1.12	.170	1.56	.208		14	17	1.39	.244	1.64	.213
13	21	0.93	.154	1.23	.205		15	17	1.08	.160	2.45	.237
14	21	0.40	.122	0.89	.152		16	17	0.69	.157	1.40	.223
15	21	0.43	.124	0.75	.173		17	17	0.49	.159	1.41	.260
16	17	0.11	.066	0.61	.158		18	10	0.43	.206	0.74	.240
		7.56		10.59		Sum of Means			7.86		11.83	
			0.226			Mean of Difference				0.44		
			.084			S.E.				.163		
			2.69			"t"				2.70		
			.03			P				.03		

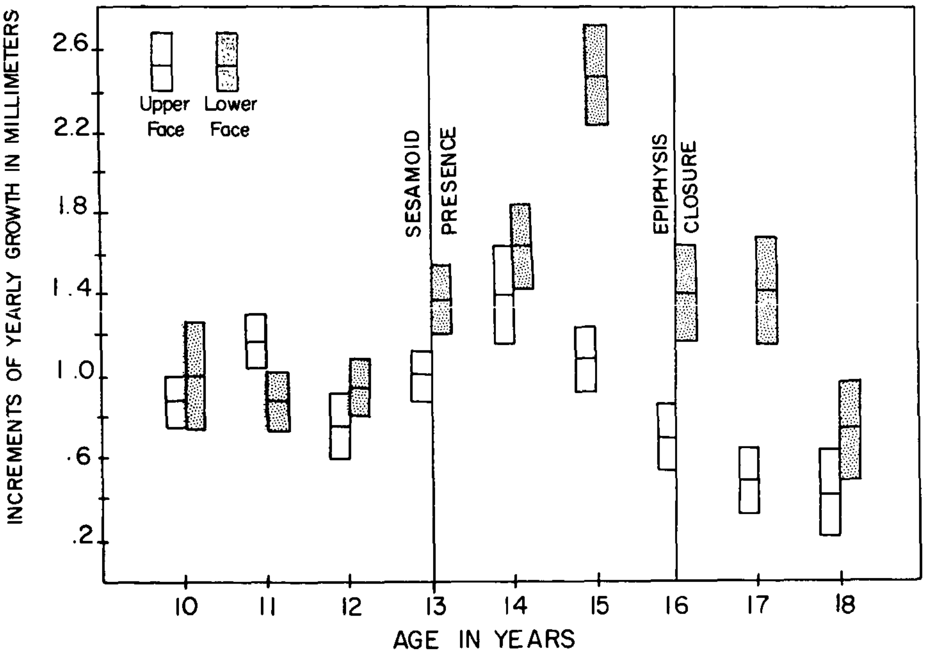

Fig. 2 The mean and standard error of the mean (S.E.) of the yearly increments for upper and lower face height from three years before the presence of the sesamoid to two years after the closure of the distal epiphysis of the second digit in males.

are seen in Table I. Also included is the sum of the increments per year for upper and lower face, the "t" value of this difference, the S.E. of the difference and the probability. The probability for males and females was .03, both being significant.

In the boys (Fig. 2) the yearly incremental growth amounts for upper face height started to increase the year

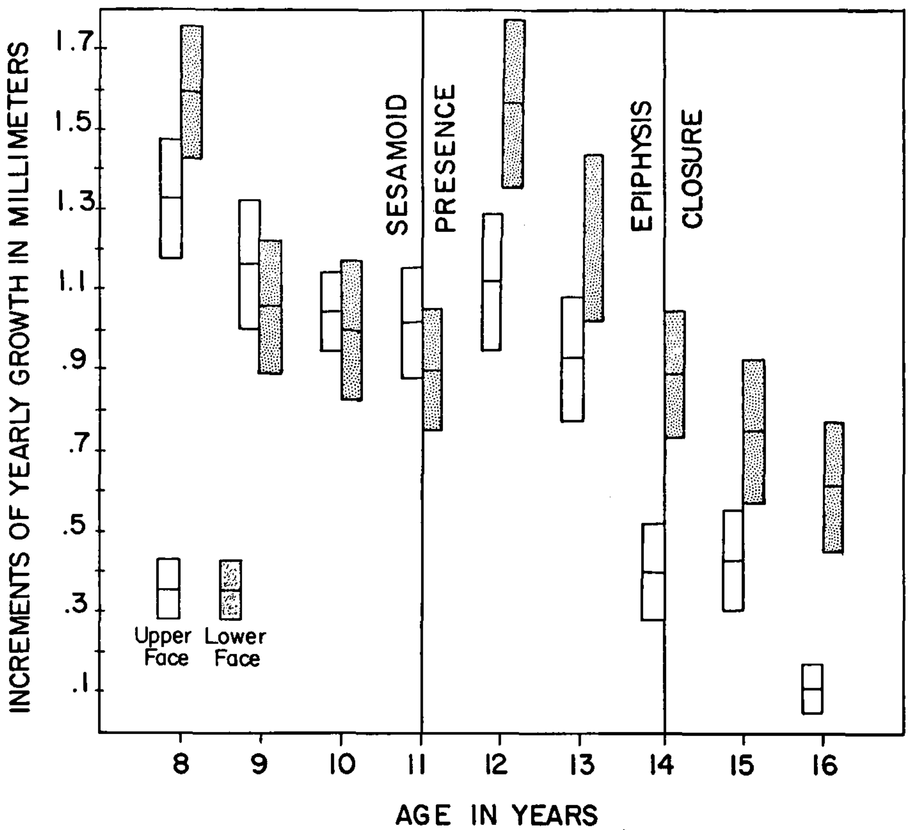

Fig. 3 The mean and standard error of the mean (S.E.) of the yearly increments for upper face height and lower face height from those years before the presence of the sesamoid to two years after the closure of the distal epiphysis of the second digit in females.

of the sesamoid appearance, peaked the next year, and decreased thereafter. Lower face height showed an increase the year of the sesamoid but did not peak until two years later, and then decreased until the end of the study.

The findings in the girls (Fig. 3) varied from that found in the boys. Both upper and lower face height showed a high yearly rate of increase at the beginning of the study and reduced yearly until the year of the sesamoid bone appearance. Upper face height increments increased the year after the sesamoid appearance and then reduced to an insignificant amount at the end of the study. Lower face height increments also increased the year after the sesamoid appearance but reduced slowly until two years after the closure of the distal epiphysis of the second digit and the end of the study.

Discussion

The initial hypothesis for this study developed over a period of years by observing treatment results and correlating height and weight gain to cephalometric changes seen in the patients' headplates. In one female patient the correction of the molar relationship of a Class II malocclusion

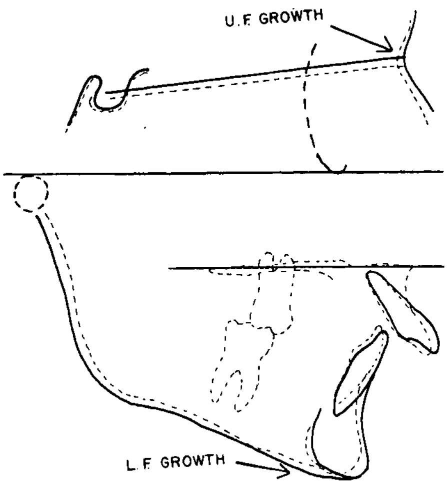

Fig. 4 Case C. P. superposed on the ANS-PNS plane, registering at point A. Upper face height increased 3 mm and lower face height increased 1 mm. Dashed line 9 years 7 months, solid line 11 years 4 months.

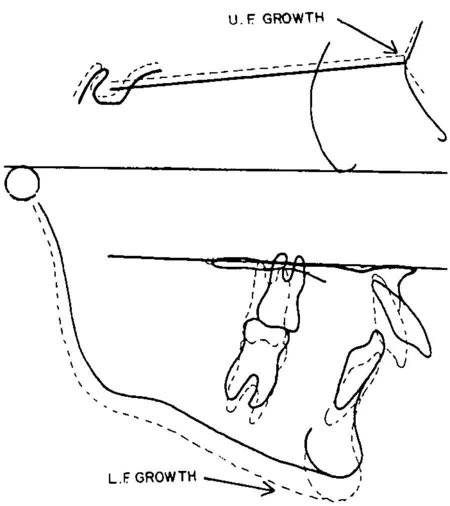

Fig. 5 Case C. P. superposed on the ANS-PNS plane, registering at point A. Upper face height increased 2 mm while lower face height increased 6 mm. Solid line 11 years 4 months, dashed line 13 years 1 month.

occurred in a period of six months during which time the patient grew in height two and a half inches.

Other observations noted were the differences of upper and lower anterior facial height growth periods. By superposing on the ANS-PNS plane and registering on "A", the amounts of upper face height could be compared with lower face height. Using a typical Class II treated case (female) as an example, the greater amount of upper face height than lower face height growth can be seen (Fig. 4). Her chronologic age was 9 years 7 months and skeletal age 9 years 6 months. At a later period of time in the treatment of the same case, there was a greater amount of lower face growth than upper (Fig. 5).

The difference in timing of upper and lower face height changes could not be explained unless they were related to skeletal developmental differences. Using a nontreated Class I sample an attempt was made to determine if such differences existed. The male results correlated to what was observed clinically. The peak of upper face incremental growth occurred one year after sesamoid bone presence. This also correlated with our previous findings as related to body height increments.[8,14] Lower face height peaked one year later and resembled the findings in Ryan's paper.[24]

In the females the upper and lower face incremental growth amounts peaked the same year as body height increments. Again the findings correlated to body height increments with our previous findings when related to sesamoid presence and closure of the distal epiphysis of the second digit.[5,10] The curves of incremental upper facial growth followed the same pattern as that seen in Dermault and O'Reilly's article;[9] they measured N-ANS distances. Our findings did not agree with theirs concerning lower face height occurring one year later than upper face height. Ryan also showed the same findings as Dermault and O'Reilly.

If the data in this study are significant, the application of cervical headgear in Class II malocclusions should show different responses in the maxilla based on the skeletal age. At the same time the mandibular response should show a later vertical growth spurt on the basis of the later and longer period of time of the growth increments. As the females in this study showed peaking of upper and lower face heights at the same time, using them as examples would be a better test of the difference of responses to treatment than would the males. Three treated Class II cases have been compared: (1) treatment starting one year before the expected presence of the sesamoid bone or approximately nine years six months skeletally in females and eleven years six months skeletally in males; (2) treatment starting at the time of the presence of the sesamoid bone or approximately ten years six months of age skeletally in females and twelve years six months skeletally in males; and (3) treatment starting about one year after the presence of the sesamoid bone or eleven years six months of skeletal age in females and thirteen years six months of skeletal age in males.

All the girls to be illustrated were treated with a cervical headgear, and a lower utility arch to level the mandibular curve of spee. Elastics on the inner bow of the headgear were used to retract the maxillary anteriors after Class I molar relationship was obtained. The tracings are superposed on the SN plane and registered at S. These superpositions will show the tipping of the palatal plane due to orthopedic force application at the pterygomaxillary fissure.

The first patient, K. J., was seven years two months old but skeletally nine years of age when records were taken. Eighteen months later after fifteen months of treatment and now skeletally ten years and six months of age, progress records were taken (Fig. 6). Superposed tracings show a tipping of the palatal plane. Vertical measurements taken perpendicular to the palatal plane show a 5 mm increase of upper face height and only 2.5 mm of lower face height. Some of the lower height increase may have been due to a clockwise rotation of the mandible as the maxillary first molars elongated and tipped distally. During this period of time K. J. grew three and one half inches in height.

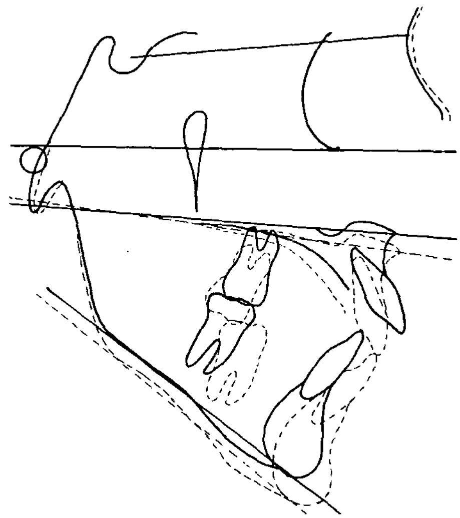

Fig. 6 K. J. was 7 years and 2 months old, but 9 years skeletally at the first record. After 15 months of treatment, the second record at 8 years 5 months of age and skeletally 10 years 6 months is superposed on SN at S.

The second case (Fig. 7), S. S., was ten years six months of age skeletally and chronologically when treatment started. After fifteen months of treatment, second headplates were taken and both ages were now twelve years. Superposed tracings showed palatal tipping as in the first example. The amount of vertical increase in the upper and lower anterior face heights was equal, each measuring 4 mm. The mandibular plane did not change and S.S. grew four and one half inches in the eighteen months between records.

The third girl, P. C. (Fig. 8), was eleven years six months of age skele-

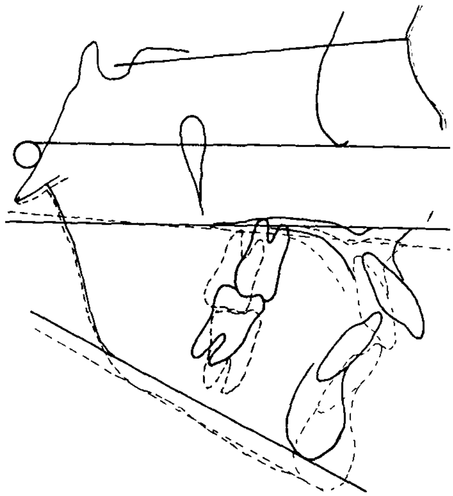

Fig. 7 S. S. was 10 years 6 months chronologically and skeletally age at the first record. After 15 months of treatment, the second record is superposed on SN at S. She was 12 years old both chronologically and skeletally.

tally at the time of records. Her chronologic age was thirteen years and eleven months. Eighteen months later, the patient was thirteen years of age skeletally, chronologically fifteen years six months, and had grown only two inches in body height. Superposed tracings showed a slight tipping of the palatal plane with 2 mm of upper face anterior height. The mandible showed 5 mm of lower anterior vertical face growth and remained parallel in its descent during the correction of the Class II malocclusion.

These three cases typified the responses seen when observing clinical progress in Class II treatment. Application of orthopedic forces to the maxilla produced a tipping of the palatal plane. The amount of tipping depended on the skeletal age treatment was initiated, that is, before, during, or just after the presence of the adductor sesamoid bone. The earlier the application of the orthopedic force, the greater the palatal plane tipped. Parallel descent of the palatal plane appeared in Class II treatment if treatment was started at an older skeletal age, approximately one year before closure of the distal epiphysis of the second digit.

Mandibular response appeared more favorable if treatment was started at or shortly after the presence of the sesamoid and before the closure of the distal epiphysis of the second digit. This correlates the findings of Fahrbach[10] and Heiber[14] who showed the peak of mandibular growth measured as Ar-Gn to follow the same pattern as body height increments. This occurred the two years after sesamoid bone presence and before the closure of the distal epiphysis of the second digit.

This study covered only the anterior vertical incremental growth changes during the period of four years before the presence of the sesamoid bone to two years after the closure of the distal epiphysis of the sec-

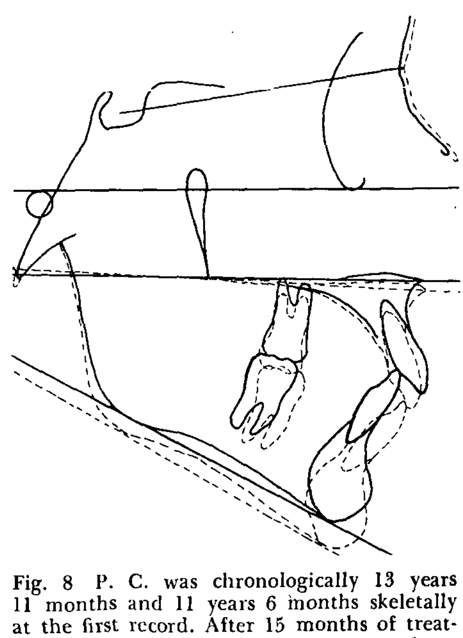

Fig. 8 P. C. was chronologically 13 years 11 months and 11 years 6 months skeletally at the first record. After 15 months of treatment, the second record is superposed on SN at S when she was 15 years 6 months of age and 13 years skeletally.

ond digit. The amount of horizontal change of the upper and lower face increments and the effects of treatment on both maxilla and mandible are under progress at this time. The effects of leveling the mandibular dental arch should also be considered when studying the reaction of the mandible to see if there is an increase of mandibular growth rates as intimated by Marschner and Harris.

Summary and Conclusions

The present study shed some light on the anterior incremental vertical growth rates of the face. Both girls' and boys' upper and lower faces were studied starting four years before the presence of the adductor sesamoid of the thumb and stopping two years after closure of the distal epiphysis of the second digit. Examples of the treatment of Class II, Division I malocclusions using orthopedic (cervical headgear) forces during the skeletal age period studied were shown. The reactions of vertical changes of the maxilla along with those of the mandible were demonstrated. The clinical responses of both maxilla and mandible should be predictable if skeletal age is used in treatment planning.

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