Changes in the Bony Facial Profile Coincident With Treatment of Class II, Division I (Angle) Malocclusion*

ABRAHAM SILVERSTEIN, D.D.S., M.S.
Bronx, New York

INTRODUCTION

Workers in the field of growth and development have greatly influenced orthodontic thinking in recent years. Changes in the facial skeleton have been zealously studied ever since orthodontia became a clinical science. In some cases, dramatic changes have been observed and the question usually arose: Did the treatment create the changes in the facial skeleton or were they merely the result of growth? Many observations and hypotheses were propounded but until recently adequate methods were not available to test them. Empiricism, combined with clinically applicable anthropological methodology, served as the only tools for research in orthodontia. The introduction of cephalometric roentgenology to orthodontia by Broadbent in 1931, supplied a valuable tool for the scientific analysis of the effects of orthodontic treatment and thus created new interest in orthodontic research.

In 1931, Hellman reported his observations made upon patients in his private practice. He used the Todd headspanner, an anthropometric device, and made all measurements in the mid-sagittal plane in order to assess anteroposterior relationships of face, teeth and jaws. His study indicated that orthodontic treatment realigned the teeth to a normal relationship by movement of the teeth themselves, but he felt that treatment had no influence on the growth of their supporting bones, i.e., the mandible and the maxilla. He believed that when skeletal changes were observed after treatment, they were the result of growth. He implied, but could not prove, that the same changes would have occurred if the cases had not been treated.

Since Hellman's report in 1931, only one study could be discovered which attempted to clarify this issue. In 1938, a preliminary report of a roentgenographic cephalometric appraisal of orthodontic results was published by the orthodontic staff of the University of Illinois. All cases had been treated by means of Angle's edgewise arch mechanism in the clinic of the school. All types of malocclusion were studied, and the age range of the cases treated extended from the late mixed dentition to early maturity. It was concluded that orthodontic tooth movement did not influence growth of the facial skeleton. Changes were restricted to the teeth and the alveolar processes of the mandible and maxilla. All other skeletal changes were found to be attributable to normal growth processes. It is now generally accepted therefore, that bony changes after orthodontic treatment are confined to the alveolar process containing the moved teeth while the rest of the facial skeleton remains unaffected.

*Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Orthodontics in the Graduate College of the Chicago Professional Colleges of the University of Illinois, 1953.

The above study came to no conclusions regarding the effect of treatment on the facial profile although such changes are obvious during and after orthodontic treatment in many cases. Hundreds of published case histories attest to this fact. The question, however, remains: Are these changes in the facial profile the result of the orthodontic manipulations, or are they merely the result of the rapid growth characteristic of the parapubertal age period? There is the additional question of whether these changes in the facial profile are the result of skeletal changes or the result of changes in the soft tissue which covers the unchanged bony skeleton.

Brodie, et al ('38) confined their study to the skeletal parts only. They indicated that their study was of a preliminary nature and that further analysis on a larger scale was necessary. The present investigation is a continuation and elaboration of their study using a larger and different sample and was designed to restudy the question of whether or not orthodontic treatment does or does not influence the growth of the skeletal parts of the jaws and face outside of the teeth and the alveolar process.

The present investigation indicates that although orthodontic treatment does not markedly alter skeletal growth it did change the facial profile. This was particularly true in many of the female cases studied (of the age group treated). The changes are very small individually but may accumulate into demonstrable changes in the bony facial profile.

Materials Studied

Control Group (Untreated). This group consisted of five series obtained from the Bolton Foundation, two from the files of the Department of Graduate Orthodontics, University of Illinois and twenty-one series from the Mooseheart collection at the University of Illinois. These cases were divided on the basis of Angle's classification of occlusion. Twenty-one were normal, six were Class II, Division 1 and one was a Class II, Division 2. The age range of the total group was from 8 to 17 years.

Treated Group. This group consisted of seventy-four orthodontically treated cases with Class II, Division 1 (Angle) type of malocclusion selected from the files of the Department of Graduate Orthodontics, University of Illinois. The cases were treated with the edgewise arch mechanism according to the methods described in the literature by Angle ('28), Brodie ('29) and Wright ('35.) The only criteria for selection was the completeness of records prior to active treatment and after removal of all appliances and that all x-rays were taken with the teeth in occlusion.

Growth Pattern in Normal and Class II, Division 1 Untreated cases. The validity of using untreated normal cases as controls for the assessment of the effects of treatment in cases with Class II, Division 1 (Angle) type of malocclusion might be questioned since the growth pattern (i.e., morphologic pattern) might be dissimilar in both groups. However, this question has been examined and the literature indicates that only slight differences in morphology exist between Class II malocclusion and normal persons and that the growth pattern is very similar in both categories.

Adams (39) found no difference between the form of the mandibles of Class II and Class I. Blair ('52) found only minor differences in the mean skeletal patterns of Class I and Class II, Division 1 malocclusions and none of the differences reached the level of significance.

Craig ('50) studied the composite facial skeletal patterns of a group of

12 year old patients with Class I malocclusions. He compared these with a comparable group of patients showing Class II, Division 1 malocclusions. Superpositioning indicated the two groups had essentially the same composite pattern with the exception that the body of mandible appeared shorter and the lower first molar more posterior in the Class II, Division 1 composite.

Fisk, et al ('53) made a statistical assay of the valid evidence of the morphologic variations in the various components of the dentofacial complex in Class II, Division 1 (Angle) malocclusion. They concluded that as regards the profile, predominant evidence to date indicated only two differences; the mandibular body length was shorter than that of persons with Class I malocclusion and that the mandible was posterior in its relation to the maxilla and cranium. No other definite conclusions could be reached because of the conflicting evidence present in the literature.

Lande ('51) showed that different individuals may have similar facial types and different dental occlusions. He further found that, regardless of original facial type, the same general tendencies in growth behavior were operative.

A review of the literature leads us to conclude that the skeletal morphology of patients with Class II, Division 1 malocclusion are not markedly or significantly different from the normal but might be only a variation of the same population and therefore not statistically significant. To test this hypothesis in the present sample, a preliminary analysis was performed by analyzing the distribution of the individual growth trends of the untreated Class II's with normals (see figures 4 to 9, bottom graphs). The mean at each age level was also plotted for both groups for each measurement used (Fig. 2B). It was found that in this sample there was no significant difference between the growth trends in the untreated Class II cases and the untreated normals. It was, therefore, considered valid to use the normals as a control for the treated patients with Class II, Division 1 malocclusion.

Method

Patients with Class II, Division 1 types of malocclusion were selected for this analysis because this group presents one of the greatest challenges to the orthodontist in restoring esthetic harmony of the facial profile. This is usually not the primary problem in Class I types of malocclusion since the latter usually present deviations only within the denture itself, while Class II and III types of malocclusions usually present skeletal disharmonies as well. These skeletal disharmonies may be present with or without muscular deviations. Class III malocclusions are relatively few in number and a sufficiently large sample was not available for analysis.

This study is confined to changes in the bony profile since cepahlometric roentgenology permits the exact measurement of changes in the skeletal parts by serial study of the same individual. It would be highly desirable to measure the muscular and other soft tissues draped over the skeleton with the same exactness. Unfortunately, this is not yet possible.

Lateral cephalometric roentgenographs taken with the teeth in occlusion provided the basis of study. Whenever right and left bilateral structures did not coincide, a mean was constructed in order to minimize the distortion of magnification, slight errors in headpositioning and skeletal or dental asymmetries.

TECHNIQUE OF ANALYSIS

This investigation was concerned only with changes in the proportions of the bony facial profile. For this reason, measurements were made of various angles (Brodie, '41). The advantage of this method is that it is possible to compare individuals who differ in absolute size.

The maxillary and mandibular portions of the face were studied in their relation to the anterior cranial base and to each other. Each was subdivided into skeletal and alveolar portions by the points A and B (Fig. 1) as defined by Downs ('48). The following angles were measured (Fig. 1B):

1. Mandibular Plane Angle

The mandibular plane was defined by drawing a line tangent to the lowest points at the gonial angle and at the symphysis (Downs, '48). The mandibular plane angle was formed by constructing a perpendicular from the anterior cranial base plane S-N at S to the mandibular plane (Fig. 1B). The angle formed anterior and superior to the intersection of these two planes was the angle measured (Downs, '48). This angle relates the inclination of the lower border of the mandible to the cranial base.

2. Facial Plane Angle (S-N-Po)

The facial plane angle (S-N-Po) measured the relation of the facial plane (N-Po) to the anterior cranial base (S-N). Since Po represents the most anterior point on the mandible, it portrays the relative anteroposterior position of the mandible as related to the anterior cranial base. Therefore, if the angle is large, the mandible is prognathic while if it is small, it is retrognathic.

3. S-N-B

Point B is the most posterior point on the anterior surface of the mandible in the mid-sagittal plane (Downs, '48). It represents the junction between the alveolar process and the mandibular base. The angle S-N-B relates point B to the cranial base. If the angle increases, point B is moving forward while if it decreases, it is moving backward. Since point B is part of the mandible, its behavior is dependent upon the position of the mandible as well as upon the relations of the mandibular teeth to their supporting bone.

4. S-N-ANS

Measures the anteroposterior relationship of the anterior part of the body of the maxilla, as it is related to the cranial base. If the angle is large, the maxilla is forward while if small, it is posterior.

5. S-N-A

Point A is the most posterior point on the anterior surface of the maxillary alveolar process in the mid-sagittal plane (Downs, '48). It represents the junction between the alveolar process and the maxilla proper. If the angle increases, point A moves forward while if it decreases, it moves back.

6. AB to Facial Plane

The AB plane is formed by connecting points A and B. The angle formed by the intersection of the AB plane with the facial plane (N-Po) is the angle used in this study. It has been arbitrarily established by Downs ('48) that if point B is behind point A, the reading is registered as negative, while if it is ahead, it is registered as positive. This procedure has been followed in this study.

The AB plane also presents a means of appraising the anteroposterior relation of the alveolar processes of the mandible and maxilla to each other and as each is related to the facial plane. This measurement is the only one in this study that does not use the cranial base as a fixed reference plane.

Growth Pattern and Growth Trend. Most studies in the past have been concerned with the morphologic character-

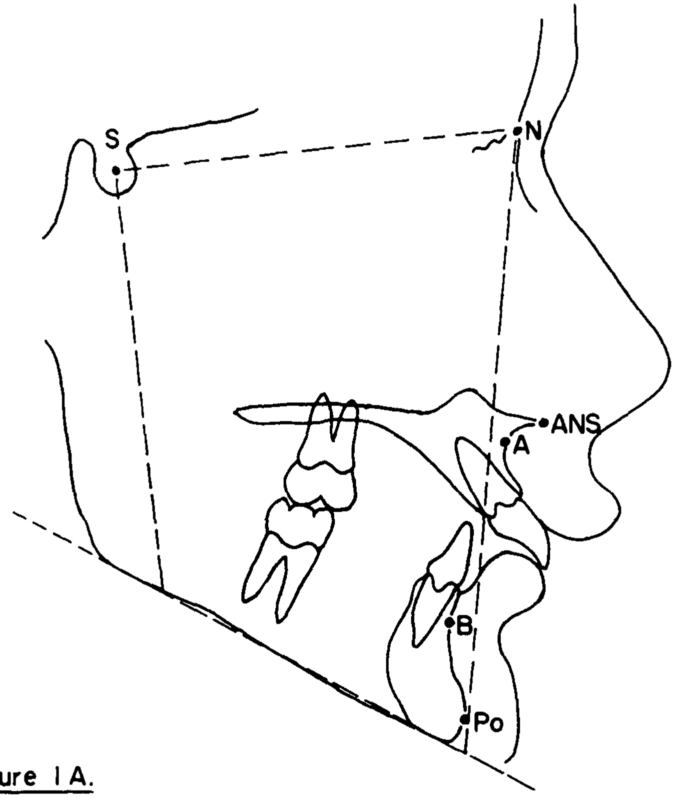

Figure 1A.

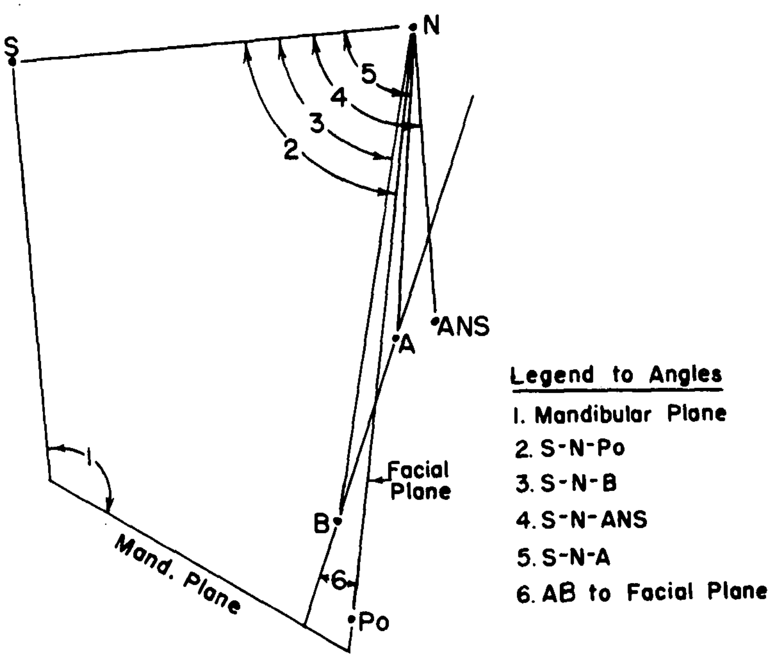

Figure 1B.

Fig. 1a, 1b. Points used in the study. Points, planes and angles in a diagrammatic form.

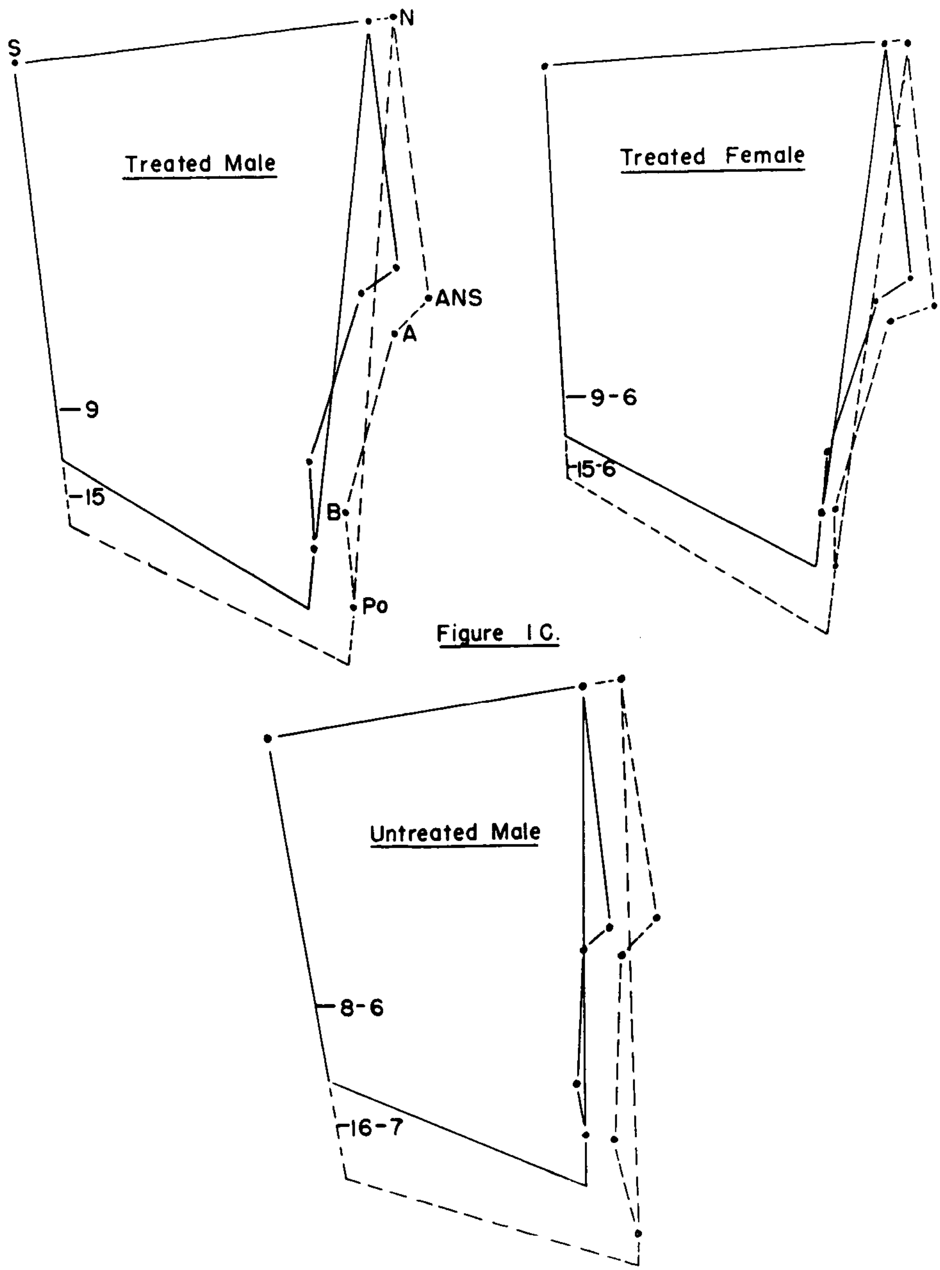

Figure 1C.

Fig. 1c. Diagrammatic tracings superposed on S-N of a treated male and female before and after treatment, and an untreated normal male at comparable ages.

istics of the individual skeletal pattern, that is, the geometric form of the bony facial structure. The changing morphology of these skeletal parts and the changes in the relationship of these parts during growth constitutes the study of growth patterns.

Growth trend refers to the rate of increase or decrease of one or more of the morphologic characteristics with age. Growth trends describe the rate of change in shape of the basic pattern as correlated with age or orthodontic treatment.

Hellman ('31), Brodie et al ('38) and Brodie ('41) have already demonstrated that the basic skeletal pattern remains the same with age and after orthodontic treatment while Craven ('52) found it to be similar in different ethnic groups. This study is therefore concerned primarily with the rate change in the skeletal pattern with age or with orthodontic treatment. For this reason trend analysis was used in this study, rather than morphologic analysis.

Validity of the Use of Straight Lines to Indicate Growth Trends in Treated and Untreated Cases. Straight lines made by connecting the measurement before and after treatment were used to indicate the trend in the growth of each individual case as well as the mean trend of the group as a whole. Since it is well established that growth is not a uniform and even process and that it rarely follows a straight line function, it became necessary to establish the validity of using straight lines to indicate growth trends.

Individual cases were sampled from each category and all measurements available before, during and after treatment were plotted as in Fig. 2A. The untreated cases were similarly sampled and analyzed.

It was found (as expected) that the individual measurements varied with age in both the untreated and the treated cases. However, Fig. 2A shows clearly that the best fitted regression line is, in each instance, a straight line. The regression lines were derived by the method of moving averages (Snedecor, '46).

In the treated cases, it was noted that the points sometimes showed a slightly parabolic function. This was due to the fact that treatment caused a progressive deviation of the points *away* from the straight line growth trend. However, after treatment was completed, there was a strong tendency to the point under scrutiny to return *towards* the original straight line. This phenomenon is well known to the clinician who terms this characteristic, the tendency of the case to relapse towards its original position. It is the reason that retention is essential in most cases after active treatment is completed. For this reason it was considered more correct to connect the points before and after treatment rather than to include all intermediate points, since the measurement made *after* treatment is actually the end point. This straight line is therefore a conservative indication of the effects of treatment.

Statistical Analysis

The behavior of each group studied was analyzed in two ways. Scatter diagrams were first constructed showing the linear trend of each individual case (Figs. 4 to 9). This type of graphic analysis indicates:

a) The specific trend of each individual.

b) The frequency distribution of the trends in the cases comprising the sample.

c) The trend of the total group (the mass trend).

The mean trend line for the entire group was derived by the method of moving averages (Snedecor, '46). The averages employed were the arithmetic means at each age level. The resulting

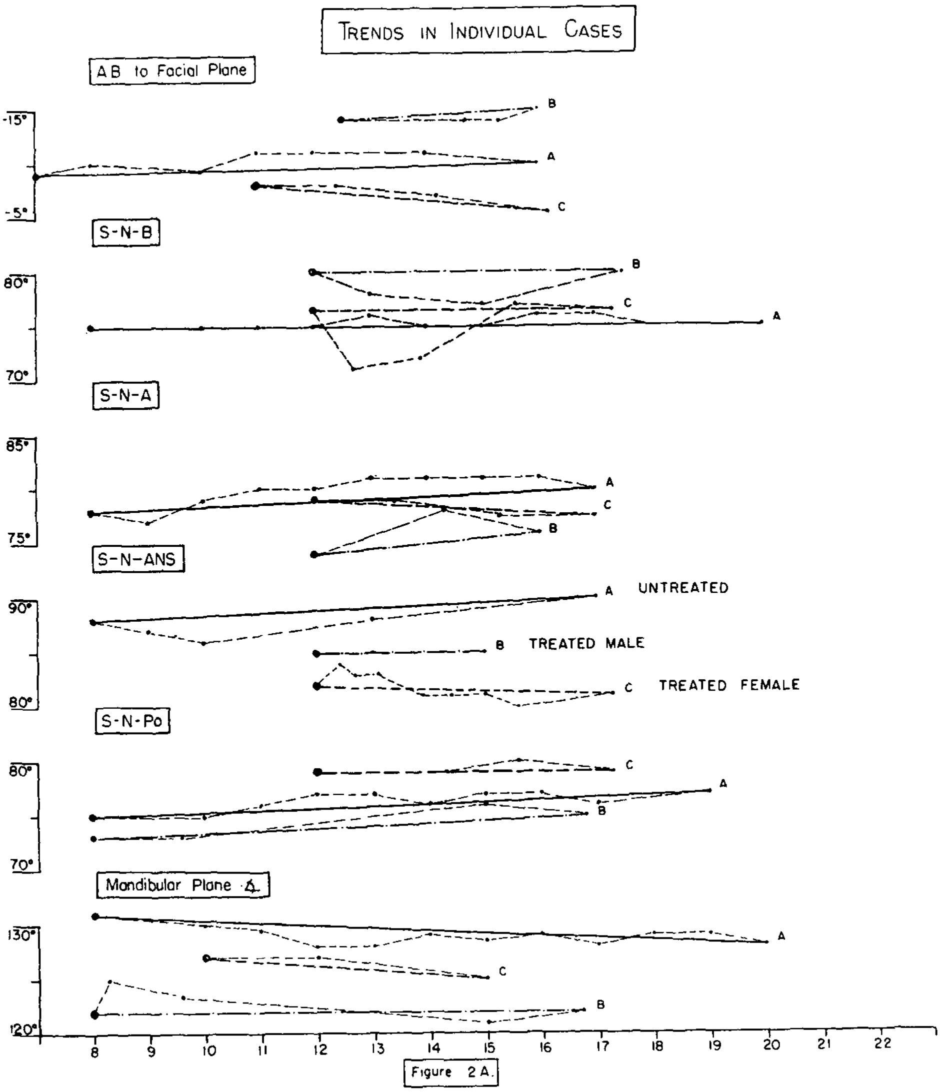

Fig. 2a. Graph showing straight line trends with age. A circle indicates a measurement before treatment; points indicate measurements during and after treatment. A, untreated; B, treated males and C, treated females.

straight regression line (mean trend line) depicts the behavior of a hypothetical "average" person representing the sample. Its use greatly simplifies comparisons between groups although it eliminates individual variations within the group. The latter are depicted by the mass trends which more correctly define the real trends of the individuals comprising the sample.

In summing up the rationale of his technique of analysis in his growth studies, Hellman ('35) wrote:

"Of course I am fully aware of the fact that in studies of this sort, it is really the nature of growth of the

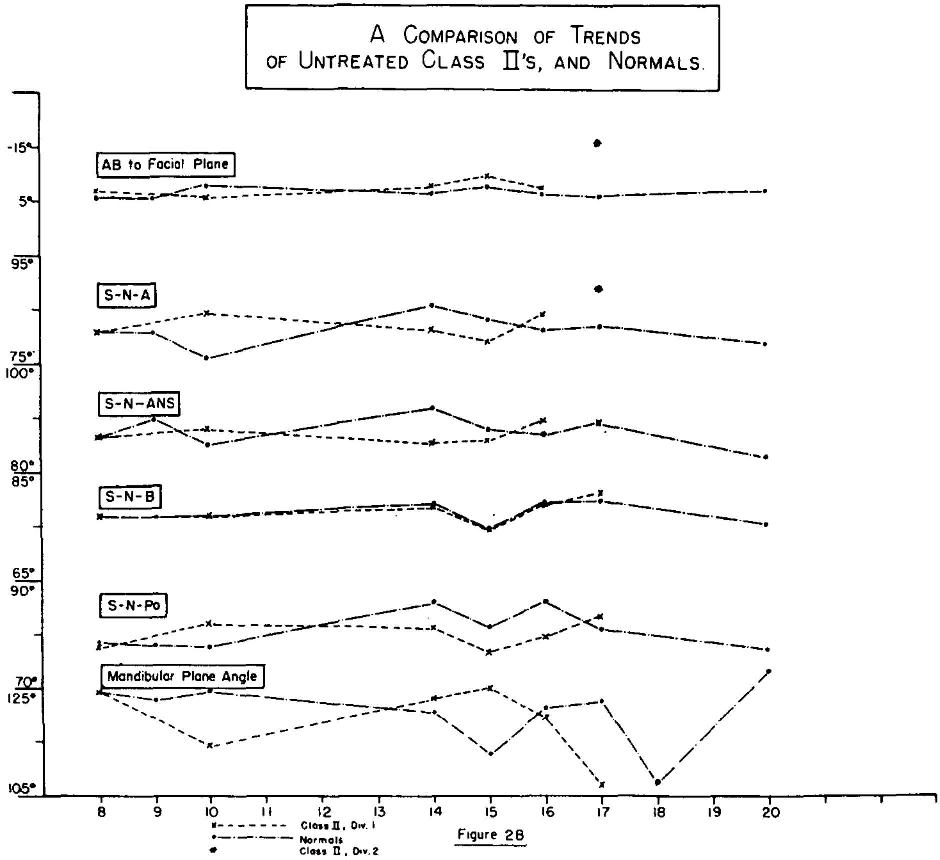

Fig. 2b. A comparison of trends of untreated Class II cases and normals.

individual which concerns the profession most, but due to the extensive variability of individuals, the problem is liable to become complicated and often tends to lead to confusion. An advantage is therfore gained by using averages derived from mass studies, instead of the individual because they point to general trends which are simpler to handle and easier to understand. These may then be used as studies for comparisons with the individual."

Treatment of Data. The significance of differences between the means of absolute measurements of angles at different age levels was tested by the "t" test for non-paired data (Table 1).

As indicated before, the linear regressions were derived by the method of moving averages. This method was selected rather than the method of least squares primarily because of the large number of individual trends used in this study. Mathematical computation by the method of least squares would have entailed an enormous amount of work.

A significant advantage of the method of moving averages is the fact that it permits a small amount of subjective weighting. This is essential in this type of study since the significance of each point differs from case to case. Obviously aberrant measurements can be de-emphasized. The method of least

TABLE 1
STATISTICAL SIGNIFICANCE TESTING (t) for MORPHOLOGIC DIFFERENCES BETWEEN THE VARIOUS GROUPS AT AGES (8-9) and (15-16-17)

Angle Measured	*Age Group*		*Untreated* Males	*Untreated* Females	*Before Treatment* Males	*Before Treatment* Females	*After Treatment* Males	*After Treatment* Females
Mandibular Plane Angle	8-9	*n	15	10	6	8		
		**m	125.00	122.00	124.83	124.25		
		***SD	3.55	3.33	6.06	4.62		
		****t	1.9		.21			
	15-16-17	n	15	8			17	20
		m	121.92	118.66			120.88	121.42
		SD	5.86	4.64			5.35	6.79
		t	0				.27	
S-N-Po	8-9	n	15	10	6	8		
		m	77.73	79.50	75.33	75.00		
		SD	3.73	3.23	2.73	3.39		
		t	0		0			
	15-16-17	n	15	8			17	20
		m	80.25	80.37			77.74	76.75
		SD	4.41	4.04			3.13	3.79
		t	.06				0	
S-N-B-	8-9	n	15	10	6	8		
		m	76.60	78.60	73.66	74.67		
		SD	2.88	3.37	2.90	3.27		
		t	1.9		0			
	15-16-17	n	15	8			17	20
		m	78.43	78.75			75.17	75.20
		SD	4.33	3.33			2.91	3.68
		t	0				0	
S-N-ANS	8-9	n	15	10	6	8		
		m	86.20	87.40	87.66	86.50		
		SD	3.07	3.46	3.83	4.58		
		t	0		0			
	15-16-17	n	15	8			17	20
		m	88.00	88.50			86.17	86.75
		SD	2.57	3.90			2.96	4.05
		t	0				0	
S-N-A	8-9	n	15	10	6	8		
		m	79.86	82.10	79.83	79.50		
		SD	3.06	3.33	3.60	3.62		
		t	1.6		0			
	15-16-17	n	15	8			17	20
		m	80.00	82.87			78.41	79.85
		SD	2.34	4.05			4.02	3.87
		t	2.2				0	
AB to FACIAL PLANE	8-9	n	15	10	6	8		
		m	5.80	5.80	11.30	9.75		
		SD	2.58	2.12	1.86	3.87		
		t	0		0			
	15-16-17	n	15	8			17	20
		m	6.00	7.50			6.40	8.15
		SD	3.29	3.02			4.95	3.44
		t	1.1				0	

*n = number of cases measured

**m = mean of total measurements

***SD = standard deviation $= \sqrt{\frac{\Sigma d^2}{n-1}}$ ****t $= \frac{M1 - M2}{sd} \times \sqrt{\frac{n1 \times n2}{n1 + n2}}$

TABLE 2

RATE OF CHANGE OF THE VARIOUS BONY FACIAL PROFILE POINTS AND PLANES WITH INCREASE IN AGE (RATE OF ANGULAR CHANGE PER YEAR)***

	Mean ± Standard Deviation			
Angle measured	*Untreated Males* *(n = 18)	*Untreated Females* (n = 10)	*Treated Males* (n = 32)	*Treated Females* (n = 42)
Mandibular Plane Angle	—0.32 ± 0.54	—0.46 ± 0.33	—0.51 ± 0.39	0.06 ± 0.51
S-N-Po	0.56 ± 0.37	0.16 ± 0.47	0.20 ± 0.41	0.12 ± 0.42
S-N-B	0.25 ± 0.31	0.04 ± 0.02	0.17 ± 0.50	0.17 ± 0.41
S-N-ANS	0.19 ± 0.28	0.18 ± 0.31	0.10 ± 0.51	0.12 ± 0.43
S-N-A	0.19 ± 0.20	0.05 ± 0.33	—0.21 ± 0.42	—0.13 ± 0.33
AB to Facial Plane	0.02 ± 0.43	—0.18 ± 0.33	0.67 ± 0.81	0.47 ± 0.42

*n = number of cases
**age range = 8-20 years
***arithmetic mean of angular changes per person per year.

TABLE 3

SIGNIFICANCE TESTING (t) OF TRENDS (RATE OF CHANGE FROM 8-20 YEARS) BETWEEN THE GROUPS STUDIED

t values

Angle Measured	*Untreated Males, Untreated Females*	*Untreated Males, Treated Males*	*Untreated Females, Treated Females*
Mandibular Plane Angle	.7	4.7**	3.1**
S-N-Po	7.4**	2.3**	2.8**
S-N-B	2.2*	.6	.9
S-N-ANS	.1	.7	.4
S-N-A	1.2	4.6**	1.5
AB to Facial Plane	3.2**	3.1**	4.5**

*Borderline significance
**Statistically significant

SIGNIFICANCE LEVEL (P)

(Appendix to Table 3)

t	*Probability (P) of obtaining an equal or greater deviation than that observed*	*Significance*
Less than 2.086	5% or more	Not statistically significant
2 — 2.5	2% to 5%	Borderline significance
2.528 or more	2% or less	Statistically

*From Fisher in Snedecor

squares allows no weighting by clinical judgment. It should be emphasized that the amount of weighting permitted by the method of moving averages is slight.

The significance of differences between trends was analyzed by obtaining a trend coefficient (rate of increase or decrease per year) for each of the categories studied. The angle was measured before and after treatment and the difference was divided in each case by the number of intervening years. This gave the arithmetic rate of angular change per year in each individual. An arithmetic average rate of change and standard deviation was then computed for each of the groups studied. This quantitated the slope of the mean trend lines constructed graphically by the direct analysis of the rate of change of each individual instead of estimating this acceleration or deceleration from the mean trend line. This was a more accurate measure of the true acceleration or deceleration of the trend lines shown in Figs. 3 to 9 (Snedicor, page 136). The mean rates of change per year thus derived for each group were tested by the "t" test for non-paired data (Table 3).

$$t = \frac{M1 - M2}{sd} \times \sqrt{\frac{n1 \times n2}{n1 + n2}}$$

where $\overline{M}$ is the respective mean and sd the pooled standard deviation.

The significance level (P) was placed at 5% (less than 5 chances out of 100 of the differences being due to chance) so that a value of "t" less than 2.0 was not statistically significant and a value of "t" greater than 2.5 was considered to be siginicant. Values between 2.0 and 2.5 were of borderline significance.

Findings

Changes in the Bony Profile with Age in Untreated Cases

Figure 3 shows the mean trends and Figs. 4 to 9 show the individual trends in the bony profile of both treated and untreated groups. All mean trend lines indicate changes from 8 to 20 years.

Analysis of trends in the untreated cases showed that, in general, changes in facial proportions (as measured by the various angles become progressively greater from nasion downwards. The upper face (S-N-A and S-N-ANS) showed very little change in angulation from 8 to 20 years. The lower face, in general, showed greater changes. S-N-B and the relation of AB to the facial plane showed slight angular changes similar to the upper face.

This study indicates that the mandibular plane angle *decreased* with age. This finding differs from the report by Brodie ('41) who found that the mandibular plane remained parallel to itself with age but confirms the findings of Lande ('51) and Bjork ('47). The latter studies included age groups similar to the present, while Brodie ('41) studied a much younger age group.

Sex Differences in Growth. During the analysis of these data, it was found that there was a tendency for the growth trends (i.e., the rates of growth) of the males and females to differ (Table 3.) It is interesting that here again, the differences were in the lower face. Differences in the upper face (S-N-A and A-N-Ans) were slight (Figs. 3, 7 and 8). However, as one progressed from S-N-B to S-N-Po to mandibular plane angle and AB to facial plane angle, the difference in trends between untreated males and females became more marked.

At 8 years, the mandibular plane angle in the male was 4.5° greater (more obtuse as related to S-N) than in the female. This difference was not statistically significant ($t = 1.9$). However, in the males this angle decreased faster than in the females so that by age 20 both males and females were similar (Figs. 3 and 4) ($t = 0$). The

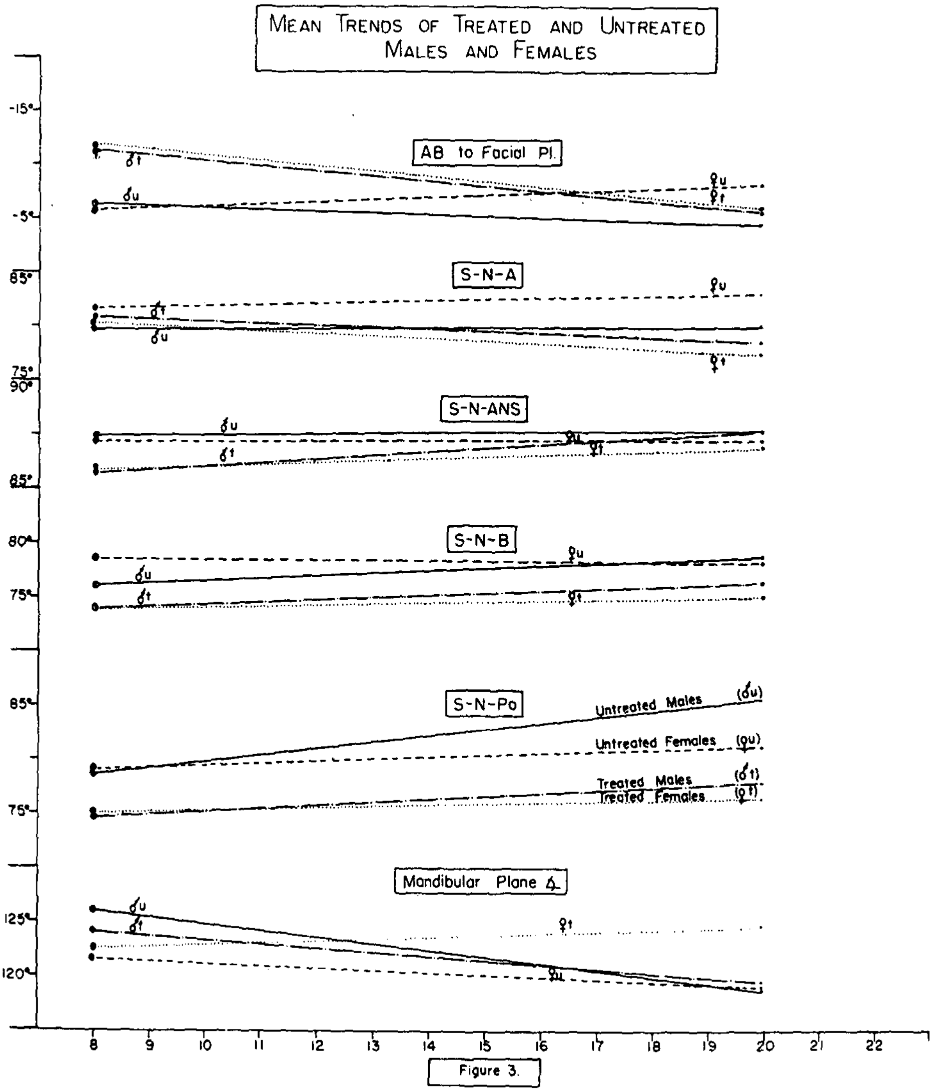

Fig. 3. Mean trends measured with age. Note tendency for the treated female line to deviate from the treated male line.

rate of decrease was thus more rapid in the males than in the females. However, this difference in growth trends was not statisically significant (t = .7).

At 8 years, the angle S-N-Po was alike in both males and females. This angle increased more rapidly in the males than in the females, so that at 20 years it was 4° larger in the males (Figs. 3 and 5). However, the difference was not statistically significant (t = .1). The male and female growth trends, however, were significantly different from 8 to 20 years (t = 7.4).

The relation of AB to the facial plane appeared to be similar in males and females at the age of 8 years. However, this angle increased much more rapidly in the females, so that at age 20 it was 4° larger than the male (Figs. 3 and 9). This difference was not statistically significant (t = 1.8). The female rate of increase, however, was significantly different from the male (t = 3.2).

Hellman ('35) similarly found differences between males and females in the growth of the various proportions of the face. He found differences in timing, quantity and rate from birth onward. The proportional changes, however, were based on the comparison of the height, width and depth of the face rather than on the anteroposterior changes in the mid-sagittal plane as in this study.

Statistical testing of the largest differences between the mean values (absolute size) of the various angles measured in males and females showed that these differences were not large enough to be statistically significant. This indicates that although the trends (i.e., the mean rate of change) in males and females are different, this does not necessarily result in significant differences in size of the various angles.

Changes in the Bony Profile after Orthodontic Treatment in Males and Females

Since sex differences were demonstrated in the untreated group, it was felt that it would be better to analyze the effects of orthodontic treatment separately in males and females, especially in view of the obvious clinical differences between the sexes.

1. Mandibular Plane Angle

The tendency of the mandibular plane angle to decrease with age was similar in the treated and untreated males, but the rate of change was significantly different (t = 4.7). Treatment inhibited the rate of angular decrease slightly, so that the expected growth potential was not attained (Fig. 4). However, this change in absolute angular size was statistically significant (t = 0).

Treatment reversed the normal growth trend in females. Instead of the mandibular plane angle decreasing with age, it increased (Figs. 3 and 4). Whereas the mandibular plane angle in the untreated group was similar in both sexes at 20 years, in the treated females this angle was 3.5° more obtuse than in the treated males at the age of 20 years. In spite of the fact that the absolute angular differences at age 20 years were not statistically significant (t = .3), the reversal of the growth trend in the treated female group was significant (t = 3.1).

2. Facial Plane Angle (S-N-Po)

At the age of 8 years, the angle S-N-Po was 4° more acute (pogonion was more posterior) in the treated than in the untreated cases. This difference was not statistically significant (t = .8). The effect of treatment in males on the absolute angular measurement of S-N-Po at age 20 was not significantly changed (t = .6). The growth trend, however, was significantly altered in females (t = 2.8) and questionably changed in males (t = 2.3).

3. Mandibular Alveolar Relationship (S-N-B)

S-N-B was more acute (B posterior) at the age of 8 years in the treated than in the untreated cases. However, the difference was not statistically significant.

The effects of treatment were less than the difference that existed between these groups before treatment. Therefore, the absolute angular difference and the differences in trends resulting from treatment were not statistically significant.

4. Behavior of the Maxillary Base (S-N-ANS)

The untreated males and females were similar at age 8 and did not change with age. The treated males

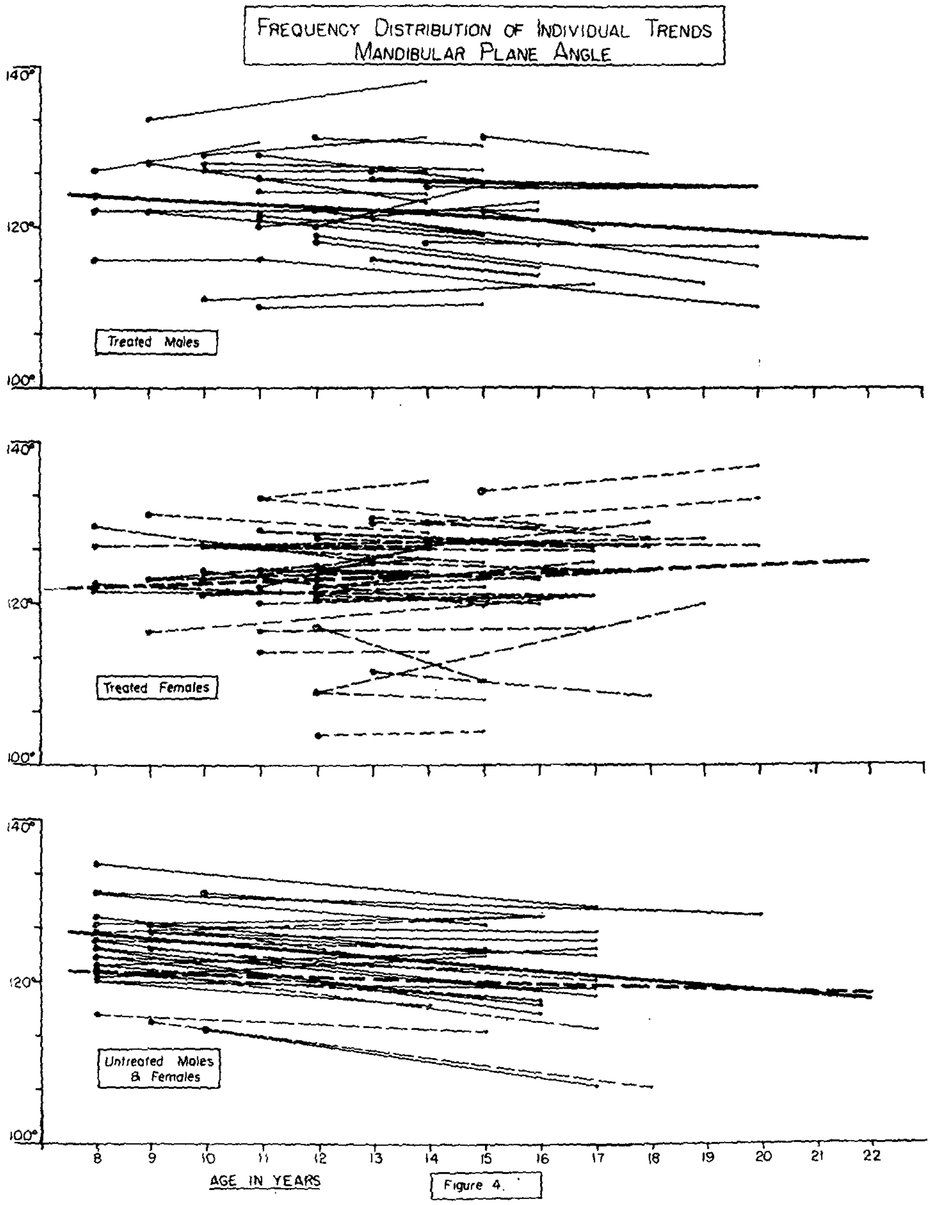

Fig. 4. Individual behavior with increase in age of the mandibular plane angle of untreated and treated groups. The untreated group is divided into normals (solid lines) and Class II (interrupted lines). The mean regression lines are indicated as solid (males) and interrupted lines (females). In the treated groups the first measurement is before treatment and the last after completion.

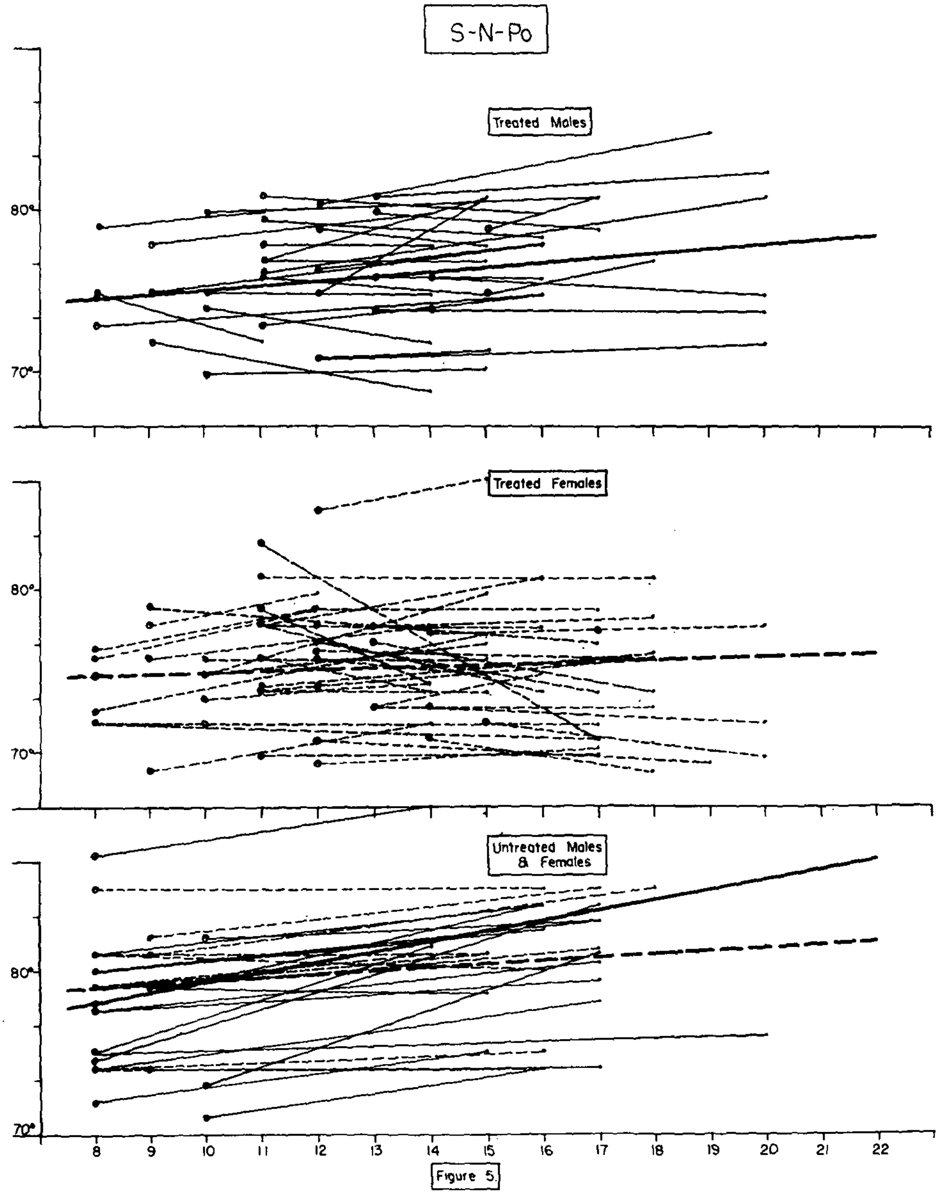

Fig. 5. Behavior of S-N-Po. The untreated group is divided into normals (solid lines) and Class II (interrupted lines). The mean regression lines are solid (males) and interrupted lines (females).

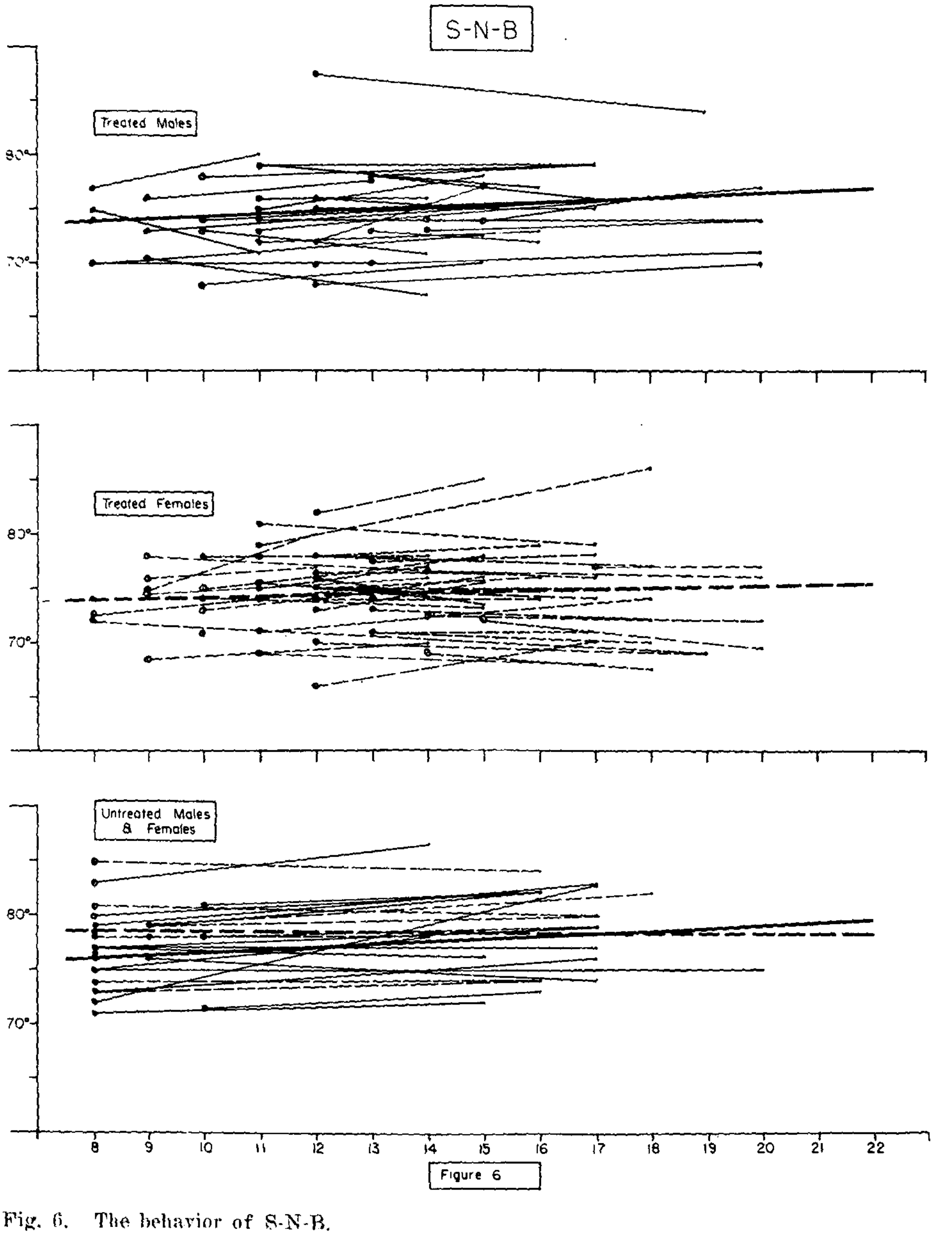

Fig. 6. The behavior of S-N-B.

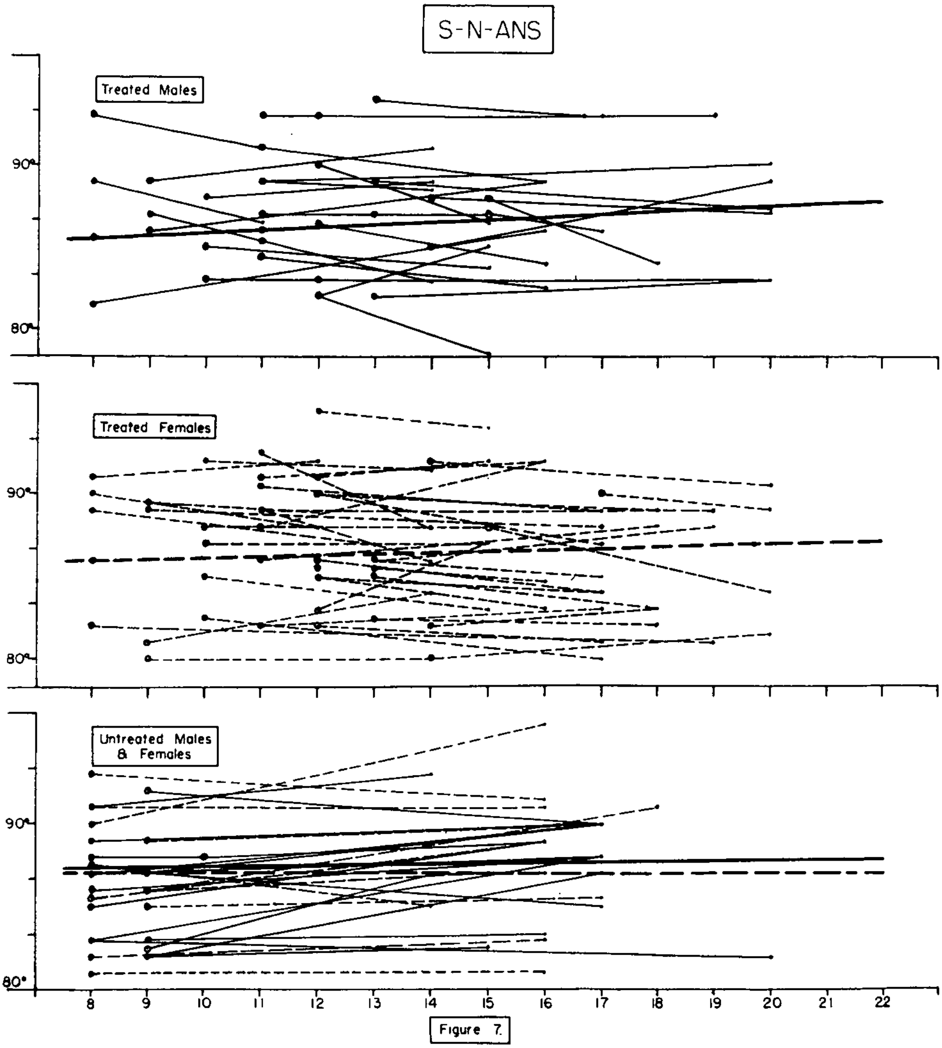

Fig. 7. Graph showing the behavior of S-N-ANS.

and females were 4° less acute (ANS forward) than the untreated cases, but this was well within the normal range of variation of the untreated cases. The changes after treatment were less than the differences that existed before treatment was started (t = .2).

5. Maxillary Alveolar Relationship (S-N-A)

S-N-A normally changed very slightly with age (Fig. 3). Treatment altered the normal growth tendency slightly by decreasing the angle S-N-A from 8 to 20 years (Figs. 3 and 8). The treated females were 4.5° smaller (in the absolute angular magnitude of S-N-A) than the untreated females at age 20, and similarly, the treated males were 2.5° less than the untreated males at 20 years. Treatment tended to decrease the absolute size of this angle, but these changes were not significant (t = 1.8

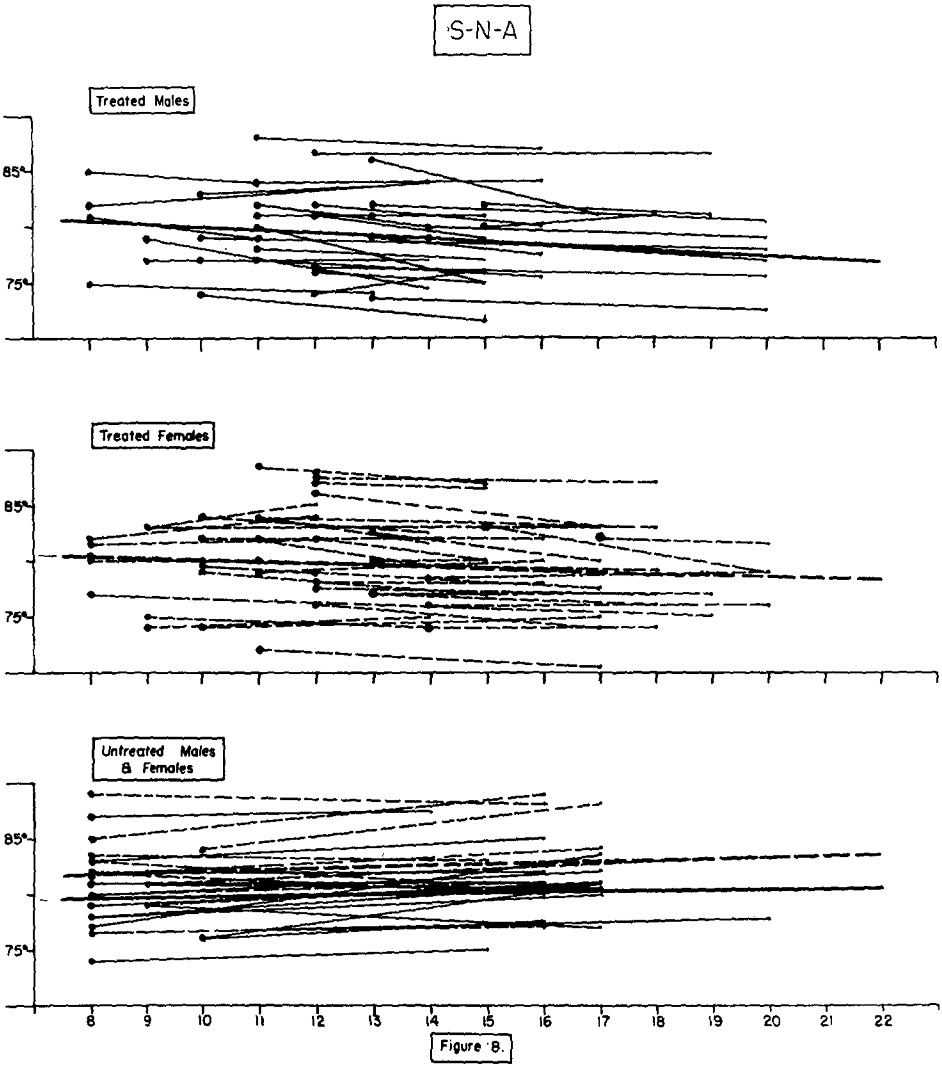

Fig. 8. Graph of S-N-A.

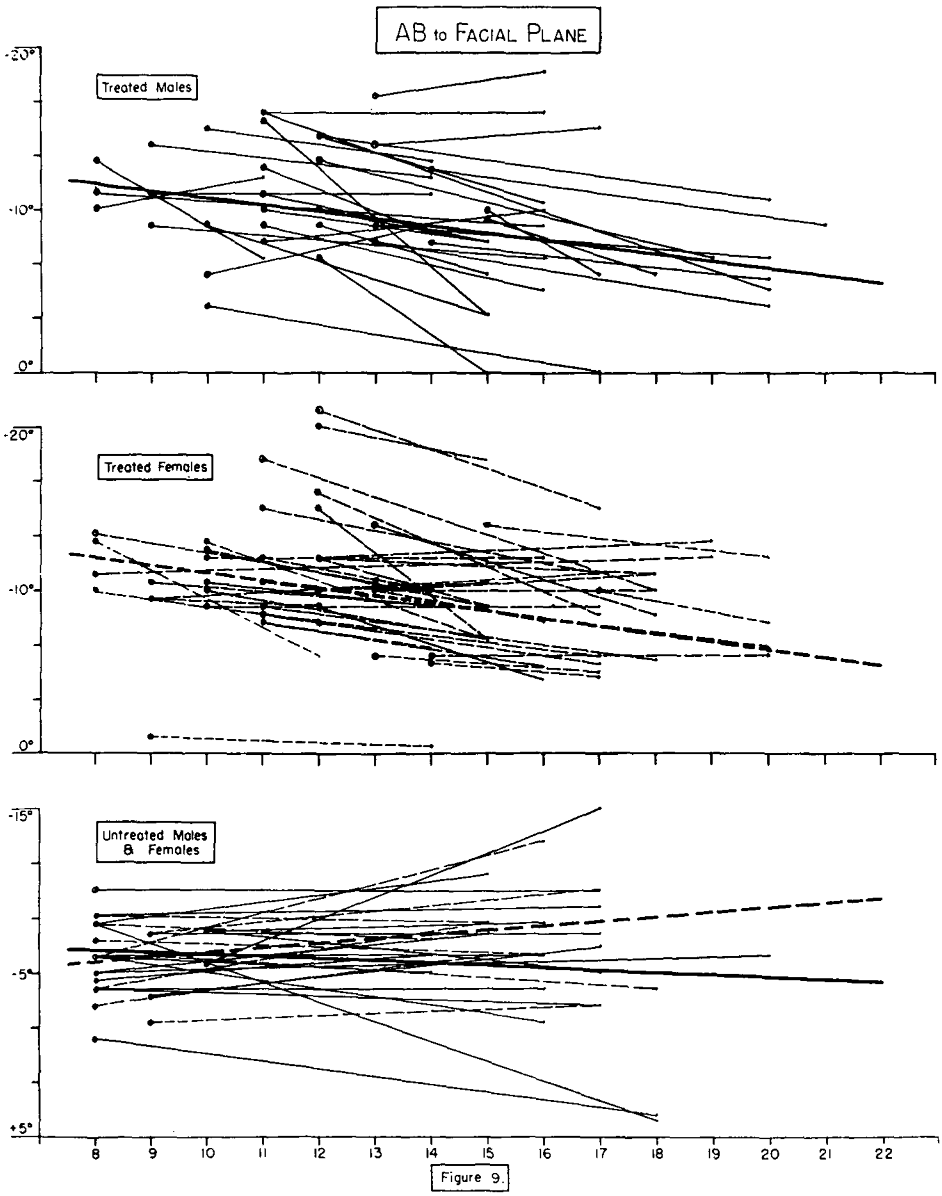

Fig. 9. Graph showing the individual behavior with increase in age of AB to facial plane. The untreated group is divided into normals (solid lines) and Class II (interrupted lines). Regression lines are indicated.

and 1.1). When the trends were examined, however, it was found that the female trend remained unaltered, while the male trend was significantly changed (t = 4.6).

6. AB to the Facial Plane

The difference between the untreated and the treated groups (prior to treatment) was most marked by this angular relationship (Figs. 3 and 9). At age 8, the difference in this angle between the untreated and treated groups was very significant (t = 4).

At 8 years, the angulations of the AB to facial plane of the untreated males and females were the same. Thereafter the female trend increased while the males decreased slightly, so that at 20 years there was a 4° differential between males and females (Fig. 3). The difference between males and females at age 20 was of border line significance (t = 2.6).

The treated males and females were similar at 8 years although quite different from the untreated males and females. Treatment, however, decreased this angle well within the range of the untreated males and females by 20 years of age and altered their growth trends significantly (t = 3.1 and 4.5).

Discussion

Profile Changes During the Normal Growth Process. Studies in the past have demonstrated that the profile changes with age. Hellman ('32) wrote that the rate of growth differed at different levels in the face. The lower face grows at a faster rate transversely and anteroposteriorly. The findings in this study coincide with Hellman's ('32), in that pogonion moved forward at a faster rate than did the anterior nasal spine.

Bjork ('47), in comparing 12 year old Swedish boys with 21-22 year old adults, found a slightly increased mandibular prognathism as compared to maxillary prognathism. This tended to straighten the profile. Basal prognathism increased faster than alveolar prognathism.

Lande ('51) found increased mandibular prognathism from ages 8 to 17. This was associated with a decreased inclination of the lower border of the mandible. The alveolar base became more recessive with age. Facial convexity almost always decreased with age. These findings were all made on untreated cases and therefore reflected normal growth tendencies.

Behavior of the Bony Profile in Males and Females. Previous cephalometric studies have detected differences between males and females. Hellman ('32) found that some proportional changes in the face in males were more pronounced than in females. The female face was relatively longer, while the male face was relatively broader and deeper. The female jaw bones and dental arches were relatively more prognathous than those of the male.

Elsasser and Wylie ('48) compared boys and girls having Class II, Division 1 malocclusions who, aside from malposed teeth, had normal facial proportions. They concluded: "Statistically speaking, the anomaly seems to be maxillary over-development in males and mandibular under-development in females, but individual cases demand specific analysis and frequently involve dimensions which cannot be made to show statistically significant differences in the mass."

This analysis shows that individual differences in growth trends do exist between males and females. The comparison of the various angles measured at each age level indicated that differences in the absolute size of these angles were, however, not significantly different in males and females. This is undoubtedly due to the fact that the variation within each sex was so large that great overlapping occurred and the actual differences were hidden. It became clear that sex differences in absolute angular size probably did exist, but that these could not be accurately studied by cross-sectional methods. A very useful approach to this problem would be the use of paired comparisons as between siblings (or even better, identical twins) studied *longitudinally.*

Profile Changes Resulting from Treatment. This study revealed that slight changes in the growth trends could be demonstrated after treatment. These were confined to the mandibular plane angle, to S-N-Po, to S-N-A (treated males) and the relation of AB to the facial plane. These changes were so slight that it is not surprising that Hellman ('31) and Brodie, et al ('38) could not demonstrate them in the relatively smaller samples by cross-sectional analyses of means.

The examiner, selecting cases for treatment, might have been biased toward selecting cases for teaching purposes which had a high AB to facial plane angle. Significantly, treatment reduced this by changing the normal growth trend, so that at completion of treatment the angle was well within the range of variation of the untreated cases. Changes in points A and B probably represent changes in the position of the denture over its supporting bone. This study suggests that persons having in common a Class II, Division 1 malocclusion may otherwise present a heterogeneous conglomeration of skeletal patterns.

The cause of differences in male and female response to treatment can only be conjectured upon. The more active the growth, the less will treatment change the normal growth tendencies. It is also possible that response to treatment is inherently different in males and females. In this study the males and females were treated at comparable ages. It is well known that the female pubertal spurt occurs earlier than the male. Therefore, the females were at a disadvantage because they were treated in a less active growth period.

Limitations of This Study. The number of untreated cases having Class II, Division 1 malocclusion was small. The age spread of the various groups studied was not uniform, so that only a limited number of age groups were available for comparison, and therefore, only limited statistical testing of comparable age behavior was possible. The use of individual and mass trends was the only means available of graphically appraising the real trends of the sample. The mean trend indicated the trend of the "average" person.

The variation within each sex, and each group (data presented in Table 2) was so large that real differences between sexes and groups were obscured. This made the comparison of the means of the absolute angular measurements statistically "not significant" (data presented in Table 1). The standard deviation of the trend coefficients often exceeded the mean rate of change and similarly reflected the great variation present in the sample (data presented in Table 2). This emphasizes the limitations of statistical testing when the sample is heterogeneous. Fisher ('49) very aptly wrote:

"In many fields of experimentation, quantitative knowledge is lacking as to the degree of heterogeneity to be anticipated in batches of material of different size, or drawn from more or less diverse sources. This is a drawback to precise planning, which increased care in experimental design will doubtless steadily remove."

This study emphasizes the fact that group analyses by the use of means and trends without careful experiment design and selection of sample is not satisfactory. Longitudinal study of carefully matched pairs is the only solution for the elucidation of growth differences between males and females, between untreated and treated cases and certainly between persons with different facial patterns (Fisher, page 31).

Summary and Conclusions

This investigation was undertaken to test the effects of treatment on the growth rates of certain bony facial profile points and planes of persons having Class II, Division 1 malocclusion of the teeth. The method of analysis was based on measurements taken from lateral serial cephalometric roentgenograms. A group of patients who had been treated for Class II, Division 1 malocclusion was compared to a combined group of persons having normal occlusion and Class II, Division 1 malocclusions who had never received any orthodontic treatment. The various categories were subdivided into males and females because sex differences were noticed early in the study.

No significant morphologic difference between treated and untreated males and females of comparable age could be demonstrated statistically except in the relation of the bony facial profile points to each other (AB to facial plane). Trend analysis, however, demonstrated significant differences between the various groups studied. Since sufficient longitudinal data was unavailable, group differences were assessed by the frequency distribution of individual trends in the mass, by mean trend regressions and by the mean changes in the slope of these regression lines as derived from individual rates of change.

The effect of treatment became more marked as the distance from nasion downward increased. Treatment inhibited the decrease of the mandibular plane angle (as it is related to the cranial base plane S-N) and reversed the normal growth tendency in the females by increasing instead of decreasing this angle. The forward movement of pogonion was inhibited in males and females so that the expected growth potential was not attained. S-N-B and S-N-ANS were not affected by treatment. S-N-A tended to decrease in males as a result of treatment, while the females were unaffected. The relation of AB to facial plane was altered in males and females by treatment, so that this angle decreased to well within the range of the untreated males and females by 20 years of age.

This analysis shows that individual differences in growth trends probably do exist between males and females. However, the comparison of the absolute measurements of the various angles measured at each age level indicated that differences in the size of these angles was not statistically different in males and females because the variation within each sex was so large that great overlapping occurred and probably masked any real differences. In order to uncover real individual differences in morphology or growth rates (trends), it would be highly desirable that future research design in orthodontics be based on longitudinal and paired comparison studies.

2070 Grand Concourse

BIBLIOGRAPHY:

Angle, E. H. 1899. Classification of malocclusions. *Dental Cosmos,* Vol. 41, No. 3.

——— 1907. *Malocclusions of the teeth.* 7th Edition. Philadelphia, S. S. White Dental Manufacturing Company.

——— 1929. The latest and best in orthodontic mechanisms. *Dental Cosmos,* Vol. 70, No. 12, 1928 and Vol. 71, Nos. 2, 3, 4.

——— 1906. The upper first molar as a basis of diagnosis in orthodontia. *Items of Interest,* Vol. 28, No. 6.

Adams, J. W. 1948. Cephalometric studies on the form of the human mandible. *Angle Orthodontist,* 18: 8.

Broadbent, B. Holly 1931. A new x-ray technique and its application to orthodontia. *Angle Orthodontist,* 1: 454-66.

——— 1937. The face of the normal child. *Angle Orthodontist,* 7: 183-208.

——— 1937. Bolton standards and technic in orthodontic practice. *Angle Orthodontist,* Vol. 7, No. 4.

Brodie, A. G. 1929. Rapid treatment of Class II, Division 1 cases with the new Angle mechanism. *Dental Cosmos,* Vol. 71, No. 8.

——— 1929. The new Angle mechanism. *J. Am. Dent. Assoc.,* 16: 2085-2108.

——— 1941. On the growth of the human head from the third month to the eighth year of life. *Am. J. Anat.,* 68: 209-262.

——— 1946. Facial Patterns: a theme on variation. *Angle Orthodontist,* 16: 75-87.

Brodie, A. G., W. B. Downs, A. Goldstein and E. Meyer 1938. Cephalometric appraisal of orthodontic results. *Angle Orthodontist,* 8: 261-351.

Bjork, A. 1947. The face in profile. *Svensk Tandlakare-Tidskrift,* Vol. 40, No. 58. Berlingska Boktryskeriet, Lund.

——— 1950. Some biological aspects of prognathism and occlusion of the teeth. *Acta Odonto. Scandinav.,* 9: 1.

Craven, A. H. 1952. A cephalometric investigation of central Australian aborigines using a roentgenographic technique. Master's Thesis, University of Illinois.

Craig, E. C. 1950. The skeletal patterns characteristic of Class I and Class II, Division I malocclusions (Angle) in norma lateralis. Master's Thesis, University of Illinois.

Downs, W. B. 1949. Variations in facial relationships: their significance in treatment and prognosis. *A. J. Orthod.,* 34: 812-840.

Elsasser, W. A. and W. L. Wylie 1948. The craniofacial morphology of mandibular retrusion. *Am. J. Phys. Anthrop.,* u. s. Vol. 6.

Fisher, R. A. 1949. *The Design of Experiments,* 5th Edition. 108 p. Edinburgh: Oliver and Boyd.

Fisk, G. V. et al 1953. The morphology and physiology of distocclusion. *Am. J. Orthod.,* 39: 3-12.

Hellman, Milo 1931. What about diagnosis and treatment of Class II malocclusions of the teeth: *Int. J. Orthod., Oral Surg. and Radiog.,* Vol. 17, No. 2.

——— 1932. An introduction to growth of the human face from infancy to adulthood. *Int. J. Orthod., Oral Surg. and Radiog.,* 18: 777..

Hellman, Milo 1935. The face in its developmental career. *Dental Cosmos,* Vol. 77, Nos. 7, 8.

Lande, M. J. 1951. Growth behavior of the human bony facial profile as revealed by serial cephalometric roentgenology. *Angle Orthodontist,* 22: 78-90.

Snedicor, G. S. 1948. *Statistical Methods.* Ames, Iowa, The Iowa State College Press.

Wright, Chester F. 1935. The edgewise arch mechanism. *Practical Orthodontia,* by M. Dewey and G. M. Anderson, 5th revised Edition, pp. 329-346.

The Angle Orthodontist

A magazine established by the co-workers of Edward H. Angle, in his memory . . .

Co-editors: Morse R. Newcomb and Arthur B. Lewis.

Business Manager: Silas J. Kloehn, Zuelke Building, Appleton, Wisconsin.

Associate Editors: Anna Hopkins Angle, Allan G. Brodie, Frederick B. Noyes, Harold J. Noyes, Robert H. W. Strang, Wendell L. Wylie.

Volume 24, Number 4 October, 1954