Behavior of the Occlusal Plane and Related Structures in the Treatment of Class II Maloclusion*

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Modern orthodontia is quite generally accepted as dating from 1899 when Angle advanced his classification of malocclusion. Using the normal anteroposterior relation of the mandibular and maxillary teeth as his base line, Angle pointed out that the mandibular teeth could deviate from this relation only in a forward or backward direction. Backward deviation he called Class II and forward deviation Class III.

Simple and obvious though this classification now seems, it brought order out of chaos and led to rapid and widespread effects in the fields of etiology, diagnosis and treatment. Among the earliest studies undertaken were those directed toward determining just what constituted malocclusion and what caused it. At first it was held to be largely restricted to the teeth and alveolar processes and etiological factors were thought to be largely environmental in nature. During this period great emphasis was laid on dental arch form, inclined plane relation, the forces of normal and abnormal functions and habits. Wolff's Law was invoked to explain the facial forms that were held to be characteristic of the different types of malocclusion.

By the use of the methods of physical anthropometry, Hellman[14] demonstrated in skulls that although the teeth might be in normal occlusion, the facial skeletons could resemble those of the malocclusion types. He found that skulls possessing normal dentitions were not of a uniform "normal type."

With the advent of roentgenographic cephalometry in 1930, it became possible to study the skeletal relationships of the entire head and, since that time, attention has come to be focused on those relationships which, in some individuals, lead to normal and in others to abnormal occlusion. The value of the study of planes has been pointed out and particularly that of the possible inter-relationship of such planes in the interpretation of malocclusion. The pioneers in this field have been Broadbent[4] and Brodie[7]. Brodie pointed out that the human head skeleton exhibited great stability of angular relations during its early growth. Tabulating the angle formed by the occlusal plane with the line S-N, he showed that this angle had a strong tendency toward stability and that, if there was any deviation, it was toward a lowering of the posterior end of the occlusal plane. Both authors have commented on the almost complete absence of angular change in the palate and of anteroposterior change in the pterygo-maxillary fissure.

Renfroe[18] studied the composite patterns of Class I, and both divisions of Class II, and announced that the occlusal plane in Class I and Class II, Division II tended to parallel each other, while that in Class II, Division I was lower in back.

Drelich[11] subjected his findings to statistical analysis and found that there was no significant difference between

*Submitted as partial fulfillment of the requirements for the degree of Master of Science in Orthodontia in the Graduate College at the Chicago Professional Colleges of the University of Illinois, 1953.

the angle formed by the occlusal plane and the S-N plane (anterior cranial base plane) in untreated Class II, Division I cases and excellent occlusions.

Bushra[9] appraised 40 cases of normal occlusion statistically and found that the more forward the face, as indicated at the chin point, the more the occlusal plane tended to become horizontal or more parallel to Frankfort plane, and that the facial plane, the line N-S, the nasal floor, the occlusal plane and the mandibular plane tended to behave in a similar manner.

Downs[10] in his study of the facial patterns of 20 individuals with clinically excellent occlusions stated:

> "The angular relation between the occlusal plane and the Frankfort plane in the control series ranged from 14° to 1.5° with a mean of 9.3°. A coefficient of correlation of —.775 between this plane and the facial angle indicated that there was a tendency for the planes to approach parallelism as the facial angle increased. Generally speaking, the Class II facial types have a relatively steep occlusal plane. As the facial type approaches the Class III pattern, the occlusal plane tends to become more horizontal."

Riedel[20] reached the conclusion that Downs' points A and B bear a highly constant relation to the occlusal plane and that a line connecting these points forms about a 90° angle with the occlusal plane in patients exhibiting normal occlusions.

Bjork[3] studied 600 individuals divided into two distinct groups. These groups consisted of Swedish boys aged 12 years and conscripts aged 21 to 22 years. Bjork demonstrated that the inclination of the occlusal plane varied considerably. In the conscript group the angle formed by the line articulaire-nasion and the occlusal plane have a calculated range of variation from 48.1° to 21.5° and a mean of 34.8°. The occlusal plane diminished in its inclination with prognathism, irrespective of whether maxillary or mandibular prognathism predominated. There was no correlation between the inclination of the plane of occlusion and the horizontal overbite. Bjork believed that this was naturally the case because the sagittal occlusion was determined by the relation of maxillary and mandibular prognathism to each other, and not by the degree of maxillary prognathism alone. There was however a correlation between the depth of bite and the inclination of the occlusal plane. The angle formed by the plane of occlusion and the mandibular base plane was considerably smaller in the group having the greatest depth of bite.

A difference in the inclination of the occlusal plane was shown to exist when the entire group of boy material was compared to the conscript material. The angle between the cranial base plane through nasion and articulaire and the occlusal plane was found to be 2.8° smaller in the adult material. This was explainable on the basis of the proportional growth that took place and the increase in facial prognathism evident in the adult group.

Another important area of research on these questions is that directed toward a study of the changes in the dento-facial relations induced by orthodontic treatment. Stallard[21] studied the effects of treatment of Class II malocclusions. He stated that intermaxillary elastics caused the following effects unless great care was exercised:

> ". . . the ugly slants of orthodontically retracted maxillary teeth, the excessive abstraction of the anterior teeth, the exaggerated angle of the occlusal plane (a too great downward and forward slant in the face) and a slanting of the lower incisors into occlusion."

Stallard believed that these undesirable results were caused by inefficient

appliance therapy and that the use of the edgewise appliance might prevent them.

Hellman[16], in 1937, discussed the effects of treatment of Class II cases and concluded that:

"Evidence from studies of treated cases reveals the fact that the fundamental patterns—so far as facial development is concerned — are not changed despite the fact that the occlusion of teeth is considerably altered in the restoration of the normal. On the strength of this evidence it would seem that differences in faces are not dependent on the occlusion of the teeth, but rather on certain inherent peculiarities of growth."

In October 1938 the staff of the Department of Orthodontia at the University of Illinois published the first appraisal of orthodontic results using the cephalometric x-ray method[8]. Some of the conclusions that Brodie, Downs, Goldstein and Myer reached were:

1. In all cases in which elastics were worn there was a disturbance in the angle formed by the occlusal plane and the Bolton plane. In Class II treatment the angle opened and in Class III it closed.

2. There was a tendency for the angle to return to its original size following treatment. This tendency diminished as age advanced.

3. In a number of cases of all classes a part of the result obtained was shown to be contributed by a change in the position of the mandible. This was occasionally a horizontal, anteroposterior shifting but more frequently it consisted of a downward and backward rotation of the mandible.

4. Changes subsequent to treatment were limited to shiftings in the occlusal plane and to changes in the axial positions of teeth in adult cases. In growing children there were, in addition, the typical changes that are expected in growth.

5. There seemed to be a definite correlation between success in treatment and growth. The adult cases, although clinically successful as far as the maintenance of occlusal relations was concerned, were not so markedly improved esthetically.

Goldstein ('40) in a similar study on deciduous and mixed dentitions presented evidence that the changes seemed to follow closely those observd in adult dentures. He stated that changes that occurred could not be attributed to orthodontic treatment alone in as much as they occurred during a growth period.

Epstein[12] studied Class II cases treated with extra-oral anchorage, i.e., without intermaxillary elastics and showed that this method of treatment did not produce any change in the inclination of the occlusal plane.

Hedges[14] observed that treatment that was not accompanied by growth appeared to cause change in the facial pattern to the extent of a tipping of the occlusal plane.

Material

The material for this study consisted of 81 series of lateral cephalometric roentgenograms of patients with Class II malocclusions. These cases were treated with the edgewise arch appliance and with intermaxillary elastics according to the writings of Angle[2], Brodie[6], etc. All records were obtained from the files of the Department of Orthodontia of the University of Illinois where treatment had been given. The only criterion for the selection of these cases was a full complement of teeth. None exhibited congenital absence of teeth and no extractions had been performed as part of the treatment plan. Each case was represented by at least three roentgenograms, one of which was taken prior to treatment, one at the end of treatment and one at least two years later.

A total of 283 roentgenograms were traced. The patients ranged from 10 years of age to 21 years of age and the sample was composed of 46 females and 35 males.

METHOD

The method employed in this study was serial cephalometric roentgenology. The technique for taking and tracing these cephalometric films has been described in detail by Broadbent[4, 5], Brodie[7] and others, and need not be elaborated upon here.

Since bilateral anatomical structures are rarely superposed even on a well-oriented head film, the distance between the shadows cast by such structures was bisected and the point of bisection was used for measurement. This generally accepted technique reduces such structures to their midsagittal value and permits accurate measurement with correctional scales. In addition it tends to minimize the errors caused by improper positioning of the patient during exposure of the film.

Because this study was to concern itself with the effects of treatment of Class II malocclusion on the occlusal plane and related structures, the following anatomical points were chosen: (Fig. 1.)

N Nasion—the mid-point of the suture between frontal and nasal bones.

S The center of sella turcica as located by inspection.

A Subspinale—the most posterior mid-line point of the maxilla between the anterior nasal spine and prosthion.

B Supramentale—the most posterior mid-line point on the mandible between infradentale and pogonion. (The above two points were used by Downs[10] to indicate the anterior limits of the maxillary and mandibular denture bases.)

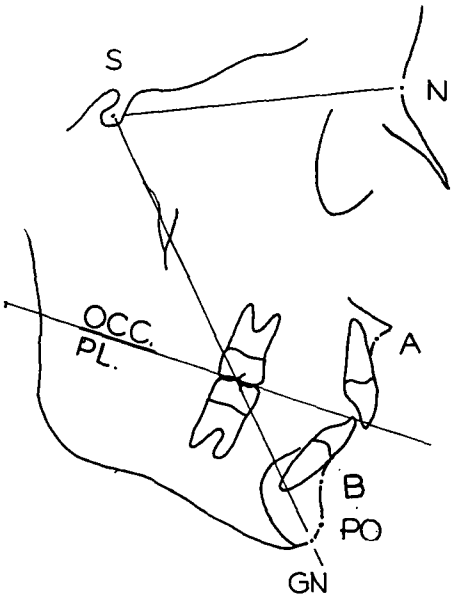

Fig. 1. Points and planes used.

Po Pogonion — the most anterior point in the mid-line of the mandibular symphysis.

Gn Gnathion—a point on the chin determined by bisecting the distance between the most anterior and most inferior points on the bony chin.

In addition the following planes were used in this study.

Occlusal Plane (O. P.) - In order to make angular readings the occlusal plane was represented as a straight line. It was laid out by bisecting the first molar cusp height and incisal overbite and connecting the two with a straight line. In the cases where the incisors were in obvious supra or infra occlusion, the incisors were disregarded and the occlusal surfaces of the molars and bicuspids were used to represent the occlusal plane as advocated by Downs.

S-N Plane—a plane passing from the center of sella turcica to nasion.

Facial Plane (N-Po) — a line from nasion to pogonion.

A-B Plane—a line connecting points A and B.

The following angular and linear measurements were taken from each tracing. The angular readings were recorded with a transparent protractor to the nearest .5°. Linear measurements were made with a transparent correctional millimeter ruler to the nearest .5 millimeter.

Angular readings

O.P.— SN

O.P. — NPo (inferior inside angle plus or minus 90°)

O.P. — NPo (inferior insideangle plus or minus 90°)

AB — SN

NPo — SN

AB — NPo (inferior angle)

Linear Measurement

S-Gn—a line from sella turcica to gnathion

The first division of the sample was done on the basis of age, but this quickly revealed discrepancies due to sex. With the exception of the group exhibiting little or no growth, the girls comprised a younger age group and were invariably at the low end of each growth range. It was felt that a more accurate appraisal of the changes due to treatment would be achieved if the cases were grouped according to the amount of growth occurring during treatment.

S-Gn has been widely accepted as representing the axis of growth of the face, being influenced by both height and depth increases. Furthermore, chang in the angle N-S-Gn. are minimal in the individual during growth. The increase in the length of this line permitted division of the sample into groups on the basis of growth that had occurred during treatment and the groups were set up as follows:

Group I — Those cases exhibiting an increase of 8 millimeters or more in the length of S-Gn during treatment. This group consisted of 18 cases (Fig. 2).

Group II — Those cases exhibiting an increase of from 5.0 to 7.9 millimeters during treatment. This group consisted of 20 cases (Fig. 3).

Group III — Those cases exhibiting an increase of from 3.0 to 4.9 millimeters during treatment. This group consisted of 21 cases (Fig. 4).

Group IV — Those cases exhibiting an increase of from 0 to 2.9 millimeters during treatment. This group consisted of 21 cases and was made up essentially of cases treated in the adult dentition. The majority of cases in this group were beyond the age of 15 years although some females showed little or no growth beyond the age of 12 years (Fig. 5).

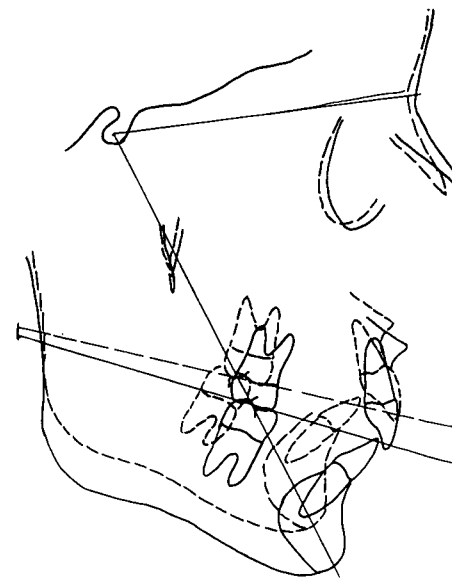

Fig. 2. Group I: 18 cases showed an increase in length of S-Gn of 8 mm. or more during treatment.

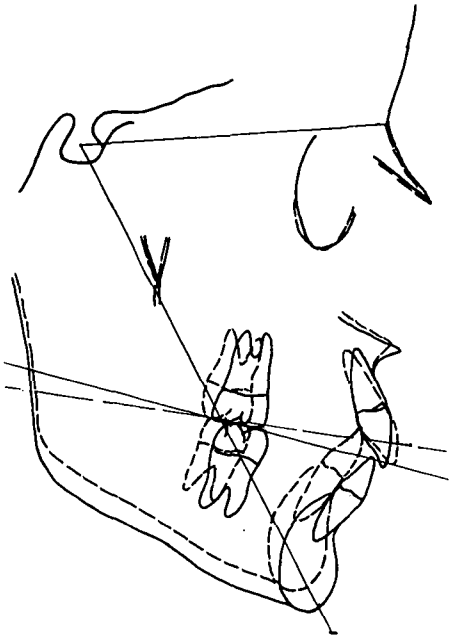

Fig. 3. Group II: 20 cases showed an increase in length of S-Gn of 5.0 to 7.9 mm. during treatment.

Findings

A comparison of the reactions of the four groups to treatment showed some significant differences, both between groups and serially within a group, when checked statistically. An effort was made to determine if any changes in angular readings could be accounted for on the basis of chance alone. The probability of a difference being due to chance was determined from a calculation of Fisher's "t" statistic[13].

The first consideration was the change that occurred in the occlusal plane when related to the S-N plane. In the period from the beginning to the end of treatment, the cases in Group I exhibited the least change in the occlusal plane relation. (Fig. 2.) Those in Groups II, III, and IV showed progressive increases in the change of the occlusal plane during the treatment period. (Figs. 3, 4, 5.)

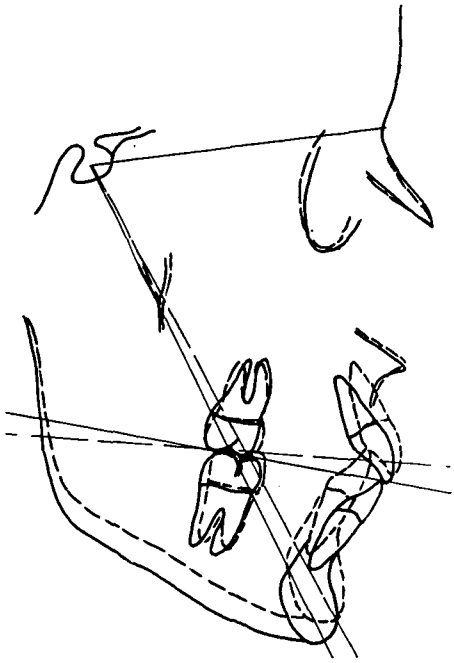

Fig. 4. Group III: 21 cases showed an increase in length of S-Gn of 3.0 to 4.9 mm. during treatment.

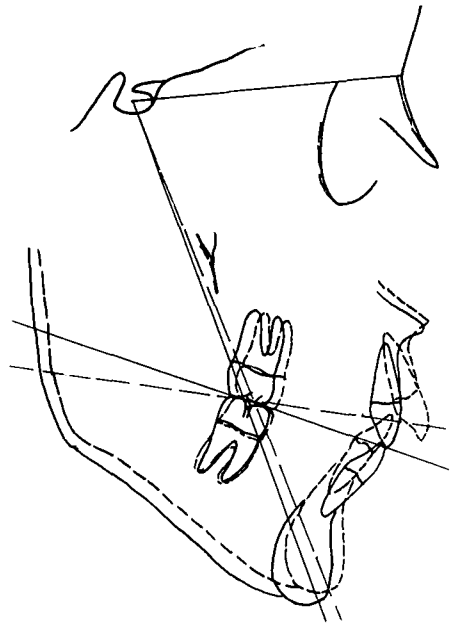

Fig. 5. Group IV: 21 cases (majority were past 15 years) showed an increase in length of S-Gn of 0 to 2.9 mm. during treatment.

In the period subsequent to treatment the Group I cases showed the greatest significant return toward the original condition, and those in Groups II, III and IV showed progressive decreases of the occlusal plane change that had taken place during treatment. In other words, the change in the occlusal plane during treatment was held subsequently to the greatest extent in Group IV and to a lesser extent in Groups III, II, and I respectively.

Groups II and III tended to show no significant difference in their behavior. The differences between Group I and Group IV were, however, highly significant.

Following is a table giving the mean angular differences of the occlusal plane to the S-N plane and the "t" values for the period B-R (before treatment to the end of treatment) as compared to the period B-S (before treatment to a period at least two years subsequent to the end of treatment).

Group	Mean B-R	Mean B-S	"t"	P (less than)
I	4.0	1.8	3.04	.01
II	5.6	3.5	2.60	.01
III	5.8	3.3	2.20	.05
IV	7.48	5.88	1.40	.20

The Change in O.P.—AB Minus the Change in O.P.—SN

In an effort to determine the change in the AB plane exclusive of the changes that occurred in the occlusal plane, the measurement O.P.—AB minus O.P.—SN was taken. This reflected the changes of AB to SN independently of the changes that occurred in the occlusal plane.

In the period from the beginning to the end of treatment, the cases in Group I exhibited the greatest change in the AB plane, in terms of an opening of the angle of AB to the occlusal plane.

In the period from the beginning to the end of treatment, Group I cases alone showed significant increases. The cases in Groups II, III and IV all showed a decrease although a very small one, i.e., less than one degree.

In the period subsequent to treatment, Group I continued to increase although not to a significant extent. Groups II, III, and IV also showed a small increase. No mean increase was over .7 degrees.

It can be shown statistically that the behavior of Groups II, III and IV does not differ significantly from zero. The formula used for this is the Standard Error of the Mean. It will be noted on the following table that, with the exception of Group I, zero falls well within the range of plus or minus three S.E. Mean and therefore the means obtained are not significantly different from zero.

Change O-SN

Group	Mean B-R	S.E.	Mean B-S	S.E.
I	1.75	.35	2.1	.50
II	—.2	.31	.4	.32
III	—.6	.24	.1	.31
IV	—.7	.39	—.5	.45

Comparison of the Change O.P.-AB and Change O.P.-NPo.

To ascertain whether or not the change in the AB relationship might be due to repositioning of the mandible, a comparison of the AB and N-Po planes was made. Another consideration was the appreciable change in the angle O.P.-NPo in Group I which is typical of a change occurring in normal growth patterns.

When the change in the angle O.P.-NPo was compared with O.P.-AB within each group, it was found that the change in the position of the AB plane still remained significant, the trend still being towards greatest change in Group I.

Change O.P.-AB Compared with Change O.P.-NPo

Group	Mean O.P.-AB	Mean O.P.-NPo	"t"	P less than
I B-R	7.1	1.75	5.3	.01
B-S	7.2	2.1	5.5	.01

II	B-R	3.6	- -.2	3.9	.01
	B-S	4.1	.4	4.9	.01
III	B-R	1.6	- -.6	3.3	.01
	B-S	2.0	.1	2.4	.02
IV	B-R	1.5	- -.7	2.1	.05
	B-S	2.5	- -.5	2.7	.01

Discussion

Numerous investigators have attempted to explain the factors responsible for successful Class II treatment. Among such factors could be listed the mesio-distal movement of the teeth in the opposing jaws, repositioning of the mandible, changes in the level of the occlusal plane and growth.

It has been previously reported that distal movement of the upper buccal teeth occurred, both by bodily and tipping movements, and that this movement of upper buccal teeth during treatment had a tendency to return subsequent to retention. Hedges[14] and Litowitz[17] both reached the above conclusions, thus corroborating the findings of the Department of Orthodontia at the University of Illinois in its preliminary study in 1938.

In the present investigation it has likewise been shown that the changes in the inclination of the occlusal plane, accompanied by treatment, have a tendency to return to the original condition although this tendency significantly decreases in those cases exhibiting little or no growth.

One of the interesting observations in the study was that in the cases of little or no growth, the mandible exhibited a distal positioning under the influence of Class II mechanics. Since intermaxillary elastics create a forward pull on the mandible, this is opposite to what we might expect. However, Ricketts[19] made the same observation and by the use of laminagraphs explained its occurrence. He showed that the rest position of the majority of Class II, Division I cases found the condyle of the mandible downward and forward on the eminentia articularis prior to treatment; following successful treatment of these cases the condyle was seated normally in the fossa even at rest. From this he deduced that the successful treatment of Class II cases involved a change in the position of the condyle-fossa relationship at rest. Where growth occurred rapidly during treatment the effects of this change, as seen at the chin point, could be attributed in large part to growth at the head of the condyle but where rapid growth did not occur, the more distal position of the mandible was interpreted as a reflection of the accommodation of the mandible to the more distal position of the maxillary teeth. This correlates very well with the changes that occur in the inclination of the occlusal plane under different rates of growth.

There is a large variation in the inclination of the occlusal plane as shown by the numerous studies on normal occlusions and the studies of the differences of patterns between normal and Class II individuals. Wylie[32] and Bjork[3] pointed out that it was a combination of numerous factors, some in the jaws and cranial base and some in the bite, that yielded the sum total of the facial pattern. Downs[10] stated the same thing in a little different way, but he stressed the importance of all the measurements of the facial pattern as against single measurements. It is therefore conceivable that a change in the inclination of the occlusal plane can, in part, compensate for unfavorable skeletal factors outside the bite to create a normal occlusion, without the necessity of changing those skeletal features by treatment.

Hellman[16] and Bjork[3] both pointed out that a so-called normal skeletal pattern may exhibit a Class II malocclusion. One of the reasons for this may be located in the inclination of the occlusal plane and whereas this change in the occlusal plane occurs as a result

of the treatment used, it may well be a desirable result of treatment. In the cases exhibiting little or no growth this may be the only way in which a Class II correction can be achieved. This bears out the clinical observations of many men that the successful use of occipital anchorage in the treatment of the Class II case is dependent on the growth of the patient during treatment.

The ideal time to treat appears to be when growth is most active. The best esthetic results are produced when cases are treated at this time. This is explained by the change in the relationship of the A-B plane to the S-N plane in the fast growing cases, and the permanency of this change subsequent to retention. Likewise the changes in the correction of the fast growing cases have been shown to be due more to growth than to the change in the occlusal plane.

Summary and Conclusions

A study has been made of the behavior of the occlusal plane and related structures in the treatment of Class II malocclusions. The material for the study was gathered from the files of the University of Illinois, Department of Orthodontia and consisted of 81 cases of treated Class II malocclusions. A cephalometric x-ray method was employed and a statistical analysis of the results was carried out. The findings seem to warrant the following conclusions:

1. The use of Class II elastics causes a disturbance of the occlusal plane, the angle of the occlusal plane with S-N increasing as the result of treatment.

2. Those cases exhibiting the greatest growth during treatment exhibited the least change in the inclination of the occlusal plane and conversely those cases exhibiting the least growth during treatment exhibited the greatest change in the occlusal plane.

3. Subsequent to treatment those cases exhibiting the most growth during treatment showed the greatest tendency to return to the original inclination of the occlusal plane and conversely those cases exhibiting the least amount of growth during treatment showed less tendency to return to the original inclination.

4. Those cases which enjoyed the greatest growth during treatment exhibited the greatest change in the A-B plane and conversely those cases undergoing the least growth during treatment exhibited the least change in treatment.

5. When the amount of forward development at the chin point was taken into consideration in the fast growing cases, they still exhibited the greatest change in the A-B plane.

6. Those changes that occurred in the inclination of the A-B plane during treatment showed no tendency to return to the original condition, regardless of the amount of growth that had occurred during treatment.

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