# Eighteen Years of Research At Illinois (*Cont.*)

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*Ed. Note—This account of the continuous program of research in orthodontia and allied fields was begun in a previous issue and is continued here. The explanatory material by Dr. Brodie integrates the separate researches with one another, and the series is most informative when read in its entirety.*

As you can see our fears were justified. The successfully treated Class II malocclusion may result from a number of different phenomena and apparently, in this sample at least, the distal movement of maxillary molars occurs less frequently than almost any other movement.

In 1936 we had seen the results of Oppenheim's head-cap treatment in Vienna and upon our return had tried it on some of our clinical cases, but only in a half-hearted manner. When he came to this country, however, interest in this method of treatment revived and his visit to the department in 1945 kindled considerable interest in it. Dr. Myer undertook the treatment of a number of cases with this method and took very careful records in order to determine exactly what changes occurred under this method of treatment. By 1946 we had collected enough material to make preliminary appraisal possible. Dr. Walter Epstein undertook this appraisal and his thesis was written on the subject:

## Analysis of Changes In Molar Relationships By Means Of Extra-Oral Anchorage (Head-Cap) In Treatment Of Malocclusion[1]

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Angle's contentions, with respect to the six-year molar and mandibular relationships, have been substantiated by scientific investigation on Class II malocclusion. It is now accepted that a Class II malocclusion is due to posterior relationship of the mandible and its dental arch to cranial anatomy. The maxillary molars are in proper anteroposterior relation to face and cranium. The mandibular molar bears the proper relation to the mandible, but the mandible is in a distal position to the maxilla.

With the acceptance of the Class II condition as a posterior position of the mandible, the objective of treatment called for a bringing forward of this bone into a correct relation with this maxilla. Various procedures of practice were advocated but with all of them the objectives were the same.

[1] Based on a thesis submitted in partial fulfillment of the requirement for the degree of Master of Science, University of Illinois, 1946.

A cephalometric appraisal of the orthodontic results by Brodie[1] and coworkers showed that:

1) The use of intermaxillary elastics changed the occlusal plane.
2) The occlusal plane tended to return to its original position.
3) The mandibular molars showed a decided tendency to come forward with this method of treatment.
4) A change in position of the mandible contributed in part to the result in a number of cases.
5) The axial inclination of the teeth, disturbed by orthodontic therapy, tended to correct itself subsequent to treatment.
6) The changes induced by tooth movement seemed to be restricted to the alveolar process.
7) The best results were obtained in those cases where growth was most active. This applied particularly to mandibular growth.

While methods of treatment were being developed, attention was also focused by some on the tissue changes that accompanied tooth movement. Albin Oppenheim[2] stressed the need for the employment of extremely light forces intermittently applied, since he found that primary osteoclasts, created in response to light stimuli, remained active for at least four days after the orthodontic force was removed.

As a result of the histologic findings in his investigations, Oppenheim advocated the use of extra-oral anchorage (head caps) applied at night only for the treatment of Class II Division 1 cases, and showed its usefulness for mass movement of teeth.

In appraising the effectiveness of this method, it is necessary to separate those changes that are brought about by treatment, from those that would occur through the growth process alone. On the basis of the growth studies of Brodie[3], it has been shown that prolific growth of the tuberosity of the maxilla resulted in a forward movement of the maxilla.

As regards the growth of the mandible, Brodie pointed out that the principal directions of growth in this bone were (1) upward at the alveolar process, (2) backward at the ramus, and (3) upward and backward at the condyles. Serial roentgenograms alone showed a downward and forward movement of this bone throughout growth.

From a consideration of the combined findings on upper and lower face, certain other facts were obtained:

1) The original angular relation between the nasal floor and cranial base remained unchanged in growth.
2) The upper alveolar process and teeth descended from the floor of the nose without change in their angular relation.
3) The angular relation of the lower border of the mandible with the cranial base was not disturbed by growth.
4) The condyle grew at a rate that was equal to the sum of all the segments comprising anterior face to the age of eight.

The glenoid fossa was seen to go downward and backward during growth, but its rate was so slow that it was able to contribute only a fraction of that added at the condyle. From the fact that there was a slight backward vector to this movement of the joint, it can be realized that the anteroposterior growth of the mandible must be in excess of that of the maxilla in order to compensate for the backward migration of the fossa.

The mandibular molars, when viewed in serial roentgenograms superposed on the cranial plane of reference, give the impression that they are moving downward and forward. Actually, this is not the case. The mandible is growing in length by additions to its posterior border, which growth would increase the anteroposterior width of the rami to an equal extent. This does not occur because the anterior margin of the ramus is trimmed back by resorption at a rate that is only slightly less than that of the deposition in back. In this manner, the molars, making their appearance first in the ramus, are slowly uncovered by the retreat of its anterior margin without having to migrate at all. Actually, these teeth are not going forward except as they are carried by the mandible.

The purpose of the investigation was to determine the changes in the several relationships that are induced by the wearing of the head-cap.

## METHODS AND MATERIALS

The material upon which this investigation was conducted, consisted of 138 roentgenograms. One hundred and five (105) of these roentgenograms composed a control series and were of twelve untreated, growing individuals between five and eighteen years of age. They were selected without regard to occlusion. Six of these series were from the files of the Bolton Foundation at Western Reserve University, and six were from the files of the Department of Orthodontia, University of Illinois. The remaining thirty-three roentgenograms were taken from the files of the clinic of the Department of Orthodontia, University of Illinois and represent twelve individuals ranging in age from six to ten years at the beginning of treatment. All were treated by means of extra-oral anchorage (head-cap) only. The average period of treatment was thirteen months. These cases represented typical Class II Division 1 malocclusions and were treated by staff members of the department. All roentgenograms were taken on the Broadbent-Bolton cephalometer according to Broadbent's technique.

Each roentgenogram was traced, and lines were drawn on the tracings between various points representing anatomical land-marks.

1) S-N: From the center of sella turcica to nasion.
2) S-/$\underline{6}$: From the center of sella turcica to the point representing the buccal groove of the maxillary left first permanent molar.
3) S-Gn: From the center of sella turcica to gnathion. The anatomical landmark gnathion is determined by bisecting the distance between the most anterior and the most inferior points on the bony chin.
4) S-$\overline{6}$: From the center of sella turcica to the point representing the distal contact point of the mandibular left first permanent molars.

The following angles formed by these lines were measured with a transparent protractor to within 0.5 of a degree:

1) Angle N-S-/$\underline{6}$: Nasion - sella turcica - maxillary first permanent molar.
2) Angle N-S-Gn: Nasion - sella turcica - gnathion.
3) Angle N-S-/$\overline{6}$: Nasion - sella turcica - mandibular left first permanent molar.

For the purpose of determining correlations of changes during treatment, the following lines were drawn on the tracings of treated cases:

1) S-Go: Sella turcica to gonion.
2) Go-Gn: Line drawn from gonion to gnathion.
3) N-Gn: Line drawn from nasion to gnathion.
4) Occlusal plane: Line connecting incisors (half the depth of the overbite) with the molars (half the height of the cusps).
5) N-$\underline{/1}$: Line from nasion to incisal edge of maxillary central incisor.
6) NS-PNS: Line representing the hard palate, formed by connecting the anterior nasal spine with the posterior nasal spine.

The following angles were measured with the universal drafting machine:

1) Angle N-S-Go: The angle formed by the line S-N with a line connecting S with Go (gonion).
2) Angle S-N-Gn: The angle formed by the line S-N with a line connecting N with the chin-point (gnathion).
3) Angle S-N-$\underline{/1}$: The angle formed by the line S-N with a line connecting $\underline{N}$ with the incisal edge of maxillary central incisor.
4) Angle N-S- Mandibular border: The angle formed by a projection of line N-S with a line tangent to the lower border of the mandible.
5) Angle N-S-Occlusal plane: The angle that would be formed by a projection of the lines N-S and occlusal plane.
6) Angle N-S to Palate: The angle that would be formed by a backward projection of the two lines S-N and NS-PNS.

To assess further the change in anteroposterior relationship, the changes in the behavior of the following points in each case was studied by means of superpositioning on S-N with S registered.

1) Maxillary first molar
2) Mandibular first molar
3) Gonion
4) Gnathion
5) Occlusal plane
6) Lower incisor
7) Upper incisor
8) Lower border of the mandible
9) Nasal floor

Linear measurements were made to determine

1. Growth of the Mandible (Anteroposterior)
2. Mesial movement of $/\overline{6}$

## FINDINGS

*Control Series*

1) The shortest series consisted of seven roentgenograms ranging in age from six to eleven years. In the longest series, there were ten roentgenograms, and the age range was five to fifteen years. There was a total of 105 roentgenograms of twelve untreated growing children in the control series.

2) The angle N-S-Gn varied with the individual ranging from a low reading of 64.9° in one case to a high reading of 76.7° in another. This angle appeared quite constant in the individual, however, varying from 1.0° in one to a maximum of 4.3° in another.

The maximum variation can be explained by the fact that roentgenograms of some individuals were taken with the mandible in rest position. This would result in an increase in the reading of the angle N-S-Gn, since the point gnathion would be thrown downward and backward, the action of the mandible in this range being that of a hinge joint.

3) The angle N-S-/$\underline{6}$ showed a constant angular relationship to S-Gn once the maxillary molar had erupted to meet its antagonist. The angle N-S-/$\underline{6}$ showed a minimum variation from the angle N-S-Gn of 0.9° and a maximum of 8.9°.

4) The angle N-S-/$\overline{6}$ showed a minimum variation from N-S-Gn of 1.2° and a maximum of 9.2°. The maximum variations were in the same individual and were attributed to the fact that in these cases the molars were unerupted or in the process of erupting.

5) The maximum variation can be reduced to an acceptable constancy of angles by the elimination of those roentgenograms which indicated that the first permanent molars had not yet reached complete eruption.

6) The first permanent molars maintained a constant relation to the line S-Gn in untreated individuals after coming into the plane of occlusion.

*Treatment Series*

The behavior of the points /$\underline{6}$, /$\overline{6}$, /$\underline{1}$, /$\overline{1}$, Go and Gn, as determined by superposing tracings on the line S-N with the point S registered, revealed that the upper molar moved posteriorly in relation to its former position in five cases. Two of the five cases gave evidence that the movement was in the nature of tipping. The remaining three cases showed only a downward and forward movement, which is the normal behavior in growth.

Superpositioning on S-N with the point S registered, superposing on the anterior nasal spine with the line NS-PNS used for orientation, clearly demonstrated that there was definite backward movement of the upper molars in relation to the maxilla.

In order to determine whether forward movement of the mandibular molars might be in part responsible for the observed changes in relationship the mandibular tracings of the first and last roentgenograms were superposed on the anterior and lower borders. Similarly, to establish the role of mandibular growth in effecting these changes, the mandibular tracings were superposed on the posterior and lower borders.

Mandibular growth in these cases ranged from 1 mm. to 4.8 mm. There was no actual forward movement of the mandibular molars in these cases treated by the head cap. One case exhibited a forward migration of /$\overline{6}$ to the extent of 2.5 mm. Rechecking the original roentgenograms, however, revealed early loss of deciduous teeth. This accounted for the anterior migration of /$\overline{6}$.

The angles NS-to-mandibular border, N-S-to-occlusal plane and N-S-to-nasal floor showed no significant changes.

## DISCUSSION

The present study of the cases treated by means of extra-oral anchorage for the purpose of establishing the correct anteroposterior relationship of the maxillary and mandibular six-year molars, permits certain conclusions concerning this method of treatment.

It was demonstrated by Brodie[4] that the upper molars, once they came into occlusion, maintained a constant relationship to the line S-Gn. The findings of the control series confirm this assertion.

Because there was a similar tendency toward constancy of the angle N-S-/6 to S-Gn in the treated cases, it was necessary to superpose on different bases in order to determine how the clinically observed changes in molar relationship were taking place. Therefore, the line S-N was chosen as a basis for superpositioning with the point S registered. This method revealed that three cases exhibited a downward and forward movement of the molars, or rather the normal developmental pattern as described by Brodie. Nevertheless, these cases showed improvement in the anteroposterior relationship of maxillary and mandibular first molars. It was necessary to seek another base for superpositioning to explain this behavior.

Since it had been shown that there is a forward positioning of the maxilla as a result of growth on its posterior border, it was felt that this phenomenon might explain the behavior of the upper molar in these cases. In the growth of the maxilla, the teeth would naturally be carried with it. Inasmuch as a superpositioning on the nasal floor with the anterior nasal spine registered clearly demonstrated that there was posterior movement of the upper molars in relation to the maxilla, it could be assumed that the downward and forward movement in three cases was the result of insufficient force to move these teeth from their original relationship to the growth axis. In effect, the extra-oral anchorage retarded their normal forward movement with the growing maxilla. The uninhibited forward movement of the lower molar and jaw was the agent which established the normal dental relationship.

Consideration of the relationship between the lower border of the mandible and cranial base, and between occlusal plane and cranial base, failed to reveal any significant changes. Further superposing on S-N with S registered failed to show any deviation of consequence in these relationships, other than the characteristic pattern of growth as previously described. It can, therefore, be stated that the method of establishing correct molar relationships by means of extra-oral anchorage does not produce any change in the position of the mandible or in the occlusal plane.

The objectives sought throughout the development of methods of treating Class II Division 1 malocclusions appear to have been realized by this method of treatment.

The small sample of material studied does not permit dogmatic statements. Nonetheless, it is apparent from the evidence gathered in this study that posterior movement of the maxillary molars is possible by means of treatment by the head-cap method, as advocated by Oppenheim.

Further study will be necessary in these individuals to determine the changes that occur following treatment, and to establish whether further orthodontic therapy will be required.

## CONCLUSIONS

1. Extra-oral or head-cap anchorage is a means of correcting the antero-posterior relationship of the molars in Class II Division 1 malocclusion.

2. In some cases, this change is brought about, partially at least, by a backward movement of the maxillary molars.

3. The establishment of the correct relationship between maxillary and mandibular first molars in other cases, is a result of holding the maxillary molars stationary in the forward growing maxilla while the mandible grows forward.

4. This method of correcting Class II malocclusions approaches an ideal that has long been sought. Forward tipping movement of the lower molars is not apparent, the occlusal plane remains unchanged, and changes in position of the mandible are the result only of growth and development.

5. Success of this method of treatment appears to be contingent upon (1) the growth and developmental changes occurring in the individual, and (2) the cooperation of the patient.

## BIBLIOGRAPHY

1. BRODIE, A. G. et al.: Cephalometric appraisal of orthodontic results. ANGLE ORTHODONTIST 8: 261 (Oct.) 1938.

2. OPPENHEIM, A.: Biologic orthodontic treatment and reality. ANGLE ORTHODONTIST Vols. 5 and 6, 1935, 1936.

3. BRODIE, A. G.: Lectures, University of Illinois Graduate Department of Orthodontia.

4. BRODIE, A. G.: On the growth pattern of the human head, from the third month to the eighth year of life. *Am. Jnl. Anat.* 68: 209-62 (March 15), 1941.

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