A Metal Implant Study of Mandibular Rotation

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In an implant study Björk[1] has shown that the mandible, during growth, may principally rotate in one of two different directions. He has described an anterior and a posterior rotation. Knowledge of this pattern of mandibular growth is of importance when planning treatment based upon growth evaluation. It is further of special value to know the possibilities of influencing mandibular rotation during treatment.

The purpose of the present investigation is to study the annual variation in the degree of mandibular rotation and the relationship to facial growth.

MATERIAL AND METHOD

The sample comprised thirty patients, seventeen boys and thirteen girls from the collection of patients with metal indicators from the Orthodontic Department, University of Bergen. None of the patients showed any pathologic conditions, but various types of malocclusion, treated and untreated, were represented.

The age distribution of the sample (7-19 yrs.) is given in Figure 1.

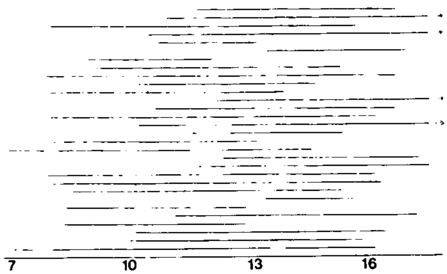

Fig. 1 Age distribution of the material.

The technique of placing the metal implants has been described previously by Björk.

Reference points and lines used are described in Figures 2 and 3. The measurements were made by each of the authors and the mean values used in the preparation of the tables. When the differences between the angular and linear measurements were larger than one degree and one millimeter, respectively, the measurement was taken again. The mean of the two nearest values was used as the mean value in the calculations.

The measurement of the degree of rotation was performed with the technique earlier described by Ødegaard.[2] Two axes have been defined: one through the mandibular implants farthest away from each other, and the second perpendicular to the first through the third implant (Fig. 3). The angles, between the first axis and ML (a), and between the second axis and NSL (b) have been measured on yearly cephalometric headfilms. The differences between the successive angular values of a and b represent the variation in the degree of mandibular rotation. A diagram was constructed in which the first value was taken as origin and the subsequent values were plotted in relation to this value. To compare the shape of two curves a Spearman rank correlation test was used. The first segment is without any value because of the arbitrary positioning of the diagrams at the zero level at the beginning of the observation. In such a diagram a negative slope represents a posterior rotation and a positive slope corresponds to an anterior rotation. Based upon the linear measurement from successive headfilms, growth velocity curves were constructed.

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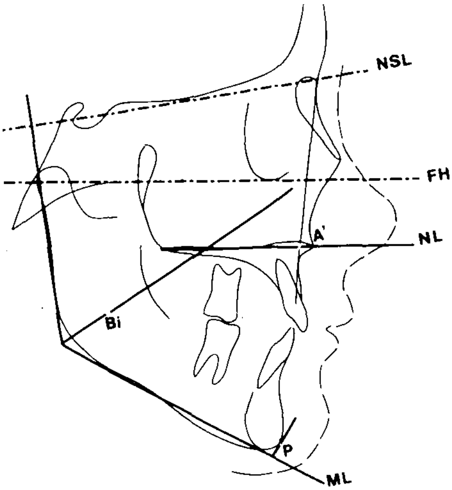

Fig. 2 Reference points. Bi, midpoint of the mandible on the bisecting line of the gonial angle. A′, intersection of NA-line with NL. P, point on the anterior part of the symphysis tangent to a perpendicular to ML.

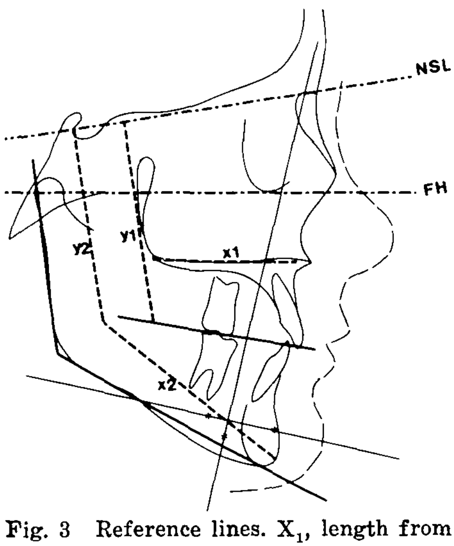

Fig. 3 Reference lines. X_1, length from PNS to A′. Y_1, distance from the occlusal plane to NSL, measured on a line tangent to the posterior wall of fossa pterygopalatina. This length represents the "functional height" of maxilla. X_2, length from P to Bi. Y_2, length from Bi to NSL measured on a perpendicular to NSL. *Implants.

To demonstrate a relation between the direction of rotation and the difference in the rate of growth of both jaws, the following values have been used:

$$(1) = \Sigma\ (\Delta x_2 - \Delta x_1)$$

which expresses the sum of the annual differences between the mandibular and maxillary length increments.

$$(2) = \Sigma\ (\Delta y_2 - \Delta y_1)$$

a value representing the sum of the differences of the annual increments of the vertical length of the mandible and clivus on one side and the functional posterior height of the maxilla on the other side.

$$(3) = (1) + (2)$$

which expresses the combined vertical and horizontal growth in one diagram. Diagrams were constructed for the variations of the linear data in the same way as for the degree of rotations.

Results

In this study twenty-six individuals with anterior and four with posterior rotation were found when only the first and the last films were considered and the rotation measured in relation to NSL. The distribution of the mean degree of annual rotation is given in Figure 4. From this diagram it is evident that there are only two individuals with genuine posterior rotation; the other two have their mean value close to zero.

The mean degree of annual rotation in relation to NSL for the twenty-six

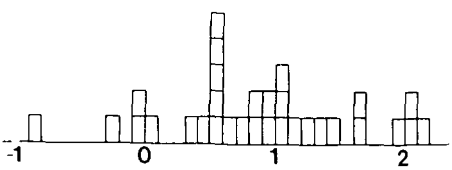

Fig. 4 Distribution of the mean degree of rotation, related to NSL. Positive values indicate anterior rotation. Negative values indicate posterior rotation.

individuals with anterior rotation was calculated to 1.07° with a range from 0° to 2.10°.

When related to ML, a mean value of 0.57° was found with a range from 0° to 1.40°.

These data confirm Björk's results.[3] He found a total rotation of 7° during a period of six years around the pubertal growth spurt.

As a mean, the degree of rotation measured in relation to ML is about half the value measured in relation to NSL. But the sample showed a great range of variation in this respect.

For the four individuals with posterior rotation measured in relation to NSL, the mean degree of rotation was —0.30° with a range from —0.06° to —0.85°. When related to ML, a mean of —0.26° was found with a range from + 0.16° to —2.25°.

Two of the cases with a negative degree of rotation related to NSL showed a small absolute value of the mean. Related to ML, however, the direction of rotation was shown to be positive. In the two other cases the rotation in relation to ML was more marked than when the NSL was used as a reference line.

The systematic yearly study of the variation of the rotation showed the following results.

In some cases the rotation is constant *in direction* during the whole period of observation (Fig. 5), but in most cases the direction of rotation varies in such a way that the same individual may present both anterior and posterior rotations during growth (Figs. 6 and 7). The variation related to ML and to NSL is in the same general direction. A Spearman rank correlation test indicates a correlation at the 0.01 level in twenty cases, at the 0.05 level in five cases, and no correlation at all in five cases for the diagrams related to NSL and ML.

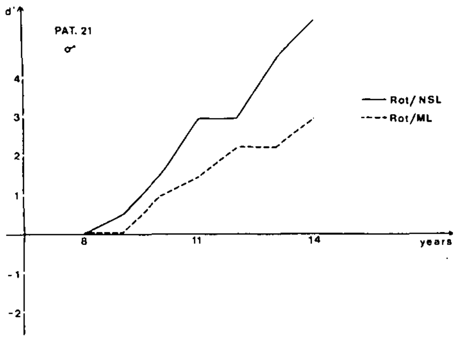

Fig. 5 Rotational diagram of a case with an anterior rotation constant in direction. Here the degree of mandibular rotation measured in relation to ML is about half the degree measured related to NSL.

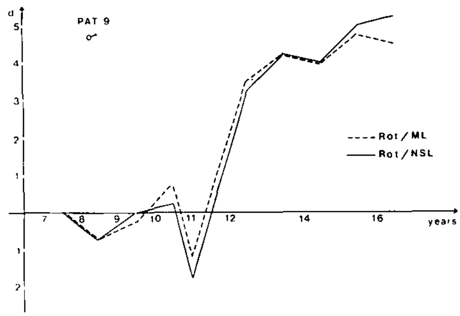

Fig. 6 Typical diagram of anterior rotation. Until the age of eleven it shows variations in direction and intensity. After eleven the direction is constant. In this case degree related to ML and to NSL is equal.

The intensity presents variation during the same period (Figs. 6 and 7).

All diagrams of rotation can be divided in two parts: 1) a first period with a high rate of variation, and 2) a second in which the variation in direction is more constant (Fig. 7).

No connection was found between the interstage limit and the maximum of growth velocity based upon a study of the curves.

The value

$$(1) = \Sigma\ (\Delta x_2 - \Delta x_1)$$

was used to investigate the relationship between the rate of growth in maxil-

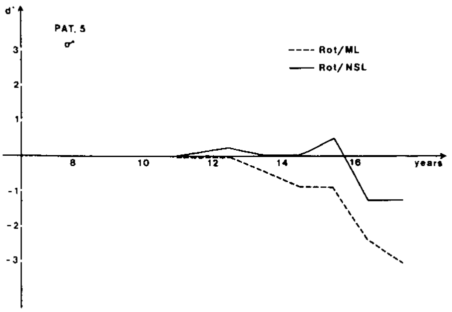

Fig. 7 Typical diagram of posterior rotation. The degree of rotation is more marked when measured in relation to ML.

lary and mandibular lengths and the direction of rotation.

In fifteen cases it was observed that the diagram based upon the value (1) presents the same variation as the diagram of the rotation in relation to NSL (Fig. 8), and in twelve cases the same variation as the diagram of the rotation related to ML. The Spearman rank correlation test indicates a corre-

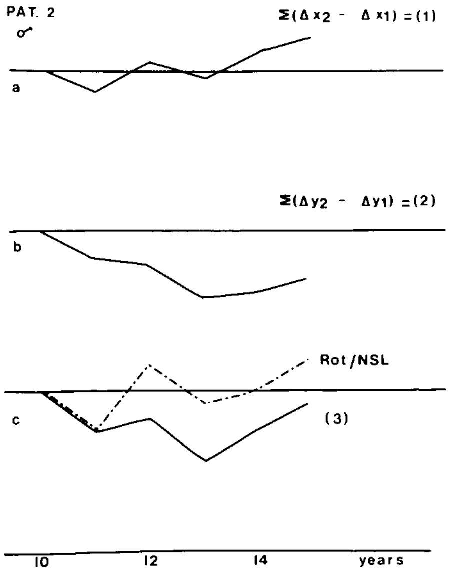

Fig. 8 Comparative diagram between values (1), (2), (3) and the degree of rotation. The variations of the degree of rotation measured to NSL are more related to value (1), line a, than to value (2), line b, but also well-related to the sum (1) + (2), line c.

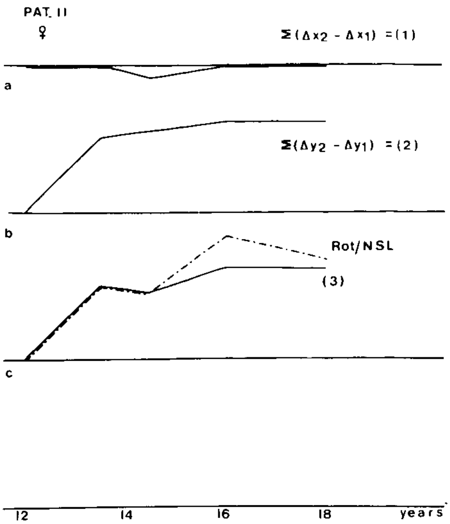

Fig. 9 Comparative diagram between values (1), (2), (3) and the degree of rotation. No correlation is shown between (1) and the degree of rotation related to NSL (line a); a strong correlation is found between (2) and the degree of rotation (line b) and a lesser degree of correlation between (3) and the degree of rotation (line c).

lation statistically significant at the 0.01 level in eight cases, and at the 0.05 level in seven cases. Related to ML, six cases showed a significant correlation at the 0.01 level and six cases at the 0.05 level (Fig. 9). As the first diagram is based upon angular measurements and the second is based upon linear measurements, it is only permissible to compare the shape of the curves on the basis of the rank correlation test.

For the vertical dimension the following value was used:

$$(2) = \Sigma\ (\Delta y_2 - \Delta y_1)$$

In only seven cases a correlation between the diagram (2) and the rotational diagram related to NSL was found, one at the 0.01 level and six at the 0.05 level, and in six cases with the diagram related to ML, one at the 0.01 level and five at the 0.05 level. However, if the values (1) and (2) are

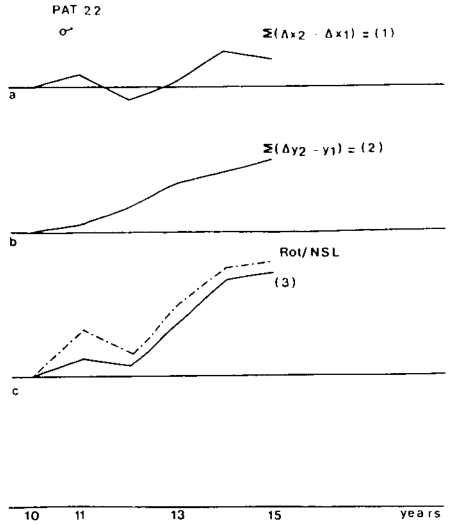

Fig. 10 Comparative diagram between values (1), (2), (3) and the degree of rotation. Here the degree of rotation related to NSL presents a poor correlation with (1) and (2), (lines a and b) and a strong correlation with (3), (line c).

combined with the use of the value

(3) = (1) + (2) as basis for a new diagram,

a similarity between this combined curve and the rotational curve related to NSL was observed in twenty-four cases (Fig. 10). The correlation was statistically significant in fourteen cases at the 0.01 level and in ten cases at the 0.05 level. When related to ML, the correlation was statistically significant in eight cases at the 0.01 level and in twelve cases at the 0.05 level.

A strong relationship between the degree of rotation and the difference in the rate of growth between the jaws is thus established in this sample. It seems that most of the time the degree of rotation is more related to the relative change in the sagittal plane than to the relative change in the vertical plane.

When the sum of maxillary sagittal and vertical growth exceeds the corresponding mandibular growth components, the rotation is going in a more posterior direction and reversely, when the mandible is growing more than the maxilla the rotation has an anterior direction.

Discussion

The results of the present investigation concerning the mean degree and range of the annual rotation in relation to NSL and ML show the same magnitude as in Björk's[3] investigation, although his material comprises more extreme variants. The present sample can be considered more representative of average orthodontic patients including individuals with and without orthodontic treatment.

Occasionally the mandible exhibits a simple pattern of rotation. In most of the cases the rotational phenomenon appears to be complex with variations in direction and intensity. The degree of rotation seems to be correlated with the relative growth rate of the maxilla and the mandible at a high level related to NSL, and at a lower level when related to ML.

The interstage limit found in most of the rotational diagrams may be explained on this background.

The first period, characterized by its instability in direction of rotation, is related with changing relationships between the rates of growth in both jaws. The second period, which is characterized by a constant direction of rotation, is, on the other hand, connected with a time in which one of the jaws continuously exhibits greater growth than the other. Usually mandibular growth exceeds the maxillary growth in this period; consequently, the diagrams of rotation demonstrate an anterior rotation at the end of the observations.

The mandibular rotation seems not only to be dependent upon an isolated mandibular mechanism, but also must be seen in relation to the growth of the total face.

After the studies of Nanda[4] and Carroll, Knott and Meredith[5] it is known that the different bones constituting the face do not exhibit the same rate of growth. This phenomenon is especially evident at the end of the growth period. The condyles continue to grow after the maxilla has completed its growth potential.

But this situation may also occur at any moment during growth related to varying growth coordination between the jaws. It seems the rotation is part of a mechanism of regulation trying to harmonize the rate of growth of the different component parts of the face. If the difference in morphology of the mandible related to anterior or posterior rotation according to Björk[6] and Ødegaard[7] is taken into consideration, the following mechanism may be described.

In individuals with posterior rotation all parts of the mandible seem to be organized to reach a maximum length of the mandible; the condyle has a posterior direction and the gonial angle has a large value.

On the other hand, in individuals with an anterior rotation all parts of the mandible seem to be adapted for a reduced length; the condyle has a vertical direction of growth and the gonial angle has a small value.

Björk and also Ødegaard used a longitudinal sample following the growth over a period of years and got the resultant of all growth components; however, it must be reasonable to expect the same phenomenon to act in the annual variations.

The results of the present investigation indicate that, when the growth of the mandible exceeds the maxillary growth, the excess is dissipated through a high degree of anterior rotation and in reverse, when the growth of the mandible is less than the maxillary growth, the lack of growth seems to be partly compensated by a lower degree of rotation of the mandible.

In man it has been demonstrated that the condyle completes its growth later than the general growth; as a mean, therefore, the mandible presents a higher growth in length than the maxilla. Consequently the average type of growth in human beings is an anterior rotation of the mandible.

Clinical Implications

The degree of mandibular rotation is directly proportional to

$$\Sigma\ (\Delta x_2 - \Delta x_1) + \Sigma\ (\Delta y_2 - \Delta y_1)$$

To influence the degree of rotation the orthodontist could act on x_2, x_1, y_2 or y_1. But there are no known possibilities to influence the length of the corpus (x_2). It is possible to act on y_2 by means of orthodontic appliances acting on condylar growth;[8-9] x_1 may be influenced by torque on the upper anterior teeth associated with extraction. The best possibility seems to be through the action on y_1 as extrusion of the maxillary molars may influence the degree of mandibular rotation leading to a posterior direction.

Ødegaard has previously shown that with an increase of the intensity of the treatment (from removable plate to fixed appliances) we get a decrease of the anterior degree of rotation. With the use of fixed appliances there may be a tendency to extrude the molars, especially when cervical traction is used. Only a tipping of the molars can, in some cases, be enough to increase y_1.

In a Class III with a tendency to deep bite an extrusion of the molars will result in a decrease of the anterior rotation of the mandible; this extrusion may open the bite and decrease the SNB angle.[10] The same effect, however, can be disastrous in a Class II case. This is in accordance with the findings of Schudy.[11,12] One must be especially prudent when using the headgear and use occipital traction in all cases with a high ANB angle. The results of this investigation are in accordance with the findings of Harvold.[13] It has also been reported that a high-pull traction reducing the posterior maxillary height may result in an anterior rotation of the mandible.[14]

Conclusions

The rotation of the mandible during growth appears to be a complex phenomenon showing annual variations in direction and intensity. Such rotation is not only dependent on mandibular intrinsic factors, but also is strongly related to the intensity of growth of both jaws.

The possibilities for an orthodontist to influence the degree of rotation and the great importance of the posterior functional height have been noted.

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