

Condylar development and mandibular rotation and displacement during activator treatment

An implant study

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An analysis of the effects of activator treatment on the spatial development of the mandible over 11 months was performed via the metal implant method for a group of nineteen patients. A series of centers of rotation were derived, the position and effect of which are described and related to observed changes in basal and dentoalveolar structures and the development of the mandibular condyle. A posteriorly directed condylar development, in conjunction with an anterior rotational pattern, was found to be optimal if a basal Class II malocclusion is to be treated by means of a forward developmental displacement of the mandible.

The growth-induced forward and downward displacement of the mandibular symphysis, an important factor in the treatment of basal Class II malocclusion, has often been described as taking place along a linear path.^{1,2} Björk,³ however, by use of the implant method, has demonstrated that a significant part of the observed mandibular displacement could be ascribed to a rotational component related to the direction of condylar growth. Patterns of mandibular rotation relative to the maxilla were described; these rotations occurred around centers related to the dentition.

Isaacson^{4,5} summarized the process of mandibular rotation and translation relative to the anterior cranial base by describing the total displacement of the mandible as a circular movement around a center, the localization of which is dependent not only on the direction of condylar growth but also on "proportionality" of vertical growth.

The aim of the present study was to analyze, by means of the implant method, mandibular development taking place during activator treatment, to construct the center of rotation for the total displacement of the mandible relative to the anterior cranial base, and to relate the localization of this center to the amount of sutural, dentoalveolar, and condylar growth in the individual cases.

MATERIAL AND METHODS

The material for the present study consisted of pairs of lateral cephalograms obtained from nineteen children from 9.3 to 13.5 years of age. Prior to the study all children had implants

inserted in the maxilla and mandible in the manner and location described by Björk.⁶ In the period between the first and second radiographs (11 months) the children were treated by means of an activator of the type described by Harvold.⁷ For a more detailed description, the reader is referred to Williams and Melsen.⁸

MEASUREMENTS ON RADIOGRAPHS

Three series of measurements were performed, expressing (1) dentoalveolar, (2) sutural, and (3) condylar development.

All measurements were recorded perpendicular or parallel to either the occlusal plane, defined as a tangent to the distobuccal cusp of the upper first molar bisecting the incisal vertical overbite, or a common occlusal plane (COP) described below.

Dentoalveolar development (Table I, variables 2 and 3) was expressed as the increase in the perpendicular distance from the posterior maxillary implants (B) (Fig. 1) and mandibular implants (C) (Fig. 2) to the occlusal plane and measured before and after treatment.

Sutural development (Table I, variable 1) was measured with the first and second radiographs superimposed on the stable structures of the anterior cranial base (Fig. 3). To avoid inaccuracies as a result of activator-induced changes in the inclination of the occlusal plane, a common occlusal plane (COP) was constructed as an angular bisector of the two occlusal planes. The quantity of vertical sutural development (variable 1) was expressed as the displacement of the posterior maxillary implants (B) parallel to the COP (Fig. 3).

Condylar development (Table I, variables 5 and 6) was established with the mandibles on the first and second radiographs superimposed on their implants (Fig. 4). The vertical and horizontal components of condylar development, represented by the displacement of the point articulare, was measured in a coordinate system consisting of the COP as X axis and a perpendicular through the anterior mandibular implant (D) as the Y axis (Fig. 4).

All measurements were repeated, and the error of the method was estimated.

All measurements were performed to the nearest 0.5 mm.

The establishment of the center of mandibular rotation was described in detail by Isaacson⁴ and is founded on the theorem that the center of any two concentric circles can be found as the point of intersection of perpendicular bisectors of any two chords of the circles. With the two radiographs superimposed on the stable structure of the anterior cranial base, the position of the two mandibular implants on each radiograph was recorded as X and Y coordinates in a coordinate system where the X axis is formed by the COP and the Y axis passes through the anterior mandibular implant (D) on the pretreatment radiograph. Calculation of the center of rotation was performed by means of a programmed pocket calculator.

Y coordinate.

The localization of the center of rotation for the total displacement of the mandible in relation to the anterior cranial base is highly related to the changes in the interjaw relationship taking place during a given observation period. In cases with similar disproportion between vertical growth at the condyle and in the sutural and dentoalveolar areas, the center of rotation will always be characterized by the same X coordinate. The X coordinate is, however, partly determinant for the amount of forward displacement taking place at the pogonion area. In Patients 7 and 8 (Figs. 5 and 6) the center of rotation has the same X coordinate. As the center of rotation in Patient 7 is localized at a much higher level than in Patient 8, a markedly greater forward displacement of pogonion with the same degree of rotation is taking place in Patient 7 than in Patient 8, in whom the center is close to the X axis—the common occlusal plane. In Patient 7 the direction of the displacement of the articulare point is backward and upward, whereas Patient 8 exhibits a slightly forward-directed growth.

In the patients exhibiting a posterior rotation of the mandible during treatment, the amount of vertical condylar growth has not been able to keep pace with the vertical sutural and dentoalveolar development. However, the localization of the center of rotation still indicates a displacement of the pogonion area. With a higher position (smaller distance to the X axis), the growth- and rotation-related changes in the face will tend to increase the sagittal discrepancy present in the patient with a Class II malocclusion as well as increase facial height. If the Y coordinate has a large negative value, even a posterior rotation may add to the improvement of the sagittal jaw relationship. This is clearly demonstrated in Cases 1 and 15 (Figs. 5 and 6). In Case 1 the displacement of articulare has been upward and forward, whereas posterior upward-directed growth has occurred in Case 15, resulting in a reduction of the sagittal jaw relationship. In patients in whom a forward positioning of the mandible is required, a posteriorly directed growth pattern of the condyle would be desirable. Simultaneously, a forward rotational pattern would optimize the effect of a given condylar growth.

Because of difficulties in defining the mandibular condyle on the radiographs, condylar development has been expressed as displacement of the point articulare in a manner similar to other studies of a similar nature.⁴

This article reflects a study of jaw displacement in relation to condylar development and not a specific study of activator treatment. Consequently, it was considered acceptable to "pool" the material, irrespective of patient cooperation or differences in appliance design.

Activator treatment has been claimed to influence the development of the occlusion in a number of ways. Harvold⁷ ascribed the treatment effect to dentoalveolar remodeling and change in the slope of the occlusal plane. Petrovic¹⁰ and McNamara¹¹ and their co-authors, on the other hand, demonstrated increase in condylar growth in animals treated with

appliances designed to force the mandible into an anterior position. The present study indicates that the induction of a condylar growth pattern in an upward/posterior direction will result in a center of mandibular rotation that is favorable for sagittal changes. The results obtained through a laminagraphic study of activator patients¹² indicated that a temporary change toward a more sagittal growth of the condyle was observed during treatment but that a return to the original growth pattern took place subsequent to treatment.

Evidence that condylar growth can be altered irreversibly in the human still remains to be found. The existing condylar growth can, however, be used in an optimal manner, bringing the mandible forward if the sutural and dentoalveolar growth can be minimized. The present study revealed that the type of activator used was not able to completely control the development in height of the maxilla. It would, therefore, seem reasonable to increase the vertical control, either through an increase in height of the construction bite as suggested by Woodside¹³ or by combining the activator with a high-pull headgear as recommended by Teuscher.¹⁴

As a *conclusion* of the present study, it could be stated that a posterior/upward growth direction of the condyle combined with an anterior rotation of the mandible is the optimal development which can improve a sagittal discrepancy in treatment of basal Class II cases and that vertical control of sutural and dentoalveolar development must be controlled to the maximum possible degree.

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