Mandibular response to orthodontic treatment with the Bionator appliance

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A group of 20 subjects who underwent successful Bionator treatment was compared with 20 subjects who were treated less successfully with the same appliance. Both groups had similar advancements in their bite registrations, as well as similar treatment times and growth-prediction parameters. Success was judged not on the final occlusion (all patients were treated to a Class I molar relationship) but on the posttreatment position of skeletal pogonion. The successful group experienced 3.5 mm or more of advancement in skeletal pogonion, whereas the less successful group had less than 3 mm of advancement of this point. The two groups were comparable in all features except, as may be expected, total mandibular growth, which was greater in the group with the larger anterior pogonion advancement. The results of this study suggest that persons who have small mandibles (as determined by comparison with published growth standards) may benefit more from functional appliance therapy than patients with normal-sized mandibles. The subjects with delayed growth may experience more mandibular development than those with average growth during treatment under the favorable growth environment created by functional appliance therapy. (Am J Orthod Dentofac Orthop 1990;97:113-20.)

The potential of functional appliances to increase mandibular growth beyond that which may be expected without treatment is an area of contention among researchers. A number of authors have suggested that mandibular length can be increased with functional appliance treatment, 1-4 whereas others have proposed that mandibular length cannot be altered through such treatment. 5-8

Few human studies have demonstrated changes in the glenoid fossa after functional appliance treatment. Vargervik and Harvold 5 reported joint remodeling and adaptation to the anterior condylar position, whereas Birkebaek et al. 4 found only minute amounts of remodeling of the glenoid fossa after 10 months of activator treatment.

Woodside et al. 9 examining continuous mandibular repositioning, observed a significant amount of glenoid fossa remodeling throughout all the ages in their primate sample. Other authors 10-12 found similar reactions in the temporomandibular joints of primates that underwent continuous mandibular repositioning.

The objectives of this investigation were (1) to examine the mandibular response to Bionator therapy and (2) to offer a possible explanation for the differences in mandibular growth experienced by two similar groups of orthodontic patients treated with the Bionator
appliance.

METHODS AND MATERIALS

Forty patients treated with Bionator appliances were selected for this study. All the subjects had Class II, Division 1 malocclusions (mandibular retrognathism). The sample was divided into two groups according to the horizontal change in skeletal pogonion point from the pretreatment to the posttreatment cephalometric radiographs (Fig. 1). Subjects with 3.0 mm or less of anterior movement of skeletal pogonion were placed in the small-advancement group; subjects with 3.5 mm or more of anterior change in skeletal pogonion position were assigned to the large-advancement group.

Comparison of the two groups revealed their comparability with respect to molar relationship, incisor overjet, and three determinants of growth direction, including Y axis, mandibular plane angle, and condylar inclination (Tables I and II). The bite registration was taken with the mandible open 3 mm beyond rest position and 3 mm short of maximum protrusion. The incisal edges were covered with acrylic to prevent tipping. Patients wore their appliances 14 hours a day.

Mandibular length in the small- and large-advancement groups was compared on the basis of age and sex with standards from the Michigan Growth Center.

CEPHALOMETRIC ANALYSIS

Lateral cephalometric radiographs used in this study were taken before treatment and at the completion of functional therapy. The radiographs were taken with the teeth in habitual occlusion. Measurements were selected to characterize the pretreatment and posttreatment changes in skeletal pogonion position (the most anterior point on the hard tissue chin) and vertical and horizontal changes in condylar position. The reference axis for these measurements was a line drawn at 8 degrees to the sella-nasion plane, at nasion, which was designated as the X axis and represented the Frankfort horizontal plane. A line perpendicular to the constructed X axis through the point sella was used as the vertical reference plane. The intersection of the vertical reference plane and the constructed X axis was labeled sellacon. Both axes served as lines from which linear measurements were evaluated (Fig. 1).

Total mandibular length was evaluated as the distance between points condyion and gnathion. Horizontal and vertical components of growth were evaluated parallel and perpendicular to the mandibular plane, respectively (Fig. 2). Angular condylar changes were measured as the changes in angle 1 (Fig. 3).

STATISTICAL ANALYSIS

The means and standard deviations were calculated for each parameter. Treatment
changes in each parameter were determined for the two groups. The significance of the
difference for treatment and growth changes (Tables III and IV) between the groups was
determined by means of the Student t test.

Pearson correlation coefficients were calculated to determine the relationship between
total mandibular growth (and its horizontal and vertical components) and changes in
pretreatment and posttreatment condylar position (Table V).

RELIABILITY OF METHOD

To assess the magnitude of measurement error involved in this study, the lateral
cephalograms of 10 randomly selected patients were remeasured. The overall mean
difference between the first and second determinations was not statistically significant for
any of the measurements used in this investigation.

RESULTS

The large- and small-advancement groups (as determined by the position of cephalometric
hard tissue pogonion) were evaluated for determinants of growth direction before treatment (Table I). The mandibular plane angle, the modified Downs Y axis, and the inclination of
the condylar axis with respect to the mandibular plane did not differ significantly between the
two groups; this indicated similar patterns of skeletal development. Molar relationship and
incisor overjet were also compared and were not significantly different.

The large-advancement group was found to have a mean age before treatment of 132
months; the smaller-advancement group had a mean age of 124 months. In spite of being
younger, the smaller-advancement group had mandibular dimensions that were equivalent to
or greater than those of the large-advancement group. Among boys mandibular length
comparisons with standards derived from the Michigan Growth Study reveal that the
large-advancement group exhibited values significantly smaller than the standards (Table IV).
The mean difference in size between the two groups was 8.1 mm before treatment. In girls
the large-advancement group revealed the same trend toward diminished values for
mandibular length when compared with untreated subjects, but not to the same degree as the
boys. The small-advancement group (both boys and girls) did not differ significantly from
growth standards in pretreatment mandibular length.

An examination of mandibular dimensions after treatment reveals that both the total
mandibular length and the horizontal mandibular dimensions in the large-advancement group
had surpassed those same dimensions in the small-advancement group. Only the vertical
mandibular dimension had remained slightly, but not significantly, reduced when compared
with the small-advancement group. Although it remained smaller, vertical mandibular
dimension increased more in the large-advancement group during treatment than in the
small-advancement group. The large-advancement group also had greater overall mandibular
growth (Table III).

Posttreatment measurements of mandibular length in the small-advancement group did not differ significantly from standards among boys or girls. Dimensional changes in mandibular length during the treatment period examined were very similar to those expected in untreated control subjects (Table IV). In the large-advancement group, posttreatment comparison revealed that the boys remained significantly smaller. They did, however, manage to outgrow the control subjects by 2.6 mm during the period observed (Table IV). The girls in the group with large pogonion advancement exceeded the growth expected in an untreated population by 4.3 mm on average. At the completion of treatment the girls were not significantly smaller than the control subjects (Table IV).

Vertical and horizontal changes in condylar position during treatment were also evaluated in the two groups. The large-advancement group experienced a mild distal movement of the condylar head with respect to structures of the anterior cranial base during treatment (Table III). In the small-advancement group the mandibular condyle was positioned anteriorly relative to its pretreatment position. Differences between the two groups in angular and horizontal changes in condyle positioning during treatment were small and not statistically significant; they do, however, represent a trend in which greater growth of the mandible leads to a reduction in condylar repositioning during treatment. This trend is more apparent when correlation coefficients relating growth and condylar movement are examined (Table V).

In the large-advancement group, correlation coefficients demonstrated a strong relationship between increases in total mandibular length and distal movement of the condylar head during treatment. Correlation coefficients relating overall mandibular growth to angular and horizontal changes in condylar position were significant at 0.67 and 0.53, respectively. Correlation coefficients calculated to determine a relationship between the horizontal component of mandibular growth and both angular and horizontal changes in condylar position were slightly larger (0.71 and 0.61, respectively) than those describing the relationship of overall mandibular growth and these parameters (Table V).

In the small-advancement group the correlation coefficients calculated for all relationships were smaller than those evaluated for the large-advancement group. The largest correlation values were those that related total mandibular growth and horizontal condylar change at 0.46 and the horizontal component of mandibular growth with horizontal condylar change at 0.56 (Table V). In both groups small correlation coefficients were found in any relationship that involved vertical mandibular growth and condylar movement during treatment. Vertical condylar change was similarly unrelated to overall mandibular growth or any component of such growth (Table V).

DISCUSSION
Neither the small- nor the large-advancement group demonstrated any significant differences in the pretreatment cephalometric parameters used to predict mandibular growth. Similarities in gender and length of treatment in each advancement category added to the expectation that similar amounts of growth should have taken place in the two groups. Examination of the data, however, revealed that significantly more growth took place in the large-advancement group (Table III). This additional growth resulted in a straighter profile for these subjects.

The large-advancement group also demonstrated a significant delay in mandibular development with respect to published mandibular size standards\textsuperscript{13} (pretreatment). The small-advancement group, unlike the large-advancement group, was not significantly delayed in mandibular growth with respect to the same data.\textsuperscript{13}

It has been suggested that subjects may channelize their mandibular growth\textsuperscript{15}, that is, those who have small mandibles at an early age will have small mandibles when their development is completed. The results of this study imply, however, that the above proposal may not apply to some subjects who are undergoing functional appliance treatment. Balters, as quoted by Carels and Van der Linden,\textsuperscript{16} proposed that functional appliances act to create an ideal environment for mandibular growth through the removal of growth-deforming influences. It is possible that the functional appliances used in this study acted to remove the growth-delaying influences (e.g., extremely deep overbites) that were present in the large-advancement group and, though not to the same degree, in the small-advancement group. The chances of achieving a larger correction may then be greater in subjects who have been delayed in their skeletal development than in those who have not.

Examination of the changes in condylar position following treatment in the two groups indicated a more distal posttreatment condylar position in the large-advancement group as compared with the small-advancement group. The large-advancement group had also undergone significantly more growth during the treatment period than the small-advancement group. Thus the anterior condylar repositioning that takes place with initial appliance placement may be diminished with greater mandibular growth.

The correlation coefficients were calculated to evaluate the relationship between mandibular growth and change in position of the condyle during treatment. The strongest relationships were observed between horizontal mandibular growth and horizontal condylar repositioning. Correlations between vertical growth parameters and vertical condylar movement were weaker than those in the horizontal dimension. The weak relationships between vertical growth and vertical condylar movement may be explained by the observation that in untreated persons the condyle and temporal fossa descend vertically and posteriorly with respect to the axes used in this study.\textsuperscript{4,17} The similar effects of both growth and therapy on condylar position during the treatment period tend to obscure any relationship that may exist between growth and condylar position in the vertical dimension.
As Birkebaek et al.\textsuperscript{4} observed, little fossa remodeling can be identified in subjects who wear functional appliances intermittently. The significance, then, of maintaining the condyle near its pretreatment fossa relationship should be one consideration in treatment. Since a relationship appears to exist between mandibular growth and a reduction of the anterior condylar displacement, which occurs at the initiation of treatment, mandibular growth plays a significant role in improving the stability of functional appliance therapy.

It is of considerable importance, then, to achieve as much mandibular growth as possible during therapy in order to maximize the esthetics and stability of the finished cases. The subjects in the large-advancement group responded to treatment with changes in mandibular dimension that exceeded standards. A possible explanation for the growth observed in the group with delayed growth may lie in the ability of the functional appliances to eliminate growth-retarding factors during treatment. The possibility of exceeding standards (e.g., jumping growth channels) would be expected only in those subjects who have experienced an environmental growth delay. If the preceding explanation is accepted as valid, it would still be extremely difficult to determine whether a person with mandibular deficiency has experienced a delay in mandibular development because of growth-restricting and deforming aberrations, genetic influences, or a combination of the two. According to the data of this study, it still appears probable that subjects with delayed growth will experience more growth during treatment than subjects with average mandibular parameters.

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