Response to activator treatment in Class II malocclusions

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A clinical study was designed to disclose the effects of activator treatment in the correction of Class II malocclusions. The rationale for the use of the activator appliance was based on the premise that correction of distocclusion can be achieved by (1) inhibition of forward growth of the maxilla, (2) inhibition of mesial migration of maxillary teeth, (3) inhibition of maxillary alveolar height increase and extrusion of mandibular molars, (4) increased growth of the mandible, (5) anterior relocation of the glenoid fossa, (6) mesial movement of mandibular teeth, and (7) combinations of these effects. The appliance, as designed for this study, could potentially have an effect on all of these factors. Measurements were obtained from cephalometric head films obtained at 6-month intervals. Matched-pairs analyses of control versus treatment change after 6 months and after 1 year of treatment were done on 36 and 29 pairs, respectively. Pretreatment versus treatment changes were analyzed on 33 subjects by means of the spline regression analysis; posttreatment versus treatment changes were analyzed on 18 subjects by means of the Student Newman-Keuls multiple comparison test. The matched-pairs analyses of mean values demonstrated significant reduction in forward growth of the maxilla, uprighting of the maxillary incisors, reduced overjet, leveling of the mandibular occlusal plane, improved molar relationship, downward and forward relocation of the glenoid fossae, increased advancement of all mandibular structures, increased face profile angle, and increased lower face height. The two longitudinal analyses yielded similar findings, but some differences were noted. Because rather severe dental malocclusions were corrected, the slight average inhibition of maxillary growth and the anterior relocation of glenoid fossae alone could not account for the correction of the Class II dental arch relationship. It was therefore concluded that, in addition to the statistically significant changes, smaller changes occurred in several areas without being consistent enough or of a large enough magnitude to become statistically significant in the analyses of mean values. Comparison of group averages may mask treatment effects that significantly contribute to the correction of malocclusions in individual cases.

RESPONSE TO ACTIVATOR TREATMENT IN CLASS II MALOCCLUSIONS

To design a functional appliance and assess its contribution to correction of Class II malocclusions, it is necessary to identify the factors that may be involved in the development of the malocclusions and to establish which of these may be modified by treatment.

Theoretically, the relationship between the maxillary and mandibular dental arches in Class II malocclusions may be the result of (1) forward displacement of the maxilla or the maxillary alveolar process, (2) excessive maxillary alveolar height with downward and posterior displacement of the mandible, (3) a small mandible or retracted mandibular teeth, (4) a posterior location of the temporomandibular joints, or (5) combinations of the above
factors. Correction of the distocclusion can be achieved by the counteraction or reversal of some or all of these factors provided they can be significantly influenced by environmental changes, such as those produced by various treatment modalities.

There is experimental and clinical evidence that some of the above mentioned factors can be significantly influenced by changes in the local environment. For example, experimental increases in condylar cartilage proliferation and mandibular-length have been demonstrated in both rats and primates.\textsuperscript{1-4} Other primate experiments have shown that significant adaptive changes can be elicited in growth direction and shape of the mandible,\textsuperscript{5-8} in maxillary and mandibular alveolar height, and dental arch form and size.\textsuperscript{8-10} Significant experimental changes in growth magnitude and direction of the maxilla have been documented in primates.\textsuperscript{4,8,10,11} Associations between environmental factors and certain characteristics of dental malocclusions have also been demonstrated in humans.\textsuperscript{12}

Various types of functional appliances have been designed for different purposes: (1) to effect neuromuscular and functional changes, (2) to impede or enhance growth or to change growth direction of certain structures, and (3) to achieve tooth movements. The activator appliance used in the present study was designed to affect the recruitment of certain masticatory and facial muscles and to control the eruption of teeth. The material was limited to subjects with Class II malocclusions and the sample was of sufficient size and homogeneity to warrant statistic analysis. The study, including the choice of cephalometric measurements and statistic analyses, was designed to disclose responses to the activator treatment in pertinent areas of the craniofacial skeleton.

MATERIALS AND METHODS

Subjects

The study extended over a 7-year period and originally included 120 children—56 girls and 64 boys. Thirty subjects were accepted into the study for each of 4 years. The only selection criteria were a Class II malocclusion in the mixed dentition stage and declared willingness of the patient and parents to participate fully in the study.

In the course of the pretreatment, treatment, or posttreatment periods, 37 subjects were lost from the study. Six moved away from the area before treatment was completed; 15 girls and 16 boys demonstrated poor cooperation and chose not to continue in the study after varying time periods. Treatment was completed in 83 of the subjects; 52 of these were treated with activators only. The remaining 31 required fixed appliance treatment subsequent to the activator treatment. The mean age at start of treatment was 10 years 7 months for the boys and 10 years 2 months for the girls. The mean activator treatment time was 35 months for the boys and 31 months for the girls. Detailed information regarding the total sample is presented in Table I.
In the analyses presented here, only treatment data obtained during activator treatment have been included. No other treatment preceded the activator treatment in any of the subjects. The mean age of the subjects included in the matched pairs analyses was 9 years 6 months at the start of treatment.

**Methods of obtaining cephalometric x-ray film data**

Records that included study models, photos, height and weight measurements, and head films were obtained at 6-month intervals ±7 days. An additional lateral head film was taken with the appliance in the mouth on the day it was delivered. This x-ray film provided good visualization of the mandibular condyles. All x-ray films were taken on the same cephalostat by the same two technicians. The measurements used in this article were obtained from lateral head films. All the head films from one subject were traced in succession by one investigator. All tracings were performed by two experienced investigators. The landmarks and constructed lines and points used are indicated on Fig. 1. Each tracing was subsequently digitized with a two-dimensional array of coordinate values. The linear measurements used are described in Table II and the angles measured are shown in Table III and Fig. 2.

**Design of the activator**

The activator was designed to affect the elastic, as well as the contractile, properties of the involved musculature. When the appliance was in the mouth, it was constructed in such a way that the mandible was protruded and lowered 6 to 7 mm from the occlusal position. The lowered and protruded jaw position increased the distance between the origin and insertion of the jaw closing muscles and their passive tension was presumably thereby increased. The altered mandibular position could also be expected to increase proprioceptive feedback from muscle spindles and the temporomandibular joints, thus resulting in more activity in the jaw elevator muscles. The lips were considerably further apart when the appliance was worn and increased lip activity was necessary to achieve lip closure.

The appliance was designed to inhibit extrusion of maxillary teeth, allow retrusion of maxillary incisors and alveolar process, allow extrusion of posterior mandibular teeth, and inhibit extrusion and protrusion of mandibular incisors (Fig. 4). To inhibit vertical development in the maxilla, the appliance was trimmed to provide a smooth plane that contacted the cusps of all posterior maxillary teeth. Contact with the appliance was removed from the maxillary anterior alveolar process and the lingual side of the incisors, but labial and incisal contact was maintained. In the mandible the molars, premolars, and canines were freed from occlusal contact with the appliance. Incisal and labial contact was maintained on the mandibular incisors, but the lingual contact was removed from these teeth, as well as from the alveolar process behind the incisors. No attempt was made to guide posterior teeth mesially or distally during their eruption. The subjects were instructed to wear the appliance a minimum of 14 hours in each 24-hour period. To monitor the hours of activator wear, each
subject kept a record of the time the appliance was put in and removed. The appliance design and some findings have been presented previously.\textsuperscript{23-26}

**Study design and statistic analyses**

The study and appliance design was based on the premise that correction of Class II dental arch relationship can be achieved by the following mechanisms:

1. Inhibition of forward growth of the maxilla
2. Inhibition of mesial migration of maxillary teeth
3. Inhibition of maxillary alveolar height increase and extrusion of mandibular molars
4. Increased growth of the mandible
5. Anterior relocation of the glenoid fossae
6. Mesial movement of mandibular teeth
7. A combination of the above mechanisms

The study and the data analyses were designed to disclose responses that occurred consistently enough and were of a large enough magnitude to become statistically significant.

In half of the subjects originally included in the study, records were obtained during a 1- to 2-year period before treatment was started. These pretreatment data served as control material to the treatment data. Thus a data bank of normally occurring growth changes was obtained from the same sample that later underwent activator treatment. Treatment data were obtained from subjects treated only with an activator, without any other treatment preceding the activator treatment. Because many of the subjects did not wear the appliance the requested 14 hours, reported wear of 8 or more hours was set as a requirement to be included in the statistic analyses. No selection on the basis of treatment results was made.

Matched-pairs analyses of control versus treatment changes in the chosen cephalometric variables were done to test the validity of the stated treatment response mechanisms. Six-month pretreatment (control) change of each measurement derived from 36 subjects was matched with the corresponding measurement change from 36 treated subjects with the same sex and age ± 3 months. There were 19 male and 17 female pairs. The matched pairs t test compared the control with the treatment difference scores. Each difference score was divided by the number of days in each control or treatment period as determined by the interval between head films and multiplied by 182 in order to arrive at the change over 6 months.

A similar analysis was carried out on treatment changes after 1 year in 29 of these pairs.
The relatively small number in each of these groups was caused by the stringent criteria used for accurate matching with control data.

To assess the posttreatment changes relative to treatment changes, a longitudinal analysis of yearly increments during the first and last year of treatment and the first year of posttreatment was carried out on data from 18 subjects, 10 boys and 8 girls. The criterion for inclusion in this analysis was the availability of data for the three periods. Difference scores, adjusted for number of days between head films in each period and representing the average 1-year change, were calculated for all three periods. The Student Newman-Keuls multiple comparison test was used. To assess possible differences in response in subjects with a high versus a low mandibular plane angle, the sample of 18 was divided into nine subjects with lower angles (under 35°), and nine with higher angles (over 35°), and the same analysis was performed. The mandibular plane was measured to SN.

On 33 subjects, 2 years of pretreatment and 2 years of treatment data were available. Longitudinal changes in the cephalometric variables over a 2-year activator treatment period were compared with the 2 years of pretreatment changes by means of a spline regression analysis (Fig. 3) (described in Neter J, Wasserman W: Applied linear statistical models; regression, analysis of variance, and experimental designs. Homewood, Ill., 1974).

**RESULTS**

The data from the analysis of 36 matched pairs of 6-month pretreatment versus 6-month treatment scores are shown in Table IV. The anterior nasal spine (point on superior contour where thickness of spine is 3 mm) came forward significantly less in the treated subjects. The face profile angle (N-ANS-Pgn) and the anterior lower face height (ANS-ME) were significantly increased in the treated subjects; the angle Co-S-N decreased significantly. Maxillary and mandibular unit length differences were significantly larger in the treated subjects, a reflection of restriction in forward growth of the maxilla and/or increased advancement of the mandible. Six months of treatment also resulted in improved molar relationship, a more anterior position of the mandibular molars and incisors, a more posterior position of the maxillary incisors, reduced maxillary overjet, reduced angle between the functional occlusal plane and the incisor line, and increased interincisal angle. All points on the skeletal, dental, and soft-tissue profile of the mandible measured to SNP came forward significantly more in the treated than in the untreated subjects.

The results from the analysis of 1-year treatment versus control changes in 29 matched pairs are shown in Table V. The significant effects on the mean values of 1 year of treatment occurred in the same areas as those recorded after 6 months with one addition—after 1 year the distance from condylium to SNP (perpendicular to SN through S) was significantly shorter in the treated subjects than in the controls.

The data from the Student Newman-Keuls multiple comparison test of posttreatment
changes versus treatment changes during the first and last year of activator treatment in 18 subjects are shown in Table VI. The mean increase in mandibular length was significantly larger during the first year of treatment than during the first year of posttreatment. The average yearly mandibular length increase during the first year of treatment was 3.25 mm, during the last year of treatment 2.83 mm, and during the posttreatment year 2.29 mm. The maxillary overjet and the distocclusion on the molars were reduced significantly more during the first year than during the last year of treatment. There was no indication of reversal or relapse of treatment effects after treatment was finished. When this sample of 18 subjects was divided into two groups of nine subjects each, according to the mandibular plane angle, significant differences between the low- and high-angle groups were found for three variables: mandibular incisor overbite (distance from mandibular incisor edge to functional occlusal plane), maxillary alveolar height, and maxillary overjet (Fig. 5). An analysis of correlation of the mandibular plane angle with other skeletal and dental variables did not reveal any correlations.

The results of the spline regression analysis (Fig. 3)—performed on data from 33 subjects over a 2-year pretreatment and a 2-year treatment period—are shown in Table VII. Lower face height, mandibular length, and face profile angle increased significantly more during the treatment period than during the pretreatment period. The dental and soft-tissue treatment effects were similar to those demonstrated in the other analyses. The distance from ANS to SNP, from Pgn to SNP, and maxillary/mandibular unit length difference were not calculated for the spline and the Student Newman-Keuls analyses.

DISCUSSION

The occlusal changes that resulted from the activator treatment included correction of the Class II dental arch relationship, reduction of excessive maxillary overjet, and leveling of mandibular occlusal plane. Areas in which the significant treatment effects occurred are discussed relative to the hypothesized response mechanisms.

Inhibition of forward growth of the maxilla

In the intrapair analyses used in this study where differences between the control and treatment samples were minimized, a significant reduction in forward growth of the maxilla, measured from ANS to SNP and to condyion, was demonstrated. Similar findings have been reported by several investigators\textsuperscript{24,25,27-30} others have found no significant effect on the maxilla by their analyses of activator treatment effects.\textsuperscript{31-33} Although the appliance design has varied among the cited reports, a common characteristic has been the advancement of the mandible by the appliance which would be expected to result in retrusive forces on the maxilla. Wide range of ages and shortcomings of the control data may account for some of the disparity in the findings. It is noteworthy that the analyses of the longitudinal data in this study did not disclose significant treatment effects on the maxilla. This emphasizes the importance of minimizing age and growth differences in the tested samples.
Inhibition of mesial migration of maxillary teeth

After 6 months and after 1 year of treatment, there was no significant intrapair difference in maxillary molar position measured to the sella-nasion perpendicular. The maxillary dental arch became significantly wider during the treatment. This resulted in a larger dental arch that allowed anterior migration of the maxillary molars. It must be concluded that the activator used here was not effective in the inhibition of mesial migration of maxillary molars in all treated persons.

Inhibition of maxillary alveolar height increase

There was no significant intrapair difference in maxillary alveolar height after 6 months or after 1 year of treatment. This finding is not consistent with previous observations based on measurements on oblique head films. In persons with very good and fast response to the activator treatment, it was found that maxillary alveolar height increase was inhibited and mandibular alveolar height increase was increased. In this sample this treatment effect was not consistent or large enough to become statistically significant. Consequently, this appliance is not always adequate to control vertical alveolar development.

Increased growth of the mandible

The matched-pairs t tests indicated that the treatment did not result in significant intrapair difference in mandibular unit length (Co-Pgn). However, the longitudinal data on 18 subjects presented in Table VI demonstrate a significantly greater mean mandibular unit length increase during the first year of treatment than during the last treatment year, or the first posttreatment year. The spline regression analysis of longitudinal changes during 2 years of pretreatment and 2 years of treatment in 33 subjects (Table VII) also demonstrated a significantly larger increase in mandibular length during the treatment than during the pretreatment period. Age change and general growth spurts may have contributed to the differences in mandibular growth between the treated and the control periods demonstrated in these two analyses on longitudinal data. Reports in the literature demonstrate conflicting findings on treatment effects by functional appliances on mandibular growth. Although some indicate that increased mandibular growth results from activator treatment, others maintain that the mandible does not respond with increased growth in length. The differences in findings may be caused primarily by differences in subject selection criteria for inclusion in the treatment and control samples. The findings from this study do not demonstrate conclusively that mandibular length can be increased by this type of appliance therapy.

Anterior relocation of the glenoid fossae

All mandibular structures measured to SNP—including prognathion, mandibular molars
and incisors, soft-tissue chin, lower lip, and labiomental sulcus—came forward significantly more during treatment. During the same treatment time, the position of condylon became more inferior and anterior as evidenced by decreased angle Co-S-N and decreased distance from condylon to SNP. Dual bite was registered in only one of the subjects and unchanged condyle position in the glenoid fossa was verified on the oblique x-ray films taken simultaneously with the lateral head films in all subjects. It therefore appears that the treatment had an effect on the location of the glenoid fossae and that this resulted in a relocation of the mandible in an anterior direction. If mandibular length is measured from articularare rather than from condylon, a distinction between mandibular length increase and anterior relocation of the glenoid fossae cannot be made. It is therefore important not to compare results from investigations that use different measuring points.

**Mesial movement of mandibular teeth**

Relative to SNP, the mandibular molars came forward significantly more as demonstrated in the treatment data than in the control data, but the chin also came further forward approximately the same amount. It was concluded that the mandibular molars came forward with the mandible and not by tooth migration. Mesial migration of mandibular molars can therefore not be expected to be a consistent factor in this treatment. The mandibular incisors came forward more than the molars relative to the sella perpendicular and it must therefore be expected that labial movement or tipping of the mandibular incisors may occur with this treatment.

**Inconsistent or small changes in several of the above mentioned areas**

The findings indicate that the correction of the dental arch relationship and the improved facial profile resulted from treatment effects in several areas of the craniofacial structures. Some of these treatment effects were too small or not sufficiently consistent throughout the sample to become of statistical significance, although they may have been clinically significant in individual cases.

These data demonstrate wide variation in response to a similar appliance. This variation may be caused largely by the way in which the sensory, and consequently the neuromuscular, systems in each person respond to the appliance. It would be desirable to consistently achieve the same responses and effects on the orofacial structures in all patients in whom the occlusal conditions and treatment goals are the same and to vary the responses according to the malocclusions to be treated. To some extent this can be done by variations in appliance design and by the addition of other appliances to be used simultaneously. For example, a high-pull headgear attached to the appliance will more effectively control the vertical and sagittal position of the maxillary teeth.\(^{30,33,35}\)

Successful activator treatment alone will often not correct all occlusal aberrations. In our sample nearly 40% of the subjects required fixed appliance therapy subsequent to correction
of the Class II molar relationship.

CONCLUSION

Treatment of Class II malocclusions in growing patients by means of an activator of the design described in this article can be expected to result in (1) correction of Class II molar relationship, (2) correction of overjet, (3) leveling of mandibular occlusal plane, (4) uprighting of maxillary incisors, (5) reduced advancement of the maxilla, (6) increased advancement of all mandibular structures, (7) increased face profile angle, and (8) increased lower face height. The treatment responses that resulted in the changes in dental arch relationship included reduced forward growth of the maxilla and anterior relocation of the glenoid fossae. Forward repositioning of the condyles and mandible relative to the fossae could not be demonstrated. Changes in other areas as well must have contributed to the Class II correction, but were too small or not consistent enough throughout the sample to become statistically significant in the analysis of mean values. These findings also demonstrate wide individual variation in response to a similar appliance.

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The computations and data analyses were performed at the University of California, San Francisco Computer Center. The SAS statistical analysis system (SAS Institute Inc., Cary, North Carolina, 1982) and the SPSS (Statistical Package for the Social Sciences, Nie NH et al.) were used. The spline regression analysis, also termed "piecewise linear regression," is described in Neter J, Wasserman W: Applied linear statistical models; regression, analysis of variance, and experimental designs. Homewood, Ill., 1974, Richard D. Irwin, Inc.

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