Intensive treatment of severe Class II malocclusions with a headgear-Herbst appliance in the early mixed dentition

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In the correction of large sagittal discrepancies in the relationship between the maxilla and the mandible, the orthopedic effect of treatment is often of small magnitude when compared with the dentoalveolar changes. A group of patients with severe Class II malocclusions were treated to assess the effects of a therapeutic approach which specifically took into consideration important factors such as type of anchorage, amount of force, age at start of treatment, and intensity of treatment to obtain the maximal orthopedic improvement. A special headgear-Herbst appliance was designed and short intensive treatment, lasting 5 months, was performed in the very early mixed dentition. Comparison with an untreated control group revealed the dramatic effects of treatment. The overall average change in the sagittal relationship between the maxillary and mandibular teeth was 7.5 mm after active treatment. The posteriorly directed effect on the maxilla of 3.1 mm was due to a combination of distal movement of the dentoalveolar arch and of posterior translation of the basal portion of the maxilla. The anteriorly directed effect upon the mandible of 4.4 mm was due mostly to anterior movement of the basal part of that bone, with a small part resulting from labial movement of the lower incisors. This appeared to be the result of a stimulation of growth of the mandibular condyles, a change in mandibular morphology, and an anteroinferior change in position of the condyles with a possible anterior translation of the glenoid fossa. After a 10-month posttreatment period during which an activator was used during the initial 6 months, a new comparison between the treated group and the control group was made. Growth continued to the same extent in the treated group as in the control group. However, a tendency toward relapse in overjet of 2.3 mm was observed, leading to some modifications in the treatment approach in recently started cases. A short period of interceptive orthopedic treatment in the very early mixed dentition may be indicated to correct skeletal deviations and establish a normal relationship between the maxilla and the mandible. Treatment could then be followed by a period without appliance wear until final dentoalveolar adjustments, if necessary, are made in the permanent dentition.

Edward Angle believed in the possibility of stimulating growth and of achieving considerable changes in maxillary and mandibular morphology. If a normal function was established, adaptation of the craniofacial pattern would subsequently follow. The introduction of cephalometric roentgenology proved, however, that this theory did not hold true, and for many years it was generally accepted that orthodontic treatment could influence only the dentoalveolar area of the maxilla and the mandible. This was a drawback, particularly in treatment of Class II cases, where changes in the position of the maxillary and
mandibular basal bones are considered to be of great importance.

In the late 1950s, however, headgear therapy in the mixed dentition produced an effect upon the base of the maxilla,\textsuperscript{3-5} and further research proved the possibility of changing the development of the entire craniofacial complex.\textsuperscript{6} Functional orthopedic therapy in Europe also gave reason to speculate upon stimulation of growth and changes in the relationship between the maxilla and the mandible.\textsuperscript{7-18}

Subsequent animal studies showed, in most investigations, considerable response to experimental treatment with headgear and with functional orthopedic appliances.\textsuperscript{19-39} The effect of treatment in these experiments is often dramatic, but a comparison of the reaction in animals and in human beings is sometimes disappointing. The extent of orthopedic treatment effect in patients is not always what we would like to see clinically in severe Class II malocclusions where we usually have both maxillary protrusion and mandibular retrusion to treat.\textsuperscript{40,41} Anchorage, force, age at start of treatment, and treatment intensity may be factors of importance.\textsuperscript{42,43}

ANCHORAGE

The use of the first molars to transfer the force to the base of the maxilla has been quite common.\textsuperscript{44,45} In ordinary headgear treatment the average treatment effect is a combination of tooth movement and an effect upon the base of the maxilla with a major response in the dentoalveolar area. In order to transfer as much force as possible to the base of the maxilla, splints may be used with an attempt to distribute the force over the total dentoalveolar area for better anchorage purposes.\textsuperscript{46-48} Furthermore, in many severe ANB cases, we would like to see an anterior movement of the mandible as well as a posterior movement of the maxilla. The use of an appliance that jumps the mandible anteriorly not only influences the effect of treatment upon the maxilla but may also affect mandibular growth and position, as demonstrated in mixed-dentition treatment.\textsuperscript{49-51}

It is important to use the total dentoalveolar area in both the maxillary and the mandibular arches as anchorage for transferring forces to affect the interrelationship between maxillary and mandibular basal bones.

FORCE

There is reason to believe that there is a certain correlation between the amount of force and the orthopedic effect of treatment.\textsuperscript{52} One reason for the dramatic effect of treatment in animal experiments could be the heavy forces used which, in relation to size and weight of the animal, vastly exceed those used in patients. If we talk about orthopedic forces in human beings, we usually mean forces in the magnitude of 500 to 1,000 gm of pressure on each side. These forces can be increased. When the total maxillary dental arch is used as anchorage, forces up to 1,500 gm on each side can be applied without discomfort to the patient.
AGE

Esthetics, possible trauma, and poor function are factors that favor early treatment for severe Class II malocclusions. The attempt to coordinate the start of treatment with the pubertal growth spurt has dominated the question of the timing of treatment. There is evidence to support the belief that orthopedic treatment is more effective in the early mixed dentition. 53-56

Sutural remodeling seems to be intensive during an active growth period but may also be related to the maturity of the skeleton. Thus, in effect, a younger child could be more susceptible to relocation of anatomic structures than an older one. Artificial deformation of the heads of newborn children was a common practice among some tribes in South America. The deformation of bony parts in young children had lasting effects, while force applied upon skeletal bone in later years gave less bone deformation. 57

In an earlier report of a headgear investigation of two groups of patients in which one group started treatment in the very early mixed-dentition period and the other group in the late mixed-dentition period, it was found that the orthopedic effect of headgear treatment was significantly greater in the younger age group. 58 Fractures of the condyle and the remodeling process in the temporomandibular joint in cases with condylar displacement have been studied. 59 The recovery and return to a normal condyle-fossa relation were faster in the younger child, with a decrease in adaptation with age. All this may lead to speculation that the components of the craniofacial complex in the young person are more receptive to change and that treatment in the very early mixed dentition may be indicated.

TREATMENT INTENSITY

In most cases treated in the mixed dentition, appliances are constructed for nighttime wear only, and 12 to 18 hours of wear is supposed to give maximum treatment effect. 38 According to other studies, the orthopedic effect of treatment may increase if proper anchorage is used and if the appliance is worn 24 hours. 60 Stimulation of mandibular growth reported in many investigations of activator treatment may not be significant in view of the fact that the appliances are worn only at night, with a reverse effect from occlusion in the absence of the appliance during the day.

The Herbst appliance has been reintroduced in the orthodontic treatment of Class II malocclusions. In several investigations a clinically significant stimulation of mandibular growth as a result of a 24-hour jumping effect upon the mandible is suggested. 61-70

Increased activity in the lateral pterygoid muscle, correlated with increased condylar growth, was a constant finding in some animal studies. 30,31 Later research has suggested that it might rather be the tension of the posterior part of the condylar capsule, the
meniscotemporal ligament, caused by the activity of the lateral pterygoid muscle that is actually responsible for increased condylar activity.\cite{32,35} Some findings, show that the activity of this muscle and the ensuing tension of structures in the posterior part of the capsule decrease after a maximum level of activity 6 to 8 weeks after the start of treatment.\cite{25,30} Therefore, a constant reactivation of the appliance may be indicated to maintain a maximum condylar growth response and treatment intensity.

An orthopedic improvement is needed in patients with large sagittal discrepancies between the maxilla and the mandible in order to accomplish a stable, esthetically and functionally satisfactory treatment result. The purpose of this investigation was to study the effect of orthopedic treatment on a group of patients with severe Class II malocclusion. A treatment approach was selected which specifically took into consideration important factors such as type of anchorage, amount of force, timing, and intensity of treatment.

**MATERIAL AND METHODS**

The material for the investigation consisted of fourteen boys and thirteen girls with severe Class II malocclusions in the early mixed dentition (Table I). These were all patients referred to the orthodontic department in Basel to be investigated because of large sagittal jaw deviations. Patients with ANB discrepancies of 8° or more were offered treatment with a headgear-Herbst appliance. The average morphology of patients in the group to be treated as compared to normal children revealed a maxillary protrusion and a severe mandibular retrusion. A shorter mandible (Co-Gn) and a face height (N-Me) that was smaller than in normal cases was also found. The mandibular plane angle was normal.

The average age of the patients was 8 years 4 months. The sample of twenty-seven children was divided into a treatment group of eighteen cases and a control group of nine cases. The treatment group consisted of nine boys and nine girls; the control group comprised five boys and four girls. The children in the control group were also offered treatment but with a later treatment start and could therefore be used as a control during the treatment and posttreatment periods. Both groups were closely matched according to sex, age, length of observation time, and severity of malocclusion.

For the treatment group, an appliance was constructed with a cast splint of Vitallium bonded to the lower arch and with bands on the upper permanent first molars. The bands were united with a palatal bar and connected to the lower splint with Herbst telescopic arms, constantly keeping the mandible in a forward, jumped position. In addition, a plate was constructed in the upper jaw as anchorage for a headgear to be worn 12 to 14 hours per day. A combination of high-pull and low-pull forces was used. Forces of 1,500 to 2,000 gm on each side were used during active treatment in the first ten cases. However, the amount of force was reduced in subsequent cases and did not exceed 1,500 gm. Initial problems, such as breakage of the upper bands, gave further reason to alter the appliance design. After 2 months an upper splint, similar to the lower splint with built-in tubes for the headgear,
replaced the bands, palatal bar, and plate in the upper arch in the 4 first patients and was a routine procedure in subsequent cases treated (Fig. 1, A).

At the start of treatment, the telescopic arms were adjusted so that the mandible was jumped to a normal Angle Class I molar relationship. Two months later the mandible was moved to an end-to-end bite in the incisor area, and after an additional period of 2 months the mandible was jumped to a slightly inverted incisor relationship in an attempt at overtreatment. This was done each time by adding a piece of tube of approximately 2.5 mm length to the telescopic arms (Fig. 1, B). The patients did not complain about discomfort from the oral or condylar area.

The average active treatment time was 5 months. At the end of active treatment the Herbst telescopic arms were removed. If, 1 week after disconnection of the telescopic arms, the patients could not bite in a more retruded position than in a Class I molar occlusion, the splints were removed. In three cases the treatment time had to be prolonged another month in order to reduce the overjet further. A 6-month period during which an activator was worn at night followed active treatment. The construction bite in wax was taken with the lower jaw positioned in the achieved Class I molar relationship and with a bite opening of 3 mm between the upper and lower incisors (Fig. 1, C).

The material for the analysis consisted of oriented lateral head roentgenograms. For each case studied, the first head film was taken prior to treatment, the second film after active treatment, and the third film 10 months posttreatment. During the posttreatment period the activator was removed after 6 months; this was followed by a 4-month period without appliances. The head films were taken in centric occlusion and also with the mouth wide open to facilitate the study of contour of the mandibular condyles. Differences in changes within the two groups were considered to be due to treatment. An area of registration for superimposition was established, using the anterior cranial base with sella-nasion as reference. The occlusal plane and a line perpendicular to it through sella formed a grid system that was transferred from the first tracing to the second, thus in effect referring all registrations to the area of superimposition. Vertical and horizontal changes in the position of the maxilla and the mandible were measured to the grid system and recorded to the nearest 0.5 mm. Some angular measurements were used. Changes in the position of the mandibular condyles were studied by measuring the distance from condyion to the intersection between the line from condyion to gnathion and the inferior outline of the cranial base (Fig. 2, A and B).

In addition, transcranial roentgenograms of the mandibular joints were taken before and after treatment and 10 months after removal of the headgear-Herbst appliance. The supracondylar space was studied on the left and right sides of each patient in the treated group. From the thirty-six sets of roentgenograms available (right and left for each patient), three were eliminated because of difficulties in exact location of the mandibular condyle.
Changes in measurements were registered from the posterosuperior part of the condyle to the outline of the fossa along a line in the direction of the condylar process. Pre- and posttreatment roentgenograms on each patient were carefully compared to find the same area and direction of measurement (Fig. 2, C).

Cephalograms of twelve patients before and after treatment were traced and superimposed with measurements recorded at 2-week intervals. The combined error in location of the anatomic landmarks, the error of superimposition, and the measurement error were estimated. Any difference obtained between the duplicated tracings will describe the magnitude of error involved. The combined standard error for landmark location, superimposition, and measurement did not exceed 0.7 mm for any of the vertical and horizontal dimensions registered

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SE\text{ Meas.} = \sqrt{\frac{\sum d^2}{2N}}
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A statistical analysis of the data was applied. The difference in changes between the two groups was subjected to analysis. Student t tests estimated the significance of differences obtained. The null hypothesis was rejected at the 0.05% level of confidence (Tables II, III, IV, and V).

**RESULTS**

**Mean changes during and after treatment (Tables II to V and Figs. 2 and 3)**

The mean change in the sagittal relationship between the maxillary and mandibular incisors after active treatment with the headgear-Herbst appliance was 7.5 mm (Tables II and III). The maxillary incisors in the treated group were 3.1 mm more posterior in position than in the control group. Half of this distance (1.5 mm) was registered as an influence upon the base of the maxilla with a posterior change in position of point A and PTM. The remaining distance (1.6 mm) was considered to be distal tooth movement of the maxillary teeth within the dentoalveolar area.

The mandibular incisors in the treated group were 4.4 mm more anterior in position than in the control group. This was mostly due to change in position of the base of the mandible with a more anterior position of point B following treatment (3.9 mm) and partly due to a labial movement of the incisors (0.5 mm). In addition, the angle between the corpus and the ramus increased (1.9°). The face height increased 1.4 mm more in the treated group than in the control group. Surprisingly, no significant change in the mandibular plane angle was found posttreatment. The mandibular condyle was in a 1.3 mm more anteroinferior position after active treatment. However, no significant difference in supracondylar space was registered (Table IV).

An activator was used during the first 6 months of the following 10-month period and
development continued within average norms for growth increments in both groups (Table V). Mandibular growth continued to the same extent in the treated group as in the control group. However, the mandibular development in an anterior direction registered as anterior movement of point B was less pronounced in the treated group, with a significant difference between the groups (1.3 mm) and with a subsequent increase in overjet posttreatment (2.3 mm).

In the treated group the mandibular condyle moved into a more posterosuperior position than in the control group (1.2 mm). No significant difference in the increase in face height was found between the treated group and the control group 10 months after treatment with the headgear-Herbst appliance. Two patients from the treated group are presented in Figs. 4 and 5.

DISCUSSION

The effect of treatment on the maxilla

In spite of the attempt to transfer as much force as possible to the base of the maxilla with a splint, distal movement of the dentoalveolar area was evident. This effect upon the maxilla with influence upon surrounding anatomic structures is similar to the findings of a previous headgear investigation in which a combination of basal and dentoalveolar changes was also found.71,72 There is, however, a difference in treatment time. The changes in this investigation are registered after 5 months of active treatment, followed by 6 months' wear of an activator to reduce relapse tendencies. Similar changes for headgear treatment are usually registered after 1½ to 2 years. In order to try to lessen the dentoalveolar effect of treatment in patients in whom distal tooth movement might be contraindicated, the headgear force against the maxilla has been reduced to 500 to 1,000 gm in recently started cases. It seems possible to get a good effect also without too heavy a force.

The effect of treatment on the mandible

All patients showed a normal relationship in the position of the jaws after 5 months of active treatment. Some investigations emphasize the importance of a functional treatment component involving muscle activity in order to influence mandibular growth.30,31 In animal experiments where the mandible was jumped forward and locked in a forward position without possible functional activity, very little stimulation of condylar growth was demonstrated. However, in cases in which the mandible was positioned anteriorly by occlusion or by functional appliances, stimulation of condylar growth was reported to be a constant finding.

It was generally accepted that only functional orthopedics could stimulate growth in these experiments. In later research, however, it was found that anterior guiding by intermaxillary traction also appeared to stimulate growth in the mandibular condylar area.36,39 Appliances
with a functional mechanism similar to the Herbst appliance would most likely give a similar treatment effect.

These animal experiments support the findings in the present investigation. In all patients a significant effect of treatment upon the mandible was registered. Increased length in distance between condylium and gnathion was a constant finding. This could be interpreted as a stimulation of growth in the mandibular condyle. Furthermore, an increase in the corpus-ramus angle was registered. A change of normal growth into a more posterior direction would explain this finding and would contribute to an increase in length of the mandible. In most cases the face was short before treatment and the increase in face height following the change in mandibular position was considered favorable. There was no significant change in the mandibular plane angle following the more anterior position of the mandible after treatment. It was possible to jump the mandible with the Herbst appliance in most cases without subsequent posterior mandibular rotation.

The change in mandibular length and morphology does not explain the total change in anterior repositioning after active treatment. The condyles were in a more anteroinferior position than in the control group. However, the supracondylar space had not increased. The mandible could not be relocated posteriorly after treatment. It is tempting to speculate that an appositional growth process in the fossa occurred, with a subsequent anteroinferior translation, following the jumping of the mandible. A double contour of the fossa outline found in nineteen of thirty-three sets of mandibular joint films may possibly indicate an anterior transformation of the fossa (Fig. 6).

The double contour in the supracondylar space found in young children following condylar displacement after jaw fractures supports this finding, as well as histologic evidence in animal experiments. Increased mandibular growth, change in mandibular morphology, and an anterior transformation of the fossa would be some factors responsible for the overall picture of anterior mandibular development.

The effect of headgear-Herbst treatment in the mixed dentition has not been reported in the literature. Changes in occlusion following Herbst treatment in the permanent dentition in children has been investigated. There is a similarity in the effects of treatment, but the amount of orthopedic change in the relationship between the maxilla and the mandible appears to be more pronounced in this investigation, where treatment was performed upon a younger age group. In some animal experiments possible degenerative changes in the condylar area have been reported following anterior jumping of the mandible. Since the adaptability of skeletal structures may improve in the younger child, there is reason to believe that the prognosis in relation to changes in the temporomandibular joint is more favorable with early treatment.

**Changes after active treatment**
Mandibular growth continued to the same extent in the treated group as in the control group during the period following headgear-Herbst treatment. However, mandibular development in an anterior direction (point B) decreased in the treated group. In spite of the favorable skeletal adaptation to the change in intermaxillary relationship, muscles and ligaments may not have fully adjusted. Consequently, anterior movement of point B was less emphasized in the treated group than in the control group after headgear-Herbst treatment with a subsequent increase in overjet.

Because of these findings, some modifications in the treatment approach have been introduced on recently started cases. Time may be needed for an adaptation to take place, and the mandible should function in an anterior position for a longer period. Headgear-Herbst treatment time is therefore increased to 6 months. In order to increase the anterior movement of point B during the period after headgear-Herbst treatment, the mandible is jumped forward to an edge-to-edge incisor relationship in the activator. Furthermore, the activator period of 6 months is not ended abruptly. A gradual decrease in wear of the activator during another 5-month period in which it is used every other night, then every third night, and at the end of the period once a week is recommended to improve the possibility of maintaining the normal intermaxillary retention until full adaptation has taken place. The question of relapse or stability can be answered only when these cases have been out of retention several years.

**Future perspective: Interceptive orthopedics**

It is possible that Edward Angle’s basic theory in relation to growth and development is correct under certain circumstances. If normal occlusal and muscular function is established early, an adjustment of the craniomaxillary pattern may follow. As far as intermaxillary orthopedic treatment effects are concerned, change in the relationship between the jaws and a favorable adaptation to the newly established function might be possible, according to Angle’s principles, if treatment is started in the very early mixed dentition.

If the results prove stable, a new approach in treatment timing of severe Class II malocclusions may be indicated. To avoid prolonged mixed-dentition treatment, often followed by further fixed appliance therapy or supplementary surgical treatment, an intensive, very early orthopedic correction may be indicated. After a normal relationship between the maxilla and the mandible has been established, treatment could then be followed by a break until final dentoalveolar adjustments, if necessary, are made in the permanent dentition.

**SUMMARY AND CONCLUSION**

The orthopedic effect of orthodontic treatment in cases of large sagittal discrepancies is often of small magnitude in relation to dentoalveolar changes. The purpose of this investigation was to study the effect of treatment on a group of patients with severe Class II malocclusions when a treatment approach was selected which specifically took into consideration important factors such as type of anchorage, amount of force, age at start of
treatment, and intensity of treatment. The attempt was to obtain a maximum orthopedic improvement.

A special headgear-Herbst appliance was constructed and a short intensive treatment in the very early mixed dentition was performed for less than 5 months. This active treatment was followed by a period of 6 months with an activator. The following average changes in dentofacial pattern were registered after active treatment in comparison to an untreated control group:

1. A very dramatic effect of treatment was found in all cases with an average change of 7.5 mm in the sagittal relationship between the maxillary and the mandibular incisor teeth.

2. The effect upon the maxillary teeth in a posterior direction (3.1 mm) was a combination of distal tooth movement (1.6 mm) and a change in position of the base of the maxilla (1.5 mm).

3. The effect upon the mandibular teeth in an anterior direction (4.4 mm) was mostly due to anterior change in position of the base of the mandible (3.9 mm) and, to some degree, following labial movement of mandibular incisors (0.5 mm). These changes were interpreted as a result of (a) stimulation of growth of the mandibular condyle, (b) change in mandibular morphology with an increase in the corpus-ramus angle, and (c) anterior change in position of the mandible with a possible tendency toward an anteroinferior translation of the condylar fossa.

4. During the period that an activator was in use following active treatment, mandibular growth continued to the same extent in the treated group as in the control group. A tendency to relapse was observed with an increase in overjet (2.3 mm). To try to decrease this tendency, some modifications in the treatment approach have been introduced in recently started cases.

If stability of the treated cases is achieved, a new approach in treatment timing of severe Class II malocclusions with maxillary protrusion and mandibular retrusion may be indicated. This approach entails a short period of interceptive orthopedic treatment to correct skeletal deviations as early as possible. I would avoid a long treatment time in the mixed dentition, and the correction could then be followed by a break until further dentoalveolar adjustments, if necessary, are made in the permanent dentition.

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