Effective temporomandibular joint growth and chin position changes: Activator versus Herbst treatment. A cephalometric roentgenographic study

Sandra Baltromejus, Sabine Ruf and Hans Pancherz
Department of Orthodontics, University of Giessen, Germany

SUMMARY In 138 successfully treated Class ll division 1 patients (40 Activator and 98 Herbst) effective temporomandibular joint (TMJ) growth changes (a summation of condylar remodelling, glenoid fossa remodelling, and condylar position changes within the fossa), and their influence on the position of the chin and the rotation of the mandible were analysed retrospectively. Lateral head films in habitual occlusion from before and after an average treatment period of 2.6 years for the Activator patients and 0.6 years for the Herbst patients were evaluated. Two different treatment changes were assessed: (1) overall growth changes and (2) treatment effects (overall growth changes minus age-related normal growth values: Bolton Standards).

   The comparison between the Activator and the Herbst group revealed larger effective TMJ and chin changes during Activator therapy due to the longer observation period (2.6 years versus 0.6 years). The treatment effects showed marked group differences for both the amount and direction of effective TMJ changes. The changes were vertical and slightly anterior in the Activator group, and predominantly posterior in the Herbst group. Concerning the chin changes, the treatment effects for the Herbst group exceeded those for the Activator group in both directions, caudally and anteriorly. The Activator group showed an anterior rotation and the Herbst group a slight posterior rotation of the mandible. The present investigation revealed that the effective TMJ and chin changes were increased by both Activator and Herbst treatment. However, the Herbst appliance renders more favourable sagittally orientated treatment effects in a much shorter period of time compared with the Activator.

Introduction

Improving a patient's facial profile and normalizing the occlusion by reducing mandibular retrognathism and producing orthognathic relationships is the general objective in dentofacial orthopaedics of Skeletal Class II malocclusions.

   Using the Activator (Andresen and Häupl, 1945) the orthopaedic effect is a topic of controversy. Some authors state that the skeletal effect of Activator therapy is confined to a restriction of maxillary growth (Jakobsson, 1967; Harvold and Vargervik, 1971; Ahlgren and Laurin, 1976; Pancherz, 1984; Steinhardt *et al.*,

1990; Hashim, 1991), whereas others are of the opinion that the Activator also stimulates condylar growth (Marschner and Harris, 1966; Parkhouse, 1969; Luder, 1981; Birkebæk *et al.*, 1984; Ehmer, 1985; Vargervik and Harvold, 1985; Versyck and Rakosi, 1989; Jakobsson and Paulin, 1990; Ruf *et al.*, 2001). An influence of Activator treatment on the glenoid fossa has also been reported (Dahan *et al.*, 1969; Birkebæk *et al.*, 1984).

   Utilizing the Herbst appliance (Herbst, 1910), skeletal treatment effects in terms of a stimulation of condylar growth (Pancherz, 1979, 1982a; Wieslander, 1984; Pancherz and Littmann, 1989; Paulsen *et al.*, 1995; Pancherz *et al.*, 1998;

Ruf and Pancherz, 1998, 1999) have been demonstrated. Fossa remodelling contributing to the skeletal effects of the Herbst appliance has also been shown (Pancherz, 1979; Wieslander, 1984; Pancherz and Hägg, 1985; Decrue and Wieslander, 1990; Paulsen *et al.*, 1995; Ruf and Pancherz, 1998).

Using classic cephalometric landmarks such as condylion, articulare, supramental, or pogonion in the analysis, it remains unclear whether the Activator is able to alter the growth of the facial skeleton. This is most probably the result of methodological problems, as the above-mentioned classic reference points have either a limited reproducibility (Adenwalla *et al.*, 1988; Moore *et al.*, 1989; Ghafari *et al.*, 1998), or are influenced by growth (Stickel and Pancherz, 1988) or mandibular rotation. These problems are overcome using the method of Creekmore (1967) in the evaluation of mandibular growth. This method assesses the so-called effective temporomandibular joint (TMJ) growth changes, which are a summation of: (1) condylar remodelling; (2) glenoid fossa remodelling; and (3) positional changes of the condyle within the fossa. Thus, three adaptive processes in the TMJ contributing to the changes in mandibular position are evaluated simultaneously.

The aim of the present investigation was to analyse and compare the effect of the Andresen type of Activator and the Herbst appliance during Class II treatment in terms of effective TMJ growth changes and their influence on the position of the chin considering mandibular rotation in the evaluation.

Subjects

The patient material comprised 40 (17 male and 23 female) Activator patients and 98 (59 males and 39 females) Herbst patients. They were selected retrospectively from the total patient pool. All subjects exhibited a Class II division 1 malocclusion of at least half a cusp distal molar relationship, which was treated successfully (Class I molar relationship, normal overjet and overbite) with their corresponding appliance. The mean pre-treatment age was 10.3 (7.5–13.6) years for the Activator group and 12.6 (9.5–16.1) years for the Herbst group. The pre-treatment mandibular plane angle did not differ between the Activator (mean = 32.4 degrees; 25–45 degrees) and Herbst subjects (mean = 32.0 degrees; 17.5–47 degrees).

Method

For each patient, two lateral head films with the teeth in habitual occlusion were available, one from before treatment and the other at the end of treatment. The average evaluation period was 2.6 (1.2–3.4) years for the Activator patients and 0.6 (0.5–1.1) years for the Herbst patients. The head films were traced by hand on matte acetate paper. Linear and angular head film measurements were performed to the nearest 0.5 mm and 0.5 degrees, respectively. All registrations were performed twice and the mean value of the duplicate registrations was used in the final evaluation. The linear roentgenographic enlargement of 7 per cent in all head films was not corrected.

To assess the effective TMJ growth changes, the chin position changes, and the rotational changes of the mandible, the roentgenograms of each patient in a series were superimposed on the first head film. Anterior cranial base and mandibular superimpositions were performed according to the method of Björk and Skieller (1983) using stable bone structures, and the lower border of the mineralized second or third molar germ (before root development begins) for orientation.

Landmarks

An arbitrary condylar point (Co) in the area of the condylar head (Creekmore, 1967; Pancherz *et al.*, 1998; Ruf and Pancherz, 1998, 1999) was used. The point was defined on the pre-treatment head film and transferred to the post-treatment head film after superimposition of the films on the stable bone structures of the anterior cranial base (Björk and Skieller, 1983; Figure 1). A chin point (Pogonion = Pg) defined as the most anterior point of the bony chin in relation to the nasion–sella line was marked separately on the pre- and post-treatment head films.
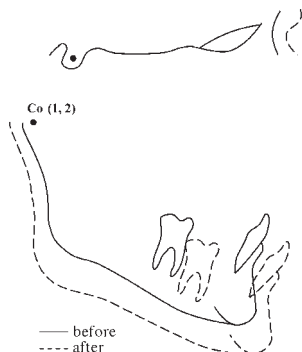
Figure 1 Definition of the condylar point: an arbitrary point in the area of the condylar head marked on the first head film (1) and transferred to the second head film (2) after superimposition of the films on the stable bone structures of the anterior cranial base.

Figure 2 Measurements of effective TMJ growth changes (point Co changes) in relation to the RL/RLp reference grid (defined on the first head film). Superimposition of the second head film (2) on the first head film (1) using the stable bone structures of the mandible for orientation.

Reference grid

A reference grid comprising of the following lines was constructed: a horizontal reference line (RL) and a reference line perpendicular (RLp). The RL was defined as a line that connects the incisal edge of the most prominent central lower incisor and the disto-buccal cusp tip of the first permanent lower molar. The line corresponds to the *X*-axis of the grid. The RLp is a line perpendicular to RL through the midpoint of the sella turcica. The line corresponds to the *Y*-axis of the grid.

The RL/RLp reference grid was defined on the pre-treatment head film and transferred to the post-treatment head film after superimposition of the films on the stable bone structures of the anterior cranial base (Björk and Skieller, 1983).

Variables and measuring procedure

The treatment changes of the reference points (Co and Pg) were related to the reference grid (RL/RLp). The sagittal (X) and vertical (Y) co-ordinates of Co and Pg were assessed. The pre-treatment values represented the 0-point on the grid. Additionally, the changes in angulation of RL from before to after treatment were measured.

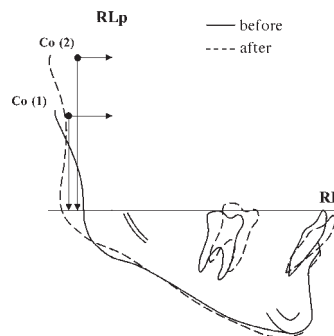For the assessment of effective TMJ growth changes, superimposition of the head films was

performed on the stable bone structures of the mandible (Björk and Skieller, 1983; Figure 2). The position change of the point Co is a summation of: (1) condylar remodelling; (2) glenoid fossa remodelling; and (3) condylar position changes within the fossa. The distance changes Co/RLp imply sagittal effective TMJ growth and for Co/RL vertical effective TMJ growth changes.

For the assessment of chin position changes, superimposition of the head films was performed on the stable bone structures of the anterior cranial base (Björk and Skieller, 1983; Figure 3).
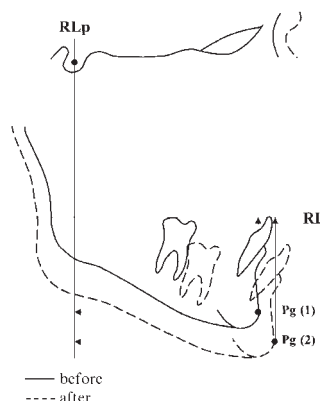

Figure 3 Measurements of chin position changes (point Pg changes) in relation to the RL/RLp reference grid (defined on the first head film). Superimposition of the second head film (2) on the first head film (1) using the stable bone structures of the anterior cranial base for orientation.

The position change of point Pg is a result of (1) effective TMJ growth changes and (2) rotation of the mandible. The distance changes Pg/RLp imply sagittal chin position changes and for Pg/RL vertical chin position changes.

For the assessment of mandibular rotation superimposition of the head films was performed on the stable bone structures of the mandible (Björk and Skieller, 1983; Figure 4). The angular change of the RL represents the rotation of the mandible (Björk and Skieller, 1983). This is a result of: (1) effective condylar growth; (2) vertical maxillary growth; (3) vertical dento-alveolar changes in the maxilla and the mandible; (4) the amount of overbite correction; and (5) the steepness of incisal guidance.

Two different treatment changes were evaluated: (1) overall growth changes and (2) treatment effects.

The overall growth changes are a summation of the changes due to: (1) physiological growth and (2) changes induced by the functional appliance (Activator/Herbst).

The treatment effects were calculated to eliminate the difference in physiological growth amount between the Activator (mean = 2.6 years) and the Herbst samples (mean = 0.6 years). The Bolton Standards (Broadbent *et al.*, 1975) were used as a control sample representing physiological growth. The standards comprise longitudinal growth data. Annual composite

Figure 4 Measurements of mandibular rotation (RL inclination changes). Superimposition of the second head film (2) on the first head film (1) using the stable bone structures of the mandible for orientation.

lateral head film tracings from 32 untreated subjects (16 males and 16 females) with ideal occlusions followed from 6 to 18 years of age were evaluated. The analysis of the effective TMJ and chin changes was performed as described above. The enlargement of the Bolton tracings varied between 5.5 and 5.8 per cent, and was adapted to that of the Activator and Herbst patients. The Bolton changes were interpolated to suit the individual age and examination interval of each Activator and Herbst patient. These age-related Bolton changes were considered as the physiological growth during the treatment period and were subtracted from the overall growth changes in the assessment of the treatment effects.

Statistical methods

The arithmetic mean (mean) and standard deviation (SD) were calculated for each variable. To assess gender and group differences Student's *t*-tests for unpaired samples were utilized. The levels of significance used were $P < 0.001$ (***), $P < 0.01$ (**), and $P < 0.05$ (*); $P \geq 0.05$ was not considered significant (NS).

Method error evaluation

The size of the combined method error (ME) in locating the reference points, superimposing the roentgenograms, and measuring the variables was assessed upon double registrations of all 40 Activator and 98 Herbst subjects. The formula of Dahlberg (1940) was used in the calculation:

$$ME = \sqrt{(\Sigma d^2/2n)}$$

where *d* is the difference between two registrations of a pair and *n* is the number of double registrations.

For the Activator sample the ME amounted to 0.80 mm for effective condylar growth (Co) and chin position changes (Pg), and to 0.75 degrees for the rotation of the mandible (RL). Concerning the Herbst sample, the ME amounted to 0.65 mm for effective condylar growth (Co), to 0.95 mm for the chin position changes (Pg), and to 0.70 degrees for the rotation of the mandible (RL).
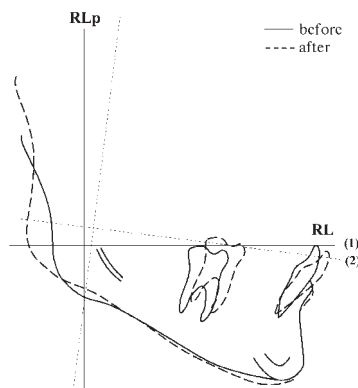
Table 1 Changes of the cephalometric variables in 40 Activator (17 males and 23 females) and 98 Herbst patients (59 males and 39 females) during 2.6 years (Activator) and 0.6 years (Herbst) of observation. The overall growth changes and the treatment effects are given.

Variable	Group	Observation period					
		Overall growth changes			Treatment effects		
		10.3–12.9 years	12.6–13.2 years		10.3–12.9 years	12.6–13.2 years	
		Activator	Herbst	Activator/Herbst	Activator	Herbst	Activator/Herbst
		Mean	Mean	*t*-value	Mean	Mean	*t*-value
Co/RLp	M	–2.71	–2.95		–0.04	–2.33	
(mm)	F	–1.74	–2.73		1.07	–2.07	
	M+F	–2.15	–2.86	2.100*	0.60	–2.23	8.223***
Co/RL	M	10.78	3.47		4.28	1.91	
(mm)	F	8.74	2.46		2.06	0.88	
	M+F	9.61	3.07	6.871***	3.01	1.50	3.666***
Pg/RLp	M	4.72	2.58		0.47	1.40	
(mm)	F	3.97	1.69		–0.05	0.60	
	M+F	4.29	2.23	4.536***	0.17	1.08	1.965N.S
Pg/RL	M	–7.84	–4.03		–2.98	–3.06	
(mm)	F	–6.07	–3.72		–0.95	–2.70	
	M+F	–6.82	–3.91	7.472***	–1.82	–2.92	2.702**
RL (°)	M	–1.66	0.22		–2.47	0.07	
	F	–1.88	0.72		–2.84	0.54	
	M+F	–1.79	0.42	7.636***	–2.69	0.26	9.737***

***$P < 0.001$; **$P < 0.01$; *$P < 0.05$; NS, $P > 0.05$.
Minus (–) implies: posterior movement of Co, caudal movement of Pg, and anterior rotation of RL.
Plus (+) implies: cranial movement of Co, anterior movement of Co and Pg, and posterior rotation of RL.

Results

All 40 Activator and 98 Herbst patients were treated to a Class I dental arch relationship with a normal overjet and overbite. The changes of the cephalometric variables during the examination period are presented in Table 1.

Effective TMJ changes

Overall growth changes (Figure 5). During the treatment period the changes of point Co in the Activator and Herbst group exhibited a large inter-individual variation. In the Activator group point Co changed its position ($P < 0.001$) almost five times more cranially (mean = 9.6 mm) than posteriorly (mean = 2.1 mm). In the Herbst group the amount of point Co changes ($P < 0.001$) was about the same in the vertical
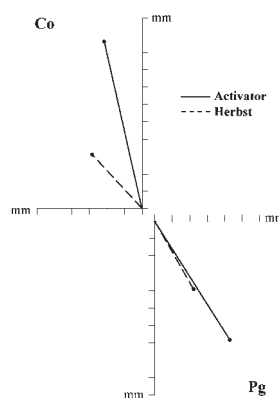

Figure 5 Overall growth changes (mean values). Effective TMJ growth changes (Co) and chin position changes (Pg) in 40 Activator patients (17 males and 23 females) and 98 Herbst patients (59 males and 39 females). Scale in 1 mm steps.

(mean = 2.8 mm) and sagittal (mean = 3.1 mm) directions. Compared with the Activator group the changes in the Herbst group were larger [mean (d) = 0.7 mm; $P < 0.001$] in the sagittal direction and smaller [mean (d) = 6.5 mm; $P < 0.001$] in the vertical direction.

When comparing male and female subjects of both groups no gender differences with respect to the direction of Co changes were found. The amount of change was more extensive in the male subjects. Statistically significant differences ($P < 0.01$), however, were only found for the vertical changes in the Herbst group.

Treatment effects (Figure 6). During the 2.6 years of Activator treatment point Co moved predominantly cranially (mean = 3.0 mm) and slightly anteriorly (mean = 0.6 mm). In the Herbst group, on the other hand, during the 0.6 years of treatment point Co moved markedly more posteriorly [mean (d) = 2.8 mm; $P < 0.001$] and only half as much [mean (d) = 1.5 mm; $P < 0.001$] cranially than it did during the 2.6 years of Activator treatment.

Chin changes

Overall growth changes (Figure 5). As with point Co, point Pg changes in the Activator and Herbst group exhibited a large inter-individual variation.
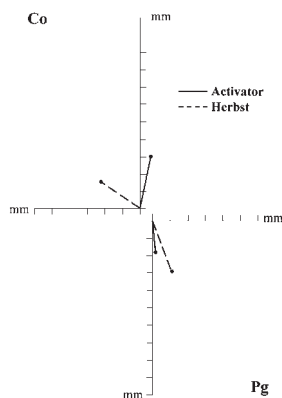
In the Activator group point Pg changed its position ($P < 0.001$) anteriorly (mean = 4.3 mm) and caudally (mean = 6.8 mm). Concerning the Herbst group point Pg also moved ($P < 0.001$) anteriorly (mean = 2.2 mm) and caudally (mean = 3.9 mm). Compared with the Activator group the amount of point Pg changes during Herbst treatment was about half as much in both sagittal [mean (d) = 2.1 mm; $P < 0.001$] and vertical [mean (d) = 2.9 mm; $P < 0.001$] directions.

When comparing the male and female subjects of both groups no gender differences with respect to the *direction* of Pg changes were found. However, the *amount* of change was more extensive in the male subjects, especially in the vertical direction in the Activator group [mean (d) = 1.8 mm; $P < 0.05$] and in the sagittal direction in the Herbst group [mean (d) = 0.9 mm; $P < 0.05$].

Treatment effects (Figure 6). During the 2.6 years of Activator treatment point Pg moved predominately caudally (mean = 1.8 mm) with almost no change taking place in the sagittal direction (mean = 0.2 mm). In the Herbst group, on the other hand, during the 0.6 years of treatment point Pg moved both more anteriorly [mean (d) = 0.9 mm, NS] and more caudally [mean (d) = 1.1 mm; $P < 0.01$] than it did during the 2.6 years of Activator treatment.

Rotation of the mandible

Overall growth changes (Figure 7). The RL rotated anteriorly (mean = –1.8 degrees) during

Figure 6 Treatment effects (mean values). Effective condylar growth (Co) and chin position changes (Pg) in 40 Activator patients (17 males and 23 females) and 98 Herbst patients (59 males and 39 females). Scale in 1 mm steps.
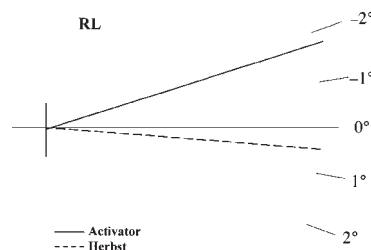

Figure 7 Overall growth changes (mean values). Mandibular inclination changes in 40 Activator patients (17 males and 23 females) and 98 Herbst patients (59 males and 39 females). Scale in 1 degree steps.

Figure 8 Treatment effects (mean values). Mandibular inclination changes in 40 Activator patients (17 males and 23 females) and 98 Herbst patients (59 males and 39 females). Scale in 1 degree steps.
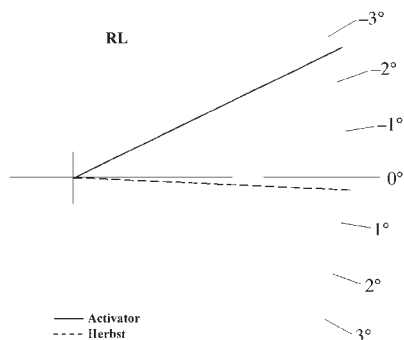
the 2.6 years of Activator treatment ($P < 0.001$) and posteriorly (mean = 0.4 degrees) during the 0.6 years of Herbst treatment ($P < 0.01$). Thus, the amount of rotation of the RL in the Herbst group was approximately 25 per cent of that in the Activator group and in the opposite direction [mean (d) = 2.2 degrees; $P < 0.001$]. However, the rotation of the RL in both groups exhibited a large inter-individual variation with both anterior and posterior directions being found.

When comparing the male and female subjects of both groups, no gender differences with respect to the direction of RL changes were found. However, the amount of change (NS) tended to be more extensive in the female subjects of both treatment groups.

Treatment effects (Figure 8). During the 2.6 years of Activator treatment the RL rotated anteriorly (mean = –2.7 degrees), whereas during the 0.6 years of Herbst treatment its inclination changed slightly posteriorly (mean = 0.3 degrees). The group difference was statistically significant [mean (d) = 3.0 degrees; $P < 0.001$].

Discussion

The present control group comprised untreated subjects with ideal occlusion (the Bolton Standards; Broadbent *et al.*, 1975). It would have been desirable to compare the data of the

Activator and Herbst group with longitudinal growth data of untreated subjects with Class II malocclusions to eliminate possible differences in growth pattern. Unfortunately, no such sample comprising a sufficient number of subjects exists. As, however, the main difference between Class I and Class II subjects has been reported to be the absolute size of the mandible rather than the growth pattern (Buschang *et al.*, 1986, 1988; Bishara *et al.*, 1997), it seemed valid to use the Bolton Standards as a control group. However, due to the lack of skeletal maturity data for the Bolton Standards, only an age-related comparison with the Activator and the Herbst group could be performed. Possible group differences with respect to growth velocity could not be excluded (Björk and Helm, 1967; Taranger and Hägg, 1980; Hägg and Pancherz, 1988). Furthermore, an earlier onset of the pubertal growth spurt in the Activator and the Herbst patients in comparison with the Bolton subjects due to secular reasons could not be ruled out (Hultgren *et al.*, 1978; Zurlo de Mirotti *et al.*, 1995; Hauspie *et al.*, 1997; Jaeger *et al.*, 1998).

Effective TMJ changes

Analysis of the overall growth changes in the Activator group and comparison with the Bolton Standards revealed that condylar growth could be increased. However, it has been suggested that an observed difference between a treated and a control group can only be considered biologically significant if it exceeds two standard deviations (Baumrind and Frantz, 1971). This was the case for only the vertical component of the effective TMJ growth changes (see Table 1). Thus, a biologically significant stimulation of condylar growth seems to be possible with Activator treatment, as has been reported earlier (Hultgren *et al.*, 1978; Birkebæk *et al.*, 1984; Jakobsson and Paulin, 1990), although not in the desired therapeutic (sagittal) direction. Additionally, remodelling of the glenoid fossa and/or condylar position changes within the fossa (Dahan *et al.*, 1969; Birkebæk *et al.*, 1984; Vargervik and Harvold, 1985; Op Heij *et al.*, 1989) contributing to the changes of the chin position cannot be excluded.

Concerning the Herbst appliance, the effective TMJ growth changes were directed mainly posteriorly and were approximately three times larger than in the Bolton Standards. This could be primarily explained by the stimulating effect of the Herbst appliance on sagittal condylar growth (Pancherz and Hägg, 1985; Pancherz and Littmann, 1989; Paulsen *et al.*, 1995). However, as also stated above for the Activator group, glenoid fossa remodelling (Pancherz, 1981; Woodside *et al.*, 1987; Decrue and Wieslander, 1990) and repositioning of the condyle within the fossa (Pancherz and Stickel, 1989) could certainly contribute to these changes.

A direct comparison of the Activator and Herbst group based on the overall growth changes is impossible. Due to the longer treatment period in the Activator subjects the physiological growth and, thus, the overall growth changes in the Activator group exceeded those in the Herbst group. Therefore, the treatment effects were evaluated. They differed significantly between the Activator and Herbst group. While the effective TMJ growth changes in the Activator group were vertically and anteriorly directed, a more posterior development was found in the Herbst group. Thus, analysis of the treatment effects suggests a strong vertical condylar growth stimulation induced by Activator therapy. This increase of the vertical growth component might be due to the intermittent forces generated by the Activator in contrast to the continuous forces delivered by the Herbst appliance. Another reason may be the differences in vertical dentoalveolar changes induced by the two treatment methods. While Activator treatment results in extrusion of the upper and lower molars (Andersson and Ahlgren, 1977), Herbst treatment enhances an extrusion of lower molars, and an intrusion of the upper molars (Pancherz, 1982b). Basic differences in the physiological condylar/mandibular growth pattern (Björk, 1963, 1969; Björk and Skieller, 1972, 1983) between the Activator and the Herbst group explaining the different Co changes seem unlikely as the average mandibular plane angle was almost identical in both groups (Activator mean = 32.4 degrees; Herbst mean = 32.0 degrees).

Chin changes

Considering the overall growth changes, Pg changed its position anteriorly and caudally during the 2.6 years of Activator treatment. However, biologically significant changes could only be achieved in the vertical direction, while the desired increase in mandibular prognathism could not be achieved. This finding is in concordance with the results of Pancherz (1984), who in his Activator study reported even larger sagittal changes for the eugnathic control group. The stronger caudal displacement of Pg compared with the Bolton Standards was probably due to the treatment approach itself during which the mandible was displaced caudally along the path of incisal guidance normalizing the overbite. Additionally, the trimming of the Activator allowing for eruption of molars and premolars might also have contributed to a vertical jaw development. As for point Co, differences in mandibular growth pattern (Björk, 1963, 1969; Björk and Skieller, 1972, 1983) seemed not to account for the observed differences.

In the Herbst group, the chin moved anteriorly and caudally as a result of the effective TMJ growth changes. The amount of caudally directed chin change was approximately five times larger in the Herbst group compared with the Bolton Standards (Pancherz *et al.*, 1998).

Considering the treatment effects, a difference in the direction of chin changes could be found between the Activator and the Herbst group; the sagittal changes of Pg being larger in the Herbst group. The larger sagittal component of chin changes in Herbst patients has been reported earlier by Pancherz (1982a) and Wieslander (1984), and is probably due to the reported posterior stimulation of condylar growth associated with Herbst therapy (Ruf and Pancherz, 1998).

Rotation of the mandible

Considering the overall growth changes, the mandible rotated anteriorly in the Activator group. Hultgren *et al.* (1978) stated that a prerequisite for mandibular rotation is a discrepancy between anterior and posterior facial height development. The fact that condylar growth was stimulated predominantly in a vertical direction

during Activator therapy was thus responsible for the stronger anterior mandibular rotation when compared with the Bolton Standards.

In the Herbst group the mandible rotated slightly posteriorly. This could explain the increased vertical component of the chin position change in comparison with the condylar change (Pancherz *et al*., 1998). Furthermore, Pancherz *et al*. (1998) showed that during Herbst appliance therapy the direction of displacement of point Pg equals that of point Co if no mandibular rotation takes place.

Considering the treatment effects, the hypothesis was underlined that the stronger vertical displacement of point Co in the Activator group was associated with a larger anterior mandibular rotation compared with the Herbst group in whom the mandible rotated slightly posteriorly.

Eighty-six per cent of the Activator studies available in the literature report a significant reduction of the ANB angle during treatment. According to Albers and Dermaut (1996) these changes are, however, within the range of physiological growth. These authors conclude, in concordance with Björk (1951), that the orthopaedic effect of the Activator is biologically insignificant, whereas the Herbst appliance is the only functional appliance that demonstrates increased mandibular growth to a biologically significant degree. Based on the results of the present study, this conclusion can be refuted. Both appliances, the Activator and the Herbst, stimulate mandibular growth to a biologically significant degree. However, the therapeutic usefulness of the stimulatory effect of the two appliances differs, the Herbst appliance being the only one inducing significant sagittal condylar and chin position changes. This may be the result of the difference in force transmission (intermittent/continuous) between the two appliances.

Furthermore, the results of the present study might help explain a commonly seen clinical observation, that hypodivergent subjects react more favourably to Activator treatment than hyperdivergent subjects. As the Activator stimulates mainly vertical condylar growth, which is the physiological condylar growth direction in hypodivergent individuals (Björk, 1963, 1969; Björk and Skieller, 1972, 1983), the appliance effect directly adds to physiological growth. In hyperdivergent subjects, on the other hand, the physiological condylar growth direction and the direction of stimulated growth differ, and so are not summative. If this hypothesis was true, larger skeletal treatment effects would be expected in hypodivergent Activator patients. Unfortunately, to our knowledge no such study comparing the skeletal treatment effects of the Activator in subjects with different growth patterns exists in the literature. For the Herbst appliance, on the other hand, larger skeletal treatment effects have been demonstrated in hyperdivergent than in hypodivergent subjects (Ruf and Pancherz, 1997). This would be in agreement with the above-mentioned hypothesis, that in hyperdivergent Herbst subjects the physiological posterior condylar growth direction and the posteriorly directed stimulatory effect of the appliance on condylar growth are additive.

Conclusions

The present investigation demonstrates that in Class II subjects the effective TMJ and chin changes can be increased by both Activator and Herbst therapy compared with individuals with normal occlusion (Bolton Standards). Thus, Activator and Herbst therapy induce a skeletal mandibular treatment effect. However, due to the pronounced vertical TMJ changes in the Activator subjects no increase in mandibular prognathism beyond the amount to be expected by physiological growth could be accomplished. In the Herbst group, on the other hand, the TMJ and chin changes are more sagittally orientated. Thus, the Herbst appliance affects mandibular prognathism more favourably and in a much shorter period of time than the Activator.

Address for correspondence

Dr Sabine Ruf
Department of Orthodontics
Dental School
Justus-Liebig-University of Giessen
Schlangenzahl 14
D-35392 Giessen
Germany

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