The skeletofacial growth pattern pre- and post-dentofacial orthopaedics. A long-term study of Class II malocclusions treated with the Herbst appliance

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SUMMARY The purpose of this investigation was to analyse cephalometrically the skeletofacial growth changes before and after dentofacial orthopaedics in 17 male subjects treated with the Herbst appliance. Herbst therapy was performed during an average time period of 7 months. The pre- and post-treatment periods in each subject were of equal lengths and amounted to an average of 31 months. No treatment was performed during the two control periods. When comparing the growth changes during Herbst treatment with those during the pretreatment control period it was found that: maxillary growth was inhibited and redirected; mandibular growth was increased; anterior mandibular growth rotation was arrested; sagittal intermaxillary jaw relationship improved; the skeletal profile straightened and the Go angle increased. During the post-treatment period several of the treatment changes reverted. The results of the study indicated that dentofacial orthopaedics using the Herbst appliance had only a temporary impact on the existing skeletofacial growth pattern.

Introduction

In the field of dentofacial orthopaedics it has been claimed that normalizing the skeletal and soft-tissue morphology at a young age would provide a basis for continuing normal development of these structures (Angle, 1907; Bass, 1983; Wieslander, 1984). This has, however, never been proven.

The Herbst bite jumping device (Herbst, 1934) has been shown to be a most suitable orthopaedic tool in clinical experimental growth studies (Pancherz, 1979, 1981, 1982a, b 1985; Wieslander, 1984; Pancherz and Hägg, 1985; Pancherz and Hansen, 1986; Pancherz and Littmann, 1988, 1989). The purpose of this investigation was to analyse cephalometrically the skeletofacial growth changes occurring before and after dentofacial orthopaedics using the Herbst appliance. The study attempted to answer the question whether there was an adaption of post-treatment growth to the new skeletal morphology seen after orthopaedic intervention or whether growth returned to its original (pretreatment) pattern.

Subjects

The original sample of consecutive male patients treated with the Herbst appliance comprised 72 cases of Class II, Division I malocclusions (Hägg and Pancherz, 1988). From this sample, 17 subjects were selected in which pre- and post-treatment records of equal lengths (at least three times the treatment period) were available. No difference in skeletofacial morphology existed between the study sample and the target population at the start and end of Herbst treatment.

In the pre- and post-Herbst periods no treatment was given in any of the 17 subjects. In the post-Herbst period an upper Hawley plate and/or a lower cuspid to cuspid lingual arch wire was used for retention in eight of the subjects. The retention appliances were, however, not consi-
odered to affect the jaw growth pattern. Thus, the pre- and post-Herbst periods in each subject could be considered as control periods.

The mean ages of the subjects at the different times of examination were: 10.3 years (SD = 1.1 years) at the beginning of the pretreatment period, 12.9 years (SD = 0.6 years) at the start of Herbst treatment, 13.5 years (SD = 0.6 years) at the end of Herbst treatment, and 16.1 years (SD = 1.2 years) at the end of the post-treatment period. Herbst therapy was performed during an average time period of 7 months (range = 6–10 months). The average lengths of the pre- and post-treatment periods were 31 months (range = 20–48 months) each. Herbst treatment in all subjects was performed during the pre-peak–peak period of pubertal growth (Pancherz and Hägg, 1985) and the skeletal developmental stage (hard radiographs) at the end of treatment ranged from MP3F to MP3FG (Hägg and Pancherz, 1988).

**Methods**

*The Herbst appliance*

The Herbst appliance (Herbst, 1934) is a fixed bite jumping appliance. A telescope mechanism on either side of the jaw attached to orthodontic bands keeps the mandible continuously in a protruded position. The design and construction of the appliance has been described in detail earlier (Pancherz, 1985). At the start of treatment the mandible is advanced to an incisal edge to edge position. In this way the posterior teeth are out of occlusion and the dental arches placed in a Class I or over-corrected Class I relationship. Treatment is generally finished after 6–8 months. After removal of the appliance the sagittal occlusion is usually over-corrected, but is settling into Class I within a year after treatment (Pancherz and Hansen, 1986) (Fig. 1).

*Analysis of lateral cephalograms*

Profile radiographs in centric occlusion of each patient were analysed on the following four occasions (average values): 31 months pretreatment (Pre), at the start of Herbst treatment before inserting the appliance (Start), at the end of 7 months of Herbst treatment (End), and 31 months post-treatment (Post). The registrations from the roentgenograms were carried out on matt acetate tracing films. All registrations were performed twice and the mean values were used in the calculations. The angular measurements were made to the nearest 0.5 degree and the linear

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*Figure 1  Herbst treatment of a 12-year-old boy. (A) Before treatment. (B) Start of treatment—with the appliance. Lower anchorage was increased by a sectional arch wire (Pancherz and Hansen, 1988). (C) After 6 months of treatment when the appliance was removed. (D) Twelve months post-treatment (no retention was used).*
the skeletal profile (variable 4) straightened \((P<0.01)\) by Herbst therapy. The Go angle (variable 15) increased \((P<0.01)\).

During the post-treatment control period of 31 months a rebound occurred for several of the treatment changes: maxillary position (variable 1; ns), mandibular inclination (variable 5; \(P<0.05\)) and the Go angle (variable 15; \(P<0.001\)). Thus, the skeletal facial growth pattern existing before treatment prevailed, on average, after treatment.

Maxillary (variable 1) and mandibular (variable 2) growth directions were comparable in both control periods: The inclination of the maxilla in relation to the cranial base (variable 6) remained unchanged; the mandible rotated anteriorly (variable 5) and the Go angle (variable 15) was reduced in both periods. The skeletal profile (variable 4) which was improved during treatment remained unchanged during the post-treatment period. When looking at individual cases, large variations in the growth were, however, seen (Figs 5 and 6).

Case presentation
The cases of two boys illustrating differences in growth patterns during the three examination periods are presented.

Table 1 Cephalometric records describing skeletal facial morphology in 17 boys treated with the Herbst appliance. Pre = 31 months pretreatment; Start = start of Herbst treatment; End = end of 7 months of Herbst treatment; Post = 31 months post-treatment.

<table>
<thead>
<tr>
<th>Variable (in degrees or mm)</th>
<th>Pre</th>
<th>Start</th>
<th>End</th>
<th>Post</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
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<tr>
<td>Sagittal jaw relationships</td>
<td></td>
<td></td>
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<tr>
<td>1. s-n-sp</td>
<td>87.09</td>
<td>3.78</td>
<td>87.94</td>
<td>3.22</td>
</tr>
<tr>
<td>2. s-n-pg</td>
<td>76.24</td>
<td>3.83</td>
<td>77.21</td>
<td>3.94</td>
</tr>
<tr>
<td>3. sp-n-pg</td>
<td>10.45</td>
<td>3.44</td>
<td>10.74</td>
<td>4.07</td>
</tr>
<tr>
<td>4. n-sp-pg</td>
<td>160.00</td>
<td>5.84</td>
<td>159.94</td>
<td>6.29</td>
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<tr>
<td>Vertical jaw relationships</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5. ML/NSL</td>
<td>32.56</td>
<td>5.21</td>
<td>31.82</td>
<td>5.83</td>
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<tr>
<td>6. NL/NSL</td>
<td>5.00</td>
<td>2.34</td>
<td>5.00</td>
<td>2.45</td>
</tr>
<tr>
<td>7. ML/NL</td>
<td>28.56</td>
<td>3.49</td>
<td>27.77</td>
<td>5.60</td>
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<td>Jaw growth parameters</td>
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<td>8. n-s-sp</td>
<td>34.94</td>
<td>2.79</td>
<td>35.74</td>
<td>2.77</td>
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<tr>
<td>9. n-s-pg</td>
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<td>4.52</td>
<td>66.00</td>
<td>4.20</td>
</tr>
<tr>
<td>10. sp-s-pg</td>
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<td>3.67</td>
<td>30.21</td>
<td>3.45</td>
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<td>11. s-sp (mm)</td>
<td>83.10</td>
<td>5.30</td>
<td>87.06</td>
<td>5.20</td>
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<tr>
<td>12. s-pg (mm)</td>
<td>110.21</td>
<td>7.20</td>
<td>117.38</td>
<td>7.29</td>
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<td>Mandibular morphology</td>
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<td>13. ar-pg (mm)</td>
<td>98.85</td>
<td>5.80</td>
<td>104.26</td>
<td>6.52</td>
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<td>14. β angle</td>
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<td>15.59</td>
<td>2.93</td>
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<tr>
<td>15. Go angle</td>
<td>124.68</td>
<td>4.81</td>
<td>123.27</td>
<td>5.27</td>
</tr>
</tbody>
</table>
treatment examination periods were 3 years each. Herbst therapy was performed during the peak period of pubertal growth (Pancherz and Hägg, 1985). The patient's skeletal maturation level, assessed by hand radiographs (Hägg and Pancherz, 1988), ranged from MP3E 3 years pretreatment to MP3J 3 years post-treatment. The boy originally had a large mandibular plane angle (ML/NSL = 37 degrees) which was reduced during the examination period of 6.5 years. The mandible was positioned forward during treatment and continued to grow forward post-treatment. The Go angle was opened by 3 degrees during therapy, but recovered completely thereafter. The skeletofacial morphological changes occurring during 6.5 years of examination are illustrated in Fig. 6F.

Discussion

This study deals with the long-term effects of dentofacial orthopaedics considering the pre-treatment skeletofacial growth pattern in the evaluation of the post-treatment changes.

With the Herbst appliance it is possible to create an experimental model, applied in clinical research, similar to that in animal studies of growth interventive measures (Stöckl and Willert, 1971; McNamara, 1973, 1987; Woodside et al., 1987). Thus, the Herbst bite jumping mechanism is worn 24 hours a day and does not require the co-operation of the patient. In the present sample, the treatment goal to correct the Class II malocclusion was achieved in a short, almost standardized, period of time. In order to avoid possible influence of sex differences the study was confined to male patients.

The skeletal and dental effects of the Herbst appliance have been thoroughly analysed in earlier studies (Pancherz, 1979, 1982a,b, 1985; Pancherz and Hägg, 1985; Pancherz and Hansen, 1986, 1988) and will not be discussed here. The results of this investigation indicated that Herbst treatment had a temporary impact on the existing skeletofacial growth pattern. After the orthopaedic interventive period maxillary and mandibular growth seemed to strive to catch up with their earlier patterns. Similar findings were reported after treatment with cervical headgear (Melsen, 1978). In spite of the recovering growth changes after Herbst treatment, functional stability of the occlusion obviously counteracted

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**Case 1**

The patient (Fig. 5) was treated with the Herbst appliance for 7 months. The pre- and post-treatment examination periods were 2 years each. Herbst therapy was performed during the prepeak period of pubertal growth (Pancherz and Hägg, 1985). The patient's skeletal maturation level, assessed by hand radiographs (Hägg and Pancherz, 1988), ranged from stage MP3F 2 years pretreatment to stage MP3G 2 years post-treatment. The boy originally had a small mandibular plane angle (ML/NSL = 26 degrees) which was unchanged during the examination period of 4.6 years. The mandible was positioned forward during treatment, but dropped back post-treatment. The Go angle was opened by 4 degrees during therapy, but recovered completely thereafter. The skeletofacial morphologic changes occurring during 4.6 years of examination are shown in Fig. 5F.

**Case 2**

The patient (Fig. 6) was treated with the Herbst appliance for 6 months. The pre- and post-
SKELETOFACIAL GROWTH PATTERN

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<table>
<thead>
<tr>
<th></th>
<th>Pre 10.8 yrs</th>
<th>Start 12.8 yrs</th>
<th>End 14.3 yrs</th>
<th>Post 17.3 yrs</th>
</tr>
</thead>
</table>

Figure 6  Case 2. Extraoral and intraoral photographs. (A) 3 years pretreatment. (B) At the start of Herbst treatment before insertion of the appliance. (C) During Herbst treatment. Lower anchorage was increased by Class III elastics (Pancherz and Hansen, 1988). (D) At the end of 7 months of Herbst treatment after removal of the appliance. (E) 3 years post-treatment. (F) Superimposed cephalometric polygons.

occlusal relapses as seen in 14 of the 17 subjects investigated.

The increase in the Go angle and mandibular plane angle (ML/NSL) during Herbst treatment can be explained by the fact that condylar growth was redirected posteriorly and bone was resorbed at the posterior part of the mandibular lower border (Pancherz and Littmann, 1989). The subsequent decrease in the Go and ML/NSL angles post-treatment resulted from a change in condylar growth to a more vertical direction in combination with bone apposition at the posterior part of the mandibular lower border (Pancherz and Littmann, 1989). Similar changes in the Go angle were reported to occur in mandibular protrusion experiments in monkeys (McNamara, 1975; McNamara and Bryan, 1987). Furthermore, an anterior rotation of the mandible during growth (Björk, 1969; Riolo et al., 1974) and a vertically-orientated condylar growth pattern (Odegård, 1970; Björk and Skjeller, 1972) is a common finding in 'normal' untreated subjects.

Concluding remarks

In dentofacial orthopaedics of Class II malocclusions using the Herbst appliance it seems as if the inherent morphogenetic pattern dominates over the treatment procedure. This could also be true for other dentofacial orthopaedic approaches as well (e.g. activator, Fränkel, bionator). However, for verification further studies are necessary. Nevertheless, in evaluating the post-treatment effects of any orthopaedic measure on the skeletofacial growth pattern it would be desirable to make a comparison with longitudinal growth data from a matching group of untreated Class II subjects. However, such a group of subjects is difficult to find. Furthermore, in order to increase our knowledge about the long-term effects of dentofacial orthopaedics in clinical patients, mandibular growth interventive measures instituted at the end of the growth period should be analysed. This is because the results from studies in animals indicate that when experimental mandibular protrusion was performed throughout the growth period the genetically predetermined final length of the mandible could be increased (Petrovic et al., 1981; McNamara and Bryan, 1987).

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