When Is the Ideal Period for Herbst Therapy—Early or Late?

Sabine Ruf and Hans Pancherz

The present article aims at answering the question whether an early or late treatment approach is the ideal period for Herbst therapy. This topic will be discussed by summarizing and evaluating the short- and long-term effects of the Herbst appliance on the dentofacial complex. Special emphasis will be given to the treatment outcome in relation to the patient’s somatic and skeletal maturity at the time of therapy. Furthermore, the long-term stability of the treatment results will be addressed. The available knowledge in the literature demonstrates that the ideal period for Herbst treatment is in the permanent dentition at or just after the peak of pubertal growth corresponding to the skeletal maturity stages FG to H of the middle phalanx of the third finger (implying the pre-capping to pre-union stages of the ephiphysis and metaphysis). As mandibular growth stimulation is also possible in postadolescent-young adult subjects a new concept of Class II therapy is presented in which the Herbst appliance is used as an alternative to orthognathic surgery in older Class II subjects. (Semin Orthod 2003;9:47-56.) Copyright 2003, Elsevier Science (USA). All rights reserved.

One of the goals of dentofacial orthopedics in Class II malocclusions is to eliminate the skeletal jaw base discrepancy by stimulating mandibular growth. In a review article on the effect of functional appliances on skeletal growth, Aelbers and Dermaut\(^1\) concluded that the Herbst appliance (Fig 1) is the only functional appliance able to influence mandibular length to a biologically significant degree.

In general, Herbst treatment of Class II malocclusions results in a Class I or overcorrected Class I dental arch relationship. The correction of the increased overjet and Class II molar relationship is the result of the following dental and skeletal changes\(^3-5\): (1) maxillary growth inhibition, (2) mandibular growth enhancement, (3) maxillary molar distalization and maxillary incisor retrusion and retroclination, and (4) mandibular molar mesialization and mandibular incisor protrusion and proclination.

Herbst appliance treatment in the department of orthodontics at the University of Giessen is most often performed during the adolescent growth period, which is a time of optimal conditions for growth modification. However, skeletal adaptation is also possible in subjects at the end of growth.\(^5-7\) However, the question arises as to which is the ideal period relative to growth development (early or late) for (1) maximal mandibular growth stimulation and (2) long-term stability. This question will be addressed in light of information available in the literature.

Overview of Material and Methods

The interrelation between the amount of mandibular growth contributing to Class II correction and skeletal and/or somatic maturity has been investigated in 6 articles\(^8-13\) and the long-term stability as well as the factors contributing to Class II relapse in 7 articles.\(^14-20\) The material and methods used in the different articles are summarized in Tables 1 and 2. A total of 6

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different cephalometric analyses were used to study the dentoskeletal effects of the Herbst appliance.

In assessing somatic maturity of Herbst patients and control subjects, longitudinal growth records of standing body height over a 5- to 10-year period were analyzed. Individual distance and velocity growth curves were constructed. The peak height velocity of growth was identified on the curves, and at least 3 growth periods were established: prepeak, peak, and postpeak. 

Skeletal maturity (Fig 2) was assessed with the help of the radiographic developmental stages of the middle phalanx of the third finger and the radius bone using the method of Hägg and Taranger.

The Ideal Treatment Period for Maximal Mandibular Growth Stimulation

In all Herbst studies assessing the interrelation between somatic or skeletal maturity and mandibular growth stimulation, a large interindividual variation existed. Nevertheless, a general pattern could be identified showing a steady increase in sagittal condylar growth stimulation from the prepeak to the peak growth period, followed by a steady decline in the postpeak period (Fig 3). Subjects treated at peak or 1 to 2 years after peak exhibited the largest sagittal condylar growth and thus the largest mandibular length increase. Correspondingly, the greatest amount of sagittal condylar growth was found in subjects treated at the skeletal maturity stage MP3-FG (Fig 2), which occurs close to the peak growth period (Fig 4). This pattern was most obvious in boys, whereas in girls no marked differences in skeletal mandibular treatment effects were found when comparing different growth periods.

The increase of sagittal condylar growth in Herbst patients (Figs 3 and 4) was significantly greater than in untreated Class II control subjects. Irrespective of the growth period, the difference of mandibular length increase when comparing Herbst and control subjects amounted to an average of 1.3 mm. Thus, the increased amount of condylar growth accomplished by the Herbst appliance seems to be the result of an equal additions of enhanced growth to normally occurring condylar growth, irrespective of the somatic or skeletal maturation stage of the patients (Figs 3 and 4). Recent studies on the Herbst appliance have shown that mandibular growth stimulation is due to a remodeling of the condyle and also of the glenoid fossa. The latter can be routinely noted on magnetic resonance images of the TMJ area taken during treatment.

It is believed that Class II correction by orthopedic means is not possible after the age of 13.5 years in girls and 15 years in boys because 97% of the growth is completed at these ages. However, in using the Herbst appliance, it is possible
Table 1. Material and Methods Used in the 6 Articles on the Interrelation between the Amount of Mandibular Growth Contributing to Class II Correction During Herbst Treatment and the Treatment Growth Period

<table>
<thead>
<tr>
<th>Article</th>
<th>Subjects</th>
<th>Maturity</th>
<th>Lateral Headfilms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
<td>No.</td>
<td>Class</td>
</tr>
<tr>
<td>1. Pancherz and Hägg, 1985</td>
<td>Herbst</td>
<td>70</td>
<td>II</td>
</tr>
<tr>
<td>Control</td>
<td>23</td>
<td>II</td>
<td>x</td>
</tr>
<tr>
<td>2. Hägg et al., 1987</td>
<td>Herbst</td>
<td>72</td>
<td>II:1</td>
</tr>
<tr>
<td>Control</td>
<td>23</td>
<td>II</td>
<td>x</td>
</tr>
<tr>
<td>3. Hägg and Pancherz, 1989</td>
<td>Herbst</td>
<td>72</td>
<td>II:1</td>
</tr>
<tr>
<td>4. Pancherz and Littmann, 1988</td>
<td>Herbst</td>
<td>65</td>
<td>II:1</td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>II:1</td>
<td>x</td>
</tr>
<tr>
<td>5. Konik et al., 1997</td>
<td>Herbst</td>
<td>43</td>
<td>II:1</td>
</tr>
<tr>
<td>6. Ruf and Pancherz, 1999</td>
<td>Herbst</td>
<td>39</td>
<td>II</td>
</tr>
</tbody>
</table>

NOTE. Given are the number of subjects, the Angle Class (Class), the gender, the age of the subjects in years, the length of the observation period, the method for maturity assessment and the kind of lateral headfilms used to analyze the dento-skeletal effects as well as the observation times.

Abbreviations: OP, observation period; HO, habitual occlusion; MO, mouth open.

Table 2. Material and Methods Used in the 7 Articles on the long-term Stability of Class II Correction and the Factors Contributing to Class II Relapse After Herbst Treatment

<table>
<thead>
<tr>
<th>Article</th>
<th>Subjects</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group</td>
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<tr>
<td>7. Pancherz and Littmann, 1989</td>
<td>Herbst</td>
<td>12</td>
</tr>
<tr>
<td>Control</td>
<td>10</td>
<td>II:1</td>
</tr>
<tr>
<td>8. Pancherz and Fackel, 1990</td>
<td>Herbst</td>
<td>17</td>
</tr>
<tr>
<td>9. Pancherz, 1991</td>
<td>Herbst</td>
<td>29</td>
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<tr>
<td>10. Hansen et al., 1991</td>
<td>Herbst</td>
<td>40</td>
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<td>11. Hansen and Pancherz, 1992</td>
<td>Herbst</td>
<td>32</td>
</tr>
<tr>
<td>Control</td>
<td>32</td>
<td>II:1</td>
</tr>
<tr>
<td>12. Pancherz, 1994</td>
<td>Herbst</td>
<td>55</td>
</tr>
<tr>
<td>Control</td>
<td>55</td>
<td>II:1</td>
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<tr>
<td>13. Hansen et al., 1995</td>
<td>Herbst</td>
<td>53</td>
</tr>
</tbody>
</table>

NOTE. Given are the number of subjects, the Angle Class (Class), the gender, the age of the subjects at start of the observation period and at follow-up in years, the methods used, and the observation times.

*Follow-up for at least 5 years; the patients had to be at the end of the growth period at follow-up (skeletal maturity R1).

†Control = Bolton standards.

Abbreviations: LH, lateral headfilms; HO, habitual occlusion; MO, mouth open; Cast, dental casts; Clin, clinical examination.
Figure 2. Skeletal maturity stages of the middle phalanx of the third finger (MP3) and the radius (R) according to Hägg and Taranger \(^{21}\) and their interrelation to the pubertal growth velocity is shown. Stage MP3-E, the epiphysis is not yet as wide as the metaphysis. Stage MP3-F: the epiphysis is as wide as the metaphysis. Stage MP3-FG: the epiphysis is as wide as its metaphysis, and there is a distinct medial and/or lateral border of the epiphysis forming a line of demarcation at right angles to the distal border. Stage MP3-G: the sides of the epiphysis have thickened and also cap its metaphysis, forming a sharp edge distally at one or both sides. Stage MP3-H: fusion of epiphysis and metaphysis has begun. Stage MP3-I: fusion of epiphysis and metaphysis is complete. Stage R-I: fusion of epiphysis and metaphysis has begun. Stage R-IJ: fusion is almost completed, but there is a small gap at one or both margins. Stage R-J: fusion of epiphysis and metaphysis is completed.

to reactivate and stimulate condylar growth even in subjects at the end of growth.\(^{6,7,13}\) Although the total amount of mandibular length increase in young adults (skeletal maturity stages R-IJ or RJ, see Fig 2) is less than in adolescents, the amount of stimulated mandibular growth is identical.\(^{13}\) This implies that young adult Class II subjects can be treated successfully by means of the Herbst appliance. Thus, the treatment method could be considered to be an alternative to orthognathic surgery (Fig 5-7).

The relative contribution of skeletal and dental changes contributing to overjet correction varies considerably between individuals irrespective of gender, somatic, or skeletal maturity.\(^{6,11,13}\) In subjects with comparably severe Class II malocclu-

Figure 3. Mandibular growth (mm) relative to the pubertal peak (peak) of growth in 72 male Herbst patients treated for an average period of 7 months and 23 untreated male Class II Control subjects.\(^8\)

Figure 4. Mandibular growth (mm) relative to the skeletal maturity in 72 male Herbst patients treated for an average period of 7 months and 23 untreated male Class II Control subjects.\(^8\)
Figure 5. A female Class II, division 1 patient, 19 years of age, treated with a cast splint Herbst/Multibracket appliance system. Dental casts and intraoral photographs from before treatment (A), at start of Herbst treatment (B), after Herbst treatment (C), during multibracket appliance treatment (D), after multibracket appliance treatment (E), and 2 years post multibracket appliance treatment (F).
The largest skeletal effects contributing to overjet correction (Fig 8) were found in the peak period (MP3 FG-G). In postpeak patients (MP3 H-I) and young adults (R IJ-J) especially, the mandibular dental changes increased.13

The Ideal Treatment Period for Long-Term Stability

It has been claimed for a long time that normalizing the skeletal and soft-tissue morphology at an early age would provide a basis for continuing normal development of these structures.24-27 This has, however, never been proven. When analyzing Herbst patients 5 to 10 years after treatment, it was found that the total amount of maxillary and mandibular growth was greatest in those Herbst patients treated during the prepeak period.14 However, the improvement in sagittal jaw base relationship was found to be comparable between prepeak, peak, and post-
peak subjects; mandibular growth exceeded maxillary growth by 4.6 mm in prepeak, 4.2 mm in peak, and 3.9 mm in postpeak patients. Thus, the growth period in which the patients were treated did not have a marked influence on the long-term treatment result.14

Furthermore, in patients treated with the Herbst appliance, mandibular length increased more than in subjects with ideal occlusions (Bolton standards).29 At the end of the growth period, however, this treatment effect is no longer evident anymore (Fig 9). Therefore, the long-term total amount of mandibular growth was almost identical in the Herbst and the Bolton ideal occlusion groups.15 This was also true for the relative growth of the maxilla and the mandible; mandibular growth exceeded maxillary growth by 3.9 mm in the Herbst and by 4.1 mm in the Bolton cases (Fig 9). Thus, in Class II subjects, Herbst treatment improves the basal jaw relationship but does not normalize it compared with ideal occlusion subjects exhibiting normal growth.15,17,18 Despite the fact that mandibular growth is improved but not normalized, a stable Class I occlusion was found in 79% of 53 Herbst patients analyzed 5 to 10 years after treatment.16 A relapse in overjet and/or molar relation was mainly the result of posttreatment dental changes, especially in the maxilla,19 and was seen more frequently in early treated Herbst patients.20 In prepeak patients, overjet and/or molar relationship relapse was found in about 30% of the subjects. In postpeak patients, relapse in overjet was seen in only 8% of patients, and relapse in molar relationship was observed in none of the subjects. The most frequent relapse promoting factors identified were early treatment, unstable occlusion, and persisting habits.20

**Figure 7.** Female Class II, division 1 patient, 19 years of age, treated with a cast splint Herbst/Multibracket appliance system. Parasagittal magnetic resonance images of the right TMJ from before, after 9 weeks and after 8 months of Herbst treatment. Please note condylar remodeling at 9 weeks of treatment.

**Figure 8.** Percentages (%) of skeletal and dental changes contributing to overjet correction in Herbst patients treated at different skeletal maturity stages: MP3 E-F (n = 13), MP3 FG-G (n = 12), MP3 H-I (n = 21), R IJ-J (n = 14).
Figure 9. Maxillary and mandibular skeletal changes (mm) contributing to Class II correction in 32 Class II, Division 1 malocclusions (16 girls and 16 boys) treated with the Herbst appliance and 32 Class I Controls (Bolton standards). P1, observation period 1 from before treatment to 6 months post-treatment; P2, observation period 2 from 6 months post-treatment until the end of growth; Total, total observation period from before treatment until the end of growth.

In late treated Herbst patients, generally all permanent teeth were completely erupted, thus promoting a good interdigitiation of the cusps of the teeth after therapy. Teeth in a stable Class I intercuspation will certainly transfer maxillary growth forces to the mandible or vice versa and may therefore coordinate maxillary and mandibular growth, thus counteracting an unfavorable posttreatment growth pattern. Therefore, a stable intercuspation is an essential factor for the prevention of both dental as well as skeletal posttreatment relapses.3,4,19,20

Long-term stability of the occlusion in young adults treated with the Herbst appliance has not yet been shown scientifically. However, young adults are always in the permanent dentition and have minimal, if any, residual growth that might compromise the treatment result because of unfavorable growth causing relapse. Thus, young adults treated with the Herbst appliance would seem to have optimal conditions for long-term occlusal stability (Fig 5).

A New Concept for Class II Therapy

The current and widely accepted concept of skeletal Class II treatment is (1) growth modification (with functional appliances and/or headgear) in prepeak and peak patients, (2) camouflage orthodontics (extractions of teeth and fixed appliances) in postpeak patients, and (3) orthognathic surgery in adults (Fig 10).

Because of the results from our latest Herbst studies and especially with respect to the following factors, we are of the opinion that it is time to revise the prevailing concept.

1. In young adults condylar and glenoid fossa growth can be reactivated and altered favorably on a regular basis.6,7
2. In young adults, on average, 22% of skeletal changes contribute to overjet correction.13
3. Comparable changes in sagittal jaw base relationship and in the skeletal profile are observed in young adult Herbst and orthognathic surgery (mandibular sagittal split osteotomy) patients.30

The new concept of Class II treatment proposes the following: (1) growth modification in children and adolescents as well as in postadolescents and young adults (up to the age of 25 years), (2) camouflage orthodontics, and (3) orthognathic surgery in older adults (Fig 11).

Growth modification in children should be performed with removable functional appliances and/or headgear. In adolescents, postadolescents and young adults the Herbst appliance should be used.

Conclusion

With respect to maximum mandibular growth stimulation and long-term stability of treatment,
The ideal period for the Herbst appliance is in the permanent dentition at or just after the pubertal peak of growth corresponding to the skeletal maturity stages FG to H of the middle phalanx of the third finger (implying the pre-capping to preunion stages of the ephiphysis and metaphysis). Because mandibular growth stimulation using the Herbst appliance is also possible in postadolescent young adult subjects, a new concept of Class II therapy is proposed in which the appliance is used as an alternative to orthognathic surgery in older Class II subjects.

References