The mechanism of Class II correction during Herbst therapy in relation to the vertical jaw base relationship: A cephalometric roentgenographic study

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The success of Class II treatment with functional appliances is said to depend, among other things, on the vertical jaw base relationship. Hyperdivergent cases are supposed to exhibit an unfavorable reaction to therapy due to a posterior mandibular growth rotation.[2-5]

Prior studies on Herbst appliance treatment[6-8] have shown that, at least on a short time basis, mandibular growth direction can be changed by therapy and an unfavorable growth pattern can be overcome.

Champagne[9] reported that hyperdivergent subjects treated with the Herbst appliance exhibited more dental than skeletal changes. He attributed this to differences in the force vector of the appliance acting on the lower dentition when comparing subjects with different vertical jaw base relationships. Unfortunately, no statistical analysis of the results was performed.

The purpose of the present retrospective Herbst study was to analyze and compare the sagittal dental and skeletal effects contributing to Class II correction in patients with small or large pretreatment mandibular plane angles in order to reveal possible differences in treatment response among these subjects.

Materials and methods

Subjects

All Class II patients of the Department of Orthodontics, University of Giessen, who had

Abstract

This retrospective Herbst study analyzes and compares the sagittal dental and skeletal effects contributing to Class II correction in subjects with small or large pretreatment mandibular plane angles. Lateral headfilms of 15 hypodivergent (ML/NSL ≤ 26°) and 16 hyperdivergent (ML/NSL > 39°) Class II subjects treated to a Class I occlusal relationship with the Herbst appliance were analyzed. Radiographs were taken before and after an average treatment period of 7 months. Cephalograms were evaluated according to the method of Pancherz.[1] In both groups, improvements in sagittal incisor and molar relationships were achieved by greater dental than skeletal changes. The amount of skeletal changes contributing to overjet and molar correction was larger in the hyperdivergent group (37% and 44%, respectively) than in the hypodivergent group (25% and 25%, respectively). Dental and skeletal changes contributing to Class II correction were found to be independent of the vertical jaw base relationship. Thus, a hyperdivergent jaw base relationship did not affect the treatment response unfavorably.

Key words

Herbst appliance • Class II • High angle • Low angle • Treatment effects • Skeletal effects • Dental effects • Mandibular plane angle

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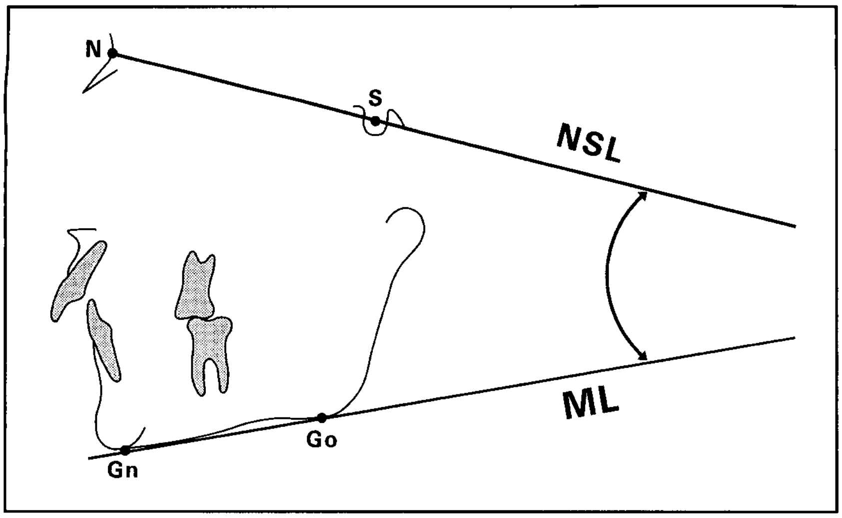

Figure 1

Figure 1
Assessment of the mandibular plane angle (ML/NSL). The following reference points were used: N (nasion), S (sella), Go (gonion) and Gn (gnathion).

Figure 2
Measuring points and the reference grid (OL and OLp) used in the cephalometric analysis. For definition of the landmarks see Materials and methods section.

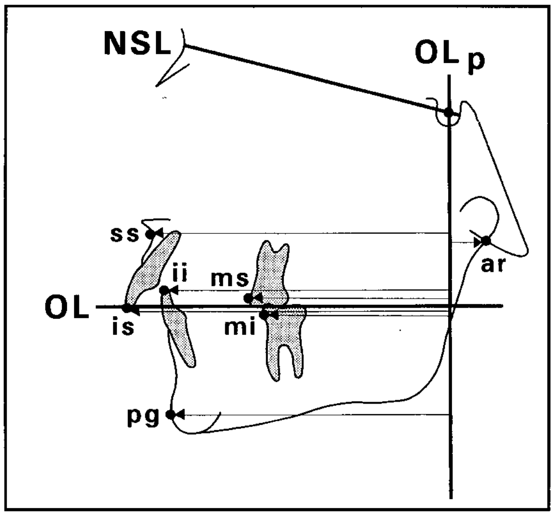

Figure 2

been treated with a Herbst appliance and exhibited a hypodivergent or hyperdivergent vertical jaw base relationship were included in the study. The patients were selected according to their pretreatment mandibular plane angle (ML/NSL) (Figure 1):

Hypodivergent, ML/NSL $\leq$ 26°(Mean= 22.1°, SD = 2.7°)

Hyperdivergent, ML/NSL > 39°(Mean = 42.1°, SD = 2.6°)

Sixteen subjects (3 females and 13 males) belonged to the hyperdivergent and 15 subjects (5 females and 10 males) to the hypodivergent group. The ages of the subjects at the start of Herbst treatment varied between 11 and 14 years. All patients were treated to a Class I or overcorrected Class I molar relationship within an average period of 7 months. The appliance used has been described earlier.[10]

Measurements

Pre- and posttreatment lateral headfilms from the patients were analyzed according to the method of Pancherz.[1] Headfilm measurements were made to the nearest 0.5 mm. For all the recordings on pre- and posttreatment radiographs, the occlusal line (OL) and occlusal line perpendicular (OLp) from the first headfilm were used as a reference grid. The grid was transferred from the first radiograph to the second radiograph by superimposition on the stable bone structures of the anterior cranial base.[11] All registrations were performed twice and the mean value was used for evaluation. The roentgenographic analysis comprised the following variables (Figure 2):

1. is/OLp minus ii/OLp = overjet.
2. ms/OLp minus mi/OLp = molar relationship (positive value indicates a distal rèlationship; negative value indicates a normal or mesial relationship).
3. is/OLp = position of the maxillary central incisor.
4. ii/OLp = position of the mandibular central incisor.
5. ms/Olp = sagittal position of the maxillary permanent first molar.
6. mi/OLp = sagittal position of the mandibular permanent first molar.
7. ss/OLp = position of the maxillary jaw base.
8. pg/OLp = position of the mandibular jaw base.
9. ar/OLp = position of the condyle.
10. pg/OLp plus ar/OLp = mandibular length.

Changes in the different measuring points in relation to OLp taking place during the treatment were calculated as the *after-minus-before* difference (*d*) in landmark position. Changes in variables 3 to 6 represent the composite effect of skeletal and dental changes while changes in variables 7 to 10 represent skeletal changes. Variables for dental changes within the maxilla and mandible were obtained by the following calculations (variables 11-14):

11. is/OLp (d) minus ss/OLp (d) = changes in position of the maxillary incisor within the maxilla.
12. ii /OLp (d) minus pg/OLp (d) = changes in position of the mandibular incisor within the mandible.
13. ms/OLp (d) minus ss/OLp (d) = changes in the position of the maxillary permanent first molar within the maxilla.
14. mi/OLp (d) minus pg/OLp (d) = changes

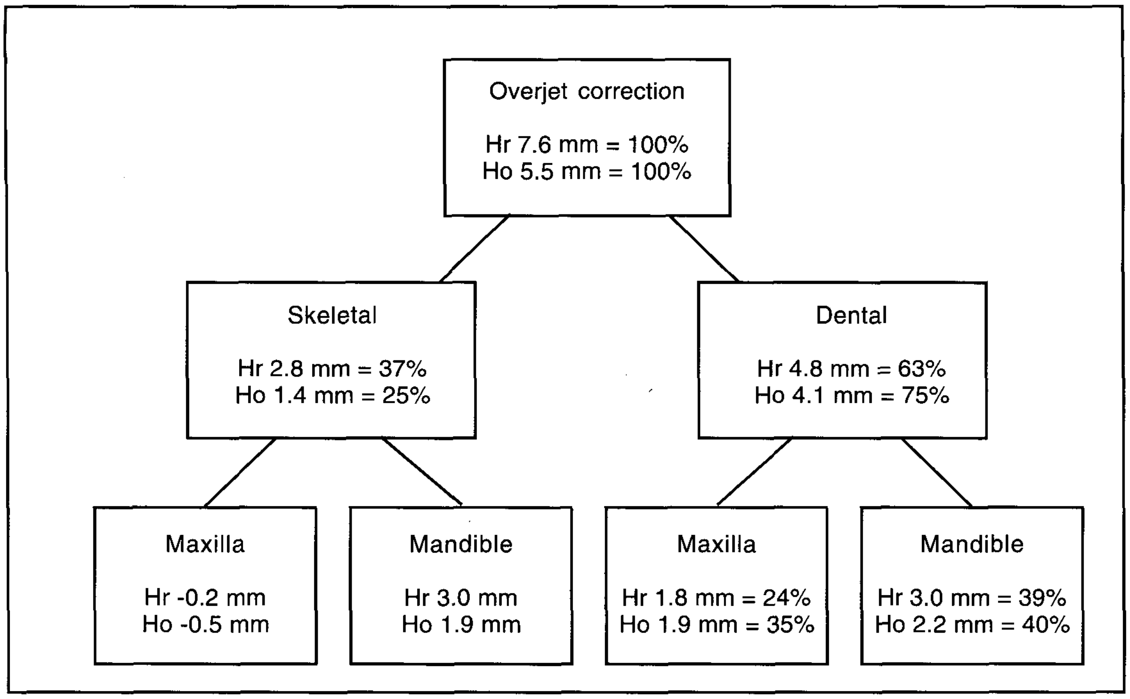

Figure 3

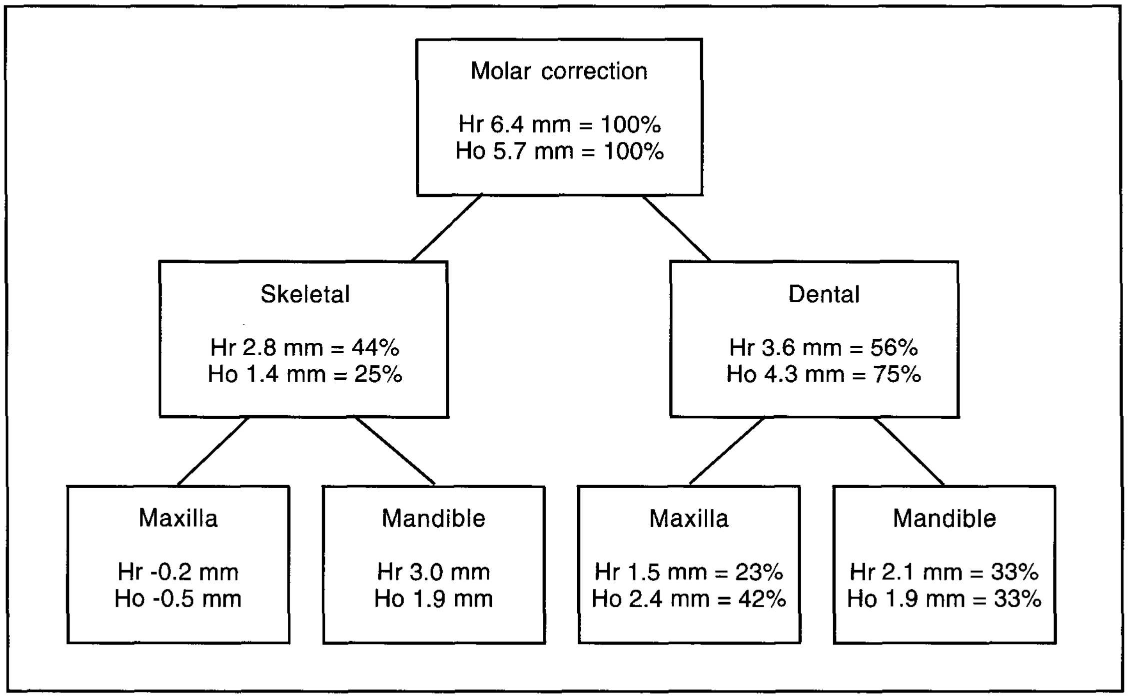

Figure 4

Figure 3
Dental (variables 11 and 12, Table 2) and skeletal (variables 7 and 8, Table 2) changes contributing to overjet correction in 16 hyperdivergent (Hr) and 15 hypodivergent (Ho) Class II malocclusion cases treated with the Herbst appliance.

Figure 4
Dental (variables 13 and 14, Table 2) and skeletal (variables 7 and 8, Table 2) changes contributing to sagittal molar correction in 16 hyperdivergent (Hr) and 15 hypodivergent (Ho) Class II malocclusion cases treated with the Herbst appliance.

in the position of the mandibular permanent first molar within the mandible.

Statistical methods

For the different variables the arithmetic mean (Mean) and the standard deviation (SD) were calculated. Student's *t*-tests for unpaired samples were performed to assess the statistical significance of the differences in the skeletal and dental changes between the two investigation groups. The significance was determined at the 0.05 (*), the 0.01 (**) and 0.001 (***) levels of confidence. A *p*-value larger than 0.05 was considered not significant (n.s.).

For assessment of the combined method error in locating, superimposing, and measuring the changes of the different landmarks, the pre- and posttreatment cephalometric radiographs from 10 randomly selected subjects were evaluated. The following formula was used for the method

Table 1
Cephalometric records before and after 7 months of Herbst appliance treatment in 16 hyperdivergent and 15 hypodivergent Class II malocclusions

Variable (mm)	Hyperdivergent group (n=16) Before Mean	S.D.	After Mean	S.D	Hypodivergent group (n=15) Before Mean	S.D.	After Mean	S.D.	Group difference Before Mean	p-value	After Mean	p-value
1. Overjet is/OLp minus ii/Olp	7.7	2.3	0.0	1.8	6.6	2.4	1.1	1.2	1.1	n.s.	-1.1	<0.05
2. Molar relation ms/OLp minus mi/OLp	+1,8*	1.7	-4,6 *	2.2	+1,6 *	1.7	-4,1 *	1.8	0.2	n.s.	-0.5	n.s.
3. Maxillary incisor is/OLp	80.8	3.5	79.1	4.6	79.9	5.0	78.4	5.3	0.9	n.s.	0.7	n.s.
4. Mandibular incisor ii/OLp	73.1	4.0	79.1	5.0	73.2	5.6	77.3	5.1	-0.1	n.s.	1.8	n.s.
5. Maxillary molar ms/OLp	50.4	3.5	49.1	4.2	49.5	4.1	47.6	4.0	0.9	n.s.	1.5	n.s.
6. Mandibular molar mi/OLp	48.6	3.3	53.7	4.8	47.9	5.0	51.7	4.5	0.7	n.s.	1.9	n.s.
7. Maxillary base ss/OLp	72.7	3.4	72.9	4.2	73.2	4.8	73.6	4.1	-0.4	n.s.	-0.7	n.s.
8. Mandibular base pg/OLp	70.3	4.1	73.3	5.5	74.4	5.3	76.3	4.5	-4.1	<0.05	-3.0	n.s.
9. Condyle ar/OLp	8.8	1.8	8.6	2.2	12.6	2.7	12.7	3.1	-3.7	<0.001	-4.1	<0.001
10. Mandibular length pg/OLp plus ar/OLp	79.1	4.3	81.8	5.2	86.9	5.5	88.9	4.0	-7.8	<0.001	-7.1	<0.001

* + indicates distal molar relationship; - indicates normal or mesial molar relationship

error (ME) calculation: $ME = \sqrt{\frac{\Sigma d^2}{2n}}$ where d is the difference between two registrations of a pair and n is the number of double registrations. The combined method error did not exceed 0.7 mm for any of the variables investigated.

Results

The results of the cephalometric analysis before and after 7 months of Herbst appliance treatment are shown in Table 1.

Before treatment, the hyperdivergent subjects exhibited a significantly reduced mandibular length ($p<0.001$), a more retruded position of the mandible (pg/OLp) and condyle (ar/OLp) ($p<0.05$ and $p<0.001$, respectively). For the dental parameters no significant group differences were perceptible.

After treatment, the group differences for mandibular length and condylar position (ar/OLp) were still present ($p<0.001$), while no group difference existed for mandibular base position (pg/OLp).

The effects for the 7 months of Herbst appliance treatment are shown in Table 2. Except for a larger overjet reduction ($p<0.05$) in the hyperdivergent group, no statistically significant differences were found for either skeletal or dental parameters. Unexpectedly, mandibular base (pg/OLp) was, on average, advanced 1.1 mm more in the hyperdivergent group than in the hypodivergent group, although the difference did not reach statistical significance.

The relationship between dental and skeletal changes contributing to Class II correction in the incisor and molar regions is shown in detail in Figures 3 and 4. In both groups the improvements in sagittal incisor and molar relationships were achieved by more dental than skeletal changes. The amount of skeletal change contributing to overjet and molar correction was larger in the hyperdivergent group

Table 2
Changes in cephalometric records during 7 months of Herbst appliance treatment in 16 hyperdivergent and 15 hypodivergent Class II malocclusions

Variable (mm)	Hyperdivergent (n = 16) Mean	S.D.	Hypodivergent (n = 15) Mean	S.D	Group difference (treatment effect) Mean	p-value
1. Overjet is/OLp(d) minus ii/Olp (d)	-7.6	3.2	-5.5	2.0	-2.2	<0.05
2. Molar relation ms/OLp (d) minus mi/OLp(d)	-6.4	2.7	-5.7	1.8	-0.6	n.s.
7. Maxillary base ss/OLp (d)	0.2	2.0	0.5	1.3	-0.2	n.s.
8. Mandibular base pg/OLp (d)	3.0	3.4	1.9	1.6	1.1	n.s.
9. Condyle ar/OLp (d)	-0.3	1.1	0.1	1.5	-0.4	n.s.
10. Mandibular length pg/OLp (d) plus ar/OLp (d)	2.7	3.2	2.0	2.4	0.7	n.s.
11. Maxillary incisor is/OLp (d) minus ss/OLp (d)	-1.8	2.7	-1.9	1.5	0.0	n.s.
12. Mandibular incisor ii/OLp (d) minus pg/OLp (d)	3.0	1.4	2.2	1.0	0.8	n.s.
13. Maxillary molar ms/OLp (d) minus ss/OLp (d)	-1.5	1.5	-2.4	1.5	0.8	n.s.
14. Mandibular molar mi/OLp (d) minus pg/OLp (d)	2.1	1.2	1.9	1.1	0.1	n.s.

(37% and 44%, respectively) than in the hypodivergent group (25% and 25%, respectively).

Discussion

Both pretreatment and posttreatment, the hyperdivergent subjects exhibited smaller mandibular lengths than the hypodivergent subjects. This was partly due to the geometrical effect of the measurement procedure. In hyperdivergent cases, increased inclination of the mandibular plane in relation to the occlusal plane[12] resulted in decreased mandibular length values. Furthermore, in interpreting the results, it should be taken into account that mandibular length was measured in relation to articulare and not in relation to a condylar landmark. This may imply a methodical error in individual cases, but it is a viable procedure for group comparison.[13] In agreement with previous Herbst studies,[1,10] Class II correction in the present subjects was a result of both dental and skeletal changes. Except for increased overjet reduction in the hyperdivergent group due to a larger pretreatment overjet, no significant group differences were present. This is in concordance with Dermaut et al.,[14] showing comparable skeletal and dental correction for hypodivergent and hyperdivergent subjects during headgear activator treatment.

Though not statistically significant, the skeletal reaction was larger in the hyperdivergent group than in the hypodivergent sample (Figures 3 and 4). This is in contrast to the findings of Champagne[9] who reported larger dental effects during Herbst treatment in hyperdivergent subjects. However, increased skeletal reaction in hyperdivergent cases has also been reported by Windmiller[15] using an acrylic-splint Herbst appliance. As Herbst treatment has been shown to stimulate bone apposition at the posterior pole of the condyle,[16-18] this therapeutic effect[6-8] coincides with the inherited horizontal condylar growth direction in hyperdivergent subjects[19] and could thus explain the unexpected favorable skeletal effect in the hyperdivergent subjects when compared with the hypodivergent group.

In conclusion, it can be said that the dental and skeletal treatment changes contributing to Class II correction during Herbst therapy are independent of the vertical jaw base relationship. Thus, a hyperdivergent jaw base relationship does not preclude a favorable treatment reaction.

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