

# Facial profile changes during and after Herbst appliance treatment

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**SUMMARY** The short- and long-term effects of the Herbst appliance on the facial profile were determined in 69 Class II, division 1 malocclusions treated for 7 months and followed for 5–10 years post-treatment. Forty-nine subjects exhibited a stable long-term treatment result, while 20 cases relapsed. Lateral cephalometric radiographs from before treatment, after treatment, 6 months post-treatment, and 5–10 years post-treatment were analysed.

As a rule Herbst treatment resulted in a reduction of the facial hard and soft tissue profile convexity. In relation to the E-line, the upper lip became retrusive, while the lower lip remained, on average, unchanged.

During the post-treatment period of 5–10 years the hard tissue profile convexity was, on average, reduced in both the stable and relapse groups. When excluding the nose in the soft tissue profile evaluation, the facial profile convexity was, on average, reduced in the stable group while it remained unchanged in the relapse group. When including the nose in the evaluation, an average increase in the profile convexity occurred in both examination groups. Furthermore, the upper and lower lips became retrusive in both groups. For all the variables, however, large individual variations existed.

In conclusion, it can be said that the Herbst appliance improves the facial hard and soft tissue profiles. Due to post-treatment growth changes the long-term effects of therapy are, however, variable and unpredictable.

## Introduction

Although the concept of an appealing facial soft tissue profile has not been clearly formulated we still seem to have definite ideals about a good profile. In accordance with the Caucasian ideal we undoubtedly prefer a fairly straight profile (Riedel, 1957; Burstone, 1958; Hambleton, 1964; Peck and Peck, 1970).

As a convex soft-tissue facial profile is the prominent feature in many Class II malocclusions one of the objectives in the orthodontic treatment is thus to improve the facial aesthetics *viz.* to reduce the profile convexity.

There appears to be agreement that treatment with fixed multibracket appliances and removable functional appliances will improve the facial appearance in Class II patients. Studies including soft tissue analysis are, however, mostly confined to the immediate treatment changes (Rudee, 1964; Roos, 1977; Forsberg and Odenrick, 1981; Falck and Köbel, 1985;

Remmer *et al.*, 1985; Haynes, 1986; Looi and Mills, 1986; Owen, 1986; Riolo and TenHave, 1986; Battagel, 1989). The facial profile changes occurring after therapy have received little attention (Anderson *et al.*, 1973; Finnöy *et al.*, 1987).

Much has been written about the skeletal and dental changes occurring during and after Herbst treatment (Pancherz, 1979, 1981, 1982a,b 1985, 1991; Wieslander, 1984; Pancherz and Hägg, 1985; Pancherz and Hansen, 1986; Pancherz and Littmann, 1988, 1989; Pancherz and Fackel, 1990; Hansen *et al.*, 1991; Hansen and Pancherz, 1992; Pancherz and Anehus-Pancherz, 1993), while studies dealing with the facial soft tissue profile changes are rare and confined to the immediate treatment effects (Pancherz, 1979; Riolo and TenHave, 1986; Eicke and Wieslander, 1990).

The purpose of this investigation was to assess the short- and long-term effects of the Herbst appliance on the facial hard and soft tissue profile, and to compare subjects with and

without post-treatment relapse in sagittal dental arch relationships.

### Subjects

The sample comprised of 69 Class II, division 1 malocclusions treated with the Herbst appliance for 6–8 months and followed for 5–10 years after therapy. Before treatment all subjects had a full Class II molar relationship, an overjet of at least 6 mm and a minimum ANB difference of 5 degrees. The Herbst therapy resulted in Class I or over-corrected Class I dental arch relationships in all cases. Following Herbst treatment retention (upper plate, activator or lower lingual arch wire) for 1–2 years was performed in 44 of the 69 subjects. At the time of follow-up the subjects were out of retention for a minimum of 4 years. No retention was performed in 25 subjects.

The patients were divided into two groups with respect to stability or relapse in sagittal dental arch relationships in the post-treatment period 2 (P2) (see the methods section):

*Herbst-stable* ( $n=49$ ): overjet unchanged or reduced and molar relationship in Class I. The group comprised of 32 males and 17 females.

*Herbst-relapse* ( $n=20$ ): overjet increased  $> 1$  mm and molar relationship in Class II (Class II = a deviation of  $> 1/2$  cusp width from normal relationship). The group comprised of 17 males and 3 females.

In the evaluation of the immediate treatment effects of the Herbst appliance 24 untreated Class II subjects were used for comparison. The control subjects had the same dentofacial morphology as the Herbst sample, *viz.* a full Class II molar relationship, an overjet exceeding 6 mm and an ANB difference of at least 5 degrees.

### Methods

Lateral cephalometric radiographs with the teeth in centric occlusion and the lips in relaxed position (Hillesund *et al.*, 1978) were examined. In the Herbst patients the radiographic records were taken before treatment (prior to the placement of the appliance), after 7 months of treatment (when the appliance was removed), 6 months post-treatment (when the occlusion had settled) (Pancherz and Hansen, 1986) and at follow-up (5–10 years post-treatment). Changes

in the cephalometric records during the four examination periods were analysed:

*Treatment period (T)*: difference between records after treatment and before treatment.

*Post-treatment period 1 (P1)*: difference between records 6 months post-treatment and after treatment.

*Post-treatment period 2 (P2)*: difference between records follow-up and 6 months post-treatment.

*Total observation period (O)*: difference between records follow-up and before treatment.

In the untreated Class II control group, lateral cephalometric radiographs from before and after 7 months were evaluated, and the cephalometric changes during the examination period ('T') were recorded.

The registrations from the roentgenograms were performed on matte acetate tracing film. Angular measurements were made to the nearest 0.5 degrees and linear measurements to the nearest 0.5 mm. No correction was made for linear enlargement (approximately 7% in the median plane). The reference points and lines used are seen in Fig. 1. and are those defined by Björk (1947), Subtelny (1959) and Ricketts (1957).

The cephalometric analysis comprised the following angular measurements (variables 1–3)

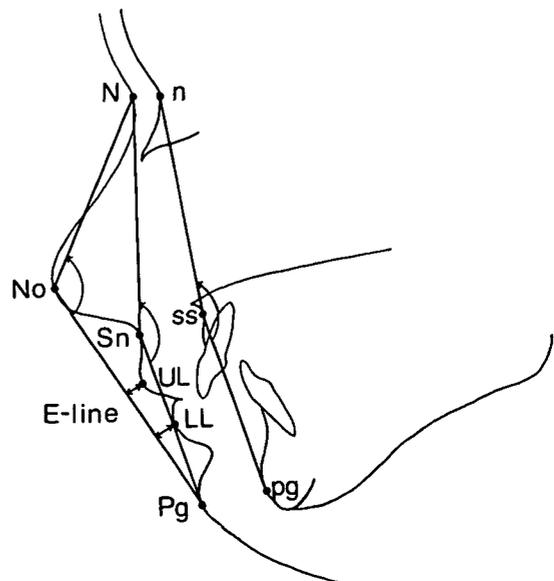


Figure 1 Reference points, planes, angles, and distances used in the cephalometric analysis.

and linear measurements (variables 4 and 5) (Fig. 1):

1. n-ss-pg: hard tissue profile convexity.
2. N-Sn-Pg: soft tissue profile convexity, excluding the nose.
3. N-No-Pg: soft tissue profile convexity, including the nose.
4. UL/E-line: upper lip position in relation to the E-line (+implies the lip in front of the E-line; -implies the lip behind the E-line).
5. LL/E-line: lower lip position in relation to the E-line (+implies the lip in front of the E-line; -implies the lip behind the E-line).

*Statistical methods*

The arithmetic mean (mean) and standard deviation (SD) were calculated for each variable. To assess the statistical significance of changes that occurred during the various examination periods, *t*-tests for paired samples were performed; to compare the Herbst-stable and Herbst-relapse subjects as well as the Herbst and control subjects, *t*-tests for independent samples were performed. The interdependence between various hard and soft tissue profile changes that occurred during the different examination periods was analysed with the Pearson coefficient of correlation (*r*).

The levels of significance used were  $P < 0.001$  (\*\*\*),  $P < 0.01$  (\*\*) and  $P < 0.05$  (\*).  $P \geq 0.05$  was considered not significant (NS). The *r*-values were appraised as follows:  $|r| > 0.70$  strong correlation,  $|r| 0.30-0.70$  moderate correlation and  $|r| < 0.30$  weak correlation.

The size of the combined method error (ME) in locating the landmarks and measuring the different cephalometric variables was calculated by the formula  $ME = \sqrt{(\sum d^2 / 2n)}$ , where *d* is the difference between two registrations of a pair, and *n* is the number of double registrations. Before treatment cephalograms from 10 randomly chosen subjects were analysed on two different occasions. The size of the method error did not exceed 0.5 degrees and 0.3 mm for any of the variables investigated.

**Results**

When comparing the males and the females in the Herbst-stable and Herbst-relapse group,

respectively, no differences were seen for any of the variables at any time of examination except for the angle n-ss-pg describing the hard tissue profile convexity: the males in the Herbst-stable group had a significantly ( $P < 0.05$ ) straighter profile than the females at all times of examination. In the presentation of the results (Tables 1-5 and Figs 2-6), the males and females were pooled.

*Hard-tissue profile convexity*

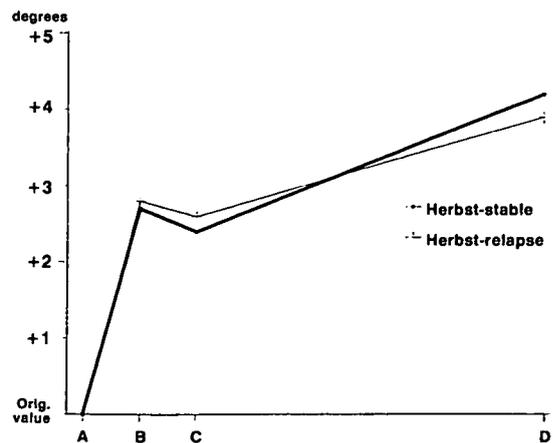
During the treatment period (T) the hard tissue profile angle increased in all subjects in the Herbst-stable (mean = 2.7 degrees;  $P < 0.001$ ) and Herbst-relapse (mean = 2.8 degrees;  $P < 0.001$ ) groups (Table 2, Fig. 2).

During the first post-treatment period (P1) the profile angle remained, on average, almost unchanged, but increased again during the second post-treatment period (P2) (Table 2, Fig. 2).

During the total observation period (O) there was an average increase in the profile angle of 4.2 degrees ( $P < 0.001$ ) in the Herbst-stable group and of 3.9 degrees ( $P < 0.001$ ) in the Herbst-relapse group (Table 2, Fig. 2).

When comparing the Herbst-stable with the Herbst-relapse subjects no differences were seen at any of the observation periods (Table 4, Fig. 2).

When comparing the Herbst and control



**Figure 2** Mean changes in the hard-tissue facial profile angle (n-ss-pg) in 49 Herbst-stable subjects and 20 Herbst-relapse subjects. (A) Before treatment (the original value at zero). (B) After 7 months of treatment, when the appliance was removed. (C) Six months post-treatment. (D) At follow-up 5-10 years post-treatment.

**Table 1** Cephalometric records describing the facial profile in 49 Herbst-stable patients, 20 Herbst-relapse patients and 24 control subjects. Registrations in the Herbst patients before treatment (before), after 7 months of treatment, when the appliance was removed (after), 6 months post-treatment (6 months), and 5–10 years post-treatment (follow-up). Registrations in the control subjects before and after 7 months of examination.

Variable (degrees or mm)	Herbst-stable				Herbst-relapse				Control	
	Before Mean SD	After Mean SD	6 months Mean SD	Follow-up Mean SD	Before Mean SD	After Mean SD	6 months Mean SD	Follow-up Mean SD	Before Mean SD	After Mean SD
Age (years)	12.7 1.2	13.3 1.2	13.8 1.2	19.5 1.2	12.2 1.1	12.8 1.1	13.3 1.1	18.9 1.5	11.3 0.8	11.9 0.9
n-ss-pg	170.8 4.6	173.5 4.4	173.2 4.3	175.0 5.1	171.6 5.5	174.4 5.4	174.2 5.6	175.5 4.7	168.5 3.1	168.3 3.3
N-Sn-Pg	156.6 6.1	159.9 4.7	159.0 4.5	160.7 5.7	159.8 4.5	163.0 5.2	162.1 4.0	161.9 4.3	158.7 3.0	158.6 3.3
N-No-Pg	131.3 5.4	132.6 5.3	131.4 5.1	129.8 5.3	134.8 5.2	135.4 5.4	133.9 5.1	131.3 4.5	133.1 3.4	132.8 3.7
UL/E-line*	+0.7 2.2	-1.1 2.1	-1.4 1.8	-3.7 2.5	+1.4 2.0	-0.9 1.9	-1.2 1.8	-3.1 1.9	+1.2 1.9	+0.9 2.1
LL/E-line*	+1.2 2.7	+0.8 2.4	-0.1 2.2	-2.2 3.0	+1.6 3.6	+0.9 2.7	+0.5 2.8	-1.3 2.9	+1.1 2.2	+0.9 2.6

\* + implies lips in front of the E-line; - implies lips behind the E-line.

**Table 2** Cephalometric records describing the facial profile changes in 49 Herbst-stable patients, 20 Herbst-relapse patients, and 24 control subjects. Registrations in the Herbst patients during the examination periods: T, P1, P2, and O. Registrations in the control subjects during the 'T' period.

Variable (degrees or mm)	Herbst-stable				Herbst-relapse				Control
	T After Before Mean SD	P1 6 months After Mean SD	P2 Follow-up 6 months Mean SD	O Follow-up Before Mean SD	T After Before Mean SD	P1 6 months After Mean SD	P2 Follow-up 6 months Mean SD	O Follow-up Before Mean SD	'T' After Before Mean SD
Period (years)	0.6*** 0.1	0.5*** 0.1	5.7*** 1.0	6.8*** 0.9	0.6*** 0.1	0.5*** 0.0	5.6*** 1.3	6.7*** 1.3	0.6*** 0.2
n-ss-pg	2.7*** 2.2	-0.3 1.7	1.8*** 2.1	4.2*** 2.6	2.8*** 1.7	-0.2 1.3	1.3* 2.5	3.9*** 2.7	-0.2 0.7
N-Sn-Pg	3.3*** 4.0	-0.9*** 1.7	1.7*** 2.9	4.1*** 4.5	3.2*** 2.7	-0.9 2.5	-0.2 2.6	2.1** 2.9	-0.1 1.3
N-No-Pg	1.3*** 2.2	-1.2*** 1.7	-1.6*** 2.6	-1.5** 3.6	0.6 1.8	-1.5*** 1.2	-2.6** 3.2	-3.5*** 3.1	-0.3 1.4
UL/E-line	-1.8*** 1.5	-0.3 1.2	-2.3*** 1.6	-4.4*** 2.2	-2.3*** 1.4	-0.3 1.1	-1.9*** 1.4	-4.5*** 1.2	-0.3 1.0
LL/E-line	-0.4 1.7	-0.9*** 1.1	-2.1*** 1.7	-3.4*** 2.2	-0.7 2.0	-0.4 1.4	-1.8*** 1.6	-2.9*** 1.9	-0.2 1.4

\*Significant at \*5% level; \*\*1% level; \*\*\*0.1% level.

subjects (T-period) there was a significant ( $P < 0.001$ ) increase in the profile angle in both the Herbst-stable and Herbst-relapse patients (Table 4).

*Soft-tissue profile convexity, excluding the nose*

During the treatment period (T) the soft-tissue profile angle (N-Sn-Pg) increased in all subjects

**Table 3** Cephalometric records describing the facial profile differences (*d*) when comparing the Herbst-stable patients (*n*=49), the Herbst-relapse patients (*n*=20) and the control subjects (*n*=24). Registrations in the Herbst patients before treatment (before), after 7 months of treatment when the appliance was removed (after), 6 months post-treatment (6 months) and 5–10 years post-treatment (follow-up). Registrations in the control subjects before and after 7 months of examination.

Variable (degrees or mm)	Herbst-stable/Herbst-relapse				Herbst-stable/control		Herbst-relapse/control	
	Before Mean (d)	After Mean (d)	6 months Mean (d)	Follow-up Mean (d)	Before Mean (d)	After Mean (d)	Before Mean (d)	After Mean (d)
Age (years)	0.5	0.5	0.5	0.6	1.4***	1.4***	0.9*	0.9*
n-ss-pg	-0.8	-0.9	-1.0	-0.5	2.3*	5.2***	3.1*	6.1***
N-Sn-Pg	-3.2*	-3.1*	-3.1*	-1.2	-2.1	1.3	1.1	4.4**
N-No-Pg	-3.5*	-2.8*	-2.5	-1.5	-1.8	-0.2	1.7	2.6
UL/E-line	-0.7	-0.2	-0.2	-0.6	-0.5	-2.0***	0.2	-1.8**
LL/E-line	-0.4	-0.1	-0.6	-0.9	0.1	-0.1	0.5	0.0

Significance at \*5% level; \*\*1% level; \*\*\*0.1% level.

**Table 4** Cephalometric records describing the difference (*d*) in facial profile changes when comparing the Herbst-stable patients (*n*=49), the Herbst-relapse patients (*n*=20) and the control subjects (*n*=24). Registrations during the examination periods: T, P1, P2 and O.

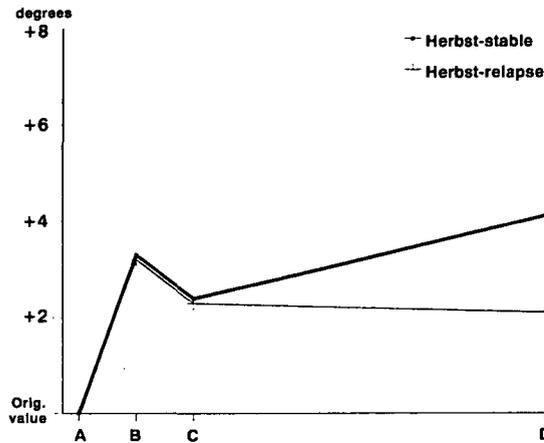
Variable (degrees or mm)	Herbst-stable/Herbst-relapse				Herbst-stable/control	Herbst-relapse/control
	T	P1	P2	O	T	T
	After   Before Mean (d)	6 months After Mean (d)	Follow-up 6 months Mean (d)	Follow-up Before Mean (d)	After   Before Mean (d)	After   Before Mean (d)
Period (years)	0	0	0.1	0.1	0	0
n-ss-pg	-0.1	-0.1	0.5	0.3	2.9***	3.0***
N-Sn-Pg	0.1	0	1.9**	2.0*	3.4***	3.3***
N-No-Pg	0.7	0.3	1.0	2.0**	1.6*	0.9*
UL/E-line	0.5	0	-0.4	0.1	-1.5***	-2.0***
LL/E-line	0.3	-0.5	-0.3	-0.5	-0.2	-0.5

Significant at \*5% level; \*\*1% level; \*\*\*0.1% level.

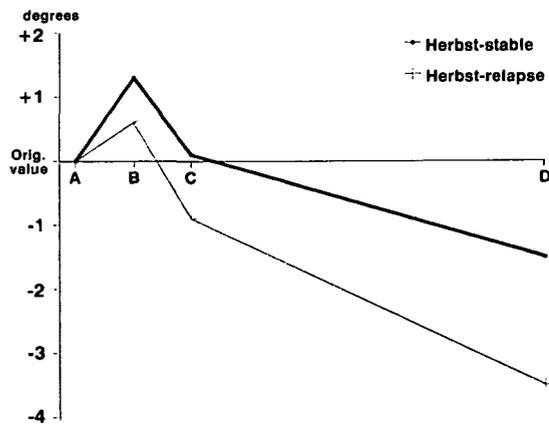
**Table 5** Associations between cephalometric records describing the facial profile changes in the total sample of 69 Herbst patients (49 stable and 20 relapse cases). Registrations during the examination periods: T, P1, P2 and O. The correlations coefficients (*r*) are given.

Variable (degrees or mm)	T	P1	P2	O
	After   Before	6 months After	Follow-up 6 months	Follow-up Before
n-ss-pg/N-Sn-Pg	0.54***	0.45***	0.37**	0.30*
n-ss-pg/N-No-Pg	0.49***	0.41***	0.09	0.14
N-Sn-Pg/N-No-Pg	0.54***	0.68***	0.53***	0.55***
n-ss-pg/UL	-0.22	-0.35**	-0.57***	-0.48***
n-ss-pg/LL	0.25*	0.02	-0.41***	-0.30*
UL/LL	0.56***	0.63***	0.78***	0.68***

UL, implies UL/E-line; LL, implies LL/E-line.  
Significant at \*5% level; \*\*1% level; \*\*\*0.1% level.



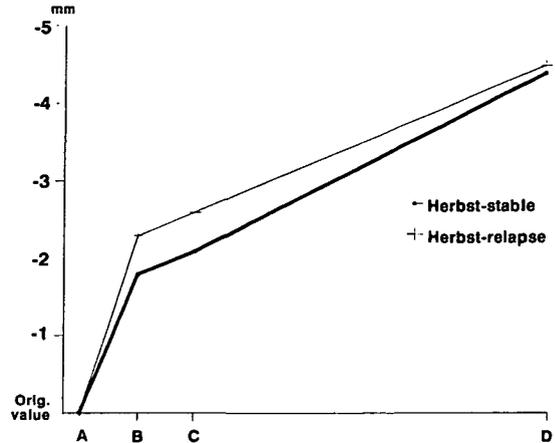
**Figure 3** Mean changes in the soft-tissue facial profile angle, excluding the nose (N-Sn-Pg) in 49 Herbst-stable subjects and 20 Herbst-relapse subjects. (A) Before treatment (the original value at zero). (B) After 7 months of treatment, when the appliance was removed. (C) 6 months post-treatment. (D) At follow-up, 5–10 years post-treatment.



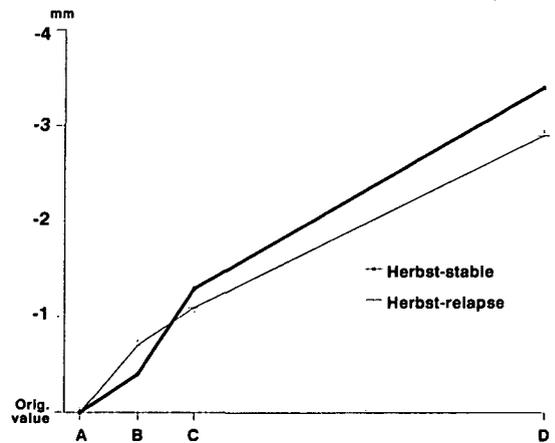
**Figure 4** Mean changes in the soft-tissue facial profile angle, including the nose (N-No-Pg) in 49 Herbst-stable subjects and 20 Herbst-relapse subjects. (A) Before treatment (the original value at zero). (B) After 7 months of treatment, when the appliance was removed. (C) Six months post-treatment. (D) At follow-up, 5–10 years post-treatment.

in the Herbst-stable (mean = 3.3 degrees;  $P < 0.001$ ) and Herbst-relapse (mean = 3.2 degrees;  $P < 0.001$ ) groups (Table 2, Fig. 3).

During the first post-treatment period (P1) the profile angle was, on average, somewhat reduced in both groups. During the second post-treatment period (P2) the angle increased in the Herbst-stable group while it remained



**Figure 5** Mean changes in the position of the upper lip in relation to the E-line (UL/E-line) in 49 Herbst-stable subjects and 20 Herbst-relapse subjects. Negative values (–) imply lip retrusion. (A) Before treatment (the original value at zero). (B) After 7 months of treatment, when the appliance was removed. (C) Six months post-treatment. (D) At follow-up, 5–10 years post-treatment.



**Figure 6** Mean changes in the position of the lower lip in relation to the E-line (LL/E-line) in 49 Herbst-stable subjects and 20 Herbst-relapse subjects. Negative values (–) imply lip retrusion. (A) Before treatment (the original value at zero). (B) After 7 months of treatment, when the appliance was removed. (C) Six months post-treatment. (D) At follow-up, 5–10 years post-treatment.

unchanged in the Herbst-relapse group (Table 2, Fig. 3).

During the total observation period (O) there was an average increase in the profile angle of 4.1 degrees ( $P < 0.001$ ) in the Herbst-stable group and of 2.1 degrees ( $P < 0.01$ ) in the Herbst-relapse group (Table 2, Fig. 3).

When comparing the Herbst-stable and the

Herbst-relapse subjects the profile angle increased more in the Herbst-stable group during the second post-treatment period (P2) and during the total observation period (O) (Table 4, Fig. 3).

When comparing the Herbst and control subjects (T-period) there was a significant ( $P < 0.001$ ) increase in the profile angle in both the Herbst-stable and Herbst-relapse patients (Table 4).

#### *Soft-tissue profile convexity, including the nose*

During the treatment period (T) the soft-tissue profile angle (N-No-Pg) increased in 90 per cent of the subjects in the Herbst-stable group (mean = 1.3 degrees;  $P < 0.001$ ) and in 75 per cent of the subjects in the Herbst-relapse group (mean = 0.6 degrees; NS) (Table 2, Fig. 4).

During the first (P1) and second (P2) post-treatment periods the profile angle was, on average, reduced in both examination groups (Table 2, Fig. 4).

During the total observation period (O) there was an average reduction in the profile angle of 1.5 degrees ( $P < 0.01$ ) in the Herbst-stable group and of 3.5 degrees ( $P < 0.001$ ) in the Herbst-relapse group (Table 2, Fig. 4).

When comparing the Herbst-stable and Herbst-relapse subjects the profile angle decreased more in the Herbst-relapse group than in the Herbst-stable group during the total observation period (O) (Table 4, Fig. 4).

When comparing the Herbst and control subjects (T-period) there was a significant ( $P < 0.05$ ) increase in the profile angle in both the Herbst-stable and Herbst-relapse patients (Table 4).

#### *Upper lip position*

During the treatment period (T) the upper lip became retrusive in relation to the E-line in all subjects in the Herbst-stable (mean = 1.8 mm;  $P < 0.001$ ) and Herbst-relapse (mean = 2.3 mm;  $P < 0.001$ ) groups (Table 2, Fig. 5).

During the first (P1) and second (P2) post-treatment periods the upper lip became, on average, further retrusive in both examination groups (Table 2, Fig. 5).

During the total observation period (O) the upper lip became retrusive by an average of 4.4 mm ( $P < 0.001$ ) in the Herbst-stable group and by 4.5 mm ( $P < 0.001$ ) in the Herbst-relapse group (Table 2, Fig. 5).

When comparing the Herbst-stable and the Herbst-relapse subjects no differences were seen at any of the examination periods (Table 4, Fig. 5).

When comparing the Herbst subjects and the control subjects (T-period) the upper lip became significantly ( $P < 0.001$ ) more retrusive in both the Herbst-stable and Herbst-relapse patients (Table 4).

#### *Lower lip position*

During the treatment period (T) the position of the lower lip in relation to the E-line became retrusive in 60 per cent and protrusive in 40 per cent of both the Herbst-stable and Herbst-relapse subjects. On average, an insignificant lip retrusion was seen in the two examination groups (Table 2, Fig. 6).

During the first (P1) and second (P2) post-treatment periods the lower lip became increasingly retrusive in both examination groups (Table 2, Fig. 6).

During the total observation period (O) the lower lip became retrusive by an average of 3.4 mm ( $P < 0.001$ ) in the Herbst-stable group and by 2.9 mm ( $P < 0.001$ ) in the Herbst-relapse group (Table 2, Fig. 6).

When comparing the Herbst-stable and the Herbst-relapse subjects no differences were seen at any of the observation periods (Table 4, Fig. 6).

When comparing the Herbst and control subjects (T-period) no differences existed between the groups. This was true for both the Herbst-stable and Herbst-relapse subjects (Table 4).

#### *Associations*

The correlation coefficients ( $r$ ) describing the associations between the different variables are given in Table 5. As no decisive difference existed between the Herbst-stable and Herbst-relapse group the two groups were pooled in the presentation of the results.

Positive correlations ( $0.09 < r < 0.54$ ;  $0.01 < P < 0.001$ ) existed between the hard tissue profile convexity changes and the soft tissue profile convexity (excluding and including the nose) changes.

Furthermore, positive correlations were found between the soft tissue profile convexity changes excluding and including the nose ( $0.53 < r < 0.68$ ;  $P < 0.001$ ) as well as between the upper and lower lip position changes ( $0.56 < r < 0.78$ ;  $P < 0.001$ ).

In most instances negative correlations ( $0.02 < r < -0.57$ ;  $NS < P < 0.001$ ) existed between the hard tissue profile changes and the upper and lower lip position changes (viz. the lips became retrusive when the hard tissue profile was straightened).

### Case reports

The facial profile photographs of two boys (Cases 1 and 2) and two girls (Cases 3 and 4) whose Class II, division 1 malocclusions were successfully treated with the Herbst appliance are presented in Fig. 7. The cephalometric records of the cases describing the hard and soft-tissue profile are presented in Table 6. On a short- and long-term basis the facial appearance in all four subjects was improved. However, large individual variations in the angular and linear measurements existed.

### Discussion

The present patient material was selected from a sample of 118 consecutive Class II, division 1 malocclusions treated successfully with the Herbst appliance (Pancherz, 1991; Pancherz and Anehus-Pancherz, 1993). All subjects were Caucasians. At the time of follow-up most of the growth was finished in all cases according to the epiphyseal union of the radius (Björk 1972). When comparing the 20 subjects with relapse with the 49 subjects without relapse, no differences existed between the two groups with respect to dento-skeletal morphology before and after Herbst treatment, as well as 6 months post-treatment. Thus, the subjects in the two groups responded equally to therapy and were comparable as to the early post-treatment changes (P1-period). Furthermore, the stable and relapse subjects were evenly distributed with respect to post-treatment management procedures (retention/non-retention).

At all times of examination the males in the Herbst-stable group had a straighter hard-tissue profile than the females. This sexual dimorphism agrees with Subtelny (1959), but disagrees with Mauchamp and Sassouni (1973). On the other hand, no male/female difference existed for any of the soft tissue variables. This disagrees with Subtelny (1959) and Mauchamp and Sassouni (1973). A possible explanation is the small sample of female Herbst patients.

The problem in this study, as in all other studies evaluating the long-term effects of an orthodontic treatment procedure, is the lack of a suitable control group of untreated malocclusion cases. The present control group of untreated Class II malocclusions was available for 7 months and could only be used for the evaluation of the immediate appliance effects. Thus, in the evaluation of the long-term effects of Herbst treatment on the facial profile the results from studies of normal growth changes (Subtelny, 1959; Mauchamp and Sassouni, 1973; Forsberg and Odenrick, 1979; Bishara *et al.*, 1984, 1985; Meng *et al.*, 1988; Zylinski *et al.*, 1992) were used for comparison.

### *Treatment changes (T1-period)*

In previous studies (Pancherz 1979, 1982a) it has been shown that the Herbst appliance stimulates mandibular growth, moves the upper dentition posteriorly and the lower dentition anteriorly. By this the hard and soft tissue profiles are straightened as shown in this investigation (Figs 2-4). Due to the forward movement of the chin the upper lip was consequently placed in a retrusive position in relation to the E-line (Fig. 5). The lower lip, on the other hand, followed the movement of the mandible only occasionally. The present findings were in agreement with those of other Herbst studies as far as the same measuring variables were used (Pancherz, 1979; Riolo and TenHave, 1986; Eicke and Wieslander, 1990).

### *Early post-treatment changes (P1-period)*

Immediately after treatment, when the appliance was removed, over-corrected sagittal dental arch relationships in combination with an incomplete cuspal interdigitation existed in all subjects (Pancherz 1982a). During the first 6 months post-treatment the occlusion settled into Class I in 60 of the 69 patients. This was in agreement with a previous study (Pancherz and Hansen, 1986) in which it was demonstrated that about 90 per cent of the post-treatment occlusal changes occurred during the first 6 months post-treatment. The changes were a result of relapsing maxillary and mandibular tooth movements (Pancherz and Hansen, 1986) and recovering jaw growth (Pancherz and Hansen, 1986; Pancherz and Fackel, 1990). Thus, it is most likely that the early post-treatment dento-skeletal changes will also affect



**Figure 7** Facial profile photographs of two boys (cases 1 and 2) and two girls (cases 3 and 4) whose Class II, division 1 malocclusions were successfully treated with the Herbst appliance. (A) Before treatment. (B) At the start of treatment, when the appliance was placed. (C) After treatment, when the appliance was removed. (D) Six months post-treatment. (E) Six to seven years post-treatment.

**Table 6** Cephalometric records describing the facial profile in two boys (cases 1 and 2) and two girls (cases 3 and 4) treated with the Herbst appliance. Registrations before treatment (before), after treatment when the appliance was removed (after), 6 months post-treatment (6 months) and at follow-up (follow-up).

Variable (degrees or mm)	Case	Before	After	6 months	Follow-up
Age (years)	1	13.0	13.8	14.3	19.9
	2	13.1	13.6	14.1	19.8
	3	11.6	12.2	12.7	19.2
	4	12.4	13.2	13.7	18.8
n-ss-pg	1	162.0	165.0	165.5	165.5
	2	177.0	182.0	180.5	181.5
	3	169.0	172.0	171.0	171.5
	4	160.0	164.0	166.0	166.5
N-Sn-Pg	1	148.0	150.0	151.0	150.0
	2	155.5	164.5	162.5	169.0
	3	157.0	160.0	158.0	157.0
	4	147.0	151.5	151.0	152.0
N-No-Pg	1	124.0	124.5	124.5	117.5
	2	129.0	130.0	127.0	130.0
	3	133.0	135.5	132.5	132.0
	4	114.5	118.0	118.5	116.5
UL/E-line*	1	+2.5	-1.5	-1.5	-5.5
	2	+0.5	-3.5	-3.5	-7.0
	3	+2.5	0	+0.5	+0.5
	4	+2.0	0	-1.0	-1.5
LL/E-line*	1	+1.0	+1.0	+1.0	-3.0
	2	+0.5	-0.5	-1.5	-3.5
	3	+2.5	+1.5	+1.0	+1.0
	4	+3.5	+2.0	+0.5	+0.5

\* +, Implies lips in front of the E-line; -, Implies lips behind the E-line.

the facial profile. However, part of the soft tissue profile (including the nose) changes may be attributed to an increase in nasal growth as well (Subtelny, 1959; Posen, 1967; Chaconas, 1969; Forsberg, 1979; Meng *et al.*, 1988).

Furthermore, nasal growth will result in retrusion of the lips in relation to the E-line (Figs 5 and 6). The lower lip did, however, become more retrusive than the upper. As the posture of the lips is closely related to the teeth and alveolar process (Subtelny, 1959) and the lower incisors are more prone to relapse (lingual uprighting) than the upper (labial tipping) during the occlusal settling phase after Herbst treatment (Pancherz and Hansen, 1986) this could be a possible explanation for the difference in upper and lower lip behaviour seen. A large individual variation in lip position changes existed, however. This was substantiated by the fact that no association existed between the

changes in the hard tissue profile and the lower lip ( $r=0.02$ ) (Table 5).

#### *Late post-treatment changes (Pz-period)*

In the period from 6 months post-treatment to follow-up (5–10 years post-treatment) the facial profile changes seen were certainly in the most part a result of post-treatment growth development.

When comparing the Herbst-stable group with the Herbst-relapse group a difference existed only for the soft-tissue profile, excluding the nose (Table 4, Fig. 3): the profile convexity was reduced in the Herbst-stable group, while it was unchanged in the Herbst-relapse group. This difference may be attributed to a rebound (forward movement) of the maxillary jaw base and upper incisors in the relapse group (Pancherz, 1991). The soft tissue (Sn-point) will follow the maxillary dento-skeletal structures

and consequently affect the profile angle. Surprisingly, no differences in the upper lip position was seen when comparing the Herbst-stable and Herbst-relapse group. Adaptive changes in upper lip thickness in relation to incisor tooth position could be an explanation (Ricketts, 1960; Anderson *et al.*, 1973; Wisth, 1974; Roos, 1977).

#### *Total observation period change (O-period)*

In the period from before Herbst treatment to follow-up (5–10 years post-treatment). The profile changes were certainly a result of both treatment and growth development (Ricketts, 1957; Burstone, 1958; Subtelny, 1959; Forsberg and Odenrick, 1981; Bishara *et al.*, 1985; Zylinski *et al.*, 1992).

However, all measurements of profile changes displayed a great degree of individual variability. This was reflected by the large standard deviations (Table 2) as well as the weak to moderate correlations existing between the hard and soft tissue profile variables (Table 5). Thus, in individual cases a prediction of the long-term facial profile changes seems not possible.

#### Conclusions

The Herbst appliance straightens the facial hard and soft tissue profile consistently. The upper lip becomes retrusive while the lower lip seems relatively unaffected by therapy. Due to post-treatment growth changes the long-term effects of Herbst therapy on the facial profile are variable and unpredictable.

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