European Journal of Orthodontics 28 (2006) 352–360
doi:10.1093/ejo/cji116
Advance Access publication 27 April 2006

Herbst/multibracket appliance treatment of Class II division 1 malocclusions in early and late adulthood. A prospective cephalometric study of consecutively treated subjects

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SUMMARY A prospective study of 23 consecutive adult Class II division 1 malocclusion subjects (19 female and 4 male) treated with the Herbst/multibracket (MB) appliance is presented. The skeletal, dental, and facial profile changes were evaluated in addition to the mechanism of Class II correction during the Herbst phase and the settling of the occlusion during the MB phase. The mean pre-treatment age of the subjects was 21.9 years (15.7–44.4 years). Lateral head films in habitual occlusion from before treatment (T1) and after the Herbst (T2) and MB (T3) phases were analysed using standard cephalometrics and the sagittal occlusion analysis. For the standard cephalometrics, normal growth standards were utilized as control parameters.

All patients were treated successfully to a Class I occlusal relationship with a normal overjet and overbite. The mandibular variables (SNB and SNPg) showed an angular increase (1.22 and 0.93 degrees, respectively) during T2–T1 followed by an angular reduction (0.40 and 0.23 degrees, respectively) during T3–T2. Compared with normal growth standards, all mandibular parameters were affected favourably by Herbst/MB treatment. Both the skeletal and soft tissue profile convexities were significantly reduced. Over the entire observation period (T3–T1), the largest amount of profile convexity reduction was seen for the soft tissue profile excluding the nose (mean 3.14 degrees). Class II correction was achieved by both skeletal and dental changes: overjet correction by 13 per cent skeletal and 87 per cent dental changes, and molar correction by 22 per cent skeletal and 78 per cent dental changes.

In conclusion, on a short-term basis, the Herbst/MB appliance combination was found to be a powerful tool for non-surgical, non-extraction, treatment of Class II division I subjects in early and late adulthood.

Introduction

During recent years, the Herbst appliance has been shown to be effective in Class II treatment of not only children and adolescents, but also adults (Ruf and Pancherz, 1998, 1999a,b, 2003; Pancherz, 2000; Pancherz and Ruf, 2000). A stimulation of condylar growth and re-modelling of the glenoid fossa occurs in adults similar to that in children and adolescents (Ruf and Pancherz, 1998, 1999b). Recently, the stimulatory effect of the Herbst appliance on the temporomandibular joint structures in non-growing subjects has been verified histologically in adult rhesus monkeys (McNamara *et al.*, 2003).

In previous adult Herbst studies, the dento-skeletal effects have only been analysed for the Herbst treatment period itself (Ruf and Pancherz, 1999a). Little is known about the changes that occur after the Herbst bite-jumping mechanism has been removed. In children and adolescents, it was found that the occlusion settles after removal of the appliance and that 90 per cent of the settling changes take place during the first 6 months after Herbst treatment (Pancherz and Hansen, 1986).

However, in modern Class II treatment using the Herbst appliance, the Herbst phase is followed by a multibracket (MB) treatment phase for final tooth alignment and controlled settling of the occlusion (Pancherz and Ruf, 2000). The aim of this study was to evaluate the skeletal, dental, and facial profile changes in consecutive adult subjects with Class II division 1 malocclusions treated with the Herbst/MB appliance. The mechanism of Class II correction during the Herbst and MB phase was also assessed.

Subjects

Twenty-three consecutive adult Class II division 1 subjects (19 females and 4 males) attending for treatment at the Department of Orthodontics of the University of Giessen were selected for this prospective investigation. All subjects were treated on a non-extraction basis with a cast splint Herbst appliance (Pancherz, 1995) in the first phase and a MB appliance in the second phase. The mean pre-treatment age of the subjects was 21.9 years (range 15.7–44.4 years).

Using the method of Hägg and Taranger (1980), adulthood was defined from pre-treatment hand–wrist radiographs as the skeletal maturity stages R-IJ (four subjects) or R-J (19 subjects). At the end of treatment, all subjects had reached stage R-J. The average treatment time was 22 months (Herbst = 9 months, MB = 13 months). All subjects were treated successfully to a Class I occlusion with a normal overjet and overbite.

Method

Lateral head films in habitual occlusion were analysed from immediately before treatment (T1), after the Herbst phase (T2), and directly after the MB phase (T3). Tracings of the radiographs were made. Linear and angular measurements were recorded to the nearest 0.5 mm and 0.5 degrees, respectively. In order to reduce the method error (ME), all registrations were performed twice with an interval of at least 2 weeks between the registrations. In the final evaluation, the mean value of the duplicate registrations was used. No correction was made for linear enlargement (approximately 8 per cent in the median plane).

The following observation periods were analysed: T2–T1 (Herbst phase = 7–9 months), T3–T2 (MB phase = 5–20 months), and T3–T1 (Herbst + MB = 12–33 months).

Standard cephalometrics

Changes in sagittal and vertical jaw base relationships, overbite, face height, facial profile convexity, and lip position were assessed using standard cephalometric variables. The cephalometric landmarks utilized are shown in Figure 1.

Sagittal occlusion analysis

The sagittal occlusion (SO) analysis (Pancherz, 1982) was used to analyse quantitatively the skeletal and dental maxillary and mandibular components that contributed to sagittal changes in occlusion during the different observation periods.

Individual changes

For the assessment of the clinical significance of individual changes, only those exceeding ±0.5 mm or degrees were considered.

Control group

For the standard cephalometrics, the growth standards of Bhatia and Leighton (1993) were utilized as control parameters. The Herbst subjects were allocated to the following age groups (considering gender differences): subjects aged 16 ± 0.5 years were compared with the 16-year growth standards, subjects aged 17 ± 0.5 years with the 17-year growth standards, etc. The total treatment changes (1.8 years) in the Herbst/MB group were compared with the standard growth changes over 2 years. Even though it might be argued that subjects beyond a certain age are unlikely to exhibit growth, changes in facial dimensions have been shown to continue throughout life (Behrents, 1985). Therefore, as Bhatia and Leighton (1993) only followed their subjects to 20 years of age, for the Herbst/MB patients aged 19–21 years, twice the growth standard changes during the 19- to 20-year growth period were used. As the amount of natural craniofacial growth declines with age (Bishara *et al.*, 1984; Behrents, 1985; Lewis and Roche, 1988; Akgül and Toygar, 2002), for the Herbst/MB subjects starting treatment at 22 years of age and upwards, the single growth standard changes for the 19- to 20-year growth period were used.

As Bhatia and Leighton (1993) corrected their head film variables for linear enlargement (7.76 per cent), their cephalometric values were recorrected to make them comparable with the non-corrected Herbst/MB variables (8 per cent). For the SO analysis (Pancherz, 1982), no data from untreated adult individuals were available.

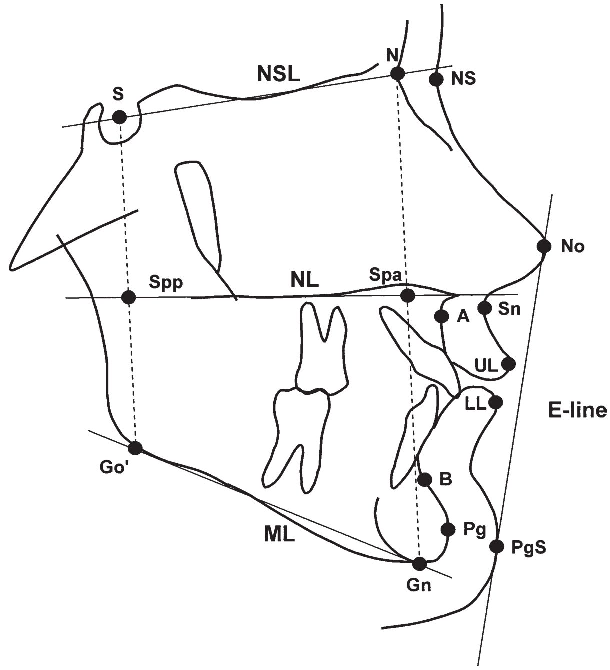

Figure 1 Reference points and lines used in the standard cephalometric analysis: S (sella), midpoint of the sella turcica; N (nasion), most anterior point of the naso-frontal suture; Spa, constructed point of intersection of the lines NL and NGn; Spp, constructed point of intersection of a line parallel to NGn through eella point and the line NL; A (point A), point at the deepest anterior concavity of the upper alveolar process; B (point B), point at the deepest anterior concavity of the lower alveolar process; Pg (pogonion), most anterior point of the bony chin; Gn (gnathion), most inferior point of the symphysis relative to nasion; Go′ (gonion), constructed point of intersection of the ramus plane and the mandibular plane; NS, point at the deepest concavity in the area of the nasal root; No, most anterior point of the nose tip; Sn (subnasale), point at the deepest concavity between the nose and upper lip; UL, most anterior point on the upper lip; LL, most anterior point on the lower lip; PgS, most anterior point on the soft tissue chin.

Statistical methods

For each variable, the mean, the standard deviation, and maximum and minimum values were calculated. A Student's *t*-test for paired samples was used to assess the significance of treatment changes. Differences between Herbst and control subjects were analysed by means of a Student's *t*-test for unpaired samples. The statistical significance was determined at the probability levels of 0.1, 1, and 5 per cent. A probability level larger than 5 per cent was not considered significant.

Error of the method

The ME of the double registrations (tracing and measurement) of all subjects was calculated using Dahlberg's formula (1940):

$$\mathrm{ME} = \sqrt{\frac{\sum d^2}{2n}},$$

where d is the difference between two registrations and n is the number of subjects. The maximum ME for the dental variables was 1.5 mm. For skeletal and soft tissue variables, the ME did not exceed 1.2 mm for linear, 1.2 degrees for angular, and 1.3 for index measurements.

Results

Due to the small number of male subjects (n = 4), possible gender differences were not assessed. Thus, in the presentation of the results, the male and female samples were pooled.

Standard cephalometrics

Sagittal jaw relationship. The sagittal position of the maxilla (SNA) was unaffected by treatment (Tables 1 and 2). The mandibular variables (SNB and SNPg) showed a similar reaction pattern in terms of a significant ($P < 0.001$) angular increase (1.22 and 0.93 degrees, respectively) during the Herbst phase (T2–T1) followed by a significant ($P < 0.05$, only SNB) angular reduction (0.40 and 0.23 degrees, respectively) during the MB phase (T3–T2).

Over the total observation period (T3–T1), treatment resulted in a significant ($P < 0.001$) increase in SNB (mean 0.82 degrees) and SNPg (mean 0.70 degrees), and a corresponding significant ($P < 0.01$) decrease in ANB (mean 0.70 degrees), ANPg (mean 0.60 degrees) and Wits (mean 1.08 mm).

Considering clinically significant individual changes over the total treatment period (T3–T1), there was an increase of the SNB angle in 70 per cent (16/23) of the subjects, while in 30 per cent (7/23) the angle was unchanged. The maximum increase in SNB angle was 2.25 degrees (Figure 2a). A reduction in ANB was seen in 61 per cent (14/23) of the subjects, while in 35 per cent (8/23) the angle was unchanged. One subject exhibited an increase in ANB (0.75 degrees). The maximum reduction in ANB was 3.0 degrees (Figure 2b).

In comparison with normal growth (Table 2), all sagittal jaw parameters were significantly ($P < 0.01$) affected by Herbst/MB treatment (T3–T1).

Vertical jaw relationship. The vertical jaw relationship (ML/NSL, NL/NSL and ML/NL) was not affected during the Herbst phase (T2–T1). During the MB phase (T3–T2), all variables exhibited an angular reduction (0.83, 0.57, and 0.20 degrees, respectively). These changes were, however, only significant ($P < 0.01$) for ML/NSL. Over the entire observation period (T3–T1), a significant ($P < 0.05$) reduction (mean 0.69 degrees) in ML/NSL was seen.

When considering clinically significant individual changes over the total treatment period (T3–T1), a reduction in ML/NSL was noted in 56 per cent (13/23) and an increase in 22 per cent (5/23) of the subjects. In 22 per cent (5/23) of the subjects, ML/NSL remained unchanged. The maximum reduction in ML/NSL was to 3.0 degrees and the maximum increase to 1.25 degrees (Figure 2c).

In comparison with normal growth (Table 2), ML/NSL and NL/NSL were significantly ($P < 0.05$) affected by Herbst/MB treatment (T3–T1). While an angular reduction (anterior rotation of the mandibular and maxillary bases) was seen in the Herbst/MB group, the two angles remained almost unchanged in the growth standard group. The group differences were 0.81 ($P < 0.01$) and 0.69 ($P < 0.05$) degrees, respectively.

Overbite. The overbite changed significantly ($P < 0.001$) during all observation periods. It was reduced (mean 3.85 mm) during the Herbst phase (T2–T1) and increased slightly (mean 1.37 mm) during the MB phase (T3–T2). Thus, during the total observation period (T3–T1), there was an average overbite reduction of 2.48 mm.

In comparison with normal growth (Table 2), the overbite was significantly ($P < 0.001$) reduced by Herbst/MB treatment (T3–T1). While a decrease in overbite took place in the Herbst/MB group, a slight increase was seen in the growth standard group. The group difference was 2.64 mm.

Face height. Both lower anterior

$$\left(\mathrm{Index} = \frac{\mathrm{Spa} - \mathrm{Gn}}{\mathrm{N} - \mathrm{Gn}} \times 100\right)$$

and posterior

$$\left(\mathrm{Index} = \frac{\mathrm{Spp} - \mathrm{Go}'}{\mathrm{S} - \mathrm{Go}'} \times 100\right)$$

face heights changed significantly ($P < 0.05$) during all observation periods. Anterior and posterior face heights

Table 1 Cephalometric treatment changes in 23 adult Class II division 1 subjects treated with the Herbst/multibracket (MB) appliance.

Variables	Before Herbst (T1)		After Herbst (T2)		After MB (T3)		Treatment changes T2–T1				T3–T2				T3–T1			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*t*	*P*	Mean	SD	*t*	*P*	Mean	SD	*t*	*P*
Sagittal jaw relationship																		
SNA (°)	80.46	3.23	80.45	3.18	80.57	3.27	−0.01	0.74	−0.07	ns	0.12	0.63	0.90	ns	0.11	0.64	0.82	ns
SNB (°)	75.27	4.06	76.49	4.25	76.09	4.19	1.22	1.16	5.05	***	−0.40	0.81	−2.38	*	0.82	0.78	5.03	***
SNPg (°)	76.84	4.28	77.77	4.58	77.54	4.58	0.93	1.11	4.05	***	−0.23	0.84	−1.30	ns	0.70	0.85	3.96	***
ANB (°)	5.18	1.69	3.96	2.04	4.48	1.79	−1.22	1.24	−4.73	***	0.52	0.85	2.96	**	−0.70	0.77	−4.33	***
ANPg (°)	3.62	2.30	2.67	2.70	3.02	2.45	−0.95	1.17	−3.87	***	0.35	0.83	2.01	*	−0.60	0.87	−3.28	**
Wits (mm)	2.55	2.06	0.25	1.89	1.47	1.95	−2.30	1.70	−6.50	***	1.22	1.46	4.01	***	−1.08	1.26	−4.12	***
Vertical jaw relationship																		
ML/NSL (°)	34.12	8.61	34.26	8.71	33.43	8.97	0.14	1.31	0.52	ns	−0.83	1.18	−3.37	**	−0.69	1.27	−2.61	*
NL/NSL (°)	7.29	3.15	7.34	3.35	6.77	3.61	0.05	1.19	0.20	ns	−0.57	1.55	−1.75	ns	−0.52	1.45	−1.73	ns
ML/NL (°)	26.83	7.91	26.92	7.42	26.72	7.72	0.09	1.23	0.35	ns	−0.20	1.76	−0.55	ns	−0.11	1.59	−0.33	ns
Incisor relationship																		
Overbite (mm)	4.43	1.83	0.58	0.86	1.95	0.68	−3.85	1.78	−10.38	***	1.37	0.95	6.89	***	−2.48	1.94	−6.14	***
Face height																		
Spa–Gn × 100/N–Gn (index)	54.55	1.83	55.69	1.43	54.97	1.74	1.14	0.78	7.01	***	−0.72	0.77	−4.46	***	0.42	0.73	2.75	*
Spp–Go′ × 100/S–Go′ (index)	41.40	5.26	43.38	4.63	42.43	5.18	1.98	1.73	5.51	***	−0.95	1.64	−2.78	*	1.03	1.45	3.41	**
Profile convexity																		
NAPg (°)	172.08	5.21	174.22	6.04	173.17	5.42	2.14	2.15	4.78	***	−1.05	1.81	−2.79	*	1.09	1.58	3.31	**
NS/Sn/PgS (°)	159.68	6.25	163.60	6.98	162.82	6.79	3.92	2.57	7.33	***	−0.78	2.11	−1.78	ns	3.14	1.79	8.39	***
NS/No/PgS (°)	126.30	3.93	128.50	4.28	127.34	4.32	2.20	1.80	5.85	***	−1.16	1.29	−4.31	***	1.04	1.97	2.54	*
Lip position																		
UL–E-Line (mm)	−3.11	2.28	−4.74	2.50	−4.37	2.49	−1.63	1.23	−6.37	***	0.37	1.18	1.50	ns	−1.26	1.07	−5.64	***
LL–E-Line (mm)	−1.64	3.28	−0.80	2.54	−1.90	3.02	0.84	1.29	3.11	**	−1.10	1.20	−4.40	***	−0.26	1.10	−1.12	ns

SD, standard deviation.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant.

Table 2 Cephalometric treatment changes in 23 adult Class II division 1 subjects treated with the Herbst/multibracket appliance compared with normal growth standards (Bhatia and Leighton, 1993).

Variables	Treatment changes (T3–T1)		Growth standards (2 years)		Group difference			
	Mean	SD	Mean	SD	Mean	SD	*t*	*P*
Sagittal jaw relationship								
SNA (°)	0.11	0.64	0.22	0.35	−0.11	0.77	−0.72	ns
SNB (°)	0.82	0.78	−0.17	0.48	0.99	0.97	5.14	***
SNPg (°)	0.70	0.85	−0.22	0.44	0.92	1.02	4.66	***
ANB (°)	−0.70	0.77	0.27	0.25	−0.97	0.83	−5.96	***
ANPg (°)	−0.60	0.87	0.44	0.32	−1.04	0.70	−5.38	***
Wits (mm)	−1.08	1.26	−0.21	0.29	−0.87	1.22	−3.01	**
Vertical jaw relationship								
ML/NSL (°)	−0.69	1.27	0.12	0.51	−0.81	1.32	−2.83	**
NL/NSL (°)	−0.52	1.45	0.17	0.64	−0.69	1.43	−2.08	*
ML/NL (°)	−0.11	1.59	−0.07	0.34	−0.04	1.69	−0.13	ns
Incisor relationship								
Overbite (mm)	−2.48	1.94	0.16	0.17	−2.64	1.95	−6.50	***
Face height								
Spa–Gn × 100/N–Gn (index)	0.42	0.73	0.11	0.35	0.31	0.70	1.81	ns
Spp–Go′× 100/S–Go′ (index)	1.03	1.45	0.29	0.13	0.74	1.46	2.48	*
Profile convexity								
NAPg (°)	1.09	1.58	−0.63	0.65	1.72	1.75	4.86	***
NS/Sn/PgS (°)	3.14	1.79	−1.25	1.78	4.39	2.67	8.34	***
NS/No/PgS (°)	1.04	1.97	−0.76	1.20	1.80	2.51	3.72	***
Lip position								
UL–E-Line (mm)	−1.26	1.07	0.42	0.72	−1.68	1.33	−6.24	***
LL–E-Line (mm)	−0.26	1.10	0.29	0.55	−0.55	1.20	−2.14	*

SD, standard deviation.
$^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$; ns, not significant.

increased (mean index 1.14 and 1.98, respectively) during the Herbst phase (T2–T1) and recovered partially (mean index 0.72 and 0.95, respectively) during the MB phase (T3–T2). Over the entire observation period (T3–T1), an overall increase for both anterior and posterior face heights (mean 0.42 and 1.03, respectively) was seen.

Compared with normal growth (Table 2), only the posterior face height index was significantly ($P < 0.05$) influenced by Herbst/MB treatment (T3–T1); it increased slightly more (mean 0.74) than expected during normal growth.

Profile convexity. Both skeletal (NAPg) and soft tissue (NS/Sn/PgS and NS/No/PgS) profile convexities changed significantly ($P < 0.05$) during all observation periods (except for NS/Sn/PgS during T3–T2). All parameters exhibited a similar pattern of changes with a reduction ($P < 0.001$) in profile convexity (2.14 degrees for NAPg, 3.92 degrees for NS/Sn/PgS, and 2.20 degrees for NS/No/PgS) during the Herbst phase (T2–T1) and a partial recovery (mean 1.05, 0.78, and 1.16 degrees, respectively) during the MB phase (T3–T2). Over the entire observation period (T3–T1), the profile convexity (all three variables) was significantly ($P < 0.05$) reduced (mean 1.09, 3.14, and 1.04 degrees, respectively). The greatest reduction was seen for soft tissue profile convexity, excluding the nose (mean 3.14 degrees).

When considering clinically significant individual changes over the total treatment period (T3–T1), a reduction in soft tissue profile convexity, excluding the nose (NS/Sn/PgS), was noted in 91 per cent (21/23) of the subjects. In two of the subjects (9 per cent), the angle was unchanged. The maximum reduction in NS/Sn/PgS was 7.5 degrees (Figure 2d).

Compared with normal growth (Table 2), all profile convexity parameters were significantly ($P < 0.001$) influenced by Herbst/MB treatment (T3–T1). However, the treatment and control groups exhibited opposite changes. While a decrease in both hard (NAPg) and soft (NS/Sn/PgS and NS/No/PgS) tissue profile convexities took place in the Herbst/MB group, the opposite was true in the growth standard group. The largest group difference was noted for soft tissue profile convexity, excluding the nose (mean 4.39 degrees).

Lip position. The positions of the upper and lower lips to the E-Line (Ricketts, 1968) exhibited opposite changes during both the Herbst (T2–T1) and the MB (T3–T2) phases. Over the entire observation period (T3–T1), however, only the position of the upper lip showed significant ($P < 0.001$) change by becoming more retrusive (mean 1.26 mm).

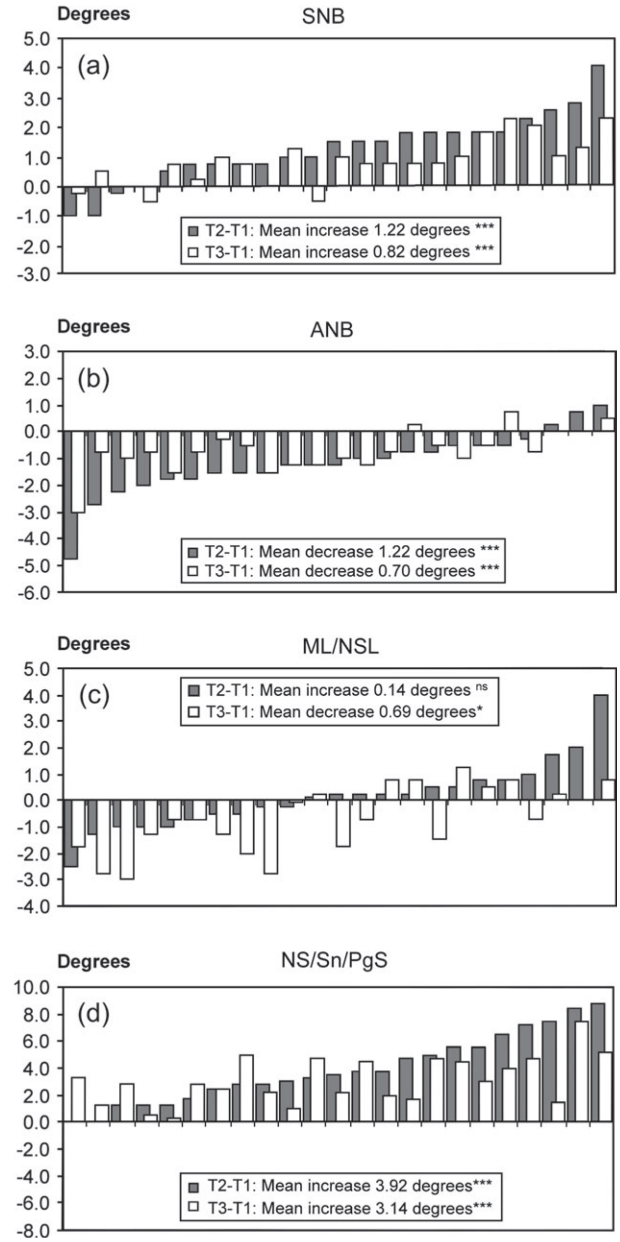

Figure 2 Individual treatment changes in 23 adult Class II division 1 subjects treated with the Herbst/multibracket approach. The changes during the Herbst phase (T2–T1) and the total treatment period (T3–T1) are given. The subjects were arranged in ascending order of the changes during the T2–T1 period. (a) SNB angle (sagittal mandibular position), (b) ANB angle (sagittal interjaw base relationship), (c) ML/NSL angle (mandibular plane angle), and (d) NS/Sn/PgS (soft tissue profile convexity, excluding the nose).

In comparison with normal growth (Table 2), both upper and lower lip positions were significantly ($P < 0.001$ and $P < 0.05$, respectively) affected by Herbst/MB treatment (T3–T1). While both lips became more retrusive in the Herbst/MB group, they became more protrusive in the growth standard group. The group difference ($P < 0.001$) was most pronounced for the upper lip position (mean 1.68 mm).

Table 3 Sagittal occlusion analysis. Treatment changes in 23 adult Class II division I subjects treated with the Herbst/multibracket (MB) appliance.

Variables (mm)	Before Herbst (T1)		After Herbst (T2)		After MB (T3)		T2-T1				T3-T2				T3–T1			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*t*	*P*	Mean	SD	*t*	*P*	Mean	SD	*t*	*P*
Overjet Is/OLp–Ii/OLp	8.88	2.66	−1.10	1.53	2.13	0.61	−9.98	3.40	−14.08	***	3.23	1.81	8.57	***	−6.75	2.63	−12.30	***
Molar relationship† Ms/OLp–Mi/OLp	+1.53	1.35	−5.29	1.27	−2.58	0.98	−6.82	1.92	−17.00	***	2.71	1.12	11.56	***	−4.11	1.45	−13.61	***
Maxillary base A/OLp	78.52	3.99	78.61	3.97	78.91	3.77	0.09	0.62	0.67	ns	0.30	0.73	2.00	*	0.39	0.65	2.88	**
Mandibular base Pg/OLp	80.07	4.94	82.25	4.95	81.35	4.77	2.18	1.40	7.46	***	−0.90	1.21	−3.56	**	1.28	1.25	4.91	***
Maxillary incisor Is/OLp	88.21	4.47	84.90	5.30	85.42	4.80												
Mandibular incisor Ii/OLp	79.33	5.36	86.00	4.93	83.29	4.88												
Maxillary molar Ms/OLp	57.78	4.70	55.65	4.81	56.35	4.68												
Mandibular molar Mi/OLp	56.25	5.32	60.95	4.67	58.92	4.97												
Maxillary incisor Is/OLp(D)–A/OLp(D)							−3.40	2.18	−7.46	***	0.22	1.66	0.64	ns	−3.17	2.11	−7.21	***
Mandibular incisor Ii/OLp(D)–Pg/OLp(D)							4.49	1.71	12.59	***	−1.80	1.60	−5.39	***	2.69	1.93	6.67	***
Maxillary molar Ms/OLp(D)–A/OLp(D)							−2.22	1.04	−10.23	***	0.39	1.01	1.85	ns	−1.83	1.10	−7.95	***
Mandibular molar Mi/OLp(D)–Pg/OLp(D)							2.51	1.50	8.01	***	−1.12	1.08	−4.96	***	1.39	1.14	5.85	***

SD, Standard deviation.
†Plus (+), Class II molar relationship; minus (−), Class I molar relationship.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns, not significant).

SO analysis

Mechanism of overjet correction. The overjet changed significantly ($P < 0.001$) during all observation periods (Table 3). It was reduced (mean −9.98 mm) during the Herbst phase (T2–T1) and exhibited some relapse (mean 3.23 mm) during the MB phase (T3–T2). Thus, over the entire observation period (T3–T1), a mean reduction in overjet of 6.75 mm was achieved. During the Herbst phase (T2–T1), overjet correction was accomplished by 21 per cent skeletal and 79 per cent dental changes. Over the entire observation period (T3–T1), 13 per cent skeletal and 87 per cent dental changes contributed to overjet correction (Figure 3).

When considering clinically significant individual changes over the total treatment period (T3–T1), a reduction in overjet was achieved in all subjects. The maximum overjet reduction was 12.25 mm (Figure 4a).

Mechanism of Class II molar correction. The molar relationship changed significantly ($P < 0.001$) during all observation periods (Figure 4b). It changed to a Class I or overcorrected Class I molar relationship (mean 6.82 mm) during the Herbst phase (T2–T1) and rebounded partially (mean 2.71 mm) during the subsequent MB phase (T3–T2). Thus, over the entire observation period (T3–T1), a mean improvement in molar relationship of 4.11 mm was achieved. During the Herbst phase (T2–T1), Class II molar correction was accomplished by 31 per cent skeletal and 69 per cent dental changes. Over the entire observation period (T3–T1), 22 per cent skeletal and 78 per cent dental changes contributed to the Class II molar correction (Figure 5).

When considering clinically significant individual changes over the total treatment period (T3–T1), an improvement in molar relationship was achieved in all subjects. The maximum improvement in molar relationship amounted to 6.25 mm (Figure 4b).

Discussion

Possibly due to the greater facial aesthetic interest of females compared with males (Hoppenreijs *et al.*, 1999), there was an over-representation of females in the present study. This seems to be characteristic for any adult treatment approach (Lawrence *et al.*, 1985; Proffit *et al.*, 1992; Cassidy *et al.*, 1993; Gerzanic *et al.*, 2002; Mihalik *et al.*, 2003).

Compared with adolescent Herbst treatment (Ruf and Pancherz, 1999a), the present adult sample exhibited, on average, a smaller mandibular base advancement during the Herbst phase (4.30 mm in adolescents and 2.18 mm in adults). This was due to the fact that the basic sagittal condylar growth rate is largest in subjects treated close to the peak period of pubertal growth (Pancherz and Hägg, 1985; Hägg *et al.*, 1987; Hägg and Pancherz, 1988; Pancherz and Littmann, 1988, 1989).

For most of the variables analysed, a characteristic pattern of treatment changes was seen. This consisted of Class II corrective changes with mandibular advancement and profile convexity reduction during the Herbst phase, followed by a settling of the occlusion during the MB phase. This pattern has also been described in adolescent Herbst subjects (Pancherz and Hansen, 1986).

The ML/NSL angle was unaffected during the Herbst phase, a finding that is in agreement with that of earlier Herbst studies in children (Ruf and Pancherz, 1996). The decrease in the mandibular plane angle during the MB phase and the total observation period as well as the mandibular advancement resulted in a reduction in both hard and soft tissue profile convexities. This development was opposite to that in the

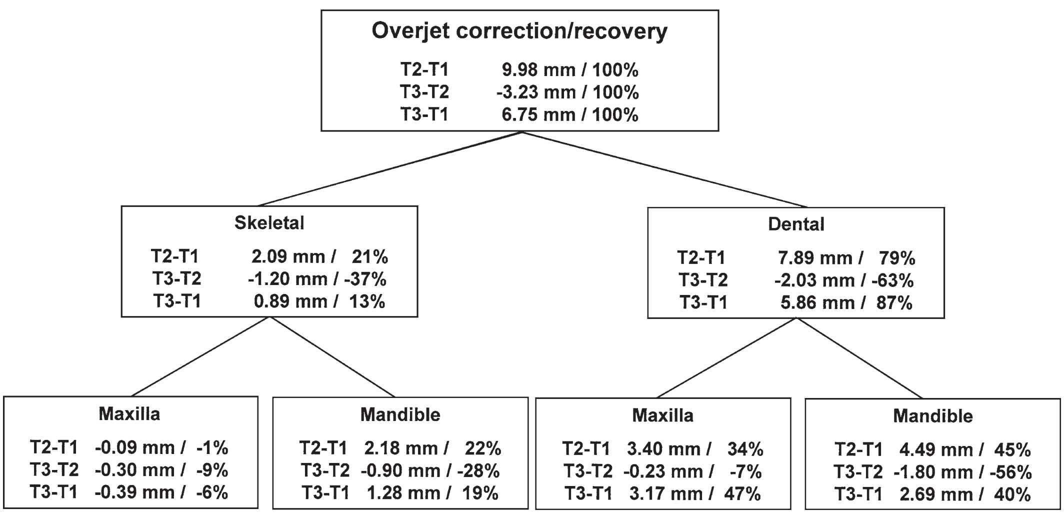

Figure 3 Mechanism of overjet correction/recovery in 23 adult Class II division 1 adult subjects treated with the Herbst/multibracket (MB) approach. The amounts of skeletal and dental changes for the Herbst phase (T2–T1), the MB phase (T3–T2), and the total treatment period (T3–T1) are given. Negative values imply changes unfavourable for overjet correction.

controls, in which an increase in the profile convexity took place with time (Bhatia and Leighton, 1993).

When comparing the effects of adult orthodontic camouflage treatment (minimum age 17 years) with the present adult Herbst/MB approach, Class II orthodontic camouflage treatment using upper premolar extractions has been reported to decrease the SNB angle (0.60 degrees) and to lead to a more posterior (1–2 mm) position of the chin (Luecke and Johnston, 1992; Proffit *et al.*, 1992). A mandibular sagittal split osteotomy, on the other hand (Pancherz *et al.*, 2004; Ruf and Pancherz, 2004), results in a more anterior position of the chin (4 mm). Thus, when comparing the effects of adult Herbst treatment with camouflage orthodontics and orthognathic surgery, it becomes clear that the indication for adult Herbst treatment, in terms of the amount of mandibular skeletal effects, lies between that of orthodontic camouflage and orthognathic surgery.

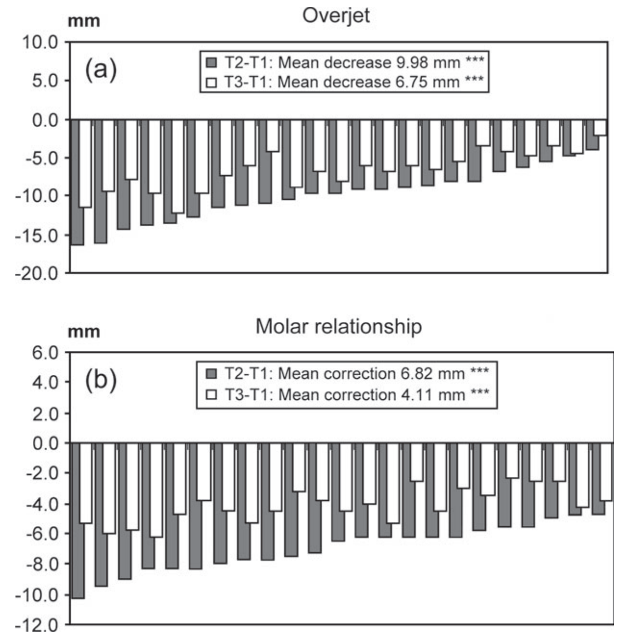

Figure 4 Individual treatment changes in 23 adult Class II division 1 subjects treated with the Herbst/multibracket approach. The changes during the Herbst phase (T2–T1) and the total treatment period (T3–T1) are shown. The subjects were arranged in ascending order of the changes during the T2–T1 period. (a) Overjet and (b) molar relationship.

In the orthodontic literature, there seems to be an agreement that mild Class II problems in adults can be solved orthodontically, while severe discrepancies require orthognathic surgery. Controversies arise, however, when the patient is borderline. This study revealed that adult Herbst appliance treatment seems to be indicated for this borderline group.

With respect to treatment stability, the data of an ongoing study reveal that the stability of adult Herbst treatment is comparable with that described for adolescent Herbst treatment (Pancherz, 1994).

Conclusion

Herbst/MB treatment of adult Class II division 1 malocclusions affects all mandibular parameters favourably and reduces both the skeletal and soft tissue profile convexities. Class II correction is, however, achieved by more dental than skeletal changes: overjet correction by 13 per cent skeletal and 87 per cent dental changes, and molar correction by 22 per cent skeletal and 78 per cent dental changes. Thus, the Herbst/MB appliance provides the orthodontist with a new option for borderline Class II division 1 subjects in early and late adulthood.

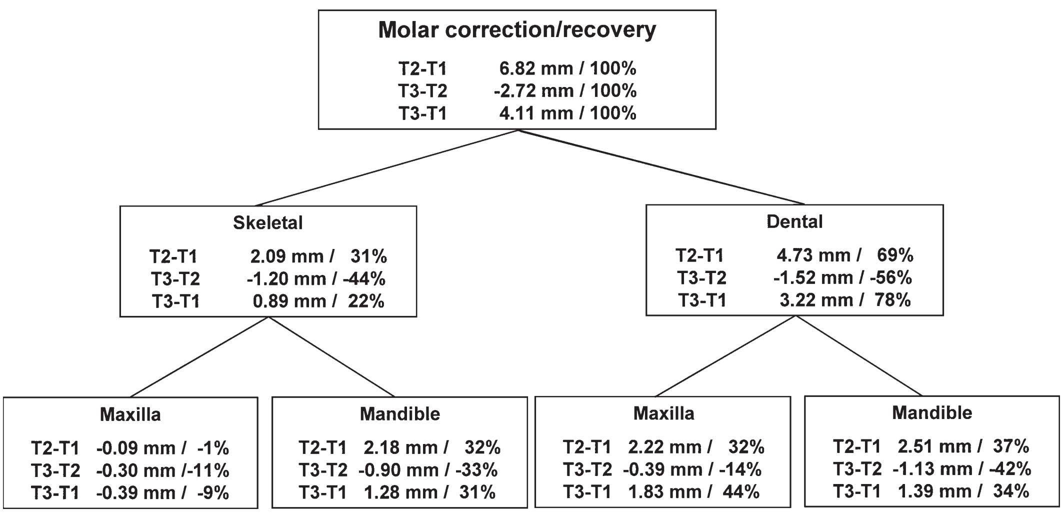

Figure 5 Mechanism of Class II molar correction/recovery in 23 adult Class II division 1 adult subjects treated with the Herbst/multibracket (MB) approach. The amounts of skeletal and dental changes for the Herbst phase (T2–T1), the MB phase (T3–T2), and the total treatment period (T3–T1) are given. Negative values imply unfavourable changes for Class II molar correction.

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Acknowledgement

We thank Dr Sabine Schindler, former Assistant Professor of the Department of Orthodontics of the University of Giessen, for evaluation of the cephalometric data.

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