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Dentoskeletal changes in adult Class II division 1 Herbst treatment—how much is left after the retention period?

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SUMMARY The aim of this study was to assess dentoskeletal changes following Herbst–Multibracket treatment in adult Class II division 1 patients. The subject material comprised 15 adult Class II division 1 subjects exhibiting a Class II molar relationship more than or equal to 0.5 cusps bilaterally or more than or equal to 1.0 cusps unilaterally and an overjet more than or equal to 6.0 mm. The average treatment time was 9 months (Herbst phase) plus 13.9 months (Multibracket phase). Lateral headfilms from before treatment (T1), after Herbst–Multibracket treatment (T2), and after at least 24 months of retention (T3) were analysed using the 'sagittal-occlusal analysis' (Pancherz, 1982) as well as standard cephalometric variables. During the treatment period (T2–T1), molar relationship, overjet (–6.2 mm), and overbite (–2.1 mm) were successfully corrected. The Class II jaw base relationship improved (ANB –0.8 degrees and Wits –1.1 mm) and the hard as well as soft tissue profile straightened (NApg +1.5 degrees, NsNoPgs +1.2 degrees, and NsSnPgs +1.5 degrees). During the retention period of on average 35.5 months (T3–T2), the amount of occlusal relapse (T3–T2) was small (less than or equal to 1.0 mm). The jaw base relationship (ANB +0.3 degrees and Wits +0.7 mm) and the profile convexities (NApg –0.3 degrees, NsNoPgs –0.6 degrees, and NsSnPgs +0.6 degrees) deteriorated slightly. Following the retention period, only minimal amounts of skeletal changes contributing to Class II correction in adult Herbst–Multibracket treatment were retained. Thus, adult Herbst–Multibracket treatment results in mainly dental changes, which however, showed good stability.

Introduction

Orthognathic surgery, camouflage treatment, and lately also Herbst appliance treatment are common modalities for Class II treatment in adults (Ruf and Pancherz, 1998, 1999a, 1999b, 2003, 2006; Pancherz, 2000; Pancherz and Ruf, 2000; Bondemark *et al.*, 2007; Chaiyongsirisern *et al.*, 2009; Bock and Ruf, 2010). The treatment decisions for adult Class II division 1 patients will—among other factors—be influenced by the patient's age, the severity of the skeletal discrepancy and/or the malocclusion's impact on the facial profile, the expected success rate, and the stability of treatment results as well as the patient's willingness to undergo surgery.

Comparing the effects of adult Herbst treatment and mandibular sagittal split osteotomy on Class II molar relationship and overjet correction, it was shown that despite larger dental changes in the Herbst patients, the occlusal results were comparable between the groups (Ruf and Pancherz, 2004; Chaiyongsirisern *et al.*, 2009). Consequently, adult Herbst treatment has been recommended for adult Class II division 1 borderline cases (Pancherz, 2000; Pancherz and Ruf, 2000; Ruf and Pancherz, 2004; Chaiyongsirisern *et al.*, 2009). This recommendation is in concordance with Cassidy *et al.* (1993), who concluded that orthodontics would be the better choice for the borderline adult Class II patient, whereas surgery would be appropriate for more severely affected individuals.

Concerning long-term stability of adult Class II treatment, Mihalik *et al.* (2003) compared the outcomes of orthodontic camouflage treatment to orthognathic surgery and found overbite to be equally stable in both groups. An overjet relapse was seen twice as often in surgery patients and also more functional/temporomandibular joint problems were reported by this group. However, the overall satisfaction with treatment was similar in both groups.

Concerning the stability of adult Herbst treatment, two papers have been published so far. Chaiyongsirisern *et al.* (2009) carried out a cephalometric investigation comparing the changes seen in young Asian/Chinese adults treated by mandibular sagittal split osteotomy or stepwise advancement using the Herbst appliance and found both treatment options to result in similarly good dentoskeletal 3 year stability. In addition, a good 2 year stability for the occlusal features of young adult Caucasian Herbst patients treated by single-step advancement was found by Bock and Ruf (2010). However, so far, no data have been published on the dentoskeletal changes taken place during the retention period after Herbst–Multibracket treatment of adult Caucasians.

Therefore, it was the aim of the present investigation to analyse the dentoskeletal changes contributing to occlusal stability or relapse after single-step Herbst–Multibracket treatment in adult Caucasian Class II division 1 patients.

Materials and methods

The records of all Class II division 1 patients that were treated with a Herbst appliance at the Orthodontic Department at the University of Giessen (Germany) were screened for the following inclusion criteria: Class II molar relationship more than or equal to half cusp bilaterally or a full cusp unilaterally, an overjet of more than or equal to 6 mm, and no remaining growth pre-treatment. In order to assure growth had ceased, the patients had to be at least 18 years of age and had to present a hand–wrist radiographic stage R–J (complete fusion of the radial epiphysis and diaphysis—Hägg and Taranger, 1980).

Fifteen patients (11 females and 4 males) fulfilled all inclusion criteria. The mean age at the start of treatment was 25.6 years (SD 10.1). The pre-treatment average Class II molar relationship amounted to 0.8 cusp widths and the mean overjet was 8.9 mm.

The same protocol was used in the therapy of all subjects—Herbst appliance followed by full Multibracket appliance treatment in both jaws. The treatment was performed by the head of department, senior residents, or postgraduate students under senior supervision. The average treatment length amounted to 9.0 months for the Herbst and 13.9 months for the Multibracket phase.

The average retention time amounted to 35.5 months (SD 11.8). In 13 of the 15 subjects, retention was performed using a removable appliance (four activators and 9 Hawley plates) in combination with a fixed lower canine-to-canine retainer. Three of these subjects had an additional fixed upper canine-to-canine retainer. The remaining two subjects were retained with fixed upper and lower canine-to-canine retainers only. At the time of the present investigation, the fixed retainers were still in place in all patients and most of the patients still used the removable appliance occasionally.

Lateral headfilms from before Herbst treatment (T1), after Herbst–Multibracket treatment (T2), and after retention (T3) were analysed. The 'sagittal-occlusal analysis' (SO analysis, Figure 1) according to Pancherz (1982) as well as standard cephalometric variables (Figure 2) were used for the assessment of the treatment and post-treatment dentoskeletal changes.

All roentgenograms were traced manually by one single investigator (NB) using matte acetate film. Linear and angular measurements were performed to the nearest 0.5 mm and 0.5 degrees, respectively. No correction was made for linear enlargement (approximately 7 per cent in the median sagittal plane). To minimize the method error, all three lateral cephalograms of one patient were traced in one session. Furthermore, all tracings and measurements were performed twice with a time interval of at least 2 weeks.

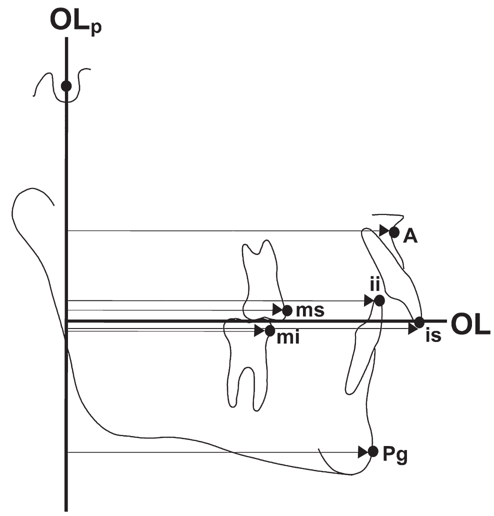

Figure 1 Sagittal-occlusal analysis (SO analysis). Measuring landmarks and measuring distances.

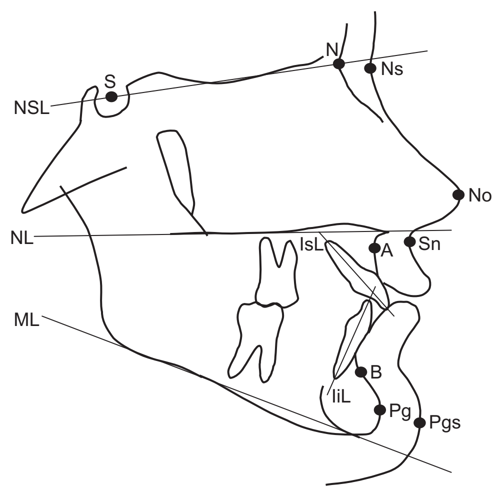

Figure 2 Standard cephalometric variables. Measuring landmarks.

The mean value of both measurements was used as the final measurement value.

The method error (ME) was calculated using the formula of Dahlberg (1940): $ME = \sqrt{\frac{\sum d^2}{2n}}$, where d is the difference between two registrations and n is the sample size (n = 15). The data are shown in Table 2 (SO analysis) and Table 3 (standard cephalometric variables).

Due to the explorative character of the study, no sample size calculation was performed. The arithmetic means (Mean) and standard deviations (SDs) were calculated for each variable. As the data showed normal distribution (Kolmogorov–Smirnov test), the changes of the variables during the different examination periods were evaluated using the *t*-test for paired samples. The following levels of significance were utilized: $P < 0.001$, $P < 0.01$ and $P < 0.05$; $P \geq 0.05$ was considered as not significant (ns).

Results

The pre-treatment, post-treatment, and post-retention characteristics (SO analysis and standard cephalometric variables) are presented in Table 1. The treatment (T2–T1) and post-treatment changes (T3–T2) as well as the changes of the whole observation period (T3–T1) are shown in Table 2 (SO analysis) and Table 3 (standard cephalometric variables).

Changes during the treatment period (T2–T1)

For the whole sample, an average overjet correction of 6.2 mm ($P < 0.001$) and a molar correction of 3.5 mm ($P < 0.001$) was determined (Figures 3 and 4). Concerning

Table 1 Pre-treatment (T1), post-treatment (T2), and post-retention (T3) values for both the sagittal-occlusal analysis (SO analysis) and the standard cephalometric variables in 15 adult Class II division 1 subjects.

	T1				T2				T3			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
SO analysis												
ss	80.5	4.30	73.0	89.3	80.3	4.08	73.5	88.0	80.8	4.25	73.3	90.0
pg	82.4	5.53	75.0	94.8	83.3	5.78	75.5	96.8	83.3	5.57	76.0	96.5
is	90.6	4.85	83.3	101.0	87.4	4.68	78.0	95.3	88.1	4.73	78.8	97.0
ii	81.7	5.11	71.5	91.0	84.7	4.63	75.8	93.0	84.4	4.35	75.0	92.3
ms	59.5	4.90	50.3	67.8	58.2	5.82	47.5	68.8	58.8	5.47	48.5	68.3
mi	55.9	6.55	46.0	66.3	58.1	6.32	48.0	68.5	58.4	6.32	47.0	68.5
Standard cephalometrics												
SNA	78.8	4.00	70.3	85.0	78.6	3.83	70.5	83.8	78.5	4.03	70.8	84.5
SNB	73.3	4.45	63.0	79.8	73.9	4.44	64.3	80.3	73.6	4.78	64.3	80.5
ANB	5.5	1.44	3.0	8.5	4.7	1.53	2.0	7.8	4.9	1.67	1.5	8.5
Wits appraisal	2.7	1.63	0.5	5.8	1.6	1.87	−1.3	4.3	2.3	1.60	−1.3	4.8
NL/NSL	9.7	4.81	3.5	23.3	9.6	4.79	3.5	23.3	9.6	4.83	3.0	22.8
ML/NSL	35.6	7.54	22.5	51.0	35.3	7.64	21.3	51.0	35.2	8.15	19.8	52.0
Overbite	4.1	2.02	1.3	7.5	2.0	0.90	0.5	3.8	3.0	0.81	1.8	4.3
IsL/NA	25.7	8.02	13.3	39.5	17.7	6.24	8.0	29.8	19.2	5.37	10.8	30.0
IiL/NB	25.1	7.04	12.8	42.0	36.0	5.13	29.3	45.8	32.8	4.52	27.8	40.8
IsL/IiL	124.3	9.15	110.5	145.5	121.6	8.23	106.0	133.8	123.6	7.25	112.8	134.8
NAPg	171.4	4.52	162.0	177.3	172.9	4.21	164.8	179.3	172.6	4.82	163.0	178.8
NsNoPgs	127.2	4.19	119.3	133.8	128.4	4.17	120.0	135.0	127.8	5.05	117.3	135.0
NsSnPgs	157.8	5.75	149.3	166.5	159.3	5.48	150.5	167.3	159.5	5.84	149.0	167.8

The arithmetic mean (Mean), standard deviation (SD), minimum (Min), and maximum (Max) of the cephalometric data are given in millimetre (SO analysis, overbite, and Wits) or degrees.

Table 2 Treatment (T2–T1) and post-treatment changes (T3–T2) as well as the changes of the entire observation period (T3–T1) for sagittal-occlusal analysis (SO analysis) in 15 adult Class II division 1 subjects.

	T2–T1						T3–T2						T3–T1					
	Mean	SD	ME	Min	Max	*P*	Mean	SD	ME	Min	Max	*P*	Mean	SD	ME	Min	Max	*P*
ss	+0.2	0.81	0.76	−1.0	+2.0	0.439	−0.5	1.02	0.71	−2.5	+1.0	0.070	+0.3	0.99	1.01	−2.3	+1.3	0.194
pg	+0.9	1.07	0.76	−1.3	+2.5	0.005	0.0	1.44	0.93	−2.8	+2.3	0.895	+0.9	1.31	0.76	−0.8	+4.0	0.013
is	+3.2	1.75	0.85	+1.0	+7.3	0.000	−0.7	1.61	0.92	−5.0	+1.0	0.042	+2.5	1.41	0.76	−0.3	+5.3	0.000
ii	+3.0	1.57	0.73	−1.0	+5.8	0.000	−0.3	2.12	0.90	−9.0	+0.5	0.250	+2.7	1.61	0.97	−1.0	+5.0	0.000
ms	+1.3	1.57	0.91	−1.0	+4.0	0.006	−0.6	0.94	0.84	−2.5	+0.5	0.023	+0.7	0.99	0.74	−1.3	+3.0	0.018
mi	+2.2	2.00	0.91	−1.5	+6.5	0.001	+0.3	1.13	0.74	−1.8	+2.0	0.295	+2.5	2.17	0.81	−1.5	+6.8	0.000
is–ss	+3.0	1.80	0.69	+0.3	+6.0	0.000	−0.2	0.86	0.77	−1.3	+1.8	0.465	+2.8	1.27	0.60	−1.0	+4.8	0.000
ii–pg	+2.1	2.32	0.60	−3.0	+5.5	0.003	−0.3	0.76	0.33	−1.5	+1.3	0.071	+1.8	1.88	0.71	−2.8	+4.8	0.003
is–ii (overjet)	+6.2	1.74	0.75	+3.8	+9.5	0.000	−1.0	0.64	0.38	−2.5	0.0	0.000	+5.2	1.68	0.75	−2.5	−8.0	0.000
ms–ss	+1.1	1.99	0.79	−2.3	+4.5	0.044	−0.1	1.10	0.67	−1.5	+2.0	0.730	+1.0	1.45	0.94	−1.0	+3.8	0.016
mi–pg	+1.3	1.49	0.85	−1.0	+4.5	0.004	+0.3	0.73	0.73	−1.0	+1.8	0.179	+1.6	1.55	0.82	−0.8	+5.0	0.002
ms–mi (molar relationship)	+3.5	2.11	0.77	+0.8	+7.5	0.000	−0.3	0.84	0.55	−1.3	+2.0	0.189	+3.2	2.12	0.70	0.0	7.0	0.000

The arithmetic mean (Mean), standard deviation (SD), method error (ME), minimum (Min), and maximum (Max) for the cephalometric data are given in millimetre. Furthermore, the statistical significance level (*P*-value) is shown. Plus (+) means favourable changes and minus (−) means unfavourable changes for the Class II correction.

Table 3 Treatment (T2–T1) and post-treatment changes (T3–T2) as well as the changes of the entire observation period (T3–T1) for standard cephalometric variables in 15 adult Class II division 1 subjects.

	T2–T1						T3–T2						T3–T1					
	Mean	SD	ME	Min	Max	*P*	Mean	SD	ME	Min	Max	*P*	Mean	SD	ME	Min	Max	*P*
SNA	−0.2	0.91	0.71	−2.0	1.3	0.410	−0.1	1.05	1.04	−3.0	1.5	0.718	−0.3	0.67	1.32	−1.8	0.5	0.105
SNB	0.6	0.55	0.52	0.0	1.8	0.001	−0.3	0.76	0.84	−2.0	1.3	0.111	0.3	0.98	0.65	−2.0	2.3	0.341
ANB	−0.8	0.96	0.80	−2.3	1.3	0.007	0.2	0.82	0.72	−1.0	2.3	0.286	−0.6	0.86	1.00	−2.8	0.5	0.026
Wits appraisal	−1.1	1.38	0.84	−2.8	1.8	0.007	0.7	1.35	0.72	−1.0	3.5	0.076	−0.4	1.23	0.93	−3.8	1.5	0.164
NL/NSL	−0.1	0.67	1.02	−1.0	1.5	0.777	0.0	0.68	0.62	−1.0	1.3	0.712	−0.1	0.69	1.11	−1.3	1.0	0.525
ML/NSL	−0.3	0.81	0.51	−1.5	1.3	0.198	−0.1	0.63	0.57	−1.5	1.0	0.482	−0.4	0.96	0.53	−2.8	1.0	0.130
Overbite	−2.1	1.90	0.58	−4.5	0.5	0.001	1.0	0.91	0.56	−0.3	3.3	0.001	−1.1	1.76	0.48	−3.8	1.0	0.023
IsL/NA	−8.0	8.68	2.59	−22.5	4.0	0.003	1.5	4.89	2.39	−10.8	10.5	0.260	−6.5	6.00	3.05	−17.8	3.8	0.001
IiL/NB	10.9	6.00	1.28	3.8	21.0	0.000	−3.2	2.90	1.91	−9.0	0.8	0.001	7.7	5.74	1.68	−4.0	17.3	0.000
IsL/IiL	−2.7	9.67	3.61	−21.3	12.5	0.304	2.0	4.95	3.18	−11.3	8.5	0.131	−0.7	8.11	2.87	−16.3	15.3	0.773
NAPg	1.5	2.13	1.35	−3.5	5.3	0.017	−0.3	2.13	1.65	−5.0	3.8	0.574	1.2	1.47	1.84	−1.3	5.3	0.008
NsNoPgs	1.2	1.68	1.62	−2.0	3.3	0.018	−0.6	1.36	0.89	−2.8	1.5	0.109	0.6	1.94	1.44	−2.8	4.0	0.278
NsSnPgs	1.5	1.60	1.57	−1.0	5.5	0.003	0.2	1.11	1.21	−2.0	1.8	0.460	1.7	1.65	1.52	0.5	4.8	0.001

The arithmetic mean (Mean), standard deviation (SD), method error (ME), minimum (Min), and maximum (Max) for the cephalometric data are given in millimetre (overbite and Wits) or degrees. Furthermore, the statistical significance level (*P*-value) is shown.

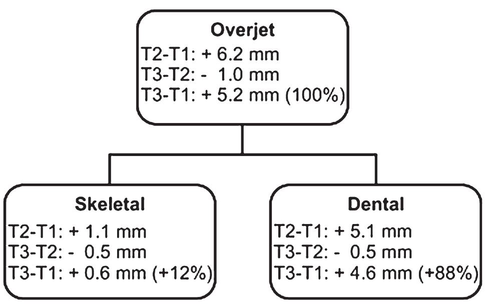

Figure 3 Mechanism of overjet changes during the treatment (T2–T1), post-treatment (T3–T2), and entire observation period (T3–T1). Plus indicates a favourable change and minus indicates an unfavourable change concerning overjet correction.

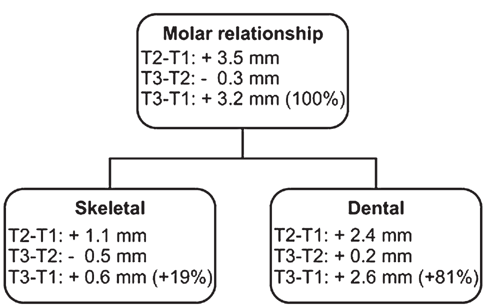

Figure 4 Mechanism of molar relationship changes during the treatment (T2–T1), post-treatment (T3–T2), and entire observation period (T3–T1). Plus indicates a favourable change and minus indicates an unfavourable change concerning molar relationship correction.

standard cephalometric variables, small but favourable changes were seen for both the sagittal (ANB: −0.8 degrees, $P < 0.01$; Wits: −1.1 mm, $P < 0.01$) and the vertical dimensions (overbite: −2.1 mm, $P < 0.01$; ML/NSL: −0.3 degrees, $P \geq 0.05$). Furthermore, the profile convexity decreased (NAPg: +1.5 degrees, $P < 0.05$; NsNoPgs: +1.2 degrees, $P < 0.05$; NsSnPgs +1.5 degrees, $P < 0.01$). Looking at incisor angulation, an average retroclination of 8.0 degrees ($P < 0.01$) was seen in the upper jaw, while a proclination of 10.9 degrees ($P < 0.001$) occurred in the lower jaw.

Changes during the post-treatment period (T3–T2)

Minor recovering changes occurred for most of the variables during the post-treatment period. The overjet (Figure 3) increased by an average of 1.0 mm ($P < 0.001$) and the molar relationship (Figure 4) recovered by 0.3 mm ($P \geq 0.05$). Concerning standard cephalometric variables, only insignificant changes were seen for most of the variables in the sagittal (ANB: +0.2 degrees, $P \geq 0.05$; Wits +0.7 mm, $P \geq 0.05$) and vertical dimensions (overbite: +1.0 mm, $P < 0.01$; ML/NSL: −0.1 degrees, $P \geq 0.05$) as well as for profile convexity (NAPg: −0.3 degrees, $P \geq 0.05$; NsNoPgs: −0.6 degrees, $P \geq 0.05$; NsSnPgs +0.2 degrees, $P \geq 0.05$). The upper incisors proclined insignificantly (+1.5 degrees, $P \geq 0.05$), while the lower incisors clearly recovered (−3.2 degrees, $P < 0.01$).

Changes during the whole observation period (T3–T1)

For the whole sample, an average overjet correction of 5.2 mm ($P < 0.001$) and a molar correction of 3.2 mm ($P < 0.001$) were determined (Figures 3 and 4). Concerning standard cephalometric variables, small but favourable changes were seen for both the sagittal (ANB: −0.6 degrees, $P < 0.05$; Wits: −0.4 mm, $P \geq 0.05$) and the vertical dimensions (overbite: −1.1 mm, $P < 0.05$; ML/NSL: −0.4degrees, $P \geq 0.05$). Furthermore, the profile convexity decreased (NAPg: +1.2degrees, $P < 0.01$;

NsNoPgs: +0.6degrees, $P \geq 0.05$; NsSnPgs: +1.7degrees, $P < 0.001$). Looking at incisor angulation, an average retroclination of 6.5degrees ($P < 0.01$) was seen in the upper jaw, while a proclination of 7.7degrees ($P < 0.01$) occurred in the lower jaw.

Mechanism of overjet and molar relationship changes

During the whole observation period (T3–T1), the overjet correction comprised 12 per cent skeletal and 88 per cent dental changes (Figure 3), while 19 per cent skeletal and 81 per cent dental changes contributed to the correction of the molar relationship (Figure 4).

Discussion

Even though all subjects presented a complete fusion of the radial epiphysis, the small sample was not completely homogeneous due to the wide age range at start of treatment and the predominance of females, probably due to their generally higher interest in facial appearance (Hoppenreijs *et al.*, 1999). Nevertheless, the severity of the malocclusion was similar and the treatment protocol identical in all subjects. As the paper deals with adult subjects, an untreated control group was not available. Although—over a long period—minor dentoskeletal changes may occur even in adults (Forsberg, 1979; Sarnäs and Solow, 1980; Behrents, 1985; Bondevik, 1995; Bondevik, 2010), no major changes would have been expected in such a control group during the present observation period. However, a comparison to data available in literature was performed (Table 4) and discussed later in this chapter.

The investigation is based on a retrospective evaluation of cephalometric and hand–wrist radiographs, which were taken quite a long time ago during regular orthodontic treatment of the patients. Therefore, ethic approval was not needed. However, nowadays, it might be contrary to the national guidelines of some countries to take all these radiographs during regular treatment.

During the Herbst–Multibracket treatment period (T2–T1) all adult Class II division 1 subjects were successfully treated to a Class I dental arch relationship. Class II correction was a result of both skeletal and dental changes. However, the amount of skeletal changes contributing to overjet and molar correction was markedly smaller than in adolescents (Ruf and Pancherz, 1999a; Purkayastha *et al.*, 2008).

While interpreting the results of the retention period in terms of stability, it must be considered that fixed retainers were still in place at the time of the present investigation. This could have influenced the stability of overjet by preventing a proclination of the upper and a retroclination of the lower incisors. However, it seems unlikely that these retainers had an influence on the stability of the sagittal molar relationship. The activator worn by four of the patients might have had an influence on both the stability of overjet and the sagittal molar and canine relationships.

During the retention period (T3–T2), the occlusion settled. Minor and clinically irrelevant changes were seen

Table 4 Overview of the present results and the data available in the literature for the changes during the post-treatment period (T3–T2; mean duration given). Ex, extraction; MB, Multibracket; (—), data not available.

Reference	Present article	Chaiyongsirisern *et al.* (2009)	Cassidy *et al.* (1993)	Mihalik *et al.* (2003)	Chaiyongsirisern *et al.* (2009)	Cassidy *et al.* (1993)	Mihalik *et al.* (2003)	
Treatment protocol	Herbst–MB	Herbst–MB	MB Ex + non-Ex	MB Ex	Surgery–MB Mandible only	Surgery–MB One/two jaws	Surgery–MB	
							Mandible only	Two jaws
Post-treatment period (T3–T2; years)	3.0	3.0	7.1	12.0	3.0	4.7	5.9	6.5
Overjet (is–ii)	1.0	0.7	1.3	0.8	0.4	0.9	1.1	0.4
Molar relationship (ms–mi)	−0.3	−0.6	−0.3	—	−0.4	−0.2	—	—
ANB	0.2	0.2	0.2	0.0	0.2	0.4	0.3	0.4
Wits appraisal	0.7	0.5	0.4	—	0.2	0.6	—	—
NL/NSL	0.0	0.4	—	—	0.2	—	—	—
ML/NSL	−0.1	−0.3	−0.3	0.1	0.0	1.7	−0.9	1.2
Overbite	1.0	0.2	1.9	1.5	0.6	1.2	0.3	0.5
NAPg	−0.3	0.0	—	—	−0.1	—	—	—
NsNoPgs	−0.6	−0.3	—	—	−0.5	—	—	—
NsSnPgs	0.2	−0.3	—	—	−0.3	—	—	—

Mean values for overjet and molar relationship as well as some of the standard cephalometric variables are given in millimetre (overjet, molar relationship, overbite, and Wits) or degrees.

for almost all dental and skeletal variables. Therefore, the overall stability of adult Class II division 1 Herbst treatment can be considered as good. Over the entire observation period (T3–T1), major changes in overjet and molar relationship prevail.

The comparison of the present data with the literature is difficult as only one paper on the stability of dentoskeletal effects after adult Herbst treatment has been published so far (Chaiyongsirisern *et al.*, 2009) and there are only few articles dealing with the stability of Class II treatment results in adult patients in general. While Chayongsirisern *et al.* (2009) evaluated Asian adult Class II division 1 patients after Herbst–Multibracket or surgical treatment, Cassidy *et al.* (1993) investigated adult borderline Class II division 1 patients after Multibracket non-extraction or surgical treatment and Mihalik *et al.* (2003) compared long-term results of adult Class II camouflage treatment to surgery. The mean observation periods of these studies ranged between 3 and 12 years. A comparison of the available data (Cassidy *et al.*, 1993; Mihalik *et al.*, 2003, Chaiyongsirisern *et al.*, 2009) and the results of the present investigation are shown in Table 4 and discussed below.

Looking at overjet relapse during the retention period, the values in the literature (Table 4) range between 0.4 mm (Chaiyongsirisern *et al.*, 2009) and 1.3 mm (Cassidy *et al.*, 1993) and for molar relationship, values between 0.6 mm (Chaiyongsirisern *et al.*, 2009) and 0.2 mm (Cassidy *et al.*, 1993) can be found. Thus, irrespective of the treatment approach (Herbst–Multibracket, Multibracket non-extraction, camouflage, or surgery), the changes during the retention period can be considered as clinically irrelevant. The present findings for adult Caucasian Herbst patients are in concordance with literature.

Also, for the sagittal skeletal relationship, similar amounts of changes have been described during the retention period with all treatment approaches (Herbst–Multibracket, Multibracket non-extraction, camouflage, or surgery). For both ANB angle—range 0.0 degrees (Mihalik *et al.*, 2003) to 0.4 degrees (Cassidy *et al.*, 1993)—and Wits appraisal—range 0.2 mm (Chaiyongsirisern *et al.*, 2009) to 0.6 mm (Cassidy *et al.*, 1993)—only minor changes are described. The present findings for adult Caucasian Herbst patients showing an ANB angle recovery of 0.2 degrees and 0.7 mm for Wits appraisal are once again comparable with literature.

Concerning the vertical dimension, the changes for both NL/NSL angle and ML/NSL angle were below 0.5 degrees for the treatment approaches Herbst–Multibracket, Multibracket non-extraction, and camouflage, which again corresponds to the present results. For surgical treatment approaches, however, changes of 0.9 degrees (Cassidy *et al.*, 1993) to 1.7 degrees (Mihalik *et al.*, 2003) were reported for three of the four groups. For overbite, a relapse of 0.2 mm (Chaiyongsirisern *et al.*, 2009) to 1.9 mm (Cassidy *et al.*, 1993) is documented in the literature; thus, the present findings (overbite relapse of 1.0 mm) are in the middle of that range.

For profile convexity, the published data show changes during the retention period up to 0.5 degrees. Once more, the present adult Caucasian Herbst values are similar. Thus, also profile convexity seems to be similarly stable irrespective of the treatment approach (Herbst–Multibracket, Multibracket non-extraction, camouflage, or surgery).

Conclusions

Following the retention period, only minimal amounts of skeletal changes contributing to Class II correction in adult Herbst–Multibracket treatment were retained. Taken together, adult Herbst–Multibracket treatment results in mainly dental changes, which however, showed good stability.

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