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Effects of activator and activator headgear treatment: comparison with untreated Class II subjects

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SUMMARY The aims of this study were to determine whether the activator and activator headgear encourage mandibular growth, and whether there is any superiority of one appliance over the other or if the resultant changes are due to normal growth. Forty-nine skeletal Class II division 1 patients were selected. Thirty-three (13 females, 20 males; mean age 12.52 ± 1.42 years) were treated with an Andresen activator and the remaining 16 (7 females, 9 males; mean age 13.04 ± 1.47 years) with an activator headgear combination. Twenty Class II subjects (9 females, 11 males; mean age 12.57 ± 1.11 years) who had previously refused treatment served as a control group. Cephalometric landmarks were marked and digitized by one author to avoid inter-observer variability. Nine angular and 12 linear measurements were established and measured using Vistadent™ AT software. A paired-sample *t*-test and an ANOVA test were used to statistically evaluate the findings.

The results revealed that both the activator and the activator headgear combination significantly ($P < 0.001$) encouraged mandibular growth, but had little restraining effect on the maxilla. The mandibular incisors were more controlled in the activator headgear combination group. The resultant skeletal, dentoalveolar and soft tissue changes differed significantly from those due to growth.

Introduction

A Class II malocclusion may result from a mandibular deficiency, maxillary excess or a combination of both, but the most common finding is mandibular skeletal retrusion (McNamara, 1981; McNamara and Ellis, 1988). Functional jaw orthopaedic appliances are designed to encourage adaptive skeletal growth by maintaining the mandible in a corrected forward position (Clark, 1995). The activator developed by Andresen is one of the most widely used functional appliances. A high-pull facebow attached to the activator is indicated in patients with an increase in the vertical dimension should be minimized or avoided (Deguchi, 1991; Stockli and Teuscher, 1994). The combined appliance is also used to provide greater cumulative skeletal growth than either appliance alone (Teuscher, 1978; Pfeiffer and Grobéty, 1982; Levin, 1985; Lagerström *et al.*, 1990; Öztürk and Tankuter, 1994; Cura *et al.*, 1996; Bendeus *et al.*, 2002).

The dentoalveolar effects of activators and activator headgear combinations have been well documented (Jakobsson, 1967; Harvold and Vargervik, 1971; Calvert, 1982; Pancherz, 1984; Lux *et al.*, 2001; Basciftci *et al.*, 2003). However, there is still much debate over the orthopaedic effects of the appliances (Calvert, 1982; Tulloch *et al.*, 1990). Many studies have compared the effects of activator and activator headgear combinations (Gögen and Parlar, 1989; Üner *et al.*, 1989; Öztürk and Tankuter, 1994; Cura *et al.*, 1996; Weiland *et al.*, 1997; Altenburger and Ingervall, 1998), but only a few of them have compared the results with an untreated Class II sample (Gögen and Parlar, 1989; Üner *et al.*, 1989; Öztürk and Tankuter, 1994).

The aims of this study were, therefore, to determine whether:

1. Activator and activator headgear encourage mandibular growth.
2. There is any superiority of one appliance over the other.
3. The resultant changes are due to treatment or normal growth.

Materials and methods

Cephalometric records of 49 skeletal Class II division 1 patients treated between 2001 and 2003 at the Orthodontic Department of Süleyman Demirel University were selected for this retrospective study. Selection criteria included: no previous orthodontic treatment, treatment with an activator or activator headgear combination, no additional fixed appliances and acceptable co-operation. The records of only one patient were excluded due to poor co-operation and discontinuation of treatment. Two groups were formed according to the treatment protocol. One group consisted of 33 patients (13 females, 20 males) who were treated with an Andresen activator, and the second group of 16 patients (7 females, 9 males) treated with an activator and a high pull headgear.

The activator appliance consisted of a bimaxillary block of acrylic with an upper labial bow (0.7 mm) and Adams' clasps on the maxillary molar teeth. The incisal third of the lower incisors were capped with acrylic to avoid extreme labial tipping. Headgear tubes were incorporated into the

interocclusal acrylic in the premolar area. The construction bite was taken with the mandible protruded in an edge-to-edge incisor relationship and the inter-occlusal space was increased to 5–7 mm. In patients with large overjets, two step activation was performed. High-pull extraoral forces of approximately 300 to 400 g per side were used. The patients were advised to wear the appliances for at least 16 hours per day. All patients were treated by the authors until the desired Class I dental relationship and overjet reduction were achieved.

A control group of 20 Class II subjects (9 females, 11 males) who had previously refused treatment were selected. Those who did not return for a second observation were excluded from the study. Informed consent was obtained from all the patients included in the study. The baseline characteristics of the groups are presented in Table 1.

Standardized lateral cephalograms of the patients in the treatment groups were obtained before (T0) and after treatment (T1). Lateral cephalograms of the subjects in the control group were obtained at the first (T0) and second (T1) observation times.

The cephalometric landmarks were marked and digitized by one author and measured using Vistadent™ AT software (GAC International, Inc., Bohemia, New York, USA). All the cephalometric measurements of 20 subjects were repeated two weeks later to determine the measurement error, which was 0.994 or above for all parameters. Descriptive statistics were calculated for all measurements and a paired-sample *t*-test was used to evaluate treatment-induced changes within each group. ANOVA and Tukey tests were used for intergroup comparison. Since the group sizes were unequal, the harmonic mean of the group sizes was used and type 1 error levels were ignored. All statistical analyses were performed using SPSS version 11.0.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Statistical comparison of the baseline variables of the groups is presented in Table 1. The groups did not differ significantly for gender or initial chronological age ($P > 0.05$). However, there were significant differences between the observation periods of the groups ($P < 0.01$). Table 2 shows the cephalometric measurements of the three groups at the beginning of the observation period. The results of the descriptive statistics and intragroup comparisons of cephalometric variables are presented in Tables 3–5. Table 6 shows the intergroup comparison of the mean changes between T0 and T1.

Intragroup changes

Activator group (Table 3). The skeletal Class II relationship was corrected in the activator group by a mean increase in SNB resulting in a reduction in ANB. Significant increases were found in ramus height and mandibular length. The dentition showed similar mean changes with retraction of the upper incisors, advancement of the lower incisors and a reduction in overjet. Some opening rotation of the mandible occurred with a mean increase in Go–Gn to SN and anterior face height (AFH).

Activator headgear group (Table 4). A similar decrease in SNA and increase in SNB resulted in a reduction of ANB. Mandibular length and ramus height significantly increased during treatment. Retraction of the upper incisors was more pronounced than advancement of the lower incisors. Overjet reduction was primarily achieved by retraction of the upper incisors. The mandibular plane angle remained almost unchanged, while a significant opening rotation of the occlusal plane occurred.

Control group (Table 5). During the observation period, mandibular length, ramus height, and posterior and anterior face heights increased significantly. The occlusal plane to SN angle decreased resulting in anterior rotation of the dentition. A slight, but not statistically significant, reduction in ANB was observed.

Intergroup comparison (Table 6)

There was no significant difference in the changes in SNA, SNB and ANB between the three groups. There was also no significant difference in overjet reduction between the two treatment groups, but both groups showed significantly greater overjet reduction than the controls. The two treatment groups both showed significantly more upper incisor retraction and lower incisor advancement than the controls, but the changes in upper and lower incisor inclination differed between the two treatment groups. Lower incisor advancement in the activator group and upper incisor retroclination in the activator headgear group were

Table 1 Baseline characteristics of the groups.

	Activator	Activator headgear	Control	*P* value
n	33	16	20	
Percentage of females	39.39	43.75	45.00	0.911 C
Mean pre-treatment age in years (SD)	12.52 (1.42)	13.04 (1.47)	12.57 (1.11)	0.425 A
Mean observation period in years (SD)	0.99 (0.30)[b]	0.87 (0.21)[a,b]	0.69 (0.25)[a]	0.001 A

A, analysis of variance; C, Chi-square test; SD, standard deviation.
Means for groups in homogeneous subsets are indicated by the same letter.

Table 2 Statistical comparison of the cephalometric variables at the beginning of the observation period.

	Activator				Activator headgear				Control				
	95% confidence interval				95% confidence interval				95% confidence interval				
	Mean	SD	Lower	Upper	Mean	SD	Lower	Upper	Mean	SD	Lower	Upper	*P*
SNA (°)	79.62	4.32	78.09	81.15	80.90	4.90	78.29	83.51	80.46	3.06	79.03	81.89	0.559
SNB (°)	74.29	3.74	72.97	75.62	73.36	3.49	71.49	75.22	74.58	3.08	73.14	76.02	0.558
ANB (°)	5.32[a]	2.09	4.58	6.06	7.55[b]	2.30	6.32	8.78	5.86[a]	1.40	5.20	6.52	0.002
Upper incisor to NA (mm)	6.38	3.25	5.23	7.53	5.94	2.21	4.76	7.12	5.67	2.27	4.61	6.73	0.654
Upper incisor to NA (°)	26.46	8.68	23.38	29.54	25.23	5.69	22.20	28.26	22.65	7.35	19.21	26.08	0.224
Lower incisor to NB (mm)	4.72[a]	2.74	3.75	5.69	7.42[b]	2.58	6.05	8.80	5.13[a]	1.83	4.27	5.98	0.002
Lower incisor to NB (°)	25.12[a,b]	7.26	22.55	27.69	29.6[b]	6.09	26.35	32.85	24.71[a]	5.46	22.15	27.26	0.050
Interincisal angle (°)	123.09[a,b]	10.08	119.52	126.67	117.62[a]	7.58	113.58	121.66	126.76[b]	9.24	122.44	131.08	0.018
Overjet (mm)	8.97	2.93	7.93	10.01	8.81	2.23	7.63	10.00	8.45	2.78	7.15	9.75	0.799
Overbite (mm)	5.42[b]	1.97	4.73	6.12	5.56[b]	2.10	4.45	6.68	3.7[a]	1.91	2.80	4.59	0.005
Occlusal plane to SN (°)	16.10	4.38	14.55	17.65	17.87	3.43	16.04	19.70	17.29	5.22	14.85	19.73	0.379
Go–Gn to SN (°)	32.28[a]	4.85	30.56	34.00	37.53[b]	4.59	35.08	39.97	35.66[a,b]	5.81	32.94	38.38	0.003
N–S–Ba (°)	132.27	5.27	130.40	134.14	130.31	6.30	126.96	133.67	132.95	3.88	131.13	134.77	0.299
Posterior face height (mm)	73.39	6.30	71.16	75.62	73.58	6.88	69.91	77.24	75.61	5.14	73.20	78.01	0.419
Anterior face height (mm)	114.92[a]	7.38	112.30	117.54	121.35[b]	6.14	118.08	124.62	117.49[a,b]	8.04	113.73	121.25	0.019
Face height ratio	63.91[b]	4.44	62.33	65.48	60.56[a]	3.83	58.52	62.60	64.51[b]	4.44	62.42	66.59	0.017
Maxillary length (mm)	89.13[b]	6.07	86.97	91.28	90.43[b]	6.29	87.07	93.78	85.02[a]	3.70	83.28	86.75	0.009
Mandibular length (mm)	109.75	6.85	107.32	112.19	110.27	5.62	107.27	113.26	109.55	6.15	106.67	112.42	0.942
Ramus height (mm)	42.77[a,b]	4.56	41.16	44.39	41.59[a]	4.65	39.12	44.07	45.62[b]	2.94	44.24	46.99	0.013
Wits (mm)	5.02[a,b]	2.29	4.20	5.83	7.06[b]	3.16	5.37	8.74	4.71[a]	3.31	3.16	6.26	0.031
Lower lip to E plane (mm)	1.17[a]	2.68	0.22	2.12	3.30[b]	2.55	1.94	4.66	0.07[a]	2.89	–1.29	1.42	0.003

SD, standard deviation.
Means for groups in homogeneous subsets are indicated by the same letter.

significantly greater. There was no significant difference in the change in interincisal angle between the activator and control group, but there was a significant difference between the activator headgear group and the control group and when comparing the two treatment groups.

There was no significant difference in the increase in the occlusal plane angle between the two treatment groups, but the decrease in the control group significantly differed from the treatment groups.

AFH showed significantly greater increases in both treatment groups compared with the controls, but the increases were not significantly different between the two treatment groups. The AFH increases were accompanied by an increase in the mandibular plane angle in both treatment groups compared with the controls. These changes were accompanied by a significant increase in ramus height in the activator headgear group compared with the controls, but there was no significant increase in the activator-treated patients over the controls or between the two treatment groups.

The two treatment groups both showed significantly greater lower lip advancement than the controls. The changes in lower lip position also differed between the two treatment groups. A greater advancement of the lower lip was observed in the activator headgear group compared with the activator group.

Discussion

To ascertain the effects of treatment, it is essential to compare the effects with a matched or at least comparable control sample. The gender distribution and pre-treatment mean ages of the children in the three groups were similar, but the length of the observation period was longer in the activator and activator headgear groups. Therefore, 20–30 per cent of the differences observed between the control group and the treatment groups might be explained by difference in growth rather than the effect of treatment. At the start of treatment, only a few cephalometric variables differed among the groups. However, most of the cephalometric measurements were comparable in all three groups. Since, no gender difference was reported when comparing female and male subjects treated with an activator (Ruf *et al.*, 2001), all female and male subjects were pooled in the present study to increase the sample size.

Effects on the maxilla

Conflicting results have been reported on the orthopaedic effect of activator and activator headgear appliances on the maxillary skeletal structures. Some authors have found little or no orthopaedic effect from activator (Chang *et al.*, 1989; Courtney *et al.*, 1996; Cura *et al.*, 1996; Ruf

Table 3 Treatment induced changes in the activator group.

	T0		T1		Difference		95% confidence interval of difference		
	Mean	SD	Mean	SD	Mean	SD	Lower	Upper	*P*
SNA (°)	79.62	4.32	79.34	4.35	–0.28	2.14	–1.04	0.48	0.454
SNB (°)	74.29	3.74	75.50	3.81	1.21	1.67	0.62	1.80	0.000
ANB (°)	5.32	2.09	3.84	1.84	–1.48	1.40	–1.98	–0.99	0.000
Upper incisor to NA (mm)	6.38	3.25	4.40	2.66	–1.98	2.53	–2.88	–1.09	0.000
Upper incisor to NA (°)	26.46	8.68	21.52	6.70	–4.94	5.86	–7.02	–2.86	0.000
Lower incisor to NB (mm)	4.72	2.74	6.97	2.23	2.25	1.15	1.84	2.65	0.000
Lower incisor to NB (°)	25.12	7.26	30.81	5.68	5.69	3.09	4.59	6.78	0.000
Interincisal angle (°)	123.09	10.08	123.82	9.43	0.73	5.22	–1.12	2.58	0.426
Overjet (mm)	8.97	2.93	2.73	1.33	–6.24	3.11	–7.35	–5.14	0.000
Overbite (mm)	5.42	1.97	2.76	2.00	–2.67	2.58	–3.58	–1.75	0.000
Occlusal plane to SN (°)	16.10	4.38	18.51	4.50	2.41	2.36	1.57	3.24	0.000
Go–Gn to SN (°)	32.28	4.85	33.14	5.20	0.86	1.38	0.37	1.35	0.001
N–S–Ba (°)	132.27	5.27	132.15	5.23	–0.12	1.95	–0.81	0.57	0.723
Posterior face height (mm)	73.39	6.30	77.14	7.31	3.75	3.21	2.61	4.88	0.000
Anterior face height (mm)	114.92	7.38	121.16	7.13	6.24	4.69	4.58	7.90	0.000
Face height ratio	63.91	4.44	63.76	4.65	–0.15	1.37	–0.64	0.34	0.530
Maxillary length (mm)	89.13	6.07	90.50	5.18	1.37	3.39	0.17	2.57	0.026
Mandibular length (mm)	109.75	6.85	114.86	6.38	5.11	4.27	3.59	6.62	0.000
Ramus height (mm)	42.77	4.56	46.05	5.52	3.28	2.73	2.31	4.25	0.000
Wits (mm)	5.02	2.29	0.90	2.55	–4.11	2.48	–4.99	–3.23	0.000
Lower lip to E plane (mm)	1.17	2.68	–0.57	2.44	–1.75	2.20	–2.53	–0.97	0.000

SD, standard deviation. T0, pre-treatment; T1, after treatment.

Table 4 Treatment induced changes in the activator headgear group.

	T0		T1		Difference		95% confidence interval of difference		
	Mean	SD	Mean	SD	Mean	SD	Lower	Upper	*P*
SNA (°)	80.90	4.90	80.07	4.64	–0.83	2.56	–2.20	0.53	0.214
SNB (°)	73.36	3.49	74.19	3.54	0.83	1.49	0.04	1.63	0.042
ANB (°)	7.55	2.30	5.89	2.32	–1.66	2.00	–2.72	–0.59	0.005
Upper incisor to NA (mm)	5.94	2.21	2.38	2.89	–3.56	3.07	–5.20	–1.93	0.000
Upper incisor to NA (°)	25.23	5.69	16.06	6.97	–9.18	6.35	–12.56	–5.79	0.000
Lower incisor to NB (mm)	7.42	2.58	8.36	3.06	0.93	1.14	0.32	1.54	0.005
Lower incisor to NB (°)	29.60	6.09	31.14	6.75	1.54	3.06	–0.09	3.17	0.062
Interincisal angle (°)	117.62	7.58	126.93	11.14	9.31	8.86	4.59	14.03	0.001
Overjet (mm)	8.81	2.23	2.56	1.67	–6.25	2.35	–7.50	–5.00	0.000
Overbite (mm)	5.56	2.10	2.38	1.02	–3.19	2.07	–4.29	–2.08	0.000
Occlusal plane to SN (°)	17.87	3.43	22.03	4.27	4.16	3.47	2.32	6.01	0.000
Go–Gn to SN (°)	37.53	4.59	38.26	4.89	0.73	1.50	–0.07	1.53	0.071
N–S–Ba (°)	130.31	6.30	130.06	6.10	–0.25	1.61	–1.11	0.61	0.544
Posterior face height (mm)	73.58	6.88	77.74	8.56	4.17	2.42	2.88	5.46	0.000
Anterior face height (mm)	121.35	6.14	127.18	7.33	5.83	2.49	4.50	7.15	0.000
Face height ratio	60.56	3.83	60.88	4.33	0.31	1.01	–0.23	0.85	0.237
Maxillary length (mm)	90.43	6.29	90.46	5.97	0.04	2.41	–1.25	1.32	0.951
Mandibular length (mm)	110.27	5.62	115.01	6.39	4.74	2.05	3.65	5.84	0.000
Ramus height (mm)	41.59	4.65	45.19	6.23	3.59	2.28	2.38	4.81	0.000
Wits (mm)	7.06	3.16	1.33	2.58	–5.73	3.54	–7.62	–3.85	0.000
Lower lip to E plane (mm)	3.30	2.55	0.04	2.77	–3.26	1.46	–4.04	–2.49	0.000

SD, standard deviation. T0, pre-treatment; T1, after treatment.

et al., 2001; Basciftci *et al.*, 2003) and activator headgear (Dermaut *et al.*, 1992) treatment, while a headgear-like effect of the activator has been reported (Jakobsson, 1967; Pancherz, 1984; Vargervik and Harvold, 1985; Gögen and Parlar, 1989; Jakobsson and Paulin, 1990; Öztürk and Tankuter, 1994). The forces generated by both appliances are of importance. Katsavrias and Halazonetis (1999) found that posteriorly directed forces acting on the maxilla during

Table 5 Longitudinal changes in the control group.

	T0		T1		Difference		95% confidence interval of difference		
	Mean	SD	Mean	SD	Mean	SD	Lower	Upper	*P*
SNA (°)	80.46	3.06	80.47	3.17	0.01	1.81	–0.84	0.86	0.981
SNB (°)	74.58	3.08	75.21	3.51	0.63	2.11	–0.36	1.61	0.202
ANB (°)	5.86	1.40	5.27	1.56	–0.59	1.42	–1.25	0.07	0.079
Upper incisor to NA (mm)	5.67	2.27	5.66	2.24	–0.01	1.56	–0.74	0.72	0.977
Upper incisor to NA (°)	22.65	7.35	23.74	7.31	1.09	3.96	–0.76	2.94	0.233
Lower incisor to NB (mm)	5.13	1.83	4.98	1.99	–0.15	1.37	–0.79	0.49	0.629
Lower incisor to NB (°)	24.71	5.46	24.74	5.57	0.04	3.33	–1.52	1.59	0.963
Interincisal angle (°)	126.76	9.24	126.26	8.14	–0.51	5.40	–3.03	2.02	0.680
Overjet (mm)	8.45	2.78	8.27	2.74	–0.18	2.52	–1.36	1.00	0.753
Overbite (mm)	3.70	1.91	3.75	2.00	0.06	1.26	–0.54	0.65	0.848
Occlusal plane to SN (°)	17.29	5.22	15.65	4.89	–1.65	2.99	–3.04	0.25	0.024
Go–Gn to SN (°)	35.66	5.81	35.15	6.10	–0.51	1.92	–1.41	0.39	0.248
N–S–Ba (°)	132.95	3.88	131.73	4.04	–1.23	2.87	–2.57	0.12	0.072
Posterior face height (mm)	75.61	5.14	77.99	5.59	2.39	1.89	1.50	3.27	0.000
Anterior face height (mm)	117.49	8.04	120.30	8.69	2.81	1.71	2.00	3.61	0.000
Face height ratio	64.51	4.44	65.00	4.92	0.50	1.64	–0.27	1.26	0.194
Maxillary length (mm)	85.02	3.70	85.51	4.22	0.49	2.47	–0.66	1.64	0.386
Mandibular length (mm)	109.55	6.15	111.39	6.65	1.84	3.27	0.31	3.37	0.021
Ramus height (mm)	45.62	2.94	47.28	3.82	1.66	2.64	0.42	2.90	0.011
Wits (mm)	4.71	3.31	4.94	2.67	0.23	2.65	–1.01	1.47	0.702
Lower lip to E plane (mm)	0.07	2.89	–0.07	3.30	–0.14	2.07	–1.10	0.83	0.774

SD, standard deviation. T0, first observation; T1, second observation.

activator wear were generally in the range of 100 g, while with activator headgear appliances the forces generated by the headgear were generally in the orthopaedic range. The evidence suggests more orthopaedic changes with the activator headgear appliances. Öztürk and Tankuter (1994) reported that restriction on sagittal displacement of the maxillary complex with the activator headgear appliance was more apparent than with the activator alone. However, no significant difference was found between the effects of the activator and the activator headgear combination on the maxilla. The reduction in SNA angle was greater in the activator headgear group than in the activator group, but the difference was not statistically, and is unlikely to be clinically, significant. This may be due to the short treatment period. Future research will determine if longer periods of treatment result in significant differences between the appliances' effects on the maxillary complex.

Effects on the mandible

It has been reported that activators increase the length of the mandible over the short-term (Harvold and Vargervik, 1971; Webster *et al.*,1996; Ruf *et al.*, 2001; Basciftci *et al.*, 2003). However, the long-term benefit of achieving greater growth has still not been confirmed (Tulloch *et al.*, 1998). A number of studies have demonstrated a 2–4 mm per year increase in mandibular growth with activators (Luder, 1981; Righellis, 1983; Remmer *et al.*, 1985; Jakobsson and Paulin, 1990; Ömblus *et al.*, 1997) and with an activator headgear combination (Dermaut *et al.*, 1992; Altenburger and Ingervall, 1998; Bendeus *et al.*, 2002). On the contrary, some authors have not found any clinically significant lengthening of the mandible (Björk, 1951; Wieslander and Lagerström, 1979; Forsberg and Odenrick, 1981; Looi and Mills, 1986; Nelson *et al.*, 1993). In the present study, the increases in effective mandibular length (Co–Gn) in both treatment groups were similar. When compared with the control group, the increases in effective mandibular length were statistically significant. A lengthening of the mandible of approximately 3 mm was achieved during the treatment period. In agreement with these results, Öztürk and Tankuter (1994) also reported an equal contribution of both appliances to acceleration of horizontal mandibular growth. Altenburger and Ingervall (1998) compared the effects of the van Beek activator with the Herren activator and an activator headgear combination and found significant increases in the length of the mandible (Pg–OLp) in all treatment groups. Although the long-term benefit of this gain has not been confirmed, these results clearly demonstrate a similar skeletal effect of both appliances on the mandible.

Effects on the maxillo-mandibular relationship

A reduction in ANB angle has been reported in previous activator and activator headgear investigations (Harvold and Vargervik, 1971; Gögen and Parlar, 1989; Üner *et al.*, 1989; Öztürk and Tankuter, 1994; Cura *et al.*, 1996; Weiland *et al.*, 1997; Lux *et al.*, 2001; Basciftci *et al.*, 2003; Haralabakis *et al.*, 2003). Cura *et al.* (1996) found

Table 6 Intergroup comparison of the mean differences.

	Activator		Activator headgear		Control		
	Mean	SD	Mean	SD	Mean	SD	*P*
SNA (°)	–0.28	2.14	–0.83	2.56	0.01	1.81	0.506
SNB (°)	1.21	1.67	0.83	1.49	0.63	2.11	0.492
ANB (°)	–1.49	1.40	–1.66	2.00	–0.59	1.42	0.076
Upper incisor to NA (mm)	–1.98[a]	2.53	–3.56[a]	3.07	–0.01[b]	1.56	0.000
Upper incisor to NA (°)	–4.94[b]	5.86	–9.18[a]	6.35	1.09[c]	3.96	0.000
Lower incisor to NB (mm)	2.25[c]	1.15	0.93[b]	1.14	–0.15[a]	1.37	0.000
Lower incisor to NB (°)	5.69[b]	3.09	1.54[a]	3.06	0.04[a]	3.33	0.000
Interincisal angle (°)	0.73[a]	5.22	9.31[b]	8.86	–0.51[a]	5.40	0.000
Overjet (mm)	–6.24[a]	3.11	–6.25[a]	2.35	–0.18[b]	2.52	0.000
Overbite (mm)	–2.67[a]	2.58	–3.19[a]	2.07	0.06[b]	1.26	0.000
Occlusal plane to SN (°)	2.41[b]	2.36	4.16[b]	3.47	–1.65[a]	2.99	0.000
Go–Gn to SN (°)	0.86[b]	1.38	0.73[b]	1.50	–0.51[a]	1.92	0.009
N–S–Ba (°)	–0.12	1.95	–0.25	1.61	–1.23	2.87	0.193
Posterior face height (mm)	3.75	3.21	4.17	2.42	2.39	1.89	0.108
Anterior face height (mm)	6.24[b]	4.69	5.83[b]	2.49	2.81[a]	1.71	0.004
Face height ratio	–0.15	1.37	0.31	1.01	0.50	1.64	0.229
Maxillary length (mm)	1.37	3.39	0.04	2.41	0.49	2.47	0.286
Mandibular length (mm)	5.11[b]	4.27	4.74[b]	2.05	1.84[a]	3.27	0.006
Ramus height (mm)	3.28[a,b]	2.73	3.59[b]	2.28	1.66[a]	2.64	0.048
Wits (mm)	–4.11[a]	2.48	–5.73[a]	3.54	0.23[b]	2.65	0.000
Lower lip to E plane (mm)	–1.75[b]	2.20	–3.26[a]	1.46	–0.14[c]	2.07	0.000

SD, standard deviation.
Means for groups in homogeneous subsets are indicated by the same letter.

greater improvement in the sagittal skeletal relationship (ANB angle) with an activator headgear combination than with an activator only. In the present study, in agreement with Gögen and Parlar (1989) and Öztürk and Tankuter (1994), treatment induced changes in ANB were similar for the activator and activator headgear combination groups. Thus it can be concluded that when compared with the untreated Class II sample, both activator and activator headgear treatment improved the maxillary and mandibular relationship in the sagittal plane. However, any superiority of the activator headgear combination over the activator alone in improving the sagittal skeletal relationship was not demonstrated.

Effects on the dentoalveolar structures

Retroclination of the maxillary incisors is a consistent finding in many activator and activator headgear studies (Gögen and Parlar, 1989; Dermaut *et al.*, 1992; Weichbrodt and Ingervall, 1992; Öztürk and Tankuter, 1994; Courtney *et al.*, 1996; Cura *et al.*, 1996; Weiland *et al.*, 1997; Lux *et al.*, 2001; Basciftci *et al.*, 2003). A more pronounced retrusion of the upper incisors with the activator compared with the activator headgear has been reported (Gögen and Parlar, 1989; Weiland *et al.*, 1997). Similarly, in the present study, the upper incisors were more retracted in the activator headgear group. The more pronounced retrusion in the activator headgear group may be due to the additional occipital headgear forces acting posteriorly on the maxillary apical base and alveolar structures.

It has been reported that axial inclination of the lower incisors is better controlled with an activator headgear combination than with an activator alone (Gögen and Parlar, 1989; Öztürk and Tankuter, 1994; Cura *et al.*, 1996; Weiland *et al.*, 1997; Altenburger and Ingervall, 1998; Bendeus *et al.*, 2002). The present results are in agreement with these findings as greater protrusion of the lower incisors occurred in the activator group than in the activator headgear group. It would appear that the activator headgear combination is a more logical treatment approach in Class II patients with protrusive mandibular incisors.

Activators promote the eruption of mandibular posterior and maxillary anterior teeth while inhibiting the eruption of maxillary posterior and mandibular incisor teeth. This differential eruption pattern causes a clockwise rotation of the occlusal plane, increases the occlusal plane angle and contributes to the correction of the Class II relationship (Harvold and Vargervik, 1971; Öztürk and Tankuter, 1994). Öztürk and Tankuter (1994) reported a slight anterior rotation of the occlusal plane during activator headgear treatment and found the vertical component of the headgear force to be effective in causing a slight intrusion of the upper incisors. In contrast with their results, a clockwise rotation of the occlusal plane was found for both treatment groups in the present study. This rotation was larger in the activator headgear group. This difference may be

due to posteriorly acting intrusive headgear forces on the maxillary posterior teeth.

Effects on the vertical dimension

Activator headgear appliances are generally used in patients in whom an increase in the vertical dimension should be minimized or avoided. Therefore, it is important to determine the effects of activator and activator headgear appliances on the vertical dimensions of the craniofacial complex. Significant increases in anterior and posterior face heights were reported in both activator and activator headgear studies (Altuğ *et al.*, 1989; Öztürk and Tankuter, 1994; Courtney *et al.*, 1996; Webster *et al.*, 1996). Öztürk and Tankuter (1994) found a greater increase in AFH with an activator than with an activator headgear. The increase in AFH in the activator group in the present investigation was slightly greater, but the difference was not statistically significant. Thus it can be concluded that both appliances equally increase anterior and posterior face heights.

Effects on the soft tissues

The soft tissues reflect the changes that have occurred in the underlying hard tissues. However, functional appliances, besides improving the skeletal relationship, also alter the soft tissue profile. Lower lip protrusion and a decrease in soft tissue profile convexity by functional appliances have previously been reported (Lange *et al.*, 1995; Morris *et al.*, 1998). Gögen and Parlar (1989) evaluated the soft tissue profile of patients treated with an activator or activator headgear. They found significant retrusion of the lower lip with the activator headgear and slight protrusion with the activator. On the other hand, Weichbrodt and Ingervall (1992) reported no significant differences in the soft tissue profile as a result of activator treatment. In the present study, significant protrusion of the lower lip was found in both treatment groups. However, this protrusion was greater in the activator headgear group. This result revealed that the activator headgear combination is more successful in altering lower lip position and improving a convex soft tissue profile.

Conclusion

1. Both the activator and activator headgear combination encouraged significant mandibular growth but had little restraining effect on maxillary growth.
2. Retroclination of the maxillary incisors and proclination of the mandibular incisors were inevitable results of using both appliances. However, the mandibular incisors were better controlled in the activator headgear combination group.
3. The resultant skeletal, dentoalveolar and soft tissue changes significantly differed from those of normal growth.

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