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Early and late facemask therapy

Sema Yüksel, Tuba Tortop Üçem and Alaaddin Keykubat
Department of Orthodontics, Gazi University, Ankara, Turkey

SUMMARY The purpose of this study was to determine the dental and skeletal effects of facemask therapy, and to evaluate the effect of age on treatment response. The material consisted of lateral cephalometric radiographs of 34 subjects with Class III malocclusions treated with a Delaire type facemask. Two groups of 17 patients each were formed: an early (six girls, 11 boys) and a late treatment group (eight girls, nine boys). At the beginning of treatment, the mean ages were 9 years 8 months for the early treatment group and 12 years 6 months for the late treatment group. The average treatment time was 7 months for both groups. A control group consisting of 17 children with a mean age of 9 years 5 months was formed that matched only the early treatment group according to age, and sagittal dental and skeletal relationships. To differentiate the orthodontic and total effects of the Delaire type facemask, superimpositions were made.

In both treatment groups forward displacement of maxilla and an increase in overjet were found to be statistically significant ($P < 0.01$). Evaluation of total superimpositions showed that there was a significant displacement of maxillary molars and incisors ($P < 0.05$, early treatment group; $P < 0.01$, late treatment group), while no significant change was observed in local superimpositions. Changes in overjet and SNB in the early treatment group showed a significant difference compared with the control group ($P < 0.001$) The increase in Co–A and the decreases in the maxillo-mandibular differential and Wits' appraisal showed significant differences compared with the control group ($P < 0.01$). No significant difference was observed in skeletal and dental antero-posterior changes between the treatment groups.

Introduction

When the prevalence of Class III malocclusions characterized by maxillary hypoplasia is considered (Jacobson *et al*., 1974; Ellis and McNamara, 1984; Guyer *et al*., 1986), it is obvious that encouragement of maxillary growth is important. A review of the literature reveals that this control is possible with maxillary protraction appliances. Several appliances have been designed to protract the maxilla by changing the extra- and intra-oral anchorage units (Delaire *et al*., 1976; Nanda, 1980; Staggers *et al*., 1992; Takada *et al*., 1993; Conte *et al*., 1997). It has been shown in human and experimental studies that maxillary protraction forces produce forward displacement of the maxilla and inhibition of mandibular growth (Dellinger, 1973; Hata *et al*., 1987; Ishii *et al*., 1987; Mergimos *et al*., 1990; Takada *et al*., 1993; Baik, 1995; Ngan *et al*., 1996a,b). Chong *et al*. (1996) reported that the major treatment effect of protraction headgear was a downward and backward movement of the mandible, and retroclination of the mandibular incisors. Some studies on post-treatment changes have reported stability of orthopaedic treatment of Class III malocclusions directed at the maxilla (Ishii *et al*., 1987; Ngan *et al*., 1998).

In recent years orthodontic researchers have tried to find an answer for optimal treatment timing of skeletal Class III patients treated with maxillary protraction appliances. A review of the literature reveals that greater skeletal changes with the use of the maxillary protraction appliance are possible in young patients (Irie and Nakamura, 1975; Proffit, 1986; Takada *et al*., 1993; Kapust *et al*., 1998). Baccetti *et al*. (1998) concluded from statistical comparisons that

facemask/expansion therapy is more effective in the early mixed dentition, especially with regard to the magnitude of the protraction effects on the maxillary structures. However, Baik (1995) and Sung and Baik (1998) reported that comparison of the measurements of the treatment effect according to age showed no statistically significant difference. It should be pointed out that most of these studies included an expansion appliance in addition to maxillary protraction devices. The purpose of this study was to determine the dental and skeletal effects of facemask therapy alone, without maxillary expansion, and to evaluate the effect of age on treatment response.

Subjects and methods

The sample consisted of 34 children with skeletal and dental Class III malocclusions, with an age range between 8 years 2 months and 14 years 3 months. None of the subjects had a history of previous orthodontic treatment. Clinically, they all had a reverse overjet. All were treated with a Delaire type facemask applied to an upper removable appliance with an anterior point of application (Figure 1). The total force was 600 g and the patients were instructed to wear the appliance 16 hours a day.

Two groups of 17 patients each were formed. The mean age for the first group (six girls, 11 boys) was 9 years 8 months (with a range 8 years 2 months–10 years 1 month), 'the early treatment group'. The mean age for the second group (eight girls, nine boys) was 12 years 6 months (with a range 11 years 8 months–14 years 3 months), 'the late treatment group'.

At the beginning of treatment and after a Class I molar occlusion and adequate overjet (a minimum of 2 mm) was obtained, lateral cephalometric radiographs were taken. The average treatment time was 7 months for both groups.

A control group consisting of 17 children with a mean age of 9 years 5 months (with an age range of 8 years 5 months–10 years 2 months) was formed matched to the early treatment group. The observation period was 9 months.

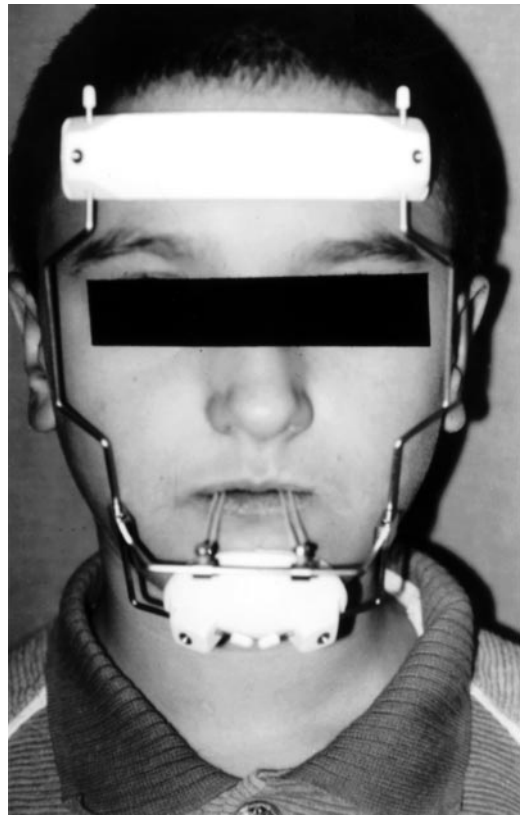

Figure 1 Extra-oral view of facemask.

Lateral cephalometric radiographs were taken at the beginning and end of the observation period. For ethical reasons it was not possible to find a control for the late treatment group.

Pre- and post-treatment lateral cephalograms were traced and digitized. Twenty parameters were evaluated using the JOE Version 5.0 package programme (Rocky Mountain Orthodontics, Denver, CO, USA; Figures 2 and 3).

To differentiate orthodontic and total effects, total superimpositions were made on Ba–N at CC [cranial centre: the intersection of Ba–N and facial axis (pterygoid point to gnathion)] (Figure 4; Ricketts, 1996). Local superimpositions were made on the palatal plane at ANS for the maxilla (Figure 5) and on the mandibular plane at Gn for the mandible (Figure 6). For each superimposition the pre-treatment tracing SN plane was used as the horizontal reference

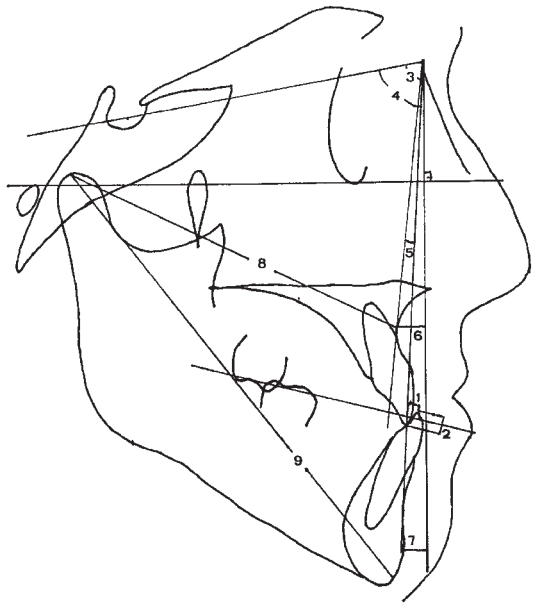

Figure 2 1, Overjet; 2, overbite; 3, SNA; 4, SNB; 5, ANB; 6, maxilla to cranium; 7, mandible to cranium; 8, Co–A; 9, Co–Gn; 10, max–mand differential [(Co–A) – (Co–Gn)].

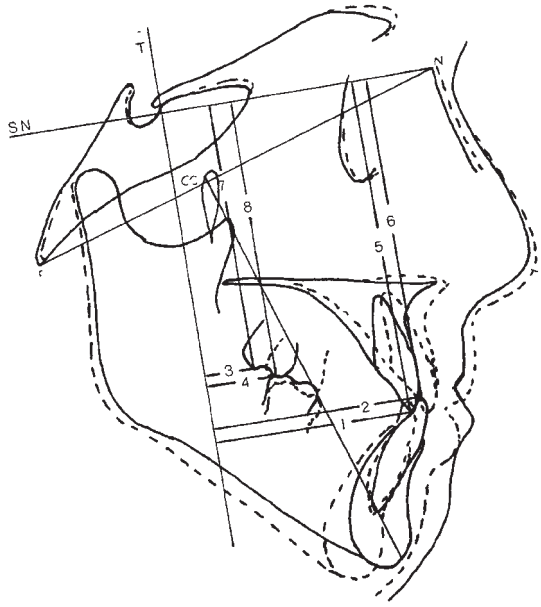

Figure 4 Total superimposition on Ba–N at CC: 1, upper incisor–T; 2, lower incisor–T; 3, upper molar–T; 4, lower molar–T; 5, upper incisor–SN; 6, lower incisor–SN; 7, upper molar–SN; 8, lower molar–SN.

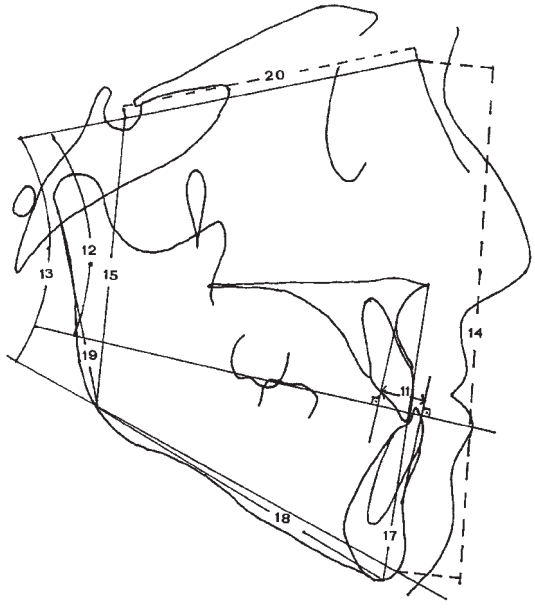

Figure 3 11, Wits' appraisal; 12, occlusal plane/SN; 13, SN/Go–Gn; 14, anterior face height; 15, posterior face height; 16, posterior/anterior face height ratio (measured by posterior face height divided by the anterior face height); 17, Me–ANS; 18, Go–Me; 19, Go–Ar; 20, SN.

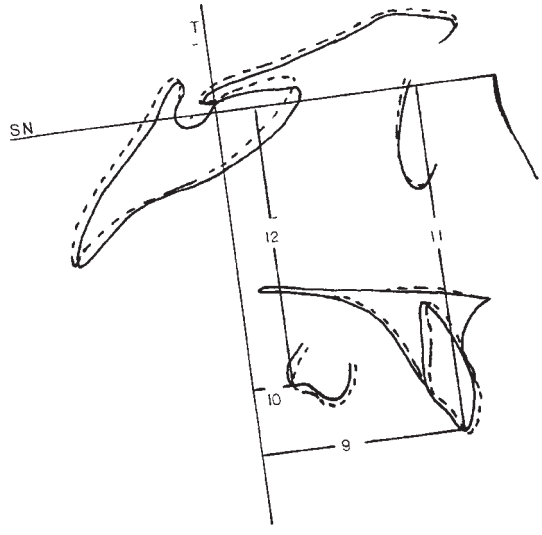

Figure 5 Local superimposition on the palatal plane at ANS: 9, upper incisor–T; 10, upper molar–T; 11, upper incisor–SN; 12, upper molar–SN.

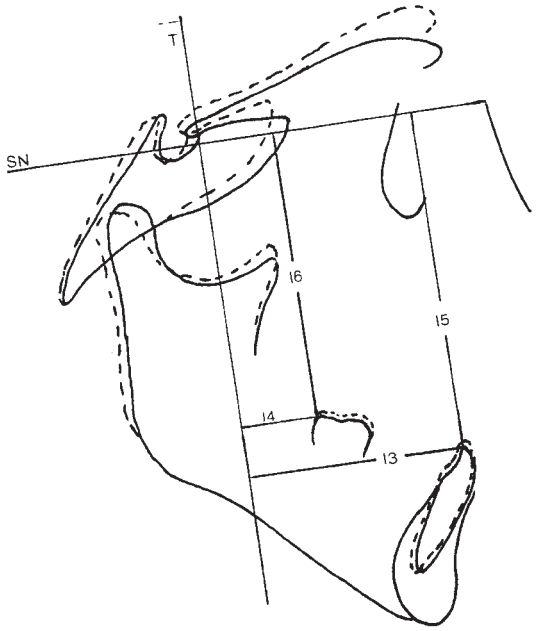

Figure 6 Local superimposition on the mandibular plane at Gn: 13, lower incisor–T; 14, lower molar–T; 15, lower incisor–SN; 16, lower molar–SN.

plane. A vertical perpendicular to SN at point T (the most superior point of the anterior wall of the sella turcica at the junction with the tuberculum sella) was used as the vertical reference plane. The vertical and horizontal orthopaedic displacement and orthodontic movements of the upper and lower incisors and upper and lower molars were evaluated according to the reference grid formed on the first cephalogram (Figures 4–6).

All cephalometric radiographs were retraced, redigitized, and superimpositions and measurements obtained were repeated after 15 days. Method error coefficients were calculated and found within acceptable limits (range 0.92–0.99; Winner, 1971).

Statistical analysis was undertaken using SPSS Win Version 6.0 package programme (Chicago, IL, USA). Wilcoxon test was used to evaluate the treatment effects and changes during the observation period in each group. Differences between the groups were determined by a Mann–Whitney *U*-test.

Results

Early treatment group

Evaluation of cephalometric findings showed that increases in overjet, SNA, ANB, Co–A, and Wits' appraisal were statistically significant ($P < 0.01$). The decrease in maxilla to cranium was statistically significant ($P < 0.05$). Anterior and posterior face heights, Me–ANS, Co–Gn, and Go–Me increased significantly ($P < 0.01$). The decrease in overbite was found to be statistically significant in this group ($P < 0.01$; Table l).

Evaluation of total superimposition showed that upper incisor–T, upper molar–T, upper incisor–SN, and lower incisor–SN were significantly increased ($P < 0.05$). Increases in upper molar–SN and lower molar–SN were found to be statistically significant ($P < 0.01$).

Lower incisor and molar distance to SN (lower incisor–SN, lower molar–SN) showed a significant decrease on mandibular local superimposition ($P < 0.05$; Table 2).

Late treatment group

In this group overjet, SNA, ANB, Co–A, and Wits' appraisal were increased significantly ($P < 0.01$). A significant decrease was observed in maxilla to cranium and in overbite ($P < 0.05$). The increases in anterior and posterior face heights, Me–ANS and Co–Gn, were found to be statistically significant ($P < 0.01$). A significant increase was observed in Go–Me ($P < 0.05$; Table l).

Evaluation of total superimpositions showed that horizontal changes in upper incisor and molar (upper incisor–T, upper molar–T) were statistically significant ($P < 0.01$). The increase in upper molar–SN was found to be statistically significant in both superimpositions (total and maxillary local; $P < 0.01$, $P < 0.05$, respectively). In local mandibular superimposition a significant decrease was observed in lower incisor–SN and lower molar–SN parameters ($P < 0.01$; Table 2).

Control group

There was a significant decrease in ANB angle at the end of the observation period ($P < 0.05$).

Table 1 Comparison of treatment groups, and early treatment and control group with descriptive statistics.

	Early treatment group (1)					Late treatment group (2)					Control (3)						
	Pre-		Post-			Pre-		Post-			Pre-		Post-				
	X	*Sx*	*X*	*Sx*	*P*	*X*	*Sx*	*X*	*Sx*	*P*	*X*	*Sx*	*X*	*Sx*	*P*	*P* (1–2)	*P* (1–3)
1. Overjet (mm)	–1.6	0.53	3.3	0.37	**	–1.2	0.49	3.9	0.44	**	–2.37	0.20	–2.5	0.23			***
2. Overbite (mm)	2.4	0.56	0.5	0.35	**	1.39	0.89	–0.6	0.86	*	3.26	0.53	3.7	0.60			**
3. SNA (°)	76.3	0.66	78.2	0.73	**	75.25	1.29	76.9	1.06	**	77.7	0.86	77.7	0.98			
4. SNB (°)	77.9	0.84	77.5	0.85		77.77	1.16	76.7	1.01		80.6	1.06	80.9	1.08			***
5. ANB (°)	–1.6	0.51	0.7	0.41	**	–2.5	0.52	0.2	0.59	**	–2.9	0.41	–3.2	0.38	*		*
6. Maxilla to cranium (mm)	6.0	0.79	4.1	0.90	*	8.1	0.98	5.5	1.08	*	5.3	0.80	4.6	0.77			
7. Mandible to cranium (mm)	–7.4	1.95	–7.9	2.21		–7.6	1.33	–9.1	2.08		–3.3	1.75	–1.4	1.77	*		
8. Co–A (mm)	79.4	1.27	82.7	0.95	**	78.9	0.92	81.9	0.92	**	77.6	0.76	77.9	0.92			**
9. Co–Gn (mm)	109.6	1.59	112.3	1.29	**	114.4	1.65	116.4	1.64	**	108.9	1.32	110.8	1.52	*		
10. Max–mand differential	30.2	0.92	29.7	0.92		35.5	1.11	34.4	1.50		31.3	0.86	32.8	0.84	**		**
11. Wits' appraisal (mm)	–7.0	0.77	–3.4	0.85	**	–8.7	0.79	–4.0	1.20	**	–8.3	0.89	–8.2	0.73			**
12. Occlusal plane/SN (°)	20.2	1.30	18.5	1.07		20.6	1.14	18.9	1.05		18.1	1.29	17.1	0.95			
13. SN/Go–Gn (°)	37.6	1.33	38.4	1.44		36.8	1.71	38.1	1.70		32.5	0.92	32.6	0.86			
14. Anterior face height (mm)	114.4	1.68	117.8	1.73	**	122.4	2.43	125.9	2.36	**	109.8	0.82	111.9	0.96	**		
15. Posterior face height (mm)	70.6	1.01	72.3	1.05	**	78.3	1.43	79.7	1.39	**	71.8	0.91	73.0	0.95	**		
16. Posterior/anterior ratio	61.8	0.90	61.4	1.00		64.1	1.04	63.5	1.04		65.4	0.80	65.3	0.74			
17. Me–ANS (mm)	64.0	1.30	67.1	1.39	**	68.6	1.84	72.4	2.00	**	60.5	0.78	61.5	0.97	*		**
18. Go–Me (mm)	69.2	0.87	71.2	0.86	**	71.7	1.59	73.2	1.41	*	69.6	1.10	71.2	1.12	*		
19. Go–Ar (mm)	41.9	0.98	42.8	0.94		47.4	1.00	48.4	1.24		43.1	0.84	44.1	0.87	*		
20. SN (mm)	66.7	0.60	67.4	0.58		68.7	0.82	69.4	0.80		65.9	0.72	66.7	0.75			

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
X, Mean values; *Sx*, standard error of mean values.

Table 2 Comparison of treatment groups, and early treatment and control group with descriptive statistics for superimpositions.

	Early treatment group (1)					Late treatment group (2)					Control (3)						
	Pre-		Post-			Pre-		Post-			Pre-		Post-				
	X	*Sx*	*X*	*Sx*	*P*	*X*	*Sx*	*X*	*Sx*	*P*	*X*	*Sx*	*X*	*Sx*	*P*	*P* (1–2)	*P* (1–3)
Total superimposition																	
Upper incisor–T	47.3	1.19	50.6	1.44	*	47.5	1.92	51.5	175	**	48.6	1.29	48.8	1.53			**
Lower incisor–T	49.0	1.33	48.3	1.39		48.8	1.96	47.9	1.82		51.6	1.31	52.2	1.57			
Upper molar–T	10.8	0.76	13.5	1.13	*	12.5	1.21	15.7	1.19	**	12.7	1.10	12.9	1.31			*
Lower molar–T	11.9	1.05	12.6	1.13		14.7	1.46	13.8	1.43		14.3	1.28	14.7	1.50			
Upper incisor–SN	76.8	1.21	77.8	1.18	*	81.6	1.46	82.4	1.27		73.8	0.71	75.2	0.83	*		
Lower incisor–SN	75.1	1.21	76.5	1.20	*	80.9	1.09	81.7	1.85		71.4	0.57	72.4	0.60	*		
Upper molar–SN	60.2	0.85	62.9	0.90	**	66.6	1.50	69.2	1.67	**	58.7	0.49	59.7	0.52	*		
Lower molar–SN	65.2	0.92	66.7	0.96	**	72.4	1.66	72.4	1.55		64.0	0.60	65.6	0.74	**		
Local superimposition of maxilla																	
Upper incisor–T	47.3	1.19	49.1	1.14		47.5	1.92	49.3	1.95		48.6	1.29	48.9	1.24			
Upper molar–T	10.8	0.76	10.8	0.79		12.5	1.21	12.9	1.28		12.7	1.10	12.7	1.13			
Upper incisor–SN	76.8	1.21	76.8	1.74		81.6	1.46	82.3	1.45		73.8	0.71	74.2	0.71	*		*
Upper molar–SN	60.2	0.85	60.9.	1.22		66.6	1.50	68.8	1.78	*	58.7	0.49	59.0	0.54			
Local superimposition of mandible																	
Lower incisor–T	49.0	1.33	48.6	1.39		48.8	1.96	48.9	1.06		51.6	1.31	51.4	1.34			
Lower molar–T	11.9	1.05	11.8	1.05		14.7	1.46	14.0	1.54		14.3	1.28	14.0	1.31			
Lower incisor–SN	75.1	1.21	73.6	1.09	*	80.9	1.09	78.7	1.97	**	71.4	0.57	70.8	0.61	*		
Lower molar–SN	65.2	0.92	63.9	0.95	*	72.4	1.66	69.9	1.73	**	64.0	0.60	63.6	0.64			

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
X, mean values; *Sx*, standard error of mean values.

Increases in mandible to cranium, Co–Gn, Go–Me, Go–Ar, and Me–ANS were found to be statistically significant ($P < 0.05$). Maxillo–mandibular differential, and anterior and posterior face heights showed a significant increase ($P < 0.01$; Table l).

Changes in the upper incisor–SN, lower incisor–SN, and upper molar–SN were found to be statistically significant on total superimpositions ($P < 0.05$). A significant increase was observed in lower molar–SN on total superimpositions ($P < 0.01$). On local superimpositions the increase in upper incisor–SN and the decrease in lower incisor–SN were statistically significant ($P < 0.05$; Table 2).

Comparison of early treatment group with control group

Changes in overjet and SNB showed significant differences between the groups ($P < 0.001$). The increase in ANB angle in the early treatment group was significantly different from the control group ($P < 0.05$). Co–A, maxillo-mandibular differential, and Wits' appraisal showed significant differences between the groups ($P < 0.01$). The decrease in overbite and increase in Me–ANS in the early treatment group was significantly different compared with the control group ($P < 0.01$; Table l).

In total superimpositions a significant difference between the groups was observed in the horizontal changes of the upper incisor and molar (upper incisor–T, upper molar–T; $P < 0.01$, $P < 0.05$, respectively). The upper incisor–SN showed a significant difference between groups in local superimposition of the maxilla ($P < 0.05$; Table 2).

Comparison of the treatment groups

There was no significant difference between the groups for the effect of age on treatment response (Tables l and 2).

Discussion

The two treatment groups comprised 17 patients, whose Class III malocclusions were successfully treated by facemask therapy. The major aim of this study was to evaluate the differences between early and late treatment, in addition to determining the treatment effects of facemask therapy.

In both age groups, increases in SNA and Co–A, and a decrease in maxilla to cranium indicate a significant forward movement of maxilla at the end of treatment. Improvement in the maxilla was a result of a significant increase in ANB and Wits' appraisal, and a non-significant decrease in maxillo-mandibular differential in both treatment groups. These parameters that define the sagittal relationship between arches showed significant difference between the early treatment and control groups. These findings are in agreement with previous studies (Mergimos *et al*., 1990; Baik, 1995; Chong *et al*., 1996; Ngan *et al*., 1996a; Gallagher *et al*., 1998; Kiliçoğlu and Kirliç, 1998; Pangrazio-Kulbersh *et al*., 1998; Sung and Baik, 1998; Üçüncü *et al*., 2000). No significant difference was observed between the treatment groups.

There was a significant correction in overjet in both age groups, and this correction created a significant difference between the early treatment and control groups. Chong *et al*. (1996) suggested that an increased overjet was mainly due to proclination of the mandibular incisors. In this study, the lower incisors showed no significant positional changes in either age group. Shanker *et al*. (1996) showed a 2.4-mm advancement of point A and reported that of this 75 per cent was due to skeletal maxillary advancement, and 25 per cent to local remodelling during maxillary protraction and expansion therapy. Merwin *et al*. (1997) reported that cephalometric changes during the treatment period were strikingly similar between 5–8- and 8–12-year groups. They found a greater skeletal movement in the 8–12-year group for the achievement of overjet correction. Takada *et al*. (1993) examined the effect of age on maxillary protraction and found a definite advantage in treating children in the prepubertal period (7–10 years), where a 2.2-mm increase in maxillary length was obtained in 13 months. In the late pubertal period (12–15 years), the 1.1-mm increase in maxillary length was not significant

compared with the control group. Baccetti *et al*. (1998) showed significant advancement of ANS, PNS, and point A in the early treatment group (mean age 6 years, 9 months ± 7 months), and reported that there was no significant improvement in maxillary growth in the late treatment group (mean age 10 years, 3 months ± 1 year) with respect to matched control groups. Franchi *et al*. (1998) confirmed these findings with a shape-co-ordinate analysis study.

In this investigation anterior and posterior face heights increased significantly, while no significant change was observed in the posterior anterior ratio at the end of the treatment in either age group. Parallel to these findings, SN/Go–Gn showed no significant increase. These results agree with Mergimos *et al*. (1990). Increases in face height were found to be statistically significant in the control group. However, only the increase in Me–ANS was significantly greater in the early treatment group compared with the control group. Ngan *et al*. (1996b) reported that lower face height, on average, increased 2.9 mm.

Total superimposition evaluation showed that upper molar extrusion was significant in both age groups, but no significant difference was observed between age groups. A significant extrusion was also noted in the control group, but compared with the early treatment group this was not significant. Sung and Baik (1998) reported that extrusion of maxillary molars in patients treated with maxillary protraction was 2.5–3.5 mm, which is similar to that found in the untreated group. Merwin *et al*. (1997) found greater extrusion in an older age group, but a banded expansion appliance was used in that study. Contrary to the present findings, in several maxillary protraction studies with or without expansion (Ishii *et al*., 1987; Takada *et al*., 1993; Filho *et al*., 1998; Kapust *et al*., 1998), it has been shown that eruption of maxillary posterior teeth results in a downward and backward rotation of the mandible.

Although the findings related to the mandibular plane showed no significant change, a significant overbite reduction was observed in both age groups, and in the early treatment group this was significantly different compared with the control group. Ngan *et al*. (1996b) reported a 2.6-mm decrease in overbite after maxillary protraction and expansion therapy. Chong *et al*. (1996), however, did not find any significant difference in overbite.

Total superimpositions showed a downward and backward movement of the mandibular dentition. This is in agreement with Baik (1995), Gallagher *et al*. (1998), and Kapust *et al*. (1998). In local superimpositions, extrusion of the lower incisor and molar was found to be statistically significant. The extrusion of the lower incisor in the early treatment group was significantly greater than in the control group. Evaluation of the findings indicate that the non-significant mandibular skeletal changes resulted from significant changes in the dental structures. All findings related to the mandibular dentition showed no significant change between age groups.

Contrary to the findings of Baccetti *et al*. (1998), a significant increase in Co–Gn and Go–Me was found in both age groups. There was no difference between age groups or the early treatment and control groups. Mergimos *et al*. (1990) reported that the only significant mandibular change was observed in Co–Gn.

Evaluation of the superimpositions showed that in both age groups forward upper incisor and molar movement was statistically significant. There was a significant difference between the early treatment and control groups. In several studies it has been shown that the maxillary dentition moved forward and downward (Baik, 1995; Kapust *et al*., 1998; Sung and Baik, 1998). Sung and Baik (1998) reported that horizontal changes in maxillary incisors were greater than those in an untreated group. In local superimpositions of the maxilla, the forward movement of teeth was found to be non-significant. In the early treatment group total superimposition showed that total displacement of the upper incisors and molars was, on average, 3.3 and 2.7 mm, respectively. Orthodontic movement on local superimpositions showed 1.8 mm forward movement for the upper incisor but no movement for the upper molars. For the late treatment group total displacement of the upper

incisor and molars was 3 and 3.2 mm, respectively. Orthodontic movement was 1.8 mm for the upper incisor and 0.4 mm for upper molars. In the control group no significant change was observed. These values show that in both age groups total orthopaedic and orthodontic movement of the dentition was greater than orthodontic movement. Pangrazio-Kulbersh *et al*. (1998) found a 2.4 mm significant mesialization of upper molars. Kapust *et al*. (1998) reported that the evaluation of orthopaedic versus orthodontic effects showed an overall ratio of 3:2 and this approached 2:1 in the 4–7-year age group. Although the finding in that study showed that facemask therapy was more effective in the 4–7- and 7–10-year age groups compared with the 10–14-year age group, they suggested that therapy can provide a viable option for older children. Sung and Baik (1998) reported that changes in maxillary incisors in 7-year-old children were greater than in older subjects, and that this difference was a result of tooth eruption in the 7-year-old group and maxillary movement was included in assessment of tooth position changes.

Conclusions

In both age groups, significant forward movement of the maxilla was observed at the end of treatment.

Evaluation of the superimpositions showed that in both age groups there was a significant forward movement of the upper incisor and molars.

Total superimposition showed a downward and backward movement of the mandibular dentition. Extrusion was observed on local superimpositions.

Although no significant difference was found between the two treatment groups, the effect of improvement in facial aesthetics on psychosocial development resulted in a significant advantage for early treatment. However, the effects of facemask therapy should be evaluated over the long-term in order to determine the relapse tendency separately in early and late treated subjects.

Address for correspondence

Sema Yüksel
Gazi Universitesi
Diş Hekimliği Fakültesi
Ortodonti Anabilim Dalı
06510 Emek-Ankara
Turkey

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