Original Article

Modified tandem traction bow appliance compared with facemask therapy in treating Class III malocclusions

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ABSTRACT

Objective: To compare the effects of the modified tandem traction bow appliance (MTTBA) and the facemask in treating patients with Class III malocclusion.

Materials and Methods: The material consisted of the pre-post treatment\pre-post observation lateral cephalograms of 65 subjects with skeletal and dental Class III malocclusion. In the first group 21 patients (mean age: 10 years, 6 months) were treated with a Delaire-type facemask (FM). In the second group 22 patients treated (mean age: 10 years) with MTTBA. The remaining 22 children (mean age: 9 years, 7 months) were observed without treatment for 11 months.

Results: Increase in SNA, N-FH$^{\perp}$ A, and ANB angles were significantly greater in the treatment groups compared to the control group. However, ANB angle showed a significantly greater increase in the FM group (2.8 $\pm$ 0.30°) than in the MTTBA group (2.0 $\pm$ 0.18°). The overjet and molar relation increased significantly in both treatment groups, but in the FM group (5.2 $\pm$ 0.40 mm) increase in overjet was significantly greater than in the MTTBA group (4.0 $\pm$ 0.27 mm). Mesial movement of upper molar and incisor were found to be greater in the FM group compared to the modified TTBA group.

Conclusions: Both appliances were found to be effective in the treatment of Class III malocclusion. Their skeletal and dental effects showed differences due to their design. (*Angle Orthod.* 2014;84:642–648.)

KEY WORDS: Class III malocclusion; Facemask; Tandem traction bow

INTRODUCTION

Facemask (FM) and its modifications are generally preferred in the treatment of children who have Class III malocclusion with an underdeveloped maxilla. Based on a review of the literature, the effects of FM therapy can be summarized as protraction of maxilla and maxillary dentition, improvement of maxillo-mandibular relation, and clockwise rotation of the mandible. Lingual tipping of lower incisors and soft tissue effects resulting from skeletal changes were also reported.[1–4]

There have been also some intraoral appliances used in the treatment of patients with Class III malocclusion.[5–13] Though most authors reported that the Fränkel III appliance was effective with regard to mandibular growth, conflict existed with regard to the effects of the appliance on the maxilla.[8–10] Comparison of plates and functional orthopedic appliances with facemask showed that sagittal skeletal effect was more pronounced by FM therapy.[12,13]

The tandem traction bow appliance (TTBA) was introduced as an intraoral appliance in the treatment of Class III malocclusion; it carried the expectation that it would result in enhanced patient cooperation.[5] Atalay and Tortop[14] reported that satisfactory correction of the skeletal and dental Class III malocclusion was obtained with a modified TTBA (MTTBA). A literature review showed that there are not any studies regarding the comparative evaluation of the effects of MTTBA and FM. Therefore, the purpose of this study was to assess and compare the dentoskeletal effects of MTTBA and FM therapy in the treatment of Class III malocclusion.

MATERIALS AND METHODS

This retrospective study comprised 65 patients with skeletal Class III relationship due to maxillary retrusion

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Figure 1. Delaire-type facemask application.

or a combination of maxillary retrusion and mandibular protrusion. None of the patients had a congenital syndrome. All of them had an Angle Class III malocclusion with a negative overjet and an optimum SN/GoGn angle (between 26° and 38°). The study protocol was approved by the Ethics Committee of Gazi University (2013/25901600-1409). Two treatment groups and an untreated control group were evaluated for this study.

In the first treatment group, 21 patients (eight girls, 13 boys; mean age: 10 years, 6 months ± 1 year, 4 months) were treated with a Delaire-type FM and a removable upper appliance (Figure 1). A total force of 600 g was applied, and the patients were instructed to wear their appliances approximately 16 hours a day. The removable upper appliance had two Adams clasps at the molars, two ball clasps, a labial bow, and two hooks at the anterior region for extraoral elastics. The average treatment time was 10.5 months.

In the second treatment group, 22 patients (eight girls, 14 boys; mean age: 10 years ± 1 year, 4 months) wore a MTTBA, which comprised an upper splint, a lower splint, and a traction bow (Figure 2). Construction bites were taken without sagittal activation and

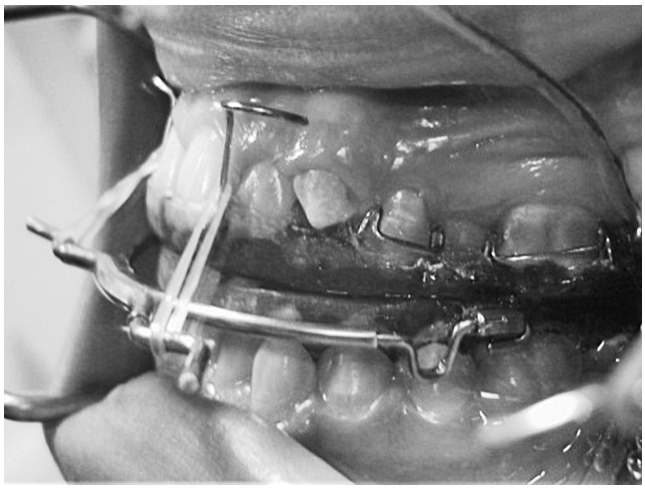

Figure 2. Modified TTBA.

with a 5–6-mm vertical opening at the molar region. A modified headgear facebow was used as the traction bow and it was applied to the activator tubes, which were embedded in the lower splint. Two elastics that exerted a force of 400–500 g on one side were worn between the labial hooks of the upper splint and the traction bow. The patients were instructed to wear the appliance approximately 14–16 hours a day. The average treatment time was 12 months.

The treatment groups were compared with an untreated control group of 22 subjects (10 girls, 12 boys; mean age: 9 years, 7 months ± 1 year, 3 months). The observation period was 11 months.

Lateral cephalometric radiographs were taken before treatment and after a Class I molar relationship was obtained with an overjet of 2–3 mm. Ten linear and 10 angular measurements were evaluated (Figure 3). Total superimpositions were made on the best fit of the anterior cranial base (Figure 4a). Local superimpositions were made on the best fit of the palatal structures for the maxilla (Figure 4b) and on the best fit of the posterior border of the symphysis and inferior border of the mandible (Figure 4c). For each superimposition, the pretreatment tracing T-W line (T: the most superior point of the anterior wall of the sella turcica at the junction with tuberculumsella; W: the point at which the middle cranial fossa is intersected by the sphenoid bone) was used as the horizontal reference line. A vertical line perpendicular to T-W at point T was used as the vertical reference plane.

The lateral cephalometric radiographs of 15 subjects were retraced, and superimpositions and measurements were repeated after 15 days. Method error coefficients were calculated and found to be within acceptable limits (range: 0.98–1.00).

Statistical analysis was done with SPSS for Windows, version 16.0 package (SPSS Inc, Chicago, Ill).

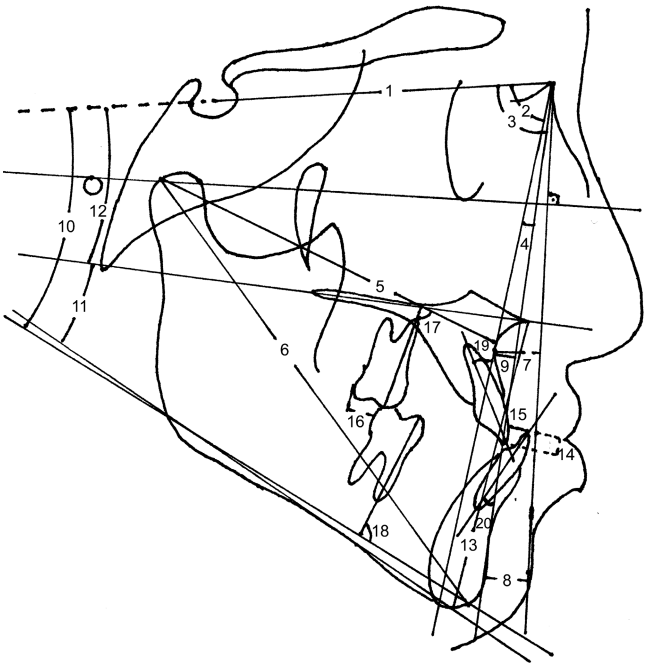

Figure 3. Cephalometric measurements: 1. SN; 2. SNA; 3. SNB; 4. ANB; 5. CoA; 6. CoGn; 7. N⊥ FH-A; 8. N⊥ FH-Pg; 9. N-Pg⊥ A; 10. SN/GoGn; 11. ANS-PNS/Go-Me; 12. SN/ANS-PNS; 13. ANS-Me; 14. overbite; 15. overjet; 16. molar relation; 17. upper molar/ANS-PNS; 18. lower molar/Go-Me; 19. upper incisor/NA; and 20. lower incisor/NB.

To check data normality the Shapiro-Wilk test was applied. As a result of the normal distribution of data, a paired *t*-test was used to evaluate the treatment effects and changes during the observation period in each group. Differences between the groups were determined by variance analysis and the Duncan test.

RESULTS

The statistical comparison of the pretreatment values showed upper molar inclination was significantly greater in the MTTBA group than in the FM group (Table 1).

In the FM group, SNA and ANB values and Co-A dimension increased significantly ($P < .001$), while SNB value and Co-Gn dimension showed a significant decrease ($P < .01$). Increase in N⊥ FH-A ($P < .01$) and decrease in N ⊥ FH-Pg ($P < .05$) were found to be statistically significant. Significant increases were observed in SN/GoGn and ANS-PNS/Go-Me ($P < .01$). SN/ANS-PNS angle decreased significantly ($P < .05$), but lower facial height (ANS-Me) showed a significant increase ($P < .001$). Decrease in overbite was found to be statistically significant ($P < .001$). Sagittal dental forces resulted in a significant increase in overjet and molar relation ($P < .001$). Upper molar/ANS-PNS and lower incisor/NB angle decreased significantly ($P < .01$ and $P < .001$, respectively) (Table 2).

On total superimposition, point A-T dimension increased significantly ($P < .01$), while pogonion-T dimension was showing a significant decrease ($P < .05$) during FM therapy. Pogonion-TW also changed significantly ($P < .001$). On local superimposition upper molar-T and upper molar TW increased significantly ($P < .01$). Increase in upper incisor-T was found to be statistically significant ($P < .001$). Lower incisor-T and lower incisor-TW showed significant decreases ($P < .05$ and $P < .001$, respectively) (Table 3).

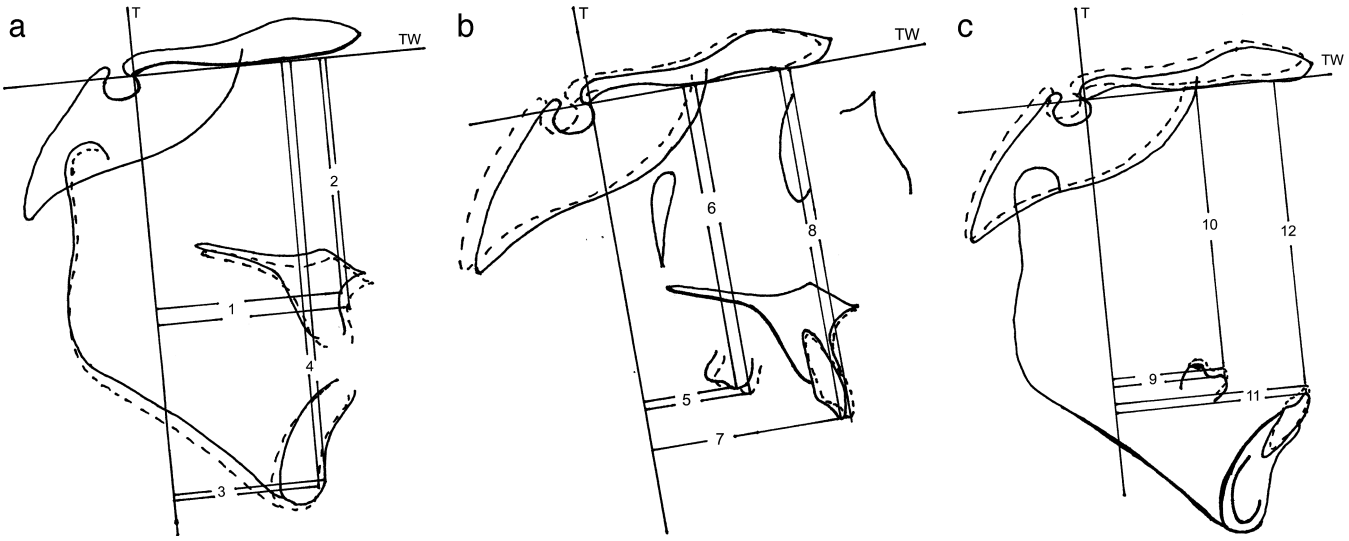

Figure 4. (a) Measurements on total superimposition: 1. point A-T; 2. point A-TW; 3. Pogonion-T; and 4. Pogonion-TW. (b) Measurements on maxillary local superimposition: 5. upper molar-T; 6. upper molar-TW; 7. upper incisor-T; and 8. upper incisor-TW. (c) Measurements on mandibular local superimposition: 9. lower molar-T; 10. lower molar-TW; 11. lower incisor-T; and 12. lower incisor-TW.

Table 1. Pretreatment Mean Values and Statistical Differences Between Groups[a]

	FM (1) (n = 21)		MTTBA (2) (n = 22)		Control (3) (n = 22)		*P*		
	X	Sx	X	Sx	X	Sx	1–2	1–3	2–3
SN, mm	68.0	0.79	68.4	0.70	67.5	0.61			
SNA, °	78.2	0.68	77.2	0.67	76.6	0.61			
SNB, °	80.7	0.72	79.9	0.63	78.6	0.61			
ANB, °	−2.5	0.34	−2.7	0.30	−2.0	0.28			
CoA, mm	80.4	1.04	82.8	0.71	80.3	0.81			
CoGn, mm	111.9	1.47	112.4	1.09	109.2	0.82			
N⊥ FH-A, mm	−3.7	0.63	−4.0	0.59	−3.5	0.58			
N⊥ FH-Pg, mm	−1.4	1.41	−1.5	0.94	−2.3	1.03			
N-Pg⊥ A, mm	−2.5	0.58	−3.4	0.36	−2.4	0.31			
SN/Go-Gn, °	33.1	1.13	33.2	0.73	34.7	0.81			
ANS-PNS/Go-Me, °	26.2	1.17	27.0	0.98	27.1	0.96			
SN/ANS-PNS, °	9.1	0.72	8.2	0.64	9.5	0.61			
ANS-Me, mm	62.0	1.13	62.9	1.19	62.5	0.93			
Overbite, mm	3.3	0.39	3.1	0.47	2.9	0.51			
Overjet, mm	−2.8	0.34	−2.3	0.27	−2.6	0.27			
Molar relation, mm	−4.8	0.42	−3.9	0.39	−3.5	0.39			
Upper molar/ANS-PNS, °	99.9	1.15	104.3	0.94	101.2	1.41	*		
Lower molar/Go-Me, °	98.9	1.17	100.0	0.90	100.6	1.06			
Upper incisor/NA, °	23.5	1.49	22.3	1.20	20.8	1.42			
Lower incisor/NB, °	20.1	1.06	19.5	1.02	19.9	1.38			

[a] X indicates mean; Sx, standard error of mean.
* $P < .05$.

In the MTTBA group SN, SNA, ANB, CoA, CoGn, and N ⊥ Pg-A measurements increased significantly ($P < .001$). SNB angle showed a significant decrease ($P < .01$). Significant increases in SN/GoGn, ANS-PNS/Go-Me, and ANS-Me were observed, and a significant decrease in overbite accompanied these changes ($P < .001$). Overjet and molar relation increased significantly ($P < .001$). Upper incisor

Table 2. Treatment Changes of Facemask (FM) and modified tandem traction bow appliance (MTTBA) groups, Observation Period Changes of Control Group, and Comparison Among Groups[a]

	FM (1) (n = 21)			MTTBA (2) (n = 22)			Control (3) (n = 22)			*P*		
	D	SD	*P*	D	SD	*P*	D	SD	*P*	1–2	1–3	2–3
SN, mm	0.7	0.22	**	0.9	0.11	***	0.6	0.12	***			
SNA, °	1.6	0.25	***	1.3	0.27	***	0.3	0.21			*	*
SNB, °	−1.2	0.33	**	−0.8	0.27	**	0.6	0.24	*		*	*
ANB, °	2.8	0.30	***	2.0	0.18	***	−0.3	0.13	*	*	*	*
CoA, mm	3.1	0.59	***	2.2	0.30	***	1.2	0.27	***		*	
CoGn, mm	2.6	0.71	**	2.4	0.44	***	2.8	0.49	***			
N⊥ FH-A, mm	1.4	0.44	**	1.0	0.29	**	0.2	0.41				
N⊥ FH-Pg, mm	−1.6	0.71	*	−1.3	0.62		1.1	0.53			*	*
N-Pg⊥ A, mm	2.2	0.44	***	1.5	0.25	***	−0.4	0.18	*		*	*
SN/Go-Gn, °	1.2	0.38	**	1.3	0.26	***	0.1	0.29			*	*
ANS-PNS/Go-Me, °	1.8	0.43	**	2.3	0.43	***	0.3	0.34			*	*
SN/ANS-PNS, °	−0.7	0.32	*	−0.7	0.37		−0.3	0.24				
ANS-Me, mm	3.0	0.44	***	3.7	0.52	***	1.3	0.37	**		*	*
Overbite, mm	−1.9	0.37	***	−2.1	0.47	***	0.2	0.17			*	*
Overjet, mm	5.2	0.40	***	4.0	0.27	***	−0.1	0.15		*	*	*
Molar relation, mm	4.2	0.40	***	3.3	0.42	***	−0.3	0.17			*	*
Upper molar/ANS-PNS, °	−4.5	1.28	**	−1.4	0.71		0.6	0.71		*	*	
Lower molar/Go-Me, °	0.5	1.15		5.1	1.59	**	−0.3	0.81		*		*
Upper incisor/NA, °	3.0	1.16	*	3.2	0.52	***	0.7	0.69				
Lower incisor/NB, °	−3.2	0.69	***	−4.4	0.56	***	0.6	0.41			*	*

[a] D indicates mean differences; SD, standard error of mean differences.
* $P < .05$.
** $P < .01$.
*** $P < .001$.

Table 3. Treatment Changes of Facemask (FM) and Modified Tandem Traction Bow Appliance (MTTBA) Groups and Observation Period Changes in Control Group on Superimpositions[a]

	FM (1) (n = 21)			MTTBA (2) (n = 22)			Control (3) (n = 22)			*P*		
	D	SD	*P*	D	SD	*P*	D	SD	*P*	1–2	1–3	2–3
Total superimposition												
Point A-T	2.0	0.5	**	2.0	0.25	***	0.5	0.33			*	*
Point A-TW	0.6	0.5		1.1	0.34	**	1.1	0.26	***			
Pogonion-T	−2.2	1	*	−1.0	0.59		1.3	0.47	*		*	*
Pogonion-TW	3.5	0.7	***	4.0	0.48	***	2.2	0.57	**			*
Local superimposition												
Upper molar-T	2.0	0.5	**	1.0	0.19	***	0.2	0.25		*	*	
Upper molar-TW	1.5	0.4	**	0.5	0.21	*	0.9	0.26	**			
Upper incisor-T	2.2	0.4	***	1.4	0.18	***	0.7	0.25	*	*	*	
Upper incisor-TW	0.4	0.4		0.7	0.18	**	0.8	0.26	**			
Lower molar-T	−0.2	0.4		−0.8	0.33	*	0.7	0.21	**			*
Lower molar-TW	−1.2	0.6		−0.5	0.29		0.1	0.36				
Lower incisor-T	−1.1	0.5	*	−1.4	0.21	***	0.4	0.14	*		*	*
Lower incisor-TW	−1.2	0.3	***	−1.5	0.31	***	−0.1	0.38			*	*

[a] D indicates mean differences; SD, standard error of mean differences.
* $P < .05$.
** $P < .01$.
*** $P < .001$.

proclination and lower incisor retroclination were found to be statistically significant ($P < .001$) (Table 2).

Significant forward (point A-T) and downward (point A-TW) movement of point A was observed in the MTTBA group ($P < .001$ and $P < .01$, respectively). Total superimpositions also showed significant downward movement of the pogonion (pogonion-TW) ($P < .001$). Increases in upper molar-T and upper incisor-T were statistically significant ($P < .001$). Lower molar-T and lower incisor-T distances showed significant decreases in this group ($P < .05$ and $P < .001$, respectively) (Table 3).

In the control group, a significant increase in SNB and a decrease in ANB were present ($P < .05$). SN, CoA, and CoGn dimensions increased significantly ($P < .001$). Lower facial height (ANS-Me) showed a significant increase ($P < .001$) (Table 2).

Point A-TW distance increased significantly in the control group ($P < .001$). Significant forward (pogonion-T) and downward (pogonion-TW) movement of pogonion were observed ($P < .05$ and $P < .01$, respectively). Forward movement of upper (upper incisor-T) and lower (lower incisor-T) incisors were found to be statistically significant ($P < .05$). Lower molar-T distance showed a significant increase ($P < .01$) (Table 3).

Comparison Among Groups

Increases in SNA, N ⊥ Pg-A, and ANB and decreases in SNB and N ⊥ FH-Pg in both treatment groups showed significant differences compared with the control group. Increase in ANB in the FM group was significantly greater than in the MTTBA group. Greater increases in SN/GoGn, ANS-PNS/Go-Me, and ANS-Me were observed in both treatment groups compared to the control group. Change in overbite in treatment subjects was significantly different compared to that noted in the control group. Although the increase in overjet in both treatment groups showed a significant difference compared with the control group, it was also significantly greater in the FM group than in the MTTBA group. Significant differences in upper molar and lower molar inclinations were observed between the treatment groups ($P < .05$) (Table 2).

Changes in the sagittal position of point A (point A-T) and pogonion (pogonion-T) in treatment subjects were significantly different compared with the control subjects. Pogonion-TW distance showed a greater increase in the MTTBA group than in the control group. Forward movement of the upper molar (upper molar-T) and upper incisor (upper incisor-T) was significantly greater in the FM group than in the MTTBA and control groups. Lower molar-T showed a significant difference between the MTTBA and control groups. Decreases in lower incisor-T and lower incisor-TW in both treatment groups were significantly different compared with the control group ($P < .05$) (Table 3).

DISCUSSION

It has been shown that the percentage of skeletal discrepancy in the etiology of Class III malocclusion is over 60%.[15] Protraction FM is a commonly used appliance to normalize this underlying skeletal discrepancy. MTTBA is offered as an alternative treatment approach for Class III malocclusion. To our knowledge, this study is the first to compare the

skeletal and dental effects of FM and MTTBA in the treatment of Class III malocclusion.

Patients treated with FM and a removable appliance were preferred for the FM group, as the MTTBA is a removable appliance.

Skeletal Changes

In both treatment groups, the skeletal complex was affected sagittally when compared with the control group. Forward movement of the maxilla was similar in both treatment groups and significantly greater compared to the control group. Statistical evaluation of treatments with FM and some removable appliance in Class III malocclusion revealed an increase in maxillary protrusion.[4,6,7,9,16,17] Though a significant decrease in SN/ANS-PNS was observed in the FM group, the vertical position of the maxilla (Point A-TW; SN/ANS-PNS) did not show any significant difference between the groups. Westwood et al.[16] noted no rotation of the palatal plane following rapid maxillary expansion and FM therapy. Contrary to the findings of the present study, significant rotation of the palatal plane was reported in some other FM studies.[17,18] It should be kept in mind that several factors, such as direction of force or point of application, might cause changes in the vertical position of the palatal plane. Decreases in SNB, N ⊥ FH-Pg, and pogonion-T measurements and increases in SN/GoGn and ANS-PNS/Go-Me indicated the backward rotation of the mandible in both treatment groups. A backward rotation of the mandible was among the results of several Class III treatment studies.[6,7,11,16,19–22] Atalay and Tortop[14] reported the vertical control of the MTTBA as doubtful.

Changes in the maxilla and mandible in the treatment groups resulted in increases in ANB (FM: 2.8°; MTTBA: 2.0°) and N-Pg ⊥ A (FM: 2.2 mm; MTTBA: 1.5 mm). Both treatment approaches could be accepted as effective in treating subjects with Class III malocclusion, as these changes were significantly different compared with the control group. Skeletal improvements in both groups were in accordance with previous FM[1,17,21,23–25] and TTBA[14,26] findings. Cozza et al.[23] reported 2.8° improvement in ANB angle with a combined protocol of FM and a removable bite block appliance.

Though the changes in the maxilla and the mandible were similar in both treatment groups, increase in ANB is greater in the FM group than in the MTTBA group. In a reverse twin block study skeletal effects were found to be minimal, while significant maxillary advancement occurred with FM therapy.[27] Because of the significantly greater increases in the SNA and ANB angles, FM treatment was reported[13] to be more effective than double plate appliance in stimulating maxillary growth. Godt et al.[12] emphasized that improvements in sagittal skeletal relation were more pronounced with FM than with functional orthopedic appliances, but they also pointed out that removable appliances were able to induce minor improvements and to counteract the progression of Class III abnormalities.

Dental Changes

Mesial movement (upper molar-T) and mesial inclination (upper molar/ANS-PNS) of the upper molar were significantly greater in the FM group compared to the MTTBA and control groups. Ucem et al.[13] reported that increase in U6-PTV distance was greater in the FM group than in the control group; however, measurements of local superimpositions did not support this finding. Uprighting (lower molar/Go-Me) of lower molar due to the forces applied by the removable appliance of MTTBA showed significant differences compared to FM and control groups.

Retrusion (lower incisor-T) and lingual tipping (lower incisor/NB) of lower incisors were observed in both treatment groups. However, protrusion of upper incisors (upper incisor-T) in the FM group was significantly different compared to the MTTBA and control groups. Most of the studies regarding the effects of FM agreed that protrusion of the upper incisor and/or retrusion of the lower incisor contributed to the correction of malocclusion.[17,18,28] Similar results were reported with intraoral appliances.[9,11,13,14,27] Lack of retroclination of the lower incisors was mentioned with the bone anchor maxillary protraction treatment.[29] Cozza et al.[23] suggested that as a result of the acrylic blocks, FM and bite block combination did not cause any change in the position of the incisors.

The positive overjet and improvement in molar relation in both treatment groups were in accordance with those observed in previous studies.[14,16,24,26] Assessment of FM and rapid maxillary expansion by pitchfork analysis showed that the contribution of dental movements to the overall molar and overjet correction was minimal.[30] Increase in overjet in the FM group was significantly greater than in the MTTBA group. Seehra et al.[27] reported that both FM and reverse twin block therapies resulted in similar overjet changes. Ucem et al.[13] concluded that changes in upper and lower incisors in the double plate group could be responsible for the overjet difference, as compared to FM treatment. In this study, changes in the upper incisor seemed to be responsible from the difference in overjet between the groups.

It could be concluded that the skeletal effects of tooth-borne appliances were limited, but they might be useful in cooperation and control of the progression of Class III malocclusion during the early treatment period.

CONCLUSIONS

- Though the changes in ANB, overjet, and molar relation showed that both treatment approaches were effective in the treatment of Class III malocclusion, greater increases in ANB and overjet during FM treatment was observed.
- Skeletal improvement occurred because of the maxillary protrusion combined with the mandibular rotation.
- While protrusion of the upper incisor and mesial movement of the upper molar were greater in the FM group, uprighting of the lower molar was found to be greater in the MTTBA group.

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