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Original Article

Treatment with facemask and removable upper appliance versus modified tandem traction bow appliance: the effects on mandibular space

Tuba Tortop, Emine Kaygisiz, Safak Erkun and Sema Yuksel

Department of Orthodontics, Faculty of Dentistry, Gazi University, Ankara, Turkey

Correspondence to: Emine Kaygisiz, Department of Orthodontics, Faculty of Dentistry, Gazi University, Biskek Cd. (8.Cd.) 82.Sk. No:4 06510 Emek, Ankara, Turkey. E-mail: dt.emineulug@mynet.com

Summary

Objective: The aim of this study was to evaluate and compare the mandibular arch posterior space changes in Class III patients treated with facemask (FM) with removable upper appliance or modified tandem traction bow appliance (MTTBA).

Methods: Pre- and post-treatment and pre- and post-observation lateral cephalograms of 76 subjects with skeletal and dental Class III malocclusion from the period 2000–10 years formed the materials of this study. In the first group, 25 patients (10 girls, 15 boys; mean age: 10 years, 1 month) were treated with MTTBA. The average treatment time was 12 months. In the second group, 26 patients were treated (13 girls, 13 boys; mean age: 10 years, 4 months) with a Delaire-type FM. The average treatment time was 13 months. The remaining 25 children (9 girls, 16 boys; mean age: 9 years, 8 months) were observed without treatment for 10 months. ANOVA, Duncan, and paired *t*-tests were used for statistical evaluation.

Results: Although ramus width and mandibular posterior space increased significantly in all groups, no significant differences were found among the groups. Significant increase in tipping of lower molar (L6/GoMe) in the MTTBA group showed a significant difference compared with the FM and control groups. Significant retroclination of the lower incisors (L1/NB) in the MTTBA and FM treatment groups was significantly different compared with the control group. Retroclination of lower incisors in the MTTBA group was significantly greater than that in the FM group.

Conclusions: FM and MTTBA treatment approaches did not affect the dimensions of posterior space.

Limitations: To generalize the results of this study, long term evaluation by considering the third molar position should be done.

Introduction

The goals of early Class III treatment generally included forward displacement of the maxilla and redirection of mandible in a backward and downward direction (1–3). Several appliances were used to achieve these goals. Rapid palatal expansion and facemask (FM) were one of the popular ones (4–7). For both functional purposes and esthetic reasons, intraoral appliances were also used to correct the skeletal discrepancies (8–13). However, besides these skeletal effects, forward movement of maxillary dentition and backward movement of mandibular dentition were also observed with most of these appliances (8, 11, 12).

Although mandibular dental effects of different types of orthodontic treatment were evaluated, few studies were concerned about the potential space for the developing second and third molars. The studies showed that fixed orthodontic treatment with premolar extractions might potentially increase the posterior space and decrease the risk of third molar impaction (14, 15). The orthodontic appliances causing posterior movement of the mandibular dentition,

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either by tipping of each tooth or by translation of dentition, may limit the space available for the second and third molars, which may result in the impaction of the third molars (16–18).

The space analysis in the posterior dental arch is of great importance and can help orthodontists to achieve a consistently high-quality result. The posterior arch area should be included in a complete orthodontic treatment planning (19, 20).

There are few studies that detect the changes in the mandibular dentition during the treatment of Class III malocclusion with either FM or removable appliances (21–24). To the best of our knowledge, there are no studies that evaluated the effect of Class III treatment on posterior space in literature. So, the aim of this study was to compare the mandibular posterior space changes in Class III patients treated with FM or modified tandem traction bow appliance (MTTBA). The null hypothesis assumed that there are no differences between the treatment effects of MTTBA and FM on mandibular posterior space.

Materials and methods

This retrospective study comprised 76 patients with skeletal Class III relationship (ANB < 0 degrees) due to maxillary retrusion or a combination of maxillary retrusion and mandibular protrusion which were treated in Faculty of Dentistry, Gazi University. All of them had an Angle Class III malocclusion with anterior crossbite and an SN/GoGn angle between 26 degrees and 38 degrees. In all cases, maxillary incisors were fully erupted. The study was approved by the Ethics Committee of the University [2013/25901600-1409]. Two treatment groups and an untreated control group were evaluated for this study. The patients with a craniofacial dysmorphology, pathology in mandible (cysts, tumors), history of dentofacial trauma or disturbances affecting dental development, or poor quality of radiographs were excluded from the study.

In the first treatment group, 25 patients (10 girls, 15 boys; mean age: 10 years, 1 month) wore an MTTBA, which comprised an upper splint, a lower splint, and a traction bow as described in a previous study (12). Construction bites were taken without sagittal activation and 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 total force of 800–1000*g* were worn between the labial hooks of the upper splint and the traction bow. The patients were instructed to wear the appliance for approximately 14–16 h per day. The average treatment time was 12 months.

In the second treatment group, 26 patients (13 girls, 13 boys; mean age: 10 years, 4 months) were treated with a Delaire-type FM and a removable upper appliance. A total force of 600*g* was applied, and the angle between the occlusal plane and the direction force applied by the FM was approximately 20 degrees. The patients were instructed to wear their appliances for approximately 16 h per day. A removable upper appliance with two hooks at the anterior region for extra-oral elastics was used. The average treatment time was 13 months.

The treatment groups were compared with an untreated Class III control group of 25 children (9 girls, 16 boys; mean age: 9 years, 8 months). The observation period was 10 months.

The first lateral cephalometric radiographs were taken before appliance insertion (T1), and the second lateral cephalometric radiographs were taken after achieving an overjet of 2–3 mm (T2). After the cephalometric evaluation, all patients were treated with fixed appliances.

Eight linear and six angular measurements were evaluated on lateral cephalometric radiographs (Figure 1). All radiographs were hand traced on acetate paper and measured by the same author (SE) after tracing 20 pilot radiographs for orientation. When double projection caused two points or the right and left sides did not superimpose, the midpoint was used.

The lateral cephalometric radiographs of 30 subjects were retraced, and superimpositions and measurements were repeated after 15 days by the same examiner (SE). Intraclass correlation coefficient method was used. Method error coefficients were very close to 1.0, indicating high reliability.

Statistical analysis

Statistical analysis was done with SPSS 16.0 (SPSS Inc., Chicago, Illinois, USA). Power analysis showed that for a power of 0.90 at $\alpha = 0.05$, 20 patients would be required for each group. Data were tested with Shapiro–Wilk test for normal distribution. As a result of the normal distribution of data, a paired *t*-test was used to evaluate the treatment effects and changes during the treatment and observation period in each group. Differences between the groups were determined by ANOVA and the Duncan test. The level of significance was set at $P < 0.05$.

Results

The sample size of patients per group at $\alpha = 0.05$ achieves a statistical power of 0.97 in this study. Descriptive data and statistical comparisons for starting forms were given in Table 1. The statistical comparison of the pretreatment values showed that L6Sym in the FM group was significantly greater than in the MTTBA group and ramus width (DC) was greater in the FM than in the control group ($P < 0.05$) (Table 1).

The cephalometric changes in groups from T1 to T2 were given in Table 2. In the MTTBA group, SNA and ANB angles increased significantly ($P < 0.001$). SNB angle showed a significant decrease ($P < 0.01$). These changes were accompanied by a significant decrease in overbite ($P < 0.001$). Overjet and molar relation increased significantly ($P < 0.001$). Ramus width (DC), CPg ($P < 0.01$), and

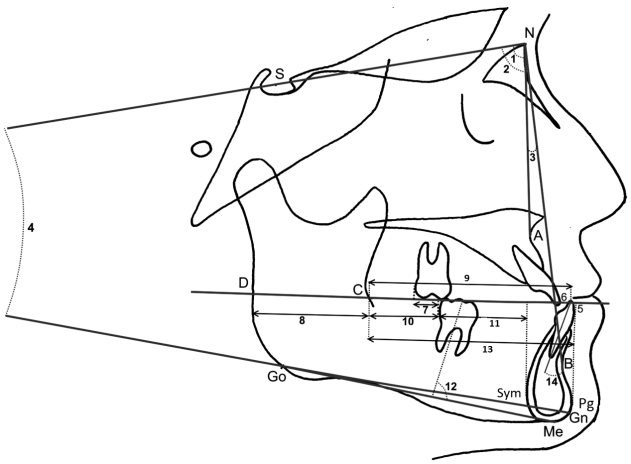


Figure 1. Cephalometric measurements: 1. SNA; 2. SNB; 3. ANB; 4. SN/GoGn; 5. overbite; 6. overjet; 7. molar relation; 8. DC (ramus width; D: intersection of the occlusal plane with the posterior border of the ramus; C: intersection of the occlusal plane with the anterior border of the ramus); 9. CPg; 10. CLMD (mandibular posterior space; LMD: the distal contact point of the mandibular first molar); 11. L6Sym; 12.L6/GoMe; 13. CL1; 14. L1/NB.

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mandibular posterior space (CLMD) ($P < 0.001$) increased significantly. A significant uprighting of lower molar (L6/GoMe) was observed ($P < 0.01$). Lower incisor retroclination (L1/NB) was found to be statistically significant ($P < 0.001$) (Table 2).

In the FM group, SNA and ANB values increased significantly ($P < 0.001$), whereas SNB value showed a significant decrease ($P < 0.001$). An increase in SN/GoGn angle was found to be significant ($P < 0.01$). A significant decrease in overbite was observed ($P < 0.001$). Significant increases in overjet and molar relation were also found ($P < 0.001$). Ramus width (DC) and mandibular posterior space (CLMD) increased significantly ($P < 0.01$, $P < 0.001$, respectively). Lower incisor retroclination (L1/NB) was found to be statistically significant ($P < 0.05$) (Table 2).

In the control group, a significant increase in SNB and a decrease in ANB were present ($P < 0.05$). Significant increases in ramus width (DC) ($P < 0.01$) and CPg ($P < 0.001$) were found. Additionally, posterior space (CLMD) increased significantly ($P < 0.001$). CL1 dimension showed a significant increase ($P < 0.01$) (Table 2).

Comparison among groups

Increases in SNA and ANB, and decreases in SNB in both treatment groups, showed significant differences compared with the control group ($P < 0.001$). Increases in SNA and ANB angles in the FM group were significantly greater than in the MTTBA group ($P < 0.001$). Change in SN/GoGn in treatment subjects was significantly different compared with that noted in the control group. Significant decreases in overbite in both treatment groups were significantly different compared with the insignificant increase in the control group (Table 2).

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 ($P < 0.001$). Increases in molar relation in both treatment groups showed significant differences compared with the control group ($P < 0.001$). Although ramus width (DC) ($P < 0.01$) and mandibular posterior space (CLMD) ($P < 0.001$) increased significantly in all groups, no significant differences were found among the groups (Table 2).

Significant increase of L6/GoMe in the MTTBA group showed a significant difference compared with the insignificant decrease in the FM and control groups ($P < 0.001$). Significant retroclination of the lower incisors (L1/NB) in the MTTBA and FM treatment groups was significantly different compared with control group ($P < 0.001$) (Table 2). Retroclination of lower incisors (L1/NB) in the MTTBA group was significantly greater than that in the FM group ($P < 0.001$, Table 2).

Discussion

The mandibular posterior space is an important component of a successful and stable orthodontic treatment. Chen *et al.* (20) emphasized that posterior, mid-arch, or anterior arch deficiencies should be evaluated together during orthodontic treatment planning. Although controversial (15, 25–28), the influence of the mandibular third molars was also suggested as a key factor in the stability of orthodontic treatment, especially for the relapse of anterior crowding. This assertion was also substantiated by Richardson (29) who observed that the incidence of crowding increases during the period of third molar eruption through total occlusion. There are few studies evaluated changes in the mandibular posterior space during orthodontic treatment. After fixed appliances therapy with premolar extraction, an increased eruption space due to mesial molar movement was reported to reduce the risk of third-molar impactions in adolescent orthodontic patients (15, 30, 31). FM and MTTBA appliances used in the treatment of Class III malocclusion generally aimed forward movement of maxilla and maxillary dentition. Chin in FM and mandibular dentition in MTTBA were used for anchorage purposes causing an inevitable mandibular dental movement (7, 11–13). However, no studies evaluated the effect of Class III orthopedic treatments on the posterior space. So, the aim of this study was to evaluate the changes in the mandibular posterior space during FM and MTTBA treatments and to determine the use of intraoral mandibular appliances whether it affects the mandibular posterior space or not.

In this retrospective study, mandibular posterior changes were evaluated on pre- and post-treatment and pre- and post-observation lateral cephalograms. CBCT images should ideally provide more accurate identification and measurements than lateral cephalograms, as these radiographs have some limitations, such as superimpositions, double projection, greater distortion, and unequal magnification

Table 1. Pretreatment mean values and statistical differences among the groups.

	MTTBA (1)		FM (2)		Control (3)			*P*		
	X	SD	*X*	SD	*X*	SD	*P*	1–2	2–3	1–3
SNA (degrees)	76.9	2.51	77.1	2.99	76.9	2.90	0.969			
SNB (degrees)	79.8	2.51	79.3	2.12	78.7	2.78	0.412			
ANB (degrees)	–2.8	1.51	–2.3	1.66	–1.7	1.18	0.068			
SN/GoGn (degrees)	33.6	3.19	33.2	3.37	34.5	3.65	0.416			
Overbite (mm)	2.7	2.11	2.7	2.08	2.8	2.36	0.982			
Overjet (mm)	–2.3	1.18	–2.6	1.32	–2.6	1.30	0.632			
Molar Relation (mm)	–4.1	1.88	–4.0	1.78	–3.4	1.92	0.326			
DC (mm)	32.4	2.48	33.2	2.42	31.4	1.49	0.020		*	
CPg (mm)	48.4	3.39	47.0	3.40	46.5	3.70	0.144			
CLMD (mm)	6.8	2.80	6.1	1.78	5.6	1.92	0.412			
L6Sym (mm)	35.4	2.56	33.3	2.08	34.4	3.34	0.044	*		
L6/GoMe (degrees)	99.9	3.39	98.1	3.97	100.0	3.72	0.264			
CL1 (mm)	44.6	2.48	44.8	1.59	43.9	2.42	0.572			
L1/NB (degrees)	19.4	3.66	22.8	3.27	20.1	4.07	0.116			

MTTBA, modified tandem traction bow appliance; FM, facemask; X, mean; SD, standard deviation of mean; *$P < 0.05$.

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Table 2. Treatment changes of modified tandem traction bow appliance (MTTBA) and facemask (FM) groups, observation period changes of control group, and comparison among groups.

	MTTBA (1)			FM (2)			Control (3)						
	D	SD	*P*	*D*	SD	*P*	*D*	SD	*P*	*P*	1–2	2–3	1–3
SNA (degrees)	1.1	1.14	0.000***	2.0	1.19	0.000***	0.2	0.99	0.238	0.000	***	***	***
SNB (degrees)	−0.8	1.13	0.001**	−1.3	1.27	0.000***	0.6	1.14	0.013*	0.000		***	***
ANB (degrees)	2.0	0.82	0.000***	3.3	1.42	0.000***	−0.4	0.80	0.027*	0.000	***	***	***
SN/GoGn (degrees)	1.0	1.21	0.064	1.3	1.77	0.001**	−0.3	1.67	0.320	0.001		**	**
Overbite (mm)	−1.7	1.29	0.000***	−0.9	1.27	0.000***	0.2	1.02	0.292	0.001		**	**
Overjet (mm)	4.3	1.19	0.000***	5.3	1.22	0.000***	0.2	0.75	0.303	0.000	***	***	***
Molar Relation (mm)	3.6	1.27	0.000***	4.1	1.59	0.000***	−0.2	1.02	0.337	0.000		***	***
DC (mm)	0.3	0.43	0.001**	0.4	0.74	0.001**	0.4	0.60	0.002**	0.793			
CPg (mm)	0.7	1.04	0.001**	0.1	1.30	0.768	1.1	1.17	0.000***	0.094			
CLMD (mm)	1.3	1.24	0.000***	1.1	1.17	0.000***	1.2	1.12	0.000***	0.905			
L6Sym (mm)	−0.3	0.87	0.124	−0.5	1.70	0.119	−0.2	2.00	0.742	0.827			
L6/GoMe (degrees)	4.8	3.09	0.001**	−1.3	3.68	0.087	−0.7	3.83	0.357	0.000	***		***
CL1 (mm)	0.0	0.96	0.838	−0.2	1.58	0.542	0.6	0.89	0.004**	0.069			
L1/NB (degrees)	−4.4	1.83	0.000***	−1.8	2.16	0.042*	0.4	2.71	0.194	0.000	***	***	***

D, mean differences; SD, standard deviation of mean differences; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

(20, 32). However, the use of CBCT is not ethically approved for evaluation of the treatment effects of the appliances used in the present study. So, post-treatment cephalograms were taken in order to continue and plan the fixed orthodontic therapy after orthopedic treatment of Class III malocclusion, and in most of these cases, there was a need for labio-lingual movement of the incisors. Different methods were preferred to determine mandibular posterior space on lateral cephalometric radiographs in previous studies (20, 31, 32). Frankfurt horizontal or true horizontal and perpendicular to these lines passing through the most concave point of the anterior border of the mandibular ramus or occlusal plane were offered as reference planes (20, 31, 32). In a longitudinal study, Chen *et al.* (20) emphasized that using occlusal plane is much more reliable. It might be interpreted that changes in this plane could affect the posterior space measurement. However, in some previous studies on FM and MTTBA, statistically significant changes in SN/Occlusal plane angle were not reported (33, 34). Hence, in this study, occlusal plane was used as a horizontal reference plane. There is not any study that evaluates posterior space changes during Class III treatment.

Both FM and MTTBA appliances were effective in the treatment of Class III malocclusion. Although the forward movement of the maxilla 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. The positive overjet in both treatment groups was in accordance with those observed in previous studies (4–7, 11–13, 24, 35). Increase in overjet in the FM group was also significantly greater than that in the MTTBA group. So, it could be suggested that the FM appliance was much more effective in sagittal correction of Class III malocclusion. Comparisons of treatments with FM and some removable appliances in Class III malocclusion revealed an increase in maxillary protrusion (11, 12, 35). Decreases in SNB measurements and increases in SN/GoGn indicated the backward rotation of the mandible in both treatment groups in this study. A backward rotation of the mandible was among the results of several Class III treatment studies (8, 12, 22, 24).

Lingual tipping of lower incisors (L1/NB) was observed in both treatment groups. Most of the studies regarding the effects of FM and some removable appliances in Class III malocclusion agreed that lingoversion of the lower incisor which contributed to the correction of malocclusion (8, 22, 24, 36). Canturk and Celikoglu (22) reported that no significant lingoversion of the mandibular incisors was found due to the presence of the lingual ark in the mandible. However, several studies regarding Class III treatment showed retrusion of lower incisors (13, 37). In this study, the distance of lower incisors to C point showed no significant change in both treatment groups (C-L1). This could not be interpreted as the control of the retrusion of lower incisors, but it could be concluded that the total arch length was preserved as in the control group.

The improvement in molar relation in both treatment groups was in accordance with those observed in previous studies (7, 11–13, 37, 38). The attribution of maxillary molars to the correction of molar relationship was evaluated in several studies. However, the changes in the sagittal movement of mandibular molars were mostly ignored. Kim *et al.* (21) reported that the contribution of mandibular molars to the correction of molar relation was 24 per cent with TTBA treatment. Canturk and Celikoglu (22) reported insignificant changes in mandibular molars during treatment with Alt-RAMEC, FM, and lingual arch combination. Ngan *et al.* (23) also reported insignificant sagittal movement of mandibular molars with both tooth-borne and bone-anchored protraction FM treatments. In accordance with these findings, the sagittal movement of molars (L6Sym) was found to be insignificant in both treatment and control groups in this study. However, distal tipping of lower molars is a common finding in Class III treatments with removable appliances (11, 12, 36). Our findings are similar to the findings of these studies. Although a significant uprighting (4.8 degrees) was observed in lower molar (L6/GoMe) in the MTTBA group, posterior arch space showed similar increases in all groups. It might be suggested that molar uprighting during removable appliances has no clinical significant effect on posterior space. However, this tipping should be considered during fixed orthodontic treatment and long-term evaluation was needed.

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In this study, in all groups, significant increases in ramus width were observed without significant differences among the groups. In accordance with this, Ledyard and Calif (39) pointed out that there was little variation of ramus width after 8 years of age; it was maintained as growth continued. Chen *et al*. (20) found that the width of the ramus was attained before the age of 13.

Bjork (40) concluded that a 1.5 mm of increase in the posterior dental arch on each side occurred per year until ages 14 for girls and 16 for boys. Richardson (41) reported that molar space increased by an average of 4 mm from 13 to 18 years of age. Chen *et al*. (20) reported a 1.5 mm increase in the age of less than 16 years per year in Class I patients. In our study, increases in posterior space were found to be 1.3, 1.1, and 1.2 mm in the MTTBA, FM, and control groups, respectively. Increases in the treatment groups showed no significant difference compared with control groups. Contrary to our expectations, the removable mandibular appliance in the MTTBA group did not restrict the increase in mandibular posterior space.

For both appliances, the major mechanism of Class III correction is anterior movement of the maxilla, maxillary dentition, and posterior rotation of the mandible. As MTTBA had a removable mandibular appliance, there were some dental changes in the posterior region of mandibular dentition (12). So, a decrease in mandibular posterior space might be expected due to the changes in the mandibular dentition. A significant 4.8 degrees of distal tipping in mandibular first molars was observed in this study. In a previous study, only 0.8 mm distal movement of the mandibular first molars was reported (13). It might therefore be inferred that the tipping accompanied with such a distalization amount did not affect the mandibular posterior space. In the light of these findings, the null hypothesis could not be rejected, as no differences were found between MTTBA and FM in respect of mandibular posterior space.

Third molar position and angulation might also be the factors that could change mandibular posterior space and be the reasons for impaction in the long-term. So, this should be considered when evaluating the effects of the appliances on mandibular posterior space in the long-term. Durations of treatment and observation were insufficient to enable an exact decision about the final mandibular posterior space. This study evaluated only the effects of different appliances as compared with a control group, and longitudinal data would be needed in order to determine the final mandibular posterior space in such cases. Furthermore, a larger sample size could increase the generalisability of the results.

Conclusions

MTTBA and FM therapies were effective in the treatment of Class III malocclusion, while FM seemed to be much more effective on the maxilla. Neither appliance affected the dimension of mandibular posterior space during the treatment of Class III malocclusions.

MTTBA can be considered as a treatment option in the early treatment of Class III malocclusion without risk of limiting the space available for second and third molars.

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Conflict of Interest

None to declare.

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