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Evaluation of the Effect of Removable Maxillary Expanders on Facial Vertical Dimension

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Abstract

Background: Palatal expansion is one of the most common types of orthodontic treatment, which is administered employing different appliances, and is used for the correction of posterior cross bite. This treatment can elevate the palatal cusp on the maxillary first molar, lead to the rotation of mandible, and increase the height of the lower third of the face. In some cases, the use of bite plane is suggested to avoid vertical dimension changes of the face. This study aimed to assess the effect of removable maxillary expanders on facial vertical dimensions.

Methods: In this cross-sectional study, 68 patients referring to Hamedan School of Dentistry and being treated using removable maxillary expander with or without bite plane were examined. Pretreatment and post treatment cephalograms of the patients were analyzed by Dolphin Imaging Software 11.9 version, and the results from 5 cephalometric variables, namely the mandibular plane related to SN line, the angle of mandibular plane related to FH, Y axis, the maxillary plane angulation, as well as the lower facial height were calculated. Patient's transverse dimension was measured by a caliper on the dental casts along the mesiobuccal cusp of maxillary first molars. Paired t test and independent t-test were adopted for carrying out data analysis.

Results: There was no significant difference between the two groups in terms of age and sex at the beginning of treatment. However, maxillary plane angulation and Y axis changed significantly in group with bite plane. ($P=0.034$, $P=0.007$). The changes were less than 1.5 degrees. No significant difference was observed between the groups with or without bite plane regarding the changes of cephalometric variables during the treatment. The transverse dimension of the arch was increased significantly in both groups. The changes were similar in two groups.

Conclusions: According to the results from this study, the presence of bite plane had no advantage over its absence. However, it seemed necessary to design a randomized clinical trial in this regard.

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Background

Transverse expansion of the palate is used to treat dental and skeletal cross bites, as well as to increase the width of a constricted maxilla (1) Most removable and fixed appliances apply pressure to the teeth and the tissue of the soft palate at the same time via a screw (2). One of the unfavorable side effects of maxillary expansion is maxillary posterior teeth extrusion and subsequent increase in vertical dimension of the face (3). The extrusion of the teeth as the palate expands depends on the location of the maxillary center of resistance. Lateral and buccal pressures are also determinants in the pyramidal opening of the midline suture of the maxilla, the apex of which is located inside the nasal cavity (4). If the central suture resists, lateral buccal forces cause small fractures in the buccal region of the maxillary alveolar bones, resulting in the lateral buccal tipping of the molar teeth. The lateral tipping causes the extrusion of the lingual cusp of the maxillary posterior teeth (5). Both orthopedic and orthodontic movements may cause the mandible to change position by making it rotate in backward and downward directions. This change can increase the height of the lower third of the face. With the mandible rotating backward, the angle of the mandibular plane increases during orthodontic treatment (6). These side effects are significant in patients with a long face, large mandibular

Highlights

- Some vertical variables may change by expanding maxillary arch due to elevation of palatal cusp during expansion.
- Vertical variables of adolescents changed similarly by appliances with or without posterior bite plane.

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angulation, and anterior open bite (7).

So far, a variety of appliances have been used to perform these treatments including W arch, hyrax, quad helix, and removable plates (8). Although providing different mechanisms for expanding the palate, they all work by opening the central maxillary suture (9).

It has been argued that bonded expansion appliances and those with posterior bite plane have several advantages for their occlusal coverage on certain posterior teeth. Seemingly, this posterior coverage can exert occlusal pressure on the surface of posterior teeth during treatment, resulting in less extrusion (10). However, the results on the effectiveness of this occlusal coverage are contradictory (11).

The present study aimed to investigate the effect of using maxillary expansion appliances with or without bite planes on the vertical dimension of the face.

Materials and Methods

This cross-sectional study was conducted to examine patients referred to Hamadan School of Dentistry and Special Dental Clinic of Hamadan. Gender and aged were matched in both groups by individual matching method. The inclusion criteria in this study were as follows:

1. Expansion of the palate using removable appliances with or without bite plane
2. Normal lower height (an assessment based on the ratio of the one-third of the facial height)
3. Class I malocclusion
4. The 10-15 age range
5. Existence of cephalometric radiography and dental casts before and after the end of maxillary expansion

Exclusion criteria in the study included the followings:

1. Craniofacial syndromes such as cleft lip and palate
2. SARPE or other types of surgery during or before palatal expansion
3. Simultaneous use of another appliance including fixed or elastic orthodontic appliances during the palatal expansion
4. Absence of maxillary first molar

Cephalometric analysis was done by aid of Dolphin Imaging software (version 11.9, Chatsworth, Calif, USA). Cast analysis was performed by a caliper (KT-Austria) with accuracy of 0.02. As for intraclass correlation, moreover, all cephalometric cases were initially analyzed by a trained person, and a number of 15 samples (20% of samples) were selected two weeks later and were calculated again, and the ICC rate was calculated to be 83% accordingly.

The patients were divided into two groups of with or without bite plane appliances (i.e., groups A and B, respectively). Both groups were treated to the point of overcorrection and final cephalometry was performed shortly after the end of the treatment.

The cephalometric images used before and after treatment were taken with the same device (PLANMECA, ProMax S2-Finlad), and all measurements were performed by Dolphin software 11.9 edition. The values of the following variables were elicited from cephalometric analyses:

the angle of mandibular plane to SN, the angle of mandibular plane to FH, the angle of Y axis, lower facial height, and the angle of the maxillary plane (Table 1).

Furthermore, the distance between the tip of the mesiobuccal cusp of the maxillary first molar along the palate was calculated by a caliper (KT-Austria) with a precision of 0.02 on dental casts before and after treatment. The caliper was held perpendicular to the cast, and the extent of maxillary width increase was matched in both groups. In other words, at the time of sampling, the subjects with narrow width increase (up to 4 mm), those with moderate width increase (4-8 mm), and those with great width increase (more than 8 mm) were matched. The values obtained from the above classification and their changes were compared in the two groups during treatment. Kolmogorov-Smirnov test was performed to determine the compliance of the data with the normal distribution. As for the data with normality of distribution, paired *t* test was applied to examine the difference between the means before and after the intervention, and independent *t* test was conducted to explore the difference between variables in both groups. *P* value less than 0.05 was considered as significant level.

Results

A number of 68 patients were examined in this research, of whom 34 patients were with bite plane, and 34 ones were without it (Table 2).

According to the results from this study, there was no significant difference between the two groups in terms of vertical variables and transverse dimension of the arch before administering the treatment. In addition, there was no significant difference between the two groups in terms of vertical variables and transverse dimension of the arch after completing the treatment (Table 3).

The results from paired *t* test and independent *t* test on changes during treatment in either of the groups are shown in Table 4. According to the results, there was no significant difference between the value of mandibular plane angle to

Table 1. Variables Chart

Variables name	Definition
MP-SN	The angle of mandibular plane to SN
MP-FH	The angle of mandibular plane to FH
Y axis	The angle between N-S-Gn
Lower facial height	Length of the line which between ANS-Me
Maxillary plane angulation	The angle of ANS-PNS line with FH

Table 2. Demographic Details of the Patients

Variables	Without Bite Plane	With Bite Plane	*P* Value
Mean age (SD)	13.91 ± 1.90	13.39 ± 1.94	0.46
Male gender (%)	21 male/23 female	20 male/24 female	0.53

SN and FH lines, and lower facial height during treatment in both groups. However, the value of the maxillary plane angulation and Y axis increased significantly in the group with bite plane ($P=0.03$ and $P=0.007$, respectively). The value of the changes was less than 1.5 degree. Comparing the two groups with and without bite plane, no significant difference was observed between the two groups in none of the cephalometric variables.

The findings of the cast analysis regarding the increase of the transverse dimension of the palate are presented in Table 5. According to our study results, an increase was detected in both groups with regard to the transverse dimension of the palate along the mesiobuccal cusp of the maxillary first molar, but no difference was found between the groups in terms of changes during treatment.

Discussion

According to the results from this study, no significant difference was found between two groups with or without bite plane regarding the final value of vertical variables and the value of variation during the treatment; that is, the presence or absence of the bite plane had no benefit to reducing the vertical dimension (12).

Our result was not in agreement with the study results from Reed et al (13) and Mossaz-Joelson et al (14). In the study by Reed et al, the effects of rapid palatal expansion with or without bite plane were compared and it was concluded that the appliance with bite plane could control vertical dimension more desirably (13). However, there was no difference between the groups in this study regarding linear variables such as lower height. Significant differences in angular variables were reported in the researches where these variables were all less than 1 degree which is not significant in clinical terms. In Mossaz-Joelson et al, the effects of the presence or absence of posterior bite plane on the slow expansion of the palate were investigated, and slight significant differences (less than 2 degrees) were observed between the two groups in terms of the mandibular angle (14). The difference between our study finding and the results from other studies might be attributed to the type of expander, as in our research removable expander was used whereas fixed expanders were employed in international studies. Patients rarely wear removable appliances full time and the vertical dimension is likely to return to normal during the time. Also, no research had ever investigated the effects of removable expanders before the present study (15,16). In addition, rapid expansion of the palate was explored in Reed et al, while slow expansion was considered in our research (13).

One of the determining factors in the results of a research examining to the subject is the initial characteristics of the patients. In the present study, an attempt was made to match the characteristics of the patients in the two groups. To this end, people with the same vertical dimension were selected in the two groups, which was manifested in the similarity of the values of variables in the two groups before treatment; in the above-mentioned studies, however, people with different vertical dimension were picked and investigated. Since appliances with posterior bite plane were prescribed for people with increased vertical dimension, it was likely that the number of people

Table 3. Comparison of the Cephalometric and Dental Cast Variables in Both Groups Before and After Maxillary Expansion

Variables	Group	Before Treatment (Mean ± SD)	*P* Value	After Treatment (Mean ± SD)	*P* Value
MP-SN	A[a]	55.48 ± 5.39	0.20	55.09 ± 5.42	0.15
	B[b]	53.57 ± 7.15		54.74 ± 8.34	
MP-FH	A	31.12 ± 4.46	0.42	31.65 ±4.68	0.49
	B	32.52 ± 6.17		31.38 ± 7.24	
Y Axis	A	69.70 ± 4.57	0.96	70.71 ± 4.51	0.85
	B	70.73 ± 4.40		70.13 ± 4.73	
Lower facial height	A	64.71 ± 10.42	0.78	64.79 ± 10.62	0.93
	B	63.27 ± 12.13		63.48 ± 11.05	
Maxillary plane angulation	A	85.05 ± 3.69	0.38	85.70 ± 3.18	0.50
	B	84.06 ± 3.89		85.43 ± 3.49	
Distance between the tip of maxillary first molar	A	45.81 ± 6.36	0.88	51.51 ± 38.39	0.41
	B	47.13 ± 5.35		5.49 ± 4.17	

SD, Standard deviation

[a] Group A: Treated by appliances with bite plane.

[b] Group B: Treated by appliances without bite plane.

Table 4. Results of Paired *T* test and Independent *T* test Regarding Changes During Treatment in Two Groups, With (Group A) and Without Bite Plane (Group B)

Variables	Group	Mean ±SD	Paired *T* test		Independent *T* test	
			T Statistic	*P* Value	T Statistic	*P* Value
MP-SN	A[a]	-1.17 ± 4.48	-1.26	0.22	1.46	0.25
	B[b]	0.39 ± 2.53	0.73	0.47		
MP-FH	A	-0.53 ± 2.84	-0.89	0.38	-1.57	0.57
	B	4.25 ± 1.14	1.29	0.21		
Y-axis	A	-1.01 ± 1.62	-2.98	0.007***	-2.55	0.43
	B	0.59 ± 2.53	1.12	0.27		
Maxillary plane angulation	A	-1.37 ± 2.92	-2.26	0.03***	0.77	0.69
	B	-0.65 ± 3.46	-0.90	0.38		
Lower facial height	A	-0.22 ± 7.25	-0.14	0.89	-1.28	0.35
	B	-3.07 ± 7.83	-1.88	0.07		
Distance between the tip of maxillary first molar	A	-3.36 ± 3.53	-4.57	0.001[c]	-1.73	0.11
	B	-5.71 ± 5.46	-5.01	0.001[c]		

SD, Standard deviation
[a] Group A: Treated by appliances with bite plane.
[b] Group B: Treated by appliances without bite plane.
[c] Statistically significant.

Table 5. Results of Paired *T* test and Independent *T* test Regarding Changes During Treatment in the Arch Width Along the Mesiobuccal Cusp of Maxillary First Molar Variable in 2 Groups, With and Without Bite Plane

Group	Mean ± SD	Paired *T* test		Independent *T* test	
		T Statistic	*P* Value	T Statistic	*P* Value
A*	-3.36 ± 3.53	-4.566	0.001	-1.733	0.112
B**	-5.71 ± 5.46	-5.015	0.001		

SD, Standard deviation
[a] Group A: Treated by appliances with bite plane.
[b] Group B: Treated by appliances without bite plane.

with increased vertical dimension grew in the group with bite plane. Besides, since these individuals experienced more vertical growth over a period of time than those with normal vertical dimension, the observed differences may have been associated with their growth rather than treatment.

Conroy-Piskai et al compared the effects of two appliances, namely Quad Helix and rapid expander with bite plane, and indicated that Quad Helix had better control over the vertical dimension comparing to the appliance with bite plane (17). Despite the differences between the appliances studied in their study and those explored in our research, it seemed that both studies had the same mechanism. Taking into consideration the results from the other studies and those from the present research, the effect of age and type of expansion (rapid vs slow) were more noticeable. Treatment with Quad Helix, a removable and slow appliance, is prescribed more in childhood and early adolescence. However, it seems that the changes resulting from the appliance during growth are compensated in patients with vertical growth, which means that none of the existing appliances have destructive effects on the vertical dimension (15).

Furthermore, no significant change was observed in mandibular plane angle and lower facial height during treatment in the present research when examining the two groups. There were significant variations between the value of Y axis in the group without bite plane and that of maxillary plane angle in the group with bite plane, though the values of both variations were about 1 degree which was not clinically significant.

These findings were consistent with the results from the study by Conroy-Piskai et al (17), though they were not in agreement with the results from the studies by Reed et al (13) and Sarver and Johnston (3). Despite the differences, the variations observed in the given studies were small in vertical dimensions, and were not considered significant clinically (3,13).

In a study by Asanza et al, it was revealed that the palatal plane had smaller vertical movement in the posterior region in the group with bite plane compared to the group without bite plane, which was also observed – to some extent, in the present research ; that is to say a significant increase was detected in the maxillary plane angle for the group with bite plane in our research, but the change were not significant in the group without bite plane (11).

According to the results from this study, in both groups the transverse dimension along the mesiobuccal cusp of the maxillary first molar increased significantly after treatment, which could be attributed to the use of palatal expander. In addition, comparing the two groups, the increase in transverse dimension was not statistically significantly different, despite the

fact that some studies had already reported different results concerning appliances with bite plane (13). In a systematic review by Harrison et al, however, the level of palatal expansion was estimated to be the same for two types of appliance (15). The difference in the rate of palatal expansion as well as the lack of group matching could account for the discrepancy in our study results and those from the study by Reed et al (13).

In this study, no significant difference was observed between two groups in terms of the initial values of the variables age, sex as well as cephalometric variables and cast, which suggested an appropriate matching of the groups under study before the initiation of treatment. It seemed that the application of bite plane in patients in childhood and adolescence had no advantage over appliances without bite plane due to the slight differences reported in previous studies. On the contrary, bite plane caused more hygiene and speech problems in patients, making it harder for patients to bear the appliance.

Conclusions

In conclusion, the use of bite plane had no advantage in children and adolescents with normal vertical dimensions. However, further studies (i.e., randomized clinical trials) are required to investigate the issue more thoroughly. Therefore, it is recommended that more researches be conducted to examine the patients with long vertical facial dimensions.

Conflict of Interest Disclosures

The authors declare that they have no conflict of interests.

Ethical Statement

The present study was approved by the Research and Medical Ethics Committee of Hamedan University of Medical Sciences (ethics code: IR.UMSHA.REC.1397.125).

Authors' Contribution

SeS: Conceptualization, Methodology. SaS: Conceptualization, Project administration. AN: Data Curation, Investigation. YA: Writing - original draft; Writing - review & Editing. PT: Validation.

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