Original Article

Effects of eruption guidance appliance in the early treatment of Class III malocclusion

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ABSTRACT

Objectives: To evaluate the dentoskeletal effects and effectiveness of the eruption guidance appliance in Class III patients in the mixed dentition.

Materials and Methods: The experimental group comprised 22 patients with Class III malocclusion and anterior cross-bite (12 males, 10 females, mean age 7.63 $\pm$ 0.96 years) treated with the eruption guidance appliance over a mean period of 1.72 $\pm$ 0.48 years. The control group comprised 22 untreated subjects (12 males, 10 females, mean age 7.21 $\pm$ 0.60 years) with Class III malocclusion. Lateral cephalometric radiographs were obtained at pretreatment (T1) and posttreatment (T2). Intergroup comparisons were performed with Mann-Whitney and *t*-tests ($P < .05$).

Results: In the experimental and control groups, the anteroposterior relationship between the maxilla and mandible (ANB angle) remained stable during the treatment period (T1 to T2). The mandibular plane angle decreased in the experimental group and increased in the control group. In the experimental group, the lower anterior face height increase and maxillary molar vertical development were significantly smaller compared to controls. Positive overjet was achieved in 54% of the experimental group.

Conclusions: The eruption guidance appliance produced no change in the skeletal anteroposterior relationship. The anterior cross-bite/edge-to-edge relationship was corrected in only about half of the treated subjects. (*Angle Orthod*. 2024;94:286–293.)

KEY WORDS: Class III malocclusion; Anterior crossbite; Eruption guidance appliance; Early treatment

INTRODUCTION

Class III malocclusion is the result of multiple genetic and environmental factors during facial growth[1] and patients with these discrepancies require early intervention to avoid functional and psychological harm.[2,3] This malocclusion is characterized by an anteroposterior dental discrepancy between the maxilla and mandible due to maxillary deficiency, mandibular prognathism, or a combination,[4] which can result in facial esthetic impairment. This condition affects between 3% and 15% of the population, with variation among ethnic groups and geographic regions.[1,5]

An important feature of this type of malocclusion is the anterior cross-bite that is established early and can lead to adverse complications, including damage to the teeth through attrition, gingival recession, and loss of alveolar bone support of the mandibular incisors, with consequent mobility.[6–8] Therefore, early correction of the anterior cross-bite is highly recommended and the evaluation of new alternatives is of clinical interest due to the limited possibilities of intervention at an early age.[5]

Among the various approaches for anterior cross-bite correction, facemask therapy is considered as the preferred treatment,[4] producing forward growth of the maxilla with a counterclockwise rotation, forward movement of the maxillary dentition, backward movement of the mandible with a clockwise rotation, and backward

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movement of the mandibular dentition. This may be accomplished using various maxillary protraction appliances, and with or without rapid maxillary expansion. Class III malocclusion can also be treated with removable appliances such as Fränkel III, that produces slight forward movement of the maxilla and slightly restricts anterior mandibular development,[9] and the Class III Bionator that corrects anterior cross-bite and decreases unfavorable mandibular growth.[10]

Eruption guidance appliances have been developed to correct Class I and II malocclusions and their effects have been previously reported.[11–14] Recently, a new prefabricated eruption guidance appliance has been developed to correct Class III malocclusion in the early mixed dentition. However, effects of this device have not yet been evaluated. Therefore, the aim of this prospective study was to evaluate dentoskeletal effects and effectiveness of the eruption guidance appliance for the early correction of Class III malocclusion associated with anterior cross-bite.

MATERIALS AND METHODS

This study was approved by the Ethics in Research Committee of Bauru Dental School, University of São Paulo, Brazil (protocol number, 24521419.6.0000.5417). Informed consent was obtained from all patients and legal guardians.

To detect a minimum intergroup difference of 2 mm in overjet with a standard deviation of 2.3 mm,[4] at a significance level of 5% and with a test power of 80%, 22 patients were found to be necessary for each group.

The experimental group included patients consecutively treated at the Orthodontic Clinic of Bauru Dental School. Subjects with ages ranging from 6 to 9 years in the mixed dentition with mild to moderate Class III were included. An edge-to-edge anterior relationship between incisors and anterior cross-bite were considered as mild and moderate dentoalveolar characteristics, respectively. Subjects with previous orthodontic treatment, skeletal discrepancy, craniofacial or dental anomalies, or syndromes were excluded. This group comprised 22 patients (12 male, 10 female) with a mean pretreatment age of 7.63 $\pm$ 0.96 years treated with the Eruption Guidance Appliance during a mean period of 1.72 $\pm$ 0.48 years (20 months). Sixteen patients had an anterior cross-bite and six had an edge-to-edge incisor relationship. Patients were instructed to use the appliance during nighttime and for an additional 4 hours during daytime.

During daytime use, the patients were oriented to use the appliance for 4 continuous hours maintaining the lips in contact. In addition, patients were trained to push the tongue against the three tabs located in the upper portion of the appliance, directly behind the anterior teeth, pressing the maxillary arch in a forward direction as hard as possible, as recommended by the manufacturer. Treatment was considered satisfactorily concluded when a Class I molar relationship and/or positive overjet was achieved. Treatment was considered unsatisfactorily concluded when the patient had been using the appliance for at least 18 months and showed lack of compliance during the COVID-19 pandemic period. Lateral cephalometric radiographs were obtained of each patient at pretreatment (T1) and posttreatment (T2) stages. Noncompliant patients had the T2 radiographs taken when in-person clinical monitoring was allowed in the university during the pandemic period.

The control group comprised 22 untreated Class III malocclusion subjects (12 male, 10 female) with a mean initial age of 7.21 $\pm$ 0.60 years. The sample was obtained from the American Association of Orthodontists Foundation (AAOF) Craniofacial Growth Legacy Collection Website. From the 35 AAOF subjects available online who fit the selection criteria, 17 subjects who had high-quality lateral cephalometric radiograph images in the age range similar to the experimental group were selected. The control group was completed with five untreated subjects with Class III malocclusion and anterior cross-bite from the files of the Orthodontic Department at Bauru Dental School. Of the 22 untreated Class III patients, eight had anterior cross-bite, seven had an edge-to-edge incisor relationship, and seven had positive overjet.

The radiographs were digitized and analyzed with Dolphin Imaging 11.9 software (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA). Image magnification was corrected prior to analysis. Points and reference lines were traced by one operator. At T1, part of the sample had their deciduous maxillary incisors traced because they were still present in the lateral radiograph. At T2, all patients displayed permanent maxillary incisors in the lateral radiograph. Twenty variables were measured on each cephalogram. The frequency of anterior functional shift in patients with anterior cross-bite was 44% (seven out of 16 patients). Overjet and overbite were measured as the horizontal and vertical distances, respectively, between the incisal edges of the maxillary and mandibular incisors.

Error Study

Thirty days after the first measurement, 10 randomly selected radiographs were retraced and remeasured by the same examiner (GPVH). Random errors were calculated with Dahlberg's formula,[15] ($S^2 = \Sigma\, d2/2n$), where S^2 is the error variance and d is the difference between two determinations of the same variable. Systematic errors were evaluated with dependent *t*-tests[16] at $P < .05$.

Table 1. Intergroup Comparisons of Initial and Final Ages, Period of Evaluation, Sex, and Anterior Tooth Relationship Distributions[a]

Variable	Experimental Group (n = 22)		Control Group (n = 22)		
	Mean	SD	Mean	SD	P*
Initial age (y)	7.63	0.96	7.21	0.60	.086[A]
Final age (y)	9.38	1.01	9.12	0.90	.369[A]
Period of evaluation (y)	1.72	0.48	1.87	0.60	.453[B]
Sex	n	%	n	%	
Female	10	45.5	10	45.5	1.000[C]
Male	12	54.5	12	54.5	
Initial	n	%	n	%	
Anterior cross-bite	16	72.73	8	36.36	.008*
Edge to edge	6	27.27	7	31.82	
Normal overjet	0	0.00	7	31.82	

[a] SD indicates standard deviation; [A] *t*-test; [B] Mann-Whitney *U*-test; [C] Chi-square test; * Statistically significant at $P < .05$.

Statistical Analyses

Normal distribution was assessed with the Shapiro-Wilk test. Intergroup comparability regarding initial and final ages, period of evaluation, and sex distribution was assessed with *t*-, Mann-Whitney, and Chi-square tests, respectively. Intergroup comparisons were performed with t and Mann-Whitney tests.

The percentage of patients with anterior cross-bite, edge-to-edge incisor relationship, and normal overbite were compared within and between the groups with McNemar and Chi-square tests, respectively. In the intragroup comparisons, the anterior cross-bite and edge-to-edge patients were grouped together to allow a 2×2 table comparison.

All statistical analyses were performed using Statistica software (Statistica for Windows, version 7.0, StatSoft Inc., Tulsa, Okla., USA) at $P < .05$.

RESULTS

The random errors ranged from 0.22 mm (Md1-MP) to 0.53 mm (Mx1-PP) and from 0.35° (ANB) to 1.36° (FMA) for linear and angular measurements, respectively, and were within acceptable limits.[17] Significant systematic errors were found for variables Mx6-PP and Md1-NB.

The groups were similar regarding initial and final ages, period of evaluation, and sex distribution (Table 1). The percentage of anterior cross-bite was greater in the experimental group.

At the pretreatment stage (T1), the experimental group displayed significantly greater maxillary molar posterior height and distal positioning than the control group (Table 2). The mandibular incisors were significantly more labially tipped and protruded in the experimental

Table 2. Intergroup Comparison of Initial Cephalometric Characteristics (*T*-Test and Mann-Whitney *U*-Test)

Variable	Experimental Group T1 (n = 22)		Control Group T1 (n = 22)		Mean Difference (T2-T1)	95% CI		P*
	Mean	SD	Mean	SD				
Sagittal skeletal component								
SNA (°)	81.25	4.09	80.31	4.16	−0.94	−1.57	3.45	.453[A]
SNB (°)	80.05	4.04	78.74	3.48	−1.31	−0.98	3.61	.254[A]
ANB (°)	1.20	1.51	1.56	2.51	0.36	−1.62	0.90	.563[A]
Wits (mm)	−5.94	3.31	−7.43	4.87	−1.49	−1.04	4.03	.245[B]
Vertical skeletal component								
FMA (°)	27.95	4.53	25.68	3.57	−2.27	−0.21	4.76	.072[A]
SN.OP (°)	18.25	5.09	20.08	3.84	1.83	−4.58	0.91	.185[A]
LAFH (mm)	55.99	3.21	58.14	4.22	2.15	−4.43	0.13	.064[A]
Maxillary dentoalveolar component								
Mx1.NA (°)	19.90	8.69	15.60	7.82	−4.30	−0.73	9.33	.092[A]
MX1-NA (mm)	1.55	2.18	0.79	2.25	−0.77	−0.58	2.12	.257[A]
Mx1-PP (mm)	23.06	1.81	23.16	2.25	0.10	−1.34	1.15	.878[A]
Mx6-PP (mm)	16.38	2.24	14.58	3.10	−1.80	0.16	3.45	.032[A,*]
Mx6-Ptv (mm)	15.30	2.35	17.96	3.40	2.66	−4.44	−0.88	.004[A,*]
Mandibular dentoalveolar component								
Md1.NB (°)	26.40	5.52	20.56	6.34	−5.84	2.22	9.45	.002[A,*]
Md1-NB (mm)	4.26	1.75	2.52	1.92	−1.74	0.62	2.85	.003[A,*]
Md1-MP (mm)	33.65	1.98	33.81	3.13	0.17	−1.76	1.43	.832[A]
IMPA (°)	90.87	5.40	85.84	7.05	−5.03	1.20	8.85	.011[A,*]
Md6-MP (mm)	23.90	1.78	24.47	2.40	0.57	−1.86	0.71	.373[A]
Dentoalveolar relationship								
Overbite (mm)	0.59	1.53	−0.33	1.56	−0.92	−0.02	1.87	.041[B,*]
Overjet (mm)	−1.20	1.49	0.08	1.94	1.29	−2.34	−0.24	.018[A,*]
Molar Relationship (mm)	−1.80	1.31	−2.15	1.58	−0.35	−0.53	1.23	.418[B]

[a] CI indicates confidence interval; SD, standard deviation; [A] *t*-test; [B] Mann-Whitney *U*-Test; * Statistically significant at $P < .05$.

Table 3. Intergroup Comparison of Interphase Changes (*T*-Test and Mann-Whitney *U*-Test

Variable	Experimental Group T2-T1 Mean	Experimental Group T2-T1 SD	Control Group T2-T1 Mean	Control Group T2-T1 SD	Mean Difference (T2-T1)	95% CI		*P**
Sagittal skeletal component								
SNA (°)	−0.06	1.42	−0.07	1.00	−0.01	−0.92	0.95	.977[A]
SNB (°)	0.52	1.51	0.26	1.77	−0.27	−0.73	1.27	.592[A]
ANB (°)	−0.58	1.01	−0.33	1.19	0.25	−0.92	0.42	.456[A]
Wits (mm)	1.10	3.85	1.98	4.32	0.89	−3.37	1.60	.159[B]
Vertical skeletal component								
FMA (°)	−1.08	2.05	0.69	2.20	1.77	−3.07	−0.48	.008[A,*]
SN.OP (°)	−2.62	2.26	−1.78	3.35	0.84	−2.57	0.90	.337[A]
LAFH (mm)	1.79	1.21	2.80	2.00	1.01	−2.02	−0.01	.048[A,*]
Maxillary dentoalveolar component								
Mx1.NA (°)	8.56	7.31	9.00	7.75	0.44	−5.03	4.15	.847[A]
MX1-NA (mm)	3.01	1.40	2.32	2.09	−0.70	−0.39	1.78	.202[A]
Mx1-PP (mm)	0.73	1.38	2.12	2.28	1.39	−2.53	−0.24	.059[B]
Mx6-PP (mm)	2.09	2.14	3.15	2.79	1.06	−2.57	0.45	.047[B,*]
Mx6-Ptv (mm)	1.83	1.35	1.07	1.41	−0.76	−0.08	1.60	.075[A]
Mandibular dentoalveolar component								
Md1.NB (°)	0.56	2.71	1.43	3.02	0.88	−2.62	0.87	.316[A]
Md1-NB (mm)	0.50	0.95	0.90	1.03	0.41	−1.01	0.20	.183[A]
Md1-MP (mm)	1.41	0.81	1.85	1.04	0.43	−1.00	0.13	.131[A]
IMPA (°)	0.97	2.56	0.95	3.30	−0.02	−1.78	1.82	.888[B]
Md6-MP (mm)	0.81	0.89	1.28	1.31	0.47	−1.15	0.21	.171[A]
Dentoalveolar relationship								
Overbite (mm)	−0.01	1.38	0.96	2.29	0.97	−2.12	0.18	.078[B]
Overjet (mm)	1.86	1.78	1.27	2.19	−0.59	−0.63	1.80	.335[A]
Molar Relationship (mm)	0.20	1.32	−0.04	1.34	−0.24	−0.57	1.04	.558[A]

[a] CI indicates confidence interval; SD, standard deviation; [A] *t*-test; [B] Mann-Whitney *U*-Test; * Statistically significant at $P < .05$.

than in the control group. Overbite was significantly greater and overjet smaller in the experimental group.

In the experimental and control groups, the anteroposterior relationship between the maxilla and the mandible remained stable during treatment (ANB angle). The mandibular plane angle decreased in the experimental group and increased in the control group. In the experimental group, the lower anterior face height increase and maxillary molar vertical development were significantly smaller compared to controls (Table 3).

At the end of treatment, the number of patients with anterior cross-bite and edge-to-edge relationships decreased significantly only in the experimental group (Table 4). Anterior cross-bite was corrected in 54% of the experimental group (Figure 1).

DISCUSSION

The experimental and control groups were similar with regard to initial and final ages, period of evaluation, and sex distribution (Table 1). However, despite all efforts, the experimental group had a significantly greater number of patients with anterior cross-bite pretreatment. Among 20 cephalometric variables, there

Table 4. Intragroup and Intergroup Comparisons of Proportions of Anterior Cross-bite, Edge-to-Edge and Normal Overjet at T1 and T2 (McNemar and Chi-Square Tests)

	Variable	Experimental Group (n = 22) n	Experimental Group (n = 22) %	Control Group (n = 22) n	Control Group (n = 22) %	*P* Value* Chi-Square Tests
Initial	Anterior cross-bite	16	72.73	8	36.36	.008*
	Edge to edge	6	27.27	7	31.82	
	Normal overjet	0	0.00	7	31.82	
Final	Anterior cross-bite	4	18.18	4	18.18	.942
	Edge to edge	6	27.27	7	31.82	
	Normal overjet	12	54.55	11	50	
P-value* McNemar tests[A]		0.007*		0.346		

* Statistically significant at $P < .05$; [A] The anterior cross-bite and edge-to-edge patients were grouped as "non-normal" to allow a 2×2 table comparison.

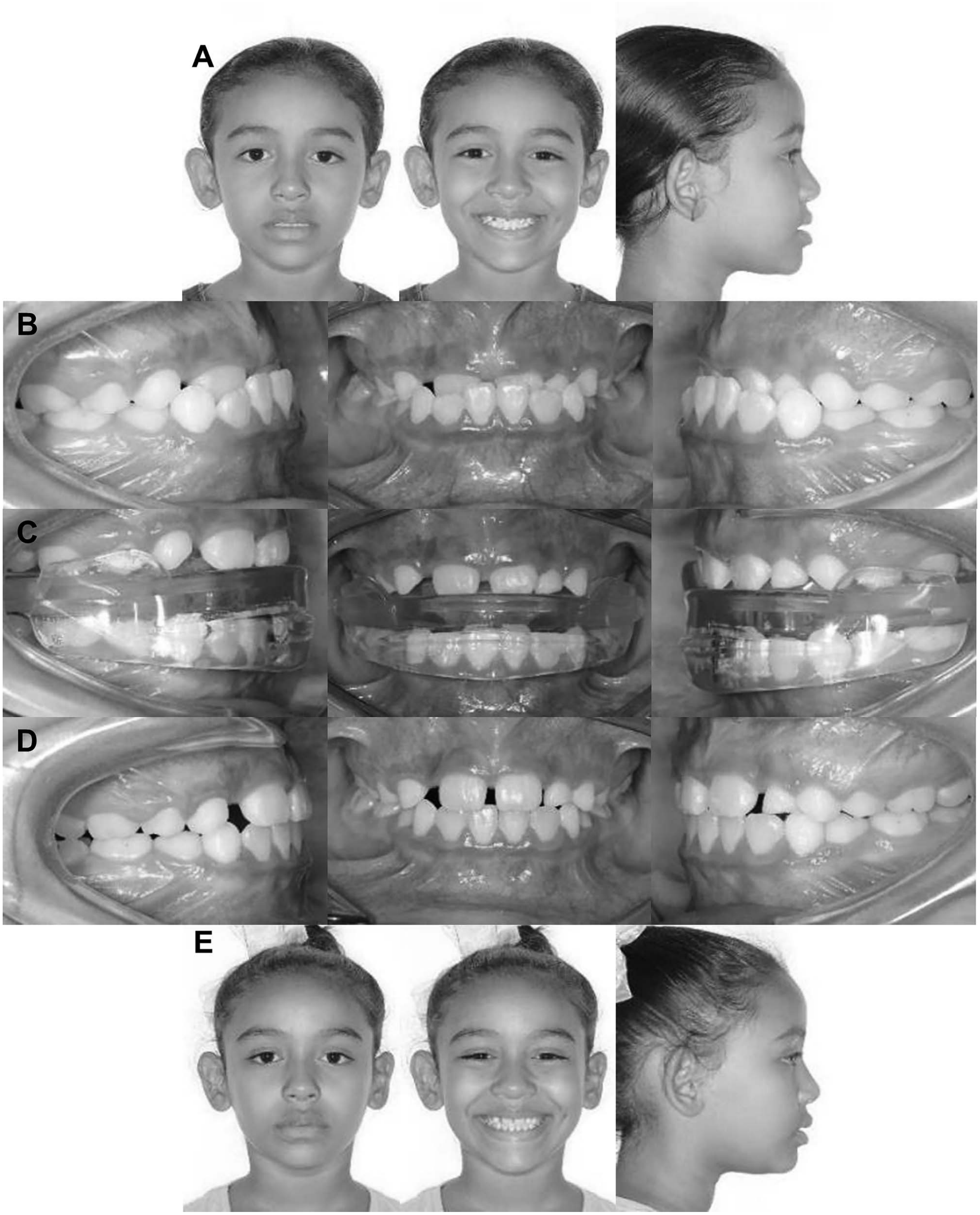

Figure 1. Pretreatment and posttreatment facial and intraoral photographs of a patient treated with the Eruption Guidance Appliance (12 months of treatment).

were significant differences for seven variables. The Class III characteristics were more severe in the experimental group compared to the control group. Ideally, the groups should have had more similar dentoalveolar characteristics at T1. However, obtaining an untreated Class III control group was extremely difficult due to ethical reasons. The use of a satisfactory historical control group was better than having no control group at all.[18] In addition, the main aim of the present study was to compare the interphase changes and not the final cephalometric characteristics. Secular trends in craniofacial growth have been reported.[19] It could be argued that this could have affected comparisons between the groups by using a contemporary sample vs an historical sample. However, this is an expected limitation when using historical controls.

This was the first study to evaluate the effects of the eruption guidance appliance in a sample of growing Class III malocclusion patients. A predominance of dental effects and minimal skeletal effects was observed after treatment with the eruption guidance appliance. These effects were expected and were similar to effects of the Frankel FRIII appliance previously described for Class III malocclusion correction.[20] Class III removable functional appliances have limited effects in the correction of skeletal Class III discrepancy.[21] Maxillary expansion followed by face mask usually has a more favorable skeletal effect in Class III malocclusion correction in a similar age range and should be considered as the first option if skeletal discrepancies are present.[22,23]

A significant decrease in the mandibular plane angle was observed after treatment with the eruption guidance appliance. Conversely, patients in the untreated group displayed a slight increase in the mandibular plane angle. The appliance also significantly restricted the increase of the lower anterior face height. These effects may have been due to the occlusal shelves of the appliance that could cause some restriction in vertical development of the posterior teeth.[13] This was demonstrated by the significantly smaller vertical development of the maxillary first molars observed in the experimental group (Table 3). These effects were opposite to the effects of the Frankel FRIII and to the face mask that usually tends to increase the mandibular plane angle and lower anterior face height, causing clockwise rotation of the mandible.[24,25] Therefore, a useful clinical application of the eruption guidance appliance would be for the early treatment of Class III malocclusion patients with a vertical growth pattern.

Labial tipping and protrusion of the maxillary incisors were similar between the groups (Table 3). Because 27% of the experimental group and 45% of the control group had deciduous incisors at pretreatment, they were traced in the initial cephalogram. At the end of the evaluation period, the permanent maxillary incisors were present and, therefore, were traced in the T2 cephalogram. This may have been a limitation in this study. However, this is what actually occurs when treating a Class III malocclusion within this age range. The appliance began acting on the deciduous incisors and, when they exfoliated and the permanent incisors erupted, it continued to act on the permanent incisors, guiding their eruption. The rationale to include patients within this age range was based on previous studies and justified by the need for early intervention.[6,7,26]

No intergroup difference was found for maxillary incisor inclination changes. Previous studies described similar effects for the Frankel FRIII appliance.[25] On the other hand, previous investigations showed that the face mask produced significant labial tipping of maxillary incisors, beyond the capability of normal growth.[24]

Mandibular dentoalveolar changes of the eruption guidance appliance were minimal. Labial tipping and protrusion of mandibular incisors increased similarly in both groups. Also, mandibular molar vertical development and mesial movement were similar to the control group.

Regarding the interarch relationship, no significant intergroup differences in overbite, overjet, and molar relationship were observed. These findings were in agreement with previously described effects of the Frankel FRIII.[25] Conversely, face-mask orthopedic treatment demonstrated significant improvement in overjet and molar relationship compared to normal growth changes.[24]

A significant decrease in the presence of anterior cross-bite was observed for the experimental group after treatment (Table 4). The frequency of patients with anterior cross-bite in the treated group was significantly greater at the initial stage than it was in the control group, and it became similar at the posttreatment stage. In the experimental group, there was an improvement of anterior cross-bite in 12 out of 16 patients (75%) who originally had anterior cross-bite. There was complete correction of anterior cross-bite or edge-to-edge anterior occlusion in 12 of the original 22 patients (54.5%) in the experimental group. In the control group, since they were untreated patients, it is logical that there was no improvement in the malocclusion. Therefore, the percentage of patients with anterior cross-bite and edge-to-edge anterior occlusion was similar at T1 and T2. Seven out of 16 (44%) patients diagnosed with anterior cross-bite pretreatment showed an anterior functional shift. This is a common finding in Class III patients with anterior cross-bite and might have influenced the results in the experimental group. Whether a shift was present in the historical control group was not possible to detect in the records available and might also have affected the comparisons.

Although the cephalometric results demonstrated minimal dentoskeletal effects of this appliance, the frequency of anterior cross-bite correction demonstrated some satisfactory results due to dental compensation from a clinical perspective. Since it is an intraoral appliance that does not compromise patient esthetics, it can be an alternative for early treatment of Class III malocclusion for patients without a sagittal skeletal discrepancy. Patient cooperation has a major role in treatment success.

Treatment of some of these patients was compromised somewhat by the COVID-19 pandemic. In March 2020, 12 patients (55%) had already finished treatment. However, 10 were still under treatment and could not be followed monthly due to a lockdown of the dental school clinics. The patients were monitored remotely by the investigator in charge of this evaluation. In October 2020, some clinical investigations were allowed to return and the patients were recalled to resume treatment and have their final records taken. This interruption could have influenced patient cooperation and treatment results. Differences between groups regarding initial characteristics, different ethnicities, and different generations should be considered as a limitation of this study. Future studies with larger samples and a more balanced control group should be planned to analyze further the effects of eruption guidance appliance in growing Class III malocclusion patients and to compare the results to those of this study. Additionally, future studies should be performed with more restrictive sample characteristics. Nonetheless, the present study was the first to examine the effects of eruption guidance appliance in Class III malocclusion treatment.

CONCLUSIONS

- The eruption guidance appliance produced counterclockwise rotation of the mandibular plane, a smaller lower anterior face height increase, and smaller maxillary molar vertical development than the control group.
- An anterior cross-bite or edge-to-edge anterior occlusion correction was observed in 54.5% of the patients treated with the eruption guidance appliance.
- The eruption guidance appliance did not change the skeletal anteroposterior relationship of subjects with Class III malocclusions.

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