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ORIGINAL ARTICLE

Influence of rapid maxillary expansion in the stability of anterior open bite treatment

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Abstract

Objectives This study aimed to compare the stability of anterior open bite (AOB) in patients treated with and without rapid maxillary expansion (RME) before fixed palatal crib (PC) therapy in the mixed dentition.

Material and methods Expansion/palatal crib group (EPC) was comprised of 25 patients (10 male, 15 female, mean initial age of 7.8 years) with AOB treated with RME before PC therapy. Palatal crib group (PC) included 25 patients with AOB (10 male, 15 female, mean initial age of 8.0 years) treated only with PC therapy. Lateral cephalograms were analyzed at pre-treatment (T0), after PC therapy (T1), and 3 years after PC removal (T2) in both groups. AOB relapse was considered when a negative overbite was observed at T2. Intergroup comparisons of interphase changes were performed using *t* and Mann–Whitney tests ($p < 0.05$).

Results Treatment and post-treatment alterations showed similar changes in both groups for all cephalometric variables. Overall changes from T0 to T2 were similar between the groups except for the maxillary incisors that tipped lingually in PC group (1.PP = −3.37°) and labially in EPC group (1.PP = 1.76°). The frequency of AOB relapse was 8% and 4% in the EPC and PC groups, respectively. Treatment time in the EPC group (9.7 months) was shorter ($p = 0.024$) when compared to the PC group (11.0 months).

Conclusions In the mixed dentition, stability of AOB treated with RME before fixed PC therapy was similar to PC therapy alone. However, treatment time with fixed PC was slightly shorter in the group treated with RME.

Clinical relevance This study aims to understand if RME performed previously to fixed palatal crib contributes to the index of stability of AOB treatment in the mixed dentition.

Keywords Stability · Anterior open bite · Palatal crib · Rapid maxillary expansion

Introduction

Anterior open bite (AOB) is a frequent malocclusion with a prevalence of approximately 15% in the mixed dentition [1–3]. AOB has a multifactorial etiology that includes finger and pacifier sucking habits, anterior tongue posture, oral breathing, and hyperdivergent facial growth [4]. The frequency, intensity, and duration of oral habits also influence the occurrence of AOB [5]. The anterior open bite is frequently associated with posterior crossbites and maxillary arch constrictions [6]. Smile esthetics and mastigatory function are impaired in patients with anterior open bite. In addition, the maintenance of an anterior open bite influences tongue posture and function [7].

AOB treatment in the mixed dentition can be performed with fixed palatal cribs (PC). Fixed palatal crib was more efficient than lingual spurs for correcting the open bite in the

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mixed dentition [8, 9]. Additionally, complications including treatment interruption and appliance breakage and bond failure were less frequent to fixed palatal crib in comparison with removable palatal cribs and bonded lingual spurs [10]. Fixed palatal crib has broken more frequently (90%) the persistent sucking habits in children with anterior open bite than bonded lingual spurs (53%) [9]. Besides interrupting deleterious habits, treatment with PC is effective and efficient for AOB correction [11–14]. PC therapy demonstrated a greater and faster correction of AOB compared to bonded spurs and removable palatal cribs, with a decreased frequency of complications [8, 10, 15]. Previous studies have shown that PC promoted an AOB reduction of 3.1 mm [15], 3.6 mm [16], and 5.01 mm [8] after 12 months of therapy.

Few studies have reported on AOB stability after treatment in the mixed dentition [17]. Huang et al. [18] collected data from 33 patients treated with PC and found AOB relapse in 4 patients. Cozza et al. [16] reported relapse of overbite correction in 15% of subjects treated with quad-helix/crib appliance in the mixed dentition. Mucedero et al. [19] found AOB relapse in 7% of the subjects treated with quad-helix/crib appliance. Cassis et al. [20] evaluated the stability of treatment with bonded spurs associated with high-pull chincup 3 years post-treatment and reported an AOB relapse of 4%.

AOB is frequently associated with posterior crossbites [6]. Subjects with deleterious oral habits present higher frequency of both anterior open bite and posterior crossbites [21]. In these cases, posterior crossbites can be treated with maxillary expansion followed by PC therapy. RME causes a downward rotation of the mandibular plane and an increase in the anterior facial height impairing the anterior open bite [22]. On the other hand, RME increases the intercanine distance permitting the extrusion of maxillary incisors in patients with anterior open bite [23]. A question, therefore, arises: would RME improve or compromise the stability of AOB correction? No previous studies have evaluated the stability of AOB correction in the mixed dentition in patients treated with RME followed by fixed PC. This information has the importance to guide clinicians to establish a long-term prognosis of open bite malocclusion treatment in the mixed dentition.

Therefore, the aim of this study was to compare the stability of AOB in patients treated with and without rapid maxillary expansion (RME) prior to fixed PC therapy in the mixed dentition. The hypothesis is that both therapies present similar post-treatment stability of the AOB.

Material and methods

This retrospective study was approved by the Ethics Research Committee of the Bauru Dental School (protocol number: 38323820.1.0000.5417). Considering an 80% of power and a significance level of 0.05, a standard deviation (SD) of 0.93 mm in the overbite relapse [20], and a minimum difference of 1 mm to be detected, a sample size of 15 subjects was required.

The sample was composed of patients treated in the mixed dentition at the Post-Graduate Program of Interceptive Orthodontics at Profis, Bauru, Brazil, from 1992 to 2010. A total of 127 patients with AOB were initially selected, and the inclusion criteria were patients with initial class I and class II malocclusions; fully erupted maxillary central incisors in the mixed dentition; presence of an initial AOB greater than 1 mm measured at the central incisors; treatment performed with either fixed PC alone or with RME followed by fixed PC; and lastly, availability of three cephalometric radiographs per patient, obtained at pre-treatment, after PC removal and at the early permanent dentition. The exclusion criteria were the presence of associated craniofacial anomalies or syndromes and the presence of a negative overjet. After application of the inclusion/exclusion criteria, 77 patients were excluded. The final sample size, therefore, was 50 patients ($n = 50$).

Two groups were then created. The expansion/palatal crib group (EPC) was composed by 25 patients (15 females and 10 males) with a mean initial age of 7.8 ± 1.0 years. These patients had anterior open bite associated with posterior crossbites or maxillary constriction and were treated with Haas-type expander followed by fixed PC. All Haas-type expanders had bands on the deciduous second molars and C-shaped clasps bonded to the deciduous canines. The Haas-type expanders were performed using 0.9-mm stainless steel wires soldered to bands on the second deciduous molars, and the acrylic pad was touching the palate without pressure. The expansion screw used was 9 mm. The expander was activated 2/4 turn twice a day (0.8 mm/day) during approximately 8 days, until an overcorrection was achieved. After a 6-month retention period, the palatal expander was removed, and a fixed palatal crib was installed.

Palatal crib group (PC) comprised 25 patients (15 females and 10 males) with a mean initial age of 8.0 ± 1.2 years. These patients had anterior open bite with no maxillary constriction and treated with fixed PC alone. In this group, no maxillary expansion was performed previously to PC therapy. The fixed palatal crib was performed using 0.9-mm stainless steel wire at the palatal arch soldered to bands on the second deciduous molars and 0.7-mm stainless steel wire at the four anterior cribs.

Lateral radiographs obtained at pre-treatment (T0), after PC removal (T1), and at the early permanent dentition before comprehensive orthodontic treatment (T2) were used. The mean age at T0, T1, and T2 for both groups is presented in Table 1. Only in the EPC group, a 6-month post-expansion cephalometric radiograph (T1') was included. The lateral radiographs were digitalized and traced by one trained examiner using Dolphin Imaging software version 11.5 (Dolphin® Imaging and

Management Solutions, Patterson Dental Supply, Inc., Chatsworth, CA). Cephalometric analysis included 9 angular and linear variables (Fig. 1).

Statistical analysis

Thirty percent of the sample was randomly selected and analyzed twice after a 15-day interval by the same examiner. Intra-examiner reproducibility was evaluated using intraclass correlation coefficients (ICC) and Bland–Altman method.

Shapiro–Wilk test was used to verify the normality of data. Intergroup comparisons for initial age and sex were assessed using Mann–Whitney test and Chi-square test, respectively. Intergroup comparisons of interphase changes were evaluated using *t* and Mann–Whitney tests. The significance level regarded was 5%. All statistical analyses were performed using Statistica software (Statistica for Windows version 11.0, StatSoft, Tulsa, Oklahoma, USA).

A clinically significant open bite relapse was considered when a negative overbite between the maxillary and mandibular incisors was observed at T2. The frequency of subjects with clinically significant relapses was calculated in each group.

Table 1 Intergroup comparison of age and sex (Mann–Whitney tests and Chi-square test, respectively)

Age / Sex		PC group		EPC group		*p*
		n = 25		*n* = 25		
		Mean	SD	Mean	SD	
Age T0 (years)		8.00	1.26	7.80	1.00	0.613
Age T1 (years)		9.00	1.26	9.08	1.12	0.802
Age T2 (years)		12.1	1.32	12.4	1.29	0.467
Sex	M	10		10		1.000
	F	15		15		

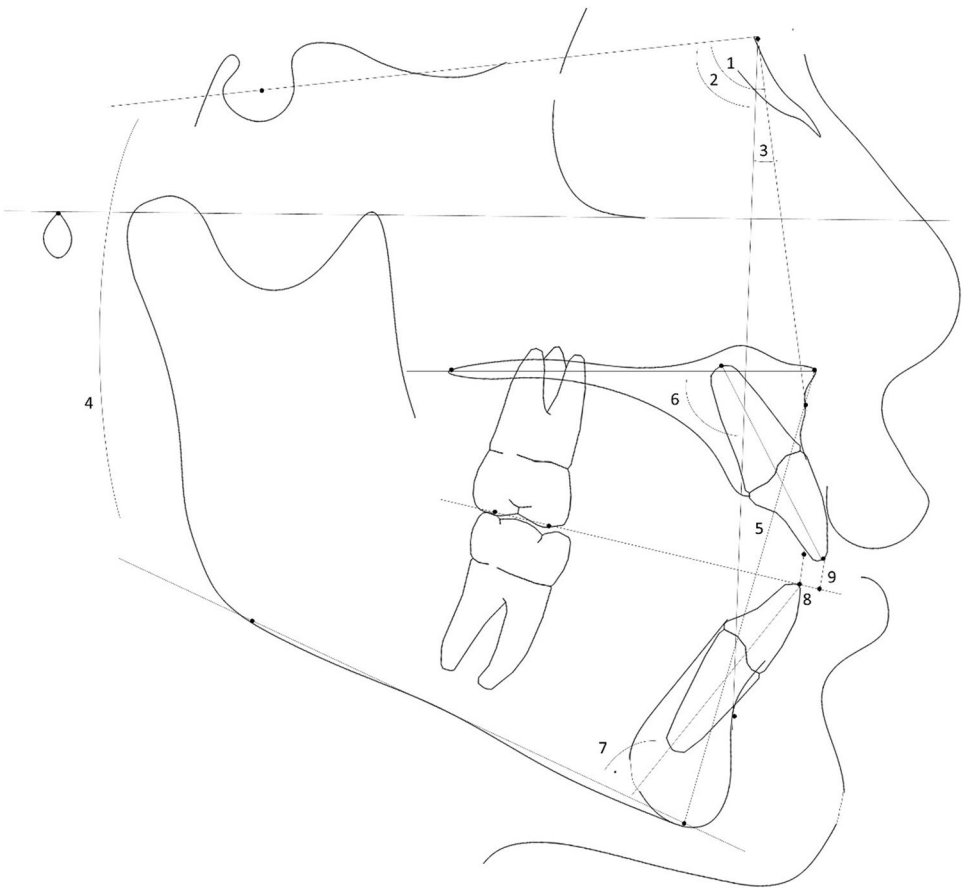

Fig. 1 Cephalometric angular and linear variables measured in the study: (**1**) SNA, (**2**) SNB, (**3**) ANB, (**4**) SN.GoGn, (**5**) LAFH, (**6**) 1.PP, (**7**) IMPA, (**8**) Overjet, and (**9**) Overbite

Results

Measurements showed an adequate reproducibility with ICC varying from 0.817 (overjet) to 0.986 (overbite). The variable with the greatest limits of agreement was the overjet (0.697 and 0.892). The variable with the smallest limits of agreement was the overbite (0.976 and 0.992).

No difference between initial age and sex distribution was found between groups (Table 1). Groups were similar at pre-treatment stage (T0) for all cephalometric variables except for the maxillary incisor inclination and overjet that were greater in the PC group (Table 2).

During treatment (T0–T1), both groups showed similar changes for all cephalometric measurements (Table 3). Post-treatment changes (T1–T2) showed no differences between groups (Table 3). Overall changes from T0 to T2 were similar between groups except for the maxillary incisors that tipped lingually in the PC group (1.PP = −3.37°) and labially in the EPC group (1.PP = 1.76°) as shown in Table 3 ($p = 0.006$). Treatment and post-treatment overbite changes in both groups were similar (Table 3, Fig. 2).

Treatment time with the palatal crib was slightly smaller in the EPC group when compared to the PC group ($p = 0.024$) (Table 4). The frequency of AOB relapse at T2 was 4% in the PC group and 8% in the EPC group.

Discussion

Digital cephalometry has been widely used in previous studies and have shown adequate reproducibility of linear and angular measurements [24]. Our study showed good to excellent intra-rater reliability (ICC ranging from 0.817 to 0.986). One limitation of this study was the intergroup difference at the baseline for the maxillary incisor inclination and overjet (Table 2). Some baseline differences are expected in retrospective studies. However, the primary outcome evaluated in this study was the overbite that was similar between groups at T0.

AOB treatment is considered challenging in the permanent dentition due to potential relapse [25]. The stability rate of AOB treatment in the permanent dentition including both non-surgical and surgical therapies ranges from 61.9 to 100% [26, 27]. However, studies that showed higher stability indexes had lower or moderate quality because of small sample size or lack of method error analysis. Only a few studies have reported stability of AOB treatment in the mixed dentition. Early treatment showed a better stability index varying from 85 to 100% [16, 18–20]. These studies indicated that AOB treatment in the mixed dentition demonstrated a better stability index than treatment in the permanent dentition. However, no previous study has evaluated the stability of AOB correction with RME followed by PC therapy in the mixed dentition.

Table 2 Intergroup comparison of starting forms (*t* tests or Mann–Whitney test)

Variables	PC group		EPC group		95% confidence interval	*p*
	n = 25		*n* = 25			
	Mean	SD	Mean	SD		
SNA	87.6	5.32	85.1	4.87	−0.900 5.50	0.204
SNB	81.4	3.56	79.9	4.20	−0.800 3.80	0.207
ANB	6.12	2.78	5.23	2.40	−0.700 1.80	0.317
SN.GoGn	33.0	4.95	34.6	4.99	−4.429 1.22	0.259
LAFH	63.0	5.05	62.2	3.52	−1.651 3.30	0.506
1.PP	119	5.37	113	5.94	3.063 9.51	< 0.001*
IMPA	93	4.42	91.3	5.16	−1.040 4.42	0.219
Overjet	4.70	1.65	3.03	2.54	0.500 2.50	0.010*
Overbite	−3.27	1.97	−4.06	2.22	−0.500 2.20	0.264

*Statistically significant at $p < 0.05$ (*t* tests)

Table 3 Intergroup comparison for interphase changes (*t* tests or Mann–Whitney test)

Variables	T1–T0						T2–T1						T2–T0					
	PC group		EPC group		95% confidence interval	*p*	PC group		EPC group		95% confidence interval	*p*	PC group		EPC group		95% confidence intervSal	*p*
	Mean	SD	Mean	SD			Mean	SD	Mean	SD			Mean	SD	Mean	SD		
SNA	− 1.20	3.38	− 1.10	3.24	− 1.990 1.774	0.909	0.66	3.24	0.63	2.88	− 1.715 1.771	0.974	− 0.54	3.48	− 0.46	3.24	− 1.990 1.830	0.933
SNB	− 0.43	2.18	− 0.05	2.61	− 1.742 0.990	0.583	1.10	2.29	1.27	2.31	− 1.480 1.136	0.793	0.66	2.40	1.21	2.85	− 2.046 0.950	0.466
ANB	− 0.78	1.82	− 1.04	1.93	− 0.810 1.322	0.631	− 0.43	1.99	− 0.62	2.03	− 0.948 1.340	0.732	− 1.21	1.85	− 1.66	2.48	− 0.792 1.696	0.469
SN.GoGn	− 0.02	2.50	− 0.29	2.41	− 1.124 1.668	0.697	− 1.07	2.37	− 1.53	2.72	− 0.991 1.911	0.527	− 1.10	3.52	− 1.83	3.20	− 1.179 2.643	0.445
LAFH	2.04	2.53	1.49	1.86	− 0.715 1.811	0.387	2.94	3.05	3.05	3.73	− 2.044 1.828	0.911	4.98	2.70	4.54	3.27	− 1.264 2.144	0.606
1.PP	− 4.82	7.17	− 2.00	5.20	− 6.381 0.741	0.118	1.45	5.00	3.77	6.12	− 5.492 0.860	0.149	− 3.37	6.62	1.76	6.13	− 8.763 − 1.509	0.006*
IMPA	− 2.86	4.51	− 2.98	4.28	− 2.383 2.615	0.926	2.02	3.66	3.57	5.16	− 4.096 0.992	0.226	− 0.84	4.91	0.58	5.91	− 4.526 1.654	0.355
Overjet	− 0.10	2.03	0.92	2.64	− 2.364 0.316	0.131	− 0.76	1.68	− 0.74	1.87	− 1.022 0.998	0.981	− 0.86	1.91	0.17	2.12	− 2.185 0.113	0.076
Overbite	4.35	1.98	5.24	2.59	− 2.198 0.422	0.179	0.51	1.51	− 0.03	1.06	− 0.194 1.290	0.144	4.86	1.99	5.20	2.52	− 1.632 0.952	0.599

*Statistically significant at $p < 0.05$ (*t* tests)

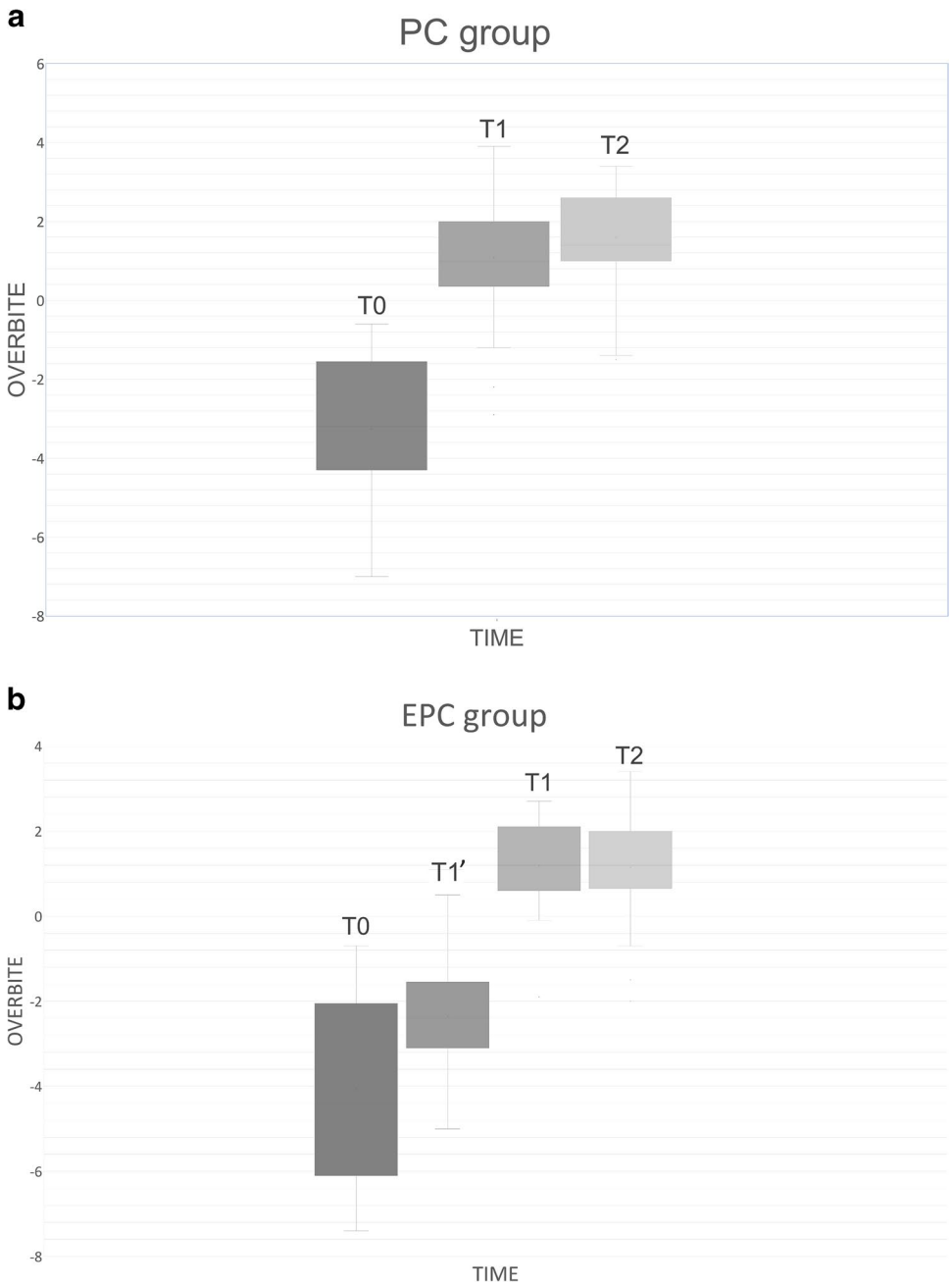

Fig. 2 **a** Overbite changes in the PC group. **b** Overbite changes in the EPC group

Table 4 Intergroup comparison of treatment time with fixed palatal crib therapy (Mann–Whitney test)

Variable	PC group		EPC group		95% confidence interval	*p*
	n = 25		*n* = 25			
	Mean	SD	Mean	SD		
Treatment time with crib therapy (months)	11.05	2.79	9.72	2.54	0.284 3.32	0.024 +

+ Statistically significant at $p < 0.05$ (Mann–Whitney test)

In this study, the overbite changes during treatment (T0–T1) were similar between groups (Table 3). However, overbite decreased after RME in the EPC group (Fig. 2b). The improvement of overbite after RME can be explained by the interruption of the deleterious oral habits due the presence of the fixed expander device in the palate. In addition,

RME increases the intercanine distance, creating room for extrusion of the maxillary incisors. Even though RME reduced the overbite immediately after the active phase due to a clockwise rotation of the mandible, a decrease in overbite was observed during the 6-month retention period with the expander in the oral cavity. The clockwise rotation of the mandible observed right after RME is usually unstable and rebounds [23, 28]. The SN.GoGn changes from T0 to T2 were similar in both groups, confirming that the vertical effects of RME are temporary (Table 3).

Changes from T1 to T2 showed that the overbite correction remained stable in the long-term in both groups. Both treatment protocols demonstrated a very small frequency of relapse. RME performed previously to PC therapy has not influenced the frequency of stability. These outcomes are in accordance to previous studies showing a high level of stability of overbite correction in the mixed dentition [16, 18–20]. Only one patient of the PC group and two patients of the EPC group presented clinical relapse of the AOB, showing a negative overbite at T2. The possible explanation for relapse in these cases was the persistence of deleterious oral habits, anterior tongue posture, and persistent oral respiration [4]. All patients were referred to a speech pathologist after PC therapy. The protocol after AOB treatment was installing a removable palatal crib and a speech pathology exam and myofunctional therapy when necessary. The removable palatal crib was instructed to be used until the end of myofunctional therapy. However, not all patients followed the posttreatment recommendations or show collaboration with the speech pathology therapy. In addition, extreme hyperdivergent facial pattern can also explain AOB relapse after treatment [29].

At baseline (Table 2), the PC group had a greater labial tip of the maxillary incisors (1.PP = 119°) than the EPC group (1.PP = 113°). The initial overjet was also greater in the PC group (4.70 mm) compared to the EPC group (3.03 mm). Class II malocclusion was more frequent in the PC group than in the EPC group, which was a limitation of this retrospective study. The PC group demonstrated lingual inclination of the maxillary incisor and a greater reduction in the overjet from T0 to T2, compared to the EPC group (Table 3). These differences might be explained due to the use of a Bionator appliance or an extraoral headgear in 7 out of 25 patients in the PC group between T1 to T2, influencing both the maxillary incisor inclination and the overjet. In the EPC group, 4 out of 25 patients were treated with a Bionator/extraoral headgear from T1 to T2.

In this study, treatment time with the PC was slightly lesser in the EPC group than in the PC group (Table 4). These results can be explained by the fact that RME produced an increase in overbite previously to PC installation. In other words, the decrease of AOB severity after RME might have shortened the treatment time with the palatal crib. The milder the open bite, the faster its correction in the mixed dentition [18, 30, 31].

The heterogeneity of this sample at baseline, characteristic of retrospective studies, was a limitation, and the outcomes should be analyzed with caution. On the other hand, this study was the first to evaluate the stability of AOB treatment in the mixed dentition with RME followed by palatal crib therapy with a sufficient sample power to detect intergroup differences. Future randomized clinical trials with long-term follow-up should be performed to compare treatment time and stability of RME followed by palatal crib, RME associated with palatal crib, and RME associated with lingual spurs. Additionally, the impact of RME on the AOB stability in the permanent dentition should also be evaluated.

Conclusion

In the mixed dentition, the stability of anterior open bite treatment with RME followed by fixed palatal crib therapy was similar to the stability of palatal crib therapy alone. Treatment time with palatal crib was slightly shorter when RME was previously performed.

Declarations

Ethics approval This retrospective study was approved by the Ethics in Research Committee of the Bauru Dental School, University of São Paulo (protocol number: 38323820.1.0000.5417).

Consent to participate Not applicable.

Conflict of interest The authors declare no competing interests.

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