Original Article

Dentoskeletal effects produced by removable palatal crib, bonded spurs, and chincup therapy in growing children with anterior open bite

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ABSTRACT

Objective: To evaluate the dentoskeletal effects of different anterior open bite treatment modalities in children.

Materials and Methods: This cephalometric study assessed changes resulting from different treatment approaches on 77 growing children with anterior open bite. A control group (n = 30) was used for comparison. Lateral cephalograms were available before treatment and after 12 months. The sample was divided into four groups: removable palatal crib associated with a chincup (G1), bonded spurs associated with a chincup (G2), chincup (G3), and nontreated control (G4). Statistical comparisons among the four groups were performed on T1 and the treatment changes using analysis of variance with Tukey's post hoc tests.

Results: No statistically significant changes in skeletal variables were found among the groups, except for lower anterior face height (LAFH) increase in G1. Overall, effects in all of the treated groups were exclusively dentoalveolar. A larger overbite (OB) increase was observed in G1 and G2 when compared with G3 and G4. The maxillary incisors in G1 showed increased palatal tipping, retrusion, and more vertical dentoalveolar development as well as increased lingual tipping among mandibular incisors. There was less vertical development of maxillary and mandibular molars in G3.

Conclusions: A removable palatal crib provided an improvement in OB (97.5%), followed by the bonded spurs (84.5%). Conversely, the chincup-only group did not have positive OB effects. (*Angle Orthod.* 2016;86:969–975)

KEY WORDS: Open bite; Orthodontic appliances; Early treatment

INTRODUCTION

The prevalence of anterior open bite (AOB) malocclusion in the mixed dentition is about 20%.[1] In most of the cases, a multifactorial etiology is presumed, which includes oral deleterious habits such as mouth breathing, abnormal tongue posture, tongue thrust, and/or a vertical facial growth pattern.[2,3] It can be manifested as a dentoalveolar and/or skeletal open bite.

Early intervention with habit-interception appliances may resolve or improve the AOB in growing patients.[4–9] The use of a palatal crib or spurs have been advocated to encourage discontinuation of such habits, thus facilitating anterior dentoalveolar changes.[10–19]

Because AOB malocclusion is common in some vertical facial patterns,[20–23] treatment objectives in these patients could include the prevention of further vertical dentoalveolar development of the posterior occlusion and/or a decrease of the gonial angle.[9,24]

The chincup therapy has been used as a supplementary device in the early treatment of AOB. It has been claimed that the use of chincup alone is effective in treating skeletal open bite,[7,8,9] but the actual evidence behind this claim is low. No studies were found comparing the use of crib, spurs, and chincup therapies.

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Table 1. Results of Intergroup Comparison of the Initial and Final Ages and Treatment/Observation Period (Student's *t*-Test)

	Group 1 Palatal Crib (n = 30)		Group 2 Bonded Spurs (n = 30)		Group 3 Chincup (n = 17)		Group 4 Control (n = 30)		
Variables (Years)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P* Value
Initial age	8.61	0.23	8.14	0.73	8.43	1.06	8.36	1.05	.166NS[a]
Final age	9.61	0.23	9.14	0.73	9.43	1.06	9.36	1.05	.166NS
Treatment/observation period	1.00	0.00	1.00	0.00	1.00	0.10	1.00	0.00	.976NS

[a] NS indicates not significant.

The present retrospective study was designed to evaluate the dentoskeletal effects produced by removable palatal crib, bonded spurs, and chincup in AOB patients.

MATERIALS AND METHODS

The sample size was calculated based on an alpha of 5% and a power of 80%, enough to detect an overbite mean difference of 1.75 mm with a standard deviation of 1.69 mm.[10] Therefore, at least 16 patients were needed in each group. Ethical approval from the ethics committee of the University of North Parana was obtained.

The sample of 107 patients with AOB was treated and observed at Bauru Dental School and at the University of North Paraná. Patients were consecutively selected according to the following criteria: children between 7 and 10 years of age with angle class I malocclusions, AOB equal to or greater than 1 mm, and erupted maxillary and mandibular permanent central incisors. The etiology of the AOB was related to nonnutritive sucking habits and/or tongue thrusting. However, the impact of concurrent airway problems was not investigated. Exclusion criteria were craniofacial anomalies, congenitally missing permanent teeth except wisdom teeth, severe crowding, maxillary constriction or posterior crossbites, and/or extracted permanent teeth. The same clinician supervised all patients. All of the patients at T1 were at stage 1 of cervical vertebral maturation, before the peak in skeletal maturity.[25] Sample characteristics are depicted in Tables 1 and 2.

Group 1 was treated with a removable appliance that was composed of a palatal crib associated with a chincup. The group consisted of 30 patients with an initial mean AOB of –5.21 ± 2.18 mm. The appliance consisted of Adams' clasps (XXXXX, XXXX, XX) on maxillary permanent first molars, a labial archwire, a palatal crib, and acrylic coverage on the palatal region contacting the lingual aspect of all teeth (Figure 1). A high-pull chincup delivering a force of 450–550 g per side was used and checked monthly with a dynamometer.[26] Patients were instructed to wear both appliances simultaneously for 14–16 hours a day during a 12-month period. To improve patients' compliance with treatment, booklets were given to the parents who were instructed to record the number of hours their child used both appliances each day for the three treated groups.

Group 2 was treated with bonded spurs combined with chincup similar to group 1 for 12 months. The group consisted of 30 patients with an initial mean AOB of –5.35 ± 2.0 mm. The lingual spurs[10] (Abzil, 3M, São José do Rio Preto, Brazil) were bonded on the palatal and lingual surfaces of maxillary and mandibular central incisors with the aid of Concise Orthodontic Chemical Curing Adhesive (3M Unitek, Monrovia, Calif). The spurs were sharpened with a carborundum disk before installation[10,12,14,17,22] and positioned in the cervical and incisal portions of maxillary and mandibular incisors, respectively, to prevent potential future occlusal interferences (Figure 2).

Group 3 was treated with only high-pull chincup (Figure 3). This group was initially composed of 30 patients and had 13 patients drop out throughout the study; eight of them refused further treatment, and five of them did not show up to follow-up appointments. Therefore, the group was composed of 17 patients with an initial mean AOB of –4.71 ± 2.15 mm. The treatment chincup protocol used was conducted as it was for groups 1 and 2.

The control group (G4) consisted of 30 untreated patients with an initial mean AOB of –3.92 ± 2.45 mm.

Table 2. Gender Distribution Comparison Among the Groups (Chi-Square Test)

	Group 1, Palatal Crib (n = 30)		Group 2, Bonded Spurs (n = 30)		Group 3, Chincup (n = 17)		Group 4, Control (n = 30)		
Gender	N	%	N	%	N	%	N	%	*P* Value
Boy	10	33.3	9	30.0	4	23.5	5	16.7	.477NS[a]
Girl	20	66.7	21	70.0	13	76.5	25	83.3	
Total	30	100.0	30	100.0	17	100.0	30	100.0	

[a] NS indicates not significant.

Figure 1. Removable palatal crib.

They were treated one year later. Informed written consent was obtained from the parents, allowing their children to participate in this research. All patients were advised on the importance of eliminating oral habits for possible success in correcting this type of malocclusion.

Cephalometric Analysis

Cephalometric data were obtained from lateral cephalograms taken at pretreatment (T1) and after 12 months of treatment/follow-up (T2). All cephalometric and landmark identifications were made by one author. The customized cephalometric analysis included 18 variables, nine angular and nine linear, for each tracing. Dolphin (11.0 Imaging Program, Chatsworth, Calif) was used for data collection and generation. A magnification factor of 9.5% was applied.

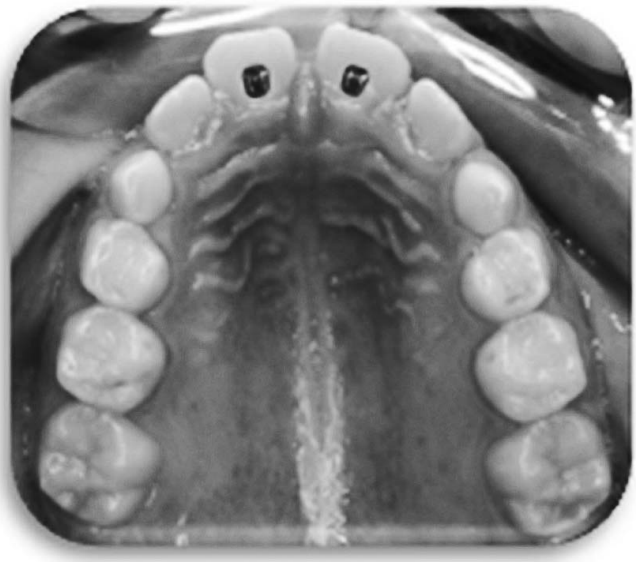

Figure 2. Bonded spurs.

Figure 3. High-pull chincup.

Error of Method

After a month from the first measurement, 40 randomly selected cephalograms from the four groups were digitized and remeasured by the same examiner.[27] Random errors were calculated by Dahlberg's formula,[28] and systematic errors were evaluated with dependent *t*-tests. No systematic errors were detected for any of the variables, with *P* values ranging from .032 (SNA) to .765 lower anterior face height (LAFH). The errors for linear measurements ranged from 0.1 mm for U6-PP to 1.2 mm for U1-NB. The errors for angular measurements ranged from 0.4° for ANB to 1.4° for SN.GoGn.

Statistical Analysis

The preliminary data assessment revealed a normal distribution (Kolmogorov-Smirnov test) for all of the variables. Intergroup comparison based on age was evaluated through a Student's *t*-test and based on sex through a chi-square test. Comparisons of the cephalometric variables at T1 and differences between T2 and T1 were assessed using analysis of variance with Tukey's post hoc tests.

RESULTS

The groups were comparable at T1 (Tables 1 to 3) regarding age, treatment/follow-up period, sex distri-

Table 3. Results of Intergroup Comparison of the Pretreatment Cephalometric Variables (One-Way Analysis of Variance Followed by Tukey Tests)

Cephalometric Measurements	Group 1, Palatal Crib (n = 30)		Group 2, Bonded Spurs (n = 30)		Group 3, Chincup (n = 17)		Group 4, Control (n = 30)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*
SNA (°)	90.20[b]	4.32	87.47[a]	4.01	87.32[ab]	2.68	87.35[a]	4.00	.009*
SNB (°)	84.34	4.04	83.23	2.85	84.01	3.00	83.02	2.80	.343
Ar-Go (mm)	39.63	4.04	40.24	3.66	38.16	3.92	40.55	4.78	.255
Ar.GoMe (°)	128.49	5.88	127.93	5.20	128.88	3.68	127.71	7.01	.893
ANB (°)	5.87[b]	2.86	4.23[ab]	2.20	3.29[a]	2.27	4.30[ab]	3.36	.010*
SN.GoGn (°)	28.40	5.13	28.24	4.16	29.63	4.88	28.78	5.69	.804
SN.PP (°)	7.37	2.97	6.74	3.61	5.04	2.66	7.13	3.48	.105
SN.Gn (°)	61.89	3.60	62.35	2.85	62.51	2.90	62.27	3.72	.913
LAFH (mm)	61.87[a]	4.33	61.53[a]	3.57	57.14[b]	3.38	61.98[a]	4.89	.001*
Overbite (mm)	−5.21	2.18	−5.35	2.00	−4.71	2.15	−3.92	2.45	.059
U1.NA (°)	27.54[ab]	7.31	31.55[b]	5.21	29.10[ab]	4.64	26.59[a]	6.94	.013*
U1-NA (mm)	5.44	2.22	5.85	1.74	5.43	1.63	5.51	2.16	.822
U1-PP (mm)	24.81[ab]	3.19	24.31[ab]	2.75	22.52[a]	2.57	25.46[b]	3.23	.014*
U6-PP (mm)	18.53	1.63	17.76	1.65	17.42	1.35	18.37	1.87	.071
L1.NB (°)	33.30	6.55	32.09	7.93	32.24	6.70	29.54	4.77	.152
L1-NB (mm)	6.09	2.24	5.50	2.12	5.45	2.05	5.90	1.58	.580
L1-MP (mm)	36.39[a]	2.66	35.35[a]	2.57	32.61[b]	1.98	35.17[a]	2.43	<.001*
L6-MP (mm)	28.37[a]	2.30	28.32[a]	1.77	25.29[b]	1.67	27.68[a]	1.87	<.001*

[a,b] Different letters indicate statistically significant differences.
* Statistically significant at $P < .05$.

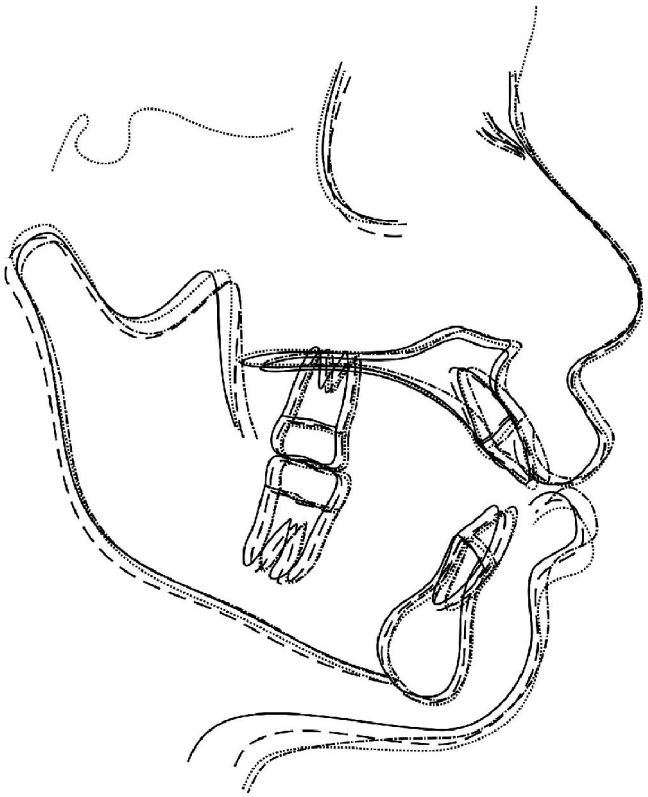

Figure 4. Superimposition of the average cephalometric tracings obtained at pretreatment (T1). Palatal Crib (-·-·-·-·-), Control group (____), Bonded spurs (– – – – –), Chincup group (.....).

bution, and severity of AOB. There was significant intergroup similarity on the cephalometric variables at the T1 stage. Although a few variables were significantly different upon group comparisons, most of them should not be considered clinically different. At pretreatment, SNA was significantly larger in G1 when compared with G2 and G4. ANB was also significantly larger in G1 when compared with G3. LAFH was smaller in G3 in comparison with all the other groups. For U1.NA(°) angle between long axis of the upper incisor and nasion-A point line, G2 had increased maxillary incisor's buccal tipping compared to the control group. In G3, there was less vertical development for maxillary incisors when compared with G4.

As for mandibular incisors, there was less vertical development in G3 than in the other groups. A smaller vertical development for mandibular molars was also observed in G3 when compared with the other groups.

Figures 4 and 5 illustrate superimpositions of the mean cephalometric tracings of all groups at T1 and T2, respectively. Results comparing T2-T1 changes among groups are presented in Table 4. A significant skeletal change was found only for LAFH, with G1 showing a significant increase in the anterior facial height when compared with all the other groups. There was a significantly larger overbite increase in G1 and G2 than in G3 and G4. The maxillary incisors of G1 showed significantly larger palatal tipping than the other groups. There was also significant retrusion of maxillary incisors in G1 when compared with G4. In the vertical plane, maxillary incisors of G1 and G2 showed

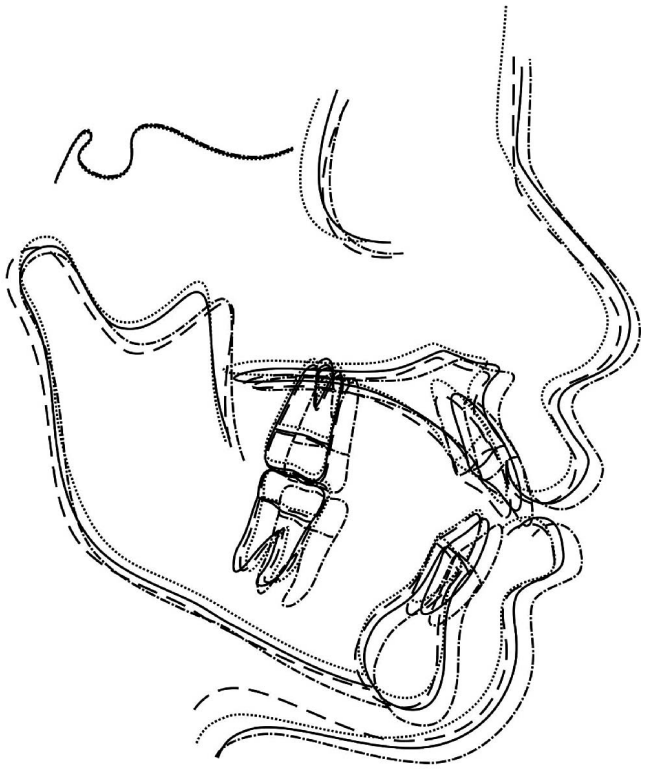

Figure 5. Superimposition of the average cephalometric tracings obtained at end of treatment T2). Palatal Crib (-·-·-·-·-), Control group (____), Bonded spurs (– – – – –), Chincup group (.....).

significantly more vertical development than G3 and G4. Similarly, mandibular incisors of G1 and G2 showed significantly more vertical development than those in G3. In G3, there was less vertical development of both maxillary and mandibular molars than in the other groups. Significant lingual tipping of mandibular incisors was observed in the treated groups when compared with the control group.

DISCUSSION

The real effects of chincup used alone in mixed-dentition AOB patients have been questioned.[29] The present study was conducted to elucidate the chincup therapeutic effects when compared with no treatment when high-pull chincup alone is used and when high-pull chincup is combined with either a palatal crib or bonded spurs.

The skeletal changes observed with the treatment protocols were similar and equivalent to normal growth, corroborating the findings of previous studies.[11,19,30] The only exception was observed for LAFH, which showed a significant increase in G1 when compared with the other groups. We suspect that this was a result of an increased clockwise mandibular rotation because of mandibular molar extrusion, explaining why the palatal crib group showed a significant increase in the LAFH compared to the other groups. Previous studies[10,30] also reported a larger increase in LAFH with bonded spurs or removable palatal crib plus chincup. Despite these changes, there were no significant intergroup differences in the mandibular plane angle. These results are consistent with the outcomes of two

Table 4. Results of Intergroup Comparison of the Treatment/Observation Changes (One-Way Analysis of Variance and Tukey Tests)

Cephalometric Measurements	Group 1, Palatal Crib (n = 30)		Group 2, Bonded Spurs (n = 30)		Group 3, Chincup (n = 17)		Group 4, Control (n = 30)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*
SNA (°)	0.17	3.11	0.16	2.73	−0.44	2.58	0.68	4.59	.750
SNB (°)	0.27	2.04	0.15	2.44	0.14	1.91	0.58	2.52	.880
Ar-Go (mm)	1.95	3.96	0.02	4.01	−0.18	2.02	1.06	5.17	.186
Ar.GoMe (°)	−0.10	4.09	−0.63	4.16	−1.49	1.99	−0.62	6.03	.778
ANB (°)	−0.11	1.98	0.03	1.36	−0.56	2.03	0.12	3.07	.763
SN.GoGn (°)	−0.49	2.05	−0.52	2.45	−1.51	2.66	−0.50	3.14	.533
SN.PP (°)	0.14	1.91	−0.25	2.38	−1.35	2.63	−0.40	2.34	.186
SN.Gn (°)	−0.31	1.74	−0.24	2.21	−0.84	2.17	−0.77	2.74	.680
LAFH (mm)	2.23[b]	2.78	0.40[a]	1.75	−0.70[a]	2.09	0.79[a]	1.46	<.001*
Overbite (mm)	5.08[b]	2.11	4.52[b]	2.34	2.30[a]	1.82	2.08[a]	1.35	<.001*
U1.NA (°)	−4.50[a]	6.71	−2.22[ab]	4.98	0.11[b]	5.73	0.31[b]	5.25	.005*
U1-NA (mm)	−0.91[a]	1.99	−0.15[ab]	1.45	0.38[ab]	2.46	0.41[b]	1.82	.027*
U1-PP (mm)	2.47[c]	1.89	2.35[bc]	1.59	0.72[a]	1.19	1.31[ab]	1.49	<.001*
U6-PP (mm)	0.65[b]	1.41	0.40[ab]	1.05	−0.35[a]	1.01	0.90[b]	1.43	.013*
L1.NB (°)	−3.81[a]	4.89	−2.67[ab]	5.21	−0.29[ab]	4.34	0.41[b]	4.00	.002*
L1-NB (mm)	0.37	2.57	−0.05	0.99	0.08	0.82	0.63	1.81	.467
L1-MP (mm)	2.12[b]	1.57	2.38[b]	1.14	0.86[a]	1.37	1.63[ab]	1.35	.002*
L6-MP (mm)	0.73[b]	1.21	0.11[ab]	0.96	−0.12[a]	0.97	0.50[ab]	1.33	.038*

[a,b,c] Different letters indicate statistically significant differences.
* Statistically significant at $P < .05$.

studies,[11,30] which found that the treatment with a palatal crib combined with chincup did not yield favorable skeletal effects on the mandibular plane angle. However, these findings contradict the results found by Cassis et al.,[10] who found significantly larger decreases in the mandibular plane angle in the spurs group when compared with a control group. Interestingly, in our study, the protocol of treatment with a chincup alone did not yield favorable skeletal control of vertical facial height.

Recently, a systematic review[31] reported the effectiveness of AOB treatment in growing children and found that only one study[9] showed positive results for the use of a chincup. Our results differ from those reported by Iscan et al.,[9] who evaluated a sample of 18 patients treated with a chincup. The authors found a positive effect on the mandibular plane angle and a reduction in AOB (3.92 mm). The fact that the sample in Iscan et al.[9] consisted of only high-angle children might explain the difference with our study that assessed only normal mandibular plane angle patients.

Favorable modifications in terms of overbite were recorded in all of the groups. These results are consistent with the outcomes of several studies.[9–11,19,30] Overbite significantly improved in G1 and G2 when compared with G3 and G4. Similar results were yielded by other studies[10,11,30] who concluded that the crib and the spurs appear effective at correcting AOB.

There was a significantly larger improvement in overbite in G1, with a mean increase of 5.08 mm. If one considered a correction of AOB as being an end-to-end position of the incisors, AOB was corrected in almost all 30 treated individuals (97.5%). Similarly, there was also a larger overbite increase in G2 (4.52 mm) with 84.5% of AOB correction. These results are quite consistent with the data reported in other studies[11,30] that found an overbite correction of 80% with the use of a palatal crib. Recently, a study[19] comparing the AOB treatment effects of fixed palatal crib and spurs concluded that both therapies provided improvement in the overbite. They noted that palatal crib was effective in AOB treatment in 100% of patients, and spurs in only 53.8%. Overbite correction probably failed in some patients as a result of the persistence of sucking habits or interposition of the tongue. Perhaps the crib and spurs are limited in habit discontinuation in all patients. This finding might be a consequence of the short-term follow-up, which might not have been enough to correct open bite in some patients.

Despite the fact that an overbite increase of around 2 mm was also seen in G3 (2.30 mm) and G4 (2.08 mm), there were no statistically significant differences between both groups. Surprisingly, this result indicated that the chincup used solely was unable to provide a significant improvement in the overbite. Of the 17 individuals in this group, only 48.8% had the AOB corrected. Of the 30 individuals in the control group, 53% of them had AOB spontaneously corrected. This is a common finding in untreated patients with AOB.[10,11,19,30] It might occur when the patient stops sucking or tongue thrust.

The dentoalveolar effects played a major role in correcting the AOB. The maxillary and mandibular incisors of G1 showed significantly larger palatal tipping and retrusion than did the other groups. The amount of maxillary incisor lingual tipping in G1 was twice that in G2 and four times more than G3 and G4. There was also a significant extrusion of maxillary and mandibular incisors in G1, which allowed a more significant correction of AOB when compared with G3 and G4. This might be a consequence of the effectiveness of a crib in the elimination of the tongue contact, clinical improvement in lip posture, and active action of the labial archwire on the maxillary incisors.[11,13,30]

The maxillary and mandibular incisors of G2 showed significantly greater palatal tipping than did those in G3 and G4, corroborating the results of Cassis et al.[10] This might have been a consequence of the decrease or elimination of tongue thrusting, anterior tongue rest posture, and sucking or lip habits, encouraged by the spurs.[10] Our results contradict the results of a study[19] that observed no lingual tipping of maxillary incisors with the use of the spur. This difference might have occurred because of the appliance design observed in the study sample (use of the spurs only in the upper incisors).[19] In the vertical plane, there was more vertical dentoalveolar development of the maxillary incisors in G2 when compared with G3. The spurs appear to interrupt sucking and thrusting habits, which may allow normal vertical development at the anterior region.

The vertical development of the maxillary and mandibular molars was statistically different among groups. Interestingly, G3 showed less vertical development of both maxillary and mandibular molars when compared with the other groups. The maxillary molars showed significant intrusion in the chincup group (–0.35 mm) compared to extrusion in G1 and G4. The mandibular molars also showed intrusion in G3 (–0.12 mm) compared to extrusion in G1. This reveals that the chincup may be effective at controlling molar vertical development. Our results are consistent with the outcomes of Iscan et al.,[9] who found an intrusion of the mandibular molars with the chincup.

Regarding the treatment approach provided for patients in G1, positive (OB correction) and negative aspects (increased LAFH) should be considered when using tongue cribs without the use of the chincup.

In summary, our results reveal that dental effects, rather than skeletal ones, were largely responsible for AOB correction. This might have been a consequence

of the sample studied, which was not significantly impaired skeletally, a common finding within this age group. Therefore, early correction of AOB may have been easier because it is mainly dental in nature. In addition, greater growth potential might also aid in correction. The limitation of this study was that it was a retrospective study. Treatment was confined to a 1-year period, and the effects of the spurs or removable crib alone were not assessed.

CONCLUSIONS

- The removable palatal crib and bonded spurs were effective at treating AOB. The high-pull chincup therapy alone did not yield favorable effects in AOB patients.
- End-to-end overbite percentage correction varied between 97.5% with the palatal crib, 84.5% with the bonded spur, 53% in the control group, and 48.8% with chincup.

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