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Anterior Open-Bite Treatment with Lingual Spurs and Chincup: a Prospective, Randomized Digital Model Study

Tratamento da Mordida Aberta Anterior com Esporão Lingual e Mentoneira: Estudo Prospectivo Randomizado em Modelos de Estudo Digitais

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Abstract

This prospective study aimed at assessing dentoalveolar changes in digital models in patients with anterior open-bite, treated with two protocols: lingual spurs and chincup. The sample consisted of 41 patients (27 girls and 14 boys) aged 7-10 years (mean age 8.37 years) during mixed dentition with anterior open-bite (mean -3.43mm), who were treated for one year. The patients were randomly divided according to the therapy applied: Group 1 (n=23) treated with lingual spurs, and group 2 (n=18) treated with prefabricated chincup. The plaster models were scanned, reproducing a three-dimensional scanned image, on which measurements were taken, at T1 (immediately before treatment) and T2 (one year after the begining of treatment). Transverse changes, length and perimeter of the upper and lower dental arches, overjet and overbite, as well as inclination of central incisors were assessed. Intraclass Correlation Coefficient (ICC) and Bland-Altman method were applied to verify the intra-examiner error. The results were analyzed through paired and independent t tests at 5% significance. After one year of treatment, all the variables were statistically changed, except for perimeter and length of upper and lower arches, upper central incisor proclination, and overjet. The changes (T2-T1) between groups showed similar results. It was concluded that both protocols were similar after one year of early treatment of anterior open-bite.

Keywords: Orthodontics. Open Bite. Models, Dental.

Resumo

Esse estudo propectivo teve como objetivo realizar a avaliação das alterações dentoalveolares em modelos digitais de pacientes cuja mordida aberta anterior foi tratada seguindo dois protocolos distintos: esporão lingual e mentoneira. A amostra foi composta por 41 pacientes (27 do sexo feminino e 14 do sexo masculino) com idades entre 7-10 anos (média de idade de 8.37 anos), dentição mista com diagnóstico de mordida aberta anterior (média de -3.43mm) e tratados ao longo de um ano. Os pacientes foram aleatoriamente dividiso em dois grupos de acordo com a terapia realizada: Grupo 1 (n=23) tratados com esporão lingual, e Grupo 2 (n=18) tratados com mentoneira pré-fabricada. Os modelos de gesso foram escaneados, gerando uma imagem tridimensionao em qual as medidas foram realizadas em 2 tempos distintos: T1 (imediatamente antes do tratamento) e T2 (um ano após o início do tratamento). Alteraçnoes transversais, comprimento e perímetro dos arcos dentários superior e inferior, trespasse horizontal e vertical, assim como inclinação dos incisivos centrais foram avaliadas. O Coeficiente de Correlação Interclasse (CCI) e o método Bland-Altman foram aplicados para verificar o erro intra-examinador. Os resultados foram analisados através do Teste T pareado e independente adotando uma significância de 5%. Após um ano de tratamento, observou-se alerações estatisticamente significantes em todas as variáveis, exceto perímetro e comprimento dos arcos superio e inferior, inclinação do incisivo central superior e trespasse horizontal. As alterações enre os grupos (T2-T1) apresentaram resultados similares. Concluiu-se que ambos os protocolos apresentaram mudanças semelhantes na mordiada aberta anterior após um ano de tratamento.

Palavras-chave*: Ortodontia. Mordida Aberta. Modelos Dentários.*

1 Introduction

Anterior open-bite (AOB) may be defined as the presence of a negative overbite between incisors, when posterior teeth are in occlusion.[1,2]

The prevalence of this malocclusion is 17% in mixed dentition and its etiology is multifactorial; it is influenced by several environmental factors, such as habits of digital sucking, pacifier sucking, mouth breathing, and tongue or lip interposition, which when combined with genetic factors, such as an unfavorable growth pattern, may lead to malocclusion aggravation.[2,3]

Many authors highlight that anterior open-bite treatment should take place early in mixed dentition, taking advantage of the growth potential, thus obtaining more favorable results and positively impacting the child's quality of life. [3,4] Spontaneous correction may occur in up to 80% of cases, when the deleterious habit is eliminated until mixed dentition.[2,4] Treatment usually involves interrupting deleterious habits with recall devices, such as spurs, removable and fixed palatal cribs and for individuals with a more vertical growth pattern, the chincup could also be usefull as a coadjuvant treatment.[5-8]

Currently in the literature, there are several studies that assess cephalometric changes[7-12] or manually on cast models after anterior open-bite treatment, and there are a few studies

on the dimensional changes of dental arches using digital models in patients subjected to open-bite treatment.[13] Thus, the main objective of this study was to assess dentoalveolar changes in dental arches, analyzed by digital models after anterior open bite treatment, using spur and chincup.

2 Material and Methods

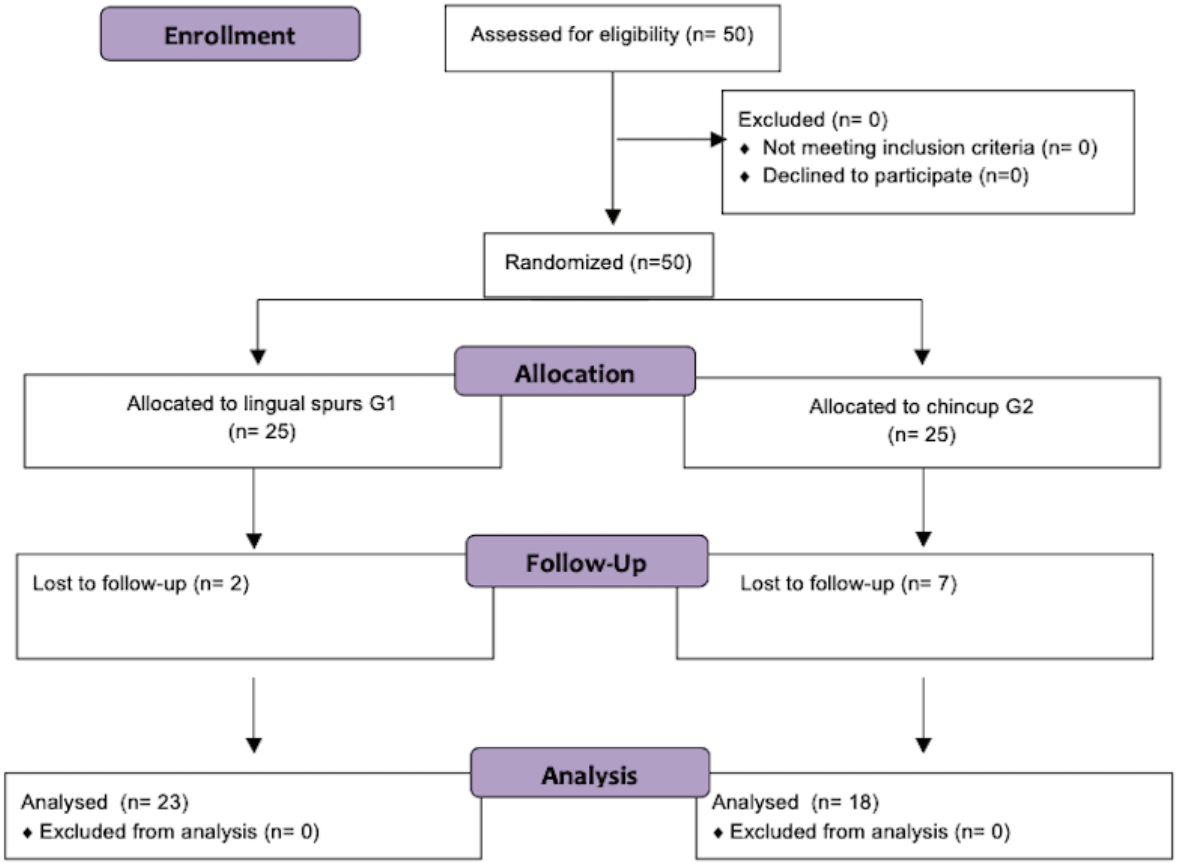
This study was approved by the Research Ethics Committee of the CAAE: 29011714.0.0000.0108.

A sample calculation was performed using an alpha of 5% and a power of 80%. This allowed the detection of a mean difference in overbite of 2.1 mm, with a standard deviation of 1 mm between the groups.[8] Therefore, at least 16 patients were required in each group.

The sample of this randomized prospective study met the following inclusion criteria: Angle Class I molar relationship, anterior open-bite larger than 1 mm, mixed dentition, ages between 7 and 10 years, first permanent molars and permanent incisors completely erupted, absence of agenesis and supernumerary teeth, no loss of permanent teeth, absence of severe crowding, and good oral health. Patients presented nonnutritive sucking habits and/or tongue thrusting. However, the patients were not evaluated regarding the impact of concurrent airway problems.

Thus, 50 patients were initially selected, but only 41 concluded the treatment. (Figure 1) These patients were randomly divided according to the treatment protocol applied in two groups: G1 - treated with lingual spurs (n=23), mean initial age of 8.47 years (± 0.67), including 9 boys and 14 girls; and G2 - treated with chincup (n=18), mean initial age of 8.28 years (± 1.05), including 5 boys and 13 girls. A computer-generated randomization list was created using Excel (2007, Microsoft Windows). During the groups allocation and the dental arch analysis blinding was possible, but it was not possible for the examiner not to identify the treatment modality. At the beginning all patients were advised to abandon oral habits for possible success in correcting the malocclusion.

Figure 1 – Flowchart



Source: resource data.

Group 1 was treated with Nogueira lingual bonded spur, developed and produced by Abzil (Abzil, 3M Unitek, São José do Rio Preto, São Paulo - Brazil). These appliances were placed with the orthodontic bonding system according to manufacturer's instructions (Transbond XT™, 3M Unitek, Monrovia, California - USA) on upper and lower central incisors, closer to the cervical region to avoid occlusal interferences during anterior open-bite closing (Figure 2).

Figure 2 - Initial photographs of a patient from G1

Source: authors.

Group 2 was treated with the pre-fabricated chincup (Morelli, Sorocaba, São Paulo - Brazil). The elastic used produced forces from 450 to 500g on each side, and covered 45° relative to the occlusal plane.[6,14] The patients were instructed to use the chincup for 12 hours at night time[15] (Figure 3).

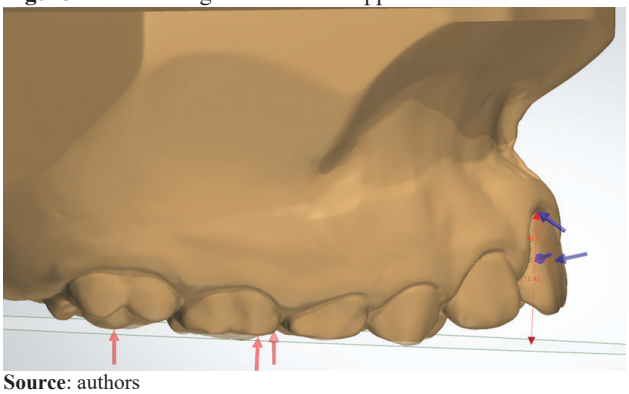
Figure 3 - Initial photographs of a patient from G2

Source: authors

2.1 Dental cast analysis

The patients' cast models at T1 (before treatment) and at T2 (after 12 months of treatment) were scanned by a laser surface scanner 3Shape R700 (3Shape A/S, Copenhagen, Denmark). After scanning, these models were measured using the OrthoAnalyzer™ 3D software (3Shape A/S, Copenhagen, Denmark), by a previously calibrated examiner. The following variables were measured: perimeter and length of upper and lower arches, inclination and height of upper central incisors (Figures 4 and 5), overjet[16-20], overbite (Figure 6)[16-20], upper vertical dentoalveolar development and transverse distance between upper and lower first permanent molars.[17,21-23]

Figure 4 - Measuring inclination of upper central incisor



Source: authors

Figure 5 - Measuring height of upper central incisors

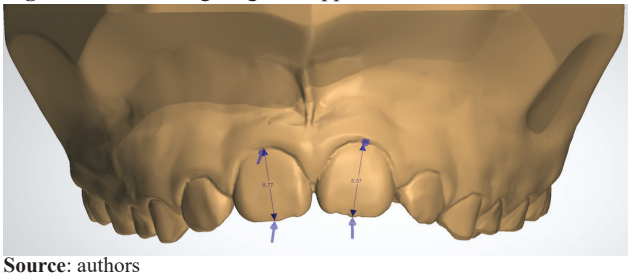


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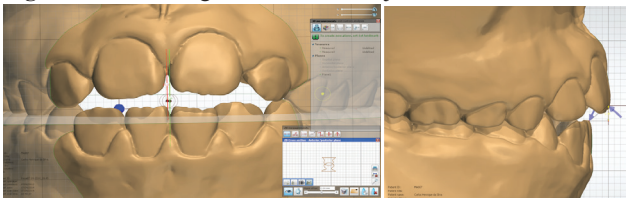
Figure 6 - Measuring overbite and overjet



Source: authors.

In order to confirm the examiner's calibration and ensure data reproducibility, an intra-examiner method error assessment was performed. Thirty percent of the total sample was randomly selected, and after 30 days, measurements were repeated. The systematic error was calculated by the t test at 5% significance level ($p<0.05$). The intra-examiner measurement error was assessed by Intraclass Correlation Coefficient (ICC) and Bland-Altman method.

2.2 Cephalometric analysis

In order to compare the groups, the cephalometric data were collected from lateral cephalograms at T1. The cephalometric analysis comprised seven variables 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. (Table 1)

Table 1 - Comparison of Cephalometric Variables Between Groups: Mean, Standard Deviation (SD), and t-Test (P)

	Group 1 n (23)		Group 2 n (18)		
	mean	SD	mean	SD	*P*
Cephalometric variables					
SNA^0	82.78	4.26	84.55	2.85	0.21
SNB^0	78.33	3.39	79.69	3.04	0.21
ANB^0	4.45	1.43	4.86	2.16	0.47
SN.PP^0	-1.41	2.44	-1.45	3.03	0.96
FMA^0	29.25	4.13	29.80	4.18	0.67
SN.Go-Gn	35.40	4.20	35.94	4.44	0.69

Source: authors

2.3 Statistical analysis

Data were described through mean and standard deviation parameters. The Kolmogorov-Smirnov test was applied to verify whether data presented normal distribution so to allow the application of parametric tests. Paired Student's t test was used to verify intragroup changes. Independent t test was applied for the comparison between groups.

All of the statistical analyses were performed by the Statistica version 5 software (StatSpft Inc., Tulsa, USA).

4 Results and Discussion

According to the results for the intraexaminers error, the ICC values (0.99) showed high rates of agreement between the first and second measurements. The Bland-Altman inferior and superior limits were -0.15 and 0.80, respectively. The systematic error analysed with the paired t test also showed no significant difference (p value varied from 0.11 to 0.52).

Initial groups compatibility regarding gender and age was confirmed respectively by the chi-square test and paired t test. This compatibility was also achieved at T1 when cephalometric variables were analyzed (Table 1).

The compatibility between groups regarding initial measurements (T1) was verified by the independent t test, a statistically significant difference was detected only for the tooth height of the upper central incisors (Table 2).

Table 2 – Comparison between groups at T1

Measurement	G1 (n=23) SPURS		G2 (n=18) CHINCUP		diff.	P value
	mean	SD	mean	SD		
Upper arch per. (mm)	78.06	3.21	77.63	2.64	-0.43	0.647
Lower arch per. (mm)	71.10	2.55	71.21	2.80	0.11	0.892
Upper arch leng.(mm)	29.43	2.22	28.78	1.53	-0.66	0.290
Lower arch leng.(.(mm)	25.14	1.70	25.38	1.37	0.24	0.628
Upper central inc. Inclination(º)	77.13	6.95	80.38	8.91	3.24	0.198
Height 11(mm)	8.62	0.91	7.64	0.93	-0.98	0.002*
Height 21(mm)	8.54	1.15	7.58	0.96	-0.96	0.007*
Overjet (mm)	4.22	1.30	3.47	1.58	-0.75	0.104
Overbite (mm)	-3.62	2.01	-3.37	1.92	0.25	0.685
Transversal dist. 16-26(mm)	35.71	2.35	35.64	1.84	-0,08	0.912
Transversal dist. 36-46(mm)	33.11	1.56	33.83	1.68	0.72	0.162
upper vertical dentoalveolar development (mm)	9.11	2.46	8.05	2,83	-1,06	0,208

Per. indicates perimeter; leng. indicates lenght; inc. Indicates incisor; dist. indicates distance. * Statistically significant at $p < 0.05$

Source: authors.

Tables 3 and 4 show the results of the paired t test in the intra-group comparison. Group 1 (Spurs) presented statistical changes for some variables, except for upper and lower arch perimeter, upper and lower arch length, upper central incisor inclination, and overjet. The incisors height and overbite increased, upper vertical dentoalveolar development decreased, which accounted for the AOB reduction. Similar changes were observed for group 2 (chincup), some variables also presented statistical changes, except for lower arch perimeter, upper and lower arch length, upper central incisor inclination, and overjet. The incisors height increased as the overbite, upper vertical dentoalveolar development decreased, which also accounted for the AOB reduction. The transversal measurements increased for the two groups.

Table 3 – Comparison between (T1) and (T2) for G1-Spurs

Measurement	Initial (T1)		Final (T2)		diff.	p
	Mean	SD	Mean	SD		
Upper arch per. (mm)	78.06	3.21	78.56	3.76	0.50	0.152
Lower arch per. (mm)	71.10	2.55	70.29	2.79	-0.81	0.064
Upper arch leng. (mm)	29.43	2.22	29.48	2.31	0.05	0.847
Lower arch leng. (mm)	25.14	1.70	25.12	1.71	-0.02	0.913
Upper central inc. Inclination(º)	77.13	6.95	78.00	6.29	0.87	0.389
Height 11(mm)	8.62	0.91	9.22	0.80	0.60	<0.001*

Measurement	Initial (T1)		Final (T2)		diff.	p
	Mean	SD	Mean	SD		
Height 21(mm)	8.54	1.15	9.17	0.78	0.63	<0.001*
Overjet(mm)	4.22	1.30	3.95	1.65	-0.27	0.215
Overbite(mm)	-3.62	2.01	-1.19	2.65	2.43	<0.001*
Transversal dist. 16-26(mm))	35.71	2.35	36.13	2.26	0.42	<0.001*
Transversal dist. 36-46(mm)	33.11	1.56	33.41	1.54	0.30	<0.001*
upper vertical dentoalveolar development (mm)	9.11	2.46	7.28	2.48	-1.83	<0.001*

Per. indicates perimeter; leng. indicates lenght; inc. Indicates incisor; dist. indicates distance

* Statistically significant at $p < 0.05$

Source: authors

Table 4 – Comparison between (T1) and (T2) for Group 2-Chincup

Measurement	Initial (T1)		Final (T2)		diff.	p
	Mean	SD	Mean	SD		
Upper arch per. (mm)	77.63	2.64	78.42	3.04	0.80	0.026*
Lower arch per. (mm)	71.21	2.80	71.21	2.83	0.00	0.994
Upper arch leng. (mm)	28.78	1.53	29.09	1.66	0.31	0.118
Lower arch leng. (mm)	25.38	1.37	25.34	1.45	-0.04	0.838
Upper central inc. Inclination(º)	80.38	8.91	78.87	5.39	-1.51	0.294
Height 11(mm)	7.64	0.93	8.67	0.88	1.03	<0.001*
Height 21(mm)	7.58	0.96	8.53	0.97	0.95	<0.001*
Overjet(mm)	3.47	1.58	3.59	1.75	0.12	0.563
Overbite(mm)	-3.37	1.92	-1.19	2.42	2.18	<0.001*
Transversal dist. 16-26(mm)	35.64	1.84	36.19	1.92	0.55	<0.001*
Transversal dist. 36-46(mm)	33.83	1.68	34.22	1.90	0.39	0.006*
upper vertical dentoalveolar development (mm)	8.05	2.83	7.14	2.40	-0.91	0.029*

Per. indicates perimeter; leng. indicates lenght; inc. Indicates incisor; dist. indicates distance

* Statistically significant at $p < 0.05$

Source: authors

For the intergroup comparison there was no statistically significant difference in the variation at T2-T1 between them (Table 5).

Table 5 – Comparison of the changes (T2-T1) between groups G1 and G2

Measurement	G1 (n=23) SPURS		G2 (n=18) CHINCUP		diff.	p
	mean	SD	mean	SD		
Upper arch per. (mm)	0.50	1.62	0.80	1.39	0.30	0.537
Lower arch per. (mm)	-0.81	1.99	0.00	1.61	0.81	0.170
Upper arch leng.(mm)	0.05	1.23	0.31	0.81	0.26	0.439
Lower arch leng. (mm)	-0.02	0.96	-0.04	0.80	-0.02	0.952
Upper central inc. Inclination(º)	0.87	4.72	-1.51	5.90	-2.37	0.161
Height 11(mm)	0.60	0.63	1.03	0.87	0.43	0.076
Height 21(mm)	0.63	0.58	0.95	0.81	0.32	0.144
Overjet(mm)	-0.27	1.01	0.12	0.87	0.39	0.200
Overbite(mm)	2.43	1.87	2.18	2.12	-0.25	0.688
Transversal dist. 16-26(mm)	0.42	0.44	0.55	0.34	0.13	0.310
Transversal dist. 36-46(mm)	0.30	0.39	0.39	0.52	0.09	0.554
upper vertical dentoalveolar development (mm)	-1.83	1.38	-0.91	1.62	0.92	0.057

Per. indicates perimeter; leng. indicates lenght; inc. Indicates incisor; dist. indicates distance

* Statistically significant at $p < 0.05$

Source: authors

The compatibility between groups regarding gender and age was important due to the growth period presented by the sample studied. It is known that different genders present different biological ages for the same chronological age. Due to differences in growth rate, each patient respond differently to the same orthodontic treatment protocol.[1,2,14] The sample was compatible regarding gender and age, and also for the initial cephalometric and dental casts measurements which confirms the reliability of results (Tables 1 and 2).

The variables that presented statistically significant changes were incisor height, overbite, transverse distances, and vertical development of the upper alveolar process. The

increase in incisors height, and decrease in overbite and vertical development of the alveolar process are expected changes with anterior open-bite closing. These changes are addressed to the removal of tongue interposition or interruption of oral habits, facial growth, and muscle balance achieved. These results agree with Hering et al.[25] who also observed extrusion of upper incisors. When the spur appliance is used, it prevents the tongue to touch the anterior teeth, taking off the pressure of the tongue over teeth. The most important variable regarding AOB treatment is the increase in overbite, accounting for the open-bite correction. Considering an end-to-end incisor relationship as an indicator for AOB correction, Group 1 showed an AOB reduction of 2.43mm, comparing to 3.07mm found by Leite et al.[9], 4.26mm found by Canutto et al.[10] and 3.09 found by Rossato et al.[11] Considering the same duration of treatment with lingual spurs, the lower amount of AOB correction in this study may be attributed to patient compliance in abandoning the deleterious oral habits and to the method for measuring this variable, in their studies a cephalometric measurement was performed and digital models were used.

In the case of the chincup group (G2), although the results for the overbite reduction (2.18mm) was lower than G1 (2.43mm), it was not statistically different. The results herein were similar to those found by Rossato et al.[11] who found an improvement in overbite of 2.26mm. However, they differ from those obtained by Iscan et al.[26] with the 3.92 mm reduction in overbite. Their positive results were achieved with the exclusive use of the chincup in patients with anterior open-bite showing an increased angle. This difference could be explained by the protocol of 16hs a day against 12hs in ours. In cases where open-bite etiology is not well defined, the treatment should usually be performed to control the vertical growth of the individual[27], highlighting the importance of the chincup protocol.[26] The vertical control associated with patient's motivation and cooperation by ceasing the sucking habit may contribute to bite closing.[6]

When evaluating the changes after one year of treatment in each group, the paired t test was used. Regarding the variables assessed in Group 1, most of them presented statistical changes, except for upper and lower arch perimeter, upper and lower arch length, upper right central incisor inclination, and overjet (Table 3). The same may be observed in group 2, except for lower arch perimeter, upper and lower arch length, upper right central incisor inclination, and overjet (Table 4).

Arch perimeter, arch length, upper central incisor inclination, and overjet presented some variations in both groups, from T1 to T2, but they were not significant. These small changes may be attributed to a limited effect of the two protocols in reducing the incisors inclination and consequently reducing the arches length and perimeters as described by others AOB devices like palatal cribs.[13,28] Even in growing patients, the removal of deleterious habits caused by the open-bite treatment for one year could not greatly influence those variables. Sinclair and Little,[29] in 1983, confirmed the transverse increase in the molar region up to 12 years old, with no increase in arch length and perimeter.

The most important results are described in Table 5, which shows the comparison of results (T2-T1) between groups. The results were similar, meaning that both treatment protocols are effective in the early treatment of anterior open bite. The changes observed in the patients of this study may occur because of the elimination of deleterious habits, such as prolonged digital sucking, use of pacifier, or because of the normalization of swallowing functions, tongue positioning, or lip sealing.[7] Probably, the failure to correct open-bite in some cases may be addressed to the persistence of habits or improper tongue posture. This happens because despite the efforts for removing the habits and controlling patient cooperation, these aspects are inherent to each individual and are not controlled by the researcher.

Thus, it is up to the clinician to indicate the best appliance (fixed or removable) considering the cost-benefit in order to obtain better results. The chincup used at night may be associated with any of the mentioned appliances, so that results may be added. An association of chincup and lingual spurs has already been tested with great results of 5.23mm of open-bite reduction.[8]

In transverse changes, despite the absence of any device in the posterior region, small changes were observed because the patients were in the growth phase. In this period it is observed a small transverse growth of the maxilla, which varies from 0.5 to 2 mm in the region of first permanent molars.[30]

All of the studies previously compared had a control group, which is a limitation of the present research: the lack of a non-treated control group. It is not always possible or ethical to perform a study with a control group.[3] When considering the present study, it would be unethical to maintain a non-treated group because patients would be exposed to unnecessary radiation and prevented from treatment for one year, despite knowing the need for immediate intervention because of their age.

One important issue is related to the design of this study, as the variables were measured in digital models, the comparison with the cephalometric studies mentioned above may be discussed. The increased results of AOB reduction in their findings may also occur depending on X-rays magnification. The digital models undoubtedly improved the accuracy of these measurements and the results obtained. In future research it is recommended longer intervention period and long-term follow-up in order to assess AOB treatment stability.

4 Conclusion

Both groups present similar changes in the early treatment of anterior open bite; providing a reduction of 2.43 mm for the spurs and 2.18 mm for the chincup. Besides increase in overbite, other vertical variables changed significantly as

incisors height and upper vertical dentoalveolar development in both groups.

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