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Anterior open bite treated with a palatal crib and high-pull chin cup therapy. A prospective randomized study

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SUMMARY The aim of this prospective randomized clinical study was to cephalometrically investigate the dentoalveolar and soft tissue changes produced by a removable appliance with a palatal crib associated with high-pull chin cup therapy in children with an Angle Class I anterior open bite (AOB) malocclusion. Thirty children (8 males and 22 females) with an initial mean age of 8.3 years and a mean AOB of 4.1 mm were treated with a removable appliance composed of a palatal crib associated with chin cup therapy for 12 months. A control group of 30 individuals (7 males and 23 females) closely matched for age, initial mean age 8.6 years, gender, and ethnicity with a mean AOB of 4.6 mm was followed without treatment. The measurements (means and standard deviations) were statistically analysed using a paired *t*-test.

The results showed no significant differences in the level of molar eruption or in lower anterior face height, suggesting that the vertical control expected from the chin cup therapy did not occur. Dentoalveolar changes at the anterior region were evident, with statistically significant extrusion, retrusion, and lingual tipping of the maxillary and mandibular incisors ($P \leq 0.05$). However, these hard tissue changes did not imply soft tissue changes and the variables related to the soft profile were not statistically significantly different between the groups. The dentoalveolar changes at the anterior region of the dental arches were mainly responsible for closure of the AOB in patients treated in the mixed dentition.

Introduction

An anterior open bite (AOB) may be defined as a negative overbite between the incisal edges of the maxillary and mandibular anterior teeth, with the posterior teeth in occlusion (Worms *et al.*, 1971; Almeida *et al.*, 1998). In the mixed dentition period, the prevalence of an AOB is approximately 17 per cent (Worms *et al.*, 1971). This malocclusion affects nearly 16 per cent of the North American black population and 4 per cent of the white population (Ngan and Fields, 1997).

Several factors are involved in the aetiology of AOB (Huang *et al.*, 1990; Insoft *et al.*, 1996; Almeida *et al.*, 1998; Chevitarese *et al.*, 2002). When there is only dental and dentoalveolar involvement, there is predominance of environmental causes such as thumb or dummy sucking habits, mouth breathing, and tongue or lip thrusting in addition to some local factors such as tooth ankylosis and eruption disturbances. However, the larger the skeletal involvement, the more the aetiology is related to genetic factors, which are restricted to an unfavourable growth tendency of the individual, i.e. a predominantly vertical pattern.

The diagnosis and treatment of this malocclusion are still controversial. Many authors agree that the clinician should be able to distinguish an open bite of dental and dentoalveolar origin from a skeletal open bite so that treatment is directed at the cause of the problem. However, in most cases, the distinction is not clear (Insoft *et al.*, 1996), since malocclusion presents both dental and skeletal components in its aetiology (Almeida and Ursi, 1990). Thus, to allow normal development of the anterior dentoalveolar region, the palatal crib may be an excellent treatment option, since it prevents thumb or dummy sucking and avoids tongue thrusting. According to Haryett *et al.* (1970), the palatal crib is effective for the elimination of a thumb sucking habit in 85 to 90 per cent of subjects.

However, most cases of AOB are related to a long face pattern (English, 2002), with an increase in lower anterior face height (LAFH), clockwise mandibular rotation and a resulting greater profile convexity (Kuster and Ingervall, 1992). In these patients, dental compensations produced by conventional orthodontic treatment may not lead to satisfactory outcomes (Cangialosi, 1984; Ngan and Fields, 1997; Hering *et al.*, 1999), thus requiring another treatment approach directed at vertical control of facial growth and/or 'real' or relative intrusion of the posterior teeth. Thus, the aim is to achieve counterclockwise mandibular rotation for closure of an open bite, especially if there is remaining growth of the mandibular ramus, in order to control the increase in anterior face height and achieve improved occlusal outcomes and a balanced profile (Sankey *et al.*, 2000).

Several approaches have been proposed for improved vertical control, such as the use of the high-pull headgear (Kuhn, 1968), bite-blocks (Kuster and Ingervall, 1992), magnets (Woods and Nanda, 1991), a palatal bar, and masticatory exercises (Spyropoulos, 1985; Insoft *et al.*, 1996), anchorage loss after extraction and either the use of a vertical (Pearson, 1978, 1991; Spyropoulos, 1985; Iscan *et al.*, 2002) or conventional (Haas, 1980; Ritucci and Nanda, 1986; Almeida *et al.*, 1998; Sankey *et al.*, 2000) chin cup. No studies appear to have addressed the use of chin cup therapy associated with a palatal crib.

Considering the importance of providing not only a pleasant smile but also a balanced profile, this prospective randomized study involved cephalometric evaluation of the dentoalveolar and soft tissue profile effects secondary to treatment of an AOB with a removable palatal crib and chin cup.

Materials and methods

The research project was approved by the Ethics Committee of the University of Bauru.

Sample selection

In order to obtain 60 children of both genders who matched the specific criteria to comprise the sample, a single operator examined a total of 1940 subjects of the city of Bauru, São Paulo, under written authorization of the respective parents and school supervisors. Selection was consecutively performed according to the following criteria: children aged 6–10 years of age with an Angle Class I AOB malocclusion greater than 1.0 mm; absence of tooth agenesis; no primary or permanent teeth extracted; absence of dental crowding; and absence of maxillary constriction or posterior crossbites. Oral habits (e.g. dummy sucking, finger sucking, or mouth breathing) were not present in any of the patients in this study. No subjects required surgery for nasal airway obstruction. The sample was then randomly divided (by shuffling cards) into two groups: 30 subjects to be immediately treated and 30 to remain untreated for 12 months (Table 1). Informed written consent was obtained from the parents of the patients, to allow their children to be treated and to participate in this research.

Treatment sample

The treated sample comprised 30 Class I AOB patients (22 girls and 8 boys), whose initial mean age was 8.3 years (range 7.0–10.1 years). The mean AOB of this sample was 4.1 mm (range −1.0 to −8.2 mm). These children were treated with a removable appliance composed of a palatal crib associated with high-pull chin cup therapy.

Appliance design

The appliance consisted of Adams' clasps on the 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). The removable appliance was used for a period of 12 months. A high-pull chin cup (Sankey *et al.*, 2000) delivering a force of 450–550 g per side was used (Figure 2). The patients were instructed to wear both appliances together for 14–16 hours a day for a 12-month period. To improve patient compliance with treatment, booklets were given to the parents and they were instructed to record the number of hours their child used the appliance each day.

Control sample

The control group comprised 30 Class I AOB patients (23 girls and 7 boys), whose initial mean age was 8.6 years (range 6.8–10.4 years). The mean AOB of this sample was 4.6 mm (range −1.0 to −12.8 mm). These children did not undergo any type of treatment.

Cephalometric analysis

The dentoalveolar and soft tissue profile measurements are shown in Figures 3 and 4, respectively. All measurements were made by one author (FT). Cephalometric tracings were analysed with the aid of the Dentofacial Planner 7.0 (Dentofacial Planner Software Inc., Toronto, Canada). Observation of the antero-posterior changes of the molars and incisors was performed using a modification of the modified Frankfort horizontal plane (FHp; Baumrind and Frantz, 1976).

Assessment of skeletal maturity

The experimental and control groups were homogeneous at the start of the treatment (T_1) as to maturation of the cervical vertebrae obtained with the aid of lateral cephalograms. The mean maturation stage for all groups at T_1 was stage 1, according to the classification of O'Reilly and Yanniello (1988) and Baccetti *et al.* (2002). Stage 1 represents the

Table 1 Mean initial and final ages of the individuals in the two groups, minimum and maximum values, and period of evaluation, analysed using the Student's *t*-test.

Group	Initial mean age (years)	Minimum	Maximum	Final mean age (years)	Minimum	Maximum	Period of evaluation (years)	*P*	Significance
1. Treated (*n* = 30)	8.33	6.96	10.14	9.33	8.20	10.65	1.00	0.230	NS
2. Control (*n* = 30)	8.61	6.82	10.44	9.61	8.35	10.85	1.00		

NS, not significant.

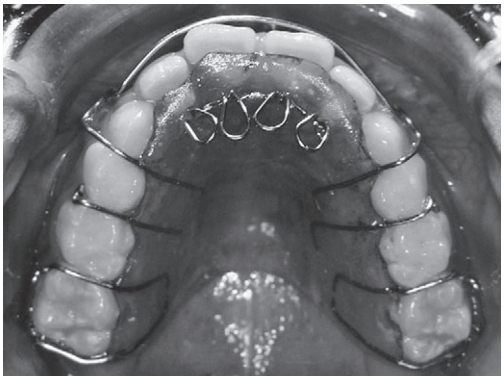

Figure 1 Removable appliance with palatal crib.

Figure 2 The chin cup used in the study.

time before the peak in skeletal maturity. Therefore, both groups were adequately matched for chronological age and skeletal maturation for direct comparison.

Statistical analysis

In order to evaluate data distribution, the data were analysed by means of a Kolmogorov–Smirnov test. To determine normal distribution of the data, a paired *t*-test was used to examine sexual dimorphism and between-group differences of the pre-treatment morphology. Comparison of T_2 (end of the treatment)–T_1 (start of the treatment) changes over time between the control and treated groups was accomplished by a paired *t*-test.

Error of the method

Forty cephalograms from the two study groups were randomly selected and remeasured by the same investigator after a period of 1 month (Baumrind and Frantz, 1976). The

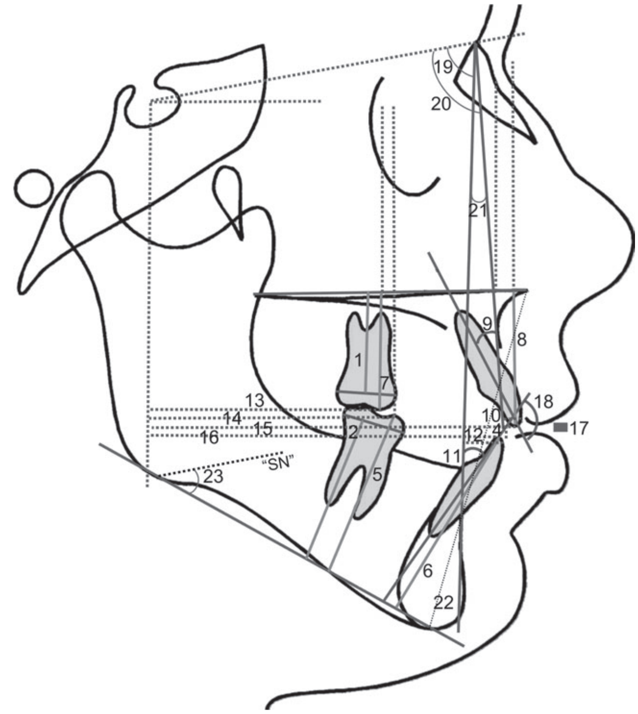

Figure 3 Dentoalveolar and skeletal measurements: 1, indicates U6 Eruption; 2, L6 Eruption; 3, Difference in eruption of molar; 4, Overbite; 5, L6-GoMe; 6, L1-GoMe; 7, U6-PP; 8, U1-PP; 9, U1.NA; 10, U1-NA; 11, L1.NB; 12, L1-NB; 13, U6-FHp; 14, L6-FHP; 15, U1-FHP; 16, L1-FHP; 17, vertical exposition of U1; 18, interincisor angle; 19, SNA; 20, SNB; 21, ANB; 22, lower anterior face height; and 23, SN.GoGn.

casual error was calculated using Dahlberg's formula ($E = \sqrt{\Sigma d^2 / 20n}$; Dahlberg, 1940) and the systematic error by a paired *t*-test.

Results

The results did not reveal evidence of intra-group sexual dimorphism between genders in either group. Furthermore, no statistically significant differences between the initial values of either group were observed (Table 2). The systematic error was significant for only one measurement, H.NB. Random measurement error did not exceed 1.57 degrees or 1.02 mm.

Comparisons of the changes occurring during the experimental period are shown in Table 3. Of the 34 variables analysed, only nine were statistically significant. All of these were dentoalveolar measurements related to the anterior region of the dental arch. No variable corresponding to the soft tissue profile or to skeletal characteristics was statistically significant between the groups.

In the treated group, the mean AOB closure was 3.86 mm, resulting in a mean final overbite of −0.21 mm. Treatment provided closure of the AOB in 26 of the 30 individuals. However, in the control group the mean change

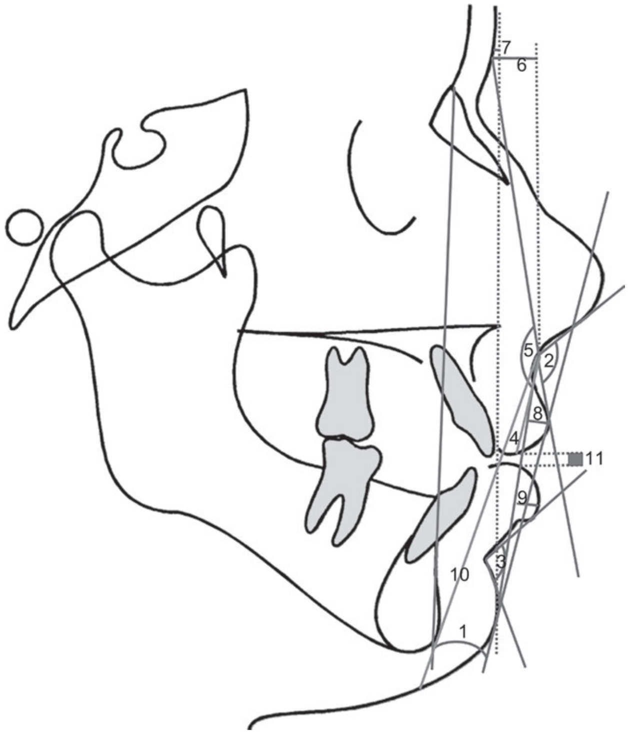

Figure 4 Soft tissue profile measurements: 1, H.NB; 2, nasolabial angle; 3, mentolabial angle; 4, subnasal-stomium; 5, Gl.Sn.P′; 6, Sn-Gl vertical; 7, P′-G vertical; 8, LS-P′Sn; 9, LI-P′Sn; 10, soft tissue AFH; and 11, interlabial gap.

in overbite was 1.59 mm (mean final overbite of −3.10 mm), with spontaneous closure of the AOB in only four subjects.

The maxillary and mandibular incisors showed greater extrusion, retrusion, and lingual tipping than the control group, with a statistically significant difference for all measurements. In the control group, the maxillary and mandibular incisors also extruded but to a lesser extent than in the treated group; the maxillary incisors were mildly tipped to the lingual, whereas the mandibular incisors were mildly tipped labially. The maxillary and mandibular incisors in the control group showed protrusion which differed from the treated group. The treated group had a mean increase in exposure of the maxillary incisors of 2.46 mm, whereas this increase in the control group was limited to 1.72 mm.

The molars did not show a statistically significant difference with regard to eruption or mesial movement. However, despite the lack of statistical significance, the molars in the treated group tended to have slightly greater vertical development than the control group, and also slightly greater mesial movement in relation to the FHp line.

Discussion

This prospective randomized clinical study was conducted on growing patients, and the groups should necessarily present similar chronological and skeletal ages to allow reliable comparison. The initial cephalometric characteristics of both groups should also be similar (Sankey *et al.*, 2000; Basciftci and Karaman, 2002; Iscan *et al.*, 2002; Janson *et al.*, 2003). Although this study did not differentiate or separate patients with a predominantly dental open bite from those with an open bite of skeletal origin, both dental and skeletal characteristics showed no significant differences between the groups at the beginning of treatment/observation (Table 2).

The changes were statistically significant for nine of the 18 dentoalveolar variables ($P < 0.05$; Table 3). The eruption of the maxillary and mandibular molars, as measured by the variables ‘U6 Eruption’ and ‘U6-PP’ and by ‘L6 Eruption’ and ‘L6-GoMe’, respectively, showed changes due to treatment that were not statistically significantly different. This demonstrates that use of the chin cup was not effective for vertical control in this sample of patients. These findings disagree with most studies (Pearson, 1978, 1991; Sankey *et al.*, 2000), yet the difference in methodologies should be taken into account with regard to the intensity and direction of the force delivered by the chin cup, the period of daily and total use, and other factors such as compliance and characteristics of the population examined. The choice of utilization of the chin cup for 14–16 hours daily was adopted to maintain the teeth in occlusion during use and to achieve more uniform compliance. The follow-up period of only 1 year might have prevented the accomplishment of greater outcomes; however, treatment of the control group could not be delayed beyond the mixed dentition period.

One of the few studies corroborating the results of the present investigation was conducted by Ritucci and Nanda (1986), with utilization of the chin cup for at least 12 hours per day, with 500 g of force (250 g per side), directed to the condyle. Those authors concluded that the chin cup controlled downward maxillary displacement, inhibited anterior and posterior vertical maxillary growth, and growth of upper anterior face height; however, they found no changes in the amount of maxillary molar eruption. The modifications in midface growth appear to be adaptational responses to similar alterations in mandibular growth caused directly by the chin cup.

In an earlier controlled study (Wendell *et al.*, 1985), the effects of a chin cup on the mandible and its dentition were evaluated in subjects with a Class III malocclusion. The results showed that absolute mandibular length was reduced by 60 to 68 per cent from the control rate during active treatment and these parameters continued to show a decrease post-treatment. The mandible exhibited less downward displacement relative to the cranial base during treatment and the skeletal profile was improved with treatment. Dental changes indicated that the percentage changes in all of the vertical movements were decreased and an orthopaedic correction occurred, with a more normal dentition displacement into a favourable Class I occlusion.

Measurement of the antero-posterior displacement of the first maxillary molars was carried out in an effort to verify whether the palatal crib would provide greater anterior

Table 2 Comparison of pre-treatment cephalometric measurements.

Cephalometric measurements	Treated group (n = 30)		Control group (n = 30)		P	Significance
	Mean	SD	Mean	SD		
Skeletal						
SNA (°)	83.18	3.54	84.26	2.95	0.207	NS
SNB (°)	77.75	3.06	77.97	3.08	0.775	NS
ANB (°)	5.41	2.56	6.29	2.32	0.167	NS
ALFH (mm)	59.44	4.87	60.40	4.38	0.429	NS
SN.GoGn (°)	36.29	5.11	36.25	4.84	0.972	NS
Dentoalveolar						
U6 Eruption (mm)	15.05	1.69	15.12	1.64	0.888	NS
L6 Eruption (mm)	25.19	2.48	24.79	1.96	0.496	NS
Difference in eruption of molar (mm)	10.13	2.75	9.67	2.04	0.467	NS
Overbite (mm)	−4.07	2.37	−4.58	2.88	0.458	NS
L6-GoMe (mm)	28.43	2.58	27.87	2.04	0.353	NS
L1-GoMe (mm)	37.00	2.83	35.34	2.14	0.010	NS
U6-PP (mm)	18.65	1.66	18.78	1.60	0.771	NS
U1-PP (mm)	24.97	3.38	24.27	2.71	0.377	NS
U1.NA (°)	26.87	6.01	26.58	4.67	0.834	NS
U1-NA (mm)	4.06	2.38	3.42	1.71	0.237	NS
L1.NB (°)	34.18	6.28	34.18	3.88	0.990	NS
L1-NB (mm)	6.81	2.81	5.56	2.11	0.058	NS
U6-FHp (mm)	36.37	4.50	36.25	3.07	0.901	NS
L6-FHp (mm)	37.88	4.44	37.82	3.31	0.944	NS
U1-FHp (mm)	73.25	4.90	70.90	3.91	0.042	NS
L1-FHp (mm)	67.80	4.78	65.89	3.98	0.093	NS
Expo U1 (mm)	0.34	1.94	−0.52	1.68	0.071	NS
Interincisor (°)	112.70	8.31	113.80	6.24	0.563	NS
Soft tissue						
H.NB (°)	17.08	4.38	16.08	3.92	0.359	NS
Nasolabial (°)	109.51	11.93	109.90	14.67	0.908	NS
Mentolabial (°)	4.23	1.07	3.81	1.09	0.146	NS
Sn-ES (mm)	25.58	2.85	25.54	2.37	0.957	NS
Gl.Sn.P′ (°)	16.15	5.57	15.06	5.52	0.443	NS
Sn-Gl vertical (mm)	5.65	4.87	4.33	4.10	0.261	NS
P′-Gl vertical (mm)	−4.18	8.20	−5.76	6.35	0.409	NS
LS-P′Sn (mm)	6.76	2.21	6.14	2.22	0.287	NS
LI-P′Sn (mm)	5.93	3.02	4.76	1.90	0.078	NS
Soft AFH (mm)	72.75	5.07	70.50	5.58	0.108	NS
Interlabial gap (mm)	1.76	1.47	1.57	0.96	0.551	NS

SD, standard deviation; NS, not significant.

displacement of the maxillary arch, secondary to tongue pressure on the crib and lead to a Class II relationship, as stated by Justus (2001). Neither the maxillary (U6-FHp) nor the mandibular (L6-FHP) molars showed any statistically significant difference in mesial movement compared with the untreated group, corroborating the maxillary results of Ritucci and Nanda (1986) and demonstrating that the Class I relationship was maintained. Sankey *et al.* (2000) also reported in their study, that molar relationship remained essentially unchanged after treatment with a Crozat/lip bumper, a bonded palatal expander, lip seal exercises and high-pull chin cup.

Dentoalveolar changes at the anterior region of the dental arches are factors that usually lead to correction of AOB malocclusions (Iscan *et al.*, 2002). In the present study, all variables that were statistically significant between the groups were related to dentoalveolar changes at the anterior region of the dental arches.

In the vertical direction, the treated group showed more extrusion of the maxillary and mandibular incisors (U1-PP and L1-GoMe), and an increase in overbite in addition to greater exposure of the maxillary incisors (Expo U1). These effects may be related to the palatal crib whose function is to interrupt sucking and thrusting habits, which limit the normal vertical development at the anterior region (Almeida *et al.*, 1998). Nevertheless, despite the chin cup and the palatal crib being two separate appliances, they were used concurrently, so that it was not possible to determine whether the dentoalveolar changes or the proportion thereof occurred as a result of which appliance.

For the treated group, the maxillary and mandibular incisors showed statistically significantly greater lingual tipping (U1.NA, L1.NB and Interincisor) with more retrusion (U1-NA and L1-NB). These modifications may be due to normalization of functions such as swallowing, lip

Table 3 Comparison of cephalometric changes between the groups.

Cephalometric-measurements	Treated group (*n* = 30)		Control group (*n* = 30)		*P*	Significance
	Mean	SD	Mean	SD		
Skeletal						
SNA (°)	−0.05	2.24	−0.41	2.39	0.557	NS
SNB (°)	0.30	1.71	0.03	1.76	0.544	NS
ANB (°)	−0.32	1.51	−0.44	2.06	0.805	NS
ALFH (mm)	0.32	1.56	0.87	2.20	0.273	NS
SN.GoGn (°)	−0.57	2.03	−0.05	2.00	0.321	NS
Dentoalveolar						
U6 Eruption (mm)	0.92	1.52	0.25	1.03	0.058	NS
L6 Eruption (mm)	1.00	1.26	0.92	1.01	0.770	NS
Difference in eruption of molar (mm)	0.09	1.99	0.68	1.57	0.200	NS
Overbite (mm)	3.86	1.85	1.59	1.48	0.000	*
L6-GoMe (mm)	1.06	1.31	0.84	1.03	0.470	NS
L1-GoMe (mm)	2.43	1.11	1.58	1.10	0.002	*
U6-PP (mm)	0.88	1.55	0.26	1.13	0.080	NS
U1-PP (mm)	2.33	1.39	1.08	0.90	0.001	*
U1.NA (°)	−6.13	5.96	−0.21	4.21	0.000	*
U1-NA (mm)	−0.69	2.89	0.81	1.59	0.012	*
L1.NB (°)	−3.18	3.98	0.12	2.67	0.003	*
L1-NB (mm)	−0.40	1.27	0.38	0.77	0.008	*
U6-FHp (mm)	4.84	5.06	4.28	4.59	0.654	NS
L6-FHp (mm)	4.70	5.68	4.19	4.70	0.702	NS
U1-FHp (mm)	3.51	5.27	5.22	4.55	0.183	NS
L1-FHp (mm)	4.06	5.61	5.31	4.73	0.352	NS
Expo U1 (mm)	2.46	1.60	1.72	1.22	0.042	*
Interincisor (°)	9.66	6.88	0.43	5.85	0.000	*
Soft tissue						
H.NB (°)	−0.17	2.32	−0.59	2.30	0.483	NS
Nasolabial (°)	−0.33	9.99	−0.08	8.55	0.914	NS
Mentolabial (°)	0.36	1.12	0.28	1.00	0.778	NS
Sn-ES (mm)	0.04	1.57	−0.39	1.41	0.277	NS
Gl.Sn.P′ (°)	0.47	2.88	0.14	2.64	0.649	NS
Sn-Gl vertical (mm)	3.53	5.37	4.67	4.46	0.371	NS
P′-Gl vertical (mm)	5.66	9.78	7.94	7.91	0.323	NS
LS-P′Sn (mm)	−0.04	1.18	0.12	1.17	0.602	NS
LI-P′Sn (mm)	0.13	1.56	0.13	1.62	0.990	NS
Soft AFH (mm)	1.29	2.56	1.30	2.69	0.981	NS
Interlabial gap (mm)	0.19	2.39	0.93	2.49	0.242	NS

SD, standard deviation; NS, not significant; *$P \leq 0.05$.

seal, elimination of tongue or lip thrusting, and sucking habits, encouraged by the palatal crib (da Silva Filho *et al.*, 1991), who obtained excellent results using the classic palatal crib. Uprighting of the maxillary incisors was attributed to wear of the acrylic palate and activation of the labial archwire.

With regard to the mandibular incisors, the force vector of the chin cup, i.e. 45 degrees upward in relation to the occlusal plane, was recorded as this may have influenced uprighting of these teeth. Modifications of mandibular growth can be attributed to a significant chin cup effect such as those exerted by the reverse-pull face mask to the maxilla, when used in the treatment of Class III malocclusions (Battagel and Orton, 1995; Gallagher *et al.*, 1998; Kajiyama *et al.*, 2004). However, Iscan *et al.* (2002), studying the effects of vertical chin cup therapy on mandibular morphology in AOB patients, found nearly the same amount of mandibular incisor retrusion in the treated and control groups, although the greater eruption of these teeth played an important role in correcting the open bites in the vertical chin cup group.

Some skeletal measurements were utilized to assess the possible vertical and horizontal changes due to AOB treatment. The antero-posterior position of the maxilla was measured by SNA; for the mandible, SNB was used; and for their interrelationship, ANB. LAFH and the mandibular plane angle (SN.GoGn) were also evaluated. The results were not statistically significant between the treated and the control group.

The findings of the present research are in part contrary to some previous studies. Iscan *et al.* (2002), using vertical chin cups, found a significant decrease of mandibular plane angle and gonial angle closure, indicating anterior rotation of the mandible, as a result of the inhibition of vertical growth in the mandibular posterior dentoalveolar region.

Sankey*et al.* (2000), treating hyperdivergent phenotype patients with a Crozat/lip bumper, a bonded palatal expander, lip seal exercises and high-pull chin cup, found that the maxillary molars presented relative intrusion, the gonial angle decreased and the mandible rotated forward, with an improvement of antero-posterior chin position. Even using the banded palatal expander, there was no increase in the mandibular plane angle. Those authors found that the ANB angle decreased significantly during treatment, particularly due to the significant increase in SNB angle, but no significant alteration was noticed in SNA angle. Moreover, none of the face height measurements showed significant group differences, although there was a tendency for anterior face heights to decrease and posterior face heights to increase in the treated group. Wendell *et al.* (1985), studying the effects of chin cup therapy in preadolescents and adolescents with mandibular prognathism, reported that the gonial and mandibular plane angles closed with growth in the Class III control sample but were variable and difficult to evaluate in the treatment group.

Evaluation of the soft tissue profile in the treated group is important, since studies have demonstrated poor acceptance by subjects with a hyperdivergent facial pattern, such as individuals presenting an AOB (De Smit and Dermaut, 1984). However, little has been reported on the changes in the soft tissue profile secondary to treatment of an AOB.

Eleven variables were used in an attempt to understand the possible changes in different aspects of the face, such as convexity, naso- and mentolabial angles, upper lip length, increase in soft tissue pogonion, lip protrusion, increase in LAFH, and modifications in interlabial space (Table 3). Comparison between the groups revealed that no variable related to the soft tissue profile was statistically significantly different. Since treatment resulted in remarkable benefits to the patients, especially in the anterior region with significant dentoalveolar changes, such changes were expected to be reflected, at least partly, in the soft tissue profile. However, this was not observed.

Clinical significance

In current orthodontics, correction of an AOB is not restricted to only one treatment protocol, or to a certain appliance; several appliances are recommended for treatment. Nevertheless, there are controversies concerning the dentoskeletal/soft tissue effects and in relation to the mechanisms of action of the different therapeutic approaches. Often, definition of the treatment plan is also established by cephalometric and facial analyses.

Analysis of the outcomes demonstrated that the expected effects of vertical control by the chin cup did not occur since there were no differences in molar extrusion or hard or soft tissue LAFH. However, the dentoalveolar effects in the anterior region, probably mainly due to the use of the palatal crib, were noticeable, but they did not result in statistically significant changes in the soft tissue profile.

The mean overbite in the control group was reduced by only 1.59 mm, resulting in open bite closure in only four individuals (13.5 per cent). This may be due to the smaller overbite of these subjects at the start of the evaluation (from −1 to −1.90 mm) or to more favourable facial growth patterns. The effects of cranio-facial growth and development in the control group of AOB patients who had not undergone any treatment were constant, maintaining the malocclusion and showing an intervention need in 26 of the 30 patients. The period of application of the treatment protocol seemed to be ideal; a mean age of 8 years is more acceptable to use removable appliances and the possibility of stability is also more favourable. According to Haryett *et al.* (1970), stability in children in the mixed dentition reaches 85 to 90 per cent when they are treated early with a palatal crib and followed-up for 3 years.

No previous clinical investigation has evaluated the treatment effects of a removable appliance with a palatal crib associated with vertical chin cup therapy and compared with a similar control group. Only one study (Erbay *et al.*, 1995) addressed early correction with a removable appliance of a skeletal AOB in mixed dentition patients, while having an adequate sample size and a matched control group. Those authors evaluated the results of AOB treatment with the Fränkel 4 appliance and exercises to improve lip seal in the mixed dentition. Evaluation of the results after 2 years of treatment showed that there were significant facial skeletal changes, maxillary and mandibular increases, and correction of the AOB. However, the present findings showed that, in a 12-month period, the treatment protocol resulted in an increase of overbite in all treated individuals. However, only anterior dental effects were found, whereas Erbay *et al.* (1995) observed skeletal effects.

The mean overbite reduction in the treated group was 3.86 mm, providing correction of the AOB in 24 individuals (80 per cent). The lack of correction of the negative overbite in six individuals was due to greater severity at the start of treatment (from −4.6 to −7.6 mm). However, the overbite remaining in these subjects ranged from −0.4 to −1.2 mm, demonstrating the success of treatment.

Despite maximum control of patient compliance in appliance wear, it should be noted that they were removable and thus the outcomes cannot be extrapolated to treatment with fixed appliances. The follow-up period was only 1 year, and thus further studies are required to evaluate the long-term stability of treatment, although comparison with the control group will not be possible once such children have been treated. Concerning the vertical control in subjects with AOB, changes in methodology, as well as a longer period of utilization of the chin cup, and use of bite-blocks or associated chewing exercises, would be interesting to investigate in future studies. The present findings suggest that the dentoalveolar changes at the anterior region of the dental arches were mainly responsible for closure of the AOB in patients treated in the mixed dentition with a palatal crib associated with chin cup therapy.

Conclusions

Twelve months treatment with a palatal crib and chin cup therapy resulted in the following changes:

1. Statistically significant extrusion of the incisors, as well as an increase in overbite and exposure of the maxillary incisors.
2. Greater uprighting and retrusion of the incisors, with a statistically significant difference compared with the controls.
3. No statistically significant changes in the level of eruption of the molars, with no real or relative intrusion of these teeth.
4. No statistically significant skeletal changes, or significant growth inhibition of LAFH, closure of the mandibular plane angle or SNA/SNB modification.
5. No statistically significant difference in soft tissue profile.
6. Mesialization of molars was not statistically significant.
7. No variation was found between genders in either group.

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References

Almeida R R, Henriques J F C, Almeida M R, Vasconcelos M H F 1998 Early treatment of anterior open bite-prevention of orthognathic surgery. In: Davidovitch Z, Mah J (eds) Biological mechanisms of tooth eruption, resorption and replacement by implants. Harvard Society for the Advancement of Orthodontics, Boston, pp. 585−588

Almeida R R, Ursi W J S 1990 Anterior open bite. Etiology and treatment. Oral Health 80: 27–31

Baccetti T, Franchi L, McNamara Jr J A 2002 An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthodontist 72: 316–323

Basciftci F A, Karaman A I 2002 Effects of a modified acrylic bonded rapid maxillary expansion appliance and vertical chin cap on dentofacial structures. Angle Orthodontist 72: 61–71

Battagel J M, Orton H S 1995 A comparative study of the effects of customized facemask therapy or headgear to the lower arch on the developing Class III face. European Journal of Orthodontics 17: 467–482

Baumrind S, Frantz R C 1976 The reliability of head film measurements 3. Tracing superimposition. American Journal of Orthodontics 70: 617–644

Cangialosi T J 1984 Skeletal morphologic features of anterior open bite. American Journal of Orthodontics 85: 28–36

Chevitarese A B A, Della Valle D, Moreira T C 2002 Prevalence of malocclusion in 4-6 year Brazilian children. Pediatric Dentistry 27: 81–85

Dahlberg G 1940 Statistical methods for medical and biological students. George Allen and Unwin, London, pp. 122–132

da Silva Filho O G, Gomes Gonçalves R J, Maia F A 1991 Sucking habits: clinical management in dentistry. Pediatric Dentistry 15: 137–156

De Smit A, Dermaut L 1984 Soft-tissue profile preference. American Journal of Orthodontics 86: 67–73

English J D 2002 Early treatment of skeletal open bite malocclusions. American Journal of Orthodontics and Dentofacial Orthopedics 121: 563–565

Erbay E, Ugur T, Ülgen M 1995 The effects of Fränkel's function regulator (FR-4) therapy on the treatment of Angle Class I skeletal anterior open bite malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics 108: 9–21

Gallagher R W, Miranda F, Buschang P H 1998 Maxillary protraction: treatment and posttreatment effects. American Journal of Orthodontics and Dentofacial Orthopedics 113: 612–619

Haas A J 1980 A biological approach to diagnosis, mechanics and treatment of vertical dysplasia. Angle Orthodontist 50: 279–300

Haryett R D, Hansen M S W, Davidson P O 1970 Chronic thumbsucking. A second report on treatment and its psychological effects. American Journal of Orthodontics 57: 164–178

Hering K, Ruf M, Pancherz H 1999 Orthodontic treatment of openbite and deepbite high-angle malocclusions. Angle Orthodontist 69: 470–477

Huang G J, Justus R, Kennedy D B, Kokich V G 1990 Stability of anterior open bite treated with crib therapy. Angle Orthodontist 60: 17–25

Insoft M D, Hocevar R A, Gibbs C H 1996 The nonsurgical treatment of a Class II open bite malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics 110: 598–605

Iscan H N, Dinçer M, Gültan A, Meral O, Taner-Sarisoy L 2002 Effects of vertical chincup therapy on the mandibular morphology in open-bite patients. American Journal of Orthodontics and Dentofacial Orthopedics 122: 506–511

Janson G, Valarelli F P, Henriques J F C, Freitas M R, Cançado R H 2003 Stability of anterior open bite nonextraction treatment in the permanent dentition. American Journal of Orthodontics and Dentofacial Orthopedics 124: 265–276

Justus R 2001 Correction of anterior open bite with spurs: long-term stability. World Journal of Orthodontics 2: 219–231

Kajiyama K, Murakami T, Suzuki A 2004 Comparison of orthodontic and orthopedic effects of a modified maxillary protractor between deciduous and early mixed dentitions. American Journal of Orthodontics and Dentofacial Orthopedics 126: 23–32

Kuhn R 1968 Control of anterior vertical dimension and proper selection of extraoral anchorage. Angle Orthodontist 38: 340–349

Kuster R, Ingervall B 1992 The effects of treatment of skeletal open bite with two types of bite-blocks. European Journal of Orthodontics 14: 489–499

Ngan P, Fields H W 1997 Open-bite: a review of etiology and management. Pediatric Dentistry 19: 91–98

O'Reilly M T, Yanniello G J 1988 Mandibular growth changes and maturation of cervical vertebrae-a longitudinal cephalometric study. Angle Orthodontist 58: 179–184

Pearson L E 1978 Vertical control in treatment of patients having backward-rotational growth tendencies. Angle Orthodontist 48: 132–140

Pearson L E 1991 Treatment of a severe openbite excessive vertical pattern with an ecletic non-surgical approach. Angle Orthodontist 61: 71–76

Ritucci R, Nanda R 1986 The effect of chin cup therapy on the growth and development of the cranial base and midface. American Journal of Orthodontics and Dentofacial Orthopedics 90: 475–483

Sankey W, Buschang P, English J D, Owen III A H 2000 Early treatment of vertical skeletal dysplasia: the hyperdivergent phenotype. American Journal of Orthodontics and Dentofacial Orthopedics 118: 317–327

Spyropoulos M N 1985 An early approach for the interception of skeletal open bites: a preliminary report. Journal of Pedodontics 9: 200–209

Wendell P D, Nanda R, Sakamoto T, Nakamura S 1985 The effects of chin cup therapy on the mandible: a longitudinal study. American Journal of Orthodontics 87: 265–274

Woods M G, Nanda R S 1991 Intrusion of posterior teeth with magnets: an experiment in non-growing baboons. American Journal of Orthodontics and Dentofacial Orthopedics 100: 393–399

Worms F W, Meskin L H, Isaacson R J 1971 Open-bite. American Journal of Orthodontics 59: 589–595