ORIGINAL ARTICLE

Comparison of 2 early treatment protocols for open-bite malocclusions

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Introduction: The aim of this study was to compare the effects of the quad-helix/crib (Q-H/C) appliance and the open-bite bionator (OBB) in patients with open-bite malocclusions. The Q-H/C sample included 21 subjects, 15 girls and 6 boys. The average age for the Q-H/C group before treatment (T1) was 8.4 ± 1.4 years, the mean age 1 year after active treatment (T2) was 10.9 ± 1.6 years, and the mean duration of treatment was 2.6 years ± 9 months. The OBB sample contained 20 subjects, 9 girls and 11 boys. The average ages were 8.3 years ± 10 months at T1 and 10.8 ± 1.5 years at T2. The mean duration of observation was 2.5 ± 1.2 years. Lateral cephalograms were analyzed at T1 and T2. The T2 to T1 changes in the 2 groups were compared with a nonparametric test for independent samples (Mann-Whitney U test). The comparison between the 2 treatment protocols for skeletal open-bite malocclusion showed that the Q-H/C appliance is significantly more effective than the OBB for the improvement of overbite (+1.9 mm) in association with extrusion (+1.5 mm) and palatal inclination (+2.9°) of the maxillary incisors. (Am J Orthod Dentofacial Orthop 2007;132:743-7)

An anterior open bite is not a rare finding in a growing patient. Epidemiologic data report that 1 of 20 subjects in the mixed dentition has a negative overbite.[1,2] Cephalometric investigations have shown that most anterior open-bite subjects have increased dentoalveolar and skeletal vertical dimensions.[3-5] From a clinical point of view, open bites associated with excessive vertical skeletal dimensions are difficult to treat and tend to relapse.[6,7] Treatment of vertical dysplasias during the early developmental ages has been advocated to reduce the burden of treatment in the permanent dentition,[8-11] when surgery becomes an option needed frequently.

An open bite develops as a result of interaction of many etiologic factors, both hereditary and environmental. Prolonged sucking habits and hyperdivergent facial characteristics are significant risk factors for anterior open bite in the mixed dentition.[12] Abnormal tongue posture (frequently associated with enlarged adenoids or tonsils) and tongue thrust also can be involved in the establishment of alveolar and skeletal discrepancies concurrent with vertical problems.[13-15]

Several treatment approaches can be found in the literature with regard to early treatment of open bite.[16-21] These treatment modalities include mainly functional or fixed appliances, with the goals of impeding mechanical factors that maintain anterior open bite (thumbsucking or tongue thrust) and limiting excessive vertical growth of the craniofacial skeletal components. This can be achieved with bite-block mechanisms, grids, or shields for the tongue.

Two proposed protocols for the early treatment of open-bite malocclusions are the open-bite bionator (OBB)[19] and the quad-helix/crib (Q-H/C) appliances.[21] The bionator is a removable functional appliance with shields for the tongue and posterior bite blocks. Weinbach and Smith[19] studied the effects of the OBB and reported good control of the vertical dimension. The results of a recent longitudinal study on the Q-H/C appliance in growing subjects with dentoskeletal open bite showed its clinical effectiveness in correcting the dental open bite in 90% of patients, in association with clinically significant improvement in vertical skeletal relationships compared with a control group of untreated open-bite subjects.[21]

Our aim in this study was to compare the therapeutic effects of the OBB with those of the Q-H/C as

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Submitted, October 2005; revised and accepted, November 2005.
0889-5406/$32.00

doi:10.1016/j.ajodo.2005.11.045

alternative treatment protocols in growing patients with open-bite malocclusions.

MATERIAL AND METHODS

In this prospective study, the Q-H/C sample was obtained from a group of consecutively treated patients from the orthodontic practice of the first author (P.C.), whereas the OBB sample comprised patients consecutively treated at the Department of Orthodontics of the University of Florence in Italy. Lateral cephalograms of all patients were analyzed regardless of treatment results. The patients had the following features: (1) skeletal open bite as derived from the cephalometric analysis before treatment (T1), and the mandibular plane angle relative to the Frankfort horizontal (MPA) 25° or greater[7]; (2) no permanent teeth extracted before or during treatment; (3) 2 consecutive lateral cephalograms of good quality with adequate landmark visualization and with minimal or no rotation of the head taken at T1 and 1 year after active treatment (T2); and (4) prepubertal stage of skeletal maturity both at T1 and T2 (according to the cervical vertebral maturation method).[7]

The Q-H/C sample consisted of 21 subjects, 15 girls and 6 boys. Their average age at T1 was 8.4 ± 1.4 years, the mean age at T2 was 10.9 ± 1.6 years, and the mean duration of treatment interval was 2.6 years ± 9 months. The sample included 9 subjects with Class I occlusion, 11 subjects with Class II malocclusion, and 1 subject with Class III malocclusion.

The OBB sample consisted of 20 subjects, 9 girls and 11 boys. The average ages were 8.3 years ± 10 months at T1 and 10.8 year ± 1.5 years at T2. Themean duration of observation was 2.5 ± 1.2 years. The sample included 5 subjects with Class I occlusion, 14 subjects with Class II malocclusion, and 1 subject with Class III malocclusion.

The Q-H/C used in this study (Fig 1) was made of .036-in stainless steel wire soldered to bands on the second deciduous molars or the first permanent molars. The lingual arms of the appliance were extended mesially to the deciduous canines or even to the permanent incisors. The anterior helices were brought as far forward on the palate as possible.

Spurs for inhibition of tongue thrust were formed from 3 segments of .036-in stainless steel wire soldered to the anterior bridge of the quad-helix. The wire segments were inclined lingually to avoid impingement on the sublingual mucosa.[22] Activation of the Q-H/C was equivalent to the buccolingual width of 1 molar.

The appliance was worn for an average of 18 months. The patients received no active treatment until T2.

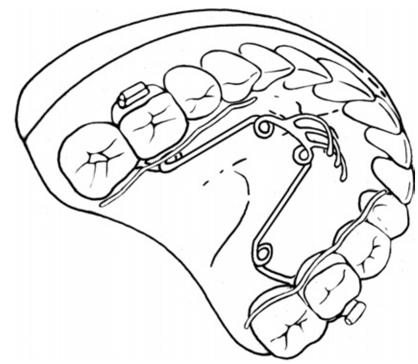

Fig 1. The quad-helix appliance with the crib for the tongue.

The OBB (Fig 2) has posterior acrylic bite blocks to prevent extrusion of the posterior teeth.[23] The acrylic portion of the lower lingual part extents into the maxillary incisor region as a lingual shield, closing off the anterior space without touching the maxillary teeth. This portion of the appliance is intended to inhibit tongue movement.

The palatal bar has the same configuration as in the standard bionator to move the tongue into a more posterior or caudal position. The labial bow is placed at the height of correct lip closure, thus stimulating the lips to achieve a competent seal.

Similarly to the Q-H/C protocol, the OBB was worn full time for an average of 18 months. Thereafter, the patients had no retention until T2, with the exception of a few patients who continued to use the OBB at night only.

The T1 and T2 cephalograms were hand traced by 1 investigator (L.F.), and another investigator (T.B.) verified landmark locations. Any disagreements were resolved by retracing the landmark or structure to the satisfaction of both observers. Cephalometric software (Viewbox, version 3.0; dHAL Software, Kifissia, Greece) was used for a customized digitization regimen that included 78 landmarks and 4 fiducial markers. This program allowed for analysis of cephalometric data and superimposition of serial cephalograms according to the specific needs of this study.

The lateral cephalograms of each patient at T1 and T2 were digitized, and 50 variables were generated for each film. The magnification factor was standardized at 10%. A cephalometric and regional superimposition analysis was performed on each cephalogram.[20]

The cranial base superimpositions were accomplished by aligning the basion-nasion line and registering at the most posterosuperior aspect of the pterygomaxillary fissure. In addition, the posterior cranial

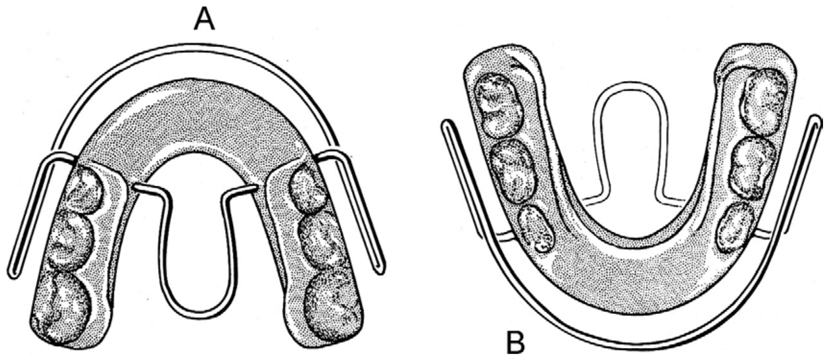

Fig 2. The OBB: **A,** maxillary occlusal view with interocclusal acrylic; **B,** mandibular view showing relief in the mandibular lingual region. Modified and reprinted with permission from McNamara and Brudon[7].

outline was used to verify the superimposition of the cranial base structures. From this superimposition, the changes in the positions of the maxilla and the mandible were measured. To superimpose the maxilla along the palatal plane, the superior and inferior surfaces of the hard palate and the internal structures of the maxilla superior to the incisors were used as landmarks. From this superimposition, the movement of the maxillary incisors and the molars in the maxilla could be assessed. The mandibular superimposition was performed by using the mandibular canal and the tooth germs posteriorly and the internal structures of the symphysis and the anterior contour of the chin anteriorly. This superimposition allowed the measurement of movement of the mandibular teeth.

Statistical analysis

The cephalometric starting forms and the T2 to T1changes (Table) in the 2 groups were compared with nonparametric tests for independent samples (Mann-Whitney U test). Because of the sample sizes in the groups, differences between treatment group effects with regard to changes in dentoskeletal dimensions were considered clinically significant if they were equal or greater than 1.5 mm or 1.5° (statistical power of the study = 0.83 on the basis of the values for intermaxillary vertical relationships).

The data were analyzed with software (version 12.0; SPSS, Chicago, Ill).

The error of the method was evaluated on 20 cephalograms that were retraced and remeasured 1 month later. No systematic error was found.[24] The estimate of random errors was made with Dahlberg's formula.[24] The errors for linear measurements ranged from 0.1 mm for pogonion to nasion perpendicular to 1.2 mm for condylion-gonion. The errors for angular measurements ranged from 0.4° for the ANB angle to 1.4° for the interincisal angle.

RESULTS

No significant differences were found between the 2 appliance groups for any examined cephalometric variable at T1 (Table). The only exception was the amount of negative overbite that was larger in the Q-H/C group.

There were no significant differences between the 2 groups for any measurements in either the sagittal or the vertical plane from T1 to T2. The Q-H/C group showed a significantly greater increase in overbite (1.9 mm more than in the OBB group) that was associated with a significantly greater amount of extrusion of the maxillary incisors (1.5 mm more than in the OBB group). No other statistically significant differences were found.

DISCUSSION

Open bite is a challenging malocclusion for the orthodontic practitioner. Early treatment of vertical dysplasia during the deciduous or the mixed dentition period has been advocated to reduce the need for treatment in the permanent dentition.[16-21] Our aim was to compare the therapeutic changes of 2 treatment protocols for early intervention in open-bite patients—the Q-H/C and the OBB. Both protocols have components to inhibit aberrant tongue function, either a crib or an acrylic shield. The Q-H/C is a fixed appliance; the OBB is removable. The requirement for the patient's compliance, therefore, is different for the 2 protocols. Furthermore, the overall observation period included a treatment interval and a postttreatment period. All patients were examined after active treatment followed by approximately 1 year without orthodontic intervention.

Table. Comparison of T2 to T1 changes

	OBB group (n = 20)		*Q-H/C group (n = 21)*			
Cephalometric measurements	*Mean*	*SD*	*Mean*	*SD*	*Difference*	*Significance*
Maxillary skeletal						
SNA angle (°)	−0.6	1.6	−0.1	2.2	−0.5	NS
Point A to N perp (mm)	0.8	2.6	0.2	2.4	0.6	NS
Co-Point A (mm)	3.2	2.8	3.5	2.7	−0.3	NS
Mandibular skeletal						
SNB angle (°)	0.1	1.3	0.5	1.7	−0.4	NS
Pg to N perp (mm)	2.6	5.5	1.8	3.7	0.8	NS
Co-Gn (mm)	6.1	3.9	6.7	2.9	−0.6	NS
Maxillary/mandibular						
ANB angle (°)	−0.7	1.5	−0.6	1.4	−0.1	NS
Wits (mm)	1.3	2.7	0.0	2.1	1.3	NS
Maxillary/mandibular difference (mm)	2.9	2.1	3.1	1.7	−0.2	NS
Vertical skeletal						
Frankfor horizontal to palatal plane (°)	0.2	2.7	1.1	2.2	−0.9	NS
MPA (°)	−1.1	3.2	−0.9	1.9	−0.2	NS
Palatal plane to mandibular plane (°)	−1.2	1.8	−2.0	2.4	0.8	NS
N-ANS (mm)	3.9	2.3	4.6	1.8	−0.7	NS
ANS to Me (mm)	2.3	2.4	2.9	2.2	−0.6	NS
N-Me (mm)	6.4	4.0	6.5	2.8	−0.1	NS
Co-Go (mm)	2.7	2.2	2.8	1.9	−0.1	NS
Gonial angle (°)	−0.4	2.2	−1.7	1.9	1.3	NS
Interdental						
Overjet (mm)	−0.7	1.5	−1.4	2.4	0.7	NS
Overbite (mm)	2.7	2.6	4.6	2.1	−1.9	*
Interincisal angle (°)	4.4	5.4	6.8	7.0	−2.4	NS
Molar relationship (mm)	0.5	1.3	0.8	1.5	−0.3	NS
Maxillary dentoalveolar						
U1 to Point A vertical (mm)	0.5	1.4	−0.2	1.6	0.7	NS
U1 to Frankfort horizontal (°)	−2.0	4.1	−4.9	5.7	2.9	NS
U1 horizontal (mm)	1.7	1.4	1.0	2.5	0.7	NS
U1 vertical (mm)	2.1	1.4	3.6	1.9	−1.5	†
U6 horizontal (mm)	1.5	1.9	1.9	1.6	−0.4	NS
U6 vertical (mm)	1.4	1.1	1.7	1.1	−0.3	NS
Mandibular dentoalveolar						
L1 to Point A Pg (mm)	0.2	1.3	0.2	1.6	0.0	NS
L1 to MPA (°)	−1.4	3.3	−1.0	4.6	−0.4	NS
L1 horizontal (mm)	0.3	1.4	0.4	1.2	−0.1	NS
L1 vertical (mm)	2.8	1.3	3.3	1.4	−0.5	NS
L6 horizontal (mm)	0.9	1.6	0.2	1.5	0.7	NS
L6 vertical (mm)	2.6	2.1	2.7	1.4	−0.1	NS
Soft tissue						
Upper lip to E plane (mm)	1.5	2.9	1.8	1.5	−0.3	NS
Lower lip to E plane (mm)	1.0	6.1	2.0	5.2	−1.0	NS
Nasolabial angle (°)	1.7	9.1	−0.1	7.5	1.8	NS

Perp, Perpendicular; *U1,* maxillary central incisor; *U6,* maxillary first molar; *L1,* mandibular central incisor; *L6,* mandibular first molar.
**P* <.05; †*P* <.01; *NS,* not significant.

The 2 protocols produced similar modifications from a skeletal point of view, on both the sagittal and the vertical planes. Although not statistically significant, some comparisons of the skeletal vertical changes should be elucidated further. The Q-H/C appliance induced a clinically significant favorable change in intermaxillary vertical relationships (a 2.0° reduction from T2 to T1) with an average downward rotation of the palatal plane to the Frankfort plane of 1.1°. These changes were much more limited in the OBB group. A clinically significant closure of the gonial angle was also found in the Q-H/C group.

The most significant differences between the 2 treatment protocols pertain to the dentoalveolar level.

The Q-H/C induced an average improvement of the overbite of 4.6 mm; the improvement produced by the OBB was 2.7 mm. However, the initial negative overjet was more severe in the Q-H/C group at T1. The main significant contribution to the modification of the overbite was due to significant extrusion of the maxillary incisors in the Q-H/C group (1.5 mm more than in the OBB group). In the Q-H/C group, this favorable change was associated with a clinically significant amount of palatal inclination of the maxillary incisors in relation to the Frankfort plane (about 3.0° more than in the OBB group), and with a clinically significant greater increase in the interincisal angle (2.4° more than in the OBB group). The expected effect of a more limited extrusion of the posterior teeth in the OBB group when compared with the Q-H/C group was not recorded in this study. Weinbach and Smith[19] in their investigation on the effectiveness of the OBB reported restriction in maxillary molar extrusion of about 1.0 mm.

Our findings appear to indicate that a compliance-free appliance such as the Q-H/C can induce more favorable changes in the vertical plane than a removable appliance such as the OBB. The significance of these results is strengthened by a posttreatment period without orthodontic treatment of approximately 1 year. When compared with previous short-term data, the outcomes of Q-H/C therapy showed stability for both dentoalveolar and skeletal vertical modifications.[21]

CONCLUSIONS

This comparison of 2 treatment protocols for open-bite malocclusions showed that the Q-H/C is more effective than the OBB for the improvement of overbite in association with extrusion and palatal inclination of the maxillary incisors.

We thank Giulia Baroni for her assistance in digitizing the cephalograms of the OBB sample.

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