Dentoskeletal changes associated with fixed and removable appliances with a crib in open-bite patients in the mixed dentition

Veronica Giuntini,[a] Lorenzo Franchi,[b] Tiziano Baccetti,[b] Manuela Mucedero,[c] and Paola Cozza[d]
Florence and Rome, Italy

Introduction: The aim of this study was to compare the effects of the quad-helix/crib (Q-H/C) appliance and a removable plate with a crib (RP/C) in patients with dentoskeletal open bite. **Methods:** Both samples consisted of 20 subjects. Lateral cephalograms were analyzed before treatment (T1) and after active treatment (T2). The average age at T1 was 8.4 years, and the mean duration of treatment was 1.5 years in both groups. The T2-T1 changes in the 2 groups were compared with a nonparametric test for independent samples (Mann-Whitney U test). **Results and Conclusions:** Both the Q-H/C and the RP/C appliances induced favorable dental effects. However, a compliance-free appliance, such as the Q-H/C appliance, produced more favorable vertical skeletal changes. (Am J Orthod Dentofacial Orthop 2008;133:77-80)

Sucking habits are frequently involved in the development of or the maintenance of anterior open bite during growth.[1-3] Thumb sucking is a significant risk factor for the establishment of an anterior open bite in subjects with increased vertical skeletal relationships.[4] The same subjects show often transverse discrepancies concurrent with the vertical problems.[5] The correction of maxillary constriction is a main target for treatment in open-bite patients.[6]

The use of a crib has been advocated to stop sucking habits by acting as a digit-inhibiting appliance.[2,7-10] A proposed treatment protocol aimed to eliminate the thumb-sucking habit and to correct both the anterior open bite and the maxillary transverse deficiency in growing high-angle subjects is a quad-helix (Q-H) appliance with the addition of a tongue crib (Q-H/C). The results of a previous longitudinal study showed the clinical effectiveness of the Q-H/C in correcting the dental open bite in 90% of patients.[10] The significant improvement in vertical skeletal relationships was due to downward rotation of the palatal plane. Removable appliances with a crib as a digit-inhibiting device have also been described.[11,12] Recently, the effects of a removable palatal crib associated with a vertical chin-cup were analyzed, and it was found that this treatment protocol did not produce significant changes in the skeletal maxillary and mandibular components; the effects of therapy were primarily dentoalveolar.[13]

Our aim in this longitudinal study was to compare the outcomes of treatment with the Q-H/C appliance with those of a removable plate with crib (RP/C) in growing subjects with thumb-sucking habits and dentoskeletal open bite.

MATERIAL AND METHODS

The Q-H/C sample was obtained from a group of consecutively treated patients from 1 orthodontic practice, whereas the RP/C sample comprised patients treated consecutively at the Orthodontic Clinic of the University of Florence, Italy. Lateral cephalograms of all patients were analyzed regardless of treatment results. The patients (Table I) had the following: thumb-sucking habit before treatment (T1), dentoskeletal open bite at T1 (negative overbite and MPA $\geq 25°$),[3] no permanent teeth extracted before or during treatment, 2 consecutive lateral cephalograms of good quality taken at T1 and posttreatment (T2), and prepubertal skeletal maturity at both T1 and T2 (CS1 or CS2 according to the cervical vertebral maturation method).[14]

The Q-H used in this study was made of .036-in stainless steel wire soldered to bands on the second deciduous molars or the first permanent molars (Fig 1).[10]

[a]Research associate, Department of Orthodontics, University of Florence, Florence, Italy.
[b]Assistant professor, Department of Orthodontics, University of Florence, Florence, Italy; Thomas M. Graber Visiting Scholar, Department of Orthodontics and Pediatric Dentistry, School of Dentistry, University of Michigan, Ann Arbor.
[c]Fellow, Department of Orthodontics, University of Rome "Tor Vergata," Rome, Italy.
[d]Professor and head, Department of Orthodontics, University of Rome "Tor Vergata," Rome, Italy.
Reprint requests to: Lorenzo Franchi, Università degli Studi di Firenze, Via del Ponte di Mezzo, 46-48, 50127, Firenze, Italy; e-mail, lorenzo.franchi@unifi.it.
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Table I. Demographics of treatment times

Treatment group	*T1 (y)*		*T2 (y)*		*T1-T2 (y)*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Q-H/C n = 20 (15 girls, 5 boys): 9 Class I occlusions, 10 Class II malocclusions, 1 Class III malocclusion	8.4	1.4	9.9	1.6	1.5	0.6
RP/C n = 20 (11 girls, 9 boys): 11 Class I occlusions, 9 Class II malocclusions, 1 Class III malocclusion	8.4	1.0	9.8	1.1	1.4	0.4

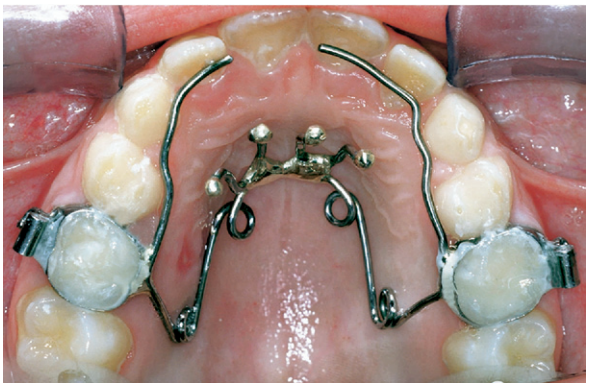

Fig 1. The Q-H/C.

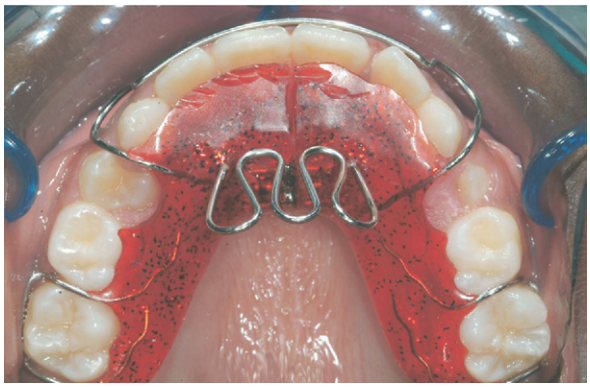

Fig 2. The RP/C.

The lingual arms of the appliance extended mesially to the deciduous canines or even to the permanent incisors. Spurs for inhibition of tongue thrust were formed from 3 segments of .036-in stainless steel wire soldered to the anterior bridge of the Q-H. Activation of the Q-H was equivalent to the buccolingual width of 1 molar. The appliance was worn for an average period of 18 months and was reactivated once or twice during treatment to achieve overcorrection of the transverse relationships.

The removable plate consisted of a modified Schwarz upper plate with Adams clasps on the maxillary first molars and ball clasps between the second and first deciduous molars (Fig 2). Additional components were a midline jackscrew, a crib consisting of loops modeled with 0.036-in stainless steel wire, and a labial wire (0.036-in stainless steel) with loops distal to the maxillary canines. The jackscrew was activated once per week for slow expansion. The appliance was worn at least 16 hours per day for an average period of 16 months. Compliance was good in all patients.

The T1 and T2 cephalograms were hand-traced by an investigator (V.G.) and verified for landmark location by a second (L.F.). 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.

Lateral cephalograms for each patient at T1 and T2 were digitized, and 50 variables were generated for each film. The magnification factor of the cephalograms was standardized at 10%. A regional superimposition analysis[10] was performed on each cephalogram analyzed in the study to investigate dentoalveolar changes in the skeletal bases.

Statistical analysis

The cephalometric starting forms and the T2-T1 changes in the 2 groups were compared with nonparametric tests for independent samples (Mann-Whitney U test, $P < .05$) (SPSS, 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 errors were found.[15] The estimate of random errors was made with Dahlberg's formula.[15] 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 vari-

Table II. Comparison of changes (T2-T1) between the 2 treated groups

	RP/C n = 20		*Q-H/C n = 20*			
Cephalometric measures	*Mean*	*SD*	*Mean*	*SD*	*Difference*	P
Maxillary skeletal						
SNA angle (°)	−0.4	1.8	−0.1	1.0	−0.3	.387
Point A to N perp (mm)	−0.4	1.9	0.7	1.5	−1.1	.014
Co to Point A (mm)	2.2	2.0	2.4	1.9	−0.2	.850
Mandibular skeletal						
SNB angle (°)	0.3	1.3	0.2	1.1	+0.1	.685
Pog to N perp (mm)	0.7	3.1	1.9	2.8	−1.2	.224
Co-Gn (mm)	4.4	2.1	3.8	1.7	+0.6	.417
Maxillary/mandibular						
ANB angle (°)	−0.7	1.2	−0.3	1.3	−0.4	.234
Wits (mm)	0.0	1.9	0.3	2.5	−0.3	.914
Maxillary/mandibular difference (mm)	2.3	1.5	1.4	1.8	+0.9	.194
Vertical skeletal						
FH to palatal plane (°)	1.2	1.6	−0.3	2.0	+1.5	.037
MPA (°)	−0.4	1.5	−0.6	1.6	+0.2	.705
Palatal plane to mandibular plane (°)	−1.6	1.8	−0.4	1.5	−1.2	.033
N-ANS (mm)	2.5	1.3	2.0	1.3	+0.5	.224
ANS to Me (mm)	1.4	1.7	1.4	1.4	0.0	.829
N-Me (mm)	4.0	2.4	3.5	1.7	+0.5	.433
Co-Go (mm)	1.8	1.8	1.5	1.4	+0.3	.978
Gonial angle (°)	−1.0	1.8	−0.2	2.2	−0.8	.267
Interdental						
Overjet (mm)	−1.0	2.5	−0.5	1.1	−0.5	.705
Overbite (mm)	4.1	1.6	3.1	1.8	+1.0	.070
Interincisal angle (°)	11.6	7.5	4.6	8.2	+7.0	.007
Molar relationship (mm)	0.5	1.1	0.2	1.3	+0.3	.402
Maxillary dentoalveolar						
U1 to Point A vertical (mm)	−0.4	1.5	−0.1	1.5	−0.3	.358
U1 to FH	−6.5	5.5	−1.6	6.4	−4.9	.033
U1 horizontal (mm)	0.0	2.0	0.7	1.2	−0.7	.291
U1 vertical (mm)	2.2	1.6	2.1	1.1	+0.1	.685
U6 horizontal (mm)	0.8	1.3	1.2	1.1	−0.4	.213
U6 vertical (mm)	0.8	0.8	1.0	1.0	−0.2	.387
Mandibular dentoalveolar						
L1 to Point A Pog (mm)	−0.3	1.6	−0.6	1.6	+0.3	.626
L1 to MPA (°)	−3.7	4.9	−3.5	4.4	−0.2	.808
L1 horizontal (mm)	−0.5	1.6	−0.3	1.0	−0.2	.589
L1 vertical (mm)	2.2	1.1	2.1	1.0	+0.1	.372
L6 horizontal (mm)	0.5	1.2	0.6	0.7	−0.1	.570
L6 vertical (mm)	1.6	1.4	1.4	1.1	+0.2	.646
Soft tissue						
UL to E plane (mm)	1.8	1.3	0.2	1.6	+1.6	.002
LL to E plane (mm)	2.4	4.8	−0.8	4.0	+3.2	.014
Nasolabial angle (°)	3.1	9.0	0.7	9.3	+2.4	.144

Perp, Perpendicular.

able at T1, with the exception of the position of pogonion relative to nasion perpendicular, which was more protruded in the Q-H/C group, and the nasolabial angle, which was smaller in the Q-H/C group when compared with the RP/C group.

There were no significant differences between the 2 groups for any measures in the sagittal plane of the maxilla and the mandible from T1 to T2 with the exception of Point A to nasion perpendicular, which demonstrated significant decreases in the Q-H/C group when compared with the RP/C group (−1.1 mm) (Table II). The changes in the sagittal intermaxillary relationships were similar in the Q-H/C and the control groups. The Q-H/C group had greater downward rotation of the palatal plane when compared with the RP/C group (1.5°). This change was associated with a significant reduction in the palatal plane-mandibular plane angle (−1.2°) in the Q-H/C group with respect to RP/C group.

The changes in dental relationships were similar in the 2 groups, except the interincisal angle, which showed significantly greater opening in the Q-H/C than in the RP/C group (7.0°) and the inclination of the maxillary incisors to the Frankfort plane, which was significantly smaller in the Q-H/C group than in the RP/C group (4.9°). Both upper and lower lips showed a significant tendency toward retraction relative to the E plane in the Q-H/C group when compared with the RP/C group (1.6 and 3.2 mm, respectively).

DISCUSSION

The prevalence of anterior open bite is 4 times greater in hyperdivergent subjects with prolonged sucking habits than in normal subjects,[4] and vertical disharmony is often associated with transverse occlusal discrepancies such as narrow maxillary arch width and increased prevalence of posterior crossbites.[5] Our aim in this study was to compare the therapeutic changes induced by 2 treatment protocols for early intervention in patients with open-bite malocclusions: the Q-H/C and the RP/C appliances. Both protocols have a crib to inhibit finger sucking and tongue thrust, and an expansion device (either a Q-H or a jackscrew). The Q-H/C appliance is a fixed appliance whereas the RP/C is removable. The requirement for the patient's compliance, therefore, is different for the 2 protocols.

The Q-H/C appliance produced a significantly favorable change in intermaxillary vertical relationships (1.2° greater reduction as a T2-T1 change) in association with a greater downward rotation of the palatal plane to Frankfort plane of 1.5°. Both treatment protocols produced minimal changes in the inclination of the mandibular plane to the Frankfort horizontal.

As for the dentoalveolar changes, the initial amount of negative overbite (a measure of anterior dentoalveolar open bite) was −2.0 mm in both groups. The Q-H/C group showed a greater increase in overbite (1.0 mm), although not statistically significant, with respect to the RP/C group. However, the analysis of data confirmed that the Q-H/C was clinically effective in 90% of patients with dentoalveolar open bite,[10] whereas clinical effectiveness with RP/C treatment protocol was significantly lower (60%, chi-square = 22.43, $P < .001$). Other favorable changes in the Q-H/C group were greater lingual inclination of the maxillary incisors (contributing to closure of the anterior open bite) associated with greater closure of the interincisal angle and greater lip retraction (contributing to the improvement of lip competence).

Our results agree with those of previous investigations that demonstrated the effectiveness of crib wear for anterior open bite closure.[7-10,13] The mean duration of crib wear in our samples was 17 months, which is relatively longer than those reported in the literature.[8,9] However, the clinical recommendation of Huang et al[8] to keep the crib in place for more than a year is substantiated by our findings.

CONCLUSIONS

Both the Q-H/C and the RP/C appliances induced favorable dental effects. However, a compliance-free appliance, such as the Q-H/C, produced more favorable vertical skeletal changes.

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