Comparison of Protraction Facemask Response Using Banded and Bonded Expansion Appliances as Anchorage

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Protraction headgear has been used in combination with various fixed appliances as anchorage to correct Class III malocclusions with maxillary deficiency. The objective of this study was to compare the treatment response of maxillary protraction in combination with either the banded or the bonded rapid palatal expansion appliance. The sample consisted of pre- and posttreatment cephalometric radiographs of 20 patients treated with the banded expansion appliance, 20 patients treated with the bonded expansion appliance, and 20 control patients with no treatment who were matched in sex, age, and skeletal morphology. The average treatment time for the bonded group was 10 ± 2.1 months and the banded group was 9.5 ± 1.9 months. Traditional cephalometric measurements as well as the Pancherz analysis were used to describe the dental and skeletal changes in response to treatment. Data were analyzed using the analysis of variance (ANOVA) and paired *t* test. There were no significant differences in the forward movement of the maxilla between the banded and bonded expansion groups. The forward movement of the maxilla was 1.0 mm and 1.7 mm greater than in the control group, respectively. The full coverage of the occlusal surface by acrylic did not increase the efficiency of forward maxillary movement. Loss of anchorage was found in both treatment groups. The skeletal and dental contributions to the correction of overjet and overbite were quite similar in the two treatment groups. Maxillary expansion and protraction was accompanied by vertical displacement of the maxilla, increase in lower face height, and vertical eruption of posterior molars, irrespective of the type of anchorage appliance. (Semin Orthod 2007;13: 175-185.)

The developing Class III malocclusion is one of the most challenging problems confronting the practicing orthodontist. The protraction facemask in conjunction with a rapid palatal expansion (RPE) appliance has been used to correct patients with maxillary deficiency and/or mandibular prognathism.[1-4] Dramatic skeletal changes can be obtained in animals with continuous protraction forces to the maxilla. Not only is point A affected through forward incisal movement, but also the entire maxilla is displaced anteriorly, with significant effects as far posteriorly as the zygomatico-temporal suture.[5-7]

In clinical studies, most investigators reported a combination of skeletal and dental contributions to overjet correction.,[1-4,8-12] an average of 2 to 3 mm of anterior movement of the maxilla was observed. The mandible is usually positioned downward and backward in response to the changes in the maxilla. This is accompanied by dental changes including proclination of the

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maxillary incisors and retroclination of the mandibular incisors.

The use of palatal expansion in conjunction with maxillary protraction helps to "disarticulate" the maxilla and initiates cellular response in the sutures, allowing a more positive reaction to protraction forces.[1-4,9,10,12,13] The use of a bonded RPE appliance offers several distinct advantages.[10,14,15] This includes reducing the number of appointments since conventional banded appliances require a separate appointment for placement of separators and fitting of orthodontic bands. In deepbite cases, bonded appliances serve as posterior bite blocks to facilitate correction of anterior crossbites. It also reduces buccal crown tipping during expansion due to the rigidity of the appliance framework.

Rapid palatal expansion is frequently accompanied by a downward movement of the maxilla due to the opening of the midpalatal suture.[16,17] but this is not desirable in patients with a hyperdivergent growth pattern and an increased lower face height. Several investigators have reported the possibility of a bite-block effect offered by the bonded expansion appliance.[14,15] Sarver and Johnston reported less inferior and anterior displacement of the maxilla when compared with treatment using the banded rapid expansion appliance.[14] The covering of the occlusal surface may eliminate occlusal interferences during lateral and forward movements of the bony segments and facilitate Class III corrections.

The objective of the present study was to compare the skeletal and dental changes using the banded and bonded RPE appliance as anchorage. It was hypothesized that forward movement of the maxilla would be enhanced by the bonded appliance and that vertical eruption of the posterior molars would be minimized with the bonded appliance.

Methods and Materials

Experimental Groups

The sample consisted of before and after treatment lateral cephalometric radiographs of two groups of patients: 20 patients with skeletal Class III malocclusion (10 boys and 10 girls) treated with a bonded RPE appliance and 20 patients (10 boys and 10 girls) treated with a banded RPE appliance in the Department of Orthodontics, West Virginia University. None of the patients had had previous orthodontic treatment. The mean age of the subjects at the start of treatment for the bonded group was 8.7 ± 1.9 years and of the banded group was 8.2 ± 1.7 years. A selection of cephalometric records describing the dentofacial morphology of the subjects in the two groups before treatment is shown in Table 1.

Table 1. Cephalometric Measurements Describing the Dentofacial Morphology of the Two Experimental Groups before Treatment

	Banded Group				*Bonded Group*				*Group Differences*	
Variables	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*Sig.*
SNA	79.5	3.6	70.0	85.0	81.0	3.1	76.0	87.0	1.5	NS
SNB	80.1	1.8	76.0	83.0	81.2	3.9	74.0	89.0	1.1	NS
ANB	−0.6	1.8	−4.0	3.0	0.1	2.8	−5.0	5.0	0.7	NS
Max incisal angle (lsi-lsa/SN)	105.5	11.0	89.0	122.0	101.9	7.6	85.0	113.5	3.6	NS
Mand incisal angle (lii-lia/ML)	88.3	10.2	72.0	104.0	85.6	4.8	76.0	95.0	2.7	NS
Interincisal angle (lsi-lsa/lii-lia)	131.6	17.5	106.0	162.0	138.7	10.5	118.0	165.0	7.1	NS
Overjet	−2.1	1.3	−4.5	0	−0.1	0.8	−4.0	5.5	2.0	*
Molar relationship	−3.2	2.1	−7.5	0	−0.1	0.8	−8.0	0.5	3.1	*
Wits	−5.0	7.6	−13.0	10.0	−4.1	5.3	−14.0	14.0	0.9	NS
Overbite	3.2	3.0	−3.0	9.0	0.9	2.9	−4.0	6.0	2.3	*
LFH (Lower Face Height)	59.8	2.4	57.0	66.0	62.4	8.8	56.0	74.0	2.6	NS
ML/NSL (Mand Plane Angle)	34.7	5.0	23.0	40.0	33.83	6.7	16.5	48.0	0.9	NS
NL/NSL (Palatal Plane Angle)	10.8	3.5	6.0	19.0	7.8	2.9	0	15.0	3.0	*
OL/OSL (Occlusal Plane Angle)	21.2	6.5	12.5	34.0	17.3	5.3	6.0	24.5	3.9	*

NS, not significantly different; $^{*}P < 0.05$.

Control Group

Twenty untreated Class III patients who were matched for age, sex, and dentofacial morphology were used as the control group. The average age of the control group was 8.3 ± 1.6 years.

Expansion Appliance Design for the Banded Experimental Group

The Hyrax rapid palatal expansion appliance (Fig 1) was constructed by using bands on the posterior teeth. Bands were fitted on the maxillary primary second molars and permanent first molars. These bands were joined by a heavy wire (0.043 inch) to the palatal plate, which had a jackscrew in the midline. The appliance was activated twice daily (0.25 mm per turn) by the patient for 1 week. In patients with a constricted maxilla, activation of the expansion screw was performed for 2 weeks. A 0.045-inch wire was soldered bilaterally to the buccal aspects of the molar bands and extended anteriorly to the canine area.

Expansion Appliance Design for the Bonded Experimental Group

The bonded rapid palatal expansion appliance (Fig 2) was constructed by soldering a wire framework with the Hyrax-type jackscrew. The framework extended around the buccal and lingual surfaces of the dentition, with the wire crossing the occlusion between the primary canines and the primary first molar. The wire also curved around the distal aspect of the permanent first molar. A facemask hook was added in the region of the primary first molar. Acrylic was applied to the occlusal surface around the framework. The appliance was activated in the same manner as the banded appliance.

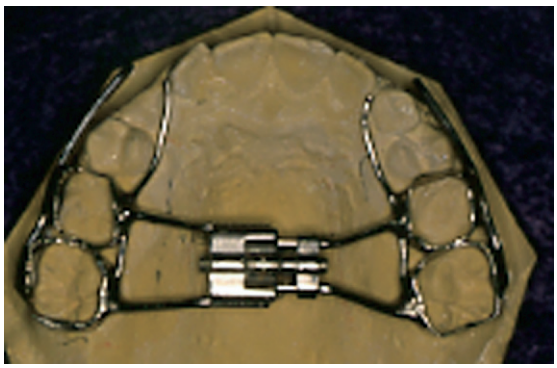

Figure 1. Banded Hyrax expansion appliance. (Color version of figure is available online.)

Figure 2. Bonded palatal expansion appliance. (Color version of figure is available online.)

Protraction Facemask

The facemask (Fig 3) was a one-piece construction with an adjustable anterior wire and hooked

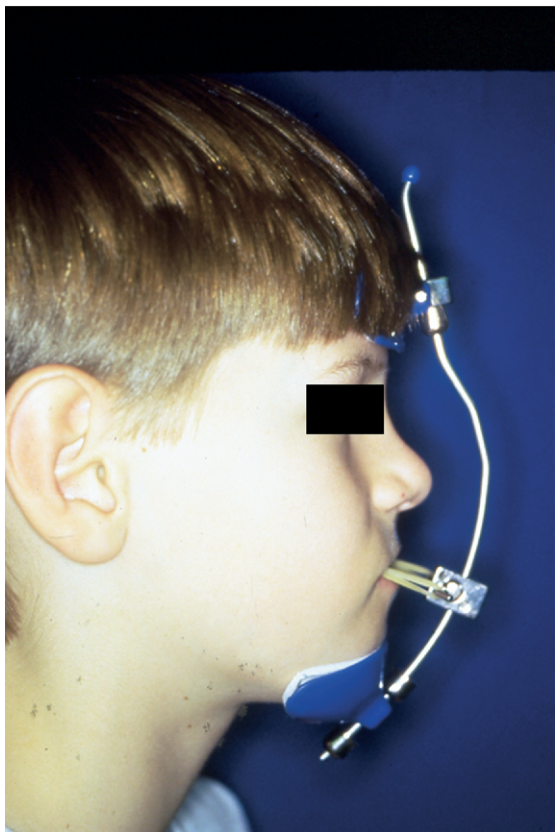

Figure 3. Protraction facemask. (Color version of figure is available online.)

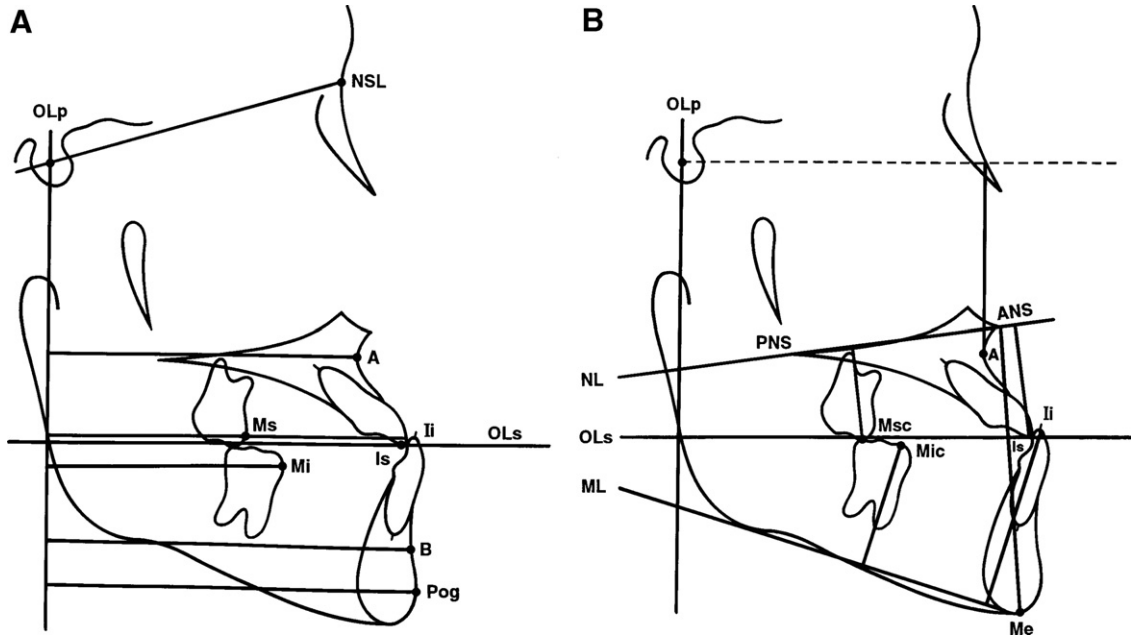

Figure 4. (A) Measuring points used in the cephalometric analysis for sagittal measurements. The registration line NSL (nasion sella line) and reference grid OLs and OLp (occlusal line and occlusal line perpendicular) are shown. A = A point; B = B point; Pog = pogonion; Is = Maxillary incisal tip; Ii = mandibular incisal tip; Ms = mesial buccal cusp contact point of maxillary first molar; Mi = mesial buccal cusp contact point of mandibular first molar. (B) Measuring points used in the cephalometric analysis for vertical measurements. The reference grid OLs and OLp (occlusal plane and occlusal plane perpendicular) is shown. A = A point; Is = maxillary incisal tip; Ii = mandibular incisal tip; Msc = mesial buccal cusp tip of maxillary first molar; Mic = mesial buccal cusp tip of mandibular first molar. ANS = anterior nasal spine; PNS = posterior nasal spine; NSL = palatal plane; MSL = mandibular plane.

to accommodate a downward and forward pull of the maxilla with elastics. To avoid an opening of the bite as the maxilla was repositioned; the protraction elastics were attached near the maxillary canines with a downward and forward pull of 30° to the occlusal plane. Maxillary sutural protraction generally requires 300 to 600 *g* per side, depending on the patient. In this study, elastics that delivered 400 *g* of force per side, as measured by a gauge, were used. The facemask was placed after the completion of the rapid maxillary expansion and patients were instructed to wear the facemask for 12 hours a day.

Cephalometric Analysis

For each patient, a lateral cephalogram was taken at the initiation and completion of the facemask treatment. The average treatment time for the bonded group was 10.3 ± 2.1 months and the banded group was 9.5 ± 1.9 months. All radiographs used in the present study were taken with the teeth in habitual occlusion with the lips in repose. The cephalometric analysis used in this study has been described by Pancherz.[18,19] The landmarks used are defined in Fig 4A and B. All radiographs were traced on acetate paper. Analysis of the sagittal and dental changes was recorded along the occlusal plane (OLs) and to the occlusal plane perpendicular (OLp) from the first cephalogram, which formed the reference grid for all of the sagittal and vertical measurements. The grid was then transferred to the second cephalogram by superimposing on the midsagittal cranial structure.

Statistical Methods

The arithmetic mean (mean) and standard deviation (SD) were calculated for each cephalometric variable, and a paired *t* test was performed to assess the statistical significance of changes occurring during the various time periods. The levels of significance used were $P < 0.05$, $P < 0.01$, and $P < 0.001$.

Results

Cephalometric Comparison of Dentofacial Morphology between the Two Treated Groups before Treatment

Comparison of dentofacial morphology of the two treated groups is shown in Table 1. Significant differences ($P < 0.05$) were found between the banded and bonded groups in the amount of overjet (−2.1 mm vs −0.1 mm), molar relationship (−3.2 mm vs −0.1 mm), overbite (3.2 mm vs 0.9 mm), palatal plane angle NL/NSL (10.8° vs 7.8°), and occlusal plane angle OL/OSL (21.2° vs 17.3°).

Comparison of Sagittal Changes between the Banded Group and the Control Group (T1 versus T2)

The cephalometric sagittal changes due to growth and treatment in the banded group and the growth changes in the control group are shown in Table 2. Significant changes ($P < 0.05$) were found in the mandibular position SNB (−2.0° vs 0.4°), sagittal jaw relation ANB (3.4° vs 0.1°), maxillary base A-OLp (1.9 mm vs 0.9 mm), mandibular base Pg-OLp (−1.5 mm vs 1.4 mm), maxillary incisor Is/OLp (3.5 mm vs 1.5 mm), mandibular incisor Ii/OLp (−2.6 mm vs 1.2 mm), overjet Is OLp−IiO Lp (6.1 mm vs 0.3 mm), maxillary molar Ms/OLp (3.6 mm vs 0.5 mm), and molar relationship Ms/OLp−Mi/OLp (3.9 mm vs −0.2 mm).

Comparison of Vertical Changes between the Banded Group and the Control Group (T1 versus T2)

The cephalometric vertical changes due to growth and treatment in the banded group and the growth changes in the control group are shown in Table 3. Significant changes ($P < 0.05$) were found in the lower facial height (LFH) (2.9 mm vs 0.5 mm), mandibular incisor (Ii-ML) (−2.9 mm vs 0.1 mm), and mandibular plane angle (ML/NSL) (2.6° vs 1.0°).

Comparison of Sagittal Changes between the Bonded Group and the Control Group (T1 versus T2)

The cephalometric sagittal changes due to growth and treatment in the bonded group and the growth changes in the control group are shown in Table 4. Significant changes ($P < 0.05$) were found in the sagittal jaw relation ANB (2.1 mm vs 0.1 mm), maxillary incisal angle (Isi-Isa/SN) (3.2° vs 0.8°), interincisal angle (Isi/Isa/Iii-Iia) (−2.7° vs −0.4°), maxillary base(A-OLp) (2.6 mm vs 0.9 mm), maxillary incisor (Is/OLp)

Table 2. Cephalometric Sagittal Changes in 20 Subjects Treated with a Protraction Facemask and a Banded Expansion Appliance Compared with 20 Control Subjects

	Banded Group				*Control Group*				*Group Differences*	
Variables	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*Sig*
Angular Measurements										
Maxillary position (SNA)	1.4	1.6	−2.5	4.0	0.5	0.8	−1.5	3.0	0.9	NS
Mandibular position (SNB)	−2.0	2.9	−6.0	2.0	0.4	1.4	−3.0	2.0	−2.4	**
Sagittal jaw relation (ANB)	3.4	1.9	−1.0	5.5	0.1	1.1	−2.8	2.0	3.3	**
Max incisal angle (lsi-lsa/SN)	1.1	7.6	−9.0	14.0	0.8	3.7	−8.0	3.7	0.3	NS
Mand incisal angle (lii-lia/ML)	−4.7	6.4	−15.5	6.4	−0.6	3.3	−6.0	3.4	4.0	NS
Interincisal angle (lsi-lsa/lii-lia)	−2.5	11.5	−30.0	11.5	−0.4	3.8	−6.0	3.8	−2.1	NS
Linear Measurements Skeletal										
Maxillary base (A-OLp)	1.9	1.4	−1.0	4.5	0.9	1.3	−1.0	3.0	1.0	*
Mand base (Pg-OLp)	−1.5	2.2	−5.0	3.0	1.4	2.4	−5.0	4.0	−2.9	*
Dental										
Max incisor (ls/OLp)	3.5	2.0	−1.0	7.5	1.5	1.3	−1.0	4.0	2.0	*
Mand incisor (li/OLp)	−2.6	2.4	−7.0	2.0	1.2	1.6	−3.5	3.0	−3.8	**
Overjet (ls/olp-liOLp)	6.1	1.8	3.0	10.0	0.3	1.0	−1.5	4.0	5.8	**
Max molar (Ms/OLp)	3.6	2.5	−2.0	7.5	0.5	1.1	−1.0	2.5	3.1	**
Mand molar (Mi/OLp)	−0.3	1.6	−3.0	4.5	0.7	1.4	−2.5	3.0	−1.0	NS
Molar relationship (Ms/OLp-Mi/OLp)	3.9	1.4	−0	7.5	−0.2	0.8	−1.5	3.5	4.1	**

NS, not significantly different; $^{*}P < 0.05$; $^{**}P < 0.01$.

Table 3. Cephalometric Vertical Changes in 20 Subjects Treated with Protraction Facemask and Banded Expansion Appliance Compared with 20 Control Subjects

	Banded Group				*Control group*				*Group Differences*	
Variables	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*Sig*
Maxillary base A(OL)	0.4	1.3	−2.0	3.0	0.2	1.8	−3.5	4.0	0.2	NS
Overbite	−1.9	3.0	−7.5	2.5	−0.2	2.1	−3.5	3.0	−1.7	NS
LFH (Lower Face Height)	2.9	2.0	0	6.0	0.5	0.8	−1.0	2.0	2.4	*
Max incisor (ls-NL)	1.0	1.9	−1.5	4.5	0.7	1.4	−1.0	3.0	0.3	NS
Mand incisor (li-ML)	−2.9	2.3	−7.0	2.0	0.1	1.8	−3.5	2.0	−3.0	**
Max molar (Msc-NL)	1.8	1.1	0	3.5	1.1	1.4	−1.5	4.0	0.7	NS
Mand molar (Mic-ML)	−1.3	2.1	−4.0	3.0	−0.8	1.5	−4.0	1.0	−0.5	NS
ML/NSL (Mand Plane Angle)	2.6	2.9	0	7.0	1.0	1.1	−3.0	2.0	1.6	**
NL/NSL (Palatal Plane Angle)	0.1	0.2	−3.0	3.0	−0.7	0.9	−5.0	2.0	0.8	NS
OL/NSL (Occlusal Plane Angle)	−1.9	1.8	−10.0	7.0	−0.6	2.6	−4.0	4.0	−1.3	NS

NS, not significantly different; $^{*}P < 0.05$; $^{**}P < 0.01$.

(3.9 mm vs 1.5 mm), overjet (IsOLp-IiOLp) (3.3 mm vs 0.2 mm), maxillary molar (Ms/OLp) (2.9 mm vs 0.5 mm), and molar relationship (Ms/OLp–Mi/OLp) (1.8 mm vs −0.2 mm).

Comparison of Vertical Changes between the Bonded Group and the Control Group (T1 to T2)

The cephalometric vertical changes due to growth and treatment in the bonded group and the growth changes in the control group are shown in Table 5. Significant changes ($P < 0.05$) were found in the changes in lower facial height (LFH) (2.6 mm vs 0.5 mm) and mandibular plane angle (ML/NSL) (0.6° vs 1.0°).

Comparison of Sagittal Changes between the Banded and Bonded Treatment Groups (T1 to T2)

Sagittal changes in the banded and bonded groups are shown in Fig 5. Changes due to growth were subtracted to obtain changes due to treatment alone. Significant differences ($P < 0.05$) were found in the changes in overjet (6.7 mm vs 3.0 mm), mandibular base (−2.9 mm vs −1.0 mm), mandibular incisors (−0.9 mm vs 0.4

Table 4. Cephalometric Sagittal Changes in 20 Subjects Treated with Protraction Facemask and Bonded Expansion Appliance Compared with 20 Control Subjects

	Bonded Group				*Control Group*				*Group Differences*	
Variables	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*Sig*
Angular Measurements										
Maxillary position (SNA)	1.6	2.7	−3.5	7.0	0.5	0.8	−1.5	3.0	1.1	NS
Mandibular position (SNB)	−0.5	1.4	−3.0	2.5	0.4	1.4	−3.0	2.0	−0.9	NS
Sagittal jaw relation (ANB)	2.1	2.2	−1.5	5.5	0.1	1.1	−2.8	2.0	2.0	*
Max incisal angle (lsi-lsa/SN)	3.2	5.7	−4.0	14.0	0.8	3.7	−8.0	3.7	2.4	*
Mand incisal angle (lii-lia/ML)	−1.4	4.5	−7.0	9.0	−0.6	3.3	−6.0	3.4	−0.8	NS
Interincisal angle (lsi-lsa/lii-lia)	−2.7	6.9	−14.0	9.0	−0.4	3.8	−6.0	3.8	−2.3	*
Linear Measurements Skeletal										
Maxillary base (A-OLp)	2.6	2.0	0	7.5	0.9	1.3	−1.0	3.0	1.7	*
Mand base (Pg-OLp)	0.4	2.6	−3.5	5.5	1.4	2.4	−5.0	4.0	−1.0	NS
Dental										
Max incisor (ls/OLp)	3.9	1.6	0.5	6.0	1.5	1.3	−1.0	4.0	2.4	**
Mand incisor (li/OLp)	0.6	2.1	−4.0	5.0	1.2	1.6	−3.5	3.0	−0.6	NS
Overjet (ls/olp-liOLp)	3.3	1.8	−1.0	6.0	0.2	0.6	−1.5	4.0	3.1	**
Max molar (Ms/OLp)	2.9	2.2	0	7.0	0.5	1.1	−1.0	2.5	2.4	*
Mand molar (Mi/OLp)	1.1	2.3	−3.5	5.5	0.7	1.4	−2.5	3.0	0.4	NS
Molar relationship (Ms/OLp-Mi/OLp)	1.8	1.6	−1.5	6.0	−0.2	0.8	−1.5	3.5	2.0	*

NS, not significantly different; $^{*}P < 0.05$; $^{**}P < 0.01$.

Table 5. Cephalometric Vertical Changes in 20 Subjects Treated with Protraction Facemask and Bonded Expansion Appliance Compared with 20 Control Subjects

	Bonded Group				*Control Group*				*Group Differences*	
Variables	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*Sig*
Maxillary base A(OL)	1.6	1.8	0	6.0	0.2	1.8	−3.5	4.0	1.4	NS
Overbite (li/OL)	−1.5	2.7	−7.0	3.5	−0.2	2.1	−3.5	3.0	−1.3	NS
LFH (Lower Face Height)	2.6	2.5	−1.0	9.0	0.5	0.8	−1.0	2.0	2.1	*
Max incisor (ls-NL)	1.7	2.3	−3.0	6.0	0.7	1.4	−1.0	3.0	1.0	NS
Mand incisor (li-ML)	−0.8	2.8	−7.5	4.0	0.1	1.8	−3.5	2.0	−0.9	NS
Max molar (Msc-NL)	2.4	1.7	0	5.0	1.1	1.4	−1.5	4.0	1.3	NS
Mand molar (Mic-ML)	−0.6	3.1	−6.0	6.0	−0.8	1.5	−4.0	1.0	0.2	NS
ML/NSL (Mand Plane Angle)	0.6	2.2	−4.0	6.0	1.0	1.1	−3.0	2.0	−0.4	*
NL/NSL (Palatal Plane Angle)	0.3	1.8	−2.5	3.5	−0.7	0.9	−5.0	2.0	1.0	NS
OL/NSL (Occlusal Plane Angle)	−1.2	2.9	−7.5	3.0	−0.6	2.6	−4.0	4.0	−0.6	NS**

NS, not significantly different; $^{*}P < 0.05$; $^{**}P < 0.01$.

mm), and molar correction (4.1 mm vs 2.0 mm). A positive overjet was obtained in all cases in both groups. Changes in overjet were contributed by forward movement of the maxilla (1.0 mm vs 1.1 mm), backward rotation of the mandible (−2.9 mm vs −1.0 mm), proclination of the maxillary incisors (1.9 mm vs 1.3 mm), and retroclination of the mandibular incisors (−0.9 mm vs 0.4 mm).

Molar relationship was overcorrected to Class I or Class II dental arch relationship (Fig 6). The average change in molar relationship was 4.1 mm in the banded group and 2.0 mm in the bonded group. Changes in molar relationship were contributed by the skeletal movements described above and the differential movement of the maxillary molars (2.1 mm vs 1.3 mm) and the mandibular molars (1.9 mm vs 1.4 mm).

Comparison of Vertical Changes between the Banded and Bonded Treatment Groups (T1–T2)

Vertical changes in the banded and bonded groups due to treatment alone are shown in Fig 7. Changes due to growth were subtracted to obtain changes due to treatment alone. Significant differences were found in the occlusal plane angle (−1.3° vs −0.6°) and mandibular plane angle (1.6° vs −0.4°). The average overbite correction was found to be −1.7 mm in the banded group and −1.3 mm in the bonded group. The overbite correction was contributed by an increase in lower facial height (2.4 mm vs 2.1 mm), counterclockwise rotation of the palatal plane (0.8° vs 1.0°), increase eruption of the maxillary molars (0.7 mm vs 1.3 mm), and eruption of the mandibular molars (−0.5 mm vs 0.2 mm). The occlusal plane with reference to SN was flattened by −1.3° in the banded group as compared with −0.6° in the bonded group due to proclination of the maxillary incisors and eruption of the posterior molars. The mandibular plane angle increased +1.6° in the banded group as compared with a decrease of −0.4 degree in the bonded group.

Discussion

There are several limitations in the present retrospective study. Despite an attempt to include patients with similar dentofacial morphology in the two experimental groups, significant differences were found in several cephalometric variables of the two groups before treatment including overjet, molar relationship, overbite, palatal plane angle, and occlusal plane angle. Most of these differences are due to the fact that the bonded appliances are preferred in the treatment of patients with hyperdivergent growth patterns or an "open bite tendency."

The majority of the protraction facemask studies have reported the use of appliances with metal bands attached to the posterior teeth for maxillary expansion.[2,3,8-12] Tooth extrusion, dental tipping, and an increase in vertical dimension are often encountered with maxillary expansion and protraction, which may not coincide with treatment objectives.[20] Bonded appliances using interocclusal acrylic may control the vertical dimension and eliminate occlusal inter-

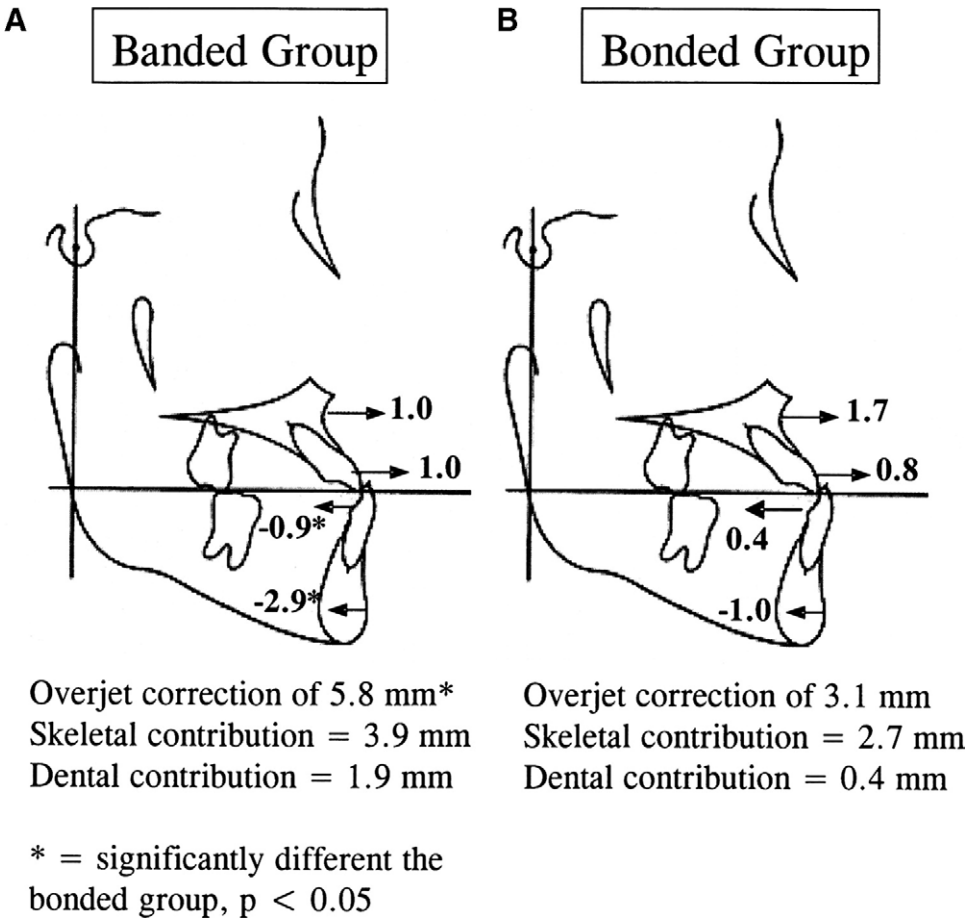

Figure 5. Skeletal and dental changes (mm) contributing to alterations in overjet in patients with (A) banded and (B) bonded expansion appliances.

ferences during lateral and forward movements of the bony segments and thus facilitate Class III corrections.[14,15] The results of the present study showed that both banded and bonded expansion appliances were effective in the correction of anterior crossbite in Class III patients. A positive overjet change was obtained in both groups with 9 to 10 months of treatment. Changes in overjet were contributed by forward movement of the maxilla, backward rotation of the mandible, proclination of the maxillary incisors and retroclination of the mandibular incisors. The amount of forward movement of the maxilla was similar in both treatment groups. The presence of a posterior bite plane does not seem to facilitate the forward movement of the maxilla. The latter is in agreement with the findings of Mossaz-Joelson and Mossaz[15] and Asanza and coworkers[21] The greater overjet correction in the banded group is probably due to the downward and backward rotation of the mandible in the banded group since a greater number of patients have deepbite malocclusion with a forward shift of the mandible on closure.

In 9 to 10 months, the molar relationship was improved to a Class I or Class II dental arch relationship in both the banded and the bonded groups. However, the maxillary molars came forward more in the banded than in the bonded group, indicating a greater loss of anchorage with the banded appliance. Kokich and colleagues attempted to use ankylosed primary canines to protract the maxilla and with some success.[22] The use of ankylosed primary teeth, however, limited the use of the maxillary protraction to the period before exfoliation of the primary teeth. A more promising approach to reduce anchorage loss is the placement of im-

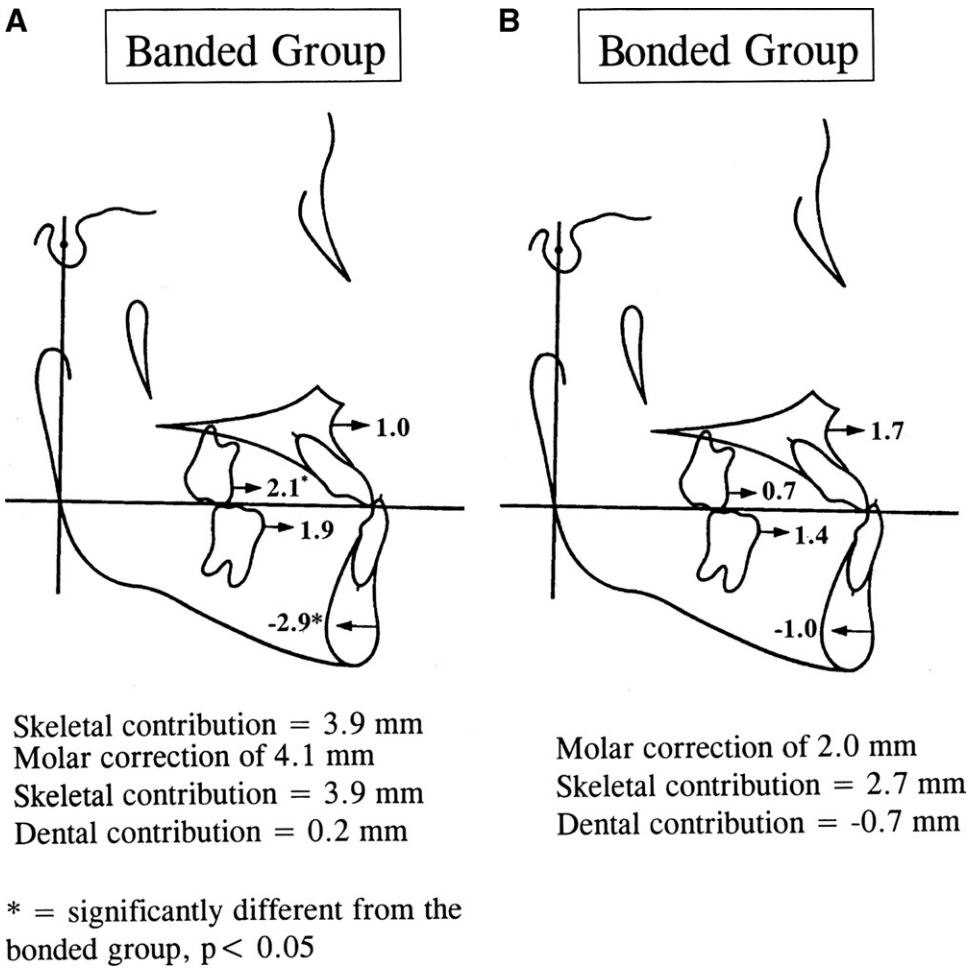

Figure 6. Skeletal and dental changes (mm) contributing to alterations in sagittal molar relationships in patients with (A) banded and (B) bonded expansion appliances.

plant in the zygomatic buttress of the maxilla or onplants on the palate to resist orthopedic forces[23,24] Singer and coworkers placed implants in the zygomatic buttress of the maxilla and used it as anchorage for facemask therapy.[24] This is quite ideal because the fixture was placed on basal bone rather than alveolar bone, and there were no adjacent tooth structure. Hong and coworkers placed a palatal onplant as stable anchorage for orthopedic facemask treatment.[24] A 7.7 mm hexagonal onplant was surgically placed on the flat part of the palatal bone near the maxillary molar region. After four months of osseointegration, a transpalatal bar was attached to the onplant and soldered to a silver cast splint for maxillary protraction. The results showed no movement of onplant during the 12 months period of protraction.

The average overbite correction is similar in the banded and bonded groups. In both groups, maxillary protraction was accompanied with an increase in the lower face height. A greater increase in the mandibular plane angle was observed in the banded group. This is probably related to the backward and downward rotation of the mandible after correction of the anterior crossbite. The bonded interocclusal splint was postulated to prevent eruption of the maxillary and mandibular molars during expansion and protraction. In the present study, no differences were found between the banded and bonded groups in the eruption of the posterior molars. In a study comparing the use of bonded and banded expansion appliances, Sarver and Johnston found a slight superior movement of the posterior aspect of the palatal plane relative

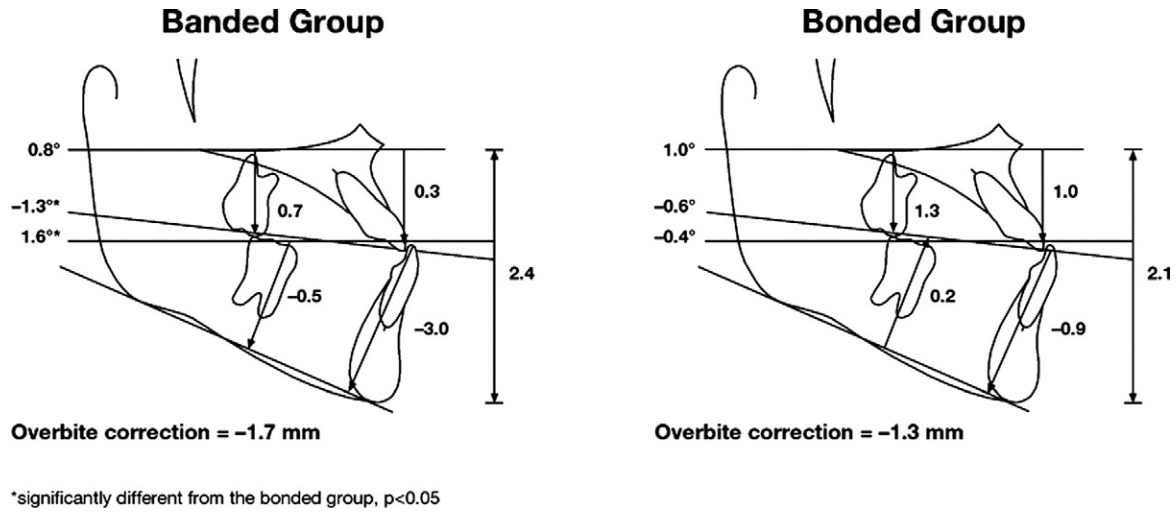

Figure 7. Skeletal and dental changes (mm and degrees) contributing to alterations in vertical changes in patients with banded and bonded expansion appliances.

to the banded appliance, and a downward and posterior movement of the anterior aspect of the maxilla.[14] In the present study, no differences were found in the tilt of the palatal plane. In both groups, the palatal plane was found to tip counterclockwise one degree or less. This is probably due to the direction of force delivery system, which affects the maxillary sutural response.[25] Experiments in animal and skull studies have shown that anterior forces along the occlusal plane have a tendency to rotate the skull counterclockwise unless accompanied by a heavy downward pull.[26,27] The use of elastics pulling at 30° forward and downward from the occlusal plane in the canine area minimized the tilting of the maxilla. Long-term studies evaluating the tilting of the palatal plane 4 years after maxillary expansion and protraction showed that the palatal plane returned to the same angulation as the control group.[28] In the treatment of patients with hyperdivergent growth patterns, a vertical or oblique pull chin cap immediately after expansion and protraction treatment may be used to prevent the side effects of maxillary expansion and to maintain and control the vertical dimension.[29]

Conclusions

Maxillary protraction in combination with either banded or bonded maxillary expansion appliances are effective in eliciting forward movement of the maxilla. Full coverage of the occlusal surface by acrylic, which was postulated to remove interferences during lateral and sagittal displacements of the maxillary bones, did not increase the efficiency of forward maxillary movement. Anchorage loss was found in both treatment groups. The skeletal and dental contributions to the correction of overjet and overbite were quite similar in both treatment groups. Maxillary expansion and protraction is accompanied by vertical displacement of the maxilla, increase in lower face height, and eruption of posterior molars, irrespective of the type of anchorage appliance.

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