Skeletal changes in vertical and anterior displacement of the maxilla with bonded rapid palatal expansion appliances

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The purpose of this study was to determine whether anterior and inferior displacement of the maxilla seen with rapid palatal expansion when done with a banded rapid palatal expansion appliance is significantly different from an occlusally bonded rapid palatal expansion appliance. It was hypothesized that the bonded appliance would limit unwanted displacement of the maxilla by producing vertical forces on both arches in a manner similar to a functional appliance. The study was conducted using the bonded appliance on 20 adolescents and comparing the results with those of a bonded appliance population—namely, 60 cases from Wertz’s study.1 Lateral cephalometric radiographs were taken before treatment and again after the expansion appliances were removed. The results of this study suggest that the downward and anterior displacement of the maxilla often associated with the banded rapid palatal expansion appliance may be negated or minimized with the more versatile bonded appliance. (Am J Orthod Dentofac Orthop 1989;95:462-6.)

Rapid palatal expansion has long been a commonly used means of correcting maxillary transverse deficiency. Although many articles have been published concerning structural and histologic changes of sutures, alterations in maxillary airway resistance, and general skeletal and dental changes, few articles have specifically addressed the basic problem of anterior and inferior displacement of the maxilla caused by skeletal changes.2-4 This movement is an obviously undesirable characteristic for many dental and skeletal types of patients. For example, the patient with a Class II dentition, long face, and open bite pattern could ill afford the extrusive characteristics of rapid palatal expansion.

Rapid palatal expansion is performed in two phases. The first phase is an active expansion of the maxilla by sutural expansion; the second phase of retention allows for reorganization and calcification of the midpalatal suture. Haas described the sequence of events that occurs during rapid palatal expansion with a bonded appliance:

- A parallel opening of the midpalatal suture in an anterior-posterior direction and a triangular opening inferior-superiorly with the apex in the nasal cavity.
- Separation of the central incisors (coincidental as the suture separates) with convergence of the clinical crowns and divergence of the roots due to transseptal fibers.
- A downward and lateral movement of the maxilla with coincidental inferior movement of the palatal processes.
- A downward and backward movement of the mandible resulting in an increased vertical dimension.

Wertz not only recorded data from his clinical study but used dried skulls to supplement his work concerning skeletal changes.1 The skulls showed changes to the maxillonasal, maxillofrontal, and maxilloethmoidal sutures but little or no changes to the pterygopalatine and maxillopalatine junctions.1 In the clinical part of his study, the lateral cephalograms showed that the maxilla consistently moved inferiorly but rarely moved anteriorly to a significant degree. Other authors had similar findings for vertical movement, but also state that their studies showed various degrees of anterior movement of the maxilla.3-5 The inferior movement of the maxilla accounted for the consequential opening of the mandibular angle while also promoting an anterior open bite.6-7 Although for some patients it is beneficial to have an increase in vertical dimension, often it is an unwanted characteristic.

Other adverse features commonly seen with banded rapid palatal expansion appliances are lack of rigidity and tooth extrusion.2 Proper rigidity of the appliance is necessary to prevent unwanted tipping of the dentition. Several authors point out that increasing the rigidity of an appliance decreases the rotational component of force along the long axis of the tooth.2-5 Extrusion of abutment teeth should be limited to prevent further vertical opening.

Bonded rapid palatal expansion appliances were designed to cover the maxillary posterior occlusal-buccal segments so that the appliance not only serves as an expansion device but intrudes on the freeway space through its vertical thickness. It acts as a functional...
Fig. 1. Maxillary expansion appliance bonded to upper posterior arch. Approximately 2 to 3 mm of acrylic is bonded to maxillary posterior teeth so that passive stretch of elevator and retractor musculature provides an apically directed force to mandible and maxilla.

Fig. 2. Bonded rapid palatal expansion appliance.

Application of this theory could possibly counteract some of the disadvantages of the orthodontically banded appliance. The bonded rapid palatal expansion appliance would increase rigidity by limiting unwanted tipping and rotation of teeth due to the increased surface of acrylic bonded to the teeth. Furthermore tooth supereruption would be limited because of the bonding of the entire posterior arch.

MATERIALS AND METHODS

The subjects of the study were 20 adolescents with bonded appliances—6 boys and 14 girls with a mean age of 10.8 years (range, 7.5 to 16 years). All patients needed posterior transverse expansion and all were treated with the bonded appliance (Fig. 2). Our sample was compared against Wertz’s data. The subjects in Wertz’s sample were 37 girls, aged 7 to 29 years, and 23 boys, aged 8 to 14 years. His study involved all banded appliances. Although there is a difference in sample size of 60 patients (banded) to 20 patients (bonded), statistically this is not a problem. If a difference between maxillary parameters is detected (in this case to a $p$ value of 0.05), then the samples are sufficient. Increasing the sample size would only detect a smaller difference in means. Lateral cephalometric radiographs were taken and comparisons were calculated before and after palatal expansion for both groups. An example of comparative points is shown in Fig. 3.

Except for appliance design, both groups had similar treatment parameters. Both groups used a similar screw mechanism and with both groups activation time was dependent on the individual case. Activation of appliances for both groups was twice daily, morning and evening. Both samples were retained for stabilization for approximately 3 months.

Frontal cephalometric radiographs of the bonded group were not taken. Although Wertz had data concerning posteroanterior cephalograms, his data showed only horizontal changes in the nasal cavity and in the
width of the maxillary molars. Our focus of comparison is the vertical displacement of the maxilla with two types of expansion appliances.

The bonded appliance differs from the banded appliance in its attachment to the teeth. Approximately 2 to 3 mm in thickness of methylmethacrylate is constructed on the occlusal-buccal surface and bonded directly to the enamel. The acrylic is equilibrated so that the bite is equal bilaterally.

**CASE REPORT**

The patient, a 13-year-old girl, was referred for correction of her crossbite and an anterior open bite. Along with her Class II skeletal pattern, she exhibited a moderately high mandibular plane angle with maxillary and mandibular proclination (ANB, 5°; Wits, + 5 mm). Rapid palatal expansion was initiated as the first phase of treatment for maxillary transverse expansion and crossbite correction. The appliance was bonded to the maxillary arch (second molar to first premolar) and was approximately 3 mm in thickness on the occlusal surface. The appliance was expanded on turn two times a day, producing 0.5 mm of expansion per day for 11 days, achieving 5.5 mm of expansion. It was then left cemented in place for 3 months to allow calcification and stabilization of the midpalatal suture. A lateral head film was taken immediately after removal of the bonded appliance and superimposed; the initial film showed no inferior movement of the maxilla and an extrusive and uprighting of the maxillary incisors (Fig. 4). In this case the anterior open bite actually decreased from 3 mm to 2 mm (Fig. 5).

This case illustrates how the bonded rapid palatal expansion appliance is valuable in patients in whom the undesirable movement of rapid palatal expansion needs to be limited or controlled.

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**Table I.** Mean value (M) of comparable measurements, standard error (SE), and range with number of applicable patients in parenthesis—Italicized values statistically significant to a p value of 0.05 using a t test

<table>
<thead>
<tr>
<th></th>
<th>Banded</th>
<th>Range</th>
<th>Bonded</th>
<th>Range</th>
<th>p value</th>
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<tbody>
<tr>
<td>SNA (°)</td>
<td>0.51 ± 0.11</td>
<td>-2.0 (1) to +2.5 (1)</td>
<td>-0.75 ± 0.32</td>
<td>-5 (1) to +1 (2)</td>
<td>0.0001</td>
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<tr>
<td>SNB (°)</td>
<td>-0.18 ± 0.13</td>
<td>-3.0 (1) to +2.0 (1)</td>
<td>-1.00 ± 0.25</td>
<td>-4 (1) to +1 (1)</td>
<td>0.004</td>
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<tr>
<td>ANB (°)</td>
<td>0.37 ± 0.14</td>
<td>-3.0 (1) to +2.0 (6)</td>
<td>0.50 ± 0.28</td>
<td>-2 (1) to +3 (1)</td>
<td>0.65</td>
</tr>
<tr>
<td>SN-PP (°)</td>
<td>0.20 ± 0.16</td>
<td>-3.5 (1) to +3.5 (1)</td>
<td>0.50 ± 0.30</td>
<td>-2 (1) to +3 (1)</td>
<td>0.36</td>
</tr>
<tr>
<td>SN-MP (°)</td>
<td>0.96 ± 0.16</td>
<td>-1.0 (1) to +4.5 (1)</td>
<td>0.75 ± 0.39</td>
<td>-3 (1) to +5 (1)</td>
<td>0.56</td>
</tr>
<tr>
<td>SN-PNS (mm)</td>
<td>0.89 ± 0.13</td>
<td>-1.5 (1) to +4.0 (1)</td>
<td>0.35 ± 0.18</td>
<td>-1 (3) to +2 (1)</td>
<td>0.03</td>
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<tr>
<td>SN-ANS (mm)</td>
<td>1.01 ± 0.14</td>
<td>-2.5 (1) to +4.5 (1)</td>
<td>1.25 ± 0.19</td>
<td>-1 (1) to +3 (1)</td>
<td>0.38</td>
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<td>S-A (mm)</td>
<td>0.41 ± 0.11</td>
<td>-1.5 (3) to +7.5 (1)</td>
<td>0.50 ± 0.18</td>
<td>-1 (1) to +3 (1)</td>
<td>0.0018</td>
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<td>S-1 (mm)</td>
<td>1.36 ± 0.14</td>
<td>-1.0 (1) to +3.5 (1)</td>
<td>1.65 ± 0.26</td>
<td>-2 (1) to +4 (1)</td>
<td>0.31</td>
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<tr>
<td>SN-1 (°)</td>
<td>-0.66 ± 0.31</td>
<td>-5.5° (3) to +5.5° (2)</td>
<td>-3.00 ± 1.06</td>
<td>-9 (2) to +8 (1)</td>
<td>0.005</td>
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<tr>
<td>S-1 (mm)</td>
<td>0.15 ± 0.13</td>
<td>-2.5 (1) to +2.0 (5)</td>
<td>-1.00 ± 0.41</td>
<td>-5 (1) to +2 (2)</td>
<td>0.0007</td>
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*Or less than; **or greater than.
eliminated. Certainly in this case, any inferior movement of the maxilla would have produced an anterior open bite. In addition any inferior positioning of the maxilla would worsen the Class II skeletal and dental relationships and the profile. The bonded appliance appeared to have been very helpful in overcoming these undesirable side effects of a banded rapid palatal expansion appliance.

RESULTS

Significant difference in data was noted (Table I). In both samples all cases were considered successful in that the crossbites were corrected. Although one child with the bonded appliance had the appliance removed because of poor compliance and subsequently was not included in the study, no other subject in either group had reason for early removal. Values of \( p \) less than 0.05 in the study were considered statistically significant.

Noted values were as follows:

1. **SNA.** This angle value, an indicator of the horizontal position of the maxilla to the cranial base, showed a significant difference from Wertz’s data. The anterior movement of the maxilla in the bonded sample was less than in the banded sample. Several patients in the bonded group actually had posterior movement, one in the amount of 3 mm.

2. **SNB.** This value was significant (\( p = 0.03 \)) and would appear to indicate a downward and backward movement of the mandible by means of a clockwise rotation. An inferior movement of the maxilla would be a likely cause of this rotation; however, inferior movements of the maxilla tended not to occur in our sample. A possible explanation is that the rotation of the mandible was caused by either posterior maxillary palatal cuspal interference after expansion with over-correction or occlusal interference from remnants of the bonding material on the occlusal surfaces.

3. **SN-PNS.** This linear measurement is an indication of the amount of movement the posterior nasal spine travels in an inferior or superior direction. This is important since the posterior reference point of the palatal plane would be expected to move inferiorly with expansion of the palate. The bonded group (range, \(-1.0 \) to \(+2.0 \) mm) had less inferior movement of PNS than the banded group (range, \(-1.5 \) to \(+4.0 \) mm).

4. **S-A.** This is a linear measurement to determine the horizontal displacement of the anterior aspect of the maxilla. The data showed the bonded group actually had a posterior displacement.

5. **SN-I.** An angular measurement to show displacement of the axis of the central incisor. Both samples showed a posterior tipping of the incisor with the bonded group being more severe.

6. **S-I.** A linear measurement to show anteroposterior displacement of the tip of the central incisor. The bonded group showed more posterior movement of the incisor tip than the banded group.

DISCUSSION

The most significant finding of this study is that the inferior displacement of the maxilla is lessened with
the use of the bonded rapid palatal expansion appliance when maxillary expansion is necessary. The downward and forward movement of the maxilla associated with the banded appliance is not necessary to achieve posterior expansion. The skeletal movement of the maxilla seen with the bonded appliance is to a small degree superior (at PNS) and posterior with a clockwise rotation (Fig. 6). This infers that the inferior displacement of the maxilla may be limited by the forces placed on the dentition by the elevator musculature and soft-tissue stretch. Wertz noted in his study that occasionally distal displacement of the maxilla also was seen in his sample. Other authors infer that the anterior movement of the maxilla is significant.3,4 The dynamics of the skeletal movement seen with the bonded appliance are summarized as follows:

1. A slight superior movement of the posterior aspect of the palatal plane relative to the banded appliance
2. A downward and posterior movement of the anterior aspect of the maxilla (ANS)
3. As the anterior maxilla moves posteriorly, inferior and posterior movement of the central incisors

The clinical significance of these characteristics of the bonded rapid palatal expansion is important. For example, in the treatment of a patient with a long face, high mandibular plane angle, and open bite tendency, extrusion of the maxilla or maxillary dentition would worsen the open bite situation and create a more difficult vertical pattern to treat. In addition Class II patients who require rapid palatal expansion often can ill afford more anterior movement of the maxilla. Limited anterior movement of the maxilla with the bonded appliance would be an indication for use in Class II patients.

Further studies would be of benefit to compare all parameters of the bonded rapid palatal expansion appliance. For the present the orthodontist should be cognizant of the possible options concerning treatment of bilateral maxillary posterior deficiency.

REFERENCES

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