# **Original** Article

# Mandibular Basal Structure Response to Lip Bumper Treatment in the Transverse Dimension

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**Abstract:** The effect of orthopedic or orthodontic treatment on the transverse dimension has been the subject of endless debate among orthodontists. The purpose of this investigation was to examine the response on the transverse dimension of the basal structure of the mandible and maxilla following two different modalities of treatment: group A—standard edgewise orthodontic treatment and group B—maxillary orthopedics with a bonded (tissue borne) rapid palatal expander (RPE) combined with a mandibular lip bumper. Each group had a matched paired untreated control according to age, sex, race, and treatment duration. For all subjects the width of the maxilla (Mx-Mx) and mandible (Ag-Ag) were measured on preand posttreatment posteroanterior cephalograms. The rate of width change in the maxilla and mandible was calculated (in mm/y). Results showed that group A had no treatment effect on the transverse dimension of the transverse dimension of Mx-Mx (P < .001) and Ag-Ag (P < .001) when compared with controls. It was concluded that the RPE treatment increased the maxillary skeletal width, and the lip bumper increased the transverse dimension of the basal structure of the maxillary skeletal width, and the lip bumper increased the transverse dimension of the basal structure of the mandible. (*Angle Orthod* 2004;74:473–479.)

Key Words: Mandibular width; Lip bumper; Posteroanterior cephalograms

# INTRODUCTION

The transverse dimension has been a focus of controversy among orthodontists.<sup>1</sup> A key issue debated has been the possibility of altering the skeletal width of the maxilla or the mandible through either orthodontic or orthopedic treatment.

In 1880, Kingsley<sup>2</sup> described an appliance to widen the palate to help in the correction of jaw relationships. He further indicated that widening of a dental and alveolar arch with no pressure on the teeth affects their osseous basal structure. In 1925, Lundstrom<sup>3</sup> emphasized that orthodontic repositioning of the teeth did not affect the apical base. In

1950, Brody<sup>4</sup> reported that the "Apical base ... is relatively immutable." He further stated that extractions were used to accommodate the dentition to the osseous base, genetically predetermined in size. Basal bone and apical base are synonymous terms for the bone that supports and is continuous with the alveolar process as well as with the maxillary and mandibular bodies.<sup>5</sup> Kusnoto et al<sup>6</sup> examined 60 orthodontically treated subjects with transverse asymmetries in arch width and found that the transverse asymmetries in arch width and found that the transverse arch form was not corrected with routine orthodontic treatment. These observations agreed with the dogma in orthodontics that arch form cannot be altered. Therefore, any change in mandibular arch form is unrealistic and would be difficult to retain.<sup>7.8</sup>

Conversely, it has been shown that maxillary width can be increased in a stable manner through orthopedic expansion.<sup>9,10</sup> Orthopedic expansion of the maxilla has been reported for over 100 years.<sup>11</sup> Most studies limited their observations to the dental effect<sup>12,13</sup> and sagittal landmarks using lateral cephalograms.<sup>14,15</sup> More recently, the posteroanterior (PA) cephalogram has been used to assess the skeletal effect of maxillary expansion.<sup>16</sup> Herberger<sup>17</sup> used PA cephalograms to examine 55 orthopedically expanded cases that went directly into conventional orthodontic treatment. He found significant skeletal expansion of the maxilla, which proved to be stable over 7 to 10 years, but no change in the mandibular skeletal base when compared with con-

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Accepted: September 2003. Submitted: August 2003.

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										T1–T2	
	n	T1 mean	SD	Minimum	Maximum	T2 mean	SD	Minimum	Maximum	mean	SD
Girls											
Group A											
Standard edgewise orthodontic treatment	9	11.94	1.41	10.00	14.00	14.00	1.81	11.42	17.08	2.06	0.97
Controls	18	11.73	1.43	9.88	14.00	13.90	1.77	10.92	17.67	2.18	1.02
Group B											
Maxillary orthopedics and mandi- bular lip bumper	15	8.33	0.84	7.33	10.17	11.10	0.94	9.00	12.75	2.77	0.92
Controls	30	8.24	1.06	6.00	10.00	10.86	1.17	8.00	12.92	2.62	0.95
Boys											
Group A											
Standard edgewise orthodontic treatment	6	12.36	0.58	11.50	13.00	14.72	0.49	14.08	15.25	2.36	0.41
Controls	12	12.19	0.73	11.08	13.00	14.73	0.63	13.67	15.67	2.54	0.45
Group B											
Maxillary orthopedics and mandi- bular lip bumper	15	8.62	1.39	5.33	11.17	11.16	1.45	8.33	13.33	2.58	0.96
Controls	30	8.13	1.28	5.75	11.00	10.69	1.31	8.75	13.00	2.55	0.91

TABLE 1. Chronological Ages (Years) of Treatment and Control Groups<sup>a</sup>

<sup>a</sup> T1 indicates pretreatment; T2, posttreatment; and T1-T2, treatment duration.

trols. Cameron et al<sup>10</sup> and Baccetti et al<sup>18</sup> studied the longterm effects of rapid maxillary expansion using PA films and found a significant increase in maxillary skeletal width but no skeletal change in the mandible. Other studies have reported dental changes in the mandible concurrent with maxillary expansion, which has been referred to as spontaneous "dental decompensation."<sup>9,19,20</sup> However, no report has shown any change of the mandibular basal structures.

The use of a mandibular lip bumper and its effects are well documented. Cetlin and Ten Hoeve<sup>21</sup> showed a significant increase in the width of the lower arch at the molars and premolars after 12 months of mandibular lip bumper therapy. Davidovitch et al<sup>22</sup> found a significant proclination in the lower incisors, distal movement of the lower molars, and an increase in arch perimeter between patients treated with a mandibular lip bumper and untreated patients. O'Donnell et al<sup>23</sup> also found a significant increase in both mandibular arch length and width in patients with lip bumper treatment.

Although these results suggest an effect of the lip bumper on the lower arch, there is no report in the literature on the effect of the lip bumper on the transverse dimension of mandibular basal structures. Moreover, normal growth in the width of the maxilla and mandible during childhood and even late adolescence has been demonstrated.<sup>24–26</sup> This suggests that the classic attitude regarding the immutability of mandibular skeletal structures may be inappropriate and that controlled clinical studies are needed.

The purpose of this investigation was to evaluate, using PA films, the effect of different treatment modalities on the transverse basal structure of the mandible. Two groups were examined on the basis of their treatment modality: group

A—standard edgewise orthodontic treatment and group B—maxillary rapid palatal expander (RPE) and a mandibular lip bumper.

# MATERIALS AND METHODS

# Subjects

Group A consisted of 15 Caucasian patients, 9 girls (mean age 11.94 years) and 6 boys (mean age 12.36 years) at the time of the pretreatment (T1) PA cephalograms (Table 1). All patients had Class II div. 1 malocclusions with no posterior or anterior crossbites. All patients were treated without extraction and with comprehensive edgewise appliances only at the Orthodontic Clinic of the University of Pennsylvania. Posttreatment PA cephalograms (T2) were obtained the same day the appliances were removed. The group A control consisted of 30 untreated subjects from the Burlington Growth Study and the Bolton-Brush Growth Center. Each patient in group A was matched with two control subjects according to age, sex, race, and treatment duration. All control cases were Class I skeletal patterns with normal arch form and without anterior or posterior crossbites.

Group B consisted of 30 Caucasian patients, 15 girls with mean age 8.33 years and 15 boys with mean age 8.62 years at the time of the pretreatment (T1) PA cephalograms (Table 1). All patients had a Class II div. 1 malocclusion and were treated in a private office without extraction by the same orthodontist (Dr Vanarsdall). Three patients had unilateral posterior crossbites, and the rest had no posterior or anterior crossbites. All patients had rapid palatal expansion with a bonded (occlusal coverage) Haas-type (tissue borne) expander, fabricated by the same orthodontic laboratory, and a mandibular lip bumper. The purpose of the rapid palatal expansion and lip bumper treatment was to correct the skeletal discrepancy in the transverse dimension. Patients were expanded at a rate of two turns (0.5 mm) a day. When the necessary expansion was achieved (each had more than six mm of expansion), the expander was sealed with acrylic and left in place for 8 to 12 months. A mandibular lip bumper (GAC International, Central Islip, NY) from first molar to first molar was tied in each patient for 18 to 32 months. At each visit the terminal adjustment loops were flattened to lengthen the bumper in order to ensure that the bumper cleared the lower incisors at the gingival margin one to two mm. The bumper was expanded facial to the buccal tube on the molar at every second and third visit to keep up with growth or one mm wider, but it was not expanded at the molar unless they were severely lingually inclined. The bumper was positioned in the middle third of the posterior teeth, two to 3 mm labial at the cuspids and three to 4 mm at the premolars.<sup>27</sup>

After lip bumper therapy, posttreatment PA cephalograms (T2) were exposed. All patients had treatment later with comprehensive edgewise appliances and were finished to a Class I molar and canine relationship. The Group B controls consisted of 60 untreated subjects from the Burlington and Bolton-Brush Growth Centers matched for age, sex, race, and treatment duration. All control cases were Class I skeletal patterns with normal arch form and without anterior or posterior crossbites.

#### Cephalometric analysis

Ricketts<sup>28</sup> landmarks were located on each PA cephalogram (Figure 1).

Bilateral skeletal landmarks consisted of

- maxillare (Mx) or J point, located at the depth of the concavity of the lateral maxillae contours, where the maxilla intersects the zygomatic buttress;
- antegonion (Ag) or antegonial notch of the mandible, defined as the innermost height of the contour along the curved outline of the inferior mandibular border, low and medial to the gonial angle.

The skeletal measurements were

- Mx-Mx, the distance between the left and right Mx (in mm), which represents the skeletal width of the maxilla;
- Ag-Ag, the distance between the left and right Ag (in mm), which represents the skeletal width of the mandible.

All measurements were made with an electronic digital caliper to the nearest 0.01 mm by one examiner (Dr Vanarsdall) and confirmed by a second examiner (Dr Secchi). To control for small differences in age and treatment duration, the rates of growth and treatment change were averaged longitudinally, ie, (width at T2 (in mm) – width at T1 (in mm))/treatment duration (years).



FIGURE 1. Posteroanterior cephalogram: skeletal landmarks and measurements.

To assess intra- and interexaminer reliability, 10 films randomly selected were remeasured by the same examiners at least four weeks after the first measurements were done. A paired *t*-test showed no significant differences for the intra- and interexaminer measurements (P > .05).

The study used cephalometric data from three different sources. At the Burlington Growth Center, the anode to subject distance and subject to film distance were fixed at 1.52 m and 15.0 cm, respectively. According to the recommendations by the Burlington Growth Center, any linear cephalometric measurement should be corrected for the fixed 9.84% magnification for all different subject ages. The Bolton-Brush Growth Study fixed the distance from the anodes to subject at 1.52 m while the film was placed against the tip of the nose. Corrections for the radiographic enlargement were done according to the individual's age as suggested by Broadbent et al.<sup>29</sup>

The subject to film distances at the University of Pennsylvania and the private practice were fixed at 13 cm for all PA cephalographs. The measurements from the growth centers were first corrected to actual size and then converted to the recommended distance of 13 cm using the magnification factor of 8.5%.<sup>30</sup> This allowed the growth center measurements to be comparable with the measurements

			3		Boys					
	n	Mean rate of change in Mx-Mx, T1–T2	SD	Mean rate of change in Ag-Ag, T1–T2	SD	n	Mean rate of change in Mx-Mx, T1–T2	SD	Mean rate of change in Ag-Ag, T1–T2	SD
Standard edgewise orthodontic treatment	9	0.51	0.25	1.18	0.82	6	0.95	0.19	1.47	0.29
Controls	18	0.57	0.36	1.09	0.55	12	0.81	0.41	1.46	0.51
Significance		NS		NS			NS		NS	

#### TABLE 2. Change (mm) per year in Mx-Mx and Ag-Ag in group A<sup>a</sup>

<sup>a</sup> T1–T2 indicates treatment duration; NS, not significant.

TABLE 3. Change (mm) per year in Mx-Mx and Ag-Ag in group B

	Girls						Boys					
-	n	Mean rate of change Mx-Mx, T1–T2	SD	Mean rate of change Ag-Ag, T1–T2	SD	n	Mean rate of change Mx-Mx, T1-T2	SD	Mean rate of change Ag-Ag, T1–T2	SD		
Maxillary orthopedics and mandibular lip bumper	15	2.70	0.75	3.69	1.28	15	2.78	1.04	3.68	1.66		
Controls	30	0.81	0.59	1.58	0.38	30	0.98	0.45	1.16	0.40		
Significance		*		*			*		*			

<sup>a</sup> (T1–T2) indicates treatment duration.

\* *P* < .001.

taken at the University of Pennsylvania and private practice. The data conversions for magnification are combined data enlarged by conversion to match film distance for the two groups.

#### **Statistical analysis**

The descriptive statistics performed included the mean, standard deviation, and range of each group. Statistical analyses of the results were carried out within sexes using paired *t*-tests with hypotheses to compare the controls and experimental treatment groups at an alpha of P < .05.

#### RESULTS

# Group A vs group A-controls

The standard edgewise orthodontic treatment (group A) had no effect on the skeletal width of the maxilla and mandible for both girls and boys. No statistically significant differences were found when comparing the Mx-Mx and Ag-Ag rates of growth between the group A and group A– control (Table 2). The Mx-Mx and Ag-Ag rates of growth were slightly greater for boys than for girls, although not significant.

# Group B vs group B-controls

The maxillary orthopedics, using RPE and mandibular lip bumper treatment (group B), had a great effect on the skeletal width of the maxilla and mandible. Both female and male groups showed a strong, statistically significant difference of Mx-Mx and Ag-Ag rates of growth when compared with control groups (P < .001) (Table 3). The values for boys were also slightly greater, except for Ag-Ag, which in both group B and group B–controls was slightly greater for girls, although not statistically significant.

### Treatment vs expected growth

The results were analyzed by expressing the difference between the Mx-Mx and Ag-Ag rates of growth as a percentage of expected normal growth rates derived from the controls (Figure 2). Values for group A were close to 100%, showing no differences with the controls. Therefore, standard edgewise orthodontic treatment had no skeletal effect on the transverse dimension. In contrast, when analyzing the effect of the maxillary RPE and mandibular lip bumper on the basal structures of the maxilla and mandible, compared with controls the rates of growth showed an Mx-Mx increase (334.5% for girls and 284.4% for boys) and an Ag-Ag increase (234.1% for girls and 317.1% for boys).

#### DISCUSSION

This study was designed to investigate the response of transverse basal structures in the maxilla and mandible to standard edgewise orthodontic treatment as compared with combined maxillary RPE and mandibular lip bumper treatment.

Ricketts<sup>31</sup> chose the frontal reference points Mx-Mx and Ag-Ag because of their proximity to the maxillary and



FIGURE 2. Difference of Mx-Mx and Ag-Ag rates of growth expressed as percentage of expected normal growth rates derived from controls.

mandibular molars. Thus, an assessment of the skeletal relationship could be made at the skeletal depth related to the molar teeth. Mx-Mx and Ag-Ag are widely used as standard landmarks to evaluate maxillary and mandibular basal structure changes.<sup>10,16,18,20,30,32</sup> Ag, specifically, is easily identified on the frontal film (PA) and lies directly below the third molar crypt at a young age.

Our data show that edgewise orthodontic treatment had no effect on the width of the maxilla and mandible (P >.05) (Table 2). These data confirm the fact that standard edgewise orthodontic treatment does not have any effect on skeletal growth of the maxilla or mandible at this age.<sup>6,10</sup> On the other hand, our results show that maxillary RPE had a strong effect on the basal structure of the maxilla and the mandibular lip bumper treatment had a strong effect on the basal structure of the mandible.

For both female and male treatment groups, the Mx-Mx rate of change was significantly higher than in the control groups (P < .001) (Table 3). This result was expected consistent with the findings of Cameron et al,<sup>10</sup> Baccetti et al,<sup>18</sup> Memikoglu et al,<sup>33</sup> and da Silva et al<sup>34</sup> who also found a significant increase in the width of the maxilla after orthopedic expansion. However, what has not been previously reported is the significant increase of the transverse basal structure of the mandible (Ag-Ag) in the lip bumper treatment group (P < .001) (Table 3).

As expected, the boys in both groups appeared to have a greater rate of change in the maxilla and mandible than did the girls (Table 3). However, for group B and its controls the rate of change of the mandible was slightly higher for girls. Group B subjects were about three years younger than group A subjects, and girls generally mature before boys. This may explain the greater rate of change in the mandible occurring earlier, which the boys will balance at a later age as seen in group A.

Despite the skeletal effect shown by the lip bumper therapy in this study, it still is possible that some of the effect was due to a normal dental decompensation of the lower arch after the maxilla was orthopedically expanded.<sup>19</sup> However, Cameron et al<sup>10</sup> used PA films to study the long-term effect (at least five years) of rapid maxillary expansion followed by edgewise treatment. They found a significant treatment effect in the maxilla (Mx-Mx) (P < .001); however, no treatment effect was seen in the mandible (Ag-Ag). Therefore, any spontaneous dental decompensation of the lower dental arch width that might occur due to maxillary expansion did not affect the basal structure of the mandible.

It has been reported that functional appliances seem to produce small sagittal increases in mandibular length that result in skeletal changes indistinguishable from normal growth.<sup>35</sup> Johnston<sup>36</sup> explained that, regardless of treatment strategy, the sagittal maxillomandibular growth or displacement improvement (apical base change) in Class II, div. 1 patients is largely due to facial growth and that facial growth may be independent of the category (fixed or functional) of treatment. However, this study provides evidence that the mandibular transverse basal dimensions can be significantly increased with changes in environment and growth.

The increased maxillary width from the RPE is relatively easy to explain,<sup>37</sup> and the maxilla also widens as vertical growth occurs.<sup>38,39</sup> The reason for increased or accelerated depositional growth of the lateral aspect of the mandibular body during lip bumper therapy is less obvious. Frankel<sup>40</sup> suggested that the shields of the functional regulators (ie, FR-2) altered the direction of muscle insertions so that the periosteum caused bone deposition in the areas of the alveolar bases. This theory has been noted by Kalogirou et al,<sup>41</sup> who, in a histologic and biometric study done in rabbits, showed no maxillary effects of the buccal shields. On the other hand, Brieden et al<sup>42</sup> evaluated the effects of the Frankel appliance on the maxilla and, in an implant study using PA cephalograms, confirmed Frankel's results. They found a significant alveolar and apical base expansion in the treatment group when compared with controls. Stimulation of bone apposition with periosteal tension has been described<sup>43</sup> and could explain the effect of a full-time lip bumper combined with growth in enhancing mandibular basal structure width. Other possible stimuli for bone apposition are increased eruption potential and changes in circumoral and perioral muscle tonicity.<sup>44</sup>

Clearly, the lip bumper resulted in significant changes in the basal dimension of the mandible for the patients of group B. To our knowledge, this is the first published report that shows a skeletal effect of the lip bumper on the mandible in the transverse dimension.

The enhanced treatment effect of maxillary and mandibular basal structures during early treatment may allow the clinician to normalize the transverse skeletal pattern. Once growth is almost completed (growth slows first in the transverse dimension), it cannot be used to correct skeletal dysplasia. Ricketts<sup>45</sup> has emphasized that a narrow maxilla characterizes most malocclusions.

Many agree that early treatment would correct skeletal problems in a more stable manner. Strang<sup>46</sup> showed that waiting for treatment until permanent dentition produces unstable expansion. The difference in stability is determined to a large extent by the effectiveness of the maxillary skeletal correction and what is done in the mandibular skeletal or dental arch. Changes in the mandibular dental arch in conjunction with maxillary orthopedic expansion have been reported.<sup>20,47</sup> However, the results we obtained in the transverse basal structure of the mandible suggest that the increase in the width of the mandibular dental arch shown with the lip bumper in previous studies<sup>21–23</sup> should be stable because the lip bumper also showed a strong effect on the skeletal structure of the mandible. This should provide a more favorable skeletal foundation for the dental changes. Clinically, the mandibular basal structure increase challenges traditional ideas of mandibular immutability and therefore provides significant consideration for treatment planning and further research.

# CONCLUSIONS

In this study, evaluation of the treatment response of the transverse basal bone after using standard edgewise orthodontic treatment and maxillary orthopedics in conjunction with mandibular lip bumper, we conclude that for our sample

· standard edgewise orthodontic treatment did not affect the

width of the basal structure in either the maxilla or the mandible,

- RPE produced a substantial increase in the width of the basal structure in the maxilla,
- lip bumper therapy produced a substantial increase in the width of the basal structure in the mandible.

# ACKNOWLEDGMENTS

The authors would like to thank Dr Dawn Wagner for her help.

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