Stability of transverse expansion in the mandibular arch

Jeffrey A. Housley, DDS, MS, Ram S. Nanda, DDS, MS, PhD, G. Frans Currier, DDS, MS, MEd, and Dale E. McCune, DDS, MS

Oklahoma City, Okla

This was a retrospective, longitudinal cephalometric and cast study of 29 white patients at pretreatment, posttreatment, and an average of 6 years 3 months postretention. The goal was to assess changes with treatment and retention with the expanding mandibular lingual arch appliance in conjunction with fixed edgewise treatment. Seven mandibular cast measurements were assessed, including arch crowding, arch perimeter, arch length, and arch width at the permanent canines, first premolars, second premolars, and first molars. Cephalometric radiographs were digitized, and 16 cephalometric measurements were made. Repeated-measures analysis of variance and 2-sample t tests were used to determine statistically significant changes. It was found that the expanding lingual arch used for less than 6 months with the mandibular fixed edgewise appliance caused an increase in both the transverse and sagittal dimensions of the mandibular dental arch. Transverse expansion was more stable in the posterior region of the mandibular dental arch than in the anterior region. Mandibular intercanine width increase could be maintained only by fixed retention. Although the maxillary and mandibular incisors were advanced and proclined, lip protrusion did not occur.


Nonextraction treatment has been gaining popularity over the past 2 decades. Bonded brackets, early space preservation including conservation of leeway space, proximal tooth reduction, rapid palatal expansion, lip bumper therapy, and functional and orthopedic appliances have allowed many patients to be treated without extraction of permanent teeth. Several types of appliances, such as headgear, palatal expansion, and intra-arch molar distalization appliances, have been used successfully to gain arch length in the maxillary arch. However, gaining space in the mandibular arch has been a limiting factor for the belief that the expansion of the arch is not stable. Lack of adequate space in the mandibular arch is often a critical factor in the decision of whether to extract teeth. In this regard, expansion of the mandibular arch has become of interest in nonextraction treatment.

Reidel stated that arch form, particularly in the mandibular arch, could not be altered by appliance therapy. Intercanine and intermolar widths tend to decrease during the postretention period, especially when expanded during treatment. Schulhof et al created a formula indicating that a patient with a brachyfacial pattern will have a wider arch than one of the dolichofacial type. He found that patients with the brachyfacial pattern could be expanded with more predictable results than could those with the dolichofacial pattern. Average mandibular intercanine widths have been reported to be 24 to 26 mm, suggesting that there might be a biologically optimum range for achieving stability. Several reports contend that moderate increases in arch width are possible, especially in the anterior regions of the arches, until the permanent canines erupt. After this, arch width usually decreases in both the anterior and posterior regions.

Crowding in the mandibular arch is very common in patients with malocclusions. Its extent is a determining factor in nonextraction treatment. How much crowding can be resolved with expansion of teeth and how much of the expansion will be stable should be considered. This study evaluated the effects of an expansion appliance in the mandibular arch and the stability of the expansion obtained. The objectives of this study were to quantify the treatment changes in mandibular arch dimensions and cephalometric values due to treatment with mandibular lingual arch expansion therapy and to quantify the posttreatment changes in mandibular arch dimensions and cephalometric valu-
ues due to relapse after mandibular lingual arch expansion therapy.

MATERIAL AND METHODS

The sample consisted of 29 white patients, 12 male and 17 female, who had received nonextraction orthodontic treatment. The patients were selected based on the availability of their long-term records. Patients with missing permanent teeth or congenitally absent teeth were excluded from this study. All patients had achieved acceptable posttreatment results and had been out of treatment for an average of 6 years 3 months. The mean pretreatment age was 12 years 5 months (± 1 year 8 months). The mean treatment time was 2 years 6 months (± 9 months), and the mean postretention period was 6 years 3 months (± 2 years 4 months). The mean pretreatment crowding in the mandibular arch was 3.33 mm (± 2.59), and the expansion appliance was used 3.5 months (± 1.3). Two patients had 1.0 mm of excess space in the mandibular arch. These patients had narrow arches; therefore, mandibular expansion was still used to develop the arch form.

There were 12 Class I, 11 Class II Division 1, and 6 Class II Division 2 patients. All patients were treated with expanding lingual arch appliances in the maxillary and mandibular arches. After the desired expansion, the expansion appliances were made passive by applying composite (cured) and held during active orthodontic treatment. The archwires were formed to fit the arches. Fourteen patients wore headgear in the maxillary arch. The treatment also consisted of a fixed edgewise appliance with a .022-in bracket system. Removable Hawley retainers were used in the mandibular arches in 19 patients. Lingual arches, bonded to the mandibular canines 10 patients, were still in place at the postretention period. The effects of mandibular dental arch expansion were studied by measuring dental casts and cephalometric radiographs. These records were available pretreatment (T1), posttreatment (T2), and postretention (T3) for each patient.

The expanding lingual arch appliance consists of 2 parts and a coil spring. The first part is a .036-in stainless steel wire soldered to the lingual side of a permanent first molar band; the wire runs lingual to the premolars and the canine on the same side and turns at a 90° angle at the midpoint of the canine and runs at the same level more than halfway across the arch. The second part is a .036-in stainless steel tube that is soldered to the opposite molar band and runs in a similar way as the wire. The wire slides through the steel tubing at the midline. A nickel-titanium open-coil spring (.012 × .040 in) covers the stainless steel wire from the solder joint and extends an inch past the end of the wire. This coil spring is compressed when the halves of the appliance are connected, as shown in Figure 1. The main effect of the expanding lingual arch is expansion and uprighting of mandibular buccal segments; this leads to increases in arch width and arch perimeter.

Seven measurements were made on photocopies of mandibular casts: arch crowding, arch perimeter (Fig 2, A), arch length (Fig 2, B), and arch width at the permanent canines, first premolars, second premolars, and permanent first molars (Fig 2, C). Arch width was measured as the distance between the cusp tips of the contralateral canines and the distance between the central occlusal landmarks (Fig 2, D) of the premolars and the molars. The dental cast measurements were made with Digimatic Calipers (no. NTD 12-6C, Mitutoyo, Japan) accurate to 0.01 mm.

Lateral cephalometric radiographs were traced by a single investigator (J.A.H.) to minimize error in measurement. Sixteen points were digitized on each cephalometric radiograph, and 16 cephalometric measurements were made.

The statistical tests to compare the changes between T1, T2, and T3 were repeated-measures analysis of variance. A 2-sample t test was used to determine the error of the method.

Sources of error included landmark identification, cephalometric tracing, and digitizing of the cephalo-
metric radiographs, as well as all linear measurements from the dental casts. Tracing error was determined by randomly selecting, retracing, and redigitizing 15 pretreatment cephalometric radiographs 1 month after the original tracings. Linear measurements on the photocopied dental casts were analyzed by randomly selecting and remeasuring 15 dental casts 1 month after the original measurements. No statistically significant difference was found for any measurement.

RESULTS

Table I shows the measurements at T1 and T2 and the changes with treatment. From T1 to T2, 3 angular skeletal measurements showed a significant change. Angle of convexity decreased 4.12°, SNA (sella, nasion, A point) decreased 1.24°, and ANB (A point, nasion, B point) decreased 1.54°. All angular dental measurements showed statistically significant changes from T1 to T2. The maxillary and mandibular incisors were proclined, based on increases of 7.45°, maxillary incisor to the S-N line (SN) and 8.70° to the N-A line (NA). The mandibular incisors increased 3.81° to the N-B line (NB) and 3.80° to the mandibular plane. Interincisal angle decreased 10.95°. All linear dental measurements showed statistically significant changes during treatment. The maxillary and mandibular incisors became more procumbent based on an increase of 2.18 mm, maxillary incisor to NA. The mandibular incisors increased 1.64 mm relative to NB and 2.60 mm relative to the A-pogonion line (A-Pog). The hard tissue chin grew forward significantly, 0.69 mm relative to NB. The soft tissue lip profile changed as the lips dropped back relative to esthetic line. The upper lip to E-line measurement decreased significantly, 1.29 mm, whereas the lower lip to E-line decreased 0.66 mm.

All mandibular cast measurements showed statistically significant changes from T1 to T2. Mandibular arch crowding decreased 3.29 mm as the teeth were aligned. On average, arch perimeter increased 3.50 mm and arch length increased 1.12 mm with transverse expansion and mandibular incisor advancement. Arch width between the mandibular canines increased 1.52 mm. Arch width between the mandibular first and second premolars and the first molars increased 2.11, 2.12, and 0.92 mm, respectively.

The T2 and T3 measurements and the amount of postretention change in cephalometric and cast measurements are shown in Table I. The only significant angular changes were in Frankfort mandibular plane angle (FMA), which decreased 1.35°, and interincisal angle, which increased 3.55°. The only linear dental measurement to show a significant change was mandibular incisor to NB, which decreased 0.50 mm. The soft tissue lip profile showed a significant posttreatment

Fig 2. A. Arch perimeter as measured in mandibular arch. B. Arch length as measured in mandibular arch. C. Arch widths as measured in mandibular arch. Maxillary arch widths are measured with same method. D. Method of constructing central occlusal landmark, determined as point on central groove that bisects mesiodistal width of tooth.
change as the lips became more retrusive relative to the E-line. The upper lip to E-line measurement decreased 1.98 mm; lower lip to E-line decreased 1.49 mm.

All mandibular cast measurements showed statistically significant changes from T2 to T3, except arch length and arch width between the mandibular first molars. Mandibular arch crowding increased 0.75 mm as the mandibular incisors relapsed mildly. Arch perimeter decreased 0.90 mm, and arch length decreased 0.29 mm. Transverse expansion relapsed the most in the canine area and progressively less posteriorly in the mandibular arch. Arch width between the mandibular canines decreased 0.80 mm. Arch width between the mandibular first premolars decreased 0.72 mm; arch width between the mandibular second premolars decreased 0.67 mm. Arch width between the mandibular first molars showed the least amount of relapse, decreasing only 0.15 mm.

The distribution of the sample according to the direction of change during treatment and after retention in mandibular arch crowding, arch perimeter, arch length, and arch width for each of the 29 patients was analyzed, and the pattern of distribution is shown in Tables II and III.

**DISCUSSION**

Nonextraction treatment might sometimes open the bite or increase the vertical dimension because of distalization of the molars into the narrow part of the wedge, resulting in a clockwise rotation of the mandible. No such effects were apparent in our sample. The sample had an average FMA of 22°, which is on the low side. The increase in interciscal angle due to anterior tipping of the incisors seemed to be well tolerated by these patients with anterior divergent growth patterns. The reduction of angle of convexity at T3 could be attributed to the growth of the mandible. Of the 29 patients, 26 experienced reduction in the angle of convexity.

The SNA angle decreased in 23 of the 29 patients.
However, the SNB angle decreased in 14 patients but increased in 15. Based on the findings of angles of convexity and SNB, one might conclude that, with growth, B point and Pog react independently. Whereas B point is an area of bone resorption and might be subject to influences of orthodontic treatment, Pog has bone deposition and is affected by anterior rotation of the mandible.

The expansion appliances yielded significant changes in all transverse dental cast measurements. Reductions in arch crowding, arch perimeter, and arch length might at least partially be attributed to the concurrent treatment with the edgewise appliance.

The average postretention age was 21 years 3 months; hence, between average posttreatment age of 15 years and the postretention period, only minimal skeletal changes were recorded. As expected, the facial profile was more orthognathic.

In our sample of 29 patients, 10 received fixed mandibular lingual arches, and 19 patients had Hawley retainers. The patients with fixed retention showed minimal changes in the arch measurements; those receiving removable retainers showed variable changes in arch measurements. Thus, our focus in judging the stability of the arch changes after retention was on the 19 patients who received Hawley retainers.

Only 8% of the arch width increase at the canines was sustained after retention, but, at the first and second premolars and the first molars, about 60% to 70% of the expansion remained. It seems that the stability of expansion in the canine region could not be sustained. However, the increase in the premolar and molar areas

Table II. Distribution of sample of 29 patients for direction of treatment change and postretention change in dental cast measurements

<table>
<thead>
<tr>
<th>Mandibular cast measurements</th>
<th>Changes with treatment (n)</th>
<th>Changes after retention (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decrease</td>
<td>No change</td>
</tr>
<tr>
<td>Arch crowding</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Arch perimeter</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Arch length</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Arch width (canines)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Arch width (first premolars)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Arch width (second premolars)</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Arch width (first molars)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table III. Changes in dental cast measurements with treatment and after retention, based on type of retention

<table>
<thead>
<tr>
<th>Mandibular cast measurement</th>
<th>Fixed retention (n = 10)</th>
<th>Removable retention (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changes with treatment</td>
<td>Changes after retention</td>
</tr>
<tr>
<td>Arch crowding</td>
<td>2.95 ± 2.51</td>
<td>−0.15 ± 0.24*</td>
</tr>
<tr>
<td>Arch perimeter</td>
<td>3.37 ± 2.86</td>
<td>−0.50 ± 0.85</td>
</tr>
<tr>
<td>Arch length</td>
<td>1.45 ± 1.36</td>
<td>−0.14 ± 0.57</td>
</tr>
<tr>
<td>Arch width (canines)</td>
<td>2.25 ± 1.05</td>
<td>−0.31 ± 0.48*</td>
</tr>
<tr>
<td>Arch width (first premolars)</td>
<td>1.65 ± 1.46</td>
<td>−0.28 ± 0.73</td>
</tr>
<tr>
<td>Arch width (second premolars)</td>
<td>1.30 ± 1.38</td>
<td>−0.47 ± 0.98</td>
</tr>
<tr>
<td>Arch width (first molars)</td>
<td>0.48 ± 2.01</td>
<td>0.21 ± 1.42</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD.
*Significant at P < .05.
was stable to a significant degree and could be used for gaining arch perimeter. Our findings relating to the stability of intercanine width expansion agree with previous findings\(^1\) that the intercanine width is an accurate index of muscular balance inherent in each person and cannot be violated during treatment. The study highlighted the importance of providing fixed retention to achieve better stability in patients treated with nonextraction methods.

**CONCLUSIONS**

The following conclusions can be drawn from this study:

1. The expanding lingual arch used for less than 6 months along with a mandibular fixed edgewise appliance caused an increase in both the transverse and the sagittal dimensions of the mandibular arch.
2. Transverse expansion was more stable in the posterior region of the mandibular arch than in the anterior region.
3. The mandibular intercanine width increase could only be maintained by fixed retention.
4. Although the maxillary and mandibular incisors were advanced and proclined, lip protrusion did not occur.

**REFERENCES**