



# Treatment effects and short-term relapse of maxillomandibular expansion during the early to mid mixed dentition

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**Introduction:** The treatment effects and the short-term ( $0.9 \pm 0.45$  years) relapse potential of phase I slow maxillary expansion, with a bonded palatal expander or a quad-helix appliance combined with a mandibular banded Crozat/lip bumper and followed by 12 to 15 months of retention, were examined. **Methods:** Pretreatment ( $8.8 \pm 1.7$  years) and posttreatment ( $11.1 \pm 1.7$  years) models of 54 patients were used to evaluate treatment effects. Posttreatment ( $11.0 \pm 1.3$  years) and follow-up ( $11.9 \pm 1.4$  years) models of 23 patients who returned for phase II treatment were used to evaluate relapse over the 11 months, during which no retention was used. The models were digitized, and 15 measures were computed. **Results:** Significant treatment increases were observed for all measurements in both arches. Treatment gains in arch perimeter (6%-8%) were due more to increases in intermolar width (11%-15%) than to increases in arch depth (5%). Posttreatment relapse was significant ( $P < .05$ ) for all measures except mandibular intercanine width and maxillary molar arch depth. After accounting for normal growth, net changes (pretreatment to follow-up) indicated significant increases for all measures except maxillary molar arch depth. In addition to maintaining leeway space, the maxilla and the mandible showed net perimeter gains of 2.9 and 1.0 mm, respectively. **Conclusions:** Slow maxillary expansion combined with a mandibular banded Crozat/lip bumper during the early mixed dentition produced clinically useful increases in arch dimensions that subsequently underwent mild-to-moderate amounts of relapse after removal of all retention appliances. (Am J Orthod Dentofacial Orthop 2007;131:456-63)

The extraction and nonextraction debate traces back to Angle,<sup>1</sup> who advocated that a full complement of teeth was essential for achieving ideal function and esthetics, and to Case,<sup>2</sup> who thought that extraction was required for long-term stability in patients with discrepancies between tooth mass and basal bone. The influence of Tweed<sup>3</sup> moved the specialty toward extraction. With the introduction of expansion appliances in the 1960s and bonded appliances in the 1970s, the popularity of nonextraction therapy increased. As orthodontists became increasingly cognizant of profile changes, the pendulum swung from extraction therapy toward nonextraction.<sup>4,5</sup> Managing

crowding during the mixed dentition to avoid future extractions has become an often-used rationale for early orthodontic treatment.<sup>6</sup> A common nonextraction approach to treating tooth size-arch length discrepancies (TSALD) in the mixed dentition is to create space with palatal expansion combined with mandibular lip bumper or Schwarz therapy.

Palatal expansion is an accepted method for separating the midpalatal suture and increasing arch perimeter.<sup>7-9</sup> The stability of maxillary expansion was well documented in both animal and human studies.<sup>10-20</sup> Suture separation is most effective if accomplished before completion of the pubertal growth spurt.<sup>10,12,14-16</sup> Although expansion can be achieved slowly (0.5-1.0 mm per week) or rapidly (0.25 mm per day or more), there is some evidence that slow expansion might be more physiologic and perhaps more stable.<sup>10,11</sup>

Mandibular lip bumpers can be used to alter muscle forces, increase arch perimeter, and allow the teeth to align in mild to moderately crowded arches. Resting lip pressures can be altered during lip bumper treatment, but it is unclear whether the altered muscle forces are maintained posttreatment.<sup>21-23</sup> Although some lip bumpers distalize the molars, all bumpers allow labial

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tipping of the incisors and increases in arch width and perimeter.<sup>24-29</sup> Most studies pertaining to the stability of mandibular arch expansion reported on the combined effects of fixed orthodontic appliances and arch expansion.<sup>26,30</sup> Recently, good long-term stability was reported for rapid palatal expansion (RPE) and lip bumper therapy performed in the late mixed dentition followed by full fixed appliances.<sup>31</sup> No studies have evaluated the relapse potential of young patients (early to mid mixed dentition) who have undergone only palatal expansion and lip bumper therapy.

The purposes of this study were to (1) evaluate the effects of slow maxillary expansion by using a bonded palatal expander or a quad-helix appliance combined with a mandibular banded Crozat/lip bumper appliance during the early to mid mixed dentition and (2) examine the short-term relapse of early treatment after all retention devices were removed. This investigation is predicated on the fact that maxillary expansion/lip bumper therapy is an often used, but poorly understood, mode of treatment in patients with mild-to-moderate crowding in the mixed dentition and straight pretreatment profiles.

## MATERIAL AND METHODS

Treatment effects of bonded palatal expansion or a quad-helix appliance combined with mandibular banded Crozat/lip bumper therapy were evaluated in 54 consecutively treated patients from the office of Dr Albert Owen III, in Austin, Tex. The sample included 25 boys and 29 girls. Follow-up records were obtained for all patients ( $n = 23$ ) who returned for phase II treatment. All patients were selected based on the following criteria: (1) no treatment other than expansion, (2) early to mid mixed dentition with all permanent first molars and incisors erupted, (3) no craniofacial anomalies or syndromes, and (4) no retention appliances used after the expansion appliances had been removed.

The records included patient charts and plaster models of the maxillary and mandibular arches taken before treatment (T1), immediately after treatment (T2), and at follow up (T3). The average age at the start of treatment was  $8.8 \pm 1.7$  years. The appliances were active for approximately 12 months and then remained in place, with no further activation, for an additional 12 to 15 months. On average, the total treatment time was about  $2.3 \pm 0.9$  years. No retention was used after the appliances were removed, and the patients returned every 6 months for observation. The average follow-up time for patients starting phase II therapy was  $0.9 \pm 0.4$  years.

Muscle strain was subjectively determined by the dimples in the chin caused by hyperactive mentalis

habit. Patients first received a plastic lip disk, resembling a poker chip, and were instructed to perform muscle-training exercises daily. The exercise consisted of holding the disk between the lips for 30 minutes per day. This therapy was continued until the patient could hold the lip disk without mentalis strain; this usually took 3 to 6 months. Positive treatment effects were judged based on the elimination of the dimples.

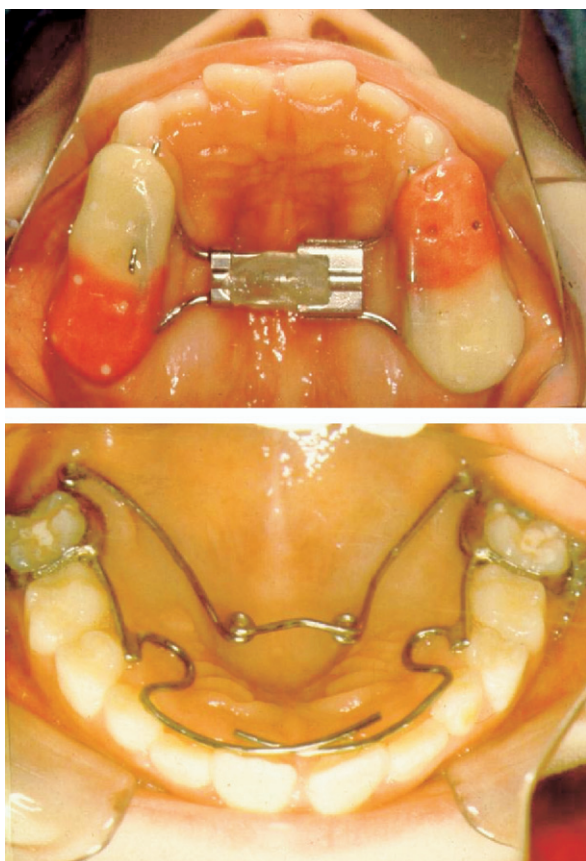
Patients were treated in 1 of 2 ways, depending on the initial clinical diagnosis. Euryprosopic (broad face) and mesoprosopic (average face) patients were treated with quad-helix appliances for maxillary expansion and banded Crozat/lip bumper appliances for mandibular expansion. Leptoprosopic (long face) and open-bite patients were treated with bonded palatal expanders for maxillary expansion and banded Crozat/lip bumpers for mandibular expansion. Leptoprosopic patients with maxillary incisor irregularity received quad-helix appliances after treatment with the bonded palatal expanders.

The bonded palatal expanders were fabricated on the patients' models (Fig 1). The expander consisted of an acrylic plate covering the occlusal surfaces from the canines to the permanent first molars. Bonded palatal expanders were activated 1 turn per week (0.25 mm per week) for an average of 24 to 32 weeks, producing 6 to 8 mm of expansion. Once the desired expansion was achieved, the appliance was left in place for an additional 4 to 6 months. The arms of the expansion screw were embedded in the acrylic, which did not extend onto the palate. The total treatment time for maxillary expansion was approximately 12 months.

The quad-helix appliance was fabricated from 0.036-in wire soldered to bands on the permanent first molars. Its arms extended anteriorly to the distal aspect of the lateral incisor on the opposite side. The quad-helix appliance was inactive at the time of bonding and remained inactive for 8 weeks to allow the patient to adapt. It was then activated 6 mm (3 mm per side) at 8 weeks and again about 3 months later. This activation schedule provided a total of approximately 5 to 7 mm of maxillary expansion over a 6 to 10 month period.

The lip bumper portion of the banded Crozat/lip bumper was fabricated from 0.45-in wire, which was bent to resemble a zigzag shape (Fig 2). On the lingual aspect, a body wire (0.040 in) extended through lingual sheaths on the molar bands. The wire was bent back on itself and extended anteriorly to form the Crozat arms of the appliance. The lingual arms extended anteriorly to the distal aspect of the lateral incisor on the opposite side.

The lingual aspect of the banded Crozat/lip bumper was inactive at the time of bonding and remained

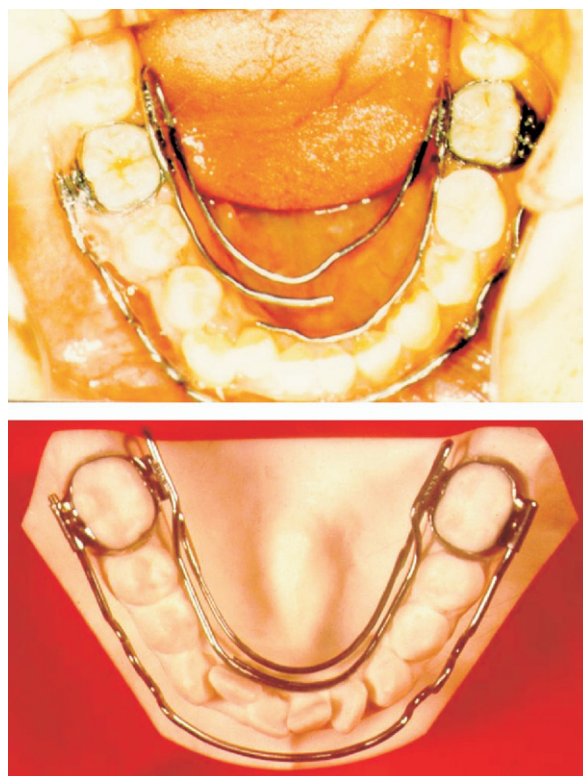


**Fig 1.** Bonded palatal expander with acrylic plate covering occlusal surfaces used for leptoprosopic patients. Quad-helix appliance soldered to permanent first molars used for mesoprosopic and euryprosopic patients.

inactive for 8 weeks. The lip bumper portion of the appliance was adjusted so that the wire was 2 to 3 mm buccal to the posterior teeth and 2 to 3 mm anterior to the mandibular incisors at the level of the gingival margin. The wire kept the buccal musculature away from the teeth without transverse activation at the molars. After the first 8 weeks, the lingual Crozat portion of the appliance was activated 1 mm per side. This activation was performed every 8 weeks for up to 24 weeks. Most patients required 3 activations; some required only 2 activations to achieve the required amounts of expansion.

Landmarks were marked on the dental models with a 0.3-mm pencil. Digitization was performed by the first author using a Microscribe (Immersion, San Jose, Calif) 3DX digitizer. The following measurements were calculated as described by Moyers et al.<sup>32</sup>

1. Intercanine (width 3-3) and intermolar (width 6-6) widths were measured as the shortest distances



**Fig 2.** Crozat/lip bumper fabricated from 0.45-in wire bent to resemble zigzag shape. Lingual arms extend anteriorly to distal aspect of lateral incisor on opposite side.

between the canine cusp tips and between the centroids of the permanent first molars, respectively.

2. Arch depth was defined as the distance from the facial aspect of the incisors at the embrasure to a perpendicular drawn from the distal aspects of the permanent first molars (depth 6).
3. Arch perimeter (perimeter) was defined as the sum of the distances from the mesial contact points of the permanent first molars to the distal contact points of the canines plus the mesiodistal widths of the canines plus the space available from the best-fit arch form from the mesial contact of 1 canine to the mesial contact of the other.

The irregularity index (irregularity) was defined as the summed displacement of the anatomic contact points of the mandibular anterior teeth, based on method described by Little.<sup>33</sup> Because irregularity was determined by using the deciduous canines, care should be taken when making comparisons with the irregularity index based on the permanent canines. TSALD was defined as the sum of the mesiodistal widths of all

**Table I.** Pretreatment measures (mm) for maxillary and mandibular arches

Measurement	Patient values		Z-scores	
	Mean	SD	Mean	SE
<b>Maxilla</b>				
Width 3-3	30.25	2.05	0.15	0.16
Width 6-6	44.64	2.04	0.56	0.15
Depth 6	28.28	1.82	-0.90	0.11
Perimeter	76.99	3.56	-0.93	0.13
<b>Mandible</b>				
Width 3-3	24.18	2.10	-0.20	0.19
Width 6-6	40.04	2.31	-0.40	0.17
Depth 6	24.18	1.46	-1.36	0.15
Perimeter	68.91	3.20	-0.51	0.13
Irregularity	9.00	3.43	N/A	N/A

N/A, Not available.

Individual Z-scores calculated from normative values provided by Moyers et al.<sup>32</sup>

permanent teeth (measured at T3) minus arch perimeter, as described above.

Reliability was assessed by using duplicate measures on a subset of randomly selected models. Systematic error, assessed by comparing the mean difference between replicates to its standard error, was not statistically significant. Random technical error was calculated by using the method error ( $\sqrt{\sum d^2/2n}$ ) statistic.<sup>34</sup> Method error was less than 0.4 mm for all measurements except irregularity, which was 0.9 mm.

**Statistical analyses**

Normality of the distributions was confirmed based on skewness and kurtosis statistics. Means and standard deviations were computed for all measurements. Measurements were made for treatment, posttreatment, and net changes. Historical reference data were used for making untreated comparisons.<sup>32</sup> Z-scores (each patient was matched by age and sex) for arch depth, arch width, and arch perimeter were calculated to evaluate treatment and posttreatment changes. The Z-score provides a measure of a subject’s arch size in standard-deviation units. A significant change in Z-score indicates a treatment effect more or less than expected from normal growth.

**RESULTS**

In the larger sample (n = 54) followed through treatment compared with the untreated controls, pretreatment maxillary and mandibular arch depths and perimeters were significantly ( $P < .05$ ) smaller than expected for the untreated controls (Table I). Pretreatment maxillary and mandibular molar widths were slightly larger and smaller than expected, respectively.

**Table II.** Treatment (T1-T2), posttreatment (T2-T3), and net (T1-T3) changes (mm) in maxillary arch dimensions (n = 54)

Measurement	Treatment changes		Z-score changes	
	T1-T2		T2-T3	
	Mean	SD	Mean	SE
<b>Maxilla</b>				
Width 3-3	4.29	2.67	2.43*	0.25
Width 6-6	6.83	3.08	2.49*	0.20
Depth 6	1.42	1.89	0.57*	0.15
Perimeter	6.15	4.33	1.39*	0.16
<b>Mandible</b>				
Width 3-3	2.84	2.35	1.44*	0.22
Width 6-6	4.55	2.10	1.93*	0.14
Depth 6	1.13	1.28	2.30*	0.14
Perimeter	4.15	2.91	1.28*	0.12
Irregularity	-3.61	3.65	N/A	N/A

N/A, Not available.

\* $P \leq .001$ .

**Table III.** Treatment (T1-T2), posttreatment (T2-T3), and net (T1-T3) changes (mm) in maxillary and mandibular arch dimensions of subsample followed post-treatment

Measurement	T1-T2		T2-T3		T1-T3	
	Mean	SD	Mean	SD	Mean	SD
<b>Maxilla</b>						
Width 3-3	3.70	2.62	-0.61	1.48	3.18	2.01
Width 6-6	6.40	3.65	-1.65	2.62	4.77	2.01
Depth 6	1.10	2.03	-0.87	1.33	0.26	1.56
Perimeter	5.61	3.59	-2.83	3.13	2.85	3.29
<b>Mandible</b>						
Width 3-3	2.40	1.83	-0.37	0.82	1.93	1.71
Width 6-6	3.90	2.26	-1.06	1.63	2.87	1.70
Depth 6	0.94	1.28	-1.31	1.18	-0.35	1.17
Perimeter	3.74	3.21	-2.92	3.05	0.96	2.53
Irregularity	-3.33	3.32	0.73	2.32	-2.71	2.91

Pretreatment mandibular incisor irregularity averaged  $9.0 \pm 3.4$  mm.

Significant ( $P < .001$ ) treatment increases were observed for all arch measurements (Table II). Posterior arch widths increased more than anterior widths; maxillary arch depth increased slightly (0.3 mm) more than mandibular arch depth. Treatment produced 6.2 and 4.2 mm gains in maxillary and mandibular arch perimeters, respectively. Mandibular incisor irregularity decreased 3.6 mm. Z-scores show that arch changes during treatment were all greater than expected during normal growth, especially maxillary widths and mandibular arch depths.

**Table IV.** Age and sex adjusted (Z-score) treatment (T1-T2), posttreatment (T2-T3), and net (T1-T3) changes (mm) in maxillary and mandibular arch dimensions of subsample followed posttreatment

Measurement	T1-T2		T2-T3		T1-T3	
	Mean	SE	Mean	SE	Mean	SE
<b>Maxilla</b>						
Width 3-3	2.08	0.36	-1.43 <sup>‡</sup>	0.20	0.75 <sup>†</sup>	0.26
Width 66	2.33	0.35	-0.61 <sup>*</sup>	0.26	1.73 <sup>‡</sup>	0.18
Depth 6	0.40	0.23	0.13	0.24	0.49	0.24
Perimeter	1.24	0.24	-0.50 <sup>†</sup>	0.17	0.71 <sup>‡</sup>	0.17
<b>Mandible</b>						
Width 3-3	1.23	0.26	-0.18	0.14	1.03 <sup>‡</sup>	0.26
Width 6-6	1.62	0.24	-0.72 <sup>‡</sup>	0.17	0.90 <sup>‡</sup>	0.18
Depth 6	2.19	0.20	-0.81 <sup>‡</sup>	0.20	1.38 <sup>‡</sup>	0.16
Perimeter	1.13	0.19	-0.70 <sup>‡</sup>	0.18	0.52 <sup>†</sup>	0.15

\* $P \leq .05$ ; <sup>†</sup> $P \leq .01$ ; <sup>‡</sup> $P \leq .001$ .

In the subsample ( $n = 23$ ) followed posttreatment, maxillary treatment changes were slightly less than the treatment changes observed for the larger sample (Table III). Statistically significant ( $P < .05$ ) posttreatment decreases were noted in maxillary intermolar width, molar arch depth, and arch perimeter. Maxillary intercanine width decreased 0.6 mm (16% of the treatment gain), intermolar width decreased 1.6 mm (26%), and molar arch depth decreased 0.9 mm (79%). Approximately 50% of the treatment gain in arch perimeter was lost after treatment. Table IV shows that intercanine width decreased (1.4 Z-scores) relatively more than intermolar width (0.6 Z-scores) and arch perimeter (0.5 Z-scores). Net (T1-T3) changes were significant for all maxillary measurements except molar depth, which did not decrease significantly more than expected during normal growth.

Mandibular treatment changes of the posttreatment subsample were also slightly less than those of the larger sample. Significant posttreatment decreases were observed for mandibular intermolar width, molar depth, and arch perimeter. Intermolar width decreased 27% of the treatment increase. The posttreatment decrease in molar arch depth was 39% greater than the treatment increase. Arch perimeter lost 78% of the treatment increases after treatment. Incisor irregularity increased 0.7 mm posttreatment, a change that was not statistically significant. Relative to the untreated controls, intermolar width, molar depth, and arch perimeter decreased approximately 0.7 to 0.8 Z-scores more than expected (Table IV). Net increases were statistically significant for all mandibular measurements except molar arch depth and arch perimeter. Z-scores showed that the net gains in mandibular arch widths, molar arch

**Table V.** TSALD (mm) (TSALD = arch perimeter minus T3 tooth size) at pretreatment (T1), posttreatment (T2), and follow-up (T3) of subsample followed posttreatment

Arch	Observation	Maxilla	Mandible
Maxilla	T1	-1.06	1.38
	T2	-6.72	-2.47
	T3	-4.13	0.58

depth, and perimeter were significantly ( $P < .001$ ) greater than expected for untreated subjects.

Pretreatment TSALD showed 1.1 mm of excess space in the maxilla and a 1.4 mm deficiency in the mandible (Table V). During treatment, excess space was produced in both arches. At follow-up, maxillary and mandibular TSALDs showed 4.1 mm of excess space and approximately 0.6 mm of crowding, respectively.

## DISCUSSION

Maxillary intercanine width increased significantly during treatment and partially relapsed posttreatment, resulting in a net gain of 3.2 mm, representing 86% of the original expansion. Although the width increases during treatment were greater than previously reported for rapid expansion,<sup>19,30,31,35</sup> the posttreatment relapse was approximately 50% of reported estimates.<sup>19,35</sup> This supports the notion that slow expansion can provide greater posttreatment stability than rapid expansion.<sup>10,11</sup> It is also possible that palatal expansion at younger ages provides greater orthopedic changes and enhanced stability.<sup>10,14-17</sup>

Maxillary intermolar width increases were similar to or greater than previously reported.<sup>18,19,30,31,35</sup> Posttreatment relapse was similar to or slighter greater than expected based on published reports.<sup>19,31,35</sup> Mew,<sup>18</sup> for example, reported no relapse after allowing the treatment overcorrection to settle. Despite the significant relapse observed in this study, over 70% of the treatment increase was maintained, resulting in a net gain of 4.8 mm, which, again, might be attributable to a greater amount of orthopedic change associated with slow expansion of younger patients.

Maxillary molar arch depth increased 1.4 mm during treatment, as previously reported.<sup>19</sup> Depth increases were probably due to anterior movement of the incisors because the molars should not have experienced a distal force from a bonded palatal expander. Approximately 20% of treatment increase in arch depth was maintained posttreatment. The posttreatment decrease in molar depth was smaller than noted by

Moussa et al,<sup>19</sup> who might have observed relapse and instability during their 8 to 10 year postretention period. The posttreatment decreases were similar to those reported for subjects who underwent comprehensive orthodontic treatment after expansion.<sup>30,31</sup> The posttreatment decrease in maxillary arch depth was expected for the untreated controls.

Maxillary arch perimeter increased 6.2 mm during treatment, which was 1 to 2 mm more than previously reported.<sup>7,8,19</sup> Arch-width, as opposed to arch-depth, increases accounted for most of the perimeter changes. Half of our perimeter increases were maintained after the expansion devices were removed, largely due to the maintenance of arch widths. Similar<sup>19</sup> or slightly smaller<sup>31</sup> amounts of posttreatment relapse in perimeter were previously reported.

Mandibular intercanine width increased approximately 2.8 mm during treatment; this was substantially greater than previously reported for lip bumpers.<sup>25,26,28</sup> The difference can be attributed to the lingual Crozat arms that actively expand the arch while the lip bumper shields the teeth from the perioral musculature. It might also be partially associated with the greater amounts of maxillary expansion that occurred. Mandibular canine arch depth increased significantly more than molar arch depth, suggesting distal movement of the canines, which also increases arch width. Importantly, posttreatment relapse of intercanine width was not significant; this could be related to maxillary intercanine stability and distal canine movements during treatment. In contrast, Moussa et al<sup>19</sup> noted a 1.1-mm decrease in intercanine width 8 to 10 years postretention after 1.8 mm of expansion with edgewise mechanotherapy. Little et al<sup>36</sup> reported a decrease in intercanine width in 88% of patients expanded with fixed orthodontic appliances. Studies evaluating combined palatal expansion/lip bumper therapy reported 0.6 to 0.8 mm postretention decreases in mandibular intercanine widths in older patients.<sup>30,31</sup>

Mandibular intermolar width increases (4.6 mm) were similar to or greater than previously reported for lip bumpers.<sup>24-26,28-30</sup> The relapse observed in this study approximated that reported by Ferris et al,<sup>31</sup> suggesting that fixed orthodontic therapy does not decrease posttreatment relapse potential. The changes that occurred were probably due to tipping during treatment and tip back after appliance removal. Although mandibular intermolar width relapsed posttreatment, the net gain (2.9 mm) was clinically significant.

Arch depth increased approximately 1 mm during treatment; this is less than previously reported for lip bumpers with acrylic shields.<sup>24,25</sup> It closely approximates increases reported for lip bumpers with shrink tubing<sup>24,28</sup> and indicates that a wire bent to resemble a

zigzag does not produce as much distal force on the molars as a lip bumper with an acrylic shield. The 0.35-mm net decrease observed in molar arch depth actually reflects a positive treatment effect because greater mandibular arch depth decreases are normally expected during the mixed dentition.<sup>32,37-40</sup>

Mandibular arch perimeter increased 4.2 mm during treatment, as previously reported.<sup>25,28</sup> Bjerregaard et al<sup>29</sup> reported greater gains in perimeter and arch length. Patients who have spaces closed during the fixed treatment phase after RPE and lip bumper therapy show substantially smaller increases or even decreases in arch perimeter.<sup>30,31</sup> Our perimeter increases were more closely related to expansion rather than arch length increase, as previously suggested.<sup>28</sup> In contrast, Davidovich et al<sup>25</sup> attributed most increases in arch perimeter to incisor proclination (45%-55%) and molar distalization (35%-50%). Arch perimeter decreased 2.9 mm posttreatment; this can be attributed primarily to sagittal changes. Although the net gain in perimeter was small (1.0 mm), it was clinically significant because arch perimeter would have decreased significantly more (approximately 2.0 mm) without treatment. Net increases in mandibular perimeter have not been previously been reported.

Incisor irregularity decreased by 3.6 mm during treatment, an improvement that compares well with previous lip bumper studies.<sup>24,26</sup> Relapse was minimal (0.7 mm), resulting in a net decrease of 2.7 mm in the irregularity index. Horton<sup>30</sup> noted a 0.7-mm increase in irregularity for patients 2 years out of retention. Ferris et al<sup>31</sup> showed an increase of 1.1 mm in subjects treated with RPE and lip bumper therapy and out of retention for 7.9 years. In contrast, Little et al<sup>36</sup> noted that 89% of their patients, who had been selected based on increased in arch length during treatment, had unacceptable (>3.5 mm) postretention irregularity.

Even though pretreatment incisor irregularity was significant, TSALD indicated that there was, on average, little lack of space in either jaw. Treatment increased arch dimensions and produced excess space posttreatment in both the maxilla and the mandible. The amounts of space produced, together with the leeway space expected, should have been sufficient to resolve mild to moderate crowding. Because teeth tend to migrate, the arch spaces created during treatment help to explain the rather large posttreatment decreases in arch perimeter observed. Patients with larger TSALD might be expected to show smaller posttreatment decreases in arch perimeter or more postretention crowding. Interestingly, excess maxillary space was maintained posttreatment. Although some orthodontists maintain mandibular arch perimeter by holding leeway space with lingual

arches, the goal of treatment in this study was increased arch perimeters.

Case selection is important in deciding whether an early expansion treatment approach is worth the time, effort, and cost to the patient and the orthodontist. In this regard, it is important to establish whether the patient and his or her parents expect improvements in self-image as a result of treatment. Moreover, the orthodontist must evaluate pretreatment incisor position, tension in the perioral musculature, and oral habits to determine the potential stability of arch expansion.

## CONCLUSIONS

1. Slow maxillary expansion, with a bonded palatal expander or a quad-helix appliance, in conjunction with mandibular expansion, by using a banded Crozat/lip bumper during the early to mid mixed dentition, provides clinically significant treatment increases in arch widths, depths, and perimeters. Expansion was greater posteriorly than anteriorly; increases in arch perimeters were primarily due to the increases in arch widths rather than the increases in arch depths.
2. Short-term posttreatment relapse was mild to moderate for all maxillary and mandibular measures except intercanine widths. Clinically significant net changes in arch width were maintained, net gains arch perimeter were produced, and incisor irregularity increased only slightly.

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