Original Article

Long-Term Stability of Lip Bumper Therapy Followed by Fixed Appliances

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Abstract: Lip bumper treatment has been shown to successfully increase arch width, procline the incisors, and distalize molars. However, few studies have been performed showing the long-term stability of lip bumper treatment. In this study, mandibular casts taken by a single practitioner from 51 patients treated with lip bumpers without rapid palatal expansion were analyzed at pretreatment, post-lip bumper treatment, posttreatment, and long-term out of treatment. Measurements of arch width, arch depth, arch length, and anterior crowding were made. During treatment, there was a mean decrease in irregularity of 3.73 mm, with a posttreatment increase of 0.76 mm, for a net decrease of 2.97 mm. Despite posttreatment decreases, significant gains in arch width were maintained for extended periods of time. The intercanine width had a net increase of 1.78 mm (19% relapse), first premolars 3.39 mm (26% relapse), second premolars 2.58 mm (34% relapse), and first molars 2.17 mm (20% relapse). Lip bumper treatment along with fixed appliances is an effective means to obtain long-term increases in arch width and decreases in the irregularity index. (*Angle Orthod* 2006;76:36–42.)

Key Words: Lip bumper; Retention; Stability; Arch width

INTRODUCTION

The degree of mandibular tooth size/arch length discrepancy is an important factor in determining orthodontic treatment. The mandibular arch has constraints that make correction of crowding more difficult than in the maxilla. These constraints include increased bone density leading to slower overall tooth movement, as well as constraints over the amount of expansion and distalization which can be performed.[1] Thus, the mandibular arch is considered the diagnostic arch and should be the determining factor for maxillary arch alignment, as well as the template for the upper arch form.[1,2]

Methods of resolving tooth size arch/length discrepancies include extraction of teeth, stripping, distalization of molars, flaring of incisors, and expansion of the arches. Expansion can be obtained in the lower arch by (1) active expansion—using forces to push or pull the teeth into a larger arch form, which might distalize the lower first molars creating a Class II relationship or possibly impacting lower second molars or (2) passive expansion—using a lip bumper, using vestibular shields—or by a reciprocal response to upper arch enlargement.[3,4]

The primary purpose of the lip bumper is to decrease the need for extractions by reducing lower anterior crowding and increasing arch width, depth, and circumference.[5] Lip bumpers can also be used for molar anchorage while using Class II elastics, to set anchorage for Class II or III elastics, to maintain the position of the first molar and leeway space, for prevention of lip habits, for vertical control of molars, or to produce molar rotation.[1,6–10] By relieving the soft tissue pressure from the teeth, the equilibrium between the tongue and lip and cheek pressure is altered, which results in dentoalveolar widening and remodeling.[5,11–15] The amount of space gained by anterior movement, lateral expansion and development, and distalization is dictated by the ability to maintain teeth in a stable relationship.[1] Proponents of the lip bumper believe a moderately crowded arch can be treated nonextrac-

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TABLE 1. Arch Measurements (Overall Sample)

	Pretreatment (T1)			Post-lip Bumper (T2)			Posttreatment (T3)			Retention (T4)		
	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD
Arch width												
Canines	42	25.18	1.64	50	27.33	1.64	51	27.38	1.29	51	26.96	1.56
First premolar	47	31.38	2.43	51	35.85	1.92	51	35.99	1.34	51	34.77	1.79
Second premolar	51	37.76	2.33	51	41.94	2.15	51	41.64	1.60	51	40.34	2.08
First molars	51	43.21	2.60	44	47.01	2.19	51	45.93	1.81	51	45.37	2.38
Total arch length	51	60.73	3.51	48	65.25	3.37	51	61.06	2.54	51	59.84	2.74
Arch depth	51	23.00	1.82	49	24.62	1.73	51	22.30	1.32	51	21.70	1.52
Irregularity	37	4.52	1.78	48	2.97	1.77	51	0.79	0.47	51	1.55	1.37

tion, and the lip bumper will enhance stability of the result.[5]

Numerous studies have documented lip bumpers as a clinically reliable method to achieve gains in arch length and resolve mild to moderate crowding by (1) increases in intercuspid width of 1.7–2.5 mm, interfirst premolar width of 2.5–4.1 mm, intersecond premolar width of 2.3–4.5 mm, and interfirst molar width of 1.2–5.5 mm; (2) decreases in the irregularity index of 1.4–3.8 mm; and (3) increases in arch length of 1.2–4.2 mm and arch circumference of 1.3–4.1 mm.[5,7,11–13,16,17]

Many studies have focused on lip bumper results, and other studies show not only the treatment changes but also the long-term stability of conventionally treated orthodontic cases. For example, it has been repeatedly shown that expansion of the mandibular arch by conventional orthodontics is unstable, especially the intercanine width.[4,18–26]

However, there is limited knowledge of the long-term stability of lip bumper treatment and, therefore, further investigation of this is beneficial. The purpose of this study was to assess the long-term stability of lip bumper therapy started in the mixed or permanent dentition followed by fixed orthodontics.

MATERIALS AND METHODS

The patients were selected from the records of the private practice of Dr W. Bonham Magness. All the records in the practice were searched, and inclusion criteria were (1) patient previously treated nonextraction with a prefabricated lip bumper (American Orthodontics Corporation, Sheboygan, Wis), (2) none of the patients were treated with rapid palatal expansion for maxillary arch development, and (3) after lip bumper therapy, the patient received fixed comprehensive orthodontic treatment. Out of a potential pool of 104 patients satisfying the above criteria, 51 were successfully contacted and willing to present for current records. Model analysis was performed on four sets of casts: (T1) pretreatment, (T2) post-lip bumper, (T3) posttreatment, and (T4) retention. The project was approved by the Institutional Review Board of the University of Texas Health Science Center at Houston Dental Branch, and informed consent statements were signed by the patients or parents of the patients.

During treatment, the lip bumper was adjusted to rest in the vestibule at the level of the free gingival margins one to two mm facial to the teeth and tied in the buccal tube of the lower first molars to ensure continuous wear. No active expansion was applied to the first molars unless they required correction for lingual tipping.

Treatment was initiated at an average age of 11.67 $\pm$ 1.37 years (range 8.84–14.72). The lip bumper was worn for an average of 16.40 $\pm$ 4.99 months (range 7.63 to 31.99), followed by comprehensive banding and bonding. Comprehensive fixed appliance treatment is necessary to finalize and detail the occlusion, especially with crown torque of all teeth. The teeth were bracketed near the end of lip bumper treatment, and both the brackets and the lip bumpers were worn for an overlapping period averaging 3.15 $\pm$ 2.28 months (range 0 to 13.58). The mean combined treatment time was 27.52 $\pm$ 6.84 months (range 15.84 to 44.44). After treatment, all patients were given upper removable retainers. Lower retention consisted of fixed cuspid-to-cuspid retention for 48 patients and lower removable retainers for three patients. At T4, 25 of the original 48 patients who had lower fixed retention presented with retention still in place. The other 23 patients who were out of retainers had been out for an average of 8.59 $\pm$ 1.57 years (range 6.37 to 14.90).

Measurements were made with a digital caliper to the nearest 0.01 mm. Reliability was established by digitizing a subset of 10 casts two times, one week apart. Means differences were compared with their respective standard errors to establish systematic error. Systematic error was not statistically significant. Random method error ranged between 0.23 and 0.47 mm. Data were saved on an Excel spreadsheet and then transferred to Minitab (Version 13.1) for statistical analysis. The following measurements were obtained:

1. Canine—canine arch width
   - at the cusp tips.
2. First premolar—premolar arch width
   - at the buccal cusp tips,
   - at the buccal cusp tips of primary first molars if present.
3. Second premolar—premolar arch width
   - at the buccal cusp tips,
   - at the buccal grooves (occlusally) of primary second molars if present.
4. First molar—molar arch width
   - at the mesiobuccal cusp tips.
5. Total arch length
   - the sum of the right and left distances from the mesial contact points of the first molars to the contact point of the central incisors.
6. Arch depth
   - perpendicular distance from the contact point of the central incisors to a line bisecting the mesial contact points of the first molars.
7. Irregularity index
   - the sum of the displacement of the six anterior contact points.[27]

The experimental groups within the sample were analyzed. These consisted of (1) 29 patients who initiated treatment in the mixed dentition (at least one primary tooth present) vs 22 patients who initiated treatment in the permanent dentition and (2) 25 patients who initially had lower fixed retention that was still present at T4 vs 23 patients who initially had fixed retention, which was removed an average of 4.08 $\pm$ 2.27 years before T4. At the start of treatment, the average age of patients in the mixed dentition group was 11.09 $\pm$ 1.04 and in the permanent dentition group 12.44 $\pm$ 1.39 years.

RESULTS

Entire sample arch width

During lip bumper treatment (T1-T2), the arch width significantly increased for all measurements (Figure 1). The greatest change was observed in the first premolars, with a 4.48 mm increase, and the least in the canines, with a 2.15 mm increase. The majority of all the increase in arch width occurred from T1 to T2.

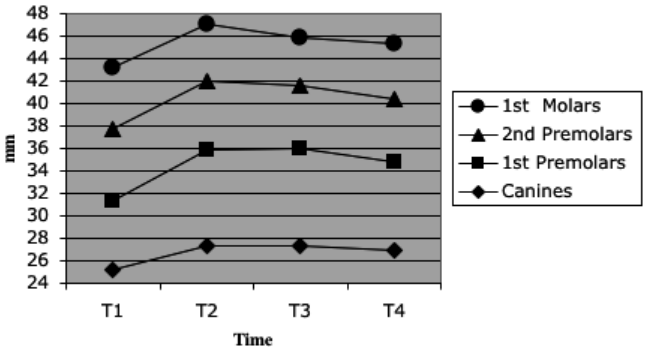

FIGURE 1. Overall sample arch width.

During fixed appliance therapy following the lip bumper (T2-T3), statistically insignificant increases or decreases in arch width occurred for all teeth. The increase in arch width was greatest for the first premolars (4.61 mm) and least for the canines (2.20 mm).

During posttreatment (T3-T4), the mean arch width decreased for all teeth. The decreases for the canines and first molars were statistically insignificant, whereas the decreases for the first and second premolars were significant.

The overall changes (T1-T4) in arch width were significant for all measurements. The canines showed the smallest increase (1.78 mm) and the first premolars the largest (3.39 mm).

Irregularity index

Significant changes in the irregularity index were observed for all time periods (Figure 2). During lip bumper treatment (T1-T2), the irregularity decreased, and during fixed treatment (T2-T3), it decreased again for a total of 3.73 mm. After the active treatment (T3-T4), the irregularity index increased 0.76 mm. Thus, the

TABLE 2. Arch Measurements (Mixed Dentition)

	Pretreatment (T1)			Post-lip Bumper (T2)			Posttreatment (T3)			Retention (T4)		
	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD
Arch width												
Canines	22	25.37	1.84	28	27.76	1.70	29	27.77	1.34	29	27.35	1.60
First premolar	25	30.60	2.65	29	35.80	2.15	29	36.30	1.41	29	35.05	1.98
Second premolar	29	37.51	2.56	29	41.84	2.30	29	41.87	1.67	29	40.38	2.27
First molars	29	43.02	2.84	23	47.25	2.38	29	46.04	1.92	29	45.36	2.41
Total arch length	29	61.45	3.95	27	66.50	2.98	29	61.66	2.35	29	60.22	2.69
Arch depth	29	23.45	1.86	28	25.28	1.57	29	22.65	1.24	29	21.98	1.47
Irregularity	17	5.20	1.86	29	3.44	1.98	29	0.80	0.49	29	1.53	1.29

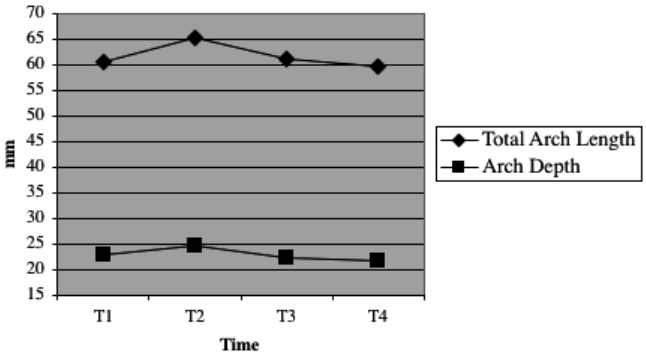

FIGURE 2. Overall sample irregularity.

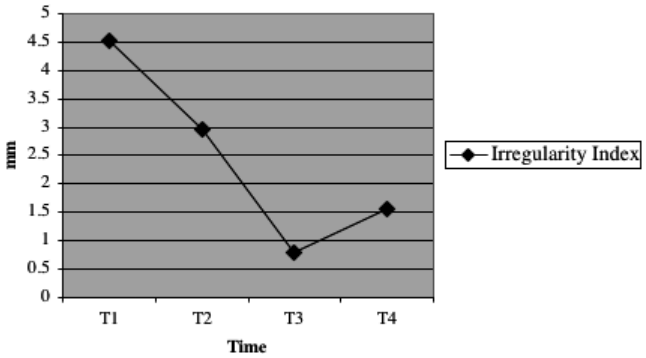

FIGURE 3. Overall sample arch depth/arch length.

overall change in the irregularity index (T1-T4) was a decrease of 2.97 mm.

Arch length

During lip bumper treatment (T1-T2), arch length significantly increased (Figure 3). However, during fixed appliance therapy (T2-T3), much of this increase was lost. During posttreatment (T3-T4), the arch length continued to decrease significantly (1.23 mm). The overall (T1-T4) change in arch length was −0.89 mm.

Arch depth

During lip bumper treatment (T1-T2), arch depth significantly increased (Figure 3). However, during fixed appliance therapy (T2-T3), much of this increase was lost. During posttreatment (T3-T4), the arch depth continued to decrease significantly. The overall (T1-T4) change in arch depth was 1.30 mm.

Mixed vs permanent dentition

For the mixed group, the largest increase in arch width from T1 to T2 was at the first premolars (5.21 mm) and the smallest at the canines (2.39 mm). The T1-T3 increase was largest at the first premolars (5.71 mm) and smallest at the canines (2.40 mm). From T3 to T4, the arch width decreased for all teeth. The decreases were insignificant for the canines (0.42 mm) and first molars (0.68 mm) but significant for the first (1.25 mm) and second premolars (1.49 mm).

Significant changes in the irregularity index were observed for all time periods. From T1 to T2 the irregularity decreased 1.76 mm and from T2 to T3 another 2.64 mm. From T3 to T4 there was an increase of 0.73 mm, resulting in a T1-T4 decrease of 3.66 mm.

For the permanent dentition group, the largest increase in arch width from T1 to T2 occurred at the second bicuspids (3.99 mm) and the smallest at the canines (1.82 mm). The T1-T3 increase was largest for the first premolars (3.31 mm) and smallest for the canines (1.82 mm). From T3 to T4, the arch width decreased for all teeth. Insignificant decreases occurred at the canines (0.43 mm) and first molars (0.40 mm) and significant decreases at the first (1.19 mm) and second premolars (1.06 mm). Significant changes in the irregularity index were observed for almost all time periods. From T1 to T2 the irregularity decreased 1.69 mm and from T2 to T3 another 1.49 mm. From T3 to T4, there was a 0.81 mm increase.

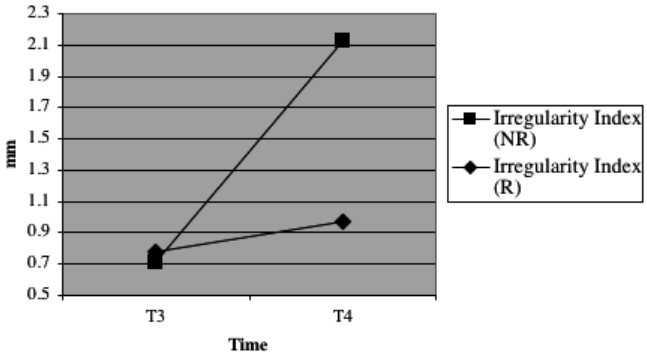

FIGURE 4. Retention/nonretention irregularity.

Retention vs nonretention

For the retention group, the greatest amount of relapse from T3 to T4 was at the second premolars (1.46 mm) and the least at the canines (0.05 mm) (Figure 4). The first premolars relapsed 1.18 mm and the first molars 0.88 mm. Only the first and second premolar decreases were statistically significant. The total arch length decreased 1.20 mm and the arch depth 0.48 mm, and neither of these changes was statistically significant. The irregularity increased insignificantly 0.19 mm.

The greatest amount of relapse for the nonretention group was at the first premolars (1.40 mm) and the least at the first molars (0.33 mm). The intercanine width relapsed 0.84 mm and the second premolars 1.23 mm. Only the first premolar relapse was statistically significant. The arch length decreased 1.17 mm

TABLE 3. Arch Measurements (Permanent Dentition)

	Pretreatment (T1)			Post-lip Bumper (T2)			Posttreatment (T3)			Retention (T4)		
	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD	Sample No.	Mean (mm)	SD
Arch width												
Canines	20	24.96	1.40	22	26.78	1.42	22	26.86	1.05	22	26.44	1.38
First premolar	22	32.27	1.83	22	35.92	1.63	22	35.57	1.13	22	34.39	1.46
Second premolars	22	38.08	2.00	22	42.07	1.97	22	41.34	1.49	22	40.28	1.86
First molars	22	43.45	2.29	21	46.74	1.98	22	45.78	1.69	22	45.39	2.39
Total arch length	22	59.79	2.64	21	63.63	3.21	22	60.28	2.62	22	59.34	2.80
Arch depth	22	22.41	1.62	21	23.75	1.56	22	21.85	1.31	22	21.34	1.52
Irregularity	20	3.95	1.52	19	2.26	1.08	22	0.77	0.45	22	1.58	1.50

and arch depth 0.58 mm, and neither of these changes was significant. The irregularity increased significantly, 1.42 mm.

DISCUSSION

Entire sample

The analysis of the effects of lip bumper treatment in this study showed significant changes in arch width, arch length, arch depth, and incisor irregularity, Table 1. Although the absolute values differ among studies, the results from this study show treatment effects similar to others. Generally, the greatest arch width gain occurs at the premolars and the least at the canines, with the molars somewhere between. Arch length and arch depth increased significantly, whereas incisor irregularity decreased.

The majority of the arch width increase was due to changes occurring during lip bumper treatment. With normal growth and relapse, the arch width decreased from T3 to T4 for all teeth. However, these decreases were only significant for the first and second premolars. The canines relapsed −19% (0.42 mm) of the treatment increase (2.20 mm). The first and second premolars relapsed, respectively, −26% (1.22 mm) and −34% (1.31 mm) of their treatment increases of 4.61 and 3.89 mm. The first molars relapsed −20% (0.56 mm) of the treatment increase (2.73 mm). Despite this relapse, significant gains were maintained from T1 to T4 canines (1.78 mm), first premolars (3.39 mm), second premolars (2.58 mm), and first molars (2.17 mm).

The decrease in irregularity shows that the lip bumper is an effective means for relieving anterior crowding. Lip bumper treatment alone accounted for 41% (1.55 mm) of the total decrease in irregularity (3.73 mm). From T3 to T4, the irregularity relapsed −20% (0.76 mm) of this decrease, resulting in a significant T1-T4 decrease of 2.97 mm.

From T1 to T2, the total arch depth and arch width increased significantly but then decreased from T2 to T3. As expected and reported in previous studies, the total arch length and arch depth measurements continued to decrease after treatment.[27,28] The 0.33 mm increase in arch length that occurred from T1 to T3 was lost after treatment, along with an additional 1.23 mm. For arch depth, in addition to the 0.69 mm lost from T1 to T3, an additional 0.60 mm decrease was observed from T3 to T4. The T1-T4 decrease of 0.89 mm in arch length and 1.30 mm in arch depth shows that despite significant increases during lip bumper treatment, one can expect a decrease after lip bumper treatment, as well as during retention.

Mixed vs permanent dentition

The overall treatment trends among the mixed and permanent dentition groups were similar, Tables 2 and 3. However, one clinically significant difference between the two groups was that the treatment gains for almost all recorded values (except T2-T3 changes in total arch length and arch depth) were higher in the mixed dentition group as compared with the permanent group. From T3 to T4, decreases in arch width, arch length, and arch depth, and increases in the irregularity index, were shown for both groups. None of the respective measurements between the two groups were significantly different from each other. In looking at the percentage of relapse in relation to treatment changes, there was no clear pattern of one group showing consistently greater relapse than the other. Except for the intercanine and irregularity index differences, all the decreases in dimension were larger for the mixed dentition than the permanent. This could be because of the fact that in the mixed dentition group, almost all values increased more during treatment, and the leeway space with its late mesial drift of the mandibular first molar was inhibited. The soft tissues will establish equilibrium, and overexpanded teeth will relapse. It appears that treatment initiated in the mixed dentition will have less relapse of the expansion.

The T1-T4 changes for both groups show significant

increases in arch width and decreases in irregularity, Table 4. For all teeth, the mean arch width increases and irregularity decreases for the mixed dentition were greater than for the permanent. These differences were due to treatment changes rather than differences in relapse.

Retention vs nonretention

From T3 to T4, decreases in arch width, arch length, and arch depth, along with increases in the irregularity index, were observed for most variables. The only measurements that showed significant differences between the two groups were the intercanine width and the irregularity index. Thus, the retention group showed significantly greater overall gains in intercanine width and decreases in irregularity. The hypothesis that fixed retention leads to greater stability of the buccal segments was not observed in this study; second premolars and first molars actually showed more relapse (nonsignificant) in the retention group. It again proves the point that the soft tissues will cause overexpanded teeth to relapse to a position of equilibrium.

Despite observing greater relapse at the cuspids and greater increases in irregularity for the nonretention group, T1-T4 gains in arch width and decreases in irregularity were observed for both groups. These changes were all significant, except for the nonretention intercanine width. Thus, significant decreases in irregularity and increases in arch width were maintained with or without retention. However, without retention, a clinically significant loss of intercanine width occurred after treatment. Despite this, 42% of the increase in intercanine width remained. The percentages of relapse in this study are similar to a study performed on conventionally treated cases by Gardner and Chaconas,[19] in which the intercanine width relapsed 58% after treatment. However, the intercanine relapse was less in this study compared with several other studies performed on conventionally treated cases in which the intercanine width was increased during treatment and later had a net loss of intercanine width ranging from 0.4 to 0.6 mm.[20,24,25]

TABLE 4. Movement (Overall Sample)

	Movement (mm)	*P* value	% Relapse (T3-T4)/(T1-T3)
Canines			
T1-T2	2.152	.000	
T1-T3	2.204	.000	
T1-T4	1.781	.000	
T2-T3	0.052	.859	
T2-T4	−0.371	.248	
T3-T4	−0.423	.139	−19.19
First premolars			
T1-T2	4.477	.000	
T1-T3	4.610	.000	
T1-T4	3.389	.000	
T2-T3	0.134	.685	
T2-T4	−1.088	.004	
T3-T4	−1.221	.000	−26.49
Second premolars			
T1-T2	4.181	.000	
T1-T3	3.886	.000	
T1-T4	2.580	.000	
T2-T3	−0.295	.434	
T2-T4	−1.601	.000	
T3-T4	−1.307	.001	−33.63
First molars			
T1-T2	3.803	.000	
T1-T3	2.725	.000	
T1-T4	2.169	.000	
T2-T3	−1.078	.011	
T2-T4	−1.634	.001	
T3-T4	−0.557	.187	−20.44
Total arch length			
T1-T2	4.516	.000	
T1-T3	0.334	.584	
T1-T4	−0.893	.156	
T2-T3	−4.182	.000	
T2-T4	−5.409	.000	
T3-T4	−1.227	.021	−367.37
Arch depth			
T1-T2	1.621	.000	
T1-T3	−0.699	.029	
T1-T4	−1.300	.000	
T2-T3	−2.320	.000	
T2-T4	−2.922	.000	
T3-T4	−0.602	.035	86.12
Irregularity index			
T1-T2	−1.549	.000	
T1-T3	−3.734	.000	
T1-T4	−2.970	.000	
T2-T3	−2.185	.000	
T2-T4	−1.421	.000	
T3-T4	0.764	.000	−20.46

CONCLUSIONS

- Lip bumper treatment results in significant gains in arch width, with the greatest amount at the premolars and the least at the canines.
- The decrease in irregularity shows that the lip bumper combined with fixed appliances is an effective means to relieve anterior crowding. Lip bumper treatment alone accounted for 41% (1.55 mm) of the total decrease in irregularity.
- The majority of the arch width increase occurred during lip bumper treatment alone, with statistically insignificant changes during fixed treatment.
- From T3 to T4, arch width decreased; however, significant gains were maintained for extended periods of time. T1-T4 gains in arch width, along with de-

creases in irregularity, were observed for every value measured.
- Although not statistically significant for all teeth, the treatment increases, posttreatment decreases, and net changes for almost all values were higher for the mixed dentition group compared with the permanent dentition group.
- Without retention, a clinically significant loss of intercanine width occurred, but 42% of the increase remained.
- Fixed cuspid-to-cuspid retention leads to greater stability of the intercanine width and irregularity but has no effect on the arch width stability of the teeth not directly involved in the retention.
- The lip bumper along with fixed appliances is an effective means to obtain long-term increases in arch width and decreases in the irregularity index.

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