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A Longitudinal Study of Incremental Expansion Using a Mandibular Lip Bumper

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ABSTRACT

A retrospective study using models was performed to evaluate the incremental expansion that occurred during mandibular lip bumper therapy in 44 adolescent patients. The purpose was to determine whether expansion occurs evenly between appointments or whether it attenuates with treatment time. Dental cast measurements were made for arch width and arch length. Treatment duration was broken into near-equal time segments and compared. Results showed that about 50% of the total expansion achieved occurred within about the first 100 days. Forty percent of the total amount of expansion occurred during the next 200 days, with only about 10% of the total expansion occurring after the first 300 days. It is unnecessary to have the appliance in place for longer than 300 days. The percentage of expansion that occurred at each time segment was not related to whether the patient had concomitant maxillary expansion.

KEY WORDS: Expansion, Mandibular, Lip bumper.

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INTRODUCTION Return to TOC

Orthodontists have always been faced with the problem of straightening crowded teeth. A variety of treatment modalities have been used to accomplish this task, some of which include tooth extraction, expansion, interproximal enamel reduction, flaring incisors, and uprighting molars. A recent trend in orthodontics is the reemergence of nonextraction treatment.[1] Because many patients have significant crowding, more focus has been placed on developing the arches through expansion therapy. The mandibular lip bumper is an aid to nonextraction therapy because of its ability to develop the lower arch.[2] The key to using this appliance effectively is in knowing exactly how it works and how the expansion is distributed throughout treatment.

The lip bumper allows for expansion of the mandibular dental arch in both an anterior-posterior and a transverse direction.[3–5] Typically, it is made of 0.045″ stainless steel wire, and it spans the mandibular dentition from molar to molar. The wire is kept away from the facial surfaces of the teeth, usually at the level of the gingival margin, and may or may not be covered anteriorly with plastic or acrylic. The appliance fits into tubes located on the lower molars and has adjustment loops located just mesial to these tubes. The lip bumper displaces the facial musculature, preventing it from coming into contact with the lower teeth, and allows the lingual forces of the tongue to

remain unbalanced, thus causing forward and lateral expansion of the mandibular dental arch. This disruption of the equilibrium surrounding the dentition is the fundamental concept on which the lip bumper is based.

The subsequent expansion has been documented in the literature as occurring between the molars, premolars, canines, and an anterior flaring of the incisors.[6–8] The mandibular lip bumper is also used to tip the molars distally utilizing the distal force created by the facial musculature on the appliance itself.[2,9,10] Osborn et al[7] quantified many of the dimensional changes that occur during lip bumper use. In their study of 32 patients, they found that the arch width increased 2 mm at the canines, 2.5 mm at the first premolars, 2.4 mm at the second premolars, and 2 mm at the first molars and that the arch length increased by 1.2 mm. Other studies had similar results.[6,11]

Previous studies attempted to quantify the experimental changes associated with the use of the mandibular lip bumper. These studies focused primarily on the final treatment result and did not discuss what actually happens to the dentition between each appointment visit. It has not been documented whether most of the dimensional change occurs at the beginning of treatment or at the end of treatment, or whether it occurs slowly throughout the entire treatment period. A study that analyzes the changes that occur between each appointment could prove useful to the patient and the clinician. In this study, we propose to identify when arch expansion occurs during lip bumper therapy. To achieve this objective, we analyzed orthodontic study models of 44 consecutively treated patients who had impressions taken at every appointment during active lip bumper treatment by a single orthodontic practitioner. This study will add valuable new information to lip bumper treatment that may help the clinician maximize treatment efficiency. If the clinician knows when most of the expansion occurs during lip bumper therapy, the patient will not have to spend unnecessary time wearing the appliance, and the clinician can change faster to fixed appliances for definitive correction of the malocclusion.

MATERIALS AND METHODS Return to TOC

In this retrospective study of 44 patients, a single orthodontic practitioner treated 24 female and 20 male patients with a mandibular lip bumper. The patients' ages were between 9 and 17 years, with a mean age of 12 years. The lip bumper treatment time ranged from 7 to 18 months, with an average of 12.5 months. The sample included patients in the mixed dentition and the early permanent dentition. Twenty-seven patients had a class I molar relationship, 13 were class II, and four were end-on class II. Appliances used on the mandibular arch consisted solely of a commercial, prefabricated lip bumper (American Orthodontics Corp, Sheboygan, Wis) of 0.045-inch stainless steel wire with no acrylic or plastic added to the anterior segment. Fifteen patients had maxillary expansion in conjunction with the lip bumper therapy, whereas 29 patients had only traditional fixed appliances on the maxillary dentition. Of those patients who had expansion, 11 had Haas-style rapid palatal expanders, three had the inner bow of a Kloehn cervical facebow, and one had a quad helix.

Clinical procedure

In all cases, the lip bumper was fixed in place 24 hours per day with ligature wire, elastic power chains, or elastic separators running from the hooks on the lip bumper to the buccal tubes on the bands of the lower first molars. It was adjusted at the level of the free gingival margin with 1.0–1.5 mm of advancement relative to the gingival margin. The lip bumper was routinely inserted without active expansion unless it was required to correct lingual torque of the mandibular molars. Mandibular alginate impressions were taken at each four- to six-week adjustment appointment and poured into diagnostic study models immediately.

Measurements

The following measurements were made to the nearest 10th of a millimeter using digital calipers, each landmark being marked with a sharp lead pencil (see Figure 1):

Mandibular arch length—measured by summing both the right and the left distances from the mesial contact points of the first permanent molars to the contact point of the central incisors or to the midpoint between the centrals if spaced.

Arch widths between mandibular canines—measured by the distance between two reproducible landmarks located near the cusp tips of both canines.

Arch width between mandibular first/second premolars—measured by the distance between two reproducible landmarks located near the cusp tips of both first/second premolars.

Arch width between mandibular first permanent molars—measured by the distance between two reproducible landmarks located near the central pits of both first molars.

To determine the incremental expansion that occurred between each appointment, the same landmark on each tooth for each successive patient cast was identified. A pilot study was done to determine the possible error in measuring the incremental differences between appointments. Three patients were selected at random, and each dimension was measured on each cast for each patient. Once completed, all marks were removed without damaging the casts, and the same protocol was performed two more times, each on separate days. The results for each of the three trials were then compared to determine the error.

Measurements for this study were only made on permanent teeth. Measurements were not analyzed for those patients whose primary teeth exfoliated during the duration of lip bumper treatment because of the tooth mobility that exists before exfoliation. There were a limited number of cases where the primary teeth were retained throughout treatment. For these specific cases, measurements were analyzed on primary teeth. Data was not analyzed for permanent teeth that erupted near the end of lip bumper treatment or for teeth that were distorted or broken.

Data analysis

The expansion was analyzed as the percentage of total expansion attained for each patient during defined time periods. This was done by dividing the small amount of expansion that occurred between each appointment by the total expansion achieved to identify what percentage of overall expansion occurred between appointments. The percentages of expansion were then grouped according to the number of appointments required to most closely approximate a time segment of 100 days.

Statistics

The data in this study were not normally distributed, and the sample sizes were small, thus a nonparametric analysis was performed taking into consideration the amounts of expansion that occurred in each of the five time segments for each patient. Median values were shown to give the most representative percentages of expansion. The first and third quartiles also were reported to give the ranges of the amounts of expansion for 50% of the patients. Mann-Whitney tests were done to check for significant differences in expansion between the 15 patients undergoing concomitant maxillary expansion and those who did not.

RESULTS Return to TOC

The appointments were pooled in groups of two or three to establish approximately equal time segments for each patient. The total sum of the days for those two or three appointments approached 100. Table 1 gives the average number of days that were included in each time segment for all patients. Because this study was retrospective, it was not possible to control the amount of time between appointments for each patient.

One hundred percent of the patients had a treatment period that extended at least through the first two time segments. Eighty-six percent of the treatment periods extended through the third time segment, 64% extended through the fourth, and 27% extended through the fifth. Only 7% extended through the sixth time segment and were thus not included in the analysis.

Table 2 shows the total expansion in millimeters that occurred for each dimension measured. The largest median increases were seen in arch length expansion, and the smallest were observed in width expansion between the canines. These values were found to be 4.4 and 2.0 mm, respectively. Because the molars are the only teeth directly attached to the lip bumper, the expansion seen between them is active in contrast to the passive expansion that occurred across the premolars and the canines. The expansion that was noted in this study can be attributed to the lip bumper itself and not to the patient's growth. This fact is supported in a previous study by Davidovich et al.[12] Their study included an experimental lip bumper group and a control group that received no treatment at all. In their study of 34 patients, they showed that their control group had a decrease in each dimension measured at the end of the six months as compared with the experimental group, which showed increases.

Table 3 shows the percentage of total expansion that occurred in each time segment for each measurement. For each dimension analyzed, the largest percentage of expansion occurred in the first time segment, during the first 100 days of treatment. As the treatment continued, the percentage of total expansion progressively decreased from one time segment to the next, with minimal expansion occurring in the last two time segments.

The greatest percentage of expansion, 59.5%, occurred during the first time segment between the second premolars. The smallest percentage of expansion, 5%, occurred between the canines during the last two time segments combined.

The percentages of total expansion per time segment can be seen in Figure 2. For each of the tooth types, there is a notable decrease in the amount of expansion that occurred as time progressed.

Mann-Whitney tests were performed to compare the amounts of mandibular expansion that occurred during lip bumper therapy in patients who had simultaneous maxillary expansion vs those who did not. These tests showed no significant differences in the amounts of expansion that occurred for each tooth type.

In determining the amount of error in measuring the incremental differences between appointments, the results of the previously described pilot study revealed the standard error of the mean to be 0.0399 and a coefficient of variation equal to 0.0021.

DISCUSSION Return to TOC

A critical aspect of nonextraction therapy is the creation of space. The results from this study show that lip bumper therapy is an effective means of accomplishing this task. Other studies have demonstrated similar results using lip bumpers but have not focused on the attenuation in expansion that occurs during treatment. A major concern for orthodontists is treatment effectiveness and efficiency. It would be beneficial to know the specific amount of time required to achieve sufficient expansion using lip bumper therapy. This information would benefit the clinician by eliminating unnecessary lip bumper wear. This would obviously be desirable for the patients as well.

The expansion achieved during lip bumper therapy is evenly distributed during treatment. However, the results clearly demonstrate that the expansion occurred unevenly and actually decreased with time. Table 4 shows that for each of the measurements, the greatest amount of expansion, about 50% of the total, occurred within about the first 100 days. During the second and third time periods, about 40% of the total amount of expansion will have occurred. During the last two time segments, the percentage of total expansion achieved is only about 10%. Therefore, about 90% of the expansion was completed in these cases within the first 300 days, and treatment effectiveness after this point yielded only about 10% of the total expansion.

Knowledge of how the lip bumper alters the equilibrium between the lingual and the vestibular forces surrounding the teeth may explain the results of this study. We speculate that upon insertion of the appliance, a new system of forces is set up around the teeth. With time, the dentition will adapt to the new force system and reestablish equilibrium. The gross movements in this process occur early in treatment, and as the teeth approach their new equilibrium position, their movement tapers down. Although we observed most of the expansion occurring at the start of treatment, we did observe some patients who had a higher than normal percentage of tooth movement toward the end of treatment. We speculate that this could be related to whether the appliance was adjusted toward the end of lip bumper therapy. More specifically, most cases in our study had minimal adjustments to the lip bumper toward the end of treatment. However, for those cases that required such adjustments, the force system was still undergoing changes, thus not approaching equilibrium.

Maxillary expansion can create secondary expansion in the mandibular dentition. Because no differences were found between those patients who received expansion and those who did not, we propose that the already expanding lower teeth were not affected by the occlusal loading of the opposing teeth.

The soft tissues surrounding the dentition both labially and lingually are proven to be major regulating factors that determine the final positions of the teeth. Stability of the dentition in the newly expanded position is dependent on how well these soft tissues maintain their relationships with one another. If there were better stability in the expansion achieved through the use of the lip bumper, clinicians would be one step closer to delivering quality treatment with more lasting potential. As orthodontists, we face the challenge of correcting dental crowding. An even greater challenge is in maintaining the results we finally achieve. Orthodontics would therefore benefit greatly from future long-term studies focusing on the stability of cases treated with lip bumper therapy.

CONCLUSIONS Return to TOC

The expansion that occurs during lip bumper therapy is not evenly distributed between appointments. Most of the expansion occurs at the beginning of treatment and then tapers down with time. In this study, we show that about 50% of the total expansion occurs in the first 100 days of treatment and that 90% of the total expansion is achieved within about the first 300 days. Any subsequent expansion thereafter is minimal. We, therefore, conclude that it is unnecessary to have the appliance in place for longer than 300 days.

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TABLES Return to TOC

TABLE 1. Average Number of Days Included in Each Time Segment for All Patients

Time Segment	Number of Days
1	105.4
2	104.6
3	97.4
4	77.5
5	85.8
6	51.7

TABLE 2. Total Expansion for Each Measurement

Measure-ment	Number of Patients	Median Change (mm)	Quartile 1 (mm)	Quartile 3 (mm)
3–3	43	2.0	1.1	2.3
4–4	42	3.0	1.8	3.9
5–5	41	3.2	2.3	4.2
6–6	44	3.5	2.4	4.7
AL	44	4.4	3.0	5.7

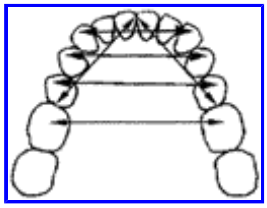
TABLE 3. Percentage of Total Expansion Per Time Segment for Each Measurement

Measure-ment	Time Segment	Number of Points	Median (%)	Quartile 1 (%)	Quartile 3 (%)
3–3	1	43	55.0	34.5	70.6
	2	43	25.0	10.0	40.0
	3	36	20.9	5.5	37.4
	4	26	0.0	0.0	12.3
	5	11	5.0	0.0	12.5
4–4	1	43	48.1	35.1	69.9
	2	43	26.7	13.5	45.8
	3	35	17.1	5.7	27.8
	4	25	5.4	0.3	20.6
	5	10	9.6	5.5	14.6
5–5	1	41	59.5	33.3	71.7
	2	40	26.3	18.5	37.4
	3	31	17.2	0.0	25.8
	4	19	3.6	0.0	23.8
	5	7	3.3	0.0	14.3
6–6	1	44	40.3	14.5	75.9
	2	44	36.7	17.1	55.1
	3	38	13.1	−8.7	27.0
	4	28	6.6	−2.3	23.8
	5	12	5.0	0.0	37.0
AL	1	44	51.9	33.2	80.3
	2	44	33.0	17.1	43.1
	3	38	15.7	−0.4	29.9
	4	27	8.3	−1.1	16.7
	5	12	4.5	0.0	15.9

TABLE 4. Summary and Averages of the Median Percentage of Total Expansion Per Time Segment for Each Measurement

	3–3 (%)	4–4 (%)	5–5 (%)	6–6 (%)	AL (%)	Average (%)
Time Segment 1	55.0	48.1	59.5	40.3	51.9	51.0
Time Segment 2	25.0	26.7	26.3	36.7	33.0	29.5
Time Segment 3	20.9	17.1	17.2	13.1	15.7	16.8
Time Segment 4	0.0	5.4	3.6	6.6	8.3	4.8
Time Segment 5	5.0	9.6	3.3	5.0	4.5	5.5

FIGURES Return to TOC



Click on thumbnail for full-sized image.

FIGURE 1. Illustration of measurements performed

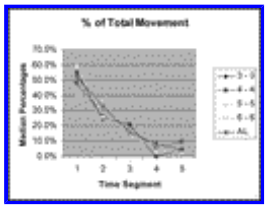


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FIGURE 2. Graphical representation showing percentage of total expansion per time segment for each measurement

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