Lip bumper therapy for gaining arch length

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With the use of pretreatment and posttreatment lateral cephalograms and study models, lip bumper therapy for two groups of 20 patients was evaluated. One group was treated with lip bumpers fabricated from stainless steel round wire covered with shrink tubing and activated every 2 to 3 months. The second group was treated with larger prefabricated lip bumpers covered with acrylic shields from canine to canine and activated every 4 to 5 weeks. Yearly rates of treatment change indicate that the type of lip bumper used and the method of clinical manipulation have no effect on mandibular incisor position. Both groups showed similar rates of controlled incisal tipping with the center of rotation at the apex. Dental movements of the posterior segment were significantly different between groups. The second group displayed significantly more molar tipping than the first group. The second group also showed significantly greater transverse expansion of the canines, first premolars, and first molars. (AM J ORTHOD DENTOFAC ORTHOP 1991;100:330-6.)

Lip bumpers have been used to gain arch length for the alignment of mild to moderately crowded dental arches.[1-5] As such, they may provide an alternative to extraction therapy. Most lip bumpers are made of stainless steel wire (usually 0.045 inch) coated with plastic or acrylic (Fig. 1). The lip bumper is positioned in front of and away from the lower anterior dentition; it inserts into buccal tubes cemented to the first or second permanent molars. Usually there are adjustment loops in the lateral arms.

The claimed therapeutic effect of the lip bumper is bodily forward incisor movement, flaring of the lower incisors, and distal tipping of the molars.[1-3] The dental changes can be attributed to removal of lip pressure on the lower anterior dentition and the distal forces exerted at the molar abutment. Labial pressure exerted against the lip bumper shield has been estimated to range between 100 and 300 gm.[6] Only 1.7 gm of lip pressure above the resting values is necessary for moving teeth.[7] The lateral arm of the lip bumper may also remove the resting pressure of the buccal musculature, allowing tongue pressure to act unopposed to increase arch widths.[8,9]

REVIEW OF THE LITERATURE

Of 116 lip bumper cases examined, 95% exhibited forward migration of the lower incisors and distal movement of the first molar[1]; 88% of the 22 cases reported by Subtelny and Sakuda[2] showed molar uprighting or distal movement. Bjerregaard et al.,[3] studying 11 patients, reported an average increase of 6 mm in mandibular arch circumference. They showed that arch width between the first molars increased by 2.9 mm, the lower incisors tipped labially approximately 5°, and the first molars tipped distally 8°. Cetlin and Ten Hoeve[4], reporting on 50 consecutively treated nonextraction cases, found an average increase of 2.5 mm between the canines, a 4 mm increase in inter–first premolar width, a 4.5 mm increase in inter–second premolar width, and a 5.5 mm increase in inter–first molar width. When the second molars were used as abutments for the lip bumper, a 4 mm increase in the width of the first molar has been reported. Apparently it is possible to get 4 to 5 mm of expansion in the premolar region within 2 years by adding a buccal acrylic shield to the lip bumper.[5] Since the pressure of

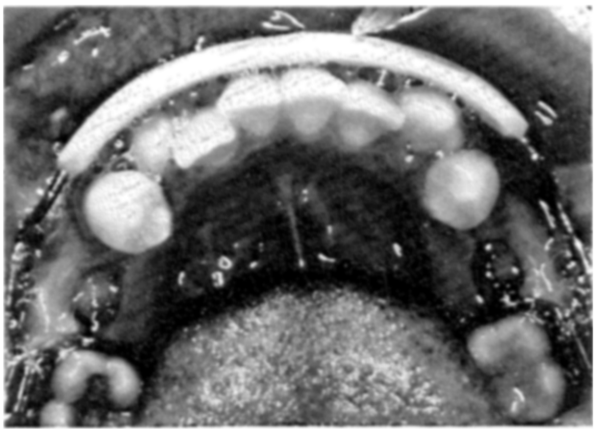

Fig. 1. Occlusal view of lip bumper used for patients in group 2.

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Table I. Cephalometric angles and distances

Description	*Abbreviation*	*Scale*	*No. of replicates*	*Mean systematic difference*	*Method error**
		Cephalometric measurements			
Central incisor to mandibular plane	I_1/MP (IMPA)	Degrees	15	0.19	1.19
Central incisor to nasion–B point line	I_1/N-B	Degrees	15	0.14	1.23
Central incisor to occlusal plane	I_1/OP	Degrees	15	−0.26	1.02
Central incisor apex to anterior reference point	I_{1a}-ARP	mm	15	−0.18	0.35
Central incisor cusp tip to anterior reference point	I_{1t}-ARP	mm	15	−0.21	0.45
Central incisor cusp tip to nasion–B point line	I_{1t}-(N-B)	mm	15	−0.05	0.29
Central incisor cusp tip to menton	I_{1t}-Me	mm	15	0.18	0.44
Molar to occlusal plane	M_1/OP	Degrees	15	−0.05	1.07
Molar apex to anterior reference point	M_{1a}-ARP	mm	15	0.01	0.35
Molar cusp tip to anterior reference point	M_{1t}-ARP	mm	15	0.01	0.89
Molar cusp tip to mandibular plane	M_{1t}-MP	mm	15	0.15	0.54
		Model measurements			
Total arch length	TAL	mm	20	−0.99	0.81
Arch Depth	AD	mm	20	0.06	0.17
Irregularity index	Irreg.	mm	20	−0.04	0.25
Intercanine width	C-C	mm	20	0.04	0.16
Interpremolar width	Pm_1-Pm_1	mm	20	−0.08	0.11
Intermolar width	M_1-M_1	mm	20	0.06	0.10

*$\sqrt{\dfrac{\sum (x_1 - x_2)^2}{2n}}$

the buccinator muscles against the shield is transmitted to the molars, active expansion may be required to prevent the molars from rolling lingually.

Previous reports of lip bumper therapy have been based on either (1) small samples studied over extended period of time or (2) adequate sample sizes followed over relatively short treatment times. Larger samples, followed over longer treatment periods, are necessary to minimize performance and transfer bias,[10] as well as to increase the power of the test statistics. In addition, studies comparing alternative approaches to therapy are required if we are to more fully understand how patients respond to different types of lip bumpers and to variation in their clinical manipulation.

MATERIALS AND METHODS

The response to lip bumper therapy was evaluated by a comparison of pretreatment and posttreatment records of 40 patients. The records included standard lateral cephalograms and study casts of the mandibular dental arch. Pretreatment arch depths and intermolar widths were reduced; the mandibular incisors were retroclined lingually before treatment. The sample includes consecutively treated cases from the private practices of two orthodontists. Each practitioner supplied 20 cases that met the following criteria:

1. Caucasian ethnicity.
2. Mandibular arch length deficiency (4 to 8 mm) treated by lip bumper appliance only.
3. All patients were judged to be good cooperators.
4. Duration of treatment greater than 9 months.
5. No class III skeletal/dental malocclusions.

Group 1 was treated with lip bumpers fabricated from 0.045-inch stainless steel round wire covered with a layer of plastic shrink tubing (1.5 mm round). The lip bumper was activated at the adjustment loops to remain approximately 2 to 3 mm in front of the lower incisors at the level of the gingiva. It was set 4 to 5 mm away from the buccal segments and expanded approximately 2 mm at the molar region. The lip bumper was reactivated every 2 to 3 months to return to its original placement position and molar expansion. Treatment was started when patients were approximately 11 years of age and lasted an average of 1.4 years. Eight patients were eliminated because of poor cooperation.

Table II. Annual rates of treatment change showing no significant group differences (n = 40)

Measure	*Scale*	*Mean annual change*	*Standard error of the mean*	*SD**	*Maximum*	*Minimum*
		Anteroposterior relationships				
I_1/MP (IMPA)	Degrees/year	2.95	0.78	4.96	15.00	−12.79
I_1/N-B	Degrees/year	3.64	0.69	4.34	14.63	−8.18
I_1/OP	Degrees/year	−3.76	0.83	5.26	13.90	−17.54
I_{1a}-ARP	mm/yr	−0.04	0.16	1.04	2.09	−2.74
I_{1t}-ARP	mm/yr	−1.42	0.26	1.67	2.35	−5.75
I_{1t}-(N-B)	mm/yr	1.17	0.24	1.48	4.29	−1.61
M_{1a}-ARP	mm/yr	−1.20	0.34	2.17	2.89	−8.84
Irreg	mm/yr	−2.23	0.52	2.64	4.12	−9.13
		Vertical dental relationships				
I_{1t}-Me	mm/yr	1.07	0.17	1.09	3.98	−1.98
M_{1t}-MP	mm/yr	0.65	0.19	1.20	3.21	−2.00

**SD*, Standard deviation.

Table III. Annual rates of treatment change showing significant differences between groups

Measure	*Group*	*Scale*	*Mean annual change*	*Standard error of the mean*	*SD*	*Maximum*	*Minimum*
			Anteroposterior dental relationships				
M_{1t}-ARP*	1	mm/yr	−0.02	0.25	1.09	3.13	−1.35
	2		1.51	0.43	1.90	6.48	−1.94
M_1/OP	1	mm/yr	−2.79	1.12	4.99	3.28	−15.61
	2		−8.04	1.88	8.39	6.54	−26.09
TAL	1	mm/yr	2.66	0.58	2.61	10.01	−1.04
	2		7.45	0.94	4.22	18.22	1.44
AD	1	mm/yr	0.91	0.31	1.40	4.34	−1.59
	2		2.47	0.39	1.76	5.57	−1.10
			Transverse dental relationships				
C-C	1	mm/yr	1.39	0.22	0.79	2.73	0.01
	2		2.82	0.56	2.09	7.05	0.45
Pm_1-Pm_1	1	mm/yr	2.09	0.24	0.98	4.03	0.70
	2		4.17	0.55	2.40	8.83	0.18
M_1-M_1	1	mm/yr	0.75	0.35	1.54	4.94	−1.28
	2		4.22	0.84	3.76	12.50	−0.05

*No significant treatment change ($p > 0.05$).

Group 2 was treated with prefabricated lip bumpers that had a relatively thick shield of acrylic from canine to canine. The shield was reshaped for the patient's comfort (the original occlusogingival dimension was 5.7 mm and 2.7 mm thick). The lip bumper was placed approximately 2 mm in front of the mandibular incisors; vertically, the top of the shield was positioned 7.2 mm from the incisal edge. The lip bumper was placed, on the average, 4 mm away from the first premolars and 4 to 5 mm away from the molars. At 4- to 5-week intervals it was reactivated to the original specifications. Treatment was initiated at a mean age of 12.1 years and lasted approximately 1 year. Ten patients were eliminated because of poor cooperation.

The pretreatment and posttreatment lateral cephalometric headfilms were randomly traced by one examiner. The occlusal plane was constructed with the use of the mesiobuccal cusp tip of the mandibular first molar and the incisal edge of the mandibular central incisors. Where right and left images of the mandibular molars and incisors were present, an effort was made to trace the image of the left side. Arbitrary anterior and posterior reference points were drawn on the constructed occlusal plane of the pretreatment tracing. The posttreatment tracing was superimposed on the pretreatment tracing with use of the cortices and internal structures of the mandibular symphysis, as described by Björk.[11] The pretreatment occlusal plane was transferred to the posttreatment tracing and used

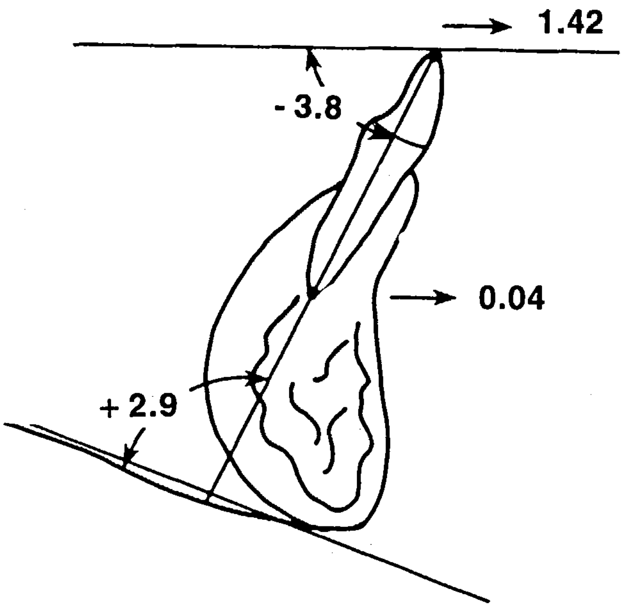


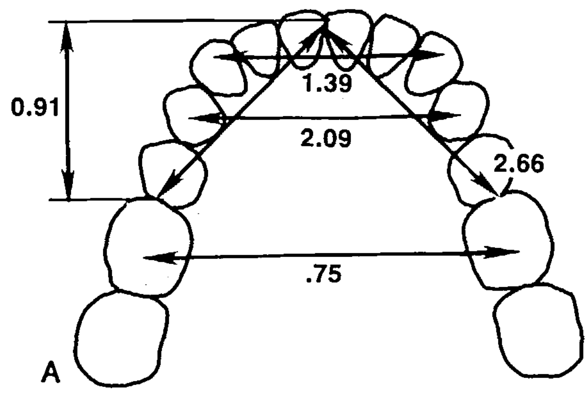
Fig. 2. Yearly changes in incisal position for groups 1 and 2 combined.

as a reference. Eleven measurements were derived for comparison, including four angles and seven linear measurements (Table I).

The dental casts were measured with electronic dial calipers, accurate to the nearest 0.01 mm. Measurements included (1) total arch length (TAL) measured as the sum of the right and left distances between the mesial contact points of the first permanent molars to the contact point of the central incisors[13]; (2) arch depth (AD) measured from a line bisecting mesial anatomic contact points of the first permanent molars to the contact point of the central incisors; (3) the irregularity index (Irreg),[12] computed as the sum of the displacement of the contact points of the six anterior teeth; (4) mandibular canine (C-C) width measured between cusp tips; (5) mandibular first premolar (Pm_1-Pm_1) width measured between centers of the occlusal developmental grooves; and (6) mandibular first molar (M_1-M_1) width measured between central pits.

Reliability (Table I) was evaluated with the method error or Dahlberg[14] statistic. No significant systematic differences between replicates were identified. Method errors ranged between 0.1 and 0.9 mm for linear measures and between 1.0° and 1.2° for angular measures. With the exception of total arch length, random errors for the model measurements were consistently less than 0.2 mm.

Yearly rates of treatment change were calculated by $(X_2\text{-}X_1)/(A_2\text{-}A_1)$, where X and A refer to the measure and exact age in years, respectively. Kurtosis and skewness of the distributions were evaluated; measures not normally distributed were transformed. Analyses of covariance showed that pretreatment age, sex, and interaction between sex and group were not statistically significant for any of the measures.



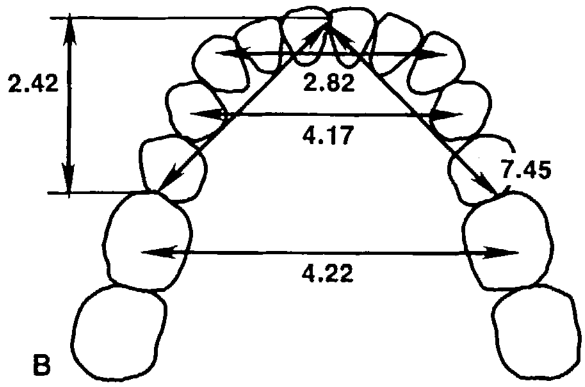
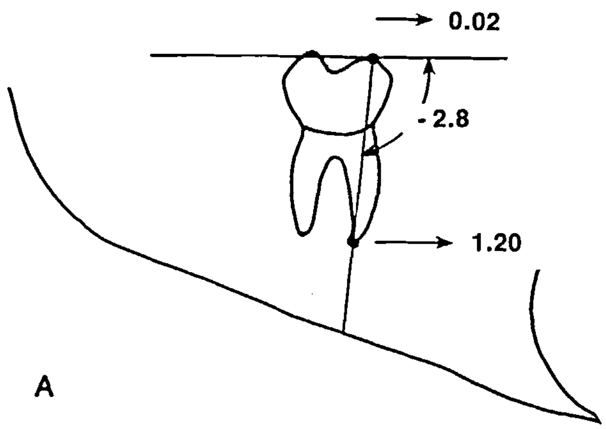


Fig. 3. Yearly changes in arch dimensions for groups 1 (**A**) and 2 (**B**).

Age- and sex-specific reference data[15,16] were used to compare the results with untreated normal values. The reference data pertain to white children of the middle to upper socioeconomic classes, of predominantly Northern European origin. Before the comparisons were made, the cephalometric measurements were adjusted for differences in magnification. Z scores were computed for each subject, and group differences were evaluated by analysis of variance. Changes in Z scores over the treatment period were evaluated by means of paired *t* tests.

RESULTS

Table II describes yearly treatment changes of measures that showed no statistically significant group differences. Except for lower incisor apex to anterior reference point, all of the variables displayed significant ($p < 0.05$) changes over the treatment period. Both groups showed controlled tipping (−3.8°/year to the occlusal plane and 2.9°/year to the mandibular plane)



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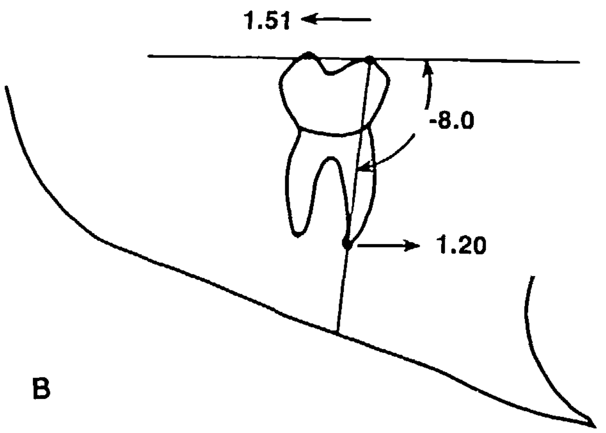

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Fig. 4. Yearly changes in molar position for groups 1 **(A)** and 2 **(B)**.

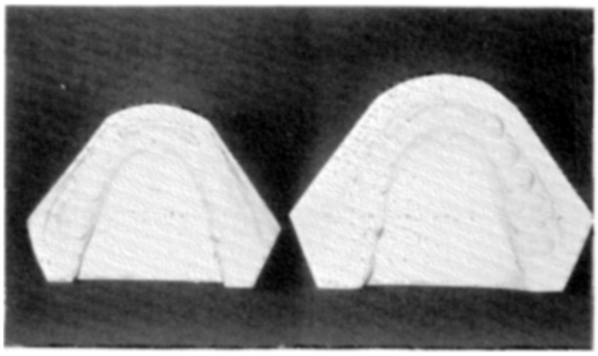

Fig. 5. Pretreatment and posttreatment occlusal views of average group 2 patient showing increased arch length for tooth alignment.

as the incisal tip moved anteriorly approximately 1.4 mm/year. The apices of the lower first molars moved mesially at a rate of 1.2 mm/year, and there was a 2.2 mm/year decrease in the irregularity index for both groups (Fig. 2).

In contrast to the incisor, most of the treatment changes pertaining to the molars were significantly different between the two groups (Table III). Yearly changes were most pronounced for patients in group 2, who showed increases in intermolar width approximating 4.2 mm/year (Fig. 3), distal movement of the molar cusp at a rate of 1.5 mm/year, and decreases in the molar to occlusal plane angle of approximately 8°/year (Fig. 4). Total arch length increased at a rate of 7.45 mm/year. Molar movements in group 1 were more limited. The molars were expanded transversely at a rate of 0.8 mm/year, total arch length increased 2.7 mm/year, and the molars tipped distally approximately 2.8°/year.

Table IV compares the lip bumper samples with untreated control values. The pretreatment vertical heights of the incisors and molars (I_i-Me, M_{it}-MP) are between 1.0 and 1.6 standard deviations shorter in the lip bumper samples; the lower incisors of the bumper groups were more upright and behind the nasion–B point plane. Before treatment, mandibular arch depth of both groups was short (−0.8 to −0.5 standard deviations) and narrow at the molar level (−1.2 to −1.4 standard deviation units). Interestingly, intercanine width closely approximated average values (Z = −0.06) at the start of treatment. With the exception of intercanine width and arch depth for group 2, all of the measures approached expected reference values during treatment. It is of importance that all of the measures showed significant treatment changes that could not be accounted for by normal growth and development.

DISCUSSION

The results clearly show that lip bumpers are effective appliances for gaining circumference in mild to moderately crowded mandibular arches (Fig. 5). Little's irregularity index[12] decreased approximately 2.2 mm/year and total arch length increased between 2.7 and 7.5 mm/year for groups 1 and 2, respectively.

The type of bumper used and its clinical manipulation appear to be important factors in determining changes in transverse dimensions and in molar position. Group 2 showed distal movement of the molar crown and mesial movement of the root, indicating a center of rotation close to the center of resistance. Bjerregaard and coworkers[3] have demonstrated 7.9° of distal molar tipping over an 8-month treatment period, which compares closely with the change (8°/year) seen in group

Table IV. Z scores describing treatment effects in standard deviation units of untreated controls

Measure	*Group*	*Pretreatment mean*	*Posttreatment mean*	*Treatment change*	*Paired t value*	*df**	*Probability*
		No pre- or posttreatment group differences					
I_u-(N-B)	1&2	−1.22	−0.58	0.65	−6.09	39	<0.00
I_l/MP (IMPA)	1&2	−1.17	−0.63	0.55	−4.74	39	<0.00
M_u-MP	1&2	−1.58	−1.15	0.43	−4.42	39	<0.00
C-C	1&2	−0.06	1.47	1.53	−8.34	26	<0.00
		Significant pre- and/or posttreatment group differences					
AD	1	−0.81	0.04	0.85	−2.83	19	<0.01
	2	−0.47	1.14	1.62	−6.17	19	<0.00
I_u-Me	1	−1.59	−0.91	0.69	−5.56	19	<0.00
	2	−0.95	−0.56	0.40	−3.84	19	<0.00
M_l-M_l	1	−1.24	−0.65	0.59	−2.19	19	<0.04
	2	−1.43	0.21	−1.64	−7.92	19	<0.00

**df*, Degrees of freedom.

2. More than 85% of the patients in group 2 showed distal movement, which closely agrees with the 88% reported by Subtelny and Sakuda[2] and the 95% reported by Bergersen.[1] In contrast, group 1 showed *no* significant distal movement of the molar crown; the roots moved mesially, with a center of rotation near the crown. As expected, tipping of the mandibular molar increases the height of the molar in relation to the mandibular plane more than expected for untreated children.

The group differences in A-P molar position might have been anticipated. Patients in group 1 probably displayed lower yearly rates of treatment change because their bumpers were activated less frequently.[1] Moreover, the lip bumpers of group 2 had a larger surface area of plastic from canine to canine, which has the potential of generating greater forces on the molars[5] and bringing about more distal movement.

The lip bumper holds the checks away from the buccal surfaces of the teeth, allowing the tongue pressure to act unopposed to increase transverse arch dimensions.[8,9] The first group expressed its greatest transverse expansion at the premolars, followed by the canines and molars, respectively. The second group realized most of its expansion at the molar and premolar levels. Group differences in transverse dimensions might again be attributed to (1) the frequency and amount of adjustment at the molars tubes and (2) differences in bumper morphology. Interestingly, transverse changes were greater than antero-posterior changes for both groups of patients. In contrast, Bjerregaard and coworkers[3] suggest that anteroposterior changes due to distal tipping of the molars and flaring of the incisors are the primary treatment results of lip bumper therapy.

Despite differences in the lip bumpers used and their clinical manipulation, the two clinicians produced similar treatment effects for the mandibular incisors. This supports the findings of Bergensen,[1] who reported that the forward movement of the incisor occurs independent of the lip bumper's placement or its linear advancement into the lower lip. Incisal angulation to the mandibular plane increased at an average rate of 2.9°/year, the incisal tip moved forward approximately 1.4 mm/year, and the apex showed no significant changes over time. Therefore the center of rotation was located close to the incisor apex. The proportion of patients whose incisors moved forward (75%) falls between the 44% reported by Subtelny and Sakuda[2] and the 95% reported by Bergersen.[1] Since the incisors were lingually retroclined before treatment, their proclination during treatment resulted in an increase of approximately 1.1 mm/year in the vertical distance between the incisal edge and menton, which was significantly greater than control values.

The clinical stability of the observed treatment results will be largely dependent on the forces exerted on the dentition and alveolar arches by the tongue, lips, and cheeks. The teeth may be expected to assume a position at equilibrium between the lingual and vestibular muscles.[17] If therapy is able to establish new relationships between the various functional components, stability might be expected. Otherwise, some degree of relapse is inevitable. Occlusal loading of opposing teeth, either distal or mesial to the centers of resistance, might be expected to further contribute to the treatment stability/instability.

CONCLUSIONS

1. The type of lip bumper and the method of clinical manipulation had no significant effect on the incisal

changes produced. The crown moved mesially and the root apex remained stationary, which indicated controlled tipping with the center of rotation close to the apex.

2. The distalizing effect of mandibular molar was variable. The centers of rotation for groups 1 and 2 were close to the crown and the center of resistance, respectively. Differences may be attributed to the lip bumpers used and the methods of manipulation.

3. Transverse arch changes, also related to the type of lip bump used and its clinical manipulation, are important to gain space for the alignment of mild to moderately crowded arches.

4. Lip bumper therapy produced small but significant amounts of molar extrusion.

5. Sex and age at the initiation of treatment were not significantly related to the changes observed; this substantiates the claim that mechanical load has greater influence than the normal physiologic parameters.

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