The effects of lip bumper therapy in the mixed dentition

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A prospective clinical trial was undertaken to study the effects of 6 months of continuous lip bumper therapy on patients in the mixed dentition with mild-to-moderate mandibular arch perimeter deficiency. Thirty-four patients, ages 7.9 to 13.1 years ($\bar{x}$ = 10.2), seeking treatment in the postgraduate orthodontic clinic of the Medical College of Virginia, presented possessing 3 to 8 mm of mandibular crowding, with both mandibular primary second molars, were randomly placed in either the treatment or nontreatment group. Treated subjects underwent continuous lip bumper therapy, whereas the control subjects were monitored without undergoing any active treatment, each for 6 months. Arch dimension changes were assessed with study models. Alterations of mandibular incisor position were measured from lateral cephalometric radiographs. Mandibular left permanent first molar position changes were determined from both lateral cephalometric and tomographic radiographs, with the resolution of each imaging technique in measuring molar tooth movement also compared. It was found that significant differences in mandibular incisor inclination, molar position, arch length, and arch perimeter existed between treated and untreated subjects. In addition, multiple observer analysis showed that cephalometric examination lacks sensitivity when used to measure molar movement. (Am J Orthod Dentofac Orthop 1997;111:52-8.)

A recent trend influencing orthodontic treatment rationale has been the return of a tendency toward nonextraction therapy. Surveys of American orthodontists revealed that approximately 75% of patients are currently being treated in this manner.[1-3] This can be contrasted with an earlier era during which extraction-based treatment modalities to resolve crowded dentitions were promoted.[4] More recently, however, the "extraction *versus* nonextraction" pendulum has again swung with the realization that the removal of teeth does not guarantee orthodontic stability.[5-8]

The renewed interest in an interceptive/early[5,6] treatment philosophy has been catalyzed by several factors and seems to have been paralleled by an increased application of nonextraction treatment modalities. Within the specialty of orthodontics itself, a subjective dissatisfaction with facial esthetics as achieved by a strictly limited extraction approach has given impetus to the increased use of nonextraction therapies.[9-11] Also, where once only orthodontic camouflage was possible, surgical techniques now allow for directly addressing malocclusions with perceived skeletal etiologic factor. Finally, and perhaps of most significance, the approach of orthodontics to arch perimeter deficiency in general has reflected the perceived concerns of an increasingly informed, prevention and risk-benefit ratio-minded public.

While social issues have affected the extraction-nonextraction debate, an increased understanding of normal development of the human dentition has provided more precise indications for orthodontic treatment. Longitudinal studies have shown that mandibular incisor liability is a normal developmental condition during the early mixed dentition.[12-14] Physiologic resolution of this crowding is derived from an increase in intercanine distance with eruption of the permanent canines. This occurs as a result of their eruption into the primate space accompanied by slight incisor proclination.[12-15] It has also been documented that the permanent first molars drift mesially into the (leeway) space created after exfoliation of mandibular second deciduous molars.[13-17] Some investigators have reported that this mesial drifting of the first permanent molar during the transition into the permanent dentition is greater than the labial repositioning/tipping shown by the incisors.[13-15,18,19] Hence, the leeway space essentially becomes unavailable for resolving anterior crowding. Orthodontic intervention is merited when it can be determined that, alone or in combination with other local factors, this transitional stage will otherwise develop into a permanent arch perimeter deficiency.

To resolve arch space deficiencies in an interceptive/nonextraction manner, treatment during the mixed dentition stage has been advocated.[20] One

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method promoted to achieve these goals is the placement of a contoured 0.045-inch wire between the lower right and left first permanent molars, keeping it labial to the teeth arranged between them. This appliance is commonly referred to as the lip bumper (Fig. 1). Its mechanism of action is analogous to what has been attributed to so-called "tissue-borne" functional appliances in the removal of the influence of muscle function on tooth position by relieving labial and buccal soft tissue pressure from the mandibular dentition.[21-29] Previous reports have hypothesized that the lip bumper would have the dual effects of increasing arch length, and "development of the arch" in a transverse direction. The most commonly reported explanation of the former effect has been labial incisor proclination,[30-39] ascribed to unopposed tongue pressure on these teeth once the lower lip is distracted from its position against them.[24,29,33,40,41] However, the magnitude and consistency with which this effect has been reported, as well as the sources of arch length increases, vary among observers.[30-39]

It has been claimed that individual clinical manipulation can account for some of the differences seen among observers.[42] Potential sources of discrepancy include the incisogingival position of the lip bumper,[35] the height of the labial shield,[31] the presence of buccal shields, and the duration of lip bumper wear.[33,36] These variations have been correlated with the appliance's effect on molar position and have shown to be associated with differences in clinical outcomes.

Previous studies have based their conclusions on data gathered with only dental casts or lateral cephalometric radiographs. Although these diagnostic tools are ideal for direct measurement of arch dimension and incisor inclination changes, respectively, their effectiveness when used to quantify specific molar position/movement is a source of significant error.[43-48] In addition, conclusions that were based on small sample sizes observed over extended or unequal periods further confound the understanding of any lip bumper effect on molar position.[25,38] The inclusion of experimental subjects simultaneously undergoing other orthodontic treatments during lip bumper therapy directly affecting the mandibular dentition further reduces the significance of any therapeutic modification attributable to the lip bumper.[34] This study was designed to remove as many of the above mentioned confounders as possible in an effort to further supplement the body of knowledge associated with the clinical effects of this appliance.

MATERIALS AND METHODS

Patients included in the study met the following qualifications: (1) white ethnicity, (2) 3 to 8 mm mandibular arch length deficiency, (3) presence of the mandibular deciduous second molars, and (4) Class I, Division 2 malocclusion. Subjects were randomly assigned to either the experimental (N = 16), or control (N = 18) group. The IDEAL type of lip bumper (GAC, Central Islip, N.Y.) was used and positioned approximately 1.5 to 2 mm labial to the gingival third of the mandibular incisors (Fig. 1). The appliance was inserted in a passive state, and continuous wear was assured by ligating the lip bumper to the mandibular first molar bands. Patients were recalled every 4 to 6 weeks for appliance adjustment and monitoring. Dental changes occurring during the study were analyzed from study casts of the mandibular arch and from lateral cephalometric and adjusted tomographic radiographs. Initial study models and radiographs were compared with corresponding 6-month progress records.

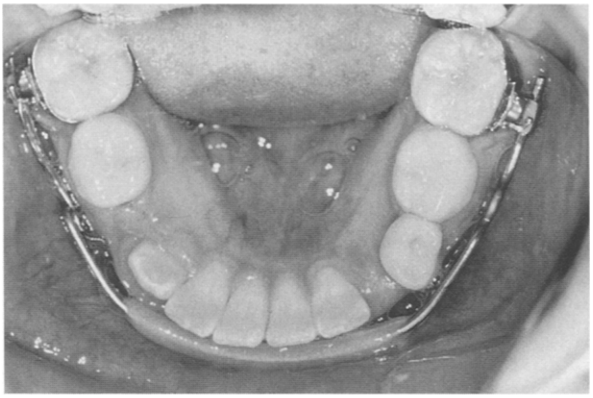

Fig. 1. Clinical view of molded-type of lip bumper in place.

Direct measurements were carried out on dental casts of the mandibular arch to ascertain passive changes in arch width between deciduous molars (central fossa-to-central fossa) and canines (cusp-to-cusp), and arch perimeter, with the straight line approximation method (Fig. 2).[49] Arch space requirement was related to the measured perimeter with Moyers prediction values at the 75% confidence level.[50] Photocopies of the occlusal surface of the mandibular models were used to measure arch length as described by Moyers.[15]

Lateral cephalometric and adjusted tomographic radiographs were taken with the Quint-Sectograph 2000 (Denar, Anaheim, Calif.). The long axis of the incisor was related to the mandibular plane (MP) and cross-referenced to the APog and NB lines of the lateral cephalograms.[51-53] A line bisecting the furcation of the mandibular first permanent molar, perpendicular to a line drawn tangent to its cusp tips, was used to assess molar angulation relative to the mandibular plane (Fig. 3). Initial and 6-month progress cephalometric radiographs were superimposed over the mandibular symphysis, mandibular canal, inferior border of the mandible, and crypts of unerupted teeth,[54] from which linear measurements of changes in molar and incisor position were made, by using

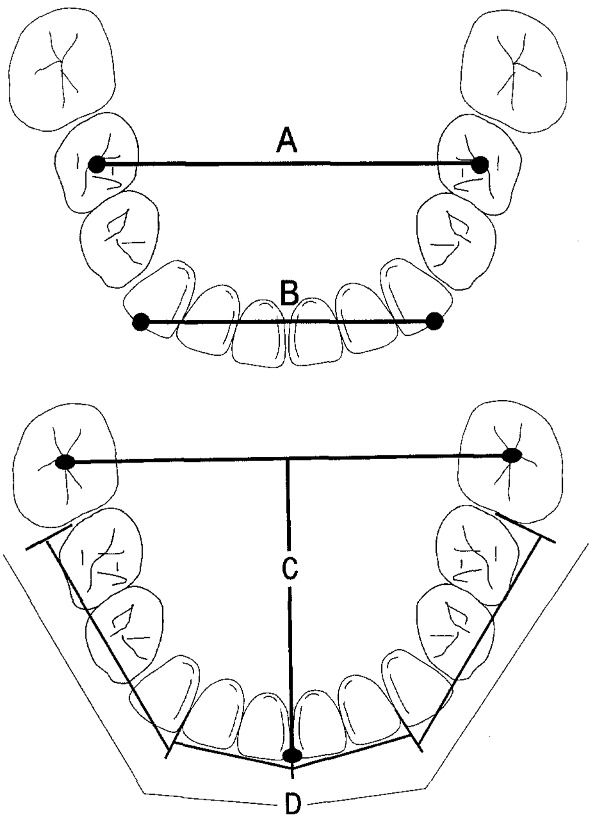

Fig. 2. Cast analysis: *(A), (B)* interdeciduous molar and canine width measurements, *(C)* arch length measured as perpendicular length of line between central pits of first permanent molars through contacts of central incisors, *(D)* segmented method of arch perimeter determination.

the center of resistance (C_{RES}) in the case of the molar, and apex of the incisor. The C_{RES} of the molar was defined as being located at the furcation.[55] Angular changes were assessed with the line bisecting the molar and long axis of the incisor, respectively.

Lateral tomographic radiographs were recorded with the patient's closed-mouth head position adjusted to an orientation of −20° in the cephalostat, paralleling the buccal surface of the permanent first molar to the film. Radiographic sections were directed to transect the mandibular left first permanent molar in the sagittal plane. These were traced and compared in the same manner as the lateral cephalometric radiographs for the left mandibular first permanent molar. Mesial/anterior movement or downward and backward rotations were noted as positive values, and distal/posterior movement or upward and forward rotations as negative.

All data were independently measured by two observers. Analysis of variance (ANOVA) was carried out to determine statistically significant differences between experimental and control patients. Comparisons were made for changes in arch length and perimeter, intercanine and

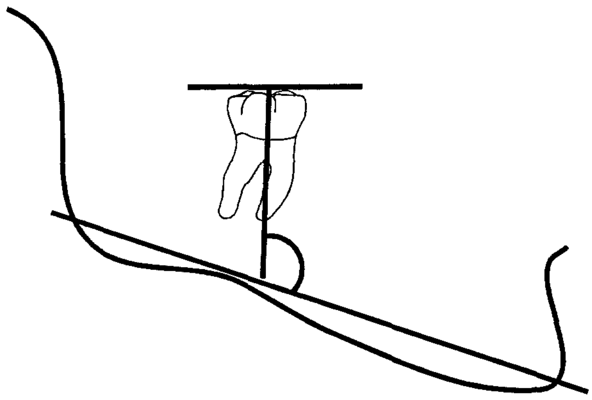

Fig. 3. Method for measuring changes in molar inclination. Angular measurement of line intersecting mandibular plane (Gn-Pg) perpendicular to line tangent to cusp tips (functional occlusal plane), and bisecting furcation.

Table I. Changes in molar angulation as measured from tomograms and cephalometric radiographs. Positive entries correspond to mesial tipping and negative to distal uprighting

	Control	*Experimental*	
Tomographic	+2.10 ± 1.37°	−6.31 ± 1.28°	$p < 0.05$
Cephalometric	−0.75 ± 1.70°	−3.38 ± 3.67°	$p = 0.23$

deciduous molar distances, crowding, and linear and angular changes in molar and incisor positions. In addition, interobserver reliability was gauged with Pearson's coefficient of correlation to establish relationships between the radiographic data gathered by each observer.

RESULTS

Molar angulation (Table I) was shown to have changed in a positive direction (i.e., mesial crown tip) for untreated patients when viewed tomographically (2.1° ± 1.37°). However, cephalometric analysis of these patients revealed a change in molar angulation that was negative (i.e., crown distal) in direction (−0.75° ± 1.7°). All treated subjects expressed distal (negative) molar tipping, regardless of the radiographic technique used for data gathering. However, quantitative differences in the magnitude of this movement were noted between the radiographic imaging techniques. Tomographic data (−6.31° ± 1.28°) showed approximately twice the angulation change as that measured from lateral cephalometric radiographs (−3.38° ± 3.67°). The average change in molar angulation of experimental *versus* control subjects was found to be statistically significant when observed tomographically ($p <$ 0.02). Comparisons made with cephalometrically

Table II. Movement of the center of resistance of the first permanent molar as measured from superimpositions of tomograms and cephalometric radiographs. Positive changes correspond to mesial movement and negative to distal movement of the C_{RES}

	Control	*Experimental*	
Tomographic	+0.65 ± 0.59 mm	−1.66 ± 0.53 mm	$p < 0.05$
Cephalometric	+0.30 ± 0.78 mm	−0.61 ± 1.15 mm	$p = 0.33$

Table III. Changes in central incisor axial inclination as measured from cephalometric radiographs. Positive changes indicate labial tipping

Control	*Experimental*
+0.05 ± 1.70°	+3.19 ± 2.40°

$p < 0.05$.

Table IV. Movement of the apex of the central incisor as measured from cephalometric radiographs. Positive changes indicate forward movement

Control	*Experimental*
+0.20 ± 0.59 mm	+0.69 ± 0.59 mm

Table V. Results of changes occurring in intersecond deciduous molar distance, intercanine distance, arch perimeter, arch length, and crowding during the 6-month clinical trial. Negative changes indicate a reduction and positive changes indicate an increase in any given parameter

	Control	*Experimental*	*p =*
E-E	−0.33 ± 0.67 mm	+1.83 ± 1.32 mm	<< 0.01
3-3	−0.25 ± 0.92 mm	+1.80 ± 0.41 mm	<< 0.01
Perimeter	−1.70 ± 1.33 mm	+4.15 ± 2.00 mm	<< 0.01
Arch length	−1.15 ± 1.00 mm	+2.19 ± 0.88 mm	<< 0.01
Crowding	−0.70 ± 1.06 mm	−5.09 ± 0.97 mm	<< 0.01

gathered data did not result in any statistical difference between the two groups ($p > 0.20$).

Anteroposterior changes in molar position, as measured by movement of the C_{RES} in the sagittal plane (Table II), were found to be positive (i.e., anterior) for control and negative for treated subjects when measured from either cephalometric or tomographic radiographs. However, cephalometric analysis of untreated subjects (0.30 ± 0.78 mm), reflected a change approximately half that seen tomographically (0.65 ± 0.59 mm). In addition, tomographic analysis of experimental subjects (−1.66 ± 0.53 mm) showed a difference of nearly three times greater in anteroposterior molar movement than observed from cephalometric data (−0.61 ± 1.15 mm). Anteroposterior changes in molar position were found to be statistically different for treated *versus* untreated subjects when compared tomographically ($p < 0.02$). No such difference was found when comparisons were made with cephalometric data ($p > 0.20$).

Angular and anteroposterior changes in incisor position were analyzed with cephalometric data only (Table III). It was found that both groups displayed discernable positive (i.e., labial) changes in long axis angulation. The experimental subjects expressed an angular change of nearly six times greater (3.19° ± 2.40°) than the untreated subjects (0.5° ±1.7°). This difference was found to be statistically significant ($p < 0.02$). Anteroposterior changes in incisor position (Table IV), measured as movement of the apex, were found to not differ significantly between the two groups ($p > 0.10$).

Changes of arch characteristics were found to be significantly different between the two groups (Table V, $p < 0.01$ for all parameters). Untreated patients experienced a reduction in transverse dimensions, arch perimeter and length, and crowding. Whereas, those treated for 6 months with lip bumpers showed increases in every parameter except crowding, which was reduced significantly more (−5.09 ± 0.97 mm) than in untreated patients (−0.7 ± 1.06 mm).

Comparison of radiographic data gathered by two separate observers showed identical trends throughout. However, quantitative differences between observers were greatest for values describing changes in molar position when measured from lateral cephalometric radiographs. Pearson's coefficient of correlation comparing tomographic and cephalometric data for changes in molar position showed that the greatest interobserver variability occurred when cephalometric radiographs were used to measure clinical differences. A greater, more significant, positive correlation ($r = +0.82$) was found for results based on tomographic evidence than the correlation for cephalometrically based observations ($r = +0.35$).

DISCUSSION

Therapeutic properties of the lip bumper appliance, as reported by previous studies, have been nonspecific because of conflicting clinical reports. Differences in methods and the inclusion of variables superimposed on lip bumper therapy have produced inconsistent experimental outcomes. In addition, many of these clinical trials were retrospective in nature with experimental subjects not compared with matched untreated controls.

This study was undertaken to apply a prospective

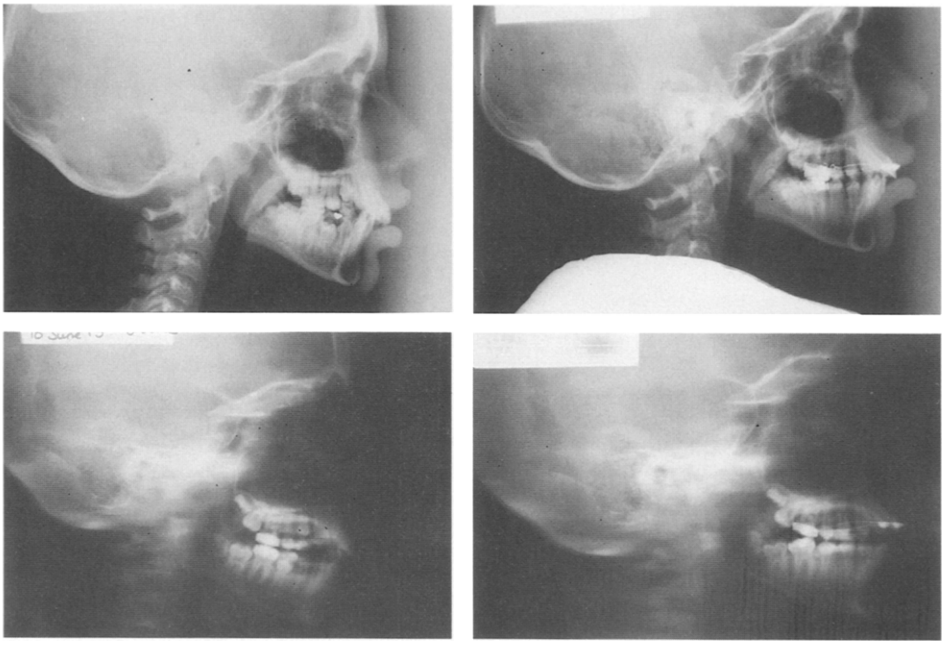

Fig. 4. Cephalometric (top row), and tomographic records of same patient at same times in treatment (initial on left), to illustrate differences in resolution of molar position between two techniques.

longitudinal experimental model to describe clinical findings of lip bumper therapy while in the mixed dentition, with reference to matched untreated controls. To separate any influence of other simultaneous treatment, the lip bumper was the only therapy administered to affect the mandibular arch directly. The continuum of change brought on by growth was accounted for by the relatively short time period for observation. In addition, previous growth studies of the developmental stage observed here qualified skeletal and dental structures as appropriate for use as superimposition landmarks to gauge change over time with or without treatment. Treatment effects were compared with similar patients who did not receive any orthodontic treatment over the same period. Assignment of each subject to either of the populations was random, and compliance with continuous wear of the lip bumper was ensured by its ligation to orthodontic bands cemented to the mandibular permanent first molars.

The tools used to measure specific tooth movement were also evaluated. All data were analyzed independently by two separate observers to compare interobserver reliability and the efficacy of the radiographic imaging techniques used. It was theorized that perhaps some of the conflicting reported clinical outcomes were a direct result of the use of cephalometric radiographs to measure changes in molar position. The difficulty in directly measuring molar movement from cephalometric radiographs is complicated by the superimposition of right and left side structures that does not occur when tomography is used (Fig. 4). The qualitative differences between the resolution power of each of these radiographic imaging techniques is further supported by the much larger standard deviations found in the data gathered when using cephalometrics as compared with tomography (Tables I to IV). Quantification of molar movement was shown to be related to the imaging technique used. Whereas cephalometric data did not show statistical differences in molar position between the experimental and control subjects, tomographic measurement revealed significant treatment effects due to use of the lip bumper. Furthermore, a much higher (Pearson's) correlation was found when the tomographically derived data from each observer were compared than when the traditional method of cephalometric evaluation was used.

Results attained in this study with cephalometric analysis of tooth movement agree with previous reports that showed no significant change in molar anteroposterior position, with some molar distal tipping at best. However, tomographic analysis revealed that distal repositioning of the molar C_{RES} as well as distal tipping had occurred and that these

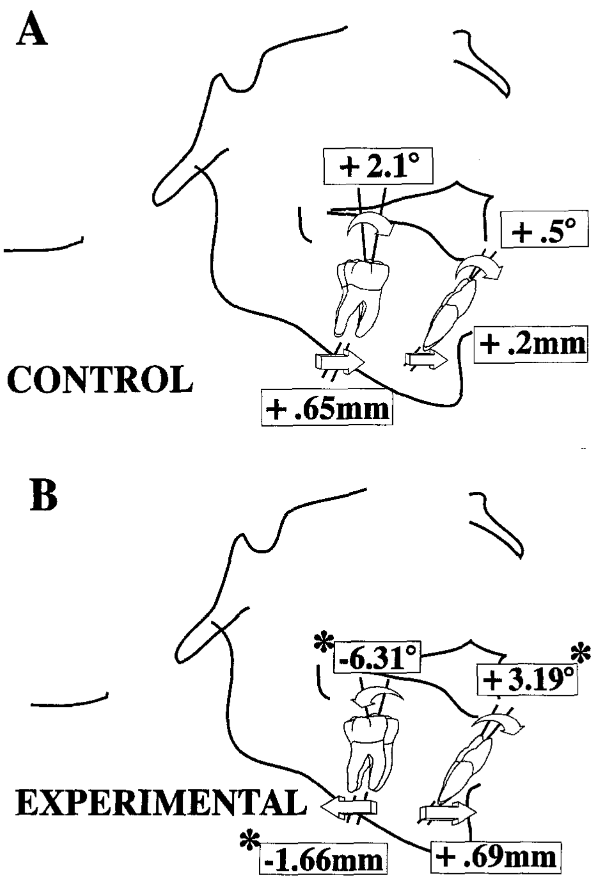

Fig. 5. Composite representations of mean changes observed within control **(A)**, and experimental **(B)** groups. * = Statistically different from control; *shaded area* = initial position; *white area* = 6-month progress.

changes were statistically different ($p < 0.05$) from those movements displayed by untreated subjects (Tables I and II). Fig. 5, *A* and *B*, are composite representations of the mean changes exhibited by each group during their inclusion in this study with the statistically significant differences ($p < 0.05$) between them noted.

The reduction of dental crowding seen in the treated group can be ascribed to increases in arch perimeter and arch length. The changes in these arch characteristics were significantly different from the concomitant decreases displayed by untreated controls (Table V). From the cast and tomographic data, the increases in arch perimeter and length under the conditions of this study can be attributed 45% to 55% to incisor proclination, 35% to 50% to molar distalization and distal tipping, and 5% to 10% to transverse increase in intercanine and deciduous molar/premolar distances.

This distribution suggests that lip bumper therapy can contribute to the resolution of arch perimeter deficiency during the mixed dentition. It confirms the often reported effect of mandibular incisor proclination with treatment, but the extent to which this was found to occur in this study was less than what has been generally reported elsewhere.[30-34,37-39] From the data, it can be concluded that arch perimeter increases due to treatment were caused by angular and linear changes of molar position, passive increases in mandibular arch transverse dimensions, and incisor proclination. Molar movement and transverse increases were found to contribute as much, if not more, to increased arch perimeter as was incisor proclination. This is contrary to many previous studies where incisor proclination was the only significant effect found to occur with clinical use of the lip bumper.

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