Original Article

Effect of Reverse Curve Mushroom Archwire on Lower Incisors in Adult Patients: A Prospective Study

Ryoon-Ki Hong, DDS, PhD[a]; Hun-Pyo Hong, DDS[b]; Hee-Sook Koh, DDS[b]

Abstract: This prospective clinical study was undertaken to analyze adult skeletodental changes induced by a reverse curve mushroom archwire during the initial stage of treatment. Lateral cephalograms from before treatment and immediately after bite opening were evaluated from 8 female adult patients who were undergoing lingual orthodontic treatment. Before treatment the patients had a mean overbite of 3.9 mm. Six linear and 5 angular measurements were selected for cephalometric analysis. The mean change in the cephalometric parameters was subjected to paired *t*-tests to determine whether the change was significant. There was a highly significant overbite reduction (−1.9 mm, $P < .001$) leaving a postintrusion overbite of 2.0 mm. The lower incisors were intruded 1.5 mm ($P < .001$) and the lower incisor edge was in an approximately stable sagittal position (L1 to NPg = −0.2 mm, NS). Some lower incisor proclination (L1 to MP = 1.2°) was seen, which was not of significance. The mandibular molars were not significantly extruded. After bite opening the mandibular plane angle was not significantly altered. Consequently, the lower anterior face height was not significantly increased. The results of this study revealed that the use of reverse curve mushroom archwire is capable of intruding the lower incisors with minimal side effects on the posterior teeth. (*Angle Orthod* 2001;71:425–432.)

Key Words: Lingual orthodontic treatment; Bite opening mechanism; Reverse curve mushroom archwire; Lower incisor intrusion

INTRODUCTION

One of the challenges of Class II treatment is the correction of deep overbite. Unfortunately, it is common for the correction to be determined by the system of mechanics that the orthodontist uses, rather than the nature of the discrepancy. Differential treatment planning for the Class II patient requires that the desired amount of anterior intrusion and posterior extrusion be determined before treatment and that differential mechanics be utilized to produce this correction. Two common bite opening mechanisms used with lingual brackets are those of Gorman et al[1] and Fujita.[2]

Gorman et al[1] stated that, with lingual brackets the correction of excessive overbite is usually accomplished by bite opening mechanism resulting from the lower incisors occluding on the maxillary incisor bracket bite planes, which permits eruption of the molars and bicuspids.

It has been suggested that in general a combination of molar extrusion and incisor intrusion occurs with the lingual appliances as a result of the anterior bite planes and posterior disclusion.[3–5] This bite opening produces both positive and negative effects.[1] In the low angle brachyfacial patterns, the bite opening is usually desirable. However, in the mesiofacial and dolichofacial types, where the bite opening may not be desirable, the lingual appliance may induce unwanted results that are difficult to control.

In deep bite malocclusions, upper anterior lingual brackets interfere with the lower incisors when the patient bites down, causing a posterior open bite. Fujita[2] recommended a bite opening mechanism that intrudes lower incisors until space is available for placement of upper anterior lingual brackets without interference. A reverse curve mushroom archwire is used to intrude the lower incisors.

The purpose of this investigation was to analyze adult skeletodental changes induced by a reverse curve mushroom archwire during the initial stage of treatment.

MATERIALS AND METHODS

Sample

The design of this study was prospective and comprised 8 female adult patients who were specifically selected for lingual orthodontic treatment with the Fujita lingual bracket. In all patients, early placement of lingual brackets on upper anterior teeth was not posssible due to the interfer-

[a] Chairman, Department of Orthodontics, Chong-A Dental Hospital, Seoul, Korea.

[b] Former resident, Department of Orthodontics, Chong-A Dental Hospital, Seoul, Korea.

Corresponding author: Ryoon-Ki Hong, DDS, PhD, Department of Orthodontics, Chong-A Dental Hospital, #648–22 Yoksam Dong, Kangnam Ku, Seoul, 135–080, Korea
(e-mail: kloa@kloa.net).

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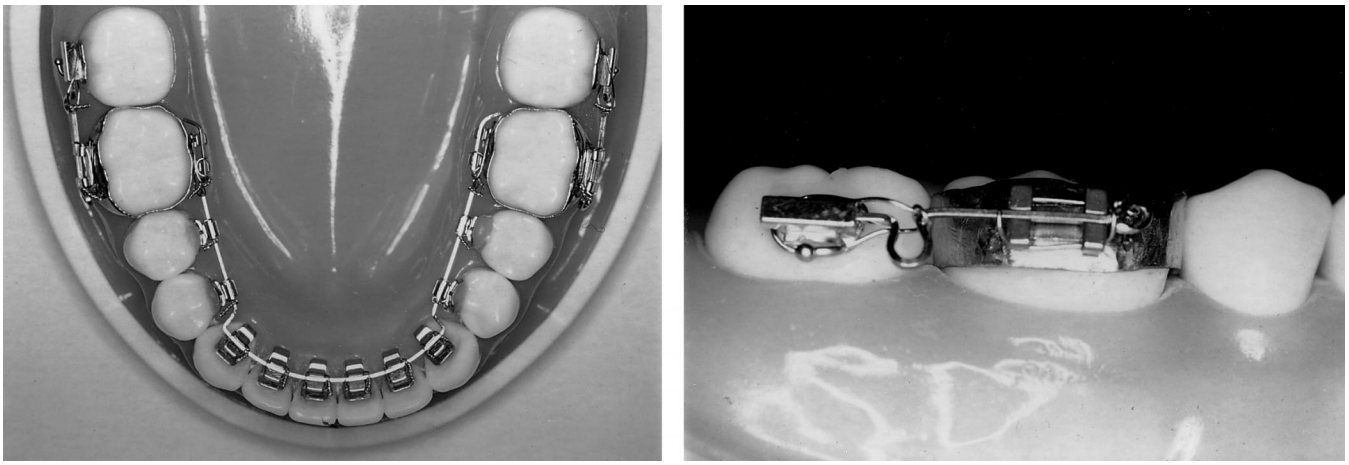

FIGURE 1. Basic mechanism for bite opening; the reverse curve mushroom arch and buccal stabilizing segment. The reverse curve mushroom arch is placed in the occlusal slot of the Fujita lingual bracket from lower right first molar to lower left first molar. With buccal stabilizing segments, lower first molars are consolidated with the lower second molars.

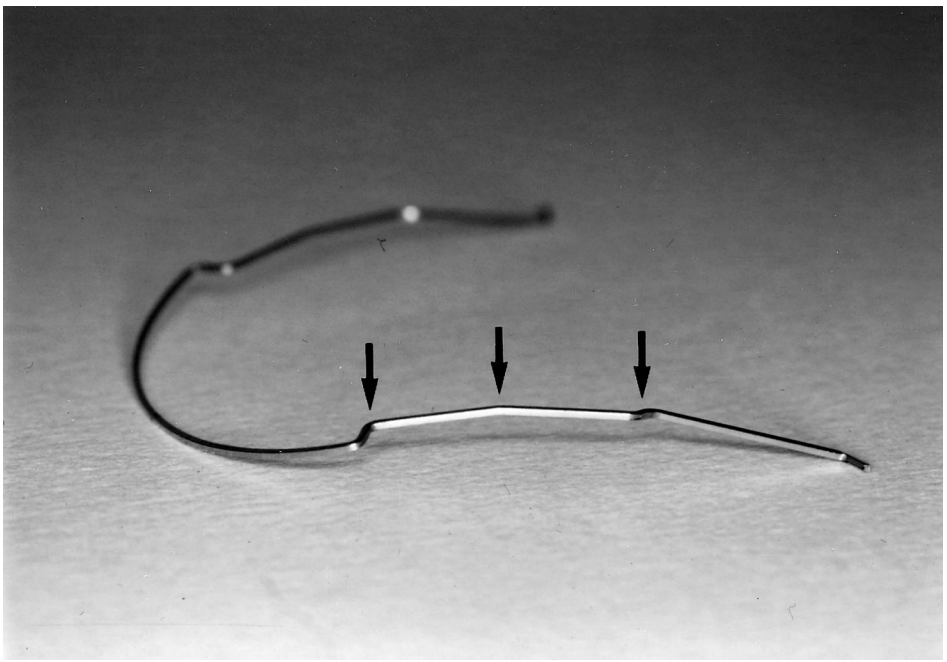

FIGURE 2. Reverse curve mushroom archwire used in this study. Tipback bends (arrows) are placed distal to the canines and premolars.

ence with the lower incisors. The mandibular incisors were initially intruded with a reverse curve mushroom archwire until space was available for maxillary anterior lingual brackets to be placed without interference. One patient demonstrated an Angle Class I and the other seven were Angle Class II malocclusions. At the beginning of treatment, mean overbite and mean age were 3.9 mm (range 2.4 to 5.9 mm) and 25.8 years (range 22 to 30.8 years), respectively.

Reverse curve mushroom arch

For all patients, Fujita lingual brackets were indirectly attached from lower right first molar to lower left first molar and standard edgewise appliances were buccally attached to the lower first and second molars.[6,7] Lower first molars were banded and the other teeth bonded. Alignment was performed by using progressively larger cross-section round mushroom archwires that were changed approximately every 3 weeks, ending a 0.016-inch stainless steel

TABLE 1. Cephalometric Measurements[a]

1. Overbite	Vertical overlap of the upper and lower central incisors perpendicular to the occlusal plane*
2. MP to FH	The angle formed by the mandibular plane† and the Frankfort horizontal plane
3. LAFH	The distance between anterior nasal spine and menton
4. U1 to FH	The angle formed by the long axis of the upper central incisor and the Frankfort horizontal plane
5. Length of L1	Length of the lower central incisor
6. L1 to NPg	The perpendicular distance between the incisal edge of the lower central incisor and the nasion-pogonion line
7. L1 to MP	The angle formed by the long axis of the lower central incisor and the mandibular plane
8. Point I to MP	The perpendicular distance between the internal reference point I and the mandibular plane. The point I was standardized as a midpoint between the incisal edge and the root apex of the lower central incisor
9. L6 tip to MP	The perpendicular distance between the mesio-buccal cusp tip of the lower first molar and the mandibular plane
10. L6 axis to MP	The angle formed by the long axis of the lower first molar and the mandibular plane
11. OP to FH	The angle formed by the occlusal plane and the Frankfort horizontal plane

[a] Refer to Figure 3.

* Occlusal plane is formed by a line bisecting the overlapping cusps of the first molars and the incisal overbite.

† Mandibular plane is formed by a line through menton, tangent to the lower border of the angle of the mandible.

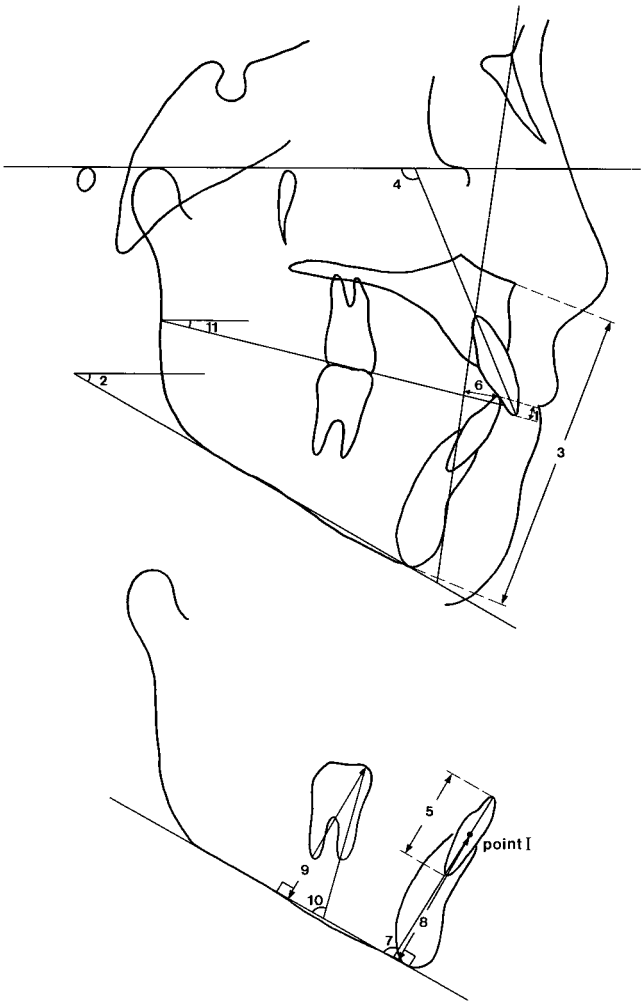

FIGURE 3. Linear and angular cephalometric measurements.

mushroom archwire to ensure complete alignment. Early in treatment, the lower first and second molars were aligned and joined together with a buccal stabilizing segment made of 0.016-inch × 0.022-inch stainless steel.

After completing alignment, a reverse curve mushroom arch was engaged into an occlusal slot of the Fujita lingual bracket and tied back at the first molar (Figure 1). The mushroom arches were constructed in 0.016-inch × 0.016-inch stainless steel and activated by placing tipback bends of 10° distal to the canines and premolars (Figure 2).

Lateral cephalometric radiograph

Lateral cephalograms were taken before treatment (T1) and immediately after bite opening (T2) enough for maxillary anterior lingual brackets to be bonded without interference. Bite opening was carried out for a mean duration of 6.9 months (range 4 to 12.5 months). After an initial period of bracket alignment with round wire arches, the reverse curve mushroom archwires were placed and left in place for a mean duration of 3.1 months (range 1 to 7 months).

Tracings were made and six linear and five angular measurements (Figure 3 and Table 1) were performed to the nearest 0.1 mm and 0.5 degrees, respectively. All registrations (tracings and measurements) were done twice by the same observer. For the final evaluation, the mean value of the double registrations was used. Assessment of incisor intrusion, when measured as a perpendicular from the incisal edge to the lower border of the mandible, was considered unreliable, since proclination of incisors would falsify the result. Measurements were taken, therefore, from a midpoint 'I' between the incisal edge and the root apex of the lower incisor. This was done on the pretreatment radiograph and the point was then relocated on the postintrusion radiograph by means of a template. All bilateral structures were located midway between the two images. No correction for linear enlargement was made.

Statistical methods

The means and standard deviation were calculated for all cephalometric measurements at T1 and T2 stages. The mean change in the cephalometric parameters was subjected to paired *t*-tests to determine whether the change was significant. The correlation coefficient *r* (Pearson) was used to describe the interrelationship between the overbite and the

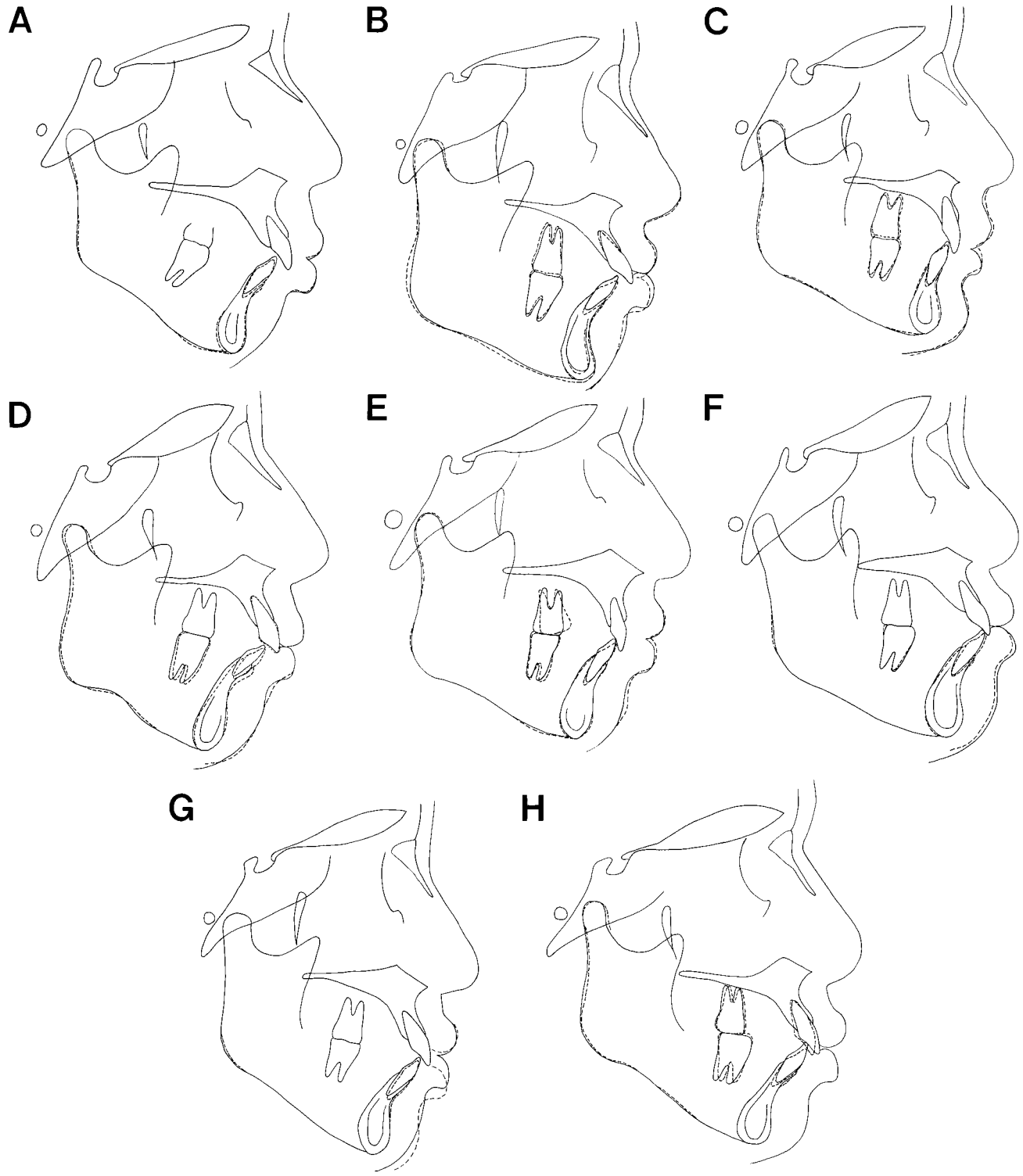

FIGURE 4. Superimpositions of the lateral cephalometric radiograph of each patient at T1 (solid line) and T2 (dotted line) stages. (A) Patient 1, (B) patient 2, (C) patient 3, (D) patient 4, (E) patient 5, (F) patient 6, (G) patient 7, (H) patient 8. The reference plane and the reference point for the superimposition of the tracings are the SN plane and the midpoint of the sella turcica.

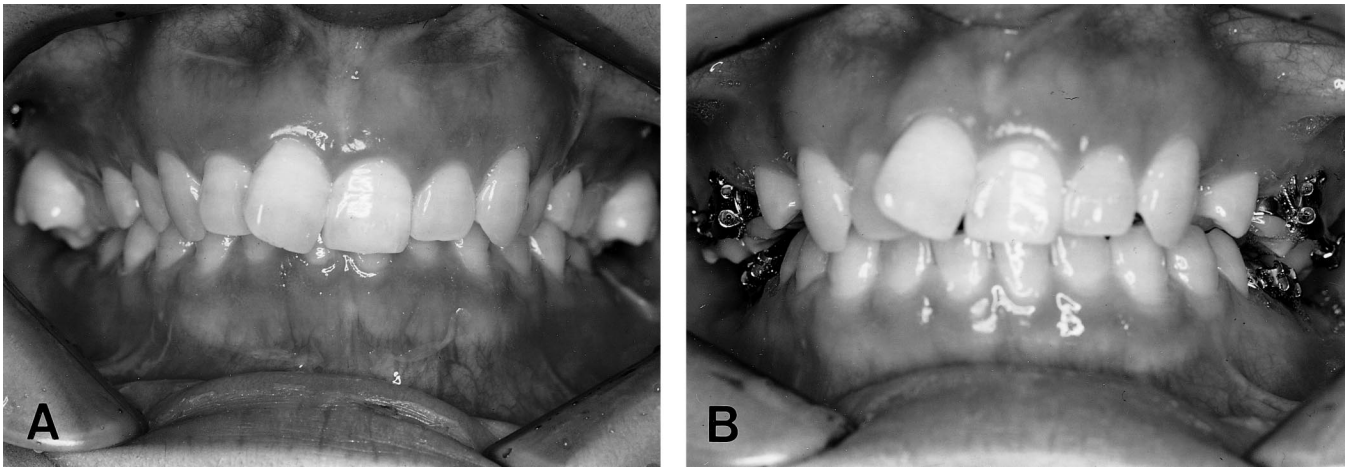

FIGURE 5. Intraoral photographs of patient 5 at T1 (A) and T2 (B) stages. It is noted that as the lower incisors were intruded, the level of the gingival margin was improved. The posterior opening in the premolar and molar areas was due to mesial tipping of the upper second bicuspids and first molars, which was induced by undesirable reaction forces during correction of buccally placed upper second molars with a modified transpalatal arch.

skeletal and dental parameters. The $P < .05$ confidence level was considered significant.

Error of the method

The method error (ME) of the double registrations from lateral cephalograms at T1 and T2 stages of all subjects was calculated using the formula: ME = square root of $\Sigma d^2/2n$, where d is the difference between 2 measurements of a pair and n is the number of subjects.

The mean error for cephalometric linear measurements was 0.3 mm (range from 0.2 mm [overbite and L6 tip to MP] to 0.5 mm [LAFH]) and for angular measurements 0.8° (range from 0.4° [MP to FH] to 1.3° [U1 to FH]).

RESULTS

The cephalometric superimpositions and changes induced by reverse curve mushroom arch in eight patients are demonstrated in Figure 4 and Table 2. Figure 5 shows the intraoral photograph of patient 5 at T1 and T2 stages. Comparison of pretreatment and postintrusion values of the sample and the correlation of changes between the overbite and skeletal and dental parameters are shown in Tables 3 and 4.

Comparison of pretreatment and postintrusion values

Dental parameters. There was highly significant reduction in overbite (−1.9 mm, $P < .001$) with a resulting postintrusion overbite of 2.0 mm. The lower incisors were intruded 1.5 mm ($P < .001$) and the lower incisor edge was in an approximately stable sagittal position (L1 to NPg = −0.2 mm, NS). Some lower incisor proclination (L1 to MP = 1.2°) was seen, which was not of significance. The mandibular molars were not significantly extruded. The inclination of the occlusal plane was increased by 1.6° ($P < .01$).

Skeletal parameters. After bite opening the mandibular plane angle was not significantly altered. Therefore, lower anterior face height was not significantly increased. The vertical dimension of the face did not change substantially.

Correlation between the overbite and skeletal and dental parameters

A significant negative correlation was found between overbite and L1 to MP ($r = -0.72$, $P < .05$). A significant positive correlation was seen between the overbite and point I to MP ($r = 0.91$, $P < .01$). No significant correlations were found between the overbite and the other parameters.

DISCUSSION

A nongrowing patient will have a different skeletodental response to orthodontic bite opening than a growing patient.[8] Even with a significantly greater amount of molar extrusion, the adolescent patients are able to maintain a stable mandibular plane angle. In nongrowing patients, minimal extrusion of the molars will increase the mandibular plane angle, making control of the vertical plane a difficult and unpredictable task.

When mandibular incisors occlude on the bracket bite planes of the maxillary incisors, immediate bite opening occurs with one lingual appliance.[1,3–5,9] Clinical evaluations have suggested that the bite opening resulting from occlusion on the maxillary incisor bite plane by the lower incisors may increase lower facial height by allowing extrusion of molars.[1,10] This molar extrusion may, in turn, lead to posterior rotation of the mandible, while the contact of the lower incisors with the bite plane on the upper incisor

TABLE 2. Cephalometric Data for 8 Patients[a]

Patient	Age (years)	Overbite, mm		MP to FH, degrees		LAFH, mm		U1 to FH, degrees		Length of L1, mm	
		T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1	25.0	5.4	3.4	31.8	32.0	77.0	77.7	109.3	109.0	21.5	20.9
2	23.7	2.9	0.6	20.0	18.8	76.8	75.8	122.8	125.0	19.6	19.6
3	23.5	5.4	3.3	21.8	22.5	66.4	66.8	97.3	97.8	20.5	20.5
4	27.1	2.4	1.7	33.0	33.8	81.9	82.2	108.3	107.5	18.9	18.5
5	26.2	5.9	2.9	27.5	26.8	76.3	76.3	93.5	94.8	22.1	22.1
6	22.0	2.5	1.3	26.3	26.3	74.6	74.8	112.8	113.8	23.4	23.4
7	30.8	2.4	1.1	31.8	32.3	73.2	73.6	114.8	114.5	21.7	21.6
8	27.8	4.2	1.8	32.3	32.5	77.6	77.1	113.0	111.0	21.4	21.4

[a] T1 indicates the pretreatment value; T2, the postintrusion value. Refer to Table 1 for definitions of other abbreviations.

brackets may cause intrusion of upper and lower incisors. This bite opening may be desirable in brachyfacial patients who have a low mandibular plane angle, but is not desirable in some patients with dolichofacial skeletal patterns. Studies have also shown with some certainty that any alteration in the mandibular plane angle created by orthodontic treatment can result in relapse in the direction of the original value.[11–13] The cephalometric measurements from this study showed that the mandibular molars were not significantly extruded and there were no significant changes in the mandibular plane angle and the lower anterior facial height. It is suggested that the use of a reverse curve mushroom archwire is capable of intruding the lower incisors with minimal side effects on the posterior teeth.

A number of methods have been described to correct deep overbites, including intrusion of the anterior teeth, extrusion of the posterior teeth, or a combination of both.[14–18] With a labial continuous archwire technique, overbite reduction will be due mainly to extrusion of molars and flaring of incisors with some intrusion.[19,20] As a consequence of correcting the deep overbite, lower incisor proclination may be undesirable as stability and esthetics could be compromised in addition to placing the labial supporting tissues at risk. The use of rectangular archwire with the edgewise appliance has been advocated with the expectation of counteracting the anticipated labial crown tipping.

AlQabandi et al[21] compared the effects of rectangular and round continuous archwires with a mild reverse curve of Spee on the axial inclination of lower incisors during the initial stage of treatment. They reported that the change in lower incisor axial inclination was similar in both groups and lower incisor proclination occurred by uncontrolled tipping around a center of rotation slightly apical to the center of resistance. In the group that received round archwires, the lower incisor proclined a mean of $6.75° \pm 4.85°$ ($P < .01$) and in the group that received rectangular archwires, it proclined a mean of $6.10° \pm 3.95°$ ($P < .01$).

The type of intrusion that the lower incisor undergoes during the application of a vertically directed intrusive force is defined by the position of the center of rotation, which is determined by the force system applied on the tooth relative to its center of resistance. When the intrusive force passes at a distance from the center of resistance, the tooth will undergo a combination of intrusion and tipping (Figure 6). With the reverse curve mushroom archwire, however, the axial inclination of lower incisors did not significantly change and the opening of the bite was primarily accomplished by intrusion of the lower incisors in each of the patients used in this study. It is suggested that although analysis of the force system of continuous arch mechanics is essentially impossible, an intrusive force from the reverse curve mushroom archwire passes close to the center of resistance of the lower incisors.

The success of orthodontic treatment often depends on the control of reaction forces. In most cases reaction forces are undesirable, and specific measures must be taken to intercept and neutralize their effects. This is also the case during intrusion of lower anterior teeth. In this study, the mandibular molars were not significantly extruded and the axial inclination of the molars did not significantly change. The undesirable reaction forces generated during intrusion seem to be neutralized by the 0.016-inch $\times$ 0.022-inch stainless steel buccal stabilizing segment of the lower first and second molars.

Every adult patient with deep overbite requires a comprehensive treatment plan that determines whether the overbite should be corrected by extrusion of posterior teeth or intrusion of anterior teeth. This decision is based on where the clinician desires to place the occlusal plane, the facial type and the vertical dimension desired at the end of treatment.

The proper cant and level of the occlusal plane should not be the result of an accident of mechanics, but should be carefully planned at the beginning of treatment.[18] Factors that should be considered are the natural plane of occlusion (the original axial inclinations and alignment of the posterior teeth) and anterior esthetics (the relationship of the incisor to the upper lip).

If one were to generalize, most Class II patients require a relatively flat occlusal plane that tends to coincide with the natural plane of occlusion of the posterior teeth. The plane should not allow more than 3 mm of the incisors to show below the upper lip. In this study, however, the inclination of the occlusal plane was significantly increased

TABLE 2. Extended

L1 to NPg, mm		L1 to MP, degrees		Point I to MP, mm		L6 tip to MP, mm		L6 axis to MP, degrees		OP to FH, degrees	
T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
10.8	10.1	97.5	97.3	35.0	33.7	33.6	33.5	102.8	102.8	12.8	14.3
6.8	6.9	112.8	115.5	37.7	35.6	37.7	38.9	94.8	94.0	2.5	4.5
4.2	3.3	91.3	92.8	30.1	28.6	32.2	32.3	90.0	92.3	8.3	9.8
15.4	14.9	109.3	108.3	41.8	41.0	42.8	42.8	94.0	93.0	15.8	16.8
6.4	6.7	98.5	102.5	35.1	33.0	36.9	36.9	87.8	83.0	12.0	13.8
11.4	11.7	105.0	106.3	36.4	35.4	37.7	37.7	90.0	90.5	9.3	9.5
10.5	9.9	101.3	97.0	33.6	32.2	35.2	35.1	86.0	84.8	14.3	14.8
13.0	13.5	95.3	101.0	38.7	36.5	38.6	39.7	80.8	73.0	11.0	15.3

TABLE 3. Comparison of Pretreatment (T1) and Postintrusion (T2) Values[a]

		T1		T2		T2–T1			
Variable	Unit	Mean	SD	Mean	SD	Mean	SD	*P* Value	Significance
Overbite	mm	3.9	1.51	2.0	1.07	−1.9	0.77	0.0002	***
MP to FH	degrees	28.0	5.04	28.1	5.45	0.1	0.72	0.8059	NS
LAFH	mm	75.5	4.47	75.5	4.36	0.0	0.57	0.7595	NS
U1 to FH	degrees	108.9	9.50	109.2	9.60	0.2	1.32	0.4836	NS
Length of L1	mm	21.1	1.42	21.0	1.50	−0.1	0.22	0.1385	NS
L1 to NPg	mm	9.8	3.75	9.6	3.85	−0.2	0.55	0.3618	NS
L1 to MP	degrees	101.3	7.25	102.6	7.28	1.2	3.11	0.3059	NS
Point I to MP	mm	36.0	3.52	34.5	3.61	−1.5	0.53	0.0001	***
L6 tip to MP	mm	36.8	3.27	37.1	3.44	0.3	0.56	0.1962	NS
L6 axis to MP	degrees	90.8	6.58	89.2	8.89	−1.6	3.18	0.2011	NS
OP to FH	degrees	10.7	4.13	12.3	4.06	1.6	1.23	0.0087	**

[a] SD indicates standard deviation; NS, not significant. Refer to Table 1 for definitions of other abbreviations.
** Significant at $P < .01$.
*** Significant at $P < .001$.

TABLE 4. Linear Correlation Between the Overbite and Skeletal and Dental Parameters[a]

Variable	*r*-Value	Significance
MP to FH	0.61	NS
LAFH	0.45	NS
U1 to FH	−0.29	NS
Length of L1	−0.38	NS
L1 to NPg	−0.37	NS
L1 to MP	−0.72	*
Point I to MP	0.91	**
L6 tip to MP	−0.43	NS
L6 axis to MP	0.45	NS
OP to FH	−0.61	NS

[a] NS indicates not significant. Refer to Table 1 for definitions of other abbreviations.
* Significant at $P < .05$.
** Significant at $P < .01$.

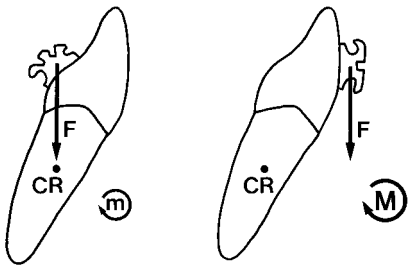

FIGURE 6. The effect of bracket position and location of the point of force application on tooth movement. The farther away the point of force application with respect to the center of resistance of a tooth, the greater the rotational moment. Lingual intrusive force is applied close to the center of resistance of the lower incisors. The possibilities of flaring out of the lower anterior teeth are less likely to occur in lingual than in labial mechanisms. CR, center of resistance; F, intrusion force; m and M, moment.

because of bite opening. The bite opening was the result of intrusion of the lower incisors so that the maxillary anterior lingual brackets could be placed without interference. In the bite opening mechanism described by Fujita,[2] intrusion of the lower incisors is inevitable at the beginning stage of treatment and the level of the occlusal plane or anterior esthetics is often compromised to some extent.

CONCLUSION

In this study, we examined adult skeletodental changes during bite opening with a reverse curve mushroom archwire, focusing on lower incisor movement. The lower incisors were intruded with minimal side effects. In considering the results, however, one should keep in mind the limitations of the present investigation such as the sample

size and the possibility of sample selection bias. In spite of these complicating factors, and on the basis of the cephalometric changes observed in each of the patients used in this study, we infer that the use of a reverse curve mushroom archwire is capable of intruding the lower incisors with minimal side effects on the posterior teeth.

Classifying the anteroposterior skeletal relationship and facial type of additional samples will provide more detailed information on the clinical validity of this bite opening mechanism and will contribute to our knowledge of lingually applied intrusion force in adult patients.

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