The Effect of the Passive Lingual Archwire on the Lower Denture

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INTRODUCTION

Since the popularization of the lingual archwire by Mershon in 1918, this appliance has been incorporated into almost all mechanical systems of tooth movement. The lingual arch has been utilized as an active appliance to move individual teeth or groups of teeth. It has also been used as a passive appliance. As such it has been reported to be of value in:

a) preserving anchorage in the lower arch;
b) holding space for eruption of permanent teeth, thus taking advantage of so-called leeway space;
c) preventing lower incisors from tipping lingually when primary cuspids have been extracted; and
d) preventing the anchor molars from tipping forward where second primary molars have been lost or extracted.

Yet, despite its widespread use and the properties attributed to it, the passive lingual archwire has been subjected to few objective analyses to determine its effect on the lower denture. Perhaps, because this particular appliance is so often used within the broad framework of total treatment, its sole effect has not been adequately investigated. The current investigation attempts to shed some light on this question.

REVIEW OF THE LITERATURE

Dewey[7] attributed the origin of the lingual archwire to Dr. L. S. Lourie in the year 1904. However, it was Mershon[17,18] who received much credit for the popularization of the lingual arch through his publications on the use and construction of this appliance. It was used primarily to produce expansion in the lower denture.

Later, Oliver[20] reported on the use of the lingual wire in conjunction with a labial wire to produce tooth movement in the maxilla as well as the mandible. Johnson[13] advocated the use of the lingual archwire in conjunction with the twin-wire appliance. Strang[25] described the use of the passive lingual wire appliance as an adjunct in the edgewise system.

The use of the lower lingual arch as an anchor unit to resist Class II elastic traction in Class II malocclusions was reported by Ross,[22] Buchner,[1] MacEwan,[15] Wein,[29] and Terry.[26] Nance[19] described the role of the lingual archwire in mixed-dentition treatment. It was his opinion that the appliance was useful only in maintaining the incisor-molar distance in specific types of cases.

Terwilliger[27] reported on the use of the passive lingual wire to allow lower anterior teeth to align themselves following extraction of primary cuspids. Lloyd[14] stated that the lingual wire was useful in controlling the position of the lower first permanent molars when primary second molars had been extracted.

Foster and Wylie[11] utilized cephalometrics and study models in their investigation of the passive lingual archwire. However, there was no correlation between the taking of records and the application and removal of the appliance. They reported that in one-third of the cases, the lower molar moved

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distally while in the other two-thirds, it moved mesially. They also noted that the incisors erupted more than the molars, and found that in no case did the incisors move labially.

Von Herzen[28] claimed that the lower molar did not move distally in his study of the passive lingual wire. In most cases, the molar moved forward. The lower incisors reportedly moved forward and tipped slightly. Once again, there was no attempt to correlate the taking of records (in this case cephalometric) with the insertion and removal of the appliance.

Recently a plethora of articles have been written extolling the virtues of the lingual wire, all without acceptable evidence (Bunch,[2] Eastwood,[8] Mehta and Barnett,[16] Reitman[21]).

Materials and Methods

This study involved two groups of individuals. Group I consisted of seventeen patients with untreated lower arches. Some of the members of this group had received maxillary headgear treatment during the period of observation while the remainder received no upper arch treatment. Thus, the members of Group I could be further subdivided into two subgroups:

a) untreated lower, untreated upper (9) and
b) untreated lower, treated upper (8).

Group II consisted of thirty-six individuals who wore passive lingual arches. Within this group some patients had received no upper arch treatment while others had worn maxillary headgear during the observation period. Therefore, Group II patients could be subdivided into two subgroups as follows:

c) treated lower, untreated upper (5) and
d) treated lower, treated upper (31).

Table I demonstrates the characteristics of each group based on age, sex, and duration of observation.

The lingual arch appliance was utilized solely as a means of saving "E" space in Group II patients. All lower dentures were undisturbed prior to lingual arch placement. In no person were permanent teeth extracted. No primary teeth were extracted prior to lingual arch placement. Lingual arch appliances were the removable type and were constructed of .036 annealed round wire. The wires were formed on plaster casts and were constructed to lie as low on the cingulum area of the incisors as possible. In addition, the wires were contoured to contact as many of the mandibular teeth as was feasible without exerting force in any area. Patients were examined at three-week intervals.

Lateral cephalometric x-rays and study casts were made at the time of placement and at the time of removal of the lingual appliances. Tracings of the headplates were made and analyzed by an orthodontist other than the author to prevent bias. Measurements on the serial study casts were also car-

TABLE I
Comparison of individuals in groups I and II based on age, sex, and duration of observation

	Age Mean	(years) S.D.	Sex Male	Female	Duration (Years)* Mean	S.D.
Group I	10.2	2.2	9	8	1.8	1.0
Group II	11.3	1.1	16	20	0.9	0.7

*Duration difference significant at the 1% level

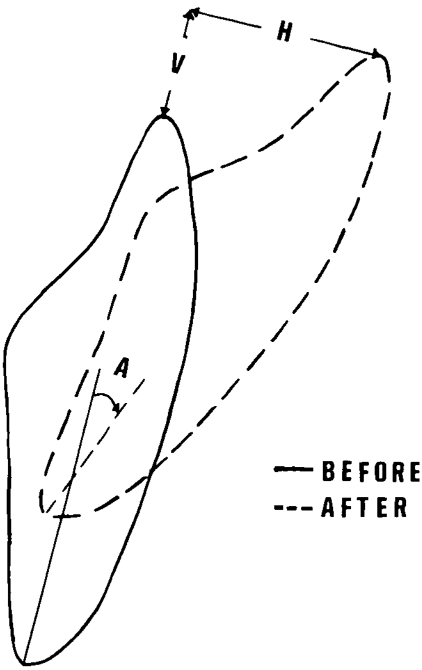

Fig. 1 Determination of positional change of incisor. A, angular change in degrees; V, vertical change in millimeters; H, horizontal change in millimeters.

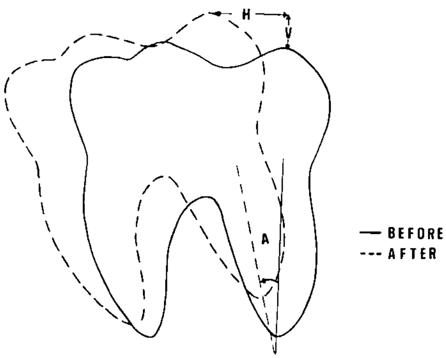

Fig. 2 Determination of positional change of molar. Symbols same as in Figure 1.

ried out by an independent observer.

The method of determining positional changes of incisors and molars is shown in Figures 1 and 2 and is based upon the original position of the tooth being studied. To determine dimensional changes in horizontal and vertical directions, a line through the long axis of the tooth in its initial position was extended incisally (occlusally) and apically so that a perpendicular could be constructed to the incisal edge (or mesiobuccal cusp tip of the molar) of the tooth in its new position. Linear changes were then determined. In the case of the molar the long axis of the mesiobuccal cusp and mesial root was employed. Angular changes were determined by comparing alterations in the long axes. Changes in a mesial direction (angular and horizontal) were assigned negative values; those in a distal direction were given positive values. Vertical changes in an incisive or occlusal direction were assigned negative values, while those in an apical direction were given positive values. Symbols representing angular and dimensional changes are shown in Chart 1.

Mandibles, in each case, were superimposed using both the Cephalometric Workshop method[23] based upon the lower border of the mandible and the inner cortical table of the symphysis (Method 1) and the Björk method utilizing the following landmarks (Figs. 3 and 4):

a) cortical outline of the mandibular canal,
b) lower border of the molar tooth germ,
c) inner cortical border of the inferior portion of the symphysis,
d) most anterior segment of the bony symphysis and
e) trabecular patterns in the lower portion of the symphysis.[5]

On the serial study models the following measurements were recorded:

a) intercanine distance (mm) of permanent cuspids only,
b) intermolar distance and
c) incisor to molar distance.

The incisor to molar measurement extended from the lingual interproximal area of the central incisors to the mesio-

CHART I
Identification of Symbols

Symbol	Description
<L1	Angular change lower incisor (degrees)
HL1	Horizontal change lower incisor (mm)
VH1	Vertical change lower incisor (mm)
<L6	Angular change lower first molar (degrees)
HL6	Horizontal change lower first molar (mm)
VL6	Vertical change lower first molar (mm)

lingual cusp of the first permanent molar. When a difference existed between the two sides of a cast, averages were calculated.

Results

Table II shows the mean positional changes of incisors and molars when compared with their original positions in Groups I and II using Methods 1 and 2. The following changes which were significant utilizing both methods of superimposition in Group I were noted:

a) vertical change of lower incisor (extrusion),

b) horizontal change of lower molar (mesial) and

c) vertical change of lower molar (extrusion).

In Group II the following positional changes using both Methods 1 and 2 were found to be significant: angular change of lower molar (distal) and vertical change of lower molar (distal). In addition, in Group II using Method 1, the vertical extrusion of the lower incisor was found to be a significant change.

An analysis of mean positional changes of incisors and molars in Groups I and II comparing Method 1 with Method 2 revealed no statistically significant difference between the two methods used in this study.

The only significant difference be-

Fig. 3 Dashed portions of mandible used for superimposition Workshop Method.

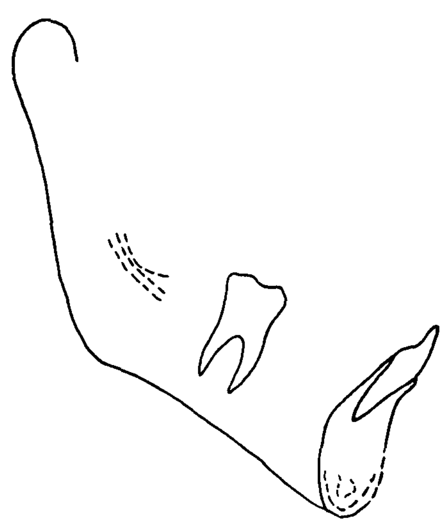

Fig. 4 Dashed portions of mandible used for superimposition. Björk Method.

TABLE II

	Method 1 Mean	Method 1 S.D.	Method 2 Mean	Method 2 S.D.
GROUP 1				
<L1	—0.9	3.6	—1.4	3.5
HL1	0.0	1.3	—0.2	1.3
VL1	—0.9*	1.4	—0.8*	1.1
<L6	+1.0	3.4	+0.6	3.0
HL6	—0.6*	1.2	—0.9**	1.0
VL6	—0.9*	1.5	—1.0**	1.2
GROUP II				
<L1	—0.3	3.4	—0.8	3.3
HL1	—0.1	1.1	—0.2	1.1
VL1	—0.3*	0.7	—0.2	0.8
<L6	+1.9**	2.8	+1.5**	3.3
HL6	+0.2	1.1	+0.1	1.1
VL6	—0.6*	1.5	—0.6*	1.4

*Change significant at the 5% level
**Change significant at the 1% level

tween means of tooth changes comparing Group I with Group II and using Methods 1 and 2 was the net distal horizontal change of the lower molar. This difference was noted using both methods of superimposition. (P=0.05 using Method 1; P=0.01 using Method 2)

The angular and horizontal positional change of the lower incisor (both in a distal direction) proved to be statistically significant when comparing subgroup *a* with subgroup *b* of Group I using Method 1. Means obtained utilizing Method 2 showed no statistically significant differences between subgroups.

Table III shows the significant differences between means when comparing horizontal molar changes in all four subgroups of Groups I and II using Method 2. An analysis of variance revealed a significant difference in the horizontal positional change of the lower molar when comparing subgroup *a* (untreated lower, untreated upper) with subgroup *d* (treated lower, treated upper) (P = 0.05). The analysis of covariance, adjusted for age and duration of observation, also revealed significant differences in horizontal positional change of the lower molar between subgroup *a* and subgroup *d* (P = 0.05).

Table IV shows the mean dimensional changes in intercuspid width, intermolar width and incisor to molar distance on the serial study casts of Group II before and after lingual arch therapy. Significant changes were as follows: intercuspid width (mean increase) and intermolar width (mean increase).

Discussion

In determining the individual movements of mandibular teeth, it has not been unusual to relate these teeth to extramandibular landmarks. The validity of utiliizng such sites, which in themselves may be subject to change with growth, seems highly questionable. Likewise, there is controversy regarding the stability of certain long-used intramandibular reference locations. Since Brodie[6] proposed the lower border of the mandible as a relatively unchanging landmark, it has been used without hesitation for superimposition. However, a number of investigators have recently

TABLE III
Significant differences between means for H6 comparing subgroups *a*, *b*, *c*, and *d* in groups I and II using method 2

	Subgroups					
	a-b	a-c	a-d	b-c	b-d	c-d
HL6[1]	—	—	*	—	—	—
HL6[2]	—	—	*	—	—	—

[1]Mean not adjusted for age and duration of observation.
[2]Mean adjusted for age and duration of observation.
*Difference significant at the 5% level.

shown that the lower border does manifest change during the growth period.[4,9,10,24] These changes usually involve periosteal deposition along the anterior portion of the lower border of the mandible and periosteal resorption along the posterior aspect. In addition, Enlow[9] has indicated that the inner cortical layer of the symphysis receives bony deposits so that the stability of this area may be subject to question.

In the present investigation it was considered important to avoid the use of extramandibular reference sites in determining changes in tooth position. In superimposing on the mandible, the traditional method (Cephalometric Workshop) as well as the Björk method were utilized for determining changes when the passive lingual archwire was used. The dual method also allowed for a statistical comparison between the two approaches.

In general, it can be said that the Björk method of superimposition tended to yield more negative (mesial) positional changes as established by the guidelines of this study than did the Workshop method. Furthermore, the Björk procedure clearly demonstrated the changes in contour of the lower border described previously. Yet, despite the general differences demonstrated between these two methods, there was no statistically significant difference between the positional results obtained using both methods.

In analyzing the individual changes in incisors and molars within each group, it was striking to note the extent of angulation and positional changes which occurred. For example, change in angulation of as much as twelve degrees was noted in the position of the lower incisor. Vertical extrusion (growth?) of five millimeters was noted in the lower molar. Intrusions (inhibition of vertical growth?) of up to three millimeters were noted in the lower molar. Horizontal changes of up to three millimeters were observed in both incisor and molar.

There was a noticeable difference in the amount of extrusion of incisors and

TABLE IV
Mean dimensional changes (MM) in lower study casts before and after the lingual arch

	N=	Before	After	Net Change	P Value
<L3 — <L3	27	25.93	26.41	+0.48	0.016*
<L6 — <L6	36	32.69	34.77	+2.08	0.000**
<L1 — <L6	36	31.03	31.51	+0.48	0.064

*Significant at the 5% level
**Significant at the 1% level

molars within the lingual arch group using both methods of superimposition, with the molars showing two to three times the extrusion of the incisors. This observation contrasts with the findings of Foster and Wylie[11] who determined that the incisors extruded more than did the molars. The observations within the treated group in this investigation also contrast sharply with those within the nontreated sample where there was almost equal extrusion of both molars and incisors.

In comparing means of the nontreated lower arch group with the treated group, several tendencies were noted: lower incisor shifted forward in the treated group, lower molar angulated distally in the treated group and incisors and molars extruded less in the treated group. However, none of these changes proved to be statistically significant.

The single positional change which was significant, using both methods of superimposition, was the horizontal change of the lower molar. This change was in a distal direction in the treated group when compared with the nontreated group. Thus, it appears from the results of this study that the lingual arch was involved in repositioning the crown of the lower molar in a distal direction.

Inasmuch as this type of study has not previously been reported in the literature, it is difficult to make valid comparisons. Foster and Wylie reported distal movement of molars using lingual arches, whereas Von Herzen[28] reported only mesial movement. The methods of determination used in both of these studies, however, were not comparable to those used in the present investigation.

The study of lingual arch effects may be complicated by the mechanical procedures occurring in the opposite arch. Interarch effects, utilizing any single appliance, were reported by Funk.[12] He stated that the lower incisor and molar moved distally with the distal movement of the upper molar induced by maxillary headgear. The question of the enhancement of distal positioning of the lower molar by the use of maxillary headgear was considered in this study. Inasmuch as some of the Group I patients had received maxillary headgear appliance therapy, an analysis of lower incisor and molar changes was carried out comparing the two subgroups of Group I. No significant differences were noted using either method of superimposition in the position of the lower molar. However, using Method 1, significant differences at the five per cent level were noted in the angulation and horizontal positioning of the lower incisor. There occurred a distal angulation and horizontal change in those cases where upper treatment had been utilized. Using Method 2, however, no significant differences were noted in the positions of the incisors. Thus, the findings, with regard to the positions of the molars, tended to conflict with those of Funk. Yet, with relation to the incisors, they were in partial agreement.

An attempt was made to further analyze the effect of treatment or nontreatment of the opposing arch upon the horizontal position of the lower first permanent molar using Method 2 for superimposition. The horizontal positional change was studied because it was the only positional change which was significantly different between the two groups. Method 2 was utilized because of the evidence offered for its accuracy. The four subgroups of Groups I and II were then tested for significant differences in the horizontal position of the lower first molar.

In comparing the four subgroups, the one outstanding finding was that a significant difference in horizontal position of the lower molar existed between those receiving no treatment in either arch and those receiving treatment in both arches. This would tend to indicate that headgear, alone, did not account for the maximal distal change in the lower first molar. Rather, the lingual arch may have enhanced this movement. This statistically significant difference was also found when adjustments (using analysis of covariance) were made between the two groups for age and duration of observation.

The expansion noted in the cuspid and molar regions of the study models would tend to indicate that either the lingual archwire was not as passive as had been believed or that the cuspids and molars were, perhaps, moving distally into a widening arc. This concept of expansion attendant to distal positioning is further supported by the cephalometric results.

Certainly, it can be seen that the appellation "passive lingual arch" is a misnomer. Certain basic dental changes were noted with the use of this appliance. A portion of the effect may be construed as active movement (distal repositioning of molars) although the reason remains obscure, whereas the other effect may be in the form of an inhibition of the normal growth process (vertical extrusion or eruption).

Summary and Conclusions

1. The effect of the passive lingual arch on the lower denture was studied using before and after cephalometric and study model records.

2. A nontreated lower arch sample was used for comparison purposes.

3. Cephalometric data were analyzed using two methods of superimposition (Cephalometric Workshop and Björk) of the mandible.

4. Individual positional changes of incisors and molars were considerable within each group, using both methods of superimposition.

5. There was a tendency (not significant) for teeth to be more mesially inclined using the Björk method of superimposition.

6. No significant differences between means were noted when the two methods of superimposition were compared.

7. The horizontal positional change of the lower molar was found to be significantly different between the two groups ($P = 0.05$ using Method 1; $P = 0.01$ using Method 2) with the lower molar in a more distal position in the treated group.

8. There was a tendency for the incisors and molars of the treated group to show less vertical development (growth?) in the lingual arch group than in the untreated group.

9. The effect of maxillary headgear on positional change of the lower incisor and molar was studied.

10. No significant difference in positional change of the lower molar was noted within the Group I sample (untreated lower) comparing those who wore maxillary headgear with those who did not.

11. Significant differences in positional change of the lower incisor were noted within subgroups *a* and *b* of Group I. In those patients receiving headgear therapy, the lower incisor angulated lingually and the crown moved lingually.

12. When the mean horizontal positional change of the lower molar was compared in all four subgroups, the only subgroups showing significant differences were those in which patients received maxillary as well as mandibular treatment and those in which patients received no treatment in either arch.

13. Analysis of serial study models in

Group II showed significant increases in intercanine (P = 0.05) and intermolar (P = 0.01) distances.

14. Passive lingual archwires appear to be significantly involved in the horizontal relocation of the crowns of the lower anchor molars in a distal direction. In addition, this appliance has a tendency to be inhibitory in terms of limiting vertical growth of both incisors and molars.

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