The Passive Lingual Arch in First Bicuspid Extraction

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The effects of a passive lingual arch on lower incisor and molar positions after extraction of first bicuspids are analyzed. Results indicate that a lingual arch can be effective in maintaining arch length, while still allowing normal changes in incisor, cuspid and second bicuspid positions.

KEY WORDS: Extraction therapy, Lingual arch

Treatment of crowding in the dental arches often involves the extraction of four teeth, frequently the first bicuspids. This may be followed by a period of active treatment in the upper arch, while treatment is delayed in the lower arch in order to allow for any spontaneous improvement that may occur in the positions of malposed teeth.

When the space available for alignment is considered to be critical, a passive lingual arch may be employed as a lower space maintainer.

Efficiency of a lingual arch in this application has often been questioned (Foster 1951, Norman 1965), but almost no attempt has been made to assess it. However, several authors do seem to suggest that it may be employed in critical cases (Nance 1947, Harvold 1974, Dale 1976). It has also been suggested (Singer 1974) that a lingual arch may have some active influence on the positions of teeth even when used as a passive appliance.

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This investigation assesses some of the effects of a passive lingual arch on the lower dentition following extraction of the first bicuspids.

Review of the Literature

The first description of the construction and use of a lingual arch is attributed to J. V. MERSHON (1917), who used it as an expansion device and as a support for auxiliary springs.

As a passive appliance such as Nance's preventive lingual arch (SALZMANN 1957), it has been used to maintain the distance between the anchor molars and the labial segment after premature exfoliation of deciduous teeth. One effect attributed to it is the prevention of tipping of the first permanent molars and lower incisors.

Even though it does not restore function as a prosthetic space maintainer (BROWN 1961), its use would seem to provide a physiological appliance that does not interfere with growth and function.

According to MILLS AND VIG (1974), when excessive crowding is present in the permanent dentition and extractions are required, the application of a lingual arch can allow spontaneous alignment of the labial segment while preventing the mesial movement of the distal teeth. Active treatment time can be considerably reduced in some of these cases.

Opinions of various authors on the changes occurring in the labial segment after extraction of the first bicuspids seem to differ. JACOBS (1965) and RONNERMANN (1965) suggest that the lack of buccal support to the lower incisors would cause their retroclination. On the other hand, MILLS (1964, 1968), CAMPBELL-WILSON (1975) AND RABINE (1978) observed only a very limited effect of bicuspid extractions on the position of the labial segment.

Space closure seems to occur mainly by mesial movement of the buccal segments as they tilt toward the extraction spaces (COOKSON 1971).

Material

This investigation is based on a study of serial lateral head radiographs from the files of the Eastman Dental Hospital in London.

Thirty-three lingual arch patients were studied, 12 male and 21 female. Average age at the beginning of the observation period was 12.0 years and the average observation period was 9.1 months.

Similar criteria were used for selection of the control group of 11 males and 19 females. The average age at the beginning of the observation period was 11.8 years, and the observation period was 14.7 months.

The control and experimental groups were statistically similar in age, length of the observation period, sex and skeletal pattern.

Children in both groups had four first bicuspids extracted at the beginning of the observation period.

A lower lingual arch, adapted as a passive space maintainer, was placed in all patients in the experimental group immediately after the extraction of the four first bicuspids. It was left in place for three months or more, with no other treatment in the lower arch during the period of observation. In some of these lingual arch cases a removable appliance with an anterior bite plane was used in the upper arch, and extraoral traction was applied to the upper first permanent molars in others.

There was no treatment in the control group after the extractions.

Lateral cephalometric radiographs were exposed immediately before the extraction of the first bicuspids, and again at the removal of the lingual arch in the experimental group or at the end of the observation period in the controls.

Method

Tracings were made of the lateral radiographs, and templates of the incisors and molars were then constructed for each individual in order to reduce the effects of error in locating the long axes of these teeth. The landmarks and measurements are illustrated in Fig. 1.

Vertical changes in the lower incisor and molar positions were measured from the mandibular plane. It has been shown that compensatory remodeling occurs in the lower border of the mandible in growth rotation (ENLOW AND HARRIS 1964, BJÖRK 1969). According to BJÖRK AND SKIELLER (1972), an analysis of the eruption of the mandibular dentition should not be based on the lower border of the mandible; however, the changes attributable to this factor during the relatively short period of observation were not considered sufficient to significantly affect the measurements in this study.

Moreover, any mesial movement of the molars in the wedge-shaped intermaxillary space is considered to require a vertical adjustment to maintain the teeth in occlusion. Therefore, an increase would be expected in the distance from the molars to the mandible plane as a consequence of any mesial drifting (PARKER 1964). Such extrusion would be reflected in the measurements of vertical changes.

In order to correct for this factor, the height of the molars was measured from a point which was established on the functional occlusal plane at the same distance from the reference line in both tracings. Thus the molars on the first tracing were corrected forward to account for the mesial drifting occurring during the observation period, and this was considered to be the initial vertical position. The net change in molar height was calculated as the difference between the final value and the forward- corrected initial value (JAMES 1978).

Error of the method

The error of the method on double determination was calculated according to Dahlberg (1940) (Table 1).

Table 1

Error of the method
AFTER DAHLBERG 1940

L1/MP	1.02
L6/MP	1.14
I–R line	0.41
L–R line	0.57
L6C–R line	0.54
L6R–R line	0.43
I–L6C	0.53
L1CEJ–L6CEJ	0.25
L1 height	0.27
L6 height	0.35

Results

Conventional statistical formulae were used to analyze the distribution characteristics of the data from the tracings. The differences between the experimental and control groups were tested with Student's t test and Snedecor's F test (Tables 2-4).

When a significant difference was found between the variances of the two samples, this was tested further by calculating the standard error of the difference between the means (Table 4).

No changes were found in the skeletal variables, so these are not reported here.

Changes were observed in all variables related to the positions and antero-posterior relationships of the lower incisors and lower first molars.

The mean values for these linear and angular measurements at the beginning and at the end of the observation period are shown in Table 2. The mean values of each dimension were used to construct a composite tracing for each group to

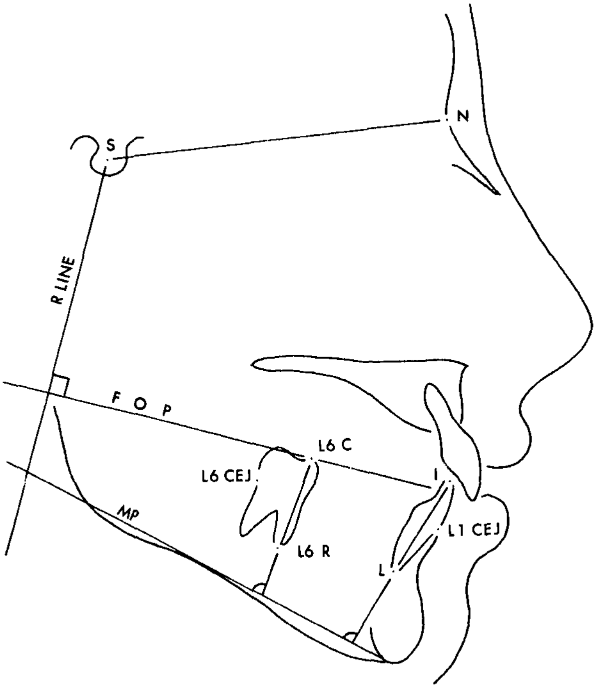

Fig. 1 Landmarks and measurements

Landmarks

L1CEJ ► The anterior cemento-enamel junction of the lower incisor

L6CEJ ► The distal cemento-enamel junction of the lower first molar (Mills et al. 1978)

I ► The point where the long axis of the most prominent mandibular incisor intersects the incisal edge (Mills 1966)

L ► The point where the long axis of the most prominent mandibular incisor intersects the root apex (Mills 1966)

L6C ► Mesial cusp tip of the lower first permanent molar (point C)

L6R ► Apex of the mesial root of the lower first permanent molar (point R)

Planes

MP ► Mandibular plane, the line joining mention and gonion

FOP ► Functional occlusal plane, the line passing through the occlusal contacts of molars and bicuspids

Constructed lines

L6 axis ► The mesial long axis of the lower first molar, passing through the mesial cusp and root, extended to the mandibular plane

R line ► Reference line, the perpendicular from sella to the initial functional occlusal plane. The reference line in the second tracing was located by superimposing on the first tracing with S–N registered at S.

Linear measurements

L1CEJ–L6CEJ ► The distance between the anterior cemento-enamel junction of the lower incisor and the distal cemento-enamel junction of the first molar

I–L6C ► The distance between the incisal edge of the lower incisor and the mesial cusp of the lower molar

L1 height ► The perpendicular distance from the incisal edge of the lower incisor to the mandibular plane

L6 height ► The perpendicular distance from the tip of the mesial cusp of the lower first molar to the mandibular plane

Measurements from the reference line

I–R ► The perpendicular distance from the incisor edge to the reference line

L–R ► The perpendicular distance from the apex of the incisor to the reference line

L6C–R ► The perpendicular distance from the lower molar mesial cusp to the reference line

L6R–R ► The perpendicular distance from the lower molar mesial root apex to the reference line

Angular measurements

L1/MP ► Angle subtended by the long axis of the mandibular incisor and the mandibular plane

L6/MP ► The distal angle subtended by the long axis of the lower first molar and the mandibular plane

Table 2

Mean values at the beginning and at the end of the observation period

		Control Group n=30				Experimental Group n=33			
Variable		Mean	S	SD	SE	Mean	S	SD	SE
L1/Mp	B	93.7	33.8	5.8	1.1	91.7	46.2	6.8	1.2
	E	89.4	34.6	5.9	1.1	90.1	40.9	6.4	1.1
L6/Mp	B	86.4	30.0	5.5	1.0	86.6	30.7	5.5	1.0
	E	88.0	25.3	5.0	0.9	84.3	31.5	5.6	1.0
I–R line	B	76.9	32.6	5.7	1.1	77.9	21.4	4.6	0.8
	E	77.3	30.8	5.5	1.0	79.1	24.9	5.0	0.9
L–R line	B	68.3	35.6	6.0	1.1	70.9	17.1	4.1	0.7
	E	70.1	37.1	6.1	1.1	72.6	23.4	4.8	0.8
L6C–R line	B	51.0	22.4	4.7	0.9	52.6	18.8	4.3	0.8
	E	54.4	28.4	5.3	1.0	55.6	20.1	4.5	0.8
L6R–R line	B	46.2	34.8	6.0	1.1	47.8	24.7	5.0	0.9
	E	48.5	36.7	6.1	1.1	51.8	27.4	5.2	0.9
I–L6C	B	26.2	6.5	2.6	0.5	25.8	8.6	2.9	0.5
	E	23.2	6.0	2.5	0.4	24.4	10.5	3.2	0.6
L1CEJ–L6CEJ	B	35.7	5.7	2.4	0.4	35.7	6.4	2.5	0.4
	E	33.8	5.5	2.3	0.4	34.8	24.3	4.9	0.9
L1 height	B	39.6	15.4	3.3	0.7	38.3	7.8	2.8	0.5
	E	40.5	17.4	4.2	0.8	39.5	9.5	3.1	0.5
L6 height	B	29.1	9.1	3.0	0.6	28.8	5.7	2.4	0.4
	C	30.2	10.2	3.2	0.6	29.7	5.7	2.4	0.4
	E	30.5	12.6	3.6	0.6	30.2	6.0	2.5	0.4

B = beginning
C = forward correction
E = end

S = variance
SD = standard deviation
SE = standard error

visualize the mean changes occurring during the observation period (Fig. 2).

The mean values of the changes in each dimension were used for the comparisons shown in Table 3. The significance of the differences in mean changes between the experimental and control groups were then subjected to statistical analysis, with the results presented in Table 4.

Discussion

Position of the lower incisors

The behavior of the two groups showed definitely different trends.

The angle subtended by the long axis of the lower incisor and the mandibular plane decreased much more in the control group than in the experimental group. The differences between the mean changes in the two groups during the observation period would seem to confirm a trend in both groups toward a decrease in the L1/MP angle, but this lingual movement was greater in the control group (Fig. 3).

The obviously different trend in the behavior of the inclination of the lower incisor in the two groups could be due to

Table 3

Mean changes during the observation period

Variable	Control Group n=30 Mean	S	SD	SE	Experimental Group n=33 Mean	S	SD	SE
L1/MP	−4.3	10.2	3.2	0.6	−1.6	18.9	4.4	0.8
L6/MP	1.2	14.1	3.8	0.7	−2.3	30.3	5.5	1.0
I-R line	0.6	3.0	1.7	0.3	1.2	3.0	1.7	0.3
L-R line	1.8	3.5	1.9	0.3	1.7	6.1	2.5	0.4
L6C-R line	3.8	5.5	2.4	0.4	3.0	5.1	2.3	0.4
L6R-R line	2.2	9.0	3.0	0.5	4.0	5.2	2.3	0.4
I-L6C	−3.0	2.3	1.5	0.3	−1.2	2.9	1.7	0.3
L1CEJ-L6CEJ	−1.9	1.6	1.3	0.2	−1.6	1.9	1.4	0.2
L1 height	0.9	5.0	2.2	0.4	0.9	1.9	1.4	0.2
L6 height	0.3	1.0	1.0	0.2	0.6	0.9	0.9	0.2

Table 4

Results of the statistical tests

NE = 33 NC = 30

Variable	F	t	P	SE Mean diff.
L1/Mp	1.85	2.84	***	***
L6/Mp	2.15	2.93	***	***
L1-R line	1.00	1.32		
L-R line	1.71	0.16		
L6C-R line	1.09	1.41		
L6R-R line	1.72	2.66	***	***
I-L6C	1.22	4.34	****	
L1CEJ-L6CEJ	1.24	1.08		
L1 height	1.64	0.04		
L6 height	1.12	1.24		

		5%	1%	
F ratios	S32 > S29	1.64	2.03	
	S29 > S32	1.62	2.01	
2-tail t test	total d.f. 61	<0.01	2.66	***
		<0.001	3.46	****

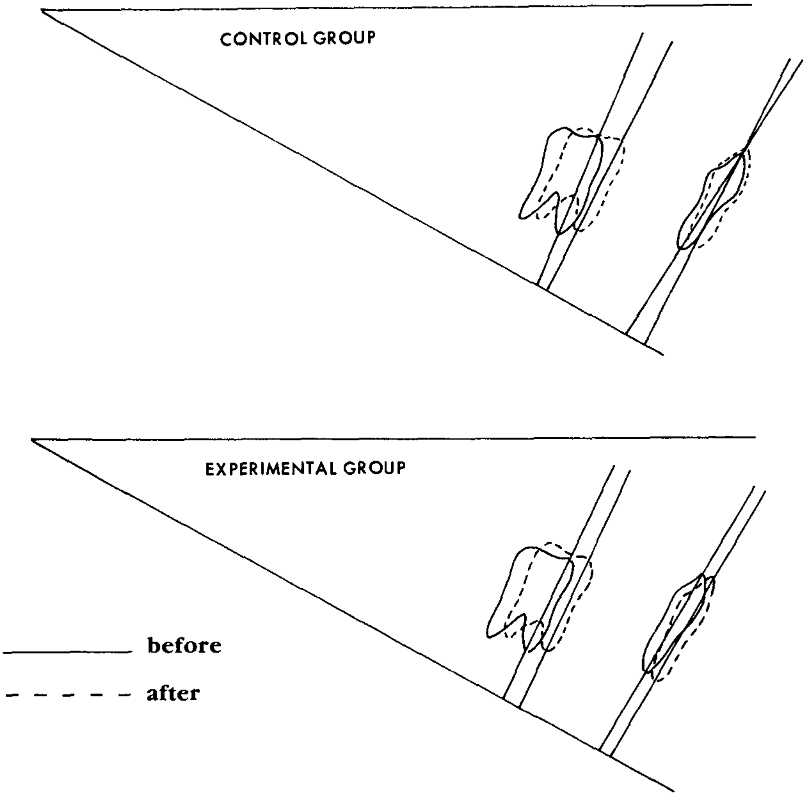

Fig. 2 Composite tracings constructed with the mean values of the two groups for each dimension

either the root apex of the incisor moving labially or the edge moving lingually, or to some combination of both. The positions of the apex and the incisal edge were analyzed to determine their relative contributions to the change in inclination of the tooth.

The linear measurements from the reference line to both the incisal edge and root apex increased during the observation period, as would be expected with the forward development of the jaws relative to the cranial base. This was quite similar for the apex in the two groups.

The incisal edge, however, showed a relatively smaller mean change in the control group than in the experimental group, which would confirm Mills' findings (1964) on the effect of the loss of first bicuspids on incisor support. Foster (1951), Jacobs (1965) and Singer (1974) seem to agree that the use of a lingual arch does not prevent the slight retroclination of the labial segment due to the loss of buccal arch continuity.

The present investigation did not seem to confirm those reports. The effect of the lingual arch on the position of the incisors appeared to be almost comparable to the presence of an intact dental arch, as it would counteract the muscular imbalance at the tip of the incisors when the lower dental arch is brought forward by mandibular growth. Therefore, the slight

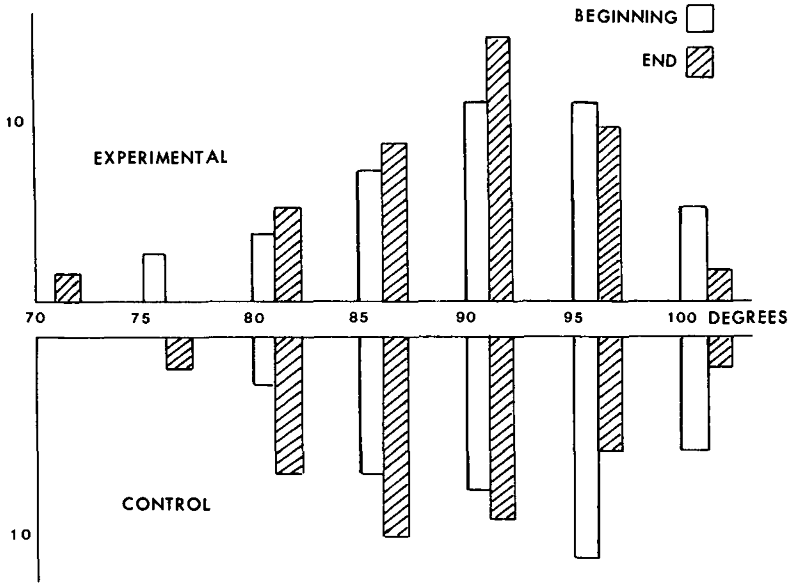

Fig. 3 Angle of the lower incisor to mandibular plane

retroclination of the lower incisors occurring with growth (Schaeffer 1949, Björk and Palling 1954, Ricketts 1960) does not seem to be prevented, but neither is it enhanced by the lack of support from the buccal segments.

Furthermore, no evidence was found in this study to support a common clinical opinion that the proclination of the lower labial segment is a frequent consequence of the use of a lingual arch (Isaacson and Williams 1978). Some of these differences may be due to subtle differences in lingual arch management in different studies.

The height of the lower incisors was also analyzed, as it has been suggested (Singer 1974) that a lingual arch would reduce the vertical development of the lower labial segment. No significant difference was found in the mean changes in the height of the incisors between the two groups, so the lingual arch did not appear to inhibit the vertical development of the lower incisors.

Consideration should also be given to the rotation of the jaws, as it can also influence the paths of eruption of the teeth in the course of occlusal development. Björk (1969) and Björk and Skieller (1972) suggested that compensatory changes occur in the inclination of the lower incisors, according to the direction of growth rotation of the jaws as their functional positions are maintained. The labial segment would be expected to tip forward on the mandibular base in a forward rotator, while it would become retroclined in a backward rotator.

However, Björk and Skieller (1972) also noted that the inclination of the anterior teeth is affected to a greater extent by functional factors, so that incisor position in the face and in relation to opposing teeth tends to be stable, regardless of the direction of any rotation. By superimposing the tracings on Björk's mandibular structures (Björk 1955, 1969), no indication of extreme rotation was found in the sample examined in the present

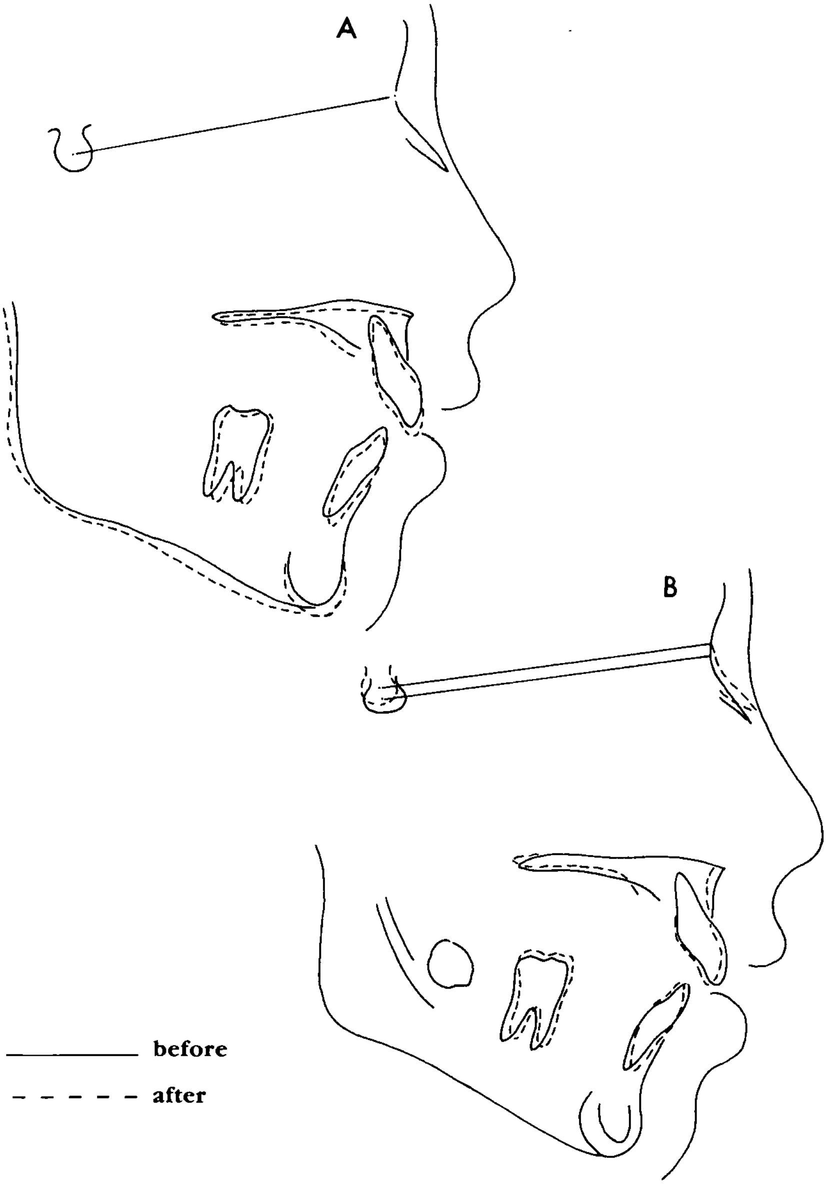

Fig. 4 Case M.K., superimposed on S-N at sella (A) and on Björk's structures (B)

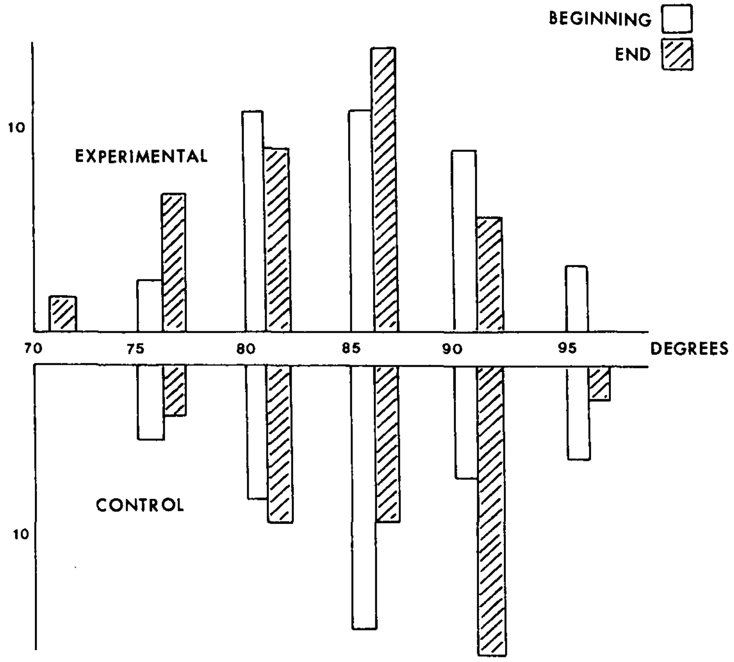

Fig. 5 Angle of lower molar to mandibular plane.

study. Most were mild forward rotators, and the eight backward rotators did not exhibit any different type of adaptive behavior in the lower incisor segment.

It would seem valid to assess changes in the position of the lower labial segment relative to the mandibular plane and to the reference line, as the trends seen by this method were the same as those seen with superimposition on Björk's mandibular structures (Fig. 4).

Position of lower molars

The inclination of the lower molars to the mandibular plane showed similar initial values in the two groups, but trends were different during the observation period. The distal angle subtended by the long axis of the lower molar and the mandibular plane tended to increase in the control group, while a decrease was observed in the experimental group.

The frequency distribution curve of the angle L6/MP seemed to be reasonably symmetrical at the beginning of the observation period in both groups (Fig. 5). At the end of the period the curve for the controls showed a definite skewing, with more movement of the mode toward higher values than in the experimental group.

The change in inclination of the lower molars could be due to changes in position of the crown or of the root, or a combination of the two, so the mesial cusp tip and root apex positions were also analyzed.

The linear measurement from the mesial cusp to the reference line increased in both groups due to growth, mesial drift and forward movement of the teeth toward the extraction space.

The linear measurement from the root apex of the molar to the reference line also increased in both groups, as would be expected to occur with growth and occlusal development (Björk 1969, Moss 1973). The mean increase in the distance from molar apex to reference line was significantly different in the two groups, with the apex moving much farther mesially in the experimental group than in the controls.

There is wide agreement on the forward drifting of the lower dental arch, including the molars, even though the exact path of such movement has not yet been established. According to Bonnot and Gabet (1972), the direction of drifting would be a "curve with an anterior concavity". However, Thilloy et al. (1973) stated that the lower permanent teeth show a relative independence from the direction of the mandibular curve, and that their forward movement would be achieved more by apical drifting than by coronal movement. Björk and Skieller (1972) suggested that this molar movement is unrelated to the rotation of the mandible.

The extraction of teeth mesial to the molars seems to enhance the natural tendency for mesial drift, with the extraction space closing more by mesial drift and tipping in the buccal segments than by reduction of anterior crowding (Cookson 1971, Mills and Vig 1973).

The significantly different behavior of molar inclination in the experimental group suggests that the lingual arch holds the crown of the molar, preventing its tilting toward the extraction space, while the root does drift mesially as would be expected with growth. In contrast to Singer's findings (1974), no "distal repositioning" of the crown seems to occur, but rather a definite mesial movement of the root with little change in crown position. Thus the lingual arch appears to only prevent the tipping into the extraction space without inhibiting the normal development of occlusion.

Nevertheless, it seems that the hypothesis of a distal repositioning of the crown of the molar cannot be absolutely rejected in all cases. The tongue sometimes acts under the archwire behind the surfaces of the incisors, and this force transmitted through the wire to the crowns of the molars can tip them distally. Slight changes in inclination of the incisors can also occur, as the altered position of the lingual arch shortens its effective length in the dental arch.

Changes in height of the lower molars were assessed by measuring the perpendicular line from the tip of the mesial cusp to the mandibular plane, which is approximately the line of eruption (Harvold 1974). The increase in height of the molars was similar in the two groups, whether measured in the actual position on the first tracing or at the forward-corrected position. This does not support Singer's (1974) suggestion that a lingual arch inhibits the vertical movement of the molars with growth.

Arch length changes

Shortening of the dental arch in the transition from mixed to permanent dentition is well established, and it is also maintained that further reduction occurs in this dimension in the following years. Extraction of teeth in the buccal segments enhances any shortening of the space between the molars and the labial segment.

Arch length changes were measured at the cemento-enamel junction level of the incisors and molars, and from the incisal edge to the mesial molar cusp. The reason for this double assessment was to distinguish between shortening of the arch because of the tilting of the teeth and those changes due to bodily movement.

The reduction in sagittal distance between the cemento-enamel junctions of the incisors and molars was not found to be statistically different between the control and experimental groups.

The sagittal distance between the incisor edge and the mesial cusp of the molar was found to decrease more in the control group, confirming that arch length does decrease significantly after the extraction of teeth in the buccal segments.

The tipping of teeth toward the extraction space, as observed to a great extent in the control group, did not seem to play a significant role in arch length changes when a lingual arch was employed. In the experimental group, the slight uprighting of the mesially moving molars also appeared to aid in preventing the proclination of the labial segment which would be expected as a consequence of the arch wire moving forward with the anchor teeth. At the same time, the lower incisors could still follow their natural course during occlusal development.

The slight mesial movement of the molars and uprighting of the incisors would account for the decrease in arch length observed in both groups, but this might be regarded more as a feature of development than a consequence of the extractions.

It might be reasonably concluded that a lingual arch can be effectively applied to maintain arch length after extractions in the buccal segments.

Conclusions

- A lingual arch seems to be effective in maintaining arch length without inhibiting normal developmental changes in the labial and buccal segments.
- Lower incisor position following extraction of the first bicuspids appears to be influenced by the presence of a passive lingual arch, with an effect somewhat comparable to that found with an intact dental arch.
- The slight retroclination of incisors with growth does not seem to be prevented, but neither is it increased by the loss of support from the buccal segments.
- Vertical development of the incisors and molars does not seem to be inhibited by the presence of a passive lingual arch.
- A lingual arch can prevent the tipping of molars toward the extraction space after removal of first bicuspids, but it does not absolutely prevent the mesial drift expected with growth.
- A further assessment evaluating the long-term presence of a lingual arch would be helpful, as some of its effects on incisors and molars could be only temporary.

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