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Mandibular arch changes following nonextraction treatment

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Objective: To evaluate mandibular tooth position changes following treatment with a lip bumper and fixed appliance. Specifically, we aimed to determine how space was obtained to align crowded lower incisors.
Methods: Thirty-four consecutively treated children with a mean age of 10.6 years (SD: 1.14 years) were selected from a specialist orthodontic practice in Eire. All subjects were treated with a lip bumper followed by a fixed appliance. The positions and angulations of the lower first molars and most proclined lower incisor were measured on the pretreatment and post-treatment lateral cephalometric radiographs and study models with a reflex metrograph. The changes were also compared with published growth data.
Results: After lip bumper and fixed appliance treatment the mandibular arch depth decreased (Mean difference: 1.2 mm; $p < 0.01$) and the mandibular intermolar width increased (Mean difference: 1.73mm; $p < 0.01$). The mandibular molars moved mesially (Mean difference: 2.14 mm; $p < 0.01$) and tipped distally (Mean difference: 4.36 degrees; $p < 0.01$). There were no significant differences between the pre- and post-treatment positions or angulations of the mandibular incisors. Compared to published growth data the arch depth decreased less, the intermolar width increased more and the mandibular molars were uprighted. There was no difference in the positions of the mandibular incisors in the treated group compared with published growth data.
Conclusions: The main effects of nonextraction treatment with a lip bumper followed by fixed appliance treatment were to maintain the leeway space, expand the mandibular arch and 'upright' the lower molars. The treatment had no effect on the position of the lower incisors.
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Introduction

The reported adverse effects of extraction on the facial profile has again focused attention on nonextraction methods of treating crowding and upper incisor protrusion.[1] This has resulted in a renewed interest in early/interceptive methods that claim to increase the length of the lower dental arch. It has been claimed that this type of treatment, described as 'arch development', can gain sufficient space to correct crowded or proclined teeth without extraction of permanent teeth. This approach to treatment has been strongly criticised by other workers because, in their view, the end result is unstable.[2,3] One aspect of arch development is to maintain the leeway space using primarily a lip bumper, and to follow this with a second phase of treatment using conventional fixed appliances.[4] Space for alignment of crowded lower teeth is thought to come from the leeway space.

Little has been published on the positions of the mandibular teeth following orthodontic treatment with both lip bumpers and fixed appliances. Several studies have reported that following the lip bumper phase of treatment there was more space in the arches because the anteroposterior and transverse arch dimensions had increased. The anteroposterior increase was due to lower incisor proclination, which has been attributed to unopposed pressure from the tongue acting on the lower incisors.[5-7] A large longitudinal study has also shown that proclined lower incisors often return to their pretreatment positions.[8] Some functional appliances also procline the lower incisors, but the proclination is often reversed with a

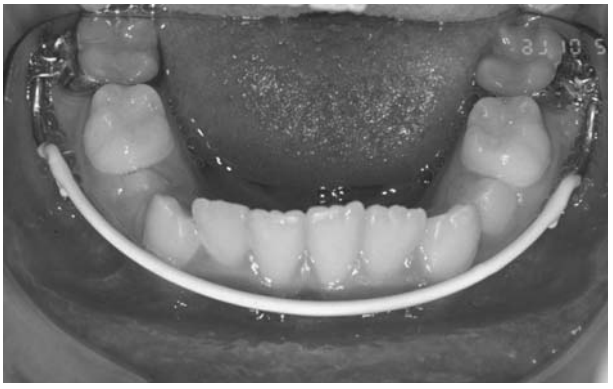

Figure 1. The type of lip bumper used in this study.

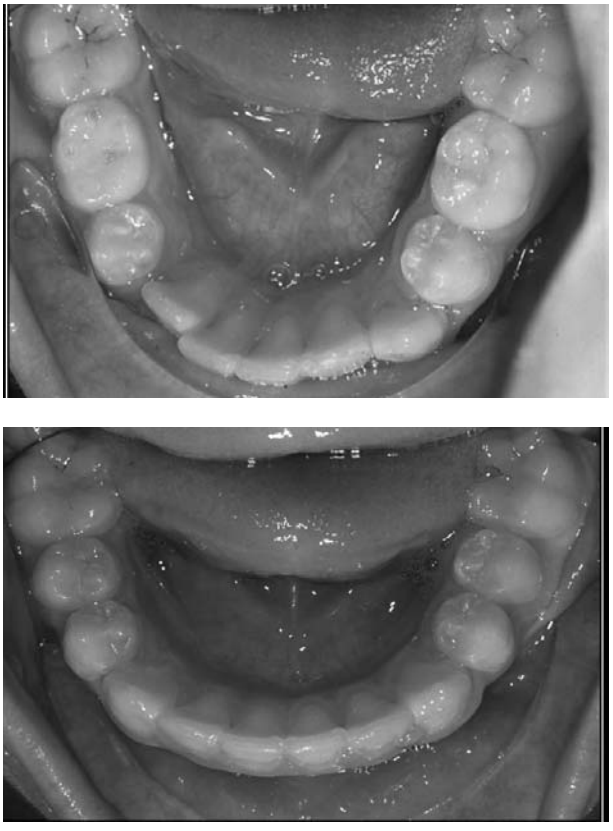

Figure 2. Pretreatment and post-treatment views of the same subject showing alignment of the lower incisors.

second phase of fixed appliance treatment. Although the effects of lip bumpers on the lower arch have been quantified, there is very little data on the tooth position changes after initial treatment with lip bumpers followed by fixed appliances.

The aims of the study were to investigate changes in the depth of the mandibular arch, and the positions and inclinations of the mandibular first molars and incisors after an initial phase of treatment with lip bumpers followed by fixed appliances. Specifically, we aimed to determine how space was obtained to align crowded lower incisors. The information obtained will provide a record of the changes that occur after lip bumper and fixed appliance treatment and may assist in predictions of future stability.

Materials and methods

Sample

The sample was drawn from a specialist practice in Eire, and all subjects were treated consecutively by the same orthodontist. Subjects were included if: the treatment consisted of an initial phase with a lip bumper followed by fixed appliances; they were in mixed dentition stage of development at the start of treatment; the second deciduous molars were present; there were no missing teeth due to caries or other reasons; there were no obvious severe skeletal or dental asymmetries. Subjects were excluded if any initial or final study models or lateral cephalometric radiographs were missing. Records were not available at the end of the first phase of treatment with lip bumpers. The type of lip bumper used and the alignment obtained at the end of treatment are shown in Figures 1 and 2.

Data from a previous study was used to determine the sample size.[9] The final sample size of 30 was based on an alpha significance level of 0.05 and a beta of 0.1. This gave a 90 per cent power to detect a difference of 2 mm (± 1.5 mm) in arch depth change.[10] Initially, the records of 36 subjects were obtained, two subjects were subsequently excluded because either final study models or final radiographs were not available. The final sample was 34 children (11 boys, 23 girls). The mean age of the subjects at the start of the treatment was 10.6 years (SD: 1.14 years). The lip bumper was worn for an average of 16 months (Range: 13 - 19 months).

Methods

All measurements were taken from the pretreatment and post-treatment study models and lateral cephalometric radiographs with a reflex metrograph, which can be used for two-dimensional and three-

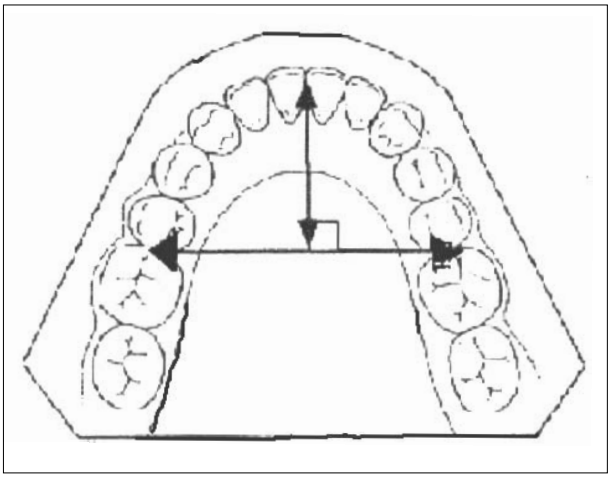

Figure 3. Study model measurements. Arch depth: the perpendicular distance from the lower midline to the line joining the most superior midpoints on the mesial contact points of the mandibular first molars. Intermolar distance: the distance between the mesial contact points of the mandibular first molars.

dimensional measurements.[11] Arch depth and the intermolar width were measured on the pretreatment and post-treatment study models (Figure 3).

On the lateral cephalometric radiographs the coordinates of the following landmarks were digitised with the reflex metrograph: first molar distal cusp tip; first molar mesial cusp tip; first molar furcation point; gonion; menton; point on the inferior lingual surface of the posterior symphysis; apex of the most proclined lower incisor; tip of the most proclined lower incisor (Figure 4). The positions and angulations of the mandibular first molar and mandibular incisor were then calculated.

1. Lower incisor inclination. The angle between the long axis and the mandibular plane (Go-Me).

2. Lower incisor distance. The distance from the incisor tip to the perpendicular to the mandibular plane through the point on the inferior lingual surface of the mandibular symphysis, described by Bjork[12] as an area of minimal remodelling.

3. Lower first molar inclination. The angle between the line intersecting the mandibular plane perpendicular to the line tangent to the cusp tips and through the furcation.[13]

4. Lower first molar distance. The distance from the perpendicular to the mandibular plane through the distal contact point of the first molar and the perpendicular to the mandibular plane through the point on the inferior lingual surface of the mandibular symphysis.

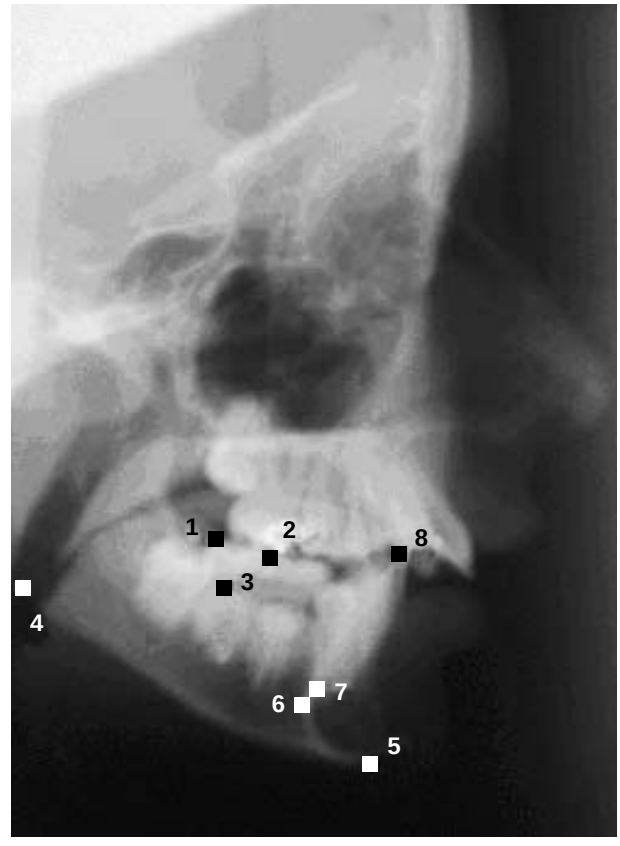

Figure 4. Cephalometric points. 1: First molar distal cusp tip. 2: First molar mesial cusp tip. 3: First molar furcation point. 4: Gonion. 5: Menton. 6: Point on the inferior lingual surface of the posterior symphysis. 7: Apex of the most proclined lower incisor. 8: Tip of the most proclined lower incisor.

Method error

Reproducibility studies on the same reflex metrograph have indicated that consistent measurements with an accuracy of ± 0.5 mm can be obtained.[14] To verify our use of the reflex metrograph 18 sets of mandibular study models and 10 cephalometric radiographs were randomly selected and measured more than three months later by the same observer. All model measurements were carried out in a random order to reduce observer bias. Intra-observer reliability between the two recordings was assessed with Pearson product-moment correlation coefficients.

Statistical analysis

The pretreatment and post-treatment differences were obtained by subtracting the pretreatment measurements from the post-treatment measurements.

Table I. Mandibular arch changes following nonextraction treatment.

		Pretreatment	Post-treatment	Mean difference	SEM	95 per cent CI	*p*
Study models	Arch depth	25.60	24.41	-1.20	0.35	-0.48, -1.92	< 0.01
	Intermolar width	38.54	40.27	1.73	0.33	2.39, 1.07	< 0.01
Radiographs	LI distance (mm)	5.59	4.83	-0.77	0.44	0.12, -1.66	NS
	LI angulation (degrees)	89.37	89.62	0.25	0.96	2.20, -1.70	NS
	Molar distance (mm)	19.56	17.42	-2.14	0.58	-0.95, -3.32	< 0.01
	Molar angulation (degrees)	77.13	72.77	-4.36	1.14	-2.04, -6.68	< 0.01

Table II. Comparison with published growth data (Moyers *et al.*,1976)

	Arch depth	Intermolar width	LI distance	LI angulation	Molar change	Molar angulation
Present study	-1.20	1.73	-0.77	0.25	-2.14	-4.36
Published data	-2.80	0.47	-0.40	-0.55	-1.75	Unavailable

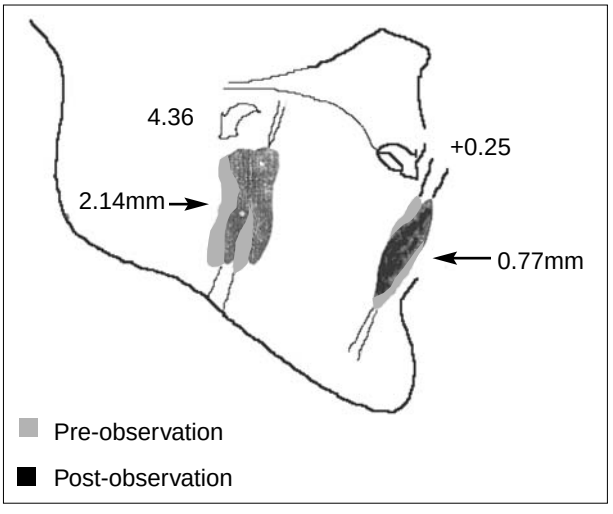

Figure 5. Overall changes following 'arch development' mechanics.

The changes calculated were: arch depth change, intermolar width change, change in lower incisor angulation, change in lower first permanent molar angulation, lower incisor movement, and lower molar movement.

All data were checked for normality by constructing distribution graphs and comparing these with the curve for normal distribution. The result was also confirmed by using the Shapiro-Wilks test for normal distribution. The normally distributed data were analysed with the Student *t*-test. If the data were not determined as normally distributed the Wilcoxon Signed Ranks test was used.

Results

The method of study proved to have acceptable intra-examiner reproducibility. The coefficients ranged from 1.000 (molar distance) to 0.931 (molar angulation). The coefficient for both study model measurements (arch depth; intermolar width) was 0.995.

The arch depth decreased significantly and the intermolar width increased significantly after both phases of treatment (Table I). Both changes were, on average, less than 2 mm. The lower molars moved mesially (Mean difference: -2.14 mm; $p < 0.01$) and tipped distally (Mean difference: -4.36 degrees; $p < 0.01$). There were no significant differences in the position or angulation of the lower incisors. The cephalometric changes in our sample are summarised in Figure 5.

The lower molars tipped mesially less in the present study compared with the published data (Table II).[15] There was no significant difference in the angulation of the lower incisor in the subjects compared with the published data for untreated individuals.[15]

Discussion

The results clearly show that nonextraction treatment with a lip bumper followed by fixed appliance treatment expands the lower arch and 'uprights' the lower first molars. These changes and maintenance of the leeway space by the lip

bumper provide the space necessary to align crowded lower teeth. The arch depth decreased in our sample to a lesser extent than in an untreated group.[15] There was no significant difference in the changes in the positions of the lower incisor in our sample as compared with published controls.

Previous studies analysing the effects of lip bumpers have demonstrated increases in arch depth and overall arch circumference, and alignment of crowded teeth.[6,16,17] However, after lip bumper and fixed appliance treatment we found that arch depth decreased 1.20 mm: less than half the reduction of 2.80 mm in an untreated group.[15] Because we analysed our subjects after fixed appliance treatment any space left over after alignment of crowded teeth would have been closed during this phase of treatment.

The method proved to have good intra-examiner reproducibility. Direct digitisation of the films without an intermediate tracing stage was both convenient and accurate. The facility to digitise the points on the study models in three-dimensions was also convenient and accurate in spite of the three month period between the two sets of measurements. Because both incisor and molar measurements were taken from stable mandibular structures they are unlikely to be confounded by remodelling changes.[12]

The treatment increased the intermolar width significantly. In our group we found that the lower arch was expanded 1.73 mm, whereas the annual changes reported in an untreated sample were less than 30 per cent of this increase.[15] It would appear that arch development depends to some extent on molar expansion. Our finding of lower arch expansion agrees with other workers who have reported similar changes after use of lip bumpers.[5,7,9] Cetlin and Ten Hoeve[4] proposed that this was due to correction of molar rotation and natural uprighting. It has been suggested that this lateral expansion may be stable in nonextraction cases and if the posterior teeth are tilted lingually before treatment.[4] In our sample it appears that the fixed appliance phase of treatment maintained the expansion achieved during the lip bumper phase of treatment.

At the end of treatment the lower molars were tipped distally 4.3 degrees, but there was no significant change in the position of the lower incisors. Previous studies have not assessed the position of the lower incisors at the end of the fixed appliance phase in cases receiving so-called arch development mechanics. However, significant incisor proclination at the end of the lip bumper phase has been reported.[18,19] As we mentioned earlier this is probably due to unopposed pressure from the tongue acting on the lower incisors. Incisor proclination was not observed in this investigation because the clinician used mechanics in the fixed appliance phase to either minimise or counteract it. Pressure from the lower lip on the vestibular shield of the lip bumper would also serve to tip the lower molars distally around their centres of resistance.

Although we used the same variables as Moyers *et al.*[15] the arch changes we found may not be directly comparable to the children used in the published study. The latter were from a different population group, and the data were collected some decades ago thereby raising the possibility of secular change. Furthermore, selection bias may have occurred because the subjects were not randomly assigned to the appliance and control groups at the outset.

The main effects of nonextraction treatment with a lip bumper followed by fixed appliance treatment were to expand the mandibular arch, maintain the leeway space and upright the lower molars. The treatment had no effect on the positions of the mandibular incisors. Previous studies have reported that arch expansion occurs during treatment with lip bumpers and this appears to have been maintained until the end of treatment. In spite of the use of lip bumper and subsequent fixed appliance treatment the arch reduced slightly due to forward movement of the lower molars.

Conclusions

In this retrospective study it was not possible to separate the effects of the lip bumper from those due to a second phase of treatment with fixed appliances.

The following conclusions can be made:

1. Nonextraction treatment in the mixed dentition with a lip bumper followed by fixed appliance treatment resulted in expansion across the first molars and distally tipped lower molars.

2. There was no change in the position and angulation of the lower incisors.

3. Arch length reduced post-treatment due to mesial movement of the lower molars, but to a lesser extent than an untreated sample.

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