CONTINUING EDUCATION ARTICLE

The use of the lingual arch in the mixed dentition to resolve incisor crowding

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In the mixed dentition, arch length preservation, maintaining the leeway space, can often provide adequate space to resolve lower incisor crowding. Yet the frequency of this occurrence is not known. To obtain this information, lingual arches were placed in the mandibular arches of 107 consecutive mixed dentition patients with incisor crowding to preserve arch length and make the leeway space available to resolve the crowding. Arch length decreased only 0.44 mm whereas the intercanine, interpremolar, and intermolar dimensions increased between 0.72 and 2.27 mm. There was adequate space to resolve the crowding in 65 (60%) of the 107 patients. If perfect arch length preservation had occurred, there would have been adequate space to resolve the crowding in 73 (68%) of the 107 patients. The correlation between leeway space and tooth size-arch size discrepancy was only 0.44. (Am J Orthod Dentofacial Orthop 2000;117:81-5)

The resolution of mandibular incisor crowding requires a space-gaining strategy to provide the space necessary to align the teeth. This approach, in turn, can be influenced by the stage of dental development. In the mixed dentition, the developmental changes in the arch, including the leeway space, can provide space for alignment. According to Moyers et al,[1] as much as 4.8 mm of space can become available as the permanent canines and premolars replace their primary successors. Normally, the first molars move mesially into the "leeway" space and arch length decreases.[2] However, this space can be preserved by maintaining arch length with passive appliances. For example, Singer[3] noted that arch length was maintained during the transition from the mixed to the permanent dentition with the use of a passive lingual arch. And other investigators[4,5] have demonstrated that arch length preservation to liberate the leeway space for incisor alignment has provided adequate space to resolve incisor crowding in many instances.

Yet the success rate of this type of treatment has not been established in a clinical trial. For this reason, the present study was undertaken to determine how often arch length preservation by means of a passive lingual arch can provide sufficient space to resolve incisor crowding during the transition from the mixed to the permanent dentition. A second aim is to quantify the arch dimensional changes that occur as a result of this treatment.

MATERIAL AND METHODS

Passive lingual arches were placed in 107 consecutive patients with mixed dentition with mandibular incisor crowding or early loss of a primary canine. Lingual arches were placed in subjects with an intact lower arch within 3 months after the initial records were taken. When 1 primary canine was lost early, the antimere was extracted in order to promote midline correction and a passive lingual arch was then placed 3 months later. If both primary canines were lost, a lingual arch was placed as soon as possible. In some instances, the primary second molars were extracted after lingual arch placement in order to encourage distal drift of the first premolars and canines. There were 43 males and 64 females in the sample; the average age of the patients was 8.6 years with a range of 7 to 11 years.

The lingual arches used in this study were constructed of 0.036 in SS wire and were made completely passive. The wire was made to contact the cingulum region of the incisors and was soldered to the lingual surfaces of the first molar bands.

TIME PERIODS EVALUATED

T1

Mixed dentition, at least all permanent mandibular incisors and first molars, were present as well as both primary second molars.

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Table I. Change in crowding (TSASD) after lingual arch therapy

	Crowding (mm)
Pretreatment (T1)	–4.85 (±2.14)
Posttreatment (T2)	+0.2 (±2.75)
Net change (T2-T1)	+5.0 (±2.1)

Table II. Crowding (TSASD) status after lingual arch therapy

(N = 107)	*Number of patients*	*%*
0 mm of crowding or spacing	65	61
0.44 or less crowding	73	68
1 mm or less crowding	81	76
2 mm or less crowding	93	87
Greater than 2 mm of crowding	14	13

T2

Early permanent dentition, all permanent mandibular teeth mesial to the first molars were erupted, with at least 50% eruption of both second premolars. In one instance, the second premolars were impacted.

MEASUREMENTS

All measures were made with digital calipers and recorded to the nearest 0.01 mm.

1. Arch length. Arch length was the combined distance between the mesial anatomic contact points of the permanent right and left first molars to the contact point between the permanent central incisors. When space was present between the central incisors, the contact point was estimated at half the distance of the space present.
2. Intercanine width. The intercanine width was the distance between the canine cusp tips or estimated cusp tips if wear facets were present. Forty-six subjects were not included in the measurement data because of the loss of at least 1 primary canine.
3. Interpremolar width. The interpremolar width was the distance between the mesiobuccal cusp tips of the primary first molars and the buccal cusp tips of the first premolars.
4. Intermolar width. The intermolar width was the distance between the central fossae of the left and right permanent first molars.
5. Arch perimeter. At T1(mixed dentition), only the perimeter of the anterior part of the arch was measured; at T2 (permanent dentition), the total arch perimeter was determined.

   At T1, a malleable brass wire was contoured from the mesial contact point of one primary first molar over the best fit of the cusp tips of the canines and incisal edges of the incisors to the mesial contact point of the opposite primary first molar. When a primary first molar was absent, the mesio-distal size of its antimere was recorded with a caliper. The caliper was then placed against the mesial contact point of the primary second molar adjacent to the missing primary first molar, and a mark corresponding to the anterior point of the caliper was placed on the model. The mark was used to represent the mesial aspect of the primary first molar.

   At T2, a malleable brass wire was contoured from the mesial contact point of one first molar, over the buccal occlusal lines of the posterior teeth and the incisal edges of the anterior teeth to abut the mesial contact point of the opposite first molar. When the lingual arch was still in position at T2, the brass wire measurement was made from the mesial band surface of one first molar to the mesial band surface of the other molar.
6. Tooth size measurements. At T1 (mixed dentition), tooth size was the sum of the mesio-distal diameters of the permanent incisors and the primary canines. When 1 primary canine was missing, the size of the other canine was used as the estimate of size of the missing tooth. When both primary canines were missing, the average size of the primary canines determined by Moyers et al,[1] 5.5 mm, was used for the size of these teeth.

   At T2 (permanent dentition), tooth size was the sum of the m-d widths of each of the 10 mandibular teeth, from second premolar to second premolar. In the patient in whom the second premolars were impacted, the m-d widths of the second premolars were estimated by adding 0.5 mm to the m-d width of the first premolars according to the relationships described by Moyers et al.[1]
7. Crowding was identified as a tooth size-arch size discrepancy (TSASD). Two types of TSASD were determined at the different time periods.

   At T1 (mixed dentition), an anterior TSASD that represented the difference between the size of the permanent incisors and primary canines and the arch perimeter from first primary molar to first primary molar was calculated. At T2 (permanent dentition), the total TSASD was the difference between the size of 10 permanent teeth and the total arch perimeter. Crowding was identified as a negative value; spacing was specified as a positive number; and no TSASD was designated by a value of zero.
8. The leeway space was calculated by subtracting the sum of the mesiodistal diameters of the permanent canines and premolars from the mesiodistal diameters of the primary canines and molars. All primary molars and canines had to be present bilaterally at T1 in order to be included in the measurement. Forty-six subjects met this criterion. The change in TSASD and arch dimensions represented the differences between these measures at T1 and T2.

STATISTICAL ANALYSIS

Paired *t* tests were performed on the changes in crowding and all arch dimensional changes T1 to T2. Pearson product moment correlation coefficients were calculated between the changes in crowding and the changes in arch length, intercanine dimension, interpremolar width, intermolar width, and the leeway space. In addition, a multiple regression analysis was used to evaluate the degree to which the change in crowding was related to these variables.

Error of the Method

All measurements on the 10 cases were duplicated 1 day apart by the same person. The standard error of method was calculated using Dahlberg's formula Sde = E D2/2n. The standard error for all measurements was less than 1 mm. The values were as follows: 0.63 mm for the intercanine width, 0.74 mm for the interpremolar width, 0.63 mm for the intermolar width, 0.45 mm for the left side arch length, and 0.47 mm for the right side arch length.

RESULTS

Changes in Crowding (TSASD) (Table I)

At T1, there was an average of –4.85 mm (≤–2.14 mm) of incisor crowding (anterior TSASD) with a range of –14.9 mm to ±1.1 mm. At T2, an average of +0.2 mm (±2.75 mm) of space was present when tooth size was compared with arch size. Thus, the average amount of incisor crowding that could be resolved was 5.0 mm (±2.1 mm). In 106 patients, the range in postlingual arch crowding was –7.5 to +4.7 mm. In the patient with the impacted second premolars, the crowding was –14.5 mm at T2. Incisor crowding decreased in 105 of the 107 patients, remained the same in 1, and increased in only 1. In 65 (61%) of the 107 subjects, there was ample space to resolve incisor crowding completely. In 73 (68%) patients, there was a TSASD of 0.5 mm or less, and in 81 (76%) patients, the TSASD was 1 mm or less. Only 14 (13%) demonstrated a TSASD greater than 2 mm (Table II).

Arch Dimensional Changes (Table III)

1. Arch length. Arch length decreased an average of –0.44 mm (±1.35 mm), which was statistically significant. The changes in arch length ranged from –4.79 mm to +2.9 mm. Arch length decreased in 62 individuals, increased in 39 and showed no change in only 6.
2. Intercanine width. The intercanine width, which was determined on only 61 individuals because of the absence of at least 1 primary canine, increased a statistically significant 1.49 mm (±1.76 mm), with a range of –2.62 mm to +6.72 mm. This dimension increased in 49 subjects, decreased in 11 individuals and was unchanged in only 1 patient.
3. Interpremolar width. The interpremolar width was determined in only 98 participants because of a missing primary first molar in the other 9. A significant mean increase of 2.27 mm (±1.74 mm) in interpremolar width occurred, with a range of –2.5 mm to +6.4 mm. This dimension increased in 89 persons, decreased in 8, and remained the same in 1.
4. Intermolar width. The intermolar width significantly increased an average of 0.72 mm (±0.96) with a range of –1.7 mm to +3.1 mm. There was an increase in 80 persons, a decrease in 2, and remained unchanged in 5.

Table III. Arch dimensional changes after lingual arch therapy

	Change (mm)	*Significance*
Arch length (N = 107)	0.44 ± 1.35	*P* < .01
Intercanine width (N = 51)	1.49 ± 1.76	*P* < .01
Interpremolar width (N = 98)	2.27 ± 1.74	*P* < .01
Intermolar width (N = 107)	0.72 ± 0.96	*P* < .01

Table IV. Leeway space

	Leeway space
N = 44	4.44 ± 2.05

Leeway Space (Table III)

The leeway space, which was calculated on only 44 of the 107 patients because of missing primary canines was 4.44 mm (±2.05) with a range of –1.1 mm to 10 mm (Table IV).

Correlations

The change in crowding was weakly correlated to the change in arch length (r = 0.41), the change in intercanine dimension (r = 0.25), and the leeway space (r = 0.44) (Table V).

The multiple regression analysis, which assessed the degree to which these factors were related to the change in crowding, indicated that the leeway space was most prominently related to the change in crowding, accounting for 35% of the variability (Table VI).

DISCUSSION

The lingual arch appliances used in the 107 patients with lower incisor crowding were effective in maintaining arch length throughout the transition from the mixed to the permanent dentition. Arch length loss was only 0.4 mm and the leeway space was essentially preserved. This observation is similar to the findings of DeBaets and Chiarini[4] who inserted passive lingual

Table V. Correlations (r) between dimensional changes and changes in TSASD

Parameter	"r"	Significance
Arch length	.41	$P < .0001$
Intercanine width	.25	$P < .05$
Interpremolar width	.13	NS
Intermolar width	–.03	NS
Leeway space	.44	$P < .0001$

Table VI. Multiple regression analysis for the relationship between dimensional changes and changes in TSASD

Parameter	Partial R^2	Cumulative % of variability
Leeway space	0.35	0.35
Arch length	0.13	0.48
Intercanine width	0.09	0.57

arches in 38 patients and noted an average decrease in total arch length of –0.5 mm that they attributed to lingual tipping of the incisors. Rebellato et al[6] also recorded a decrease in both total arch length of –0.07 mm and arch depth of –0.37 mm after passive lingual arch therapy. Singer,[3] on the other hand, reported a slight increase of 0.2 mm as a result of the distal movement of the molars after lingual arch placement. The reason for these small differences between the various investigations may reflect minor differences in appliance design/fabrication and insertion.

After lingual arch therapy, adequate space to resolve incisor crowding was available in 60% of the 107 patients with an average of 4.85 mm of crowding at the start of treatment. Interestingly, this percentage would be improved to 68% if perfect arch length preservation occurred because approximately 0.5 mm additional space would be available for alignment. This finding is remarkably consistent with the observations of DeBaets and Chiarini[4] who noted that sufficient space to resolve incisor crowding was available after lingual arch therapy in 70% of the patients in their sample. Similarly, Arnold[7] indicated that leeway space preservation would provide ample space for alignment in 72% of patients with an average of 4.5 mm of incisor crowding.

The lingual arches were designed to be passive with the intent of preserving arch length by avoiding the expected mesial movement of the permanent molars and/or lingual tipping of the incisors during the transition from the mixed to the permanent dentition. However, only 6 of the 107 patients demonstrated no change in arch length. Although the average change in total arch length was an inconsequential –0.44 mm, arch length decreased in 59 patients and increased in 42. Most of these changes were less than 0.5 mm, although some were surprisingly large. In one subject, there was a loss of –4.79 mm; in another, there was a gain of +2.9 mm. The reason for this high range is unclear. It may reflect changes in incisor and molar position that accompany facial growth[8] or distortion of the appliance. From a clinical perspective, these unexpected changes in arch length indicate that passive lingual arch therapy may lead to unanticipated results in individual patients. This observation is consistent with the findings of Sampson and Richards[9] who noted that spontaneous changes in arch dimension in the transitional dentition were one factor that made prediction of incisor crowding in the permanent dentition difficult.

The intercanine dimension increased a mean of 1.49 mm in the present group of patients. Similarly, DeBaets and Chiarini[4] noted a 1.1 mm increase in the intercanine dimension after lingual arch therapy. They attributed this increase to the lateral migration of the canines as they drifted into the leeway space. Singer,[3] on the other hand, found only a 0.5 increase in intercanine width after lingual arch placement.

The increase in intercanine width noted in this investigation is approximately 1 to 1.5 mm greater than the observations of others who evaluated the developmental changes in arch dimension. For example, in untreated "normal" occlusions, Moorrees and Chada[2] found that the intercanine dimension was stable after the eruption of the incisors, whereas Bishara et al[10] recorded only a 0.5 mm increase as the permanent canines erupted. Although disto-lateral migration of the canines as they moved into the leeway space, as noted by DeBaets and Chiarini,[4] may be one reason for these different findings, another factor could be the amount of incisor crowding present in the various groups of subjects. In the present sample, there was an average of 4.85 mm of incisor crowding, whereas the incisor crowding in the individuals evaluated by Moorrees and Chada[2] was only 1 to 2 mm. This raises the possibility that larger amounts of crowding may "force" the canines more laterally and result in larger increases in intercanine dimension.

The interpremolar and intermolar widths also increased after lingual arch placement. The interpremolar width increase was anticipated because increases in the interpremolar width normally occur throughout dental development as the premolars replace the primary molars.[2,10] Moyers et al[1] suggested that this increase is due to the fact that the premolar crown buds lie slightly buccal to the primary molar roots. The +0.7 mm increase in intermolar width was unexpected because a passive lingual arch was in place. Singer[3] and Rebellato et al[6] also reported a 1 mm increase in intermolar width during similar passive lingual arch treatment. These changes mirror the normal intermolar width increase of approximately 1 mm observed during the transitional dentition stage.[10] This suggests that the forces that account for the normal increase in intermolar dimension are stronger than the "restraining" effects of the lingual arch.

The 4.44 mm average leeway space found in these patients was similar to the 4.8 mm reported by Moyers et al.[1] After space maintenance, the mean amount of space available to resolve crowding was 4.9 mm. As anticipated, the 4.44 mm of leeway space closely approximated the amount of space available for the resolution of crowding. However, when the relationship between leeway space and change in crowding was evaluated by means of a multiple regression analysis, the leeway space accounted for only 35% of the change in crowding. This was contrary to our expectations, although it helps explain why space was available to resolve 4.8 mm of incisor crowding in 1 patient even though the leeway space was only 2.5 mm. Clearly, there was not a strong relationship between these 2 variables. The weak association between leeway space and change in crowding also indicates that other factors including dimensional changes occurring between T1 and T2 have an influence on the amount of crowding in the arch. For example, the change in arch length and intercanine width were also correlated, although weakly, to the change in crowding. This indicates that an increase in these dimensions would provide some space to resolve crowding. However, both the low correlations and the small changes in these dimensions mean that they would not make a substantial contribution.

Because arch length preservation by a simple passive appliance, such as a lingual arch, along with other developmental changes in the transitional dentition, can provide adequate space to correct 4 to 5 mm of crowding in the majority of persons, the clinician has an opportunity with minimal intervention to correct crowding as long as arch length is preserved. This places the focus of the timing of treatment for the resolution of crowding on the terminal phase of the late mixed dentition because the changes that appreciably affect arch dimensions normally occur at this time. One major exception is the early loss of the primary canines, which as indicated previously, requires immediate intervention to control both arch length and symmetry. Under these conditions, the opposite canine is removed and a lingual arch inserted as soon as possible.

Treatment to preserve the leeway space is indeed necessary to use this space effectively to resolve crowding. A number of investigators[1,6,11,12] indicated that the leeway space is not normally used for resolution of incisor crowding in untreated dentitions because of the rapid decrease in arch length and arch depth that occurs after the exfoliation of the primary second molars. Sinclair and Little[12] found essentially no change in incisor crowding throughout the transition from mixed to permanent dentition in untreated individuals, whereas others[13,14] reported increases in incisor crowding.

In addition, the stability of the lower incisors after passive lingual arch therapy appears satisfactory. For example, Dugoni et al[5] indicated that lower incisor alignment of 76% of patients treated successfully with only a lingual arch in the mixed dentition were considered stable 9 years postretention. Also, the average amount of irregularity index (2.65) in this group of patients was one of the lowest ever recorded many years after retention. (Interproximal reduction and gingival fiberotomies were done on some of these patients.) In sharp contrast, the postretention irregularity index of the lower incisors in patients with arch lengths that were expanded more than 1 mm (0.5 mm/side) was 6.06 or more than twice that noted in patients treated with passive lingual arches.[15] This comparison suggests that the more appropriate treatment for crowding in the mixed dentition may be arch length preservation, particularly because it provides the space to correct crowding in the majority of patients.

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