European Journal of Orthodontics 33 (2011) 37–42
doi:10.1093/ejo/cjq022
Advance Access Publication 25 July 2010

Effectiveness of a lower lingual arch as a space holding device

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SUMMARY The aims of this study were to evaluate the effectiveness of a lower lingual holding arch (LLHA) in maintaining arch length, and to compare the effectiveness of two LLHAs made of two different gauges (0.9 and 1.25 mm) of stainless steel (SS) wire.

The sample comprised 44 subjects (24 males and 20 females) who for various reasons attended orthodontic clinics at Jordan University of Science and Technology Dental Teaching Center. The subjects were randomly divided into two treatment groups. The first group contained 20 subjects (12 males/8 females, average age 10.76 ± 0.75 years). The LLHA used in this group was made of 0.9 mm SS wire. The second group comprised 24 subjects (12 males/12 females, average age 10.57 ± 0.54 years). The LLHA used in this group was made of 1.25 mm SS wire. The third group consisted of 23 subjects (15 males/8 females, average age 10.63 ± 0.66 years) who served as the control. The records consisted of lateral cephalograms, dental pantomograms, and study casts. Paired *t*-test, analysis of variance, and chi-square tests were used to determine whether significant differences existed between the groups.

In both treatment groups, the lower incisors proclined and moved forward, and space loss of the lower primary second molar occurred. The LLHA made of 0.9 mm SS was superior to that made of 1.25 mm SS in terms of arch length preservation.

Introduction

Arch length deficiency as a result of early loss of primary teeth may lead to the development of crowding, impaction, and irregularity of the permanent dentition (Brothwell, 1997). Early loss of the primary second molars had the greatest effect on dental arch length and resulted in 2–4 mm of space closure per quadrant in both arches. The greatest space loss has been attributed to mesial movement of the permanent molars (Northway *et al.*, 1984). In preventive and interceptive orthodontics, the use of a lower lingual arch is a widely accepted procedure. A lingual arch has been used to maintain arch length by preventing mesial movement of the molars and lingual collapse of the lower incisors (Gianelly, 1995). That author recommended the use of a lower lingual holding device utilizing the leeway space to resolve mild lower arch crowding. Moyers *et al.* (1976) suggested that as much as 4.8 mm of space can become available as the permanent canines and premolars replace their primary successors. Brennan and Gianelly (2000) studied the efficiency of a lower lingual arch in the mixed dentition stage to preserve arch length. They concluded that preservation of arch length using a lingual arch resolved crowding in 68 per cent of subjects. Rebellato *et al.* (1997) investigated the efficiency of a lower lingual arch in preventing mesial migration of the first permanent molars. They reported that the lingual arch reduced arch perimeter loss but at the expense of mandibular incisor proclination. Villalobos *et al.* (2000) treated 32 patients with a lower lingual arch to control arch perimeter. They concluded that the lingual arch is an effective appliance for preserving arch length.

Despite its widespread use, comparatively little is known concerning the efficiency of a lower lingual holding arch (LLHA) as a space holding device and its effect on the dimensions of the lower arch. The purposes of this investigation were to evaluate the effectiveness of the LLHA in maintaining arch dimensions, and to compare the effectiveness of two LLHAs made of two different gauges (0.9 and 1.25 mm) of stainless steel (SS) wire.

Subjects and methods

The sample comprised 67 subjects (39 males and 28 females) who for various reasons attended orthodontic clinics at Jordan University of Science and Technology Dental Teaching Center (JUST). Space maintainers were inserted in 53 subjects, 7 failed to attend future appointments and 2 lost their appliances and refused replacements. These nine subjects were excluded from the study. The subjects selected to participate in this study fulfilled the following criteria:

1. Mixed dentition stage
2. Class I or mild Class II skeletal pattern (ANB ≤5 degrees)
3. Mild lower arch crowding (less than 2 mm)
4. Normal or increased overbite
5. One or both mandibular primary second molars indicated for extraction
6. Average maxillary mandibular angle 27 ± 5 degrees
7. No congenitally or prematurely missing teeth

The subjects were randomly assigned to one of two groups by a dental nurse. A list of eligible patients was prepared and each name was given a number. Group allocation was undertaken by choosing odd numbers for group 1 and even numbers for group 2. Group 1 consisted of 20 subjects (12 males and 8 females), average age 10.76 ± 0.75 years. The LLHA used in this group was made of 0.9 mm SS wire. Group 2 comprised 24 subjects (12 males and 12 females), average age 10.57 ± 0.54 years. The LLHA used in this group was made of 1.25 mm SS wire. In both groups, the wire contacted the cingulae of the lower incisors and was soldered to the lingual surfaces of the lower first molar bands (Victory Series™ Standard Contoured Plane Molar Band; 3M, Monrovia, California, USA) and cemented with glass ionomer cement (Ketac™ Cem Easymix; 3M Espe, Landshut, Germany). A third group, which served as the controls, consisted of 23 subjects (15 males and 8 females), average age 10.63 ± 0.66 years. The subjects in this group had attended the JUST Dental Center for treatment and for whom full records were available. This group received no treatment.

Treatment involved placement of a LLHA followed by extraction of one or both primary second molar as indicated. Written consent was obtained from parents or legal guardians in order to undergo treatment. Ethical approval for this study was provided by the JUST Institutional Research Board. All patients were observed monthly. Any problem with the appliance (band, wire, or solder breakage, and cement failure or loss) was recorded and corrected within 24 hours of the occurrence. Patients who lost their appliances were excluded from the study.

The material for this study consisted of the pre-treatment (T1) lateral caphalograms, dental pantomograms (DPTs), and study models. Six months (T2) records (for the treatment groups) consisted of study casts only. End of treatment (T3) records were taken after the second premolars were at least 90 per cent erupted. The mean observation periods averaged 1.40 ± 0.23, 1.28 ± 0.12, and 2.42 ± 0.63 years in groups 1, 2, and 3, respectively.

Lateral cephalograms were taken for each participant in centric occlusion with the lips in repose and the Frankfort plane horizontal, according to the natural head position, using an Orthoslice 1000 C (Trophy, Marne La Vallee, France) cephalostat at 64 kV, 16 mA, and 0.64 seconds exposure according to the standard Broadbent technique (Broadbent, 1931). DPTs were taken for each participant with the upper and lower incisors in an edge-to-edge relationship using an Orthoslice 1000 C (Trophy) cephalostat at 64 kV and 16 mA.

Lateral skull radiographs and DPTs were traced manually in a darkened room by the same investigator (MER) on acetate tracing paper using a 0.3 mm HB mechanical pencil. During tracing, the radiographs were mounted on a viewing box and the margins of each radiograph were masked to exclude unwanted light. Thirteen hard tissue cephalometric points and three cephalometric planes yielding one linear and seven angular measurements were registered (Figure 1). From DPTs, the angulation of each lower first permanent molar (that was adjacent to an extracted primary second molar) in relation to the mandibular plane was recorded. This was performed by measuring the angulation of a line passing between the bifurcation of a lower first permanent molar and its central fossa with respect to a tangent constructed on the inferior mandibular border (Figure 2). The angular measurements were performed utilizing a protractor to the nearest 0.5 degrees, and the linear measurements using a ruler to the nearest 0.5 mm.

Alginate impressions for each subject, together with a wax bite, were taken and poured within 1 hour (Elite model; Zhermack dental stone, Rovigo, Italy; water:powder ratio 30:100) by an orthodontic technician. The following dental arch measurements were carried

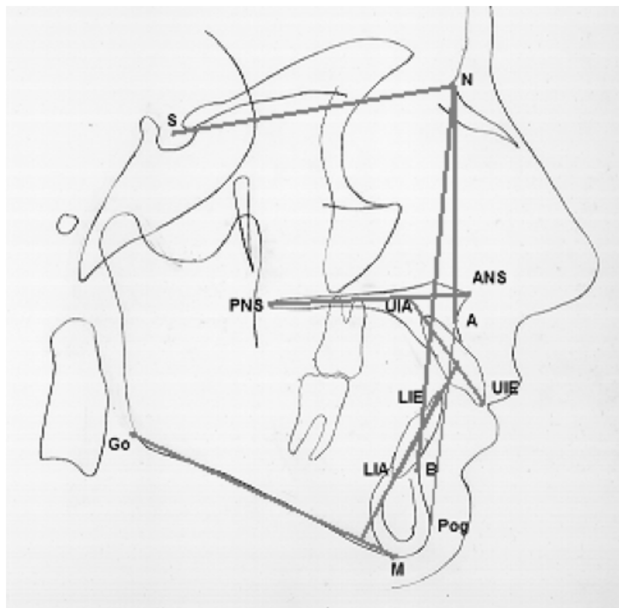

Figure 1 Cephalometric points and planes used in the analysis: S, sella; N, nasion; ANS, anterior nasal spine; PNS, posterior nasal spine; point A; point B; Pog, pogonion; Me, menton; Go, gonion; UIE, midpoint of the upper central incisor edge; UIA, apex of the upper incisor; LIE, midpoint of lower central incisor edge; and LIA, apex of lower central incisor.

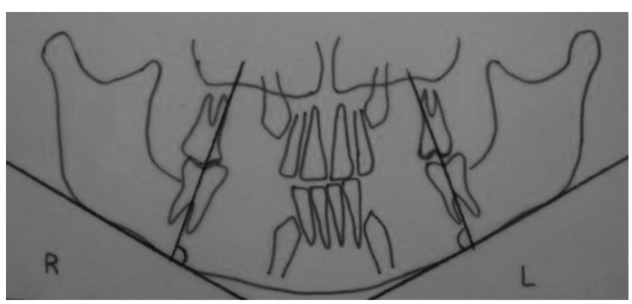

Figure 2 Lower molar angulation to the mandibular plane

out with a Boley calliper gauge and recorded to the nearest 0.5 mm.

Arch length: the combined distance between the mesial anatomic contact points of the lower permanent right and left first molars to the contact point between the lower permanent central incisors.
Arch depth: the distance from a point bisecting the mesial anatomic contact points of the first permanent molars to the contact point of the permanent central incisors.
Intercanine width: the distance between the primary canine cusp tips or estimated cusp tips if wear facets were present.
Intermolar width: the distance between the central fossae of the left and right permanent first molars.
Lower second primary molar extraction space: the distance between the mesial aspect of the lower first permanent molar and the distal aspect of the first primary molar.

Problems occurring during treatment period were recorded and dealt with as appropriate. The patient's guardians were instructed to contact immediately a problem was noticed. All problems were rectified within 24 hours from their occurrence. Only subjects who lost their appliances were excluded from the study. The problems are listed below.

Cement failure: unilateral or bilateral decementation of LLHA band resulting in its loosening. Corrected by recementation;
Band breakage: vertical tearing of the band resulting in a broken band circumference resolved by remaking of the appliance;
Solder breakage: detachment of the wire from the lingual surface of the band. Both intact but with a welding failure. Corrected by remaking;
Wire breakage: a cut in the wire that occurred just anterior to the solder. In such a case, the appliance was remade; and
Loss: cement failure of the appliance, and its removal by the patient or guardian indicated a lack of cooperation and the patient was excluded.

Statistical analysis

Data analysis was carried out using the Statistical Package for Social Science version 15 (SPSS Inc.®, Chicago, Illinois, USA). Descriptive data were tabulated. A paired *t*-test was used to identify changes in cephalometric, DPT, and study cast variables between T1 and T2. In addition, analysis of variance was used to determine whether significant differences existed between the groups. Bonferroni multiple comparison test was used to identify differences between the groups. A chi-square test was applied to identify differences between the treatment groups with respect to problems during the observation period. The level of significance was set at $P < 0.05$.

Method error

All measurements of 10 randomly chosen cases were duplicated by the same examiner 3 days apart. Dahlberg's (1940) formula was used to calculate the standard error of the method ($\sqrt{\sum D^2/2n}$) and the coefficient of reliability (Houston, 1983) were calculated. Dahlberg error ranged from 0.19 to 0.42 for linear measurements and from 0.34 to 0.42 degrees for the angular measurements. The coefficient of reliability was above 90 per cent for all measured variables.

Results

The means, standard deviations, and mean differences for the variables studied are shown in Tables 1–3.

Table 1 Means, standard deviations (SD), and differences between means (MD) for the radiographic variables measured at the beginning (T1) and end (T3) of treatment for all groups

	Group 1 (0.9 mm SS)			Group 2 (1.25 mm SS)			Control		
	T1, mean ± SD	T3, mean ± SD	MD	T1, mean ± SD	T3, mean ± SD	MD	T1, mean ± SD	T3, mean ± SD	MD
Lateral cephalogram									
SNA	80.13 ± 3.69	81.30 ± 4.28	−1.17	79.36 ± 3.35	79.98 ± 4.74	−0.62	79.48 ± 4.35	79.95 ± 4.13	−0.48
SNB	76.30 ± 3.56	77.03 ± 3.99	−0.73	75.48 ± 3.22	76.43 ± 3.87	−0.95	74.86 ± 4.41	75.43 ± 4.53	−0.57
ANB	3.83 ± 1.81	4.23 ± 1.92	−0.40	3.88 ± 1.72	3.57 ± 2.16	0.31	4.62 ± 1.57	4.52 ± 1.54	0.10
UI–Max	112.13 ± 5.23	112.03 ± 6.81	0.10	111.38 ± 4.57	111.81 ± 5.70	−0.43	111.31 ± 5.95	111.24 ± 5.34	0.07
LI–Mand	93.50 ± 4.67	98.00 ± 5.72	−4.50***	94.36 ± 6.61	97.71 ± 7.96	−3.36**	95.05 ± 6.94	94.81 ± 5.61	0.24
UI–LI	124.00 ± 6.53	119.57 ± 8.03	4.43**	123.81 ± 6.85	120.33 ± 8.22	3.48***	122.69 ± 9.88	122.98 ± 8.55	−0.29
LI–A-Pog (mm)	3.23 ± 1.87	3.93 ± 1.63	−0.70**	2.86 ± 2.23	4.05 ± 2.02	−1.19***	2.43 ± 2.57	3.10 ± 2.63	−0.67**
Max–Mand	30.80 ± 4.21	30.97 ± 4.34	−0.17	30.79 ± 4.59	30.81 ± 5.15	−0.02	31.67 ± 5.17	31.31 ± 4.99	0.36
Dental pantomograph									
Li–mandibular plane	99.11 ± 5.77	100.70 ± 7.61	−1.59	94.23 ± 4.41	94.73 ± 4.51	−0.50	98.35 ± 6.54	99.68 ± 6.35	−1.33*

$^*P \le 0.05$, $^{**}P \le 0.01$, $^{***}P \le 0.001$

Table 2 Means, standard deviations (SD), and differences between means (MD) for the variables measured from dental casts at the beginning (T1) after 6 months (T2) and at the end (T3) of treatment for all groups

Variable	T1, mean ± SD	T2, mean ± SD	T3, mean ± SD	T1–T2, MD	T2–T3, MD	T1–T3, MD
Group 1 (0.9 mm stainless steel)						
Arch length (mm)	68.47 ± 3.61	68.50 ± 3.48	69.00 ± 3.47	−0.03	−0.50	−0.53
Arch depth (mm)	24.26 ± 2.02	24.32 ± 1.76	24.18 ± 2.81	−0.06	−0.15	0.09
Intercanine width (mm)	27.00 ± 1.87	27.35 ± 1.77	27.80 ± 1.87	−0.35	−0.45	−0.80
Intermolar width (mm)	41.27 ± 2.31	42.07 ± 1.89	41.47 ± 2.00	−0.80***	0.60	−0.20
E extraction space (mm)	18.32 ± 3.39	17.46 ± 3.70	16.84 ± 3.68	0.86***	0.61	1.48***
Group 2 (1.25 mm stainless steel)						
Arch length (mm)	67.90 ± 2.83	66.76 ± 2.96	66.93 ± 3.11	1.14***	−0.17	0.98**
Arch depth (mm)	24.26 ± 1.82	24.05 ± 1.74	24.02 ± 1.62	0.21	0.02	0.24
Intercanine width (mm)	25.59 ± 1.86	26.35 ± 1.71	26.57 ± 2.05	−0.76***	−0.11	−1.00**
Intermolar width (mm)	39.78 ± 1.85	39.98 ± 1.60	39.68 ± 1.47	−0.20	0.30	0.10
Primary second premolar extraction space (mm)	17.32 ± 2.99	16.39 ± 3.09	15.79 ± 3.14	0.94***	0.60***	1.53***
Group 3 (control)						
Arch length (mm)	70.93 ± 3.53		71.09 ± 3.32			−0.16*
Arch depth (mm)	25.57 ± 1.92		25.80 ± 1.86			−0.23
Intercanine width (mm)	26.08 ± 1.89		26.38 ± 2.00			−0.44**
Intermolar width (mm)	41.22 ± 2.34		41.05 ± 2.39			0.18

*$P \leq 0.05$, **$P \leq 0.01$, ***$P \leq 0.001$.

Table 3 Differences between the means from the beginning (T1) to the end (T3) of treatment (MD 1–3), standard errors of the mean (SE) and differences between means (MD) of the different groups

Variable	Group 1 (G1), MD 1–3 ± SE	Group 2 (G2), MD 1–3 ± SE	Group 3 (G3), MD 1–3 ± SE	G1–2, MD	G1–3, MD	G2–3, MD
Lateral cephalogram						
Difference Li–Mand	4.50 ± 0.77	3.36 ± 1.07	−0.24 ± 0.82	1.14	4.74**	3.60*
Difference Li–A-Pog	0.70 ± 0.23	1.19 ± 0.29	0.67 ± 0.16	−0.49	0.03	0.52
Dental pantomograms						
LM1–Mand	1.59 ± 1.50	0.50 ± 0.82	1.33 ± 0.64	1.09	0.26	−0.83
Study cast						
Arch length	0.53 ± 0.73	−0.98 ± 0.28	0.16 ± 0.33	1.51	0.37	−1.14
Arch depth	−0.09 ± 0.52	−0.24 ± 0.15	0.23 ± 0.18	0.15	−0.32	−0.47
Intercanine width	0.80 ± 0.63	0.82 ± 0.26	0.44 ± 0.13	−0.02	0.36	00.38
Intermolar width	0.20 ± 0.29	−0.10 ± 0.32	−0.18 ± 0.14	0.30	0.38	0.08
Primary second premolar extraction space	−1.48 ± 0.17	−1.53 ± 0.18		0.05		

*$P \leq 0.05$, **$P \leq 0.01$.

After 6 months

Only study cast measurements were evaluated at T2. In group 1 (0.9 mm LLHA), intermolar width increased ($P \leq 0.001$) and the primary second premolar extraction space reduced ($P \leq 0.01$). In group 2 (1.25 mm LLHA), arch length reduced ($P \leq 0.001$), intercanine width increased ($P \leq 0.001$), and the primary second premolar extraction space reduced ($P \leq 0.001$).

Overall effect

Lower incisor inclination to the mandibular plane (Li–Mand) was increased in groups 1 and 2 ($P \leq 0.001$ and $P \leq 0.01$, respectively). No significant differences between the two treatment groups were observed. However, significant differences were found when groups 1 and 2 were compared with the controls ($P \leq 0.01$ and $P \leq 0.05$, respectively).

The distance of the lower incisor edge to the A-Pogonion line (Li–A-Pog) increased in both treatment groups with a mean difference of 0.70 mm ($P \leq 0.01$) and 1.19 mm ($P \leq 0.001$) in groups 1 and 2, respectively. No significant differences between any of the studied groups were found. Lower molar angulation to the mandibular plane (LM1–Mand) increased in all groups. However, significance was only reached in the control group.

The second primary molar extraction space loss continued during T1–T2 in both treatment groups but reached significance only in group 2 ($P \leq 0.001$). Overall (T1–T3), second primary molar extraction space loss of 1.48 mm occurred ($P \leq 0.001$) in group 1 compared with 1.53 mm in group 2 ($P \leq 0.001$). In addition to space loss in group 2, arch length reduced ($P \leq 0.01$) and intercanine width increased ($P \leq 0.01$). The differences between the groups were not significant.

Cement failure and loosening of the LLHA was found to occur more frequently in group 2 compared with group 1 ($P \leq 0.001$) (Table 4).

Discussion

A lower lingual arch is usually recommended as a holding device to maintain mandibular arch length and to prevent mesial migration of the mandibular first molars (Gianelly, 1995). Despite its widespread use, comparatively little is known about the effect of a LLHA on preserving lower arch dimensions, tooth position, and the efficiency of this device in preserving the space of lost primary teeth (Gianelly, 1995; Rebellato *et al.*, 1997).

The subjects who participated in this study were in the late mixed dentition period. Exfoliation of the mandibular primary molars is usually expected within this dental age, so space preservation becomes more critical if leeway space utilization is planned to resolve expected crowding (Brennan and Gianelly, 2000). Also, more cooperation was expected from the patients in terms of oral hygiene care during this age (McDonald and Avery, 1987).

Lower first molar angulation was measured using DPTs. It has been shown that comparing linear and angular measurements on DPTs is sufficiently accurate provided that the occlusal plane is kept at a similar angulation (Stramotas *et al.*, 2002).

The LLHA used in both treatment groups tended to cause proclination of Li–Mand and forward movement of the lower incisors relative to the A-Pog line (Li–A-Pog). The change in the position of Li to the A-Pog line in the control group may be explained as a consequence of normal mandibular growth (Björk and Skieller, 1972). This finding is in agreement with Rebellato *et al.* (1997), who reported that the lingual arch can reduce arch perimeter loss, but at the expense of mandibular incisor proclination. These authors inserted lower lingual arches in 14 patients who were observed for 10.5 months. They noted average forward tipping of the lower incisors of 0.73 degrees. On the other hand, Villalobos *et al.* (2000) studied the effect of a lower lingual arch on 23 patients with a mean age of 10.4 ± 0.6 years. They reported backward tipping of the lower incisors of 0.51 degrees during the study period of 18 months.

Table 4 Types of problems and their frequencies in the treatment groups

Problem	Group 1 (0.9 mm stainless steel lower lingual holding arch) frequency	Group 2 (1.25 mm stainless steel lower lingual holding arch) frequency	χ^2	*P* value
Cement failure	7	21	17.70	***
Band breakage	4	5	0.191	0.473
Solder breakage	1	1	0.001	0.745
Wire breakage	2	0	2.002	0.255
Loss	3	0	3.06	0.125

***$P \leq 0.001$.

No significant effect was observed on the angulation of the lower first permanent molar in relation to the mandibular plane as a result of the LLHA. Distal tipping was found in all groups, including the controls. However, less distal tipping was observed in group 2 (1.25 mm SS LLHA). This finding regarding the effect of a LLHA on lower first molar angulation is in agreement with those reported by others (Rebellato *et al.*, 1997; Villalobos *et al.*, 2000). Rebellato *et al.* (1997) recorded significant lower molar backward tipping of 0.54 degrees in 14 patients treated with lower lingual arches for 10.5 months. Their control group, which contained 16 children, showed significant forward tipping of the lower molar of 2.19 degrees. Villalobos *et al.* (2000) observed significant lower molar backward tipping of 0.54 degrees in 23 patients with lower lingual arches during a study period, which lasted 18 months. The control group in their study ($n = 24$) showed significant forward tipping of the lower molar forward tipping of 2.10 degrees at 12 months and 2.68 degrees at 24 months. However, the first molars in the control group in the present study moved distally, which is contrary to the control groups of the above studies.

The LLHA used in both treatment groups preserved arch length throughout the study duration. There was arch length gain of 0.53 mm in group 1 and arch length loss of 0.98 mm in group 2. The reduction in arch length observed in group 2 is in agreement with the observations of DeBaets and Chiarini (1995) and Brennan and Gianelly (2000). DeBaets and Chiarini (1995) used lower lingual arches made of 0.9 mm SS wire in 38 children and observed an average reduction in total arch length of 0.5 mm, which was attributed to lingual tipping of the lower incisors. Brennan and Gianelly (2000) inserted 107 lower lingual arches made of 0.9 mm SS wire and reported a reduction of 0.4 mm in total arch length. On the other hand, the increase in arch length observed in group 1 is in agreement with the observations of Singer (1974) and Rebellato *et al.* (1997). Singer (1974) noticed a slight increase in arch length of 0.2 mm as a result of distal movement of the molars after lingual arch insertion (0.9 mm SS). An increase in total arch length of 0.07 mm was recorded by Rebellato *et al.* (1997) as a result of lower incisor proclination.

There was an overall increase of 0.80 and 1.00 mm in intercanine width in groups 1 and 2, respectively. This finding is in agreement with others. DeBaets and Chiarini (1995) reported a 1.1 mm increase in intercanine width with the use of a lower lingual arch. They believed that this increase was due to lateral migration of the canines as they drifted into the leeway space. Brennan and Gianelly (2000) reported a 1.5 mm increase in intercanine dimension in patients treated with a lower lingual arch.

The lower primary second molar extraction space was noticeably decreased in both treatment groups; 1.48 and 1.53 mm in groups 1 and 2, respectively. Although the lower second primary molars were extracted after the LLHAs were inserted, a significant decrease in the extraction spaces was observed in both treatment groups.

In both treatment groups, the lower incisors proclined and the lower second primary molar extraction spaces reduced, although the lower first permanent molars did not show any significant change in their angulation. These changes were more pronounced in subjects treated with an LLHA made of 1.25 mm SS wire. This may be attributed to the mesial component of the occlusal forces as described by several investigators (Southard *et al.*, 1989, 1990a,b; Acar *et al.*, 2002). As the gauge of the LLHA wire increased, the forces on the lower incisors and first molars increased, resulting in more proclination and lower second primary molar extraction space loss.

The 1.25 mm LLHA subjects (group 2) had more problems than the 0.9 mm LLHA subjects (group 1). Group 2 subjects showed 21 cement failures, 5 band breakages, and 1 solder breakage. The stiffness of the 1.25 mm SS wire may explain the occurrence of such problems. On the other hand, group 1 subjects showed seven cement failures, four band breakage, one solder breakage, two wire breakages, and three complete losses. The problems associated with the 0.9 mm LLHA are similar to those found by other investigators (Qudeimat and Fayle, 1998; Rajab, 2002; Moore and Kennedy, 2006; Fathian *et al.*, 2007) who studied problems associated with an LLHA of the same wire gauge.

Conclusions

1. LLHAs made of 0.9 mm SS wire were superior in terms of arch length preservation.
2. Arch length preservation occurred at the expense of mandibular incisor proclination with both types of LLHA
3. The lower first molars did not show a significant change in their angulation in relation to the mandibular plane.
4. Lower second primary molar extraction space was reduced in both treatment groups.
5. Cement failure was seen more frequently with the 1.25 mm LLHA.

Funding

Deanship of Research, Jordan University of Science and Technology (20/2006).

References

Acar A, Alcan T, Erverdi N 2002 Evaluation of the relationship between the anterior component of occlusal force and postretention crowding. American Journal of Orthodontics and Dentofacial Orthopedics 122: 366–370

Björk A, Skieller V 1972 Facial development and tooth development: an implant study at the age of puberty. American Journal of Orthodontics 62: 339–383

Brennan M M, Gianelly A A 2000 The use of the lingual arch in the mixed dentition to resolve incisor crowding. American Journal of Orthodontics and Dentofacial Orthopedics 117: 81–85

Broadbent B H 1931 A new X-ray technique and its application to orthodontia. Angle Orthodontist 1: 45–66

Brothwell D J 1997 Guidelines on the use of space maintainers following premature loss of primary teeth. Journal of the Canadian Dental Association 63: 753–766

Dahlberg G 1940 Statistical methods for medical and biological students. Interscience Publications, New York, pp. 122–132

DeBaets J, Chiarini M 1995 The pseudo Class I: a newly defined type of malocclusion. Journal of Clinical Orthodontics 29: 73–87

Fathian M, Kennedy D B, Nouri M R 2007 Laboratory-made space maintainers: a 7-year retrospective study from private pediatric dental practice. Pediatric Dentistry 29: 500–506

Gianelly A A 1995 Leeway space and the resolution of crowding in the mixed dentition. Seminars in Orthodontics 1: 188–194

Houston W J B 1983 The analysis of errors in orthodontic measurements. American Journal of Orthodontics 83: 382–390

McDonald E, Avery D R 1987 Dentistry for the child and adolescent. 5th edn. C V Mosby Co, St. Louis, pp. 451–452

Moore T R, Kennedy D B 2006 Bilateral space maintainers: a 7-year retrospective study from private practice. Pediatric Dentistry 28: 499–505

Moyers R E, van der Linden F P, Riolo M L 1976 Standards of human occlusal development. Monograph No. 5 Craniofacial Growth Series. Center for Human Growth Development, University of Michigan, Ann Harbor

Northway W M, Wainright R L, Demirjian A 1984 Effects of premature loss of deciduous molars. Angle Orthodontist 54: 295–329

Qudeimat M A, Fayle S A 1998 The longevity of space maintainers: a retrospective study. Pediatric Dentistry 20: 267–272

Rajab L D 2002 Clinical performance and survival of space maintainers: evaluation over a period of 5 years. Journal of Dentistry for Children 69: 156–160

Rebellato J, Lindauer S T, Rubenstein L K, Isaacson R J, Davidovich M, Vroom K 1997 Lower arch perimeter preservation using the lingual arch. American Journal of Orthodontics and Dentofacial Orthopedics 112: 449–453

Singer J 1974 The effect of the passive lingual arch on the lower denture. Angle Orthodontist 44: 146–155

Southard T E, Behrents R G, Tolley E A 1989 The anterior component of occlusal force. Part 1. Measurement and distribution. American Journal of Orthodontics and Dentofacial Orthopedics 96: 493–500

Southard T E, Behrents R G, Tolley E A 1990a The anterior component of occlusal force Part 2. Relationship with dental malalignment. American Journal of Orthodontics and Dentofacial Orthopedics 97: 41–44

Southard T E, Southard K A, Stiles R N 1990b Factors influencing the anterior component of occlusal force. Journal of Biomechanics 23: 1199–1208

Stramotas S, Geenty J P, Petocz P, Darendeliler M A 2002 Accuracy of linear and angular measurements on panoramic radiographs taken at various positions *in vitro*. European Journal of Orthodontics 24: 43–52

Villalobos F J, Sinha P K, Nanda R S 2000 Longitudinal assessment of vertical and sagittal control in the mandibular arch by the mandibular fixed lingual arch. American Journal of Orthodontics and Dentofacial Orthopedics 118: 366–370