

ORIGINAL RESEARCH

Maxillary Dental Arch changes following the Leveling and Alignment Stage with Lingual and Labial Orthodontic Appliances: A Preliminary Report of a Randomized Controlled Trial

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ABSTRACT

Background: No randomized controlled trial has tried to compare transverse dental arch changes between the lingual and labial orthodontic fixed appliances in the early stage of treatment.

Objective: To compare upper dental arch changes between lingual and labial fixed orthodontic appliances after leveling and alignment.

Design, setting: Parallel-groups randomized controlled trial on patients with class I moderate crowding teeth treated at the University of Al-Baath Dental School in Hamah, Syria.

Participants: About 102 patients with crowded teeth and class I malocclusion were evaluated and 58 patients fulfilled the inclusion criteria. Randomization was performed using computer generated tables; allocation was concealed using sequentially numbered opaque and sealed envelopes. About 52 participants were analyzed (mean age 21.5 ± 3.2 years). They were randomly distributed into two groups with 26 patients in each (1:1 allocation ratio).

Intervention: Lingual vs labial fixed orthodontic appliances were used.

Main outcome measure: Inter canine width, interpremolar width, intermolar width, and arch length were measured on study models before brackets' placement (T1), at the end of leveling and alignment stage (T2).

Results: Statistically significant increase was detected in the inter canine width in the lingual group (1.99 mm, $p < 0.001$) and in the labial group (1.22 mm, $p < 0.001$). The interpremolar width had a significant decrease in the lingual group (-0.70 mm, $p < 0.001$), whereas there was a significant increase in this width in the labial group (1.73 mm, $p < 0.001$). A significant decrease in intermolar width was detected in the lingual group (-0.79 mm, $p < 0.001$) whereas a significant increase was observed in the

labial group (0.81 mm, $p < 0.001$). The differences between the two groups were significant for all comparisons ($p < 0.001$).

Conclusion: The labial appliance produced a significant increase in all horizontal transverse arch dimensions, whereas in the lingual appliance group the inter canine width increased significantly in conjunction with a significant narrowing of posterior segments.

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Keywords: Lingual brackets, Labial brackets, Arch dimensions, Inter canine width, Intermolar width.

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INTRODUCTION

In the early 1980s, lingual orthodontics was introduced as a final esthetic solution for patients who seek invisible orthodontic treatment. However, after a period of clinical experience, the 'lingual orthodontic fever' began to diminish, because many orthodontists considered the lingual technique difficult to employ,^{1,2} more time consuming for both patients and orthodontists,³ and unable to meet the excellent outcomes that could be achieved by labial appliances.⁴ The development of new archwire materials, advanced laboratory techniques, and the widespread use of sophisticated computer programs have reintroduced lingual orthodontics once again as a promising and a competing technique.⁵⁻⁷

In comparison with the labial technique, the biomechanics of lingual orthodontics differ considerably from the labial one.⁸ Inter bracket distance on the lingual side is shorter than on the labial side requiring lighter force application for tooth movement,^{1,9-12} and generating more frictional forces between lingual brackets and the inserted archwire.¹³ Another important biomechanical issue between the two techniques is the bracket location; lingual brackets are

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positioned closer to the centers of resistance of the teeth than labial brackets in the sagittal plane,¹³ so whenever a specific amount of force is applied in both techniques, a different moment of force is generated.¹⁴

During the leveling and alignment stage, tooth movement is directly affected by many factors, such as inter-bracket distances,¹⁵ archwire selection^{15,16} and the friction generated between the bracket and the archwire.¹⁷ Since all these factors are different between the two techniques, various dental arch responses are expected. Some authors have postulated that the lingual appliance causes more remarkable dentoalveolar expansion than the labial counterpart,¹⁸ others argued that the expansive effect of the lingual appliance is a myth and a restrictive transverse effect is expected after treatment with lingual orthodontics.¹¹ It seems to be that all published papers about dimensional arch changes following lingual orthodontic treatment are dependent on clinical experience with no evidence-based conclusions.

The aim of the current randomized controlled trial (RCT) was to compare upper dental arch dimensional changes in the horizontal plane between lingual and labial fixed orthodontic appliances after completing the first stage of orthodontic treatment (i.e. leveling and aligning) in a sample of class I malocclusion patients treated on a nonextraction basis.

MATERIALS AND METHODS

Patients' Recruitment and Assignment

This research project was approved by University Al-Baath Dental School Ethics Committee (UBDS-2185-2010PG) and was funded by University of Al-Baath Postgraduate Research Budget. The following assumptions were used to calculate the required sample size:

1. The smallest difference requiring detection in the transverse arch dimensions changes was 1 mm.
2. The significance level of two-sided tests was set at 0.05.
3. The statistical power was set at 80%.
4. The standard deviation (SD) of the intermolar width was found to be 1.16 mm in a previous study.¹⁹
5. The intended inferential statistical approach was two-sample t-tests. The calculation revealed that a sample size of 23 patients was required for each group.

Prospective participants were derived from 720 patients' records in Orthodontic Department at University of Al-Baath Dental School referred between January 2010 and June 2011. One hundred and two patients with crowding of upper teeth as their chief complaint were recalled for further examination. After clinical, dental cast and radiographic assessments, 58 patients accurately met the inclusion criteria:

1. Class I division 1 malocclusion on a class I skeletal relationship (based on ANB angle between 2°-4°).

2. Moderate crowding in the anterior segment of the upper dental arch (3-5 mm tooth-size-arch-length-discrepancy) which could be treated on a nonextraction basis.
3. Age range: 15 to 30 years.
4. The presence of all permanent teeth with the exclusion of third molars.
5. No anterior crossbites.

One of the academic staff at the Department of Orthodontics (not involved in this research) performed a simple randomization. He created a randomization list using Minitab® V.15 with an allocation ratio of 1:1. The allocation sequence was concealed from the principal researcher (TK) enrolling and assessing participants in sequentially numbered opaque and sealed envelopes. To prevent subversion of the allocation sequence, the name and the date of birth of each participant was written on the envelope and these data were transferred onto the allocation card inside each envelope. Corresponding envelopes were opened only after completing all baseline assessments and the time came to allocate the intervention.

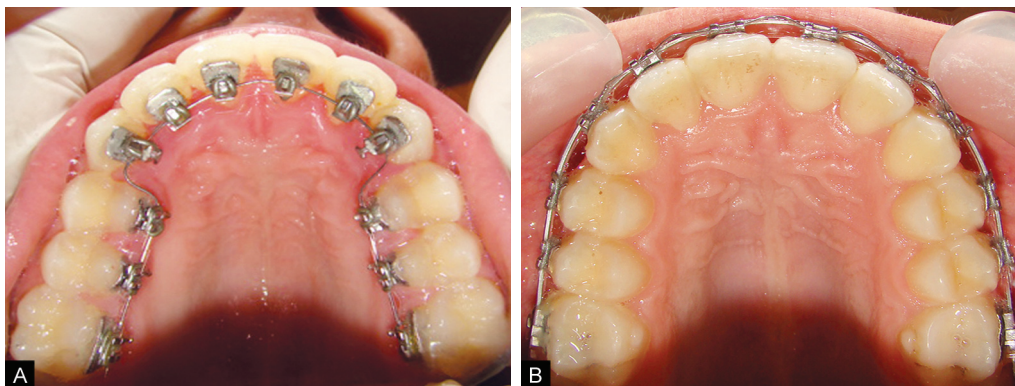
Lingual Appliance

Twenty-six patients in this group (15 females, 11 males; mean age 20.6 years; SD 2.9 years) were treated with lingual appliances (LI) (Stealth® 0.022" slot height, American Orthodontics®, Sheboygan, WI, USA). Lingual brackets were indirectly bonded in the upper arch only using the TARG+TR (Torque Angulation Reference Guide + Thickness and Rotation) System.²⁰ Roth™ perception values (in terms of tip and torque) were inserted into lingual brackets during laboratory procedure (Fig. 1A).

Individual lingual archwires (Forestadent®, Germany) were fabricated directly on the initial dental cast using a standardized arch form template (Template for Biolingual® arches, Forestadent®, Germany) with a prominence premolar offset only. Archwires sequence was 0.012" NiTi – 0.014" NiTi – 0.016" copper NiTi. All the archwires were fabricated precisely and individually by the same principal researcher (TK). Stealth® brackets did not have a built-in bite-plane, so bite rising in this group was achieved using 0.5 to 1.00 mm posterior bite-blocks (Resilience®, Ortho Technology, Florida, USA) bonded to the occlusal surfaces of the first lower molars.

LABIAL APPLIANCE

Twenty-six patients in this group (17 females, 9 males; mean age 21.8 years; SD 3.3 years) were treated with labial straight wire appliances (LA) (Mini-Master series brackets, Roth™ prescription, 0.022" slot height, American Orthodontics®, Sheboygan, WI, USA). Prefabricated archwires (Ormco,



Figs 1A and B: (A) Maxillary dental arch after leveling and alignment with the lingual appliance and (B) With the labial appliance

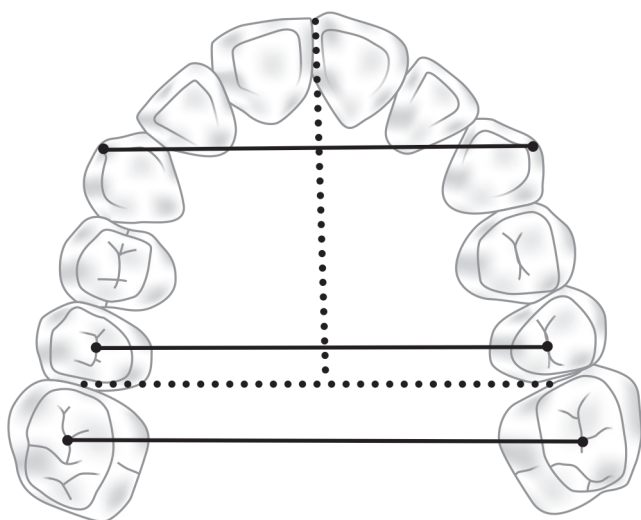


Fig. 2: Measurements used in the assessment of dental arch changes. Intercanine width: the distance between the tips of the cusps of the maxillary canines. Interpremolar width: the distance between the central fossa on the occlusal surfaces of the maxillary second premolars. Intermolar width: the distance between the mesial fossa on the occlusal surface of the maxillary first molars. Arch length: distance from a point midway between the facial surfaces of the central incisors to a line tangent to the mesial surfaces of the first permanent molars.

Sybron Dental Specialties, Orange, Calif) were used in the following sequence 0.012" NiTi – 0.014" NiTi – 0.016" copper NiTi. Lower arches were treated in both groups with labial fixed appliance (Fig. 1B).

Outcome Measures: Dental Casts' Analysis—Transverse Arch Dimensions

Dental casts of the maxillary dental arch were produced at the following assessment times such as immediately before treatment (T1), at the end of leveling and aligning phase (T2). The end point of leveling and alignment stage was identified as the ability to passively place a 0.016" × 0.022" SS archwire in the brackets' slots. The duration of leveling and alignment phase was on average 117 days in the LI group and 135 days in LA group. To avoid impression distortion upon removal from the oral cavity at T2, labial and lingual

brackets were carefully covered by a thin layer of dental wax (Cavex Set Up, Cavex, Haarlem, Netherlands) without approaching areas used for the analysis. Four transverse dental arch measurements were made on the maxillary dental casts. These measurements were taken at T1 and T2 (Fig. 2) using an electronic caliper (Digital 6, Mauser, Winterthur, Switzerland) with an accuracy of 0.01 mm. All measurements were taken by the same principal researcher (TK).

Blinding of study models to avoid assessor's bias was based on trimming off the brackets from the lingual surfaces of upper teeth on the study models of patients in the lingual group. This was accompanied by scratching and roughening the buccal surfaces of the same teeth in order to avoid assessor's recognition of actual group to which the model belonged. The opposite procedure was performed for study models belonging to the labial group. Great care was given to make both surfaces of each tooth alike in terms of coarseness.

Interproximal Reduction

Using 45 micron single-sided hand-held metal abrasion strips (Galaxy™, Ortho Technology®, Florida, USA), a gentle interproximal reduction was carried out in both groups on five contact areas (from canine to canine) to create the required space for aligning the crowded teeth. This procedure was repeated every one or two visits (with/without archwire change). The amount of overall enamel reduction accomplished in each group was calculated by measuring the difference in the mesiodistal width of six anterior teeth between T1 and T2.

Statistical Analysis

Statistical analysis was conducted using Minitab® 15 (Minitab Inc, State College, PA). Parametric tests (i.e. related-samples t-tests) or Wilcoxon matched-pairs signed-rank tests (the nonparametric equivalent) were employed to evaluate intragroup changes between assessment times. Two-sample t-tests (or its nonparametric equivalent: Mann-

Whitney U tests) were applied to evaluate intergroup differences. The level of significance was set at 5%. Error of the method was evaluated based on double measurements on 20 dental casts selected randomly from the two groups using Dahlberg's formula.²¹ The measurement was repeated after an interval of 1 month for the selected casts. The error of the method was minimal for all the evaluated variables indicating a relatively low range of error that does not affect the interpretation of the findings (Table 1).

RESULTS

Inter canine Width

Before brackets' placement in the LI group, the mean of intercanine width was 33.36 mm (Table 2). A significant increase was observed at T2 with a mean value of 35.35 mm. In the LA group, a highly significant increase from 32.98 to 34.28 mm was recorded. Inter canine width had a mean increase of 1.99 and 1.22 mm in the LI and the LA groups, respectively. The intergroup difference was also statistically significant.

Interpremolar Width

In the LI group, a significant decrease was observed in second interpremolar width from 40.24 to 39.54 mm (a mean decrease of 0.7 mm), whereas a significant increase was observed in this measurement in the LA group (a mean increase of approximately 2 mm). A statistically significant difference was found between the two groups.

Intermolar Width

At T1, the mean of intermolar width in the LI group was 45.22 mm (refer Table 2). A significant decrease was observed with a mean of 0.79 mm, whereas intermolar width increased significantly from 44.19 to 44.99 mm in the LA group (a mean increase of 0.81 mm). A statistically significant difference was observed between the two groups.

Arch Length

Arch length showed a nonsignificant decrease in the LI group ($p = 0.2$) and a nonsignificant increase in the LA group ($p = 0.18$). The difference between the two groups was also not significant ($p = 0.08$).

Amount of Enamel Reduction

It was found that the amount of enamel reduction was significantly higher in lingual appliance group compared to that of the vestibular group ($p < 0.001$).

DISCUSSION

It seems to be that this is the first randomized controlled trial comparing maxillary arch changes between lingual and labial fixed orthodontic appliances after the first stage of orthodontic treatment. This paper is just a preliminary report of the changes observed following leveling and alignment, but the final aim of this study is to draw a complete picture of the treatment outcomes following the completion of orthodontic treatment between labial and lingual appliances.

Table 1: Error of the method

Measurements	Dahlberg's error of the method	Systematic error*		Pearson's correlation coefficients**
		Mean difference	p-value	
Inter canine width	0.11 mm	-0.03	0.322	0.977
Interpremolar width	0.17 mm	-0.05	0.384	0.993
Intermolar width	0.13 mm	0.02	0.403	0.999
Arch length	0.14 mm	0.06	0.175	0.992

* Systematic error was assessed using paired t-tests; ** Pearson's correlation coefficients for random error assessment

Table 2: Changes of maxillary arch dimensions after leveling and alignment stage with lingual and labial fixed appliances

Measurements	T	LI (n = 26)				LA (n = 26)				p-value LA vs VA
		Mean (mm)	SD	T1-T0 Mean	p-value	Mean (mm)	SD	T1-T0 Mean	p-value	
Inter canine width	T1	33.36	1.59	1.99	<0.001	32.98	1.95	1.22	<0.001	<0.001
	T2	35.35	1.57			34.28	1.62			
Interpremolar width	T1	40.24	2.46	-0.70	<0.001	38.67	2.10	1.73	<0.001	<0.001
	T2	39.54	2.70			40.41	2.33			
Intermolar width	T1	45.22	2.78	-0.79	<0.001	44.19	2.80	0.81	<0.001	<0.001
	T2	44.43	2.85			44.99	2.69			
Arch length	T1	30.30	1.78	-0.35	0.2	30.50	1.84	0.67	0.18	0.08
	T2	29.95	1.55			31.18	1.91			
Sum of 6 anterior teeth widths	T1	49.68	0.42	-1.4	<0.001	50.06	0.43	-2.07	<0.001	<0.001
	T2	48.27	0.43			47.98	0.44			

T0: before brackets' placement; T1: after leveling and alignment stage; LI: lingual appliance; LA: labial appliance

To distinguish between bodily tooth movements and tipping movements when evaluating transverse arch changes on study models, it has been recommended that measurements should be made between landmarks positioned at lingual surfaces of contralateral teeth and compared to those performed on landmarks placed at the occlusal surfaces.¹⁹ However, in this study, it was difficult to study lingual landmarks, since lingual brackets were positioned at the lingual surfaces in the lingual appliance group.

Patients in both groups showed a significant increase of intercanine width, but this was significantly higher in the lingual appliance group ($p < 0.001$). In this study, the lingual archwire was simply fabricated in a mushroom shape with a prominence offset placed at the premolar region with no molar or vertical offset bends using an arch form template. This premolar offset may have caused this transverse expansion in the intercanine distance. Other laboratory lingual positioning techniques use computer software to trace proper archwires individualized for each patient as shown in the BEST technique or even to produce an automated archwire sequence for each case by a computer-controlled bending robot as in the TOP technique.²² The small interbracket distance in the anterior region and the thickness of lingual brackets may have played a role in this intercanine increase.^{1,12}

In this study, the significant difference between the two groups was located in the posterior region assessed by interpremolar and intermolar widths. Following leveling and alignment, the labial appliance resulted in an increase in these dimensions, whereas the lingual appliances caused the opposite effect. There has been an assumption that lingual brackets may cause irritation to the tongue forcing it into a posterior and inferior position, which may allow forces originating from lips and cheeks to outweigh those of the tongue causing upper dental arch constriction.¹¹ According to the findings of this study, it seems important to avoid unfavorable effects on posterior segments by reinforcement of molar anchorage. This can be probably achieved by banding or bonding tubes to the first and second molars, and combining them together from the vestibular surface. Another solution is to use a transpalatal arch attached to either first or second molars.⁴

Arch width increase during the first stage of labial fixed appliance treatment was observed in the current study and goes in line with other studies.^{23,24} Since, two objects cannot occupy the same space at the same time,²⁵ this expansion in arch dimensions occurs to accommodate and align the crowded teeth. Intercanine and interpremolar widths showed higher magnitude of expansion compared to the intermolar width; a finding, which has been also documented by Franchi et al.¹⁹ This might be explained by the shape of prefabricated labial archwires used in the current study.

Torque expression following rectangular arch engagement has been shown to be different between lingual and labial brackets.²⁶ However, in this preliminary report, torque expression was not considered, since the rectangular arch engagement stage was not reached and the dimensional dental arch changes following leveling and alignment was the primary goal for this report.

In both the groups, interproximal stripping was often performed every archwire replacement visit until the alignment of crowded teeth was achieved. When the amount of reduced enamel at the end of leveling and alignment stage was measured, it was found that enamel reduction was significantly higher in lingual brackets group (Table 2). The extra amount of enamel reduction and the greater extent of intercanine expansion may explain the alignment of crowded teeth that occurred in the lingual group despite the observed nonsignificant reduction in arch length and the significant narrowing of posterior teeth.

There were a number of limitations in this study; lingual archwires were made manually, which may have affected arch form response to treatment. Interproximal reduction may be considered as a confusing factor in this study. On the other hand, there was no way to align such a moderate crowding of teeth without creating a necessary space for appropriate alignment.

CONCLUSION

Both types of appliances caused an increase in intercanine width following the first stage of orthodontic treatment.

Different directions of tooth movements in the posterior region were found between the two techniques. The lingual appliance caused significant arch narrowing, whereas the labial appliance caused slight posterior arch expansion.

The effects of the two appliances upon arch length were not significant.

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