Evaluation of Skeletal and Dental Effects of Lower Lingual Arches

Volkan Ciftci* / Aslıhan Uzel** / Muharrem Cem Dogan***

Objective: *A lower lingual arch is usually recommended as a holding device to maintain arch length and to prevent mesial migration of the mandibular first molars. Despite its widespread use, comparatively little is known about the effects of a lower lingual holding arch on preservation of lower arch dimensions and tooth position and the impact of the device on mandibular growth. The aim of this study is to evaluate the skeletal and dental effects of the lower lingual holding arch with regard to arch dimension, positions of mandibular molars and incisors, and usual mandibular growth.* ***Study design***: *Thirty-four children (18 males and 16 females) who needed space maintainers were included in the present study. The patients were divided into two groups according to whether they were missing second primary molars on one or both sides. Group I comprised 16 children (8 males and 8 females, average age 8.8 ± 0.9 years) with a missing second primary molar on one side; Group II comprised 18 children (10 males and 8 females, average age 8 ± 0.7 years) with extractions on both sides. Lateral cephalograms, dental pantomograms, and study casts of the patients were taken at the beginning and the end of the study period. Average treatment time was 20.4 ± 4 months.* ***Results***: *Lower incisors moved forward and Incisor Mandibular Plane Angle (IMPA°) increased in both treatment groups. Statistically significant differences between the groups were found when comparing pre-treatment and post-treatment arch dimension and position of mandibular molars. Results were better for lingual arches with extraction on one side than with extraction on both sides* ***Conclusions:*** *A lingual arch seems to be an effective tool for maintaining arch length, and was not found to impair mandibular growth.*

Key words: *lingual arch, Space maintainer, Lower incisors, Mandibular growth*

INTRODUCTION

Davenport was the first investigator to describe the loss of space resulting from early loss of primary teeth[1]. Exfoliation of primary teeth affects the development of the dental arch and permanent dentition. Space management is an important issue in pediatric dentistry, and many studies have been published about space maintainers related to the early extraction of primary teeth[2–5]. In particular, early loss of primary second molars has been noted to have the greatest effect on dental arch length and may lead to the impaction of permanent teeth and development of crowding.

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The greatest loss of space has been attributed to mesial tipping of the permanent first molars[6]. Many types of space maintainers have been used to prevent the loss of space after early extraction of primary teeth. Mershon popularized the use of the lower lingual arch for this purpose[7]. Earlier, Nance had described the indication of the lingual arch to maintain the distance between permanent incisors and molars during the transition from mixed dentition to permanent dentition. The use of a lower lingual arch as a space maintainer is now a commonly accepted clinical procedure[8-11,16]. Despite its widespread use in pediatric dentistry, however, relatively little is known about the effects of a lower lingual holding arch on preservation of lower arch dimensions and tooth position orthe impactof the device on mandibular growth.

Previous studies have shown that a lower lingual arch space maintainer preserves the arch perimeter, but this occurs by protrusive movement of the lower incisors as the molars migrate mesially. Rebellato included patients in his lingual arch study who had spaces from the extraction of both mandibular second primary molars, while other researchers did not describe the amount of extraction space in their patients[9–12,16]. In addition, the literature does not indicate whether use of a lingual arch space maintainer might negatively affect mandibular growth. The aim of this study was to evaluate the effects of a lower lingual arch upon arch dimension and positions of first mandibular molars and incisors, as well as mandibular growth, in patients with premature loss of second primary molars on one or both sides.

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MATERIALS AND METHOD

Thirty-four children (18 males and 16 females) referred to the Pediatric Dentistry clinic at Cukurova University were included in the present study. They were selected to participate based upon the following criteria:

The patients were in the mixed dentition stage, the permanent incisors and primary canines were present in the mandibular arch, the patients had Class I or Class II skeletal patterns (1 ≤ ANB° ≤ 5), premature loss of mandibular primary second molars was present on one or both sides, overbite was ≥ 1 mm, Ar-Go-Me≤136°, Facial axis-ricketts ≤93°. Exclusion criterias were functional perioral problems, congenitally missing teeth, anduse of any space maintainer other than lower lingual arch.

The patients in both groups were statistically similar in age, sex, and skeletal growth pattern. Lower lingual arches were placed in 34 patients whose guardians gave written consent after being fully informed about the study. The study was approved by the Ethics Committee of Cukurova University Faculty of Medicine in Turkey.

Figure 1: Lower lingual arch used in Group I

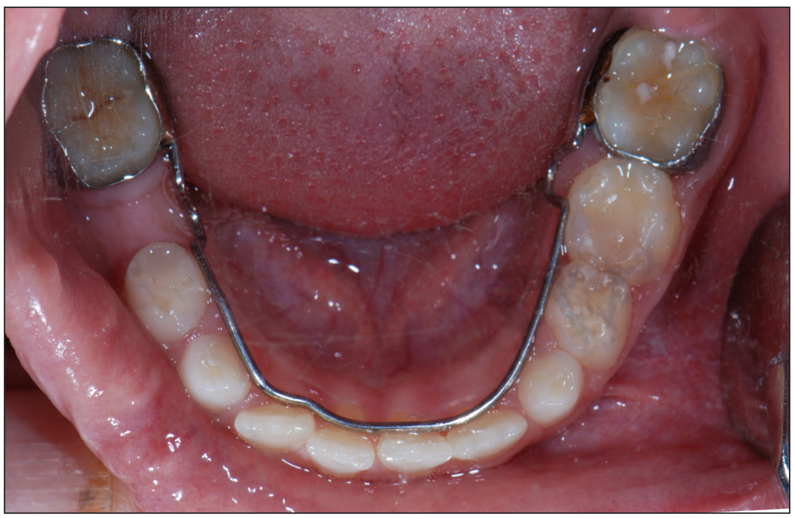


Figure 2: Lower lingual arch used in Group II

The patients were divided into two groups according to whether they were missing second primary molars on one or both sides. Group I consisted of 16 children with second primary molar extraction space on one side (8 males and 8 females, average age 8.8 ± 0.9 years), and Group II consisted of 18 children with second primary molar extraction spaces onboth sides (10 males and 8 females, average age 8 ± 0.7 years). 0.9 mm stainless steel wire was used for the lower lingual arch space maintainer in both treatment groups (Fig. 1 and Fig.2).

Measurements were taken from good-quality lateral cephalograms, dental pantomograms, and study casts at the beginning (T1) and end (T2) of the study. An orthodontic technician took lateral cephalograms for each child in centric occlusion with the mandibular plane horizontal according to the resting position of the head using a Planmeca digital radiological imaging unit (PM 2013 CC Promax, 5 Ma, 10 seconds). Digital dental pantomograms were taken with the upper and lower incisors in an occlusal relationship and first molars in normal occlusal relationship, again using a Planmeca digital radiological imaging unit (PM 2013 CC Promax, Pediatric mode, 7 Ma, 12 seconds). Lateral cephalograms were traced digitally with the Dolphin imaging program (10.5 software). Eight hard tissue cephalometric points, four cephalometric planes, and nine angular and linear measurements were marked on lateral cephalograms (Fig. 3). Study casts were made using alginate impressions (Zhermack: Extra-rapid dust-free orthodontics alginate, mixed 8 seconds with Tecno-Gaz Algimix 2/2, water/powder). Dental arch measurements were takenfrom the study casts at T1 and T2.

Dental arch measurements

1. Arch length: the distance from the distal contact points of the lower permanent right and left first molars to the contact points
2. Arch depth: the distance from a point bisecting the mesial anatomic contact points of the first permanent molars to the contact points of the permanent central incisors,
3. Intermolar distance: the distance between the central fossa of the left and right permanent first molars
4. Intercanine distance: the distance between the primary canine cusp tips.

Dental pantomograms were traced and stored using the PACS dental imaging program. Molar angulation was performed on the dental pantomograms 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 mandibular border (Fig. 4). The observation period was terminated when the roots of unerupted second premolars reached the development rate of 2/3 or cuspids erupted. The data from T1 to T2 were collected, statistically analyzed, and compared. Average treatment time was 20.4 ± 4 months.

Statistical analysis

Data statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS 15 Inc., Chicago, USA). Chi-square or Fisher's exact test statistics were used to compare categorical variables. A paired sample t-test and Wilcoxon Friedman test were used to identify changes between T1 and T2. Repeated Measures Analyses was used to determine whether significant differences existed between the groups.The results were considered significant the level of significance was 0.05. The results were indicated average ± standard deviation.

Figure 3: Cephalometric points and planes used in the cephalometric analysis: S, sella; N, nasion; Ar, articulation point; Go, gonion; Gn, gnation; point A; point B; L1, midpoint plane of lower central incisor edge; mandibular plane; plane between Go and Me points; gonial angel; angle between Ar-Go-Me points, FMA angle; angle between of Frankfort plane and mandibular plane, Facial axis angle; angle between Na-Ba plane and Pt-Gn plane, IMPA angle; angle between of mandibular plane and L1 plane, Mandibular length; distance between Go and Gn points.

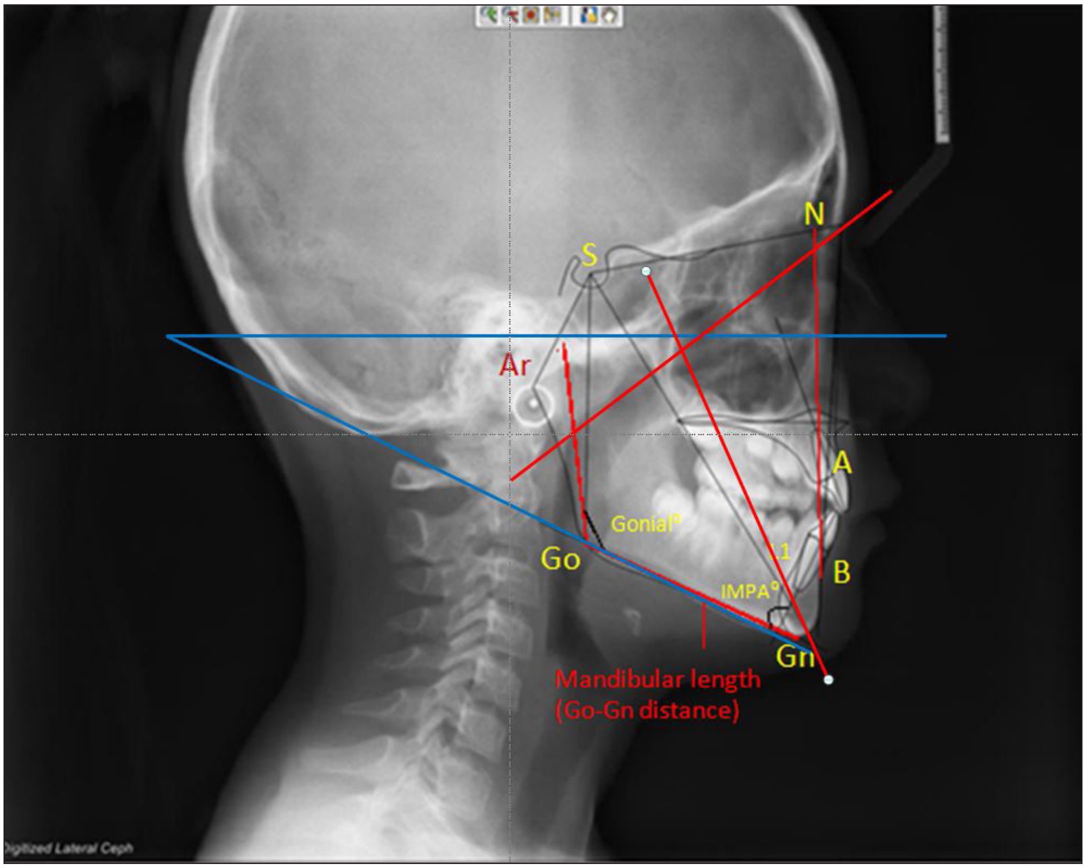
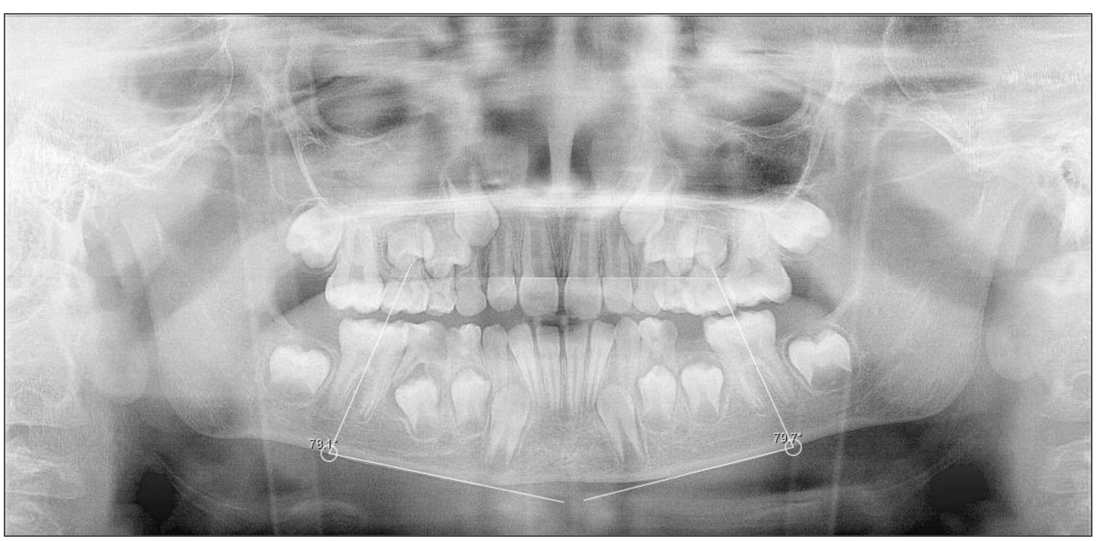


Figure 4: Lower molar angulation to the mandibular plane[16]



RESULTS

The means, standard deviations (SD), differences between means (MD) for the variables, and p values for the parameters measured are shown in Tables 1–3.

Table 1 show the arch dimensional changes after lingual arch treatment for the two treatment groups at T1 and T2. Table 2 show the lateral cephalogram analysis for the two treatment groups at T1 and T2. Lower molars angulation degrees in relation to the mandibular plane for the two treatment groups at T1 and T2 are shown at Table 3.

DISCUSSION

Since 1989, lower lingual arch appliances have been commonly used in pediatric dentistry to maintain mandibular arch length and prevent changes in the position of the mandibular first molar and lower incisors after early loss of the second primary molar during transitional dentition[35]. Even so, there are few qualified clinical studies in the dental literature about the lower lingual arch as a space maintainer[9,11,12,32]. The existing studies have focused on changes in dental arch dimensions, but currently there is no any study evaluating its effects on mandibular growth.

Rebellato *et al*. observed an average reduction in total arch length of −2.54 mm with no treatment in children with second molar extraction spaces on both sides[9]. The same study showed an average increase in total arch length of 0.07 mm in the treatment group. By comparison, De Beats *et al*. found a 0.05 mm decrease in total arch length in 38 children treated with a lower lingual arch[13]. In the present study, total arch length decreased by 0.4 mm in Group I (space on one side) and increased by 0.9 mm in Group II (space on both sides). Changes in arch length between pretreatment and posttreatment measurements were statistically insignificant for both treatment groups.

Thilander showed an average intercanine width increase in a model study with children between the ages of 5 and 10 years[14]. Bishara *et al* found a 0.5 mm increase in intercanine width as a result of normal growth[15]. In lingual arch studies, the increase in intercanine width was found to vary between 0.5 mm and 1.1 mm[10,13,16]. In the present study, intercanine width increased 0.5 mm in Group

Table 1: Study model measurements for the two treatment groups at T1 and T2

Variable	T1,Group I, mean ± SD	T2,Group I, mean ± SD	MD	p	T1,Group II, mean ± SD	T2,Group II, mean ± SD	MD	p	p group
Arch depth	24.6 ± 1.2	24.7 ± 1.3	0.1	0.432	22.8 ± 1.7	22.6 ± 1.7	−0.2	0.205	*0.142*
Arch length	68.4 ± 1.8	68.0 ± 1.9	−0.4	0.181	64.2 ± 3.8	65.1 ± 4.1	0.9	0.195	*0.094*
Intercanine	26.1 ± 1.3	26.6 ± 1.8	0.5	0.0118	25.2 ± 2.1	26.1 ± 2.2	0.9	0.015	*0.427*
Intermolar	40.7 ± 1.9	42.0 ± 1.9	1.3	0.0001	40.0 ± 2.0	42.1 ± 2.6	2.1	0.0001	*0.123*

p≤0,05=statistically significant p:Paired sample t-test, pgroup: Repeated Measures Analyses

Table 2: Cephalometric measurements for the two treatment groups at T1 and T2

Measurements	T1,Group I mean ± SD	T2,Group I, mean ± SD	MD	p	T1,Group II mean ± SD	T2,Group I Imean ± SD	MD	p	p group
SNA°	81.0 ± 4.3	81.1 ± 4.9	0.1	0.801	81.6 ± 4.9	80.9 ± 4,3	−0.7	0.030	*0.086*
SNB°	77.3 ± 3.6	77.1 ± 4.5	−0.2	0.525	77.1 ± 4.1	76.8 ± 3.6	−0.5	0.324	*0.873*
ANB°	3.7 ± 1.9	4.0 ± 1.9	0.3	0.375	3.9 ± 2.0	4.2 ± 2.1	0.3	0.114	*0.088*
SN-GoGn°	33.6 ± 4.4	34.1 ± 6.2	0.5	0.261	33.7 ± 4.2	34.2 ± 4.7	0.5	0.249	*0.972*
FMA°	24,6±3,7	25,6±3,5	1	0,056	26,7±2,5	27,3±2,8	0,6	0,993	*0,297*
Facial Axis°-Ricketts	86,8±5,6	86,7±5,1	-0,1	0,786	85,8±4,3	85,7±3,7	-0,1	0,942	*0,897*
Gonial°	126.5 ± 4.8	127.2 ± 5.7	0.7	0.297	127.9 ± 5.4	129.2 ± 4.6	1.3	0.126	*0.570*
L1–NB (mm)	4.7	6.2	1.5	0.0001*	4.1	5.2	1.1	0.0001*	*0.763*
IMPA°	93.5 ± 6.4	96.8 ± 6.4	3.3	0.001	91.7 ± 5.8	95.4 ± 5.2	3.7	0.0001	*0.708*
Go-Gn (mm)	67.6 ± 4.2	70.3 ± 3.9	2.7	0.0001	64.0 ± 5.3	66.5 ± 4.0	2.5	0.013	*0.883*

p≤0,05=statistically significant p:Paired sample t-test, p*:Wilcoxon Friedman test , pgroup: Repeated Measures Analyses

Table 3: Right first molar and left first molar angulation measurements for the two treatment groups at T1 and T2

Tooth number	T1, Group 1, mean ± SD	T2, Group 1, mean ± SD	MD	p	T1,Group II, mean ± SD	T2,Group II, mean ± SD	MD	p	p group
46 angular°	71.7 ± 6.5	72.8 ± 7.2	1.1	0.772	72.4 ± 7.7	71.5 ± 7.1	-0.9	0.540	*0.121*
36 angular°	69.8 ± 6.3	71.7 ± 7.1	1.9	0.289	74.5 ± 7.6	73.3 ± 4.9	-1.2	0.120	*0.031*

p≤0,05= Statistically significant

p:Paired sample t-test, p*:Wilcoxon Friedman test , pgroup: Repeated Measures Analyses

I and 0.9 mm in Group II. The increase was statistically significant in Group II. This finding agrees with De Beats *et al*. as a result of lateral migration of the primary canines[13].

Moyers *et al*. showed that intermolar width expands spontaneously due to biological mechanisms[17]. In addition, Bishara *et al*. reported that intermolar width increases by an average of 1 mm in the general population during transitional dentition[15]. Brennan and Gianelly reported a 0.72 mm increase in intermolar width after lingual arch therapy[18]. Rebellato *et al*. and Singer also showed a 1 mm increase in intermolar width during similar lingual arch treatment[9,10]. In the present study, intermolar width increased by 1.3 mm in Group I and 2.1 mm in Group II. These are statistically significant increases. Our finding is in agreement with Singer and Rebellato *et al* who reported that intermolar width increased after lingual arch treatment.

Rebellato *et al* using Björk's superimposition technique, found backward tipping of 0.54 degrees in the position of the first molars after lingual arch treatment in 14 patients[9]. They also showed mesial tipping of 2.19 degrees in the lower molars in their control group. Similarly, Villalobos *et al*. observed distal drift of 0.54 degrees in the mandibular first molars in 23 treated patients, while the control group in their study showed mesial tipping of 2.68 degrees in lower first mandibular molars at 24 months[11]. Owais *et al*. measured molar angulation in relation to the mandibular plane with a different tracking technique using pantomograms after lingual arch treatmen, and they found distal tipping in all first molars[16]. In the present study, mandibular right first molars moved on average by 1.1 degrees distally and mandibular left molars moved on average by 1.9 degrees in relation to the mandibular plane distally in Group I. In Group II, mandibular right first molars tipped on average by 0.9 degrees mesially and mandibular left first molars shifted an average of 1.2 degrees in relation to the mandibular plane mesially. The changes in our Group I corresponded with the findings of Oawis *et al*., who found 1.59 degree distal tipping of mandibular first molars. Our Group II showed unexpected forward tipping of the lower molars. This finding regarding lower molar angulation is in disagreement with Rebellato *et al*. and Villalobos *et al*., who found 0.54 degrees of backward tipping in the lower molars[9,11].

According to Enlow, a physiological remodeling mechanism in the alveolar region causes a lingual inclination of the lower permanent incisors[19]. Watanabe observed the same in untreated patients ages 8–15 in a clinical study[20]. In the present study, IMPA°,which was used to determine changes in the position of lower incisors in the sagittal direction, increased for both treatment groups (3.3 degrees in Group I and 3.7 degrees in Group II), and these changes were found to be statistically significant. L1–NB distance also increased for both treatment groups. In addition, the present study found that the lower incisors were proclined after lingual arch treatment, which agrees with Singer *et al*, Villalobos *et al* Letti *et al* and Owais *et al* [10,11,12,16]. A review by Viglianisi also reported that protrusion of incisors occurred after lingual arch treatment[31]. The reason for protrusion or proclination is impairment in the balance of forces exerted on the incisors by the tongue and the perioral muscles.

Most authors agree that the tongue influences dentofacial morphology and dental arch morphology during mastication and rest[23–26]. According to Winders, tongue pressure during deglutition ranges from 41 to 709 g/cm² [27]. Other researchers have reported similar data[23,28]. Some who have investigated the effects of fixed Transpalatal Arch (TPA) appliances found additional tongue pressure on the surface of the first molars, hard palate, the alveolar ridge[29,30,36]. In the present study, the tongue might deliver orthodontics forces with considerable frequency and create extra tongue force on lingual arch fixed appliances bonded to the back surfaces of the molars. This intermolar width increase might be related to variable tongue functions, in addition to the mechanism of growth. The greater change in Group II than in Group I can be explained by the change of tongue position in the neutral zone and the expanded extraction space in Group II.

Facial vertical growth pattern plays an important role in achieving facial balance. Variance in vertical growth may alter mandibular growth rotation and result a long face[38,39]. Villalobos et al[11] treated 23 patients, whom average mandibular plane inclination was 24°±2°, with a lower lingual arch. They found significant differences between the lingual arch treatment group and the control group. They concluded that lower lingual arch is a useful tool to control the vertical development of the mandibular molars. Fichera[37] evaluated the effects of lingual arch in subjects with different mandibular growth patterns. In that study the patients with an mandibular posterior rotation (MPR) were exhibited a greater mesial movement of the first molars compared to the mandibular anterior rotation (MAR) and mandibular growth in straight-downward direction (MSD). In our study, the possible change in the first molar angulation after lower lingual arch treatment was evaluated. Althought the Group II demostrated greater mesial angulation of the first molar compared with the Group I, no statistically significant changes were found in skeletal vertical dimension between two treatment groups at the end of the treatment. We assume that, lingual arch didn't change the vertical growth pattern in our study population. On the other hand, our study population was consisted of normal or low angle growth pattern patients and this is the limitation of our study. Further research is needed to evaluate the effects of lower lingual arch treatment in the patients with different mandibular growth patterns.

Many studies have noted that the mandibles grow sagittally during transitional dentition[22,33,34]. Ochoa and Nanda also studied the growth of the maxilla and mandibles with longitudinal cephalometric radiography and analyzed developmental stages[21]. They demonstrated that mandibular length (Go-Gn) increased by 2.1% from age 8 to age 10 in patients with similar skeletal growth patterns. In the present study, the mandibles grew an average of 2.6 mm in both treatment groups. Comparing pretreatment and posttreatment measurements, sagittal growth occurred normally and was not restricted by the lingual arch. This agrees with both Ochoa and Nanda and Jamison *et al*., who also studied mandibular growth and development[21,22].

CONCLUSIONS

- Lower lingual arch prevents total arch length lost after extraction of lower second primary molar or molars.
- Lower incisors proclined after lingual arch treatment in both treatment groups.
- Lower lingual arch treatment had no negative effect on mandibular sagittal growth.
- Lower lingual arch had no effect on vertical facial dimensions of patients with normal or low angle growth pattern.

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