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ORIGINAL RESEARCH

The Effects of Functional Appliances on Female Patients with Skeletal Class II Malocclusion 6 Months after Menarche

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ABSTRACT

Aim: To investigate the skeletal, dental, and soft tissue changes in girls with class II division 1 malocclusion after growth spurt peak under the effect of activator appliance.

Materials and methods: In this clinical trial study, 15 female patients, with skeletal class II and mandibular growth deficiency and at least 5 mm overjet, were randomly selected 6 months after their menarche. The mean of their ages at the beginning was 12.33 ± 0.81 years, and in the end it was 13.73 ± 0.79 years; the mean duration of treatment was 12.2 ± 3.18 months. Lateral, cephalometric radiographs were taken from all the patients before and after the treatment. Data were analyzed with Statistical Package for the Social Sciences (SPSS) 20 using paired t-test.

Results: On an average, the ANB angle, the angle of the upper incisors with the S-N, facial convexity, and overjet decreased by 2.6° ± 0.9, 5.4° ± 0.8, 3.8° ± 3.4, and 5.6 ± 1.8 mm respectively. The SNB angle, the angle of the lower incisors with the N-B, the labiomental angle, the total length of the mandible, the lower anterior facial height, the lower lip distance, the first molar of the mandible, and the soft tissue pogonion to the vertical line from the S point increased by 2.8° ± 1.8, 3.4° ± 3, 14.7 ± 15, 3.7 ± 2.6, 2.1 ± 1.6, 6.3 ± 2.5, 4.4 ± 2.4, and 6 ± 3.3 mm respectively. All these figures were statistically significant ($p = 0.000$).

Conclusion: The functional appliance improved the dental–skeletal relations and the soft tissue profile of patients after the growth spurt peak of puberty in a group of Iranian girls, whereas dental changes were more than skeletal ones.

Clinical significance: Functional appliances can be used for correction of skeletal class II malocclusion 6 months after menarche in girls.

Keywords: Activator appliance, Growth modification, Skeletal class II division 1.

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INTRODUCTION

The essential stimulus for craniofacial skeletal development is obtained through the evolution and growth of soft tissues and the active elements of skeletal structures. This concept is known as the functional matrix theory. According to this hypothesis, the skeletal tissues do not have the initial potential for their growth and evolution. From this perspective, soft tissues grow, affecting the bone and cartilage and making them move. They need functional stimulus to perform these reactions.[1] One of the problems of patients referring to orthodontic clinics is the ugliness caused by the mandibular growth defects with dental problems. For these patients, the best time to initiate the treatment of growth modification is during puberty. Therefore, growth modification should be undertaken before the end of the growth spurt. Since many patients have skeletal class II malocclusion with mandibular growth defects, various functional appliances are used to solve their problems. It seems that the treatment with functional appliances occurs with the additional growth in response to the condyle movement out of the glenoid fossa and the decrease of pressure on the condylar tissue or the changes of muscular tension on it.

Although the acceleration often occurs in the mandibular growth, it is difficult to indicate the increase in mandible size for a long time. Approximately, there is always a small amount of growth modification in maxilla with this modification in the mandible. Although in general the use of functional appliances has a greater impact on the mandible, especially in the short term, they have some growth inhibition on the maxilla at the same time. Some believe that since the fixed treatment is usually needed for these patients in the permanent dentition period, it is better to treat the growth modification in one phase in the early permanent dentition as some growth of the patient remains and the time of treatment will be shorter.[2] However, there are different ideas on how much growth modification can improve the skeletal class II malocclusion after growth peak, i.e., loss of the ideal age for treatment. In 2002, von Bremen and Pancherz[3] found that the one-stage treatment in the permanent dentition period was more effective than the two-stage treatment in mixed dentition in patients with class II division 1 malocclusion. In 2007, Marşan[4] found that functional appliances in patients with class II division 1 malocclusion in the early permanent dentition period lead to positive skeletal and dental modifications and positive changes in soft tissue profiles. In 2008, Hagglund et al[5] treated class II malocclusion patients with Herbst functional appliances, and the patients were in puberty phase at the beginning of this treatment (average age: 14.2 years). As a result, they found positive dental changes and some skeletal changes, too. Baysal and Uysal[6] in 2013 studied the dentoskeletal effects of the twin block appliance in 20 patients with skeletal class II Division 1 malocclusion (mean age: 13 years). They observed the correction of skeletal and dental relationships. Previous studies and clinical experience also suggest the possibility of response to functional appliances after the growth spurt of puberty. Therefore, this study was designed to determine whether skeletal modifications could be observed after the peak of growth spurt.

MATERIALS AND METHODS

In this clinical trial, 15 female patients who were referred to the Orthodontic Department of the Faculty of Dentistry and had their menarche 6 months earlier were randomly selected. The subjects had skeletal class II malocclusion, mandibular deficiency, normal height of face, and sufficient overjet as shown by clinical and radiographic examination. The subjects had not undergone any previous orthodontic treatment. Treatment plan was explained to the patients and their parents and voluntary and written informed consent was obtained. Lateral cephalometric radiography was carried out under the supervision of a radiologist before initiating the treatment of all the patients. Alginate impressions and construction bite with a thickness of 3 to 4 mm were prepared to build the activator appliances. The activator appliance used in the present study was modified by adding labial bows in the maxilla and mandible and adding two Adams on the first molars (Fig. 1).

All the patients used the appliances day and night except during eating. Patients who did not use functional appliances as ordered were excluded from the study. This treatment continued to reach acceptable overjet and overbite, as well as the desirable profile. At the end of the treatment, cephalometric radiography was prepared by the same radiologist and the patients were referred to the appropriate department to continue treatment with fixed appliances. Modifications of soft and hard tissues were traced by an orthodontist, using pretreatment and posttreatment lateral cephalograms. Tracing measurements were recorded in patients' files stored in the Orthodontic Department documentation. Modifications before and after treatment were analyzed by Statistical Package for the Social Sciences (SPSS) version 20 (SPSS Inc., Chicago, IL, USA) using paired t-test ($p < 0.05$). Cephalometric landmarks, the linear measurements, and angular measurements are shown in Figures 2, 3A, and 4A and B respectively.

At first, the S-N plane and then a line with a 7° angle to S-N from the N point, which seemed to be closer to the actual horizon, were designed to draw the lines (Fig. 3B). The perpendicular line was drawn from S point and called S vertical (SV) and all the modifications of the posterior–anterior soft tissue were measured in horizontal dimension from the SV line in millimeters. Profile modifications were calculated in vertical dimension by measuring the Sn-Me and N-Me lines. E line was designed to evaluate the position of the lips to the chin and nose as the reference plane. The measurement of lines and angles was made in millimeters.

Fig. 1: Design of the activator appliance used in the study

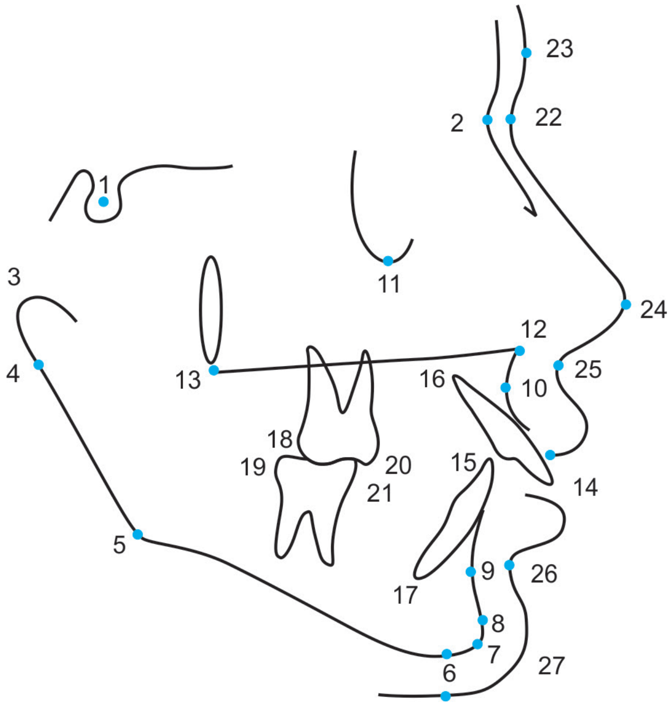


Fig. 2: Points used in the cephalometric analysis: 1 = Sella turcica (S); 2 = Nasion (N); 3 = Condilion (Cond); 4 = Articular (Ar); 5 = Gonion (Go); 6 = Menton (Me); 7 = Gnathion (Gn); 8 = Pogonion (Pog); 9 = B point; 10 = A point; 11 = Orbital (Or); 12 = Anterior nasal spine (ANS); 13 = Posterior nasal spine (PNS); 14 = Upper incisor incisal edge; 15 = Lower incisor incisal edge (LIE); 16 = Upper incisor apex (UIA); 17 = Lower incisor apex (LIA); 18 = Upper molar mesial cusp tip (UMT); 19 = Lower molar mesial cusp tip (LMT); 20 = Upper molar distal contact point (UDC); 21 = Lower molar distal contact point (LDC); 22 = Soft tissue nasion (N′); 23 = Glabella (G); 24 = Nose tip (p); 25 = Subnasal (sn); 26 = Labiomental (Sl); 27 = Pogonion soft tissue (pog); 28 = Menton soft tissue (Me′)

RESULTS

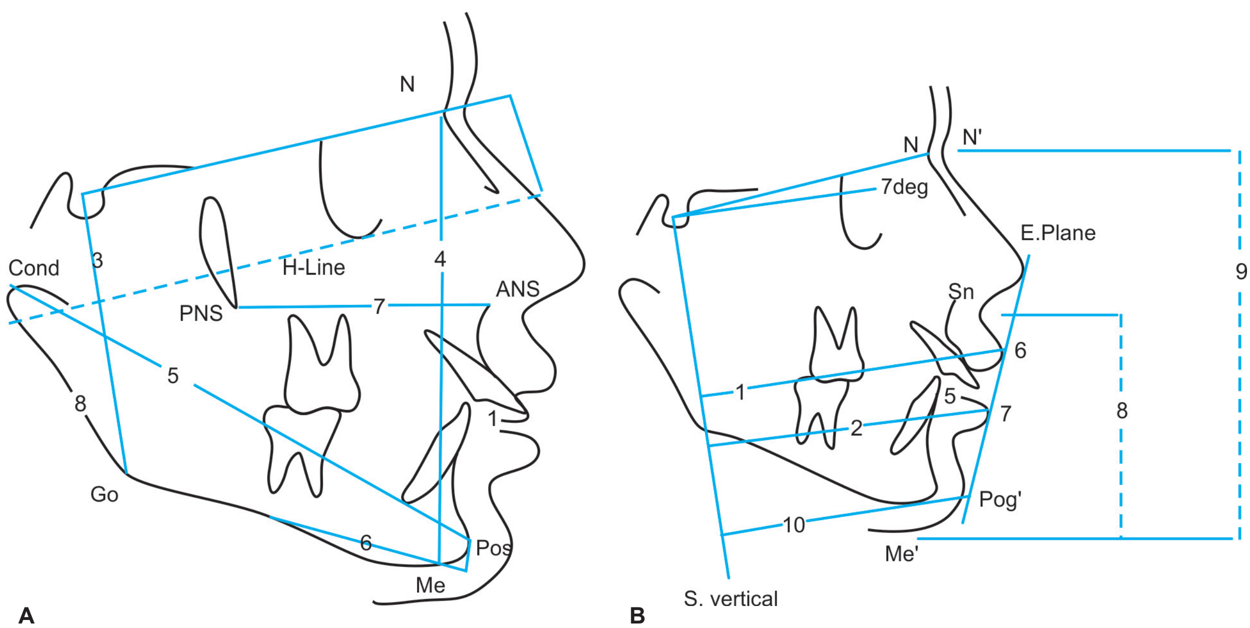
The present study aimed to investigate the effects of activator appliance on girls (n = 15) with skeletal class II malocclusion and with increased overjet, 6 months after the start of their menstruation period. At the beginning of the study, the mean age of the subjects was 12.33 ± 0.81 years and at the end it was 13.73 ± 0.79 years and the mean treatment period was 12.2 ± 3.18 months.

The following results were obtained by cephalometric analysis and comparison of pre- and posttreatment tracings: Among the parameters of the hard tissue (skeletal and dental), there was a significant relationship between the rate of overjet modifications and SNB ($p = 0.014$, $r = 0.62$), the distance from the edge of the maxillary incisors to the S vertical line ($r = 0.5$, $p = 0.037$), and the angles of maxillary incisors to the SN line ($r = 0.62$, $p = 0.014$).

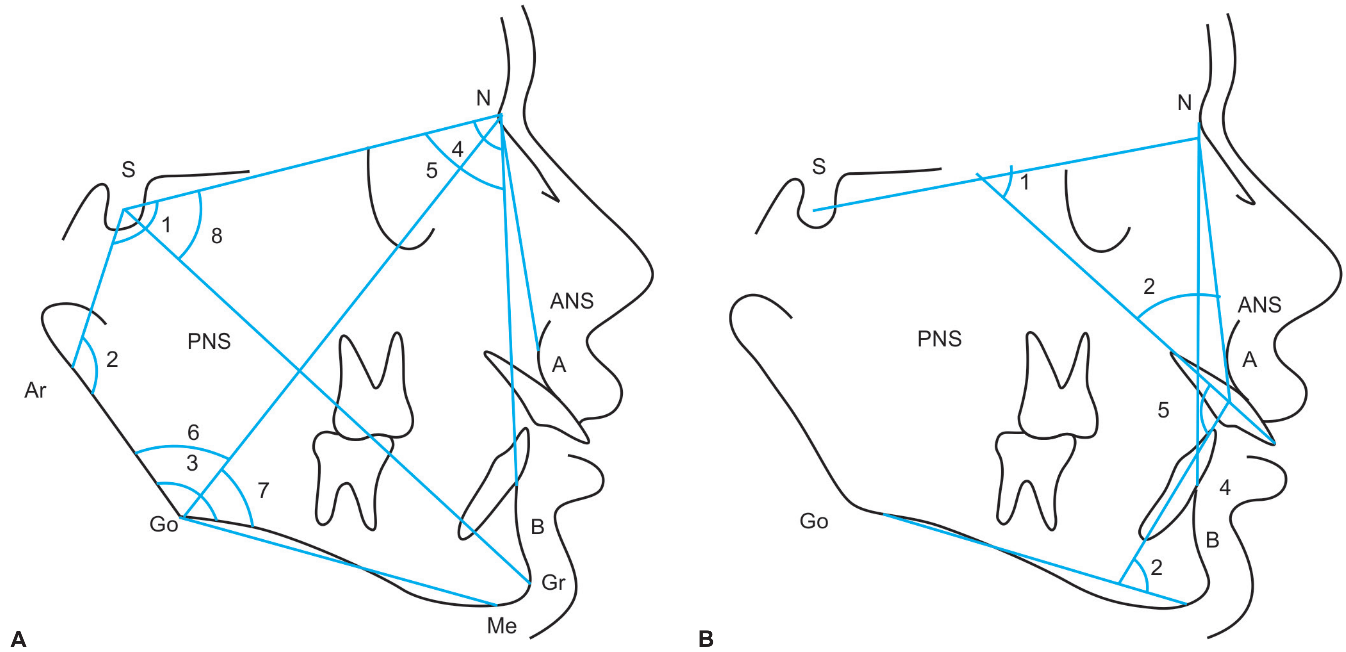
DISCUSSION

Hard Tissue Analysis

The lower incisors were tipped about 1.8° labially relative to the mandibular plane, resulting in the lingual movement of the roots of incisors (Table 1). Subsequently, the alveolar bone was remodeled, point B moved lingually, and the SNB angle decreased. However, a significant increase in the SNB angle – approximately 2.8° – indicated improvement in the position of the mandible drawn back. On the contrary, the entire length



Figs 3A and B: Linear measurements: (A) (skeletal): 1 = Overjet, 2 = Overbite, 3 = S-Go, 4 = N-Me, 5 = Mandibular length (Cond-Pog), 6 = Mandibular base length (Go-Pog), 7 = Maxillary length, 8 = Ramus length; (B) (soft tissue): 1 = Upper lip to S vertical, 2 = Lower lip to S vertical, 6 = Upper lip to E plane, 7 = Lower lip to E plane, 8 = Anterior lower face height, 9 = Total anterior face height, 10 = Pog to S vertical



Figs 4A and B: Angular measurements: (A) (skeletal): 1 = Saddle angle (N-S-Ar), 2 = Articular A (S-Ar-Go), 3 = Gonial A (Ar-Go-Me), 4 = SNA, 5 = SNB, 6 = Go1, 7 = Go2, 8 = Y-axis (N-S-Gn); (B) (dental): 1 = U1-SN, 2 = L1-Mand plane, 3 = U1 to NA, 4 = L1 to NB, 5 = U1/L1

of the mandible (Cond-POG) and the length of the mandibular base (POG-GO) increased about 3.8 and 3.2 mm respectively. All these changes were statistically significant and showed an increase in the length of the mandible. The results of the present study were consistent with those of studies carried out by Šidlauskas,[7] Tumer and Gultan,[8] and Lund and Sandler.[9] The effect of the activator device on the advancement of the maxilla could be measured through changes in the length of the maxillary base and the SNA angle. In this study, small changes in the SNA angle (an increase of 0.2°) and in the length of the maxillary base (an increase of 1 mm) showed that the maxillary growth was limited. On the contrary, palatal tipping of maxillary incisors was significant – about 5.4° – and the root apex might have moved forward, resulting in remodeling of the alveolar bone and setting forward of the A point. The results of the present study were also consistent with those reported by Lai and McNamara[10] and Šidlauskas.[7] The ANB angle significantly decreased – approximately 2.6° – which could suggest the improvement in the intermaxillary relationship and advancement of the mandible since the share of SNB in this change was significantly higher. These results are consistent with those of studies by Tumer and Gultan,[8] Clark,[11] Šidlauskas,[7] and Lai and McNamara.[10] On an average, the overjet significantly reduced (5.6 mm) at the end of treatment compared with baseline ($p = 0.00$). About 65% of these changes were related to the dental movement, particularly the maxillary incisors, and 35% of these changes were related to skeletal movements, especially the advancement of the mandible. Pancherz[12] found that more than 70% of overjet decrease was related to the tipping of incisors, especially the movement of maxillary incisors. Reey and Eastwood[13] found that the reduction of overjet was due to the simultaneous growth stimulation of mandible advancement and lingual tipping of maxillary incisors. Basciftci et al[14] also reported that the reduction in overjet was due to the growth stimulation of the mandible advancement, lingual tipping of maxillary incisors, and proclination of mandibular incisors. The overbite significantly decreased (about 0.9 mm), which is supported by the findings of Tumer and Gultan,[8] Basciftci et al,[14] Gill and Lee,[15] Jena et al,[16] and Šidlauskas.[7] The entire length of the mandible significantly increased (7.3 mm, $p = 0.000$), and this result was compatible with those reported by Basciftci et al,[14] Šidlauskas,[7] Tumer and Gultan,[8] and DeVincenzo.[17] Figures 5A to C the length of the mandibular base (Gon-Pog) increased by up to 2.3 mm ($p = 0.000$). In the present study, it was not possible to determine the amount of changes related to the growth and/or due to the effect of the functional device because from an ethical perspective there was no control group. Lai and McNamara[10] reported that the increase in mandibular length in girls at puberty was mild. However, Al-Rawi and Ali[18] believed that the increase in mandibular length occurs through an increase in the Cond-Gn distance or remodeling of the position of the glenoid fossa. The length of the ramus also significantly increased up to approximately 3.3 mm. The increase in total mandibular length (Cond-POG) and in ascending ramus (Ar-Gn), which led to the forward and downward mandibular movements, showed the skeletal effect of

Table 1: Comparison of the means of hard tissue parameters (skeletal, dental) of patients before and after treatment*

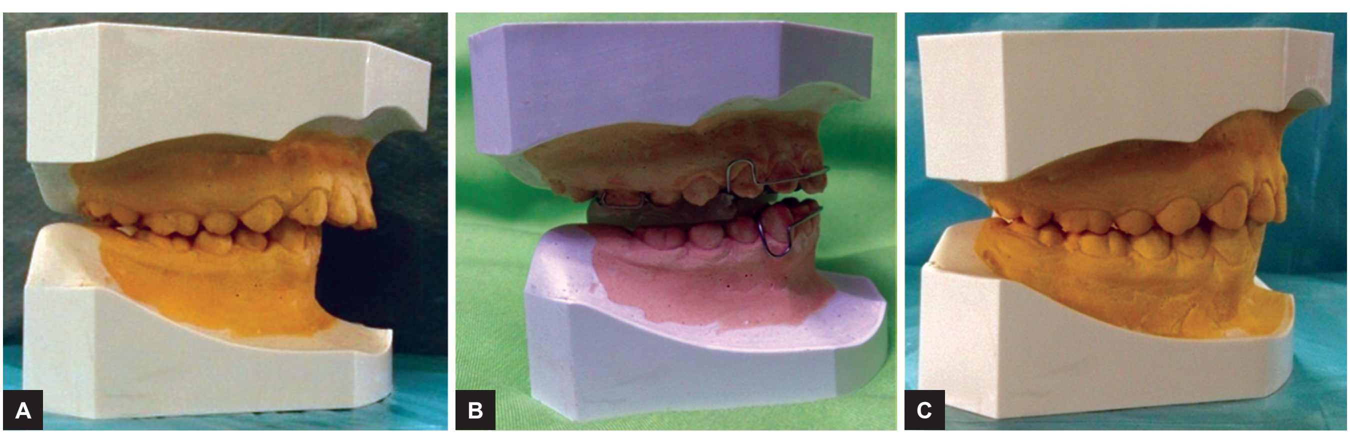
	Pretreatment		*Posttreatment*		*Difference of posttreatment and pretreatment*		
Parameters	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p-value*
N-S-Ar (°)	126.8	5.7	127.4	5.6	0.53	3.34	0.56
S-Ar-Go (°)	137.6	6.1	138	6.8	0.46	4.7	0.718
Ar-Go-Me (°)	131.3	5.5	129.8	4.7	–1.4	3.2	0.117
SUM (°)	395.7	5.2	395.3	5.5	–0.4	3.5	0.677
SNA (°)	80.2	4	80.4	4.1	0.2	1.5	0.629
SNB (°)	72.8	3.3	75.6	3.9	2.8	1.8	0.000
ANB (°)	7.4	1.1	4.8	1.4	–2.6	0.9	0.000
N-A-Pog (°)	169.2	3.1	171.8	3.9	2.6	2.1	0.000
Overjet (mm)	8.4	1.7	2.8	0.9	–5.6	1.8	0.000
Overbite (mm)	3.4	1.3	2.5	1.1	–0.9	1.4	0.027
Y-axis (°)	68.6	3.6	68.3	3.9	–0.3	1.6	0.454
S-Go (mm)	67.6	6.1	69.6	8.1	2	5.1	0.165
N-Me (mm)	107.4	9.2	111.2	7.5	3.8	4.9	0.011
Jaraback index	0.63	0.5	0.62	0.5	0	0	0.363
Cond-Pog (mm)	103	7.9	106.7	8.4	3.7	2.6	0.000
Go-Pog (mm)	66.6	5.8	69.8	5.2	3.2	2.6	0.000
Maxillary length (mm)	54	5.3	55	5.5	0.9	1	0.005
Ramus length (mm)	43.8	5.2	47.1	5.7	3.3	1.7	0.000
Facial A (°)	75	3.5	77.5	4	2.4	1.8	0.000
A to S vertical (mm)	64	4.16	64.2	5	0.1	2.5	0.846
B to S vertical (mm)	53.4	4.5	57	4.6	3.6	1.9	0.000
U1 to S vertical (mm)	68.6	5.1	67.1	5.5	–1.5	2.7	0.058
L1 to S vertical (mm)	60.3	5	63.7	5.3	3.4	2.1	0.000
U1-SN (°)	107.8	7.2	102.4	8.5	–5.4	8	0.024
L1-Man.P (°)	95.8	6.8	97.6	7.2	1.8	3.3	0.053
U-L1 (°)	122.5	10	124.7	9.8	2.2	12.3	0.516
U1 to NA (°)	28	8.3	21.3	6.4	–6.6	7.1	0.004
L1 to NB (°)	25.4	5.5	28.8	5.4	3.4	3	0.001
U6 to P.P (mm)	19.4	2.3	20	2.2	0.6	1.1	0.070
U6 to S vertical (mm)	38.9	4.3	39.2	4.7	0.3	2	0.554
L6 to GO-Me (mm)	26.4	1.6	27.7	1.9	1.2	1.3	0.003
L6 to S vertical (mm)	35.4	4.3	39.9	4.1	4.4	2.4	0.001

*Statistical significance at $p<0.05$; SD: Standard deviation

the activator device system, consistent with previous findings.[10,18,19] The length of the maxilla significantly increased (approximately 1 mm) with slight changes that were negligible compared with the mandibular growth stimulation. However, due to the lack of a control group, it cannot be claimed that this change was related to the inhibitory effect of the device or to the normal growth of the maxilla.[8,16] The facial angle increased 4.2° on average, which was statistically significant and showed that the Pog point was to move forward. The entire anterior height of the face (N-Me = 3.8 mm) compared with the posterior facial height (S-Go = 2 mm) increased significantly, possibly due to the rotation of the mandibular plane forward and downward. Means of saddle, articular, and gonial angles exhibited insignificant changes at the end of the treatment compared with the initial treatment ($p=0.56$, 0.76, and 0.11 respectively). The sum of Bjork was almost identical at the end of the treatment compared with baseline, with no significant differences ($p=0.67$). Both U1-SN and U1-NA angles significantly decreased (5.4° and 6.6° respectively), indicating retrusion of maxillary incisors under the effect of the functional device.[8,15,18] The angle of lower incisors compared with the mandibular plane (L1-Man.p) increased up to about 1.8°, which was not significant (p = 0.053). This inclination might be related to the increase in mandibular length (Go-Gn).[20-22] Al-Rawi and Abid Ali[18] explained the significant retrusion of the upper incisors and the insignificant protrusion of lower incisors. Previous studies also confirmed these findings.[23,24] However, it would probably be possible to claim that the treatment of class II malocclusion and the decrease in patients' overjet are mostly related to the retrusion of maxillary incisors. The angle of lower incisors relative to the NB plane significantly decreased (approximately 3.4°). Basciftci et al[14] reported that the increase in this angle might be related to preceding the B point or proclination of lower incisors. Incisal angle (U1-L1) increased nearly 2.2° after treatment due to greater retroclination of upper incisors compared with the proclination of lower incisors, which was not statistically significant (p = 0.51). Mesiocclusal movement of upper molars was mild and not statistically significant, whereas lower molars significantly moved mesially and occlusally, leading to the correction of molar relations (Fig. 5).[7,8,15,16]

Soft Tissue Analysis

Lower lip is averted or located under the upper incisors, which makes the labiomental sulcus deeper and the labiomental angle more acute in class II division 1 malocclusion (Table 2). In the present study, the labiomental angle significantly increased up to nearly 14.7°, as in the studies by Baysal and Uysal[25] and Sharma and Lee[26] respectively. Lange et al[27] reported similar results after using Bionator device for treatment. They reported that the increase in labiomental angle might have occurred due to two reasons: First, due to the disappearance of overjet: when the overjet decreased by the functional appliance, the physical barrier of upper incisors was eliminated; second, due to changes in tonicity and posture of labial muscle. As a result, deformity of the lower lip disappeared through the increase in labiomental angle and thickness of the lower lip. Nasolabial angle increased slightly compared with the baseline, which was not statistically significant, and this angle could be due to retrusion of maxillary incisors under the effect of the functional appliance. Facial convexity angle increased significantly up to approximately 3.8° (p = 0.000). The decrease in facial convexity and the improvement in soft tissue could be due to the advancement of mandibular position and the pogonion of hard tissue and the subsequent advancement of soft tissue pogonion. Morris et al,[28] Sharma and Lee,[26] and Baysal and Uysal[25] reported that facial convexity decreased by functional appliance after treatment. The distance between S vertical plane and the upper lip significantly increased up to nearly 2.4 mm (p = 0.004). The increase in this distance and the subsequent increase in lip thickness could be attributed to the continuous growth of the maxilla toward the anterior or to the enhancement of soft tissue of the lip during the maturing process. Although the upper incisors were retruded, the upper lip moved forward, demonstrating a nonlinear relationship between the lip and the movement of the incisors. Therefore, the movement of the lips was affected by various factors.[26,29,30] The distance between the S vertical plane and the lower lip significantly increased up to nearly 6.4 mm (p = 0.004), which might have resulted from the advancement of mandibular position and the protrusion of the lower incisors. These results are consistent with those of previous studies.[28,31] Morris et al[28] and Sumitra and Tandur[31] reported that the rates of lower-lip protrusion relative to S vertical were nearly 3.8 and 2.8 mm respectively. The distance between the upper lip and the E line increased up to about 0.6 mm, which was not statistically significant. Morris et al[28] reported a positive modification of nearly 4.1 mm, whereas McDonagh et al[32] found a negative modification of about 7.1 mm in their study. The distance from the lower lip to the E line decreased about 0.9 mm and became closer to the line, and the difference was almost significant (p = 0.054). McDonagh et al[32] found that the lower lip



Figs 5A to C: Casts of the patient treated with an activator appliance: (A) occlusion before treatment, (B) activator appliance construction, and (C) occlusion after treatment

Table 2: Comparison of the means of soft tissue parameters of patients before and after treatment*

	Pretreatment		*Posttreatment*		*Difference of posttreatment and pretreatment*		
Parameters	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*p-value*
Nasolabial angle (°)	103.5	12.4	105.5	11.1	1.7	6.2	0.317
Labiomental angle (°)	82.7	20.6	97.4	17.1	14.7	15	0.003
Facial convexity angle (°)	159.8	4.5	163.6	4.3	3.8	3.4	0.000
Upper lip to S vertical (mm)	81.4	6.1	83.8	5.9	2.3	2.5	0.004
Lower lip to S vertical (mm)	71.2	5.6	77.6	5.6	6.3	2.5	0.000
Upper lip to E plane (mm)	2.2	2.5	2.8	2.3	0.6	2	0.230
Lower lip to E plane (mm)	2	2.1	1.1	2.1	–1	1.7	0.054
Anterior lower face height (mm)	67.6	6	69.7	5.8	2.1	1.6	0.000
Total anterior face height (mm)	134.4	12.9	139.4	14.9	5	8.4	0.045
Pog to S vertical (mm)	65.3	6.1	71.3	6.1	6	3.3	0.000

*Statistical significance at $p < 0.05$; SD: Standard deviation

moved forward up to about 0.7 mm and approached the E line. However, Morris et al[28] saw a 1 mm increase in this distance and the lower lip moved backward away from the E line. The anterior facial height significantly increased up to about 5 mm. Sharma and Lee[26] observed a 4.4 mm increase in the total facial height. Morris et al[28] found a 3 mm increase. In the study by Sumitra and Tandur,[31] the total facial height increased up to 2.5 mm. The distance from the soft tissue pogonion to S vertical dramatically increased up to about 6 mm. Sharma and Lee[26] concluded that the pogonion protruded up to 4 mm at the end of the treatment. McDonagh et al[32] reported that the rate of protrusion of pogonion was 3.1 mm. Sumitra and Tandur[31] reported that the increase in Pog-S vertical distance was 3.6 mm.

CONCLUSION

Skeletal and dental changes can be induced up to 6 months after the start of the growth spurt peak by using functional appliances to improve the soft tissue profile, while dental modifications are more than skeletal ones.

CLINICAL SIGNIFICANCE

Functional appliances can be used to treat class II malocclusion even after growth spurt in girls.

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