ORIGINAL ARTICLE

The effect of functional orthopedic treatment with removable appliance on young adults

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ABSTRACT

Objective: To evaluate the treatment effects of a removable functional appliance (modified bionator) on young adults. **Materials and Methods:** A total of 12 skeletal CLII (class two) female patients, with average skeletal age 15.8-years old, used the modified bionator 16 h a day for 8 months. Lateral cephalometric X-rays were taken and analyzed before and after the treatment using paired *t*-test. Hand wrist X-rays were taken before the application of the appliance only. **Results:** After 8 months of treatment Angle CLI (class one) relationship was achieved; there was a significant reduction in the ANB (A-point Nasion B-point), SNA (Sella-Nasion-Apoint), face convexity, and overjet. SNB (Sella-Nasion-Bpoint) and face length significantly increased. **Conclusion:** The removable functional appliance — modified bionator — is an available option for correcting of borderline skeletal class II malocclusion in young adults or patients in late developmental stage.

Key words: Functional treatment, modified bionator, young adults

Introduction

Among all malocclusions, CLII contributes approximately 15%. The CLII malocclusion is used to describe the condition in which the mandibular first molars occlude distal to the normal relationship with the maxillary first molars. CLII can be further divided to dental and skeletal malocclusions.[1] Two treatment options are available for young adult patients with skeletal class II malocclusion caused by mandibular deficiency. The first option is combined surgical and orthodontic treatment, which lengthens the mandible anteriorly through mandibular sagittal split osteotomy; this, in turn, can correct the skeletal and soft tissue relationship.[2-4] The second option is functional orthopedic treatment, Herbst appliance therapy, which reactivates condylar growth to correct mandibular deficiency.[5-11] In consecutively treated class II division 1 malocclusion cases, the immediate as well as the short-term follow-up effects of the Herbst appliance[12] have been thoroughly analyzed in several investigations.[13-20]

At the end of functional treatment, an overcorrected class I dental arch relationship with incomplete cuspal interdigitation is a common finding.[21-24] In general, after the first 6 months of functional treatment, however, the occlusion settles into class I due to recovering tooth movements.[25,26]

When relating the appliance effects to the patient's level of somatic maturation at therapy, a larger increase in sagittal condylar growth was found when treatment was performed at peak height velocity of growth than when treatment was performed before or after that period.[15,27]

Previous researchers looked into the possibility of stimulating growth of the condyle in adults. Among them, Xiong *et al*.,[21-24] showed that forward mandibular positioning affected the biophysical environment of the temporomandibular joint (TMJ), and this induced recruitment of mesenchymal cells. These cells underwent endochondral ossification, which resulted in new bone formation in adult rats. Purkayastha *et al*.,[11] demonstrated

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the formation of new cartilage and bone in the condylar areas of adult patients, along with a concomitant reduction in facial convexity, following stepwise Herbst appliance therapy. The studies mentioned earlier suggest that there exists a possible nonsurgical treatment modality for skeletal class II malocclusion in adults, especially among borderline cases.

The previous studies that evaluated the effects of the functional treatment on young adults usually used fixed functional appliances like Herbst and forsus.[10,28,29]

The aim of this research was to evaluate the treatment effects of a removable functional appliance (modified activator) on young adults.

Materials and Methods

The patient group consisted of 12 females and four males, exhibiting skeletal and dental CLII due to mandibular retrognathism [Figure 1]. The four males were excluded from the research because of low cooperation. The chronological age was 15.5 years (14.5-16) and the skeletal age was 15.8 years (14.5-16.5). The growth potential of the patients was 0.9% (0.3-1.4%). The skeletal age was predicted using hand wrist X-rays, which were taken in the beginning of the treatment. All patients were in the stages between MP3 union and Ru stages according to the hand-wrist Atlas.[30]

Patient Selection Criteria

The patients were selected from the clinic of the Arab American University. The patient selection criteria included the following:

1. Skeletal and dental CLII due to mandibular retrognathism
2. Late stage of growth and development (less than 1.5% of growth potential).
3. All patients were in the stages between MP3 union and Ru stages.

Appliance Design

The original bionator appliance was modified by replacing the palatal and lingual arches with acrylic to acquire maximum skeletal pressure on the mandibular lingual bone and maximum anchorage from the palatal side [Figures 2 and 3]. All the patients were asked to use the appliance 16 h a day for 8 months. We believed that after 8 months, the residuals of the growth and development will be completely ceased. To ensure the treatment results, the patients used the appliance for another 6 moths at night for retention.

Cephalometric Analysis

To predict the results of the treatment, lateral cephalometric X-rays were taken before and after the treatment. All cephalograms were traced manually on acetate paper by the same doctor. Cephalometric planes for dental, skeletal, and soft tissue measurements are illustrated in Figures 4-7.

Figure 1: One of the patients profile photos, before and after the treatment

Figure 2: Intraoral photograph of the modified bionator

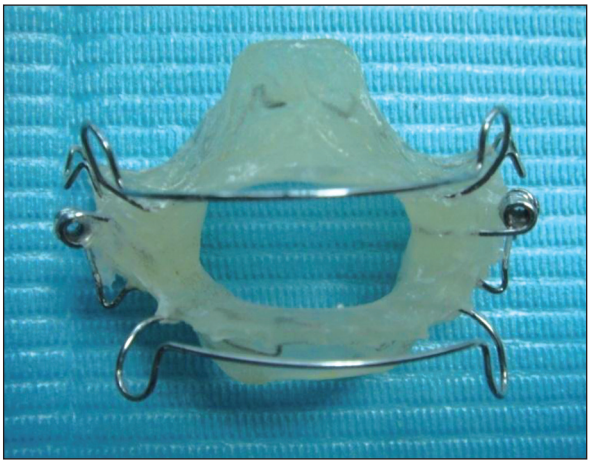

Figure 3: Extraoral photograph of the modified bionator, the lingual and palatal arches were replaced by acrylic

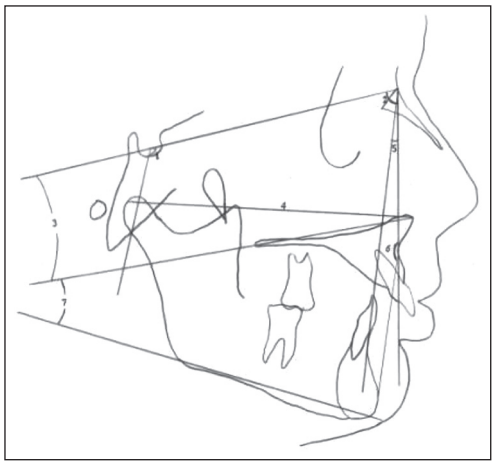

Figure 4: Cranial, maxillar, and maxillomandibular values used in the research. Cranial: 1-N-S-Ar (Eyer angle). Maxillar: 2-SNA angle, 3-SN/ANS-PNS (palatal plane to SN angle), 4-Co-ANS length. Maxillomandibular: 5-ANB angle, 6-N-A-Pg angle, 7-ANS-PNS/Go-Gn maxillomandibular angle

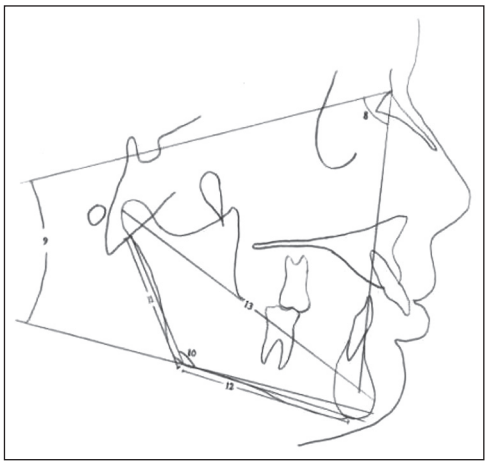

Figure 5: Mandibular measurements used in the research. 8-SNB angle, 9-SN/Go-Gn angle, 10-Ar-Go-M articular angle, 11-Ar-Go ramus length, 12-Go-M corpus length, 13-Co-Pg effective mandibular length

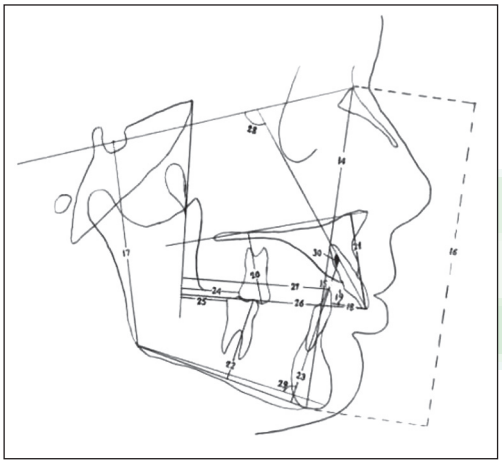

Figure 6: Face-height, dental and dentoalveolar measurements used in the research. 14-N-ANS upper face height, 15-ANS-M lower face height, 16-N-M anterior total face height, 17-S-Go posterior face length, 18-over-jet, 19-overbite, 20-U6⊥ANS-PNS upper posterior dentoalveolar height, 21-U1⊥ANS-PNS upper anterior dentoalveolar height, 22-L6⊥Go-M lower posterior dentoalveolar height, 23-L1⊥Go-M lower anterior dentoalveolar height, 24-U6⊥Ptv upper first molar to pterogoid vertical length, 25-L6⊥Ptv lower first molar to pterogoid vertical length, 26-U1⊥Ptv upper incisor to pterogoid vertical length, 27-L1⊥Ptv lower incisor to pterogoid vertical length, 28-U1/SN angle, 29-L1/Go-Gn angle, 30-U1/L1 interincisal angle

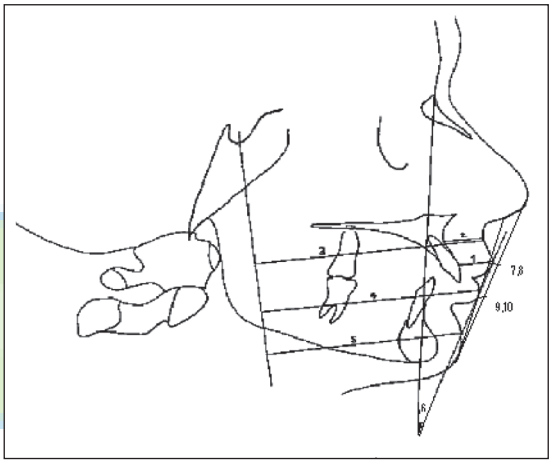

Figure 7: Soft tissue measurements. 1. upper lip thickness, 2. Lower lip thickness, 3. Lab. sup. ⊥RL, 4. Lab. inf. ⊥RL, 5. Pg_ ⊥RL, 6. H-angle, 7. E-line upper lip, 8. S-line upper lip, 9. E-line lower lip, 10. S-line lower lip

Statistical Method

The data obtained from the cephalometric tracings were evaluated statistically by using the *t*-test, Statistical Package for the Social Sciences (SPSS) version 17 was used. Operator precision was tested by random selection of seven of the cephalograms before and after treatment. The tracings and measurements were repeated 3 weeks after the first measurements. Correlation analysis applied to the same measurements showed the high ranges for r values (0.096-1.00).

No control group from same age was used for ethical reasons. It is not ethical to use individuals from the same skeletal age and miss the chance of treating them without surgery.

Results

During the treatment, the cooperation of the patients was very good. Full Angle CLI relationship was achieved after 6 months, and the posttreatment cephalometrics were taken after 8 months of the appliance usage to be sure of the end of the growth and development. The results of the cephalometric X-ray tracing are shown in Tables 1 and 2.

Skeletal Changes

SNA decreased significantly (−1.000°, $P < 0.001$); ANB showed significant decrease (−2.333, $P < 0.0001$), whereas B point moved forward (2.333 mm,

Table 1: The results of the paired *t*-test of the skeletal and dental variables before and after the treatment

	Variable		Mean	Difference	SD	Significance
Cranial	N_S_AR	Before	127.6667	−1.667	4.459	NS *P*>0.05
		After	126.0000			
Maxillary and Maxillomandibular	SNA	Before	82.1667	−1.000	0.853	***P<0.001
		After	81.1667			
	SN_ANS_PNS	Before	11.5000	0.500	2.393	NS *P*>0.05
		After	12.0000			
	Co_ANS	Before	98.5000	0.667	1.670	NS *P*>0.05
		After	99.1667			
	ANB	Before	10.1667	−2.333	0.779	****P<0.0001
		After	7.8333			
	N_A_Pg	Before	171.8333	1.000	1.206	**P<0.01
		After	172.8333			
	ANS_PNSGoGn	Before	28.3333	−0.167	3.157	NS *P*>0.05
		After	28.1667			
Mandibular	SNB	Before	72.0000	1.333	0.492	****P<0.0001
		After	73.3333			
	SN_GoGn	Before	39.8333	−0.167	1.850	NS *P*>0.05
		After	39.6667			
	Ar_Go_Me	Before	121.8333	1.667	3.055	NS *P*>0.05
		After	123.5000			
	Ar_Go	Before	41.6667	2.833	2.517	***P<0.001
		After	44.5000			
	Co_Pg	Before	112.8333	4.167	1.749	****P<0.0001
		After	117.0000			
	Go_Me	Before	69.0000	2.500	2.468	***P<0.001
		After	71.5000			
	N_ANS	Before	54.1667	1.333	1.155	***P<0.001
		After	55.5000			
Facial heights	ANS_Me	Before	67.5000	2.167	0.937	****P<0.0001
		After	69.6667			
	N_Me	Before	120.1667	3.000	0.853	****P<0.0001
		After	123.1667			
	S_Go	Before	70.6667	2.500	1.679	****P<0.0001
		After	73.1667			
Dental-dentoalveolar	Overjet	Before	10.1667	−7.333	3.339	****P<0.0001
		After	2.8333			
	Overbite	Before	1.1667	0.167	0.718	NS *P*>0.05
		After	1.3333			
	ANS_PNS_U6	Before	22.5000	0.167	1.403	NS *P*>0.05
		After	22.6667			
	ANS_PNS_U1	Before	28.1667	1.833	1.115	****P<0.0001
		After	30.0000			
	Go_Me_L6	Before	30.3333	2.667	1.969	***P<0.001
		After	33.0000			
	Go_Me_L1	Before	41.8333	0.333	1.775	NS *P*>0.05
		After	42.1667			
	PtV_U6	Before	14.3333	−1.667	1.557	***P<0.001
		After	12.6667			
	PtV_L6	Before	12.0833	3.250	3.130	***P<0.001
		After	15.3333			
	PtV_U1	Before	59.6667	−5.333	5.416	***P<0.001
		After	54.3333			
	PtV_L1	Before	50.0833	1.581	3.417	NS *P*>0.05
		After	51.6667			

Table 1: The results of the paired *t*-test of the skeletal and dental variables before and after the treatment (Continued)

	Variable		Mean	Difference	SD	Significance
Dental-dentoalveolar	SN_U1	Before	107.333	−15.000	5.657	****$P < 0.0001$
		After	92.3333			
	GoGn_L1	Before	101.333	1.000	7.483	NS $P > 0.05$
		After	102.333			
	U1_L1	Before	111.333	14.333	3.798	****$P < 0.0001$
		After	125.667			

SD: Standard deviation

$P < 0.0001$) Co-Pg length increased significantly (4.167 mm, $P < 0.0001$), N-ANS, ANS-Me significantly increased causing a significant increase in the total face height N-Me (3.000 mm, $P < 0.0001$), S-Go distance showed significant increase (2.500 mm, $P < 0.0001$).

Dent Alveolar Changes

The upper incisor teeth were retroclined and the lower incisor teeth were proclined significantly resulting in a very significant decrease in the over jet (7.333 mm, $P < 0.0001$), Ptv_U1 (5.333 mm, $P < 0.001$), and SN_U1 (15.000°, $P < 0.0001$). Ptv_U6 showed significant decrease (1.667 mm, $P < 0.001$). The upper and lower incisor teeth were extruded significantly ANS-PNS_U1 (1.833 mm, $P < 0.0001$). The lower molar teeth significantly drifted mesialy Ptv_L6 (3.250 mm, $P < 0.001$). The interincisal angle UI_L1 showed significant increase (14.333 degree, $P < 0.0001$).

Soft Tissue Changes

The soft tissue variables in general did not change significantly after treatment, except for the upper lip that has retruded significantly after treatment upper lip E-Line (-3.5833 mm, $P < 0.0001$), the lower lip thickness decreased significantly (-0.5833 mm, $P < 0.05$), and also the H-angle decreased significantly ($-11.250°$, $P < 0.05$).

Discussion

Very few studies examined the effect of the functional orthopedic treatment on young adults and individuals in the very late stage of growth and development. All these studies searched the effect of the fixed functional appliances,[10,28,29] thus the aim of this research was to examine the effect and the efficiency of a removable functional appliance on these patients. The original bionator appliance was modified by replacing the lingual and palatal arches with acrylic to maximize the forward pressure on the lingual side of the mandibular bone and the anchorage from the palatal side. This study consisted only female patients. The reason for this might be associated with the fact that women generally showed a greater interest in improving their dental and facial appearance.[25]

Table 2: The results of the paired *t*-test of the soft tissue variables before and after the treatment

Variable	Paired differences		
	Mean	Standard deviation	Significance
E-line upper lip	−3.5833	1.0624	***$P<0.0001$
E-line lower lip	−1.3333	3.3934	NS $P>0.05$
S-line upper lip	−0.5833	2.4939	NS $P>0.05$
S -line lower lip	−0.5833	1.7816	NS $P > 0.05$
Upper lip thickness	2.6667	3.5248	NS $P>0.05$
lower lip thickness	−0.5833	3.8248	*$P<0.05$
lab. Sup. _I_ RL	14.8333	29.9176	NS $P>0.05$
Lab. Inf. _I_ RL	−2.2500	6.2249	NS $P>0.05$
Pg_I_ RL	−4.6667	9.8381	NS $P>0.05$
H.Angle	−11.250	15.4927	*$P<0.05$

Skeletal Findings

The backward movement of the A-point indicates that the appliance has restriction effect on the maxilla, what is known as head gear-like effect of the functional appliances. On the other hand, the B-point moved forward 1.3° due to the growth stimulation of the mandible by the functional appliances. These results are supported by many clinical studies.[28,29]

The value of the ANB angle showed a statistically significant change after the treatment, it has decreased by about 2.33°. This consisted of both growth restriction of the maxilla and growth stimulation of the mandible. This value is near to the values found by Chaiyongsirisern A, *et al*.,[28] and Adusumilli *et al*.,[29] but it a little far away from the results of Hansen *et al*.,[8] who showed this value as 1.6°. This difference could be distributed to the sex of the patients, our group consisted of females only, whereas the Hansen *et al*.,[8] group consisted of males.

In this study, the effective mandibular length, represented by the Co-Pg distance, increased significantly after treatment. The pogonion might have moved forward as a result of the mandibular length increase or mesial relocation of the mandible as a whole.[31] The situation may be the result of the remodeling processes in the articular fossa.[32-36]

After the treatment face convexity decreased due to the backward movement of the A-point and the forward movement of the Pg, this was expressed by the significant increase in the N-A-Pg value. This result is similar to many other previous studies.[28,29,37]

The downward forward growth of the mandible resulted in an elongation of the anterior face height.[28,29,37]

Dental Findings

The significant decrease in the overjet, 7.33 mm, was a combination of skeletal and dental effects, the restriction of the maxillary growth, the enhancement of the mandibular growth, retroclination of the maxillary incisors, and the protrusion of the mandibular incisors. Our finding is similar to the result of studies of Ruf *et al*.,[9] 7.7 mm, and Chaiyongsirisern *et al*.,[28] 8.3 mm, and also it is supported by many previous studies.[8,11,29]

There was a significant mesial drift in the lower dental arch PtV_L6 (3.2 mm), PtV_L1 (1.6 mm), and a very significant distal drift in the upper dental arch PtV_U6 (1.6 mm), PtV_U1 (5.4 mm). The protraction amount of the lower incisors is very similar to the results of Kucukkeles *et al*.,[36] but it is small compared with other studies by Ruf *et al*.,[10] and Chaiyongsirisern *et al*.[28] The reason for that could be the effect of the lower vestibular arch, which prevented the extra protrusion of the lower teeth.

The nonsignificant change in the overbite 1.67 mm, although there was a significant increase in the anterior face height and the effective length of the mandible, was due the significant retraction of the upper incisor teeth and the nonsignificant protraction of the lower teeth.

Soft Tissue Findings

The upper lip moved posteriorly 3.58 mm due to the refraction and retroclination in the upper incisor teeth. This result is supported by Chaiyongsirisern *et al*.[28] On the other hand, the lower lip did not move forward, which is not supported by other studies[28,37] due to the minimal protraction of the lower incisor teeth.

The forward movement of the mandible and the Pg resulted in a significant decrease in the soft tissue convexity in the H-angle. This result is supported by Kucukkeles *et al*.[36]

Conclusion

The removable functional appliance — modified bionator — is an available option for correcting borderline skeletal class II malocclusion in young adults or patients in late developmental stage.

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