Original Article

Functional therapy effects on airway dimension in mandibular deficient patients

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Abstract

Background and Aim: Severe mandibular deficiency may result in reduced oropharyngeal airway (OAW) dimensions and predispose patients to respiratory dysfunctions such as obstructive sleep apnea and snoring. The aim of this study was to assess the effects of functional treatment on anteroposterior and vertical dimensions of airway in skeletal class III patients with mandibular deficiency.

Materials and Methods: This interventional study was done on lateral cephalogerams of 25 mandibular deficient patients with average 9.9 years of age who were treated with modified activator appliance. Digitized cephalograms were traced and analyzed by ViewBox version 3,1,1,3 cephalometric software. Paired t-test was performed to evaluate pre- and post-treatment data.

Results: Skeletal sagittal discrepancy was improved with decreasing ANB angle from 6.68 º to 4.48º and increasing SNB angle from 74.48 º to 76.78 º (p<0.001). Anterior–posterior dimensions of nasopharynx were increased from 19.64 to 21.52 mm (P=0/021) , Anterior–posterior dimensions of oropharynx increased in AW2 and AW4 (p<0/05) but in AW3 increasing from11.26 to12.27 mm was not statistical significant(p=0.091). Anterior–posterior dimensions of hypopharynx increased from 16.54 to 19.22 mm (p<0/001). Vertical dimension of airway increased from 60.73 to 64.79 mm (p<0/05.

Conclusion: Treatment of mandibular deficient patients with functional appliances improved mandibular position as well as airway dimensions.

Key Words: Airway remodeling , functional orthodontic appliance , mandibular advancement

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Introduction

Mandibular deficiency is one of most common craniofacial discrepancies among orthodontic patients. Deficiency of mandible can affect esthetics rather than occlusion, which is considered the major cause of demand for treatment. If the patient's problem is diagnosed as mandibular deficiency, it is tried to aggravate mandibular growth by functional appliances with regard to the functional matrix theory. The remodeling can occur in two areas; the condylar head and the glenoid fossa. It is predicted that after treatment the mandible be repositioned to a more forward position- a phenomenon that can only ensue during growth [1]. Mandible is intimately related to the airway apparatus it is an important organ which affect airway. Discrepancies and abnormal positions of the mandible can affect airway dimensions. Severe mandibular deficiency can reduce airway dimensions [2-4] and may predispose patients to breathing problems such as snoring , upper airway resistance syndrome and oral sleep apnea syndrome [2-3,5-7]. Such breathing problems are very important because they can reduce blood oxygen which may result in aggressive systemic side effects such as myovascular problems [9-8].

Although, researchers believe that mandibular deficiency is not the only reason for impaired breathing [10-11] and other factors such as obesity [12-13] age, sex and other craniofacial factors e.g. hyoid to mandibular plan distance and anterior facial height are also effective.

In adult patients with sleep apnea and mandibular deficiency, different treatments are indicated for advancement of mandible such as intraoral functional appliances [15-22], or in severe problems, mandibular or bimaxillary surgery [23] which is usually accompanied by increased risks, costs and difficulties in patient's acceptance. Therefore, if mandibular advancement is done during the patient's growth period through growth stimulation by functional treatment, it can be cost-effective in case it is influential in the patient's airway dimensions.

In addition to its functional and esthetic problems, severe mandibular deficiency can predispose patients to breathing problems. Hence, different treatment methods are possible, one of which being growth modification by advancement of mandible with functional appliances in order to aggravate mandibular growth.

It is expected that this treatment increases the length of mandibular body and affects glenoid fossa and condyle so that the mandible is displaced forward [10].

The question is whether after functional therapy and improvement of skeletal jaw relationships in growth period, the airway dimensions will increase. The aim of this study was to evaluate functional treatment effects on airway dimensions of mandibular deficient skeletal class II patients.

Methods and Materials

In this interventional study, class II division 7- to 13-year-old Persian patients were included. The patients were treated by the same operator. Patients with class II division 1 malocclusion, more than 6mm of overjet, more than 4 degrees of ANB angle, mandibular deficiency (SNB angle of less than 80 degree, normal maxillary position (SNA less than 84), no systemic problems, breathing problems, craniofacial syndromes, cleft lip/palate, past orthodontic treatment, nor orthognathic or any other orofacial or airway surgery were included. Existence of treatment records (lateral cephalograms, medical and dental history, photographs and casts), as well as previous treatment with modified activator appliance were mandatory. Completion of the treatment period with final class I molar and canine relationship was considered necessary for inclusion in the study.

Based on the inclusion/eclusion criteria 25 patients (15 girls and 10 boys), were selected from 33 treated patients with an average 9.9 years of age. Patients were treated with modified activator (fig1) which resembled bionator and a tooth and tissue borne appliance, in the same clinic and with one operator.

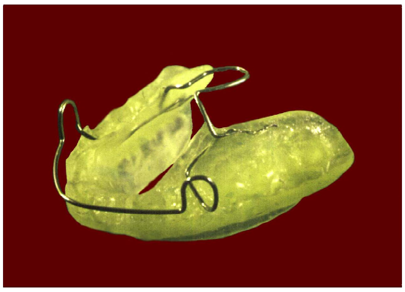

Fig 1: Modified activator used for treatment of the patients in this study. This appliance is similar to bionator with this difference that the only metal part is a labial bow in anterior region

The mean treatment period lasted 14.6 ± 3.2 month and patients wore the appliance for 16 hours per day. Pre- and post-treatment radiographs were taken in the same center with Sordex Cranex(made in fenland). The radiographs were taken at a patient-to-film distance of 15 cm, and patient-to-source

distance of 150 cm. The exposure factors were set at 60kv, 6 mA and exposure time of 1 to 1.2 seconds.
Cephalograms were fixed on a viewbox and were photographed using a digital camera (FujiFilm6900, Japan) under similar conditions, in a semi- dark room and with a 70-cm distance to the camera. Picture resolutions were set at 1 megapixel and were taken by the same operator. Then all pictures were transferred to a tracing software (ViewBox 3,1,3,1 version) by the aid of which and cephalometric landmarks were detected (fig2).
Fourteen skeletal (Table 1) and 9 airway variables (Table 2) (fig 3) were measured before and after treatment. The horizontal and vertical reference lines was the Frankfort (Po-Or) and the PTV line (the line vertical to Frankfort from Ptm), respectively. Magnification was applied to all linear data. Precision of the measurements in ViewBox software was 0.01 mm for the linear and 0.01° for the angular data. Data were analyzed by SPSS software using paired T –test.
P values of less than 0.05 was considered as statistically significant.

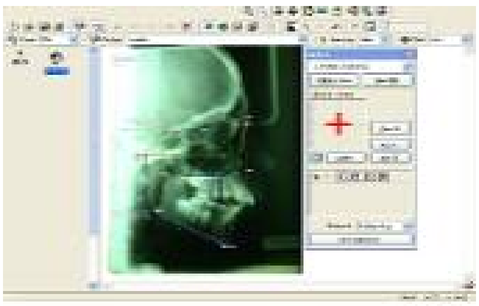

Fig 2: Analysis of cephalograms by ViewBox software

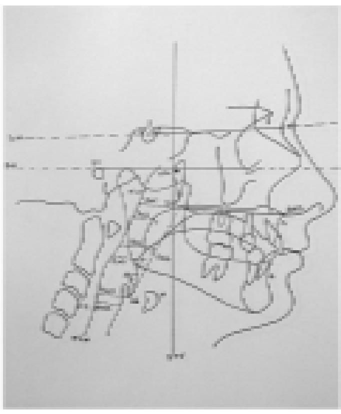

Fig 3: Airway variables used in this study

Results

Skeletal and airway dimensional changes are demonstrated in table 3.
Study results show that ANB angle decreased from 6.68±0.34 to 4.48± 0.25 degree ($p<0.0001$). Mandibular position changed by increasing SNB angle from 74.44±0.59 to 76.78±0.42 degree, ($p<0.0001$). SNA angle changed from 81.09±0.3 to 81.67±0.2 ($p=0.03$). Mandibular length increased from 194.87 to 109.65 mm, ($p< 0.001$). Mandibular plane angle did not change significantly ($p=0.96$) (table 3).
Anterior posterior airway dimension of nasopharynx (AW1) increased from 19.64 to 21.52 mm ($p=0.021$). There was a significant change in oropharyngeal anterior-posterior dimension, ($p<0.05$) but there was no significant change in AW3 although it increased from 11.26 to 12.27 mm ($p= 0.091$). Anterior-posterior dimension of hypopharynx, increased from 16.54 to 19.22 mm (p, 0.001). Vertical dimension of airway increased from 60.73 to 64.79 mm ($p<0.001$), (table 4).
Measurement error was 0.39 mm for linear and 0.45 for angular variables.

Discussion

In this study, treatment appliances for all cases were the same, a better judgment can be carried out about the results of this study. The ViewBox software is capable of changing the contrast, resolution and magnification of pictures. Therefore better and more precise detection of landmarks especially for soft tissues of the airway system can be achieved.
Four cephalograms were excluded from the study because of their low quality for soft tissue landmarks detection.
Skeletal changes after treatment by modified activator included improvement of skeletal discrepancy by SNA and SNB angle changes ($p<0.0001$) that was similar to Ordoobazari [11] and Ozbek et al's [2] studies. It seems that this improvement is due to mandibular change. SNA angle increased significantly and indicate that maxillary growth pursued and there was no headgear effect in treatment by modified activator.

Table 1: Definition of skeletal variables

Variable	Definition
SNA	angle between anterior cranial base and deepest point of maxillary alveolar process
SNB	angle between anterior cranial base and deepest point of mandibular alveolar process
ANB	difference between SNA and SNB
MXUL	maxillary unit length; anterior nasal spine (ANS) to posterior nasal spine (PNS)
MDUL	mandibular unit length: distance between Ar to pog
ULD	maxillary ad mandibular unit length difference
FMA	the angle between mandibular plan and Frankfort plan (FH)
Basal angle	the angle between mandibular plan (Go Me) ad maxillary plan (ANS-PNS)
AFH/PFH	anterior facial height to posterior facial height ratio (N-Me / S-Go)
UFH/LFH	upper facial height to lower facial height (N-ANS/ ANS-Me)
UFH	upper face height (N-ANS)
LFH	lower face height (ANS-Me)
PP-FH	the angle between palatal plan (ANS-PNS) and FH
C3-c4-SN	cervical angle; between line through anterior superior point of C3, C4 and SN

Table 2: Definition of skeletal variables

Variable	Definition
AW1	distance between PNS to posterior pharyngeal wall (PPW) parallel to palatal plan
AW2	distance between most prominence point of soft palate and PPW
AW3	distance between tip of soft palate to PPW
AW4	distance between prominence point of tongue base to PPW
AW5	distance between epiglottis base to PPW
AW6	distance between anterior and posterior pharyngeal wall on the line through C4
AW7	vertical distance of airway from epiglottis bases to PNS
AW8	vertical distance of airway from epiglottis bases to P

Table 3: Mean of skeletal variables before and after treatment

Variable	Mean & SD pretreatment	Mean & SD Post treatment	PV	Significancy	Sample number
SNA	81.09±0.3	81.67±0.2	0.03	+	25
SNB	74.44±0.59	76.78±0.42	0	+	25
ANB	6.68±0.34	4.84±0.25	0	+	25
MXUL	58.32±0.22	59.85±0.35	0.006	+	25
MDUL	104.87±1.87	109.65±2.2	0.002	+	25
ULD	46.51±1.05	51.09±1.3	0	+	25
FMA	29.1±1.02	29.12±1.15	0.96	-	25
Basal angle	28.54±1.12	27.98±1.72	0.33	-	25
UFH/LFH	0.753±0.01	0.739±0.007	0.03	+	25
UFH	53.82±1.31	54.91±1.42	0.06	-	25
LFH	71.26±1.25	73.36±0.39	0	+	25
AFH/PFH	1.597±0.24	1.527±0.12	0.105	+	25
PP-FH	1.32±0.2	1.95±0.7	0.229	-	25
C3-C4-SN	115.82±4.3	116.73±2.3	0.6	-	21

Angular variables are in degrees and linear variables are in millimeters.

Table 4: Mean of airway variables pre and post treatment

Variable	Mean & SD pretreatment	Mean & SD Post treatment	PV	Significancy	Sample number
AW1	19.64±0.71	21.52±0.5	0.021	+	21
AW2	11.72±0.32	13.3±0.8	0.012	+	21
AW3	11.26±1.2	13.27±0.9	0.091	-	21
AW4	11.630.3	12.5±0.25	0.03	+	21
AW5	16.54±1.3	19.22±0.7	0.001	+	21
AW6	17.42±0.5	19.45±0.5	0.01	+	21
AW7	60.73±1.1	64.79±0.54	0	+	21
AW8	31.58±1.23	33.08±0.45	0.15	-	21

Increased maxillary and mandibular lengths indicated improvements in sagittal skeletal discrepancy.

Above changes showed that treatment with functional appliance in growth period could help in producing natural skeletal structure and normal occlusion. According to the maxillary changes it seemed that there was not any restriction of maxillary growth. Hence, improvement of skeletal relationships could be attributed to mandibular changes.

FMA and Basal angles did not show any significant change. This indicated that there was no change in vertical facial growth pattern similar to Ozbek et al's study [2]. Although LFH / UFH decreased significantly, UFH did not change significantly and therefore it could be concluded that lower face height increased. Since AFH/ PFH ratio did not change, posterior face height increased as much as did anterior face height. Therefore, there was no changes in vertical growth pattern of face. In some studies it is mentioned that mandibular plane rotation and increase in UFH/ PFH ratio are side effects of functional treatment [10]. Fortunately, these side effects did not happen in this study; because backward rotation of mandible has a negative effect on airway dimensions [11]. Palatal plane did not change and it was important because some variables were drawn parallel to this plan.

Anteroposterior (A-P) dimension of nasopharynx (AW1) increased after treatment. According to Ashok Kumar who explained that nasopharynx is not affected by mandibular development [24] so increase in horizontal dimension of nasopharynx could be from normal growth. There was a significant change in A-P oropharynx dimension in soft palate area (AW2) similar to Ozbek and Ordoobazari [2, 11]. In AW3 the distance between tip of soft palate and posterior pharyngeal wall, there was about a 2-mm increase but it was not esthetically significant (p=0.091). It could be due to high mobility of this region and it may show significant changes by increasing the sample size of the study. This variable has shown significant changes in some studies [2,11]. The distance between posterior surface of the tongue to posterior pharyngeal wall (AW4) increased and it was considered as a positive effect of treatment. There was no control group in this study because of ethical restrictions, but in Ordoobazari et al's study there was a difference between treatment and control groups [11]. Also A-P dimension of hypopharynx in hypoglossal area (AW5) increased significantly similar to Ordoobazari et al's study [11].

Vertical dimension of airway from PNS to epiglottis increased (AW7) because of lower anterior face height growth. Such vertical increase is related to normal growth [17-18]. More increases of vertical dimension can predispose patient to OSA [13]. In this study vertical increase is in normal range.

Airway dimensions in this study increased. This was corroborated by the results of Zhao who mentioned different airway area changes after treatment by Frankel's appliance in comparison with the control group [2].

Since advancement of the mandible for even a few millimeters can improve airway cross section at sleep [26], and according to the effects of functional therapy on mandible position, in case long-term stability of the treatment results is achieved, airway conditions can be in improved. Airway variables changed significantly after treatment and growth. This showed improved airway conditions in treated class II patients and so it could be considered as a positive effect of this treatment.

Although because of absence of control group no difference between treatment and growth changes could be established. On the other hand, similar controlled studies, reported a significant effect of treatment rather than growth [11, 2]. In addition, evaluation of long term stability after retention highlighted the need for further research. Also this study was done on lateral cephalograms which is a two dimensional image from a three dimensional airway, so for a more precise evaluation, a three-dimensional imaging procedure is suggested.

Conclusions

Functional treatment with modified activator resulted in improved anterior posterior relationship of the jaws, better mandibular position, increased mandibular length and no change in vertical growth pattern during growth period.

These changes in addition to other changes in airway dimensions include increases in A-P dimension of nasopharynx, hypopharynx and oropharynx. Vertical dimension of airway was positively affected by functional treatment. It is expected that functional treatment has positive effects on airway, occlusion, and correction of class II malocclusion.

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