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Effects of Twin Block Appliance Treatment on Pulmonary Functions in Class ii Malocclusion Subjects with Retrognathic Mandibles

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Abstract

Background: Mandibular retrognathism is considered as one of the risk factors of obstructive sleep apnea. Narrowing and various anatomical adaptations in upper airway are common among subjects with retrognathic mandibles. Such adaptive changes in upper airway might also have adverse effects on lower airway i.e. lung functions. Treatment of mandibular retrognathism by functional appliances improves the anatomical adaptations in upper airway and also increases the upper airway dimensions. So correction of mandibular retrognathism by functional appliances might have beneficial effect on lower airway functions. Thus the present study was conducted to evaluate the effect of twin block appliance treatment on various lung functions in class II malocclusion subjects with retrognathic mandibles.

Material and Methods: Thirty-two class II division 1 malocclusion subjects with retrognathic mandible were divided equally into a treatment and control group. The mandibular retrusion in treatment group subjects was corrected by twin-block appliance. The effects of twin-block appliance on various lung functions were evaluated from pulmonary function tests performed before the start of treatment, approximately 8-weeks after the delivery of twin-block appliance and after a follow-up period of approximately 6-months by using body plethysmograph. Student's t-test was used for statistical analysis; P-value 0.05 was considered statistically significant level.

Results: Various lung functions in spirometry test were comparable among treatment and control subjects. The thoracic gas volume was increased significantly ($P<0.05$) at the end of 8-weeks of twin-block therapy. The residual volume of lungs increased significantly ($P<0.05$) in treatment group subjects and it decreased significantly ($P<0.05$) in control group subjects; and the difference was significant ($P<0.01$). The change in total lung capacity between treatment and control group subjects at the end of 8-weeks of follow-up was significant ($P<0.05$).

Conclusion: Correction of mandibular retrusion by twin-block appliance had temporary beneficial effects on various lung functions.

Keywords: Functional Appliance; Twin-block; lung functions; lung volume; airway resistance

Introduction

Retrognathic mandible is a common feature among children and adolescents with sleep disordered breathing (SDB) [1]. When the mandible is retrognathic, the space between cervical column and the mandibular corpus decreases and leads to a posteriorly postured tongue and soft palate; thus increasing the chances of impaired respiratory function during the day and possibly causing nocturnal problems like snoring, upper airway resistance syndrome, and obstructive sleep apnea (OSA) syndrome [2,3]. Various adaptive changes and narrowing of the upper airway are well established facts among class II malocclusion subjects with retrognathic mandibles [4,5]. Adaptive changes in upper airway might have adverse affects on lower airway functions i.e. lung functions. The correction of mandibular retrognathism by functional appliances not only increases the dimensions but also improves the anatomical adaptations in upper airway passage [6]. So correction of mandibular retrognathism by functional appliances might also have beneficial effects on various lung functions. Thus the present study was conducted to evaluate the effect of twin-block appliance treatment on various lung functions in class II malocclusion subjects with retrognathic mandibles.

Materials and methods

Thirty-two (M=17, F=15) consecutively treated subjects in the age range of 9-14 years were selected for this prospective longitudinal study. The subjects had skeletal class II malocclusion with normal maxilla and retrognathic mandible, Angle's class II molar relationship bilaterally, FMA in the range of 20^0–25^0, minimal or no crowding or spacing in either arch and overjet of 6-10mm. Subjects with a history of orthodontic treatment, anterior open-bite, severe proclination of anterior teeth, any known breathing or respiratory disorder or any systemic disease affecting bone and general growth were excluded from the study. A written understood consent was obtained from each subject and the study was approved by Institute Review Board (PUIEC/11/372).

Among 32 subjects, 16 subjects (M=8, F=8) were included in the treatment group and rest 16 subjects (M=9, F=7) formed the control group. The class II malocclusion in the treatment group subjects was corrected by standard twin-block appliance. One-step mandibular advancement was carried out during wax bite registration. An edge-to-edge incisor relationship with 2-3mm bite opening between the maxillary and mandibular central incisors was maintained for all of the subjects. The patients were instructed to wear the appliance 24-hours/day, especially during mealtimes and they were followed once in every 4-week. The inter-occlusal acrylic was trimmed in all of the subjects.

The control group included those subjects who required a phase of pre-functional therapy which included sectional fixed orthodontic appliance for the correction of mild crowding and/or rotations.

The skeletal changes by the twin-block appliance were evaluated from lateral cephalograms. Lateral cephalograms with the teeth in occlusion were obtained for all subjects before the start of treatment (T_0) and after a follow-up period of approximately 6-months (T_1) in treatment subjects, and at the beginning (T_0) and approximately after 6-months (T_1) of observation in control subjects. While recording the lateral cephalograms, patients were placed in the standing position with the FH-plane parallel to the floor and the teeth in centric occlusion. The head of the patient was erect. Subjects were instructed not to move their heads while during cephalogram exposure. All of the cephalograms were recorded in the same machine with same exposure parameters. All lateral cephalograms were traced manually and all variables were measured thrice and their mean was subjected for statistical analysis. The method error was calculated according to Dahlberg's formula [7]. The reliability of measurements is described in Table-1.

The changes in various lung functions were evaluated from pulmonary function tests (Spirometry, static lung volumes and airway resistance) performed before the start of treatment (T_0), approximately 8-weeks after the delivery of twin-block appliance (T_1) and after a follow-up period of approximately 6-months (T_2) in treatment subjects and at the beginning (T_0), approximately after 8-weeks (T_1) and 6-months (T_2) of observation in control subjects, by using body plethysmograph (P. K. Morgan Ltd., Model No-1190).

Prior to start of pulmonary function test, the height and weight of each subject was measured. The test procedure was explained and demonstrated to each subject. The nose clip was put and appropriate sized mouthpiece was placed in the mouth. The subject was asked to tightly close the lips around the mouthpiece and to breathe gently from and into the mouthpiece. Such procedure was repeated for several times to accustom the subject to breathe through the machine and also to generate a recording for tidal volume. Then the subject was asked to inhale as completely as possible at end tidal expiration. Then the subject was instructed to exhale forcefully and rapidly and for as long as possible into the mouthpiece till no more air could be expelled out from the lung. This defined the forced vital capacity. This maneuver was repeated for minimum three times and the quality of test was assessed by reproducibility of multiple tests. The reproducibility of the test was assessed by matching the results of three maneuvers. Then the observed values were compared to the predicted normal values. The predicted normal values were obtained from studies carried out in health subjects. A regression equation describing the predicted value as a function of gender and anthropometric data like height and weight etc was used to determine the predicted normal values. All measurements were done at BTPS (body temperature and pressure saturated) conditions.

The airway resistance was computed as the ratio between the slopes of mouth pressure-plethysmograph pressure and air flow-plethysmograph pressure change. The value was standardized to the lung volume by multiplying it by simultaneously determined thoracic gas volume.

Stastical analysis

The statistical analysis was carried out using SPSS-software (version-15.0). Descriptive statistics were used. Shapiro-Wilk test was used to examine the normality of the data. For normally

Table 1 Reliability for the measurement of various cephalometric variables.

Parameter	Method Error	Mode of Variance	Reliability
SNA (^{0})	0.52	3.66	0.92
Maxillary length (mm)	0.68	19.84	0.98
Effective maxillary length (mm)	0.46	21.15	0.99
SNB (^{0})	0.45	2.77	0.93
Mandibular length (mm)	0.49	19.44	0.99
Effective mandibular length (mm)	0.84	37.04	0.98
FMA(^{o})	0.35	14.23	0.99

distributed data, means were compared using student's t-test for two groups. For time related variables, paired t-test was applied. All statistical tests were two-sided. P-value 0.05 was considered statistically significant level.

Results

The mean age of subjects at the beginning of study in treatment and control group subjects was 11.06±1.28 years and 10.69±1.49 years respectively. The mean duration of follow-up of subjects in treatment and control group was 196±10.60 days and 196±14.14 days respectively. The mean duration between T_0 and T_1 for the evaluation of lung function was 60.62±4.01 and 61.25±2.23 days for the treatment and control group subjects respectively. The mean BMI of the subjects was 16.67±1.84 and 17.95±1.83 in the treatment and control groups respectively.

The skeletal changes in treatment and control subjects are described in Table-2. The maxillary change was comparable among the groups. The change in position and length of mandible between the groups was significant (P<0.001). The FMA increased significantly in treatment group subjects (P<0.01).

The changes in various pulmonary function tests are described in Table-3. Various parameters like FVC, FEV1, FEV1/FVC%, PEF and FEF25-75% in the spirometry test showed no significant change in treatment and control subjects. The thoracic gas volume (Vtg) increased at the end of 8-weeks of twin-block therapy in treatment group subjects but it decreased during the same period in control group subjects and the difference was statistically significant (P<0.05). The slow vital capacity (SVC) reduced in treatment group subjects but it increased in control group subjects but the difference was comparable. The changes in functional residual capacity (FRC) and expiratory reserve capacity (ERV) were comparable in treatment and control group subjects. The residual volume (RV) of lung increased significantly at the end of 8-weeks of twin-block therapy but it decreased significantly in control group subjects and the mean difference between the groups was significant (P<0.01). The RV/TLC% increased significantly during the T_0-T_1 period in treatment group subjects (P<0.05) where as it reduced significantly during the same period in control group subjects (P<0.05). The total lung capacity (TLC) increased in treatment group subjects and it decreased in control group subjects and the difference was significant (P<0.05). There was no significant change in airway resistance during inspiration (RAWinsp) and airway resistance during expiration (RAWexp) following twin-block therapy in treatment group subjects.

Discussion

In the present study it was observed that the sagittal jaw relationship improved significantly in treatment group subjects. When the mandible was postured forward by twin-block appliance, a reciprocal force acted distally on maxilla, restricting its forward growth and stimulating the mandibular growth. Many previous studies also reported similar observation following twin-block therapy [8-14].

It is well established that the dimensions of upper airway increased with forward positioning of mandible as by various oral appliances [15-18] and functional appliances [19-27].In the present study we found increased thoracic gas volume and residual volume of lungs at the end of 8-weeks of twin-block therapy in treatment group subjects. This could be secondary to improvement in upper airway passage dimension following forward repositioning of mandible by twin-block appliance. When the upper airway volume was increased following mandibular advancement by oral appliances in obstructive sleep apnea patients, the upper airway resistance also decreased [28]. In contrast to the oral correction of mandibular retrognathism by twin-block appliance had no significant appliance [28], effect on airway resistance. The changes in airway by twin-block appliance usually related to upper airway region which forms a very small part of the total respiratory tract. However, various pulmonary function tests determine the function of whole respiratory tract. So this could be the possible reason why we did not find any change in the airway resistance. Lorino et al. [29] observed that the effects of mandibular advancement on upper airway resistance differ from patients to patients, depending on whether advancement was passive or active, and suggested that in order to simulate the actual effects of therapeutic devices, mandibular advancement should be passive. However, in our study the mandible was advanced actively by the twin-block appliances and this could also be another reason why we did not get any significant change in airway resistance. However, Foltan et al. [30] reported significant improvement of ventilation during sleep in obstructive sleep apnea patients treated with mandibular advancement. As the subjects of present study had no breathing disorders and the mandibular retrognathism was less severe, so improvement of jaw relationship and upper airway dimensions following twin-block therapy had no effect on the lower airway.

Although the present study revealed that correction of mandibular retrognathism by twin-block appliance had modest effects on the pulmonary functions but these effects were only temporary and disappeared towards the end of functional appliance therapy.

Conclusion

Correction of mandibular retrusion by twin-block appliance had temporary effects on various pulmonary functions among Class II malocclusion subjects with retro gnathic mandible.

Authors Contribution

Dr. Ashok Kumar Jena formulated the research question and designed the study. Dr. Pankaj Pupneja performed the clinical assessments, carried out the x-ray examinations and collected the data; Dr. Ashutosh supervised in pulmonary function test. Dr. Satinder Pal Singh and Dr. Ashok Kumar Utreja supervised the study, checked the data. Dr. Ashok Kumar Jena prepared the manuscript and did correspondence. All authors read and approved the final manuscript.

Conflict of Interest

None

Table 2 Changes in the skeletal tissue among treatment and control group subjects.

Variables	Groups						Comparison of mean difference among treatment and control groups (P-value)
	Treatment Group			Control Group			
	Pre-treatment (T_0)	6-months Post-delivery of appliance (T_1)	Significance (P-value)	Pre-follow-up (T_0)	6-months Post-follow-up (T_1)	Significance (P-value)	
	Mean±SD	Mean±SD		Mean±SD	Mean±SD		
SNA (^{0})	79.50±4.06	79.19±4.14	0.106^{NS}	80.56± 3.91	80.63±3.77	0.751^{NS}	.168^{NS}
Maxillary length (mm) (ANS-PNS)	44.72±2.23	44.97±2.32	0.178^{NS}	44.25±3.00	44.69±2.89	0.004**	.397^{NS}
Effective maxillary length (mm) (Co-A)	79.66±4.38	79.81±4.42	0.672^{NS}	80.75±5.28	80.75±5.22	1.000^{NS}	.738^{NS}
SNB (^{0})	72.28±3.62	74.53±3.40	0.000***	73.19±3.5	73.63±3.50	0.014*	.000***
Mandibular length (mm) (Go-Pog)	64.44±2.85	65.88±2.77	0.000***	63.94±4.13	64.44±4.22	0.002**	.000***
Effective mandibular length (mm) (Co-Gn)	95.69±4.09	99.63±4.74	0.000***	95.50±6.35	96.06±5.67	0.267^{NS}	.000***
FMA(^{0})	24.63±4.54	26.00±4.39	0.000***	24.19±4.14	24.38±4.01	0.882^{NS}	0.001**

SNA, angle between ‘S,’ ‘N,’ and ‘A’; it represents the antero-posterior position of the maxilla in relation to the anterior cranial base; Maxillary length, the linear distance between ‘ANS’ and ‘PNS’ points; Effective maxillary length, the linear distance between ‘Co’ and ‘point-A’; SNB, angle between ‘S,’ ‘N,’ and ‘B’; it represents the antero-posterior position of the maxilla in relation to the anterior cranial base; Mandibular length, the linear distance between ‘Go’ and the intersection of the perpendicular drawn from ‘Pog’ on mandibular plane (Go-Me); Effective mandibular length, the linear distance between the ‘Co’ and ‘Gn’; FMA indicates Frankfort mandibular plane angle.

Table 3 The changes in the pulmonary function test among treatment and control group subjects.

Variables	Groups								Comparison of mean difference among treatment and control groups (P-value)
	Treatment Group				Control Group				
	Pre-treatment (T_0)	8-weeks Post-delivery of appliance (T_1)	6-months Post-delivery of appliance (T_2)	Comparison (P-value)	Pre-follow-up (T_0)	8-weeks Post-follow-up (T_1)	6-months Post-follow-up (T_2)	Comparison (P-value)	
	Mean±SD	Mean±SD	Mean±SD	T_0-T_1/ T_0-T_2/ T_1-T_2	Mean±SD	Mean±SD	Mean±SD	T_0-T_1/ T_0-T_2/ T_1-T_2	T_0-T_1/ T_0-T_2/ T_1-T_2
Spirometry									
FVC (L)	2.19±0.49	2.23±0.47	2.29±0.51	NS/ */ NS	2.04±0.63	2.13±0.68	2.19±0.70	*/ */ NS	NS/ NS/ NS
FEV1 (L)	2.00±0.41	2.01±0.39	2.06±0.39	NS/ NS/ NS	1.84±0.57	1.89±0.62	1.94±0.65	NS/ NS/ NS	NS/ NS/ NS
FEV1/FVC%	92.05±4.70	90.94±5.20	90.63±4.73	NS/ NS/ NS	90.44±3.96	88.56±4.69	88.63±5.62	NS/ NS/ NS	NS/ NS/ NS
PEF (L/min)	241.81±66	244.56±68.76	250.11±59.07	NS/ NS/ NS	226.13±81.11	224.81±75.27	240.81±82.56	NS/ NS/ NS	NS/ NS/ NS
$FEF_{25-75\%}$ (L/min)	168.35±39.03	153.32±38.14	161.96±39.77	NS/ NS/ NS	147.72±56.76	147.90±52.83	147.08±60.32	NS/ NS/ NS	NS/ NS/ NS
Lung Volume									
Vtg (L)	3.85±0.61	4.17±0.89	3.94±0.56	NS/ NS/ NS	4.19±0.80	3.87±0.76	4.06±1.26	NS/ NS/ NS	*/ NS/ NS
SVC (L)	2.34±0.53	2.18±0.46	2.26±0.52	NS/ NS/ NS	2.13±0.59	2.17±0.58	2.26±0.71	NS/ NS/ NS	NS/ NS/ NS
FRC (L)	3.69±0.76	3.97±0.89	3.69±0.73	NS/ NS/ NS	4.09±0.87	3.71±0.82	3.96±1.33	NS/ NS/ NS	*/ NS/ NS
ERV (L)	1.24±0.38	1.07±0.39	1.05±0.42	NS/ NS/ NS	1.06±0.42	1.05±0.39	1.13±0.51	NS/ NS/ NS	NS/ NS/ NS
RV (L)	2.37±0.62	2.82±0.96	2.58±0.62	*/ NS/ NS	2.93±0.63	2.59±0.70	2.74±1.17	*/ NS/ NS	**/ NS/ NS
TLC (L)	4.71±0.79	5.00±1.04	4.84±0.69	NS/ NS/ NS	5.07±0.89	4.76±1.02	4.97±1.31	NS/ NS/ NS	*/ NS/ NS
RV/TLC%	49.94±8.35	55.69±9.69	53.10±9.15	*/ NS/ NS	57.94±8.03	54.13±7.73	53.19±13.45	*/ NS/ NS	**/ */ NS
Airway Resistance									
$R_{AW\ insp}$	2.32±0.39	2.43±0.69	2.46±0.58	NS/ NS/ NS	2.72±0.74	2.81±0.67	2.40±0.49	NS/ NS/ *	NS/ */ NS
$R_{AW\ exp}$	2.28±0.4132	2.23±0.549	2.29±0.46	NS/ NS/ NS	2.34±0.54	2.44±0.45	2.26±0.42	NS/ NS/ NS	NS/ NS/ NS

FVC: Forced vital capacity; FEV1: Forced expiratory volume; FEV1/FVC%; PEF: Peak expiratory flow; $FEF_{25-75\%}$; Vtg: Thoracic gas volume; SVC: Slow vital capacity; FRC: Functional residual capacity; ERV: Expiratory reserve capacity; RV: Residual volume; TLC: Total lung capacity; $R_{AW\ insp}$ =Airway resistance during inspiration, $R_{AW\ exp}$ =Airway resistance during expiration.
L = Litre
SD indicates standard deviation; NS, nonsignificant; * $P < .05$; ** $P < .01$.

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