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Upper airway obstuction in class II patients. Effects of Andresen activator on the anatomy of pharingeal airway passage. Cone beam evalution

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SUMMARY

Aim. The aim of this study is to assess the response and changes on pharyngeal airway passage (PAP) to class II Andresen appliance in class II growing patients with obstructive sleep apnea syndrome (OSAS).

Methods. The sample consisted of forty patients with a class II malocclusion in the age range of 9 to 14 years with mandibular retrusion and OSAS and ten control group subjects. A CBCT was taken before treatment (T0) and a second one after a follow-up period of approximately 16 months (T1). The dimensions of PAP were determined according to the method described by Jena et al. with Mimics program.

The following parameters were considered: DOP, DPH, MP-H, PAS, PNS-U, SNA, SNB, ANB. The statistical analysis was carried out with t test.

Results. The change in ANB, SNB, MP-H, PNS-U, PAS was significantly more in the patients undergoing treatment as compared to the control group.

The improvement of DOP and DPH among the treatment group subjects was significantly more compared to the control group subjects.

Conclusions. Class II correction by functional appliances during childhood might help to eliminate the adaptive changes in the upper airway and predisposing factors to OSAS, thus decreasing the risk of OSAS development in adulthood.

Key words: Skeletal class II, Oropharyngeal airway, Functional Orthopedic treatment, OSAS, Andresen activator.

INTRODUCTION

Upper airways seem to play a key role in the development of the dento-facial complex (1-3). Analyzing subjects with sleep-disorders breathing (SDB), the position of the mandible is often retruded in relation to the cranial base and this can cause narrowing of the palate) and adaptations in the soft palate (1, 3, 4). Decreased space between the cervical column and the mandibular body may lead to a posterior position of the tongue and soft palate, increasing the chances of impaired respiration function during the day and possibly causing nocturnal problems such as snoring, upper airway resistance syndrome and obstructive sleep apnea syndrome (OSAS). OSAS present recurrent events of upper airway obstruction during sleep associated with clinical signs and symptoms (5-6). According to the American Association of Sleep Medicine, OSAS diagnosis requires the occurrence of at least five episodes of apnea hypopnea per hour of sleep combined with clinical symptoms, the most important of which are loud snoring and excessive daytime sleepiness (5-6). The apnea event is considered when the airflow is interrupted during sleep for a period of 10s or more, and hypopnea when there is a reduction of at least 50% of the breathing capacity combined with a saturation decrease of the oxyhemoglobin in at least 3%. OSAS treatment should be addressed to normalize breathing during sleep, consequently eliminating excessive daytime sleepiness and neuropsychiatric and cardiovascu-

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lar changes (2). OSAS treatment modalities range from sleep hygiene, which involves withdrawal from alcohol and other drugs, proper body position, and slimming (2), to surgical procedures such as glossectomy, uvulopalatopharyngoplasty, and maxillo-mandibular advancement procedures (2-3, 7). At the same time, it should provide patients with a good quality of life with no side effects or risks (2, 8). Functional appliances are considered a valid treatment option for patients with obstructive sleep apnea/hypopnea syndrome (9). The use of functional appliances for the correction of retruded mandible is very common in today orthodontics. These devices aim at increasing the volume of the airways through a mechanical maneuver (5, 10-11). Several authors stated in their studies (5, 12-16) that oral appliances are a good alternative for the treatment of snoring and OSAS due to their low cost, relative comfort, and ease of use, which can therefore lead to greater patient compliance (5).

Similar appliances are also frequently used in adults for the treatment of mild to moderate OSAS (1, 17). Many previous studies reported improvement of PAP dimensions following functional appliance therapy in children (1, 7-8, 18-23) and oral appliance therapy in adults (1, 24-27, 28-31).

The benefits of oral appliances on upper airway dimension in OSAS patients are well described in literature (24-27). Restrepo et. al in a sample of 50 lateral cephalograms of class II retruded patients in a pre-pubertal stage, before and after the use of functional appliances (Klammt or Bionator II) found a statistically significant increase in the airway dimensions after treatment. Ozbek *et al.* evaluate the use of functional-orthopedic devices in increasing oropharyngeal airway dimensions in children with Class II skeletal patterns and clinically deficient mandibles. They concluded that oropharyngeal airway dimensions increased significantly in treated patients, especially those with sagittally smaller and more retruded maxillo-mandibular complexes and smaller oropharyngeal dimensions. Also Michael *et al.* found that the activator headgear therapy has the potential to increase pharyngeal airway dimensions. Jena *et al.* (23) recently, reported increase in the PAP dimension following twin-block therapy among subjects with retruded mandible. Achilleos *et al.* in a study regarding surgical mandibular advancement and changes in uvuloglossopharyngeal morphology and head posture underlined that when the mandible was displaced anteriorly by the twin-block appliance, it influenced the position of the hyoid bone and consequently the position of the tongue and thus improved the morphology of the upper airway (32).

Traditionally, the effects of functional appliances are evaluated using casts and/or two-dimensional (2D) radiographs, but the reproducibility of 2D is complex, and overlapping images are difficult to assess (33). Cone-beam computed tomography (CBCT) provides more accurate and reproducible imaging for assessing all craniofacial skeletal structures, including the circummaxillary sutures (33-34). Advancements in cone beam computed tomography technology has introduced the possibility of rendering high-quality dento-facial images at a submillimeter level. Three-dimensional records allow the unique advantage of viewing objects in a 1:1 ratio without the concerns of distortion, magnification, or superimposed anatomical objects typical with plane film images (35). Additionally, Timock *et al.* (35) observed that the overall agreement between CBCT and direct measurement was strong. Moreover, CBCT can be used to quantitatively assess buccal bone height and thickness with high accuracy and reliability (35).

Thus, the present study was conducted to evaluate the effects on Andresen appliance on PAP dimensions in class II malocclusion subjects with retruded mandibles and OSAS evaluated on CBCT.

MATERIAL AND METHODS

Subjects

Forty patents with a class II malocclusion in the age range of 9 to 14 years (17 females between 8-10 years, and 23 males between 10-14 years) with mandibular retrusion and OSAS were considered. Ten control group subjects (n=10, 5 female between 9-10 years and 5 males between 11-14 years) were enrolled. The mean BMI of the subjects in the treatment and control group was 16.63±2 and 17.84±1.76 respectively. The subjects had a skeletal class II malocclusion with normal maxilla (SNA 82 ±2) and a retruded mandible (SNB<80°).

Study material was obtained from orthodontic, ear nose and throat (ENT) and neurologic Departments of Milan University.

Selection criteria

The inclusion criteria were:

- Unremarkable medical history except OSAS;
- Caucasian ethnicity;
- Availability for scheduled appointments;
- No history of orthodontic treatment;
- Pre-treatment and post-treatment CBCT;
- Availability of a signed and written informed consent statement;
- Growing patients.

All the patients have documented nocturnal symptoms monitored for at least 1 night during sleep. The polygraphic records were scored for sleep in 30-s epochs according to the standard criteria (36-37). Respiration during sleep was scored for apnea, hypopnea and oxygen desaturation, following the criteria previously outlined by Guilleminalult *et al.* (36, 38). Based upon the results of the polygraphic recording during sleep, the severity of the problem varied. The Apnea-Hypopnea Index (A+H)I defined as the number of apneas and hypopneasx60/total sleep time in minutes, ranged from 11 to 76 in the total patients.

Exclusion criteria

The exclusion criteria were

- Congenital and dental anomalies
- Systemic or local condition that might have jeopardized the results
- Failure to attend more than two appointments
- Facial or dental asymmetries.

Radiographic examination

A CBCT was taken before treatment (T0) and a second one was taken after a follow-up period of approximately 16 months (T1). All CBCT were recorded in the same machine with same exposure parameters. Scans were taken using a CBCT scanner. Each scan was taken for 20 seconds at 3.8 mA enhanced setting. The scans were then reconstructed at 0.3mA. A 3D volumetric image of the patient was obtained using the iCAT® cone-beam dental-imaging system (1910 N. Penn Road, Hatfield, PA 19440). The scanning protocol involved a 4 mm slice thickness, a 16×22 cm field of view, a 20-second scan time, and a 0.49/0.49/0.5 mm voxel size.

The scans were saved in Digital Imaging and Communications in Medicine (DICOM) format, transferred to a personal computer and reconstructed with a 3D image segmentation program (Mimics 11.1 Materialise, Leuven Belgium).

CBCT were taken by the same technician (C. R.), traced by the Mimics Software by one operator (L. G.), and verified for landmark location and anatomic contours by a second operator (C. M.). Any disagreements were solved by retracing the landmark or structure to the mutual satisfaction of both of the operators.

The pre-treatment CBCT were taken because it was necessary an accurate diagnosis to see posterior airway space and so decide the correct wax registration bite to increase it with the removable appliance. The post-treatment CBCT were taken to see if optimal clinical results have been obtained.

The ALARA principles requirements have been followed including:

- minimizing the time of exposure;
- doubling the distance between the body and the radiation source;
- shielding using absorber materials.

This investigation is a retrospactive study approved by the Ethical Commetee of Fondazione IRCCS Cà Granda, Ospedale Maggiore Policlinico UOC Chir. Maxillo Facc ed Odontostomatologia.

Measurements

The following measurements have been considered:

Landmarks

S – sella; N – nasion; Go – gonion; A – Point A; B – Point B; Pog – pogonion; Gn – gnathion; Me – menton; PNS – posterior nasal spine; U – tip of soft palate; Ptm – pterygomaxillary fissure; Ba – basion; UPW – (upper pharyngeal wall), the intersection of line Ptm-Ba and posterior pharyngeal wall; MPW (middle pharyngeal wall), the intersection of perpendicular line on Ptm perpendicular from ‘U’ with posterior pharyngeal wall; V – vallecula; and LPW (lower pharyngeal wall), the intersection of perpendicular line on Ptm perpendicular from ‘V’ with posterior pharyngeal wall; hyoid (H) (Fig. 1).

Linear parameters

SN plane, the line joining ‘S’ and ‘N’; DOP (U–MPW); DHP (V–LPW); SPL (U–PNS); SPT, the maximum thickness of the soft palate, N.ANS, MP-H, PNS-U, PAS, mandibular plane (Go-Me).

The posterior airway space (PAS) was evaluated by a line drawn from point B through Go. This line intersects the base of the tongue and posterior pharyngeal wall. The linear measurement between the base of the tongue and the posterior pharyngeal wall is the posterior airway space (PAS, M=11 mm, SD±1) (36).

The soft palate was evaluated by a line constructed from PNS to the tip of the soft palate contour (U) (M=37 mm, SD±3 mm).

The position of the hyoid bone was determined by a line perpendicular to the mandibular plane (MP, Go-Gn) through the hyoid (H) (M=15.4 mm, SD±3 mm) (MP-H) (36).

Angular parameters

SNA, angle between ‘S,’ ‘N,’ and ‘A’; SNB, angle between ‘S,’ ‘N,’ and ‘B’; ANB, angle between ‘A,’ ‘N,’ and ‘B’.

The dimensions of the PAP were determined according to the method described by Jena *et al.* (3, 39)

To exclude intra-operator error, the same operator repeated each measurement after a period of 7 days. The mean between the two values were

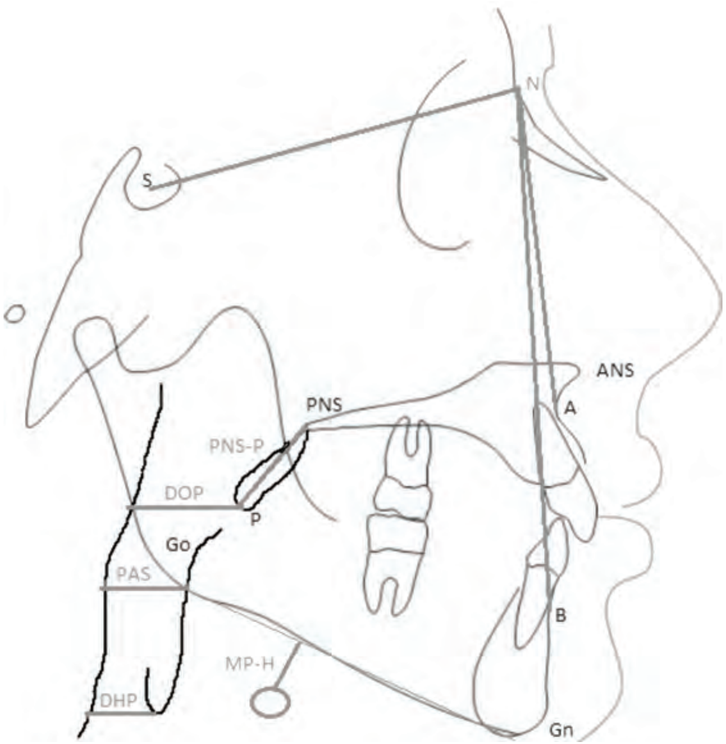

Fig. 1. Anatomical points and measures considered

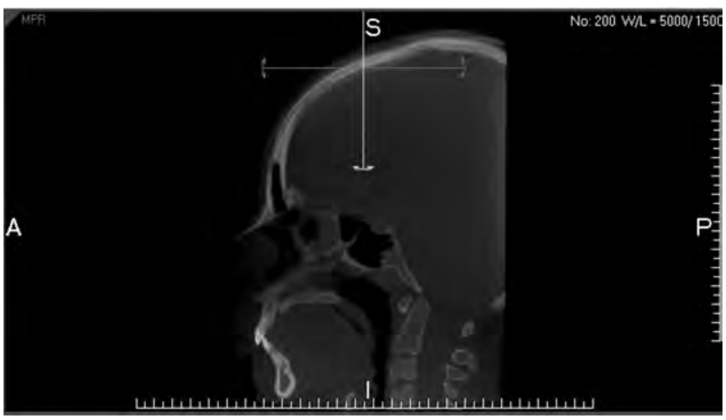

Fig. 2. CBCT showing upper airways before treatment

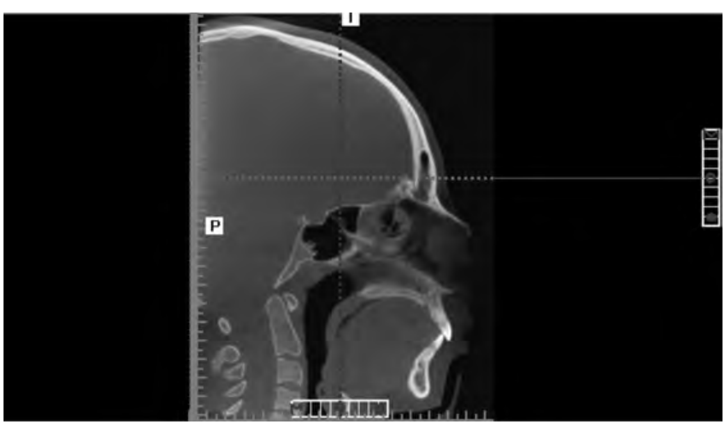

Fig. 3. CBCT showing upper airways after treatment

considered. No other treatment took place during the period extending from T0 to T1.

Treatment

The patients with the class II malocclusion in treatment group was corrected by an Andresen appliance. All the functional devices were constructed by the same technician. Mandibular advancement was carried out during the wax bite registration. An edge-to-edge incisor relationship with 2 to 3 mm opening between the maxillary and mandibular central incisors was maintained for all subjects.

The patients were instructed to wear the appliance 16 h/day, and they were followed once in every 4 weeks. The inter-occlusal acrylic was trimmed in all subjects to allow unhindered vertical development of the mandibular buccal segments.

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

Statistical analysis

The statistical analysis was carried out using the t test for paired sample in order to analyze the difference between T0 and T1 in both the patients and control group and with the t test for unpaired sample in order to analyze the difference between patients and control group. Descriptive statistics consisted in analyzing data average and standard deviation. The *P*-value of 0.05 was considered significant and *P*-value of 0.001 was considered highly significant. The method error was calculated according to Dahlberg's formula.

RESULTS

The skeletal changes in the treatment and control group subjects are described in Table. The change in the sagittal position of the mandible (SNB angle) was significantly more in the treatment group compared to the control group ($P<0.001$).

The change in ANB, MP-H, PNS-U, PAS was significantly more in the treatment group as compared to the control group ($P<0.001$).

The DOP improved by 2.43 mm in the treatment group patients ($P<0.001$) and it increased by 0.15 mm ($P<0.001$) in control group subjects. The improvement of DOP among the treatment group subjects was significantly more compared to the control group subjects ($P<0.001$).

The DHP was improved significantly in treatment group subjects ($P<0.001$).

The PAS increased significantly in treatment group subjects ($P<0.001$) and the difference between the treatment and control group was statistically significant ($P<0.05$) indicating that the airway space improved significally producing an expansion of the PAP.

MP-H decreased significally of 4.93 mm ($P<0.001$) indicating that the body of the hyoid bone moved superiorly by the traction of the mandible.

The length of the soft palate, PNS-U, in treatment group subjects was improved compared to control group subjects.

In the polygraphic recording during sleep at T1 the (A+H) Index demonstrated that none of the treated patients had an (A+H) I above 5.

Snoring was reduced in all the treated patients.

The follow-up polysomnography confirmed improved breathing parameters in the treated group while in the control group no changements were observed (Figures 2, 3).

DISCUSSION

Anatomical adaptation of the soft palate and small PAP dimension are common features in subjects with retruded mandible (39-42). Functional appliances aiming at correcting mandibular retrusion improve the dimensions of the upper airway (7-8, 18-23).

Reproducibility of airway dimensions on (43) CBCT imaging is a more appropriate and highly accurate and precise method for the evaluation of the PAP dimension and it is a valuable and reliable diagnostic tool.

The present study showed that the sagittal jaw relationship improved significantly in treatment group subjects.

The Andresen appliance acted posturing the mandible forward and creating a reciprocal distal force on the maxilla, restricting its forward growth and stimulating the forward mandibular growth.

The sagittal dimension of the PAP was increased secondary to the forward positionig of the tongue caused by the anterior relocation of the mandible. Many previous studies also reported similar observation following activator therapy (44-48). Cozza *et al.* (2008) reported that the use of oral appliances in OSAS patients produce a significant expansion of the posterior pharyngeal wall by 13% in the areas most involved in the collapse (49).

In this study, a significant improvement in the depth of the oropharynx and hypopharynx, and inclination of the soft palate following the correction of mandibular retrusion was observed. Also Schutz *et al.* (22) found that after class II correction, the anterior displacement of the mandible and the hyoid bone caused an anterior traction of the tongue, which increased the posterior airway space by 3.2 mm and reduced the airway resistance.

Table. Patients' and control group's statistical values and differences among groups

Control group																
Patients	**SNA**		**SNB**		**ANB**		**MP-H**		**PNS-P(0)**		**PAS**		**DOP**		**DHP**	
	T0	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**
Average	81.3	81.67	73.97	77.2	7.33	4.43	28.13	23.20	43.00	42.20	3.74	8.20	4.53	6.97	10.97	13.03
Difference T1-T0	0.37		3.23		-2.90		-4.93		-0.80		4.46		2.43		2.07	
Standard deviations	0.96	0.84	2.35	2.14	2.31	1.96	1.06	3.61	1.85	1.82	1.11	1.42	0.92	1.20	1.19	1.48
t-test (P values)	0.001		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Treatment group																
Patients	**SNA**		**SNB**		**ANB**		**MP-H**		**PNS-P(0)**		**PAS**		**DOP**		**DHP**	
	T0	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**	**T0**	**T1**
Average	73.91	81.85	69.09	76.75	4.82	5.10	24.73	27.10	39.55	43.50	3.46	4.20	4.32	4.90	8.36	10.45
Difference T1-T0	7.94		7.66		0.28		2.37		3.95		0.74		0.58		2.09	
Standard deviations	24.53	1.03	22.93	0.95	1.76	0.99	8.63	2.73	13.20	1.58	1.36	0.82	1.97	1.43	4.13	1.48
t-test (P values)	0.001		0.000		0.309		0.343		0.453		0.000		0.193		0.257	
t-test (P values) Differences among groups		0.645	0.006	0.482	0.006	0.276	0.339	0.005	0.478	0.072	0.853	0.000	0.676	0.002	0.126	0.000

S – sella; N – nasion; Go – gonion; A – Point A; B – Point B; Pog – pogonion; Gn – gnathion; Me – menton; PNS – posterior nasal spine; U – tip of soft palate; Ptm – pterygomaxillary fissure; Ba – basion; UPW (upper pharyngeal wall) – the intersection of line Ptm-Ba and posterior pharyngeal wall; MPW (middle pharyngeal wall) – the intersection of perpendicular line on Ptm perpendicular from 'U' with posterior pharyngeal wall; V – vallecula; and LPW (lower pharyngeal wall) – the intersection of perpendicular line on Ptm perpendicular from 'V' with posterior pharyngeal wall; hyoid (H); MP-H – mandibular plane-hyoid; PAS – posterior airways space; DOP – distance from U to MPW; DHP – distance from V to LPW.

In class II controls considered in this study, the PAP dimension change was very minimum. The backward position of the tongue in subjects with retruded mandible pushes the soft palate posterior and decreases the dimension of the upper airway (3). Hänggi *et al.* (7) also reported no significant change in the PAP dimensions during adolescence without therapy.

Thus, the present study showed that there is a positive impact of Andresen appliance therapy on the PAP dimension.

Similar benefits are also produced by various functional appliances (7-8, 18-23).

Class II correction by functional appliances during childhood might help to eliminate the adaptive changes in the upper airway and predisposing factors to OSAS, thus decreasing the risk of OSAS development in adulthood.

The literature also supports that the changes in the PAP dimension following functional appliance therapy are maintained in long term (7, 50).

CONCLUSIONS

From the present study the following conclusions can be drawn:

1. Correction of mandibular retrusion in patients with a class II malocclusion can increase the sagittal dimension on the posterior oropharyngeal airway.
2. The length of the soft palate improves following the correction of mandibular retrusion.
3. The data suggest that in addition to control polysomnographic examinations, orthodontic treatment can be considered for patients with obstructive sleep apnea/hypopnea.
4. To maximize treatment success in patients with OSAS a close collaboration with neurologist and ENT specialist is advisable and necessary.

Statement of conflicts of interest

The authors declare that there are no conflicts of interest.

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