Oropharyngeal airway dimensions and functional-orthopedic treatment in skeletal Class II cases

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Severe mandibular deficiency has been linked to reduced oropharyngeal airway (OAW) dimensions.[1,2] Decreased space between the cervical column and the mandibular corpus may lead to a posteriorly postured tongue and soft palate, increasing the chances of impaired respiratory function during the day, and possibly causing nocturnal problems as well, such as snoring, upper airway resistance syndrome (UARS), and obstructive sleep apnea syndrome (OSAS).[3-7]

OSAS results from repeated partial and/or total obstruction of the upper airway during sleep. Certain anatomic and/or physiologic factors contribute to OSA, including decreased upper airway dimensions, mandibular deficiency, and increased tongue and soft palate size.[8-11]

Pierre Robin[12] used an intraoral appliance to bring the lower jaw forward in newborns with mandibular deficiency, thereby preventing posterior relocation of the tongue during sleep and the occurrence of oropharyngeal collapse. Today, this concept is widely used in dentofacial orthopedics to stimulate mandibular growth in skeletal Class II growing cases with mandibular deficiency. Similar oral appliances are also used in adult OSA patients to prevent upper airway collapse during sleep.[13-15] These oral appliances are thought to prevent apneas by bringing the lower jaw and hyoid bone, tongue, and soft palate forward to increase the OAW dimensions. Surgical advancement of the maxillomandibular complex has also been proposed to treat certain OSA cases with retrognathic facial structures, again by increasing OAW dimensions.[16,17]

We have hypothesized that the functional-orthopedic treatment of growing patients who have skeletal Class II patterns with deficient

Abstract

Mandibular deficiency may be a factor in reduced oropharyngeal airway (OAW) dimensions and related impaired respiratory function. The purpose of this study was to evaluate the use of functional-orthopedic devices in increasing OAW dimensions in children with Class II skeletal patterns (ANB>4) and clinically deficient mandibles. Comparisons were made between two groups, one comprising 26 treated patients and the other comprising 15 controls. Student's *t*-tests, paired *t*-tests, discriminant analyses, and Pearson's *r*-correlation coefficients were performed to evaluate group differences and to search for characteristics that might suggest which patients would be better candidates for significant increase in OAW dimensions. Compared with controls, OAW dimensions increased significantly in treated patients, especially those with sagittally smaller and more retrognathic maxillomandibular complexes and smaller OAW dimensions.

Key Words

Skeletal Class II • Oropharyngeal airway • Functional-orthopedic treatment

Submitted: April 1997 **Revised and accepted:** July 1997 Angle Orthod 1998;68(4):327-336.

Figure 1
Anatomic landmarks used in the study

Figure 2
Skeletal measurements used in this study: 1. Sagittal maxillary position (SNA); 2. Maxillary unit length (MxUL); 3. Sagittal mandibular position (SNB); 4. Mandibular unit length (MdUL); 5. Sagittal intermaxillary relation (ANB); 6. Sagittal intermaxillary unit length discrepancy (ULD=MdUL-MxUL); 7. Mandibular plane angle (SNMP); 8. Ratio of upper to lower facial height (UFH/LFH). Measurements of craniocervical angulation: 9. NSL.OPT; 10. NSL.CVT.

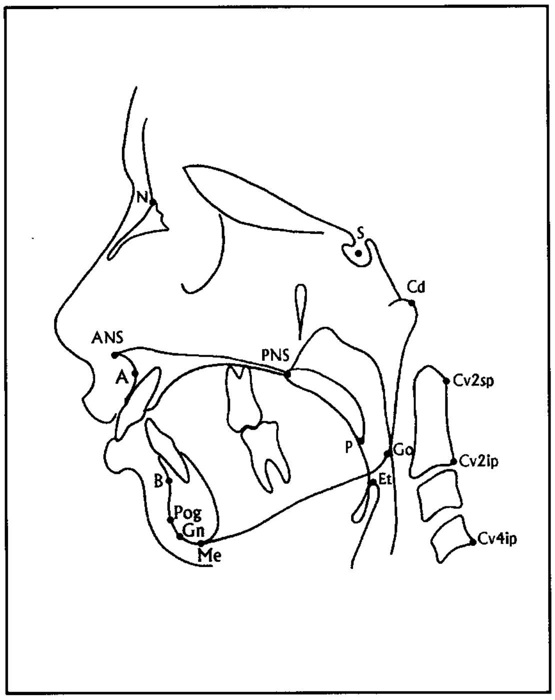

Figure 1

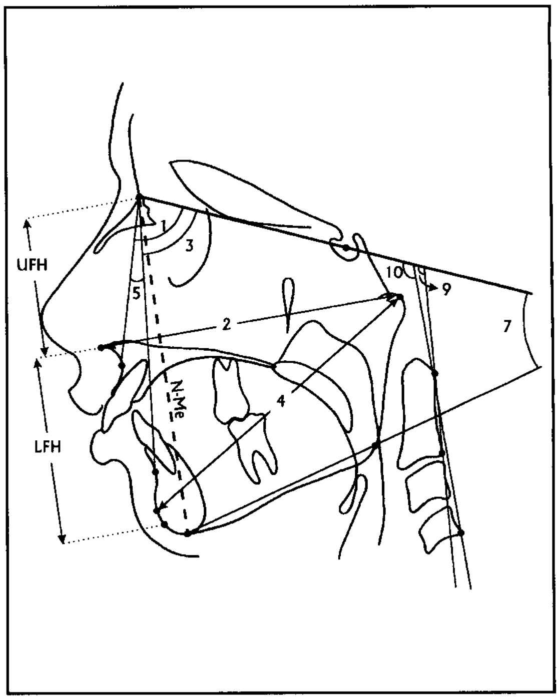

Figure 2

mandibles may lead to increased OAW dimensions, thereby reducing the risk of respiratory problems in the future. The purpose of this retrospective study was to test the first part of our hypothesis, i.e., will OAW dimensions increase in individuals with retrognathic mandibles when they receive functional-orthopedic (F/O) treatment during the growth period? The following questions were addressed:

Do changes in OAW dimensions differ between treated and untreated children with mandibular retrognathia?

Can the OAW changes that occur during treatment be predicted?

Material and methods

Study material was obtained from the archives of the orthodontic department of the University of Ankara, and comprised lateral cephalograms, hand-wrist radiographs, questionnaires, and clinical records of 41 skeletal Class II growing children. Twenty-six of the children (11 boys and 15 girls, average age 11 years 6 months) had been treated with F/O appliances between 1980 and 1996; the 15 control subjects (7 boys and 8 girls, average age 11 years 3 months) came from a longitudinal sample that had been formed between 1977 and 1984.

The following selection criteria were used:

1. ANB > 4 degrees with a clinically retrognathic mandible (determined by the patient sitting upright in a dental chair and assuming a natural head position while looking at a distance with the visual axis parallel to the floor).
2. Overjet > 5 mm
3. Angle Class II molar relationship
4. All teeth present
5. No respiratory problems (determined by questionnaire), no obvious naso-oropharyngeal obstructions (determined by clinical examination and lateral cephalometric films), and no surgical upper airway operations (adenoidectomy, tonsillectomy, etc.) before or during the treatment/observation (T/O) periods
6. Significant growth potential at the beginning of the T/O periods (before MP_{3cap} period[18])
7. Quality cephalograms at the beginning and end of T/O periods (teeth in centric occlusion, easily recognized soft and hard tissue structures, X-rays not taken during deglutition)
8. Treatment by Harvold-type activator,[19] with or without occipital high-pull headgear; no treatment for the controls
9. Achievement of an Angle Class I molar relationship and reduction of overjet to less than 3 mm at the end of treatment.

Treatment

Of the 26 treated cases, 14 were treated using a Harvold-type activator and 12 were treated using a Harvold-type activator in conjunction with occipital high-pull headgear. Construction bites were taken 2 to 3 mm vertically beyond the freeway space. In the sagittal dimension, either a single or a two-step activation was performed, depending on the severity of the anteroposterior discrepancy. Records were taken after the Class

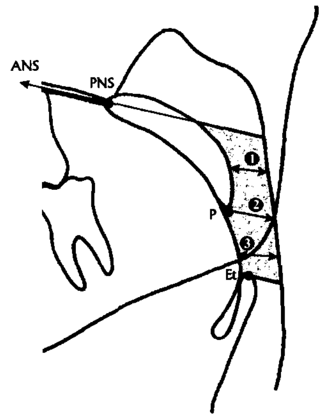

Figure 3

Figure 3
Oral airway (OAW) measurements of the study: 1. Superior posterior airway space (SPAS): Smallest distance between the posterior border of the soft palate and the posterior pharyngeal wall; 2. Middle airway space (MAS): Smallest distance between the posterior border of the tongue and the posterior pharyngeal wall, through the tip of the soft palate (p); 3. Inferior airway space (IAS): Smallest distance between the posterior border of the tongue and the posterior pharyngeal wall; Oropharyngeal cross-sectional area (ORO): The cross-sectional area of the oropharynx between the ANS-PNS line and a parallel line through epiglottis (shaded area).

Table 1
Reliability of the measurements (n=15)

Measurements	Coefficient of reliability
MxUL	0.9452
MdUL	0.9547
ANB	0.9464
SNMP	0.9703
ULF/LFH	0.9173
IAS (mm.)	0.9357
MAS (mm.)	0.8810
SPAS (mm.)	0.8358
Oro (area)	0.9040
CVT.NSL	0.9735
OPT.NSL	0.9430

I relationship had been obtained, with optimum interdigitation of the maxillomandibular posterior dentition. As neither pretreatment nor posttreatment OAW measurements nor the changes that occurred during treatment revealed statistically significant differences between these patients, these two groups were combined and assessed as a single "treatment" group.

Measurements

A total of 14 cephalometric and 2 demographic (age and growth potential[20]) parameters were assessed. Anatomic landmarks were identified, films were traced, and point-mode and stream-mode digitizations were performed to calculate linear, angular, and area measurements (Figures 1 to 3).

Statistics

Intraclass correlation coefficients were performed to assess the reliability of double tracing, landmark identification, digitization, and calculation of measurements (Table 1).

Student's *t*-tests were performed to evaluate the homogeneity of the groups at the beginning of T/O periods; and to evaluate intergroup differences in craniocervical angulation, growth potential, and age at the beginning and end of the T/O periods (Table 2).

Paired *t*-tests were used to analyze the significance of differences between the changes during the T/O periods (Table 2).

Discriminant analysis[21] was performed to test whether the changes in overall 2D OAW capacity were characteristic for treatment and control groups (Table 3).

Discriminant analyses (Tables 4 and 5) and Pearson's *r*-correlations (Table 6) were performed to find out if changes in OAW dimensions in "treatment plus growth" (responders and nonresponders), "growth only" (good candidates and poor candidates), and in the total sample could be predicted.

Discriminant analysis (DA)

To further analyze group characteristics, a DA that could take into account complex interrelationships among multiple variables was used.[1,21] The DA mathematically classifies each subject into a theoretical group for which the highest probability of membership occurs. Comparison of true and theoretical group membership provides the proportion of correct classification (p-correct) of the model.

In this study, DA was used to analyze potential differences between subjects who had a significant increase in OAW dimensions and those who did not, and thereby to find out if potential changes in OAW dimensions could be predicted:

1. A subset of OAW measurements was formed to represent overall OAW capacity in terms of 2D distance and area measurements.

2. The discriminant function was used to classify all subjects (26 treated patients and 15 controls) into *theoretical groups* for which the highest probability of membership occurs, in terms of changes in OAW dimensions during the T/O periods. In other words, the discriminant function was used to mathematically calculate which

Table 2
Descriptive statistics of the control and treatment groups and the statistical evaluation of intra- and intergroup differences

Measurements	Control group (n=15) Preobservation $\bar{x} \pm S_x$	Treatment group (n=26) Pretreatment $\bar{x} \pm S_x$	test	Control group (n=15) Difference $\bar{D} \pm S_x$	Treatment group (n=26) Difference $\bar{D} \pm S_x$	test
Skeletal morphology						
SNA (°)	83.54±0.98	80.83±0.60	*	0.27±0.44	-0.44±0.29	
MxUL (mm)	92.29±1.14	93.92±0.92		2.43±0.64**	1.81±0.58**	
SNB (°)	78.03±0.77	74.69±0.56	***	0.61±0.39	1.83±0.32***	*
MdUL (mm)	106.73±1.31	107.18±1.18		4.41±0.95***	6.24±0.60***	
ANB (°)	5.50±0.44	6.16±0.34		-0.33±0.25	-2.29±0.25***	***
ULD (mm)	14.43±1.05	13.25±0.75		1.99±0.79*	4.42±0.56***	*
SNMP (°)	35.91±1.02	35.51±0.78		-1.01±0.51	-0.25±0.33	
ULF/LFH (ratio)	89.29±1.64	88.04±1.40		-0.66±0.93	-3.54±0.59***	**
OAW morphology (2D OAW capacity)						
IAS (mm)	9.94±0.86	8.61±0.78		-0.87±0.67	1.87±0.73*	*
MAS (mm)	10.90±0.69	9.35±0.63		-0.76±0.57	2.28±0.59***	**
SPAS (mm)	9.42±0.70	8.58±0.53		-0.44±0.48	2.15±0.47***	***
ORO (area)	462.7±33.6	458.6±27.6		39.60±28.20	153.90±17.30***	***
Craniocervical angulation (°)						
NSL.OPT (°)	101.32±1.54	102.78±1.34		2.20±1.24	2.35±1.51	
NSL.CVT (°)	97.59±1.52	98.05±1.53		1.45±1.54	1.79±1.19	
Age (years/months)	11.29±0.25	11.63±0.24		1.92±0.05**	1.45±0.10**	
Growth potential %	85.70±1.32	90.50±0.97	**	6.03±0.46***	3.98±0.40***	**

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

subject belonged in which group by discriminating them into separate groups. This way a subject was put into either a group in which changes in OAW dimensions were significant or into a group where these changes were not significant. For example, if the OAW changes of a *treated* subject were not significant, DA theoretically accepted that patient to be a member of the control group (true group: treatment; theoretical group: control), or vice versa. The proportion of correct classification (p-correct) was calculated to determine if the changes in overall 2D OAW capacity were characteristic for treatment and control groups (Table 3).

For the next step, subjects who did not take part in their true groups were detected for further analysis. For this purpose, treated subjects were separated into two groups to find out the potential characteristics of responders and nonresponders before treatment (Table 4). Similarly, controls were separated into two groups to find out the potential characteristics of those who were already candidates for significant increases in OAW dimensions, even without treatment, and those who were not (Table 5). This time, the discriminant function was applied to all variables and to subsets of variables that represent certain anatomic patterns (such as SNA and MxUL to represent maxillary position and dimension, or SNMP and UFH/LFH to represent vertical skeletal pattern). If the value of p-correct was within the limits of clinical acceptance for a given subset of variables, that pattern was accepted to be a good predictor of the amount of changes in overall OAW dimensions. In other words, it was assumed that change in overall OAW dimensions could be predicted using that subset of variables.

Results

Reliability of measurements (Table 1)

All procedures for measurement calculation (tracing, landmark identification, digitization) were repeated on 15 randomly selected cephalograms. While the reliability of all measurements was found to be within clinically acceptable limits, the reliability of soft tissue measurements was slightly lower (intraclass correlation coefficients ranged from 0.84 to 0.94) than the reliability of hard tissue measurements (0.92 to 0.97), as expected.

Were the groups comparable in terms of skeletal patterns before the T/O periods? (Table 2)

Treatment and control groups were found to be comparable at the beginning of the treatment and observation periods in terms of sagittal and vertical skeletal patterns (ANB, ULD, SNMP, and UFH/LFH) and OAW dimensions. Although the severity of maxillary and mandibular retrognathia was higher in the treatment group (SNA, SNB), maxillary and mandibular dimensions (MxUL, MdUL) were comparable in the two groups.

Were the groups comparable in terms of age, growth potential, and craniocervical angulation before the T/O period, and in terms of changes in these variables during the T/O period? (Table 2)

Differences in mean age between groups before the T/O periods and time spent during these periods were not found to be significantly different. On the other hand, both the amount of growth potential that existed at the beginning of T/O periods, and the amount spent during these periods were significantly different ($p<0.01$, $p<0.001$). At the beginning of the T/O periods, the treatment group was slightly more mature than the control group ($p<0.01$). Although both groups had a significant amount of growth potential ($p<0.001$), controls grew more than those who received treatment ($p>0.01$).

Craniocervical angulation (NSL.OPT and NSL.CVT) was comparable at the beginning of the T/O periods. Changes in craniocervical angulation during these periods were also not found to be significantly different.

Comparison of changes during the T/O periods within the 2 groups (Table 2)

In the control group, significant increases in maxillary and mandibular dimensions ($p<0.01$ for MxUL and $p<0.001$ for MdUL) were observed. Maxillomandibular unit length discrepancy showed a tendency to diminish (ULD; $p<0.05$). No significant changes in OAW dimensions were observed in the control group.

In the treatment group, significant increases occurred in both maxillary and mandibular dimensions (MxUL, $p<0.01$; MdUL, $p<0.001$). A highly significant reduction in

Table 3
Discriminant analysis to test the proportion of correct classification of the total sample (n=41) into treatment and control groups, in terms of changes in 2D OAW Capacity

Theoretical group. % 71 of total cases were correctly clasified (p-correct: 0.707)

2D	True group	Control	Treatment	p-correct
OAW	Treatment (n=26)	7/26	19/26	0.731
Capacity D̄	Control (n=15)	10/15	5/15	0.667

Table 4
Discriminant Analysis to test if there were any characteristic measurements that may predict the patients who will respond favorably to treatment (responders), in terms of increases in overall OAW dimensions (a/b values indicate the proportion of cases who were theoretically placed into their true groups by DA).

	Responders	Nonresponders	p-correct
True group			
n	19	7	
Theoretical group Pretreatment values			
SNA-MxUL	13/19	5/7	0.692
SNB-MdUL	15/19	5/7	0.769
ANB-ULD	9/19	4/7	0.500
SNMP-ULF/LFH	11/19	5/7	0.615
2D OAW Capacity	17/19	5/7	0.846

Table 5
Discriminant Analysis to test if there were any characteristic measurements that may predict those subjects who will have favorable increases (good candidates) in overall OAW dimensions even without treatment (a/b values indicate the proportion of cases who were theoretically placed into their true groups by DA).

	Poor candidates	Good candidates	p-correct
True group			
n	10	5	
Theoretical group Preobservation values			
SNA-MxUL	6/10	3/5	0.600
SNB-MdUL	7/10	5/5	0.800
ANB-ULD	7/10	2/5	0.600
SNMP-ULF/LFH	7/10	3/5	0.667
2D OAW Capacity	8/10	5/5	0.687

Figure 4A-B
A: A patient who responded favorably to treatment in terms of increases in 2D OAW dimensions.
B: A patient who did not respond to treatment in terms of increases in 2D OAW dimensions.

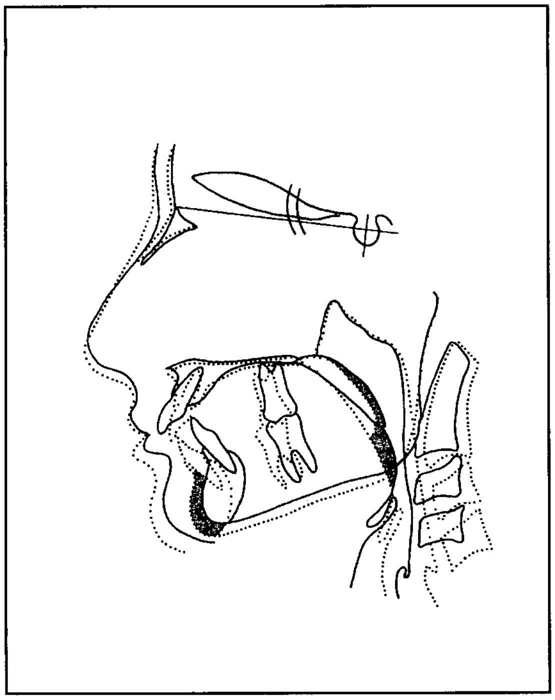

Figure 4A

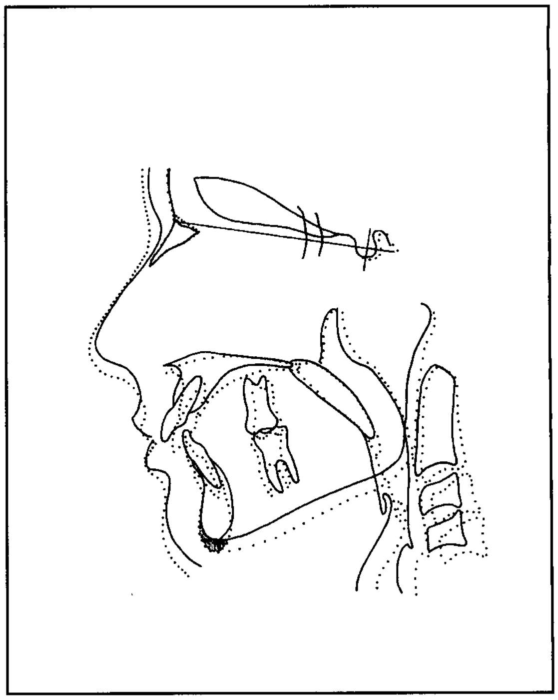

Figure 4B

maxillomandibular unit length discrepancy (ULD, p<0.001) was noted, along with a significant decrease in the amount of mandibular retrognathism (SNB, p<0.001). The skeletal Class II relationship was also significantly reduced (ANB, p<0.001), and lower facial height was significantly reduced relative to upper facial height (UFH/LFH, p<0.001).

All oropharyngeal airway dimensions showed significant increases during the treatment period (IAS, p<0.05; SPAS, MAS, ORO, p<0.001).

Comparisons of changes between the 2 groups during the T/O periods (Tables 2 and 3)

Statistically significant differences between the changes in the treatment and control groups were observed in the following hard tissue measurements: SNB, ULD (p<0.01); UFH/LFH (p<0.01); ANB (p<0.001).

The changes in all OAW dimensions were significantly different between the treatment and control groups (p<0.05-p<0.001).

Discriminant analysis (Table 3) revealed that changes in overall OAW dimensions (2D OAW capacity: SPAS, MAS, IAS, and ORO) were characteristic for treated patients and controls (p-correct; 0.707): When DA function was applied to the total sample to discriminate those who had a significant increase in 2D OAW capacity from those who did not, 10 out of 15 controls were theoretically accepted as members of their own group (p-correct, 0.667), and 19 out of 26 patients were correctly classified as members of the treatment group (p-correct, 0.731). In other words, 5 out of 15 controls were good candidates for significant increases in OAW dimensions, even without treatment, and 7 out of 26 patients did not respond to treatment in terms of increases in 2D OAW capacity. These results suggest that, although DA correctly placed most subjects in their true groups, some cases were theoretically accepted to be members of the false group. Therefore, a further attempt was made to analyze the potential characteristics of these cases, by use of DA.

Predictability of possible changes in OAW dimensions with growth and growth plus treatment (Tables 4, 5 and 6)

Table 4 shows the potential characteristics of responders (n=19) and nonresponders (n=7) before treatment. 2D OAW capacity, mandibular size and position, and maxillary size and position were among the characteristics that had relatively higher p-correct values (0.846, 0.769, and 0.692 respectively). For example, regarding 2D OAW capacity measurements, 17 of 19 responders were theoretically placed in their true group by the DA, as were 5 of 7 nonresponders. The p-correct value of 0.846 suggests that the 2D OAW capacity at the beginning of treatment was characteristic of responders vs. nonresponders.

Table 5 shows differences at the beginning of the observation period between those who did have a significant increase in 2D OAW capacity without treatment and those who did not. Again, OAW dimensions and mandibular measurements had relatively higher p-correct values

(0.867 and 0.800, respectively). These were followed by the vertical skeletal pattern measurements (p-correct, 0.667).

Pearson's *r*-correlation coefficients (Table 6) revealed that those subjects who had relatively smaller OAW dimensions and more retrognathic maxillomandibular complexes at the beginning of T/O periods were more likely to have significant increases in OAW dimensions, with or without treatment (Table 6; $p<0.05$ to $p<0.001$).

Discussion

To our knowledge, this is the first study to evaluate the effect of F/O treatment on OAW dimensions in patients who have skeletal Class II morphology with deficient mandibles.

To eliminate some of the drawbacks of the retrospective design of this study, strict selection criteria were applied. Furthermore, we believe that our study design in itself eliminated bias, since the clinicians who treated these cases were unaware of the problem examined at the time of the treatment.

In addition to pairwise statistics, such as student *t*-tests and Pearson's correlation coefficients, multivariate statistical methods were performed in this study. This is because we wanted to understand the interrelationships between treatment and some overall characteristics of skeletal and soft tissue structures of the craniofacial complex, rather than evaluating only interrelations between singular measurements.

Tables 2 and 3 show the clear difference of changes in OAW dimensions in the subjects who received treatment and those who did not, and that the 2D OAW response was characteristic for the treated cases and controls. These findings suggest that OAW dimensions may be increased significantly by treatment. Some linear measurements of OAW dimensions were even *reduced* during the observation period in controls. Especially those subjects who had retrognathic maxillomandibular complex and smaller OAW dimensions at the beginning of T/O periods were better candidates to have a significant increase in OAW capacity determined by 2-D cephalometric measurements, with or without treatment (Table 6). This might be due to a compensatory mechanism that exists in living organisms to survive, that acts to increase the capacity for vital needs, such as respiration. Those cases with retrognathic facial structures and relatively smaller OAW dimensions may have a greater intrinsic stimulus to increase their capacity for respiratory function, which may result in a greater increase of OAW dimensions in these subjects compared with those who probably already have adequate OAW capacity and thus may not need to increase these dimensions. The inclusion of an additional extrinsic stimulus (such as treatment) may increase the organism's ability to further increase its capacity (compared with those who do not receive treatment).

Table 6
Pearson correlation analysis for the total sample (n=41)

	IAS $\bar{D}$	MAS $\bar{D}$	SPAS $\bar{D}$	ORO $\bar{D}$
Preobservation measurements				
SNA	-0.486**	-0.279	-0.353*	-0.326*
MxUL	-0.206	0.210	0.233	-0.072
SNB	-0.556**	-0.317*	-0.350*	-0.389*
MdUL	-0.242	0.108	0.095	-0.036
ANB	0.064	0.036	-0.050	0.080
ULD	-0.110	-0.092	-0.138	-0.139
SNMP	0.220	0.073	0.068	0.077
ULF/LFH	0.010	-0.092	-0.108	-0.076
IAS	-0.648***	-0.395*	-0.470**	-0.536***
MAS	-0.566***	-0.463**	-0.417**	-0.600***
SPAS	-0.503***	-0.310*	-0.422**	-0.466**
ORO	-0.257	-0.139	-0.146	-0.320*

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

This "catch-up growth" concept is also supported by the results of Figueroa et al.,[1] who demonstrated dramatic differences in the amount of mandibular growth between infants with Pierre Robin sequence and controls during the first 2 years of life. They proposed that "partial mandibular catch-up growth" might help in the resolution of respiratory distress.

Structural superimpositions[22] of pre- and posttreatment cephalometric tracings of two cases are shown in Figure 4A-B. One case (4A) initially had reduced OAW dimensions and seems to have responded favorably to treatment, with a considerable amount of anterior relocation of the tongue and soft palate, together with a significant increase in mandibular unit length, mainly in the horizontal direction. On the other hand, the nonresponder case (4B) had relatively larger OAW dimensions before treatment. This case demonstrated a vertical growth pattern during treatment, although there was, again, a significant increase in mandibular unit length. Prospective studies in larger samples are needed to search for potential factors that may be related to these variations in OAW response to F/O treatment.

Although the average ages of treated patients and controls were not significantly different at the beginning of T/O periods, controls had a slightly better growth potential, and this difference was found to be statistically significant. These results clearly show the drawback of using age as the sole indicator of growth potential in studies that evaluate the effects of growth and/or growth plus treatment on craniofacial soft and hard tissue structures. During the T/O periods, both groups spent a significant amount of growth potential. The difference was also significant between the two groups. However, as this difference was in favor of controls, we propose that it does not change our results, which show a significant effect of treatment on OAW dimensions. It may even have weakened the favorable treatment effects on these dimensions, as the effect of growth was less in the treated cases.

A relationship between head position (such as head extension/flexion or upright/supine positions) and upper airway dimensions has been proposed by many investigators.[23,24] Therefore, to avoid misinterpretations, headfilms should be taken in natural head posture (NHP). Unfortunately, this could not be accomplished due to the retrospective design of this study; all X-rays had been taken using conventional methods, that is, Frankfurt horizontal parallel to the floor. Therefore, measurements of craniocervical angulation were calculated to test if there were any significant differences between groups at the beginning, and of changes within the groups during the T/O period. As differences were not found to be significant, we propose that our results were not significantly affected by differences of head posture at various stages of the T/O periods. However, this definitely does not underestimate the use of NHP films, as they would certainly better serve the purpose of this study.

An increase in OAW dimensions in growing patients with mandibular deficiency may have some major benefits in terms of craniofacial growth and function. If increases in these dimensions result in an increase in OAW capacity and thereby better daytime and nocturnal respiratory function, the possible effect of an impaired OAW function as an etiological factor for abnormalities in facial structures might be reduced and might even modify the vertical and/or sagittal growth pattern of the craniofacial complex. Again, if there are no other upper airway pathologies, such as oversized adenoids or tonsils, or chronic respiratory problems, it might reduce the chances of having disturbed respiratory function during sleep, such as snoring, UARS, or OSA. It is not surprising that many orthodontic patients who have a history of snoring at the beginning of F/O treatment report a reduction in these symptoms, even at the early stages of treatment. This benefit should not be underestimated, as it has been demonstrated that there may be a link between sleep patterns (or stages) and nocturnal release of growth hormone.[25,26] Any factor that leads to an insufficient sleep pattern may cause a reduction in plasma growth hormone levels, which may, in turn, not only slow down the overall growth rate, but also cause a reduction in condylar activity and, thereby, mandibular growth.

A significant relationship is also known to exist between retrognathic maxillary and mandibular structures and OSA in adult patients. Therefore, an additional benefit of early orthopedic treatment may be that it reduces the chances of having OSA later, if the orthodontist can correct the skeletal pattern and increase OAW capacity permanently, especially in those patients who have retrognathic and small maxillomandibular structures and small OAW dimensions.

Conclusion

Our results clearly suggest the existence of a relationship between functional-orthopedic treatment and increases in OAW dimensions in certain skeletal Class II growing subjects. However, it would be premature to arrive at general clinical conclusions. Further studies are needed to evaluate if increasing OAW dimensions by means of F/O treatment in cases with skeletal Class II pattern and mandibular deficiency will prove to have favorable outcomes, such as modification of growth pattern of the craniofacial structures and/or a reduced chance of having impaired respiratory function in short- and long-term.

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