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Relationship between head posture and the severity of obstructive sleep apnea

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Introduction: The objective of this study was to compare the head posture of patients with obstructive sleep apnea (OSA) having different levels of severity with that of control subjects. **Methods:** One hundred subjects participated in this study. Seventy-five subjects underwent overnight polysomnography in a sleep laboratory and were allocated into "mild," "moderate," or "severe" OSA groups, and 25 subjects with no complaints regarding OSA were allocated into 1 group and served as the controls. Cephalometric radiographs were obtained from all participants in natural head position. Craniocervical, craniovertical, and cervicovertical angles were measured in the groups. Data were analyzed using the least significant difference. **Results:** The results showed significant differences between the OSA groups and the control group, and among the test groups, in all craniocervical, craniovertical, and cervicovertical angles ($P < 0.05$), except for 1 craniovertical measurement ($P > 0.05$). There were no significant differences in this measurement among the test groups and in any measurement between the mild and moderate OSA groups ($P > 0.05$). **Conclusions:** Head posture showed significant differences in patients with OSA. In general, the more severe the OSA, the more extended the natural head position as indicated by increases in the craniocervical angles. The cervical posture parameters may indicate existing OSA. (Am J Orthod Dentofacial Orthop 2016;150:945-9)

The word "apnea" originates from the Greek word "apnoia" and means "without breathing." This terminology was initially used by Guilleminault et al[1] in defining sleep apnea syndrome. Obstructive sleep apnea (OSA) causes obstruction of the upper airway during sleep and is also associated with daytime symptoms. Untreated patients with OSA may have an increased risk of comorbid disease, such as systemic hypertension, depression, stroke, angina, and cardiac dysrhythmias,[2,3] and it is also known that OSA is associated with motor vehicle accidents,[4] poor work performance, and reduced quality of life.[5] It is difficult to determine the etiology of OSA because this syndrome is multifactorial, with neural, hormonal, muscular, and structural anatomic factors.[6] It occurs in 2% to 4% of adults aged between 30 and 60 years.[7]

There is a relationship between craniofacial changes and postural development, which Solow and Kreiborg[8] termed "the soft tissue stretching hypothesis." Upper airway obstruction causes a change in posture via extension of the craniocervical angle. This leads to an increase of the forces on skeletal structures and decreases forward growth of the maxilla and the mandible. In accordance with this hypothesis, many studies have declared that the people with OSA have an extended natural head posture (NHP), reduced posterior airway space, an abnormally long soft palate, and a low position of the hyoid bone.[9-11]

Polysomnography (PSG), which is recommended as the gold standard for the diagnosis of OSA, plays a crucial role in OSA research and involves an overnight sleep study conducted in a laboratory. The polysomnogram tests electrocephalography (brain waves), electrooculography (eye movement), electrocardiography, electromyography (chin and leg movement), sleep positioning, respiratory activity, and oxygen saturation.[12,13]

Previous studies have shown that people with sleep apnea have a small, retruded mandible, a narrow posterior airway space, enlarged tongue and soft palate, an inferiorly positioned hyoid bone, and retroposition of the

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, January 2016; revised and accepted, May 2016.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2016.05.011

Table I. Study groups

Group	N	Age, mean ± SD (y)	Sex, male/female
1 (control)	25	33.40 ± 10.81	18/7
2 (mild OSA)	25	49.08 ± 12.92	13/12
3 (moderate OSA)	25	54.20 ± 11.13	17/8
4 (severe OSA)	25	50.44 ± 7.49	18/7

maxilla. However, the effects of the severity of OSA on head posture remain controversial. Therefore, the aim of this study was to compare the NHP of patients with different degrees of OSA. For the purposes of this study, the null hypothesis assumed that there are no statistically significant differences among various NHP measurements of the different OSA groups and the controls.

MATERIAL AND METHODS

A total of 100 subjects participated in the study; they were referred from both the Department of Orthodontics and the Department of Pulmonary Diseases, University of Gaziantep, in Turkey. Ethical approval was obtained from the university's ethics committee.

The participants underwent overnight PSG in the sleep laboratory in the Pulmonary Disease Department of Gaziantep University. PSG data were obtained while they were asleep, under the supervision of a sleep laboratory technician.

The severity of OSA was determined using the apnea-hypopnea index (AHI), which was defined as the sum of mixed obstructive apnea and hypopnea events per hour of sleep when the participant was undergoing PSG. The study sample consisted of 3 groups of 25 subjects each (Table I). They were allocated into groups according to the severity of their OSA. The guidelines of American Academy of Sleep Medicine Task Force were used for grouping: mild OSA (AHI, 5-15), moderate OSA (AHI, 16-30), and severe OSA (AHI, >30). The mean ages of the participants were 49.08 ± 12.92, 54.20 ± 11.13, and 50.44 ± 7.49 years for the mild, moderate, and severe groups, respectively.[14,15] The control group consisted of another 25 adults from the Department of Orthodontics who did not undergo PSG. The control group selection criteria were no report of sleep disorder or snoring, no previous apnea, and no surgery related to the maxillary or mandibular region. The mean age in the control group was 33.40 ± 10.81 years.

Cephalometric radiographs were obtained from all participants under standardized conditions with their teeth in centric occlusion, their head in a natural position (mirror position) without a head holder, and their lips in a habitual posture, as described by Solow and Siersbaek-Nielsen.[16] The radiographs were taken with the same

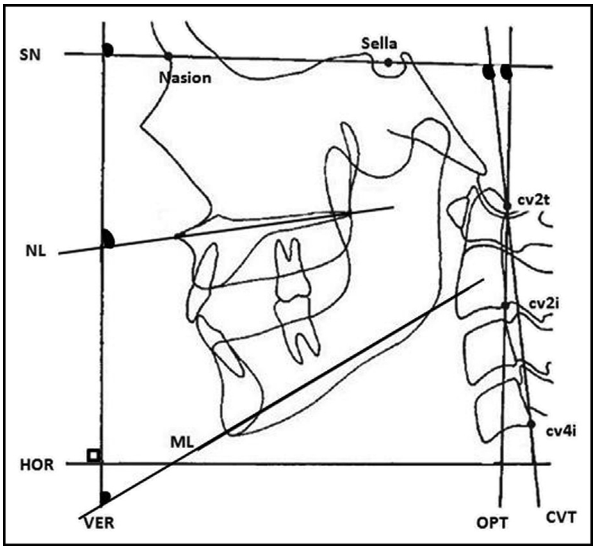

Fig. Reference lines on cephalometric radiographs. *cv2t*, the tangent point on the back contour of cv2 odontoid process; *cv2i*, the most postero-inferior point on the cv2 corpus; *cv4i*, the most postero-inferior point on the cv4 corpus.

digital x-ray unit (XG 3; Sirona, München, Germany), and 9 angles were used to evaluate the postural variables. All cephalometric radiographs were traced by the same experienced investigator (R.O.).

The craniocervical angulations (SN-OPT, SN-CVT) (the inclination of the head in relation to the cervical column) were expressed by angles between the craniofacial reference lines and the cervical column reference lines odontoid process tangent through cv2i-cv2t (OPT) and cervical vertebral tangent through cv4i-cv2t (CVT). The craniovertical angulations (SN-VER, NL-VER, ML-VER) (ie, the inclination of the head in relation to the true vertical) were expressed by the angles between the craniofacial reference lines, sella-nasion line, nasal line (spina nasalis anterior to spina nasalis posterior), mandibular line (gonion to gnathion), and the true vertical. The cervicovertical angulations (OPT-VER, CVT-VER) (ie, the inclination of the cervical column in relation to the true vertical) were expressed by the angle between the cervical column reference lines and the true vertical (Fig; Table II).

Dahlberg's formula[17] was used to assess the reliability of the cephalometric measurements. A total of 20 randomly selected radiographs were retraced and remeasured by same investigator (R.O.) 3 weeks after the initial analysis. The method error ranged from 0.30° to 0.71° for the craniocervical, craniovertical, and cervicovertical angles, and the mean difference was not significant.

Table II. Definitions of anatomic reference lines and measurements

Reference line	*Definition*
SN	Sella-nasion line
NL and ML	Nasal line (spina nasalis anterior to spina nasalis posterior) and mandibular line (gonion to gnathion)
OPT	Odontoid process tangent through cv2i-cv2t
CVT	Cervical vertebra tangent through cv4i-cv2t
VER	True vertical line
HOR	Horizontal line

Statistical analysis

The statistical analysis was carried out with SPSS software for Windows (version 20; IBM, Armonk, NY). The Kolmogorov-Smirnov statistical test was used for normality analysis, which showed that the data were normally distributed: ie, the distance between the empirical distribution function of the sample and the cumulative distribution function of the reference distribution was not statistically significant, and parametric tests were used (Table III). The least significant difference test (Table IV) was applied to evaluate the intergroup differences in the variables.

RESULTS

The statistical evaluation of the measurements showed significant differences among the test groups, and between the test groups and the control group. The null hypothesis was thus rejected.

For the craniocervical angles, the SN-CVT angle was statistically significantly larger in the moderate and severe OSA groups compared with the control group (P <0.05), and the SN-OPT angle was statistically significantly larger in all OSA groups compared with the control group (P <0.05; Table IV).

For the craniovertical angles, there were no statistically significant differences among the groups in the SN-VER angle, which indicates the inclination of the anterior cranial base in relation to the true vertical (P >0.05). The NL-VER angle was statistically significantly smaller in the severe OSA group compared with the control and mild OSA groups (P <0.05). The ML-VER angle, which indicates the inclination of the mandibular plane, was statistically significantly smaller (smaller angle indicates a steeper mandibular plane) in all OSA groups compared with the control group (P <0.05), and the difference was not significant between the mild and moderate OSA groups (P >0.05; Table IV).

For the cervicovertical angles, the OPT-VER and CVT-VER angles, which indicate the inclination of

Table III. Kolmogorov-Smirnov normality test results

Variable	*n*	*Kolmogorov-Smirnov normality test, P value*
SN-CVT	100	0.200*
SN-OPT	100	0.200*
SN-VER	100	0.114*
NL-VER	100	0.200*
ML-VER	100	0.200*
OPT-VER	100	0.200*
CVT-VER	100	0.200*

*$P > 0.05$ showed normal distribution: ie, the distance between the empirical distribution function of the sample and the cumulative distribution function of the reference is not statistically significant, and parametric tests were applied to these variables.

cervical column in relation to the true vertical, were statistically significantly larger in all OSA groups compared with the control group (P <0.05). Both angles were also significantly larger in the severe OSA group compared with the mild and moderate OSA groups (P <0.05), but there were no significant differences between the latter 2 groups (P >0.05; Table IV).

DISCUSSION

In this study, we aimed to compare the head posture of patients with mild, moderate, and severe OSA and the otherwise healthy subjects who comprised the control group. The control group did not have the PSG study, and the major inclusion criterion was that these subjects perceived their sleep as healthy according to previous studies.[18,19]

NHP is the upright position of the head via the balancing of the cervical and muscle groups. Head posture is a dynamic concept; ideally, its measurements should be performed in a dynamic and continuous manner.[20] Therefore, it may be influenced by numerous parameters.[21-23] For example, the visual axis plays a role in the posture of the head.[24] Previous studies have compared the cranial and cervical postures of blind and sighted persons. The blind people had a more flexed head than did the sighted ones because they have a smaller anterior facial height, due to deficient development of the orbital region. In orthodontics, Linder-Aronson[21] reported that after tonsillectomy or adenoidectomy, there are reductions in craniocervical angulations and head flexion in children. Solow and Sandham[25] stated that pathologic and functional disturbances can affect postural changes, and that spinal column anomalies may influence craniocervical and craniohorizontal posture.

Therefore, it is not surprising that the obstruction of the airway may affect head posture. However, the effect of OSA severity on head posture has not been previously

Table IV. Descriptive statistics and multiple comparisons of variables between the groups according to the least significant difference test

Variable	Group 1 (control), mean ± SD	Group 2 (mild), mean ± SD	Group 3 (moderate), mean ± SD	Group 4 (severe), mean ± SD	Comparisons between groups 1-2	1-3	1-4	2-3	2-4	3-4
Craniocervical										
SN-CVT	104.16 ± 6.88	108.48 ± 7.86	110.44 ± 8.03	111.34 ± 8.46	0.054	0.006*	0.002*	0.378	0.200	0.685
SN-OPT	99.18 ± 8.00	104.74 ± 7.63	106.38 ± 7.65	108.18 ± 10.83	0.025*	0.004*	0.000*	0.503	0.162	0.463
Craniovertical										
SN-VER	97.60 ± 6.15	95.72 ± 6.96	95.20 ± 7.96	92.86 ± 5.59	0.325	0.210	0.014*	0.785	0.136	0.222
NL-VER	89.42 ± 5.60	88.50 ± 7.49	87.40 ± 7.48	84.12 ± 6.61	0.636	0.299	0.007*	0.571	0.026*	0.094
ML-VER	66.00 ± 5.41	60.82 ± 6.37	60.46 ± 8.14	55.42 ± 8.62	0.013*	0.008*	0.000*	0.861	0.010*	0.016*
Cervicovertical										
OPT-VER	4.14 ± 7.40	9.04 ± 7.81	11.86 ± 6.19	16.20 ± 9.02	0.026*	0.001*	0.000*	0.197	0.001*	0.048*
CVT-VER	7.28 ± 6.28	13.08 ± 7.80	15.72 ± 6.58	20.66 ± 6.95	0.004*	0.000*	0.000*	0.181	0.000*	0.013*

*The mean difference is significant at the 0.05 level.

evaluated. Patients with severe and mild OSA may have some different properties. In this study, our purpose was to determine whether there are any significant differences with the different degrees of AHI scores and head posture.

Craniocervical angles relate the posture of the head (measured at the anterior cranial base) to a line representing the cervical column. Our results showed that the SN-OPT values are higher in subjects with OSA than in healthy persons. This finding is supported by the results of many previous studies because it has been shown that subjects with OSA put their head forward, so that the craniocervical angles are in an extension position. One study showed that complete obstruction of the nasal airway is associated with an increase in craniocervical extension of 5°.[21] This new position of the head changes the rest position of the mandible and leads to an increase in occlusal freeway space. The anatomic dimension of the airway directly affects normal respiration. Our results showed that the craniocervical angles increased with the severity of OSA. The severe OSA group had approximately 8° larger craniocervical angles than did the control group for the craniocervical parameters (SN-CVT, SN-OPT). The craniocervical measurements increased from mild to severe patients. Özbek et al[26] compared the craniocervical angles of OSA subjects with snorers and found correlations with craniocervical extension and severity of OSA. Behfelt et al[27] stated that people with large adenoids have a craniocervical angle that is 4° to 8° higher than that found in those without enlarged tonsils. In another study, Solow and Siersbaek-Nielsen[16] reported a craniocervical angle of 10° higher in patients with OSA, and our results support these findings. The increase of the craniocervical parameter is the result of extension of the head, followed by reduced forward rotation of the mandible. Vig et al[28] reported that the craniocervical angle is associated with the nasopharyngeal airways. The nasal obstruction increases the craniocervical angle; after removal of the obstruction, the head posture returns to the baseline value of the parameter. Our study demonstrated that moderate and severe OSA may have significant effects on the craniocervical and cervicovertical angles. These patients seem to extend their head by tilting the cervical column forward, possibly to overcome the physical obstruction of the airway. On the other hand, increased craniocervical angles of NHP cephalograms may indicate a tendency toward OSA. Therefore, the routine cephalograms in the NHP may have an additional diagnostic value.

Sleep apnea was shown to be associated with hypertension, ischemic heart disease, stroke, pulmonary hypertension, cardiac arrhythmia, and cardiovascular mortality and is an independent risk factor of cardiovascular morbidity and mortality.[29] The human body is a complex structure in which every part is interrelated. Many systemic conditions manifest in the oral cavity; any problem in the neighboring tissues affects craniofacial structures, which are the area of interest for orthodontics. Our findings showed that people gain a new head position because of obstruction of the upper airway. However, the interesting point of this study is that the patients with severe OSA showed significantly different properties of the cervical parameters. In particular, the increased forward inclination of the cervical column on lateral cephalograms taken for routine orthodontic purposes may indicate that these patients already have or may develop OSA later in life. In these patients, treatment plans that may hinder the airway (setback surgeries, maximum retraction of the teeth with extractions, and so on) should be avoided, and the airway should be further developed if possible (functional jaw orthopedics, expansion, advancement surgeries). It may also be a good practice to consider referring these patients for a medical evaluation to make sure that they receive professional care for prevention or treatment of OSA if they are diagnosed.

CONCLUSIONS

The measurements related to head posture showed significant differences in apnea patients compared with the controls. In general, the more severe the OSA, the more extended the NHP as indicated by increases in the craniocervical angles.

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