RESEARCH ARTICLE

Determine and Compare the Volume and Length of the Upper Airway Using Cone-beam Computed Tomography Images in Patients with Obstructive Sleep Apnea

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Abstract

Introduction: The disease is one of a variety of respiratory disorders during sleep. This disorder caused by the obstruction of the upper airways leads to a reduction in nighttime oxygenation and sleep disruption during the night. In this study, using cone-beam computed tomography (CBCT) images in patients with obstructive sleep apnea (OSA), we compared their airway volume and length with healthy people. **Methodology:** This descriptive cross-sectional study was carried out on CBCT scans of 50 patients (25 patients with OSA and 25 healthy subjects) who referred to the Department of Oral and Maxillofacial Radiology, School of Dentistry, Tabriz University of Medical Sciences. The data obtained from CBCT entered into the NNT viewer version 2.21 software. In this study, the mean area, mean volume, and total length of the upper airway were measured. The results of this study were conducted using SPSS version 17 software, and a significance level of $P < 0.05$ was considered. **Results:** The findings of this study revealed that the area and length of the upper airway were higher in patients with OSA than in healthy people, but the volume of airway in healthy subjects was higher than those with OSA. As well as, the vertical and horizontal length of soft palate was higher in people with OSA than in healthy people. The anteroposterior distance in patients with OSA was lower than normal subjects. Meanwhile, there was a difference between the vertical and horizontal length of the soft palate in healthy subjects and patients, both of which were statistically significant ($P < 0.05$). **Conclusion:** The final results of this study indicated that the area and length of the upper airway were higher in people with OSA than in healthy people, meaning that people with a longer upper airway have a higher risk of developing OSA.

Key words: Cone-beam computed tomography images, length and volume of upper airway, obstructive sleep apnea

INTRODUCTION

The most common form of sleep apnea is obstructive apnea. From a clinical point of view, sleep disorder during sleep is said to have symptoms such as drowsiness during the day, snoring, stopping breathing, and feeling choking during sleep next to at least 5 times per hour of apnea or obstructive hypopnea or apnea or hypopnea more than 15 times/h without an asymptomatic sign.[1,2] The prevalence of this disorder is about 2%–4% for men and 1%–2% for women. However, the majority of people with this disease are often not diagnosed.[3,4]

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In previous studies, sleep disorder, which is hypopnea apnea, is more prevalent than the occurrence of either of these disorders alone. The position of the tongue has an important role in airway size. The reduction in the size of the airway occurs through the back of the tongue, which was observed by Camacho *et al*. in supine patients.[5] An obstructive sleep apnea (OSA) arises from the anatomical point of view due to the relaxation of the nasopharyngeal muscle and collapse of the upper airway.[6] Considering the previous studies, two factors, including localized accumulation and dissemination of fat in the neck and para pharyngeal regions, as well as increased edema of the pharyngeal region and congestion of the cervical vertebrae, seem to be the most important causes of neck enlargement and consequently an increased risk of OSA. This finding indicates that central obesity and decompensated heart failure can intensify the risk of OSA.[7,8]

A definitive diagnosis of OSA is done by polysomnography, but this method is time-consuming and requires special laboratory measures, so OSA remains unknown and is not treated in most cases. This method is based on the number of abnormal breathing events that occur every hour of sleep, which is referred to as the apnea–hypopnea index (AHI).[9,10] The evaluation of upper airways in patients with OSA is very important, because in reports of this way, patients with OSA have a smaller airway than those without OSA.[11,12] This route is easily visible during the use of cone-beam computed tomography (CBCT) with a field of view larger than the upper airway, so the CBCT technique is a very useful tool for airway assessment.[13] Using CBCT images, Enciso *et al*. found that the presence and severity of OSA were associated with a lateral dimension of airway obstruction.[14] Similarly, using computed tomography, Mayer *et al.* reported a decrease in transverse width of the oropharynx in patients with OSA.[15]

As OSA has only been investigated using CBCT or cephalometric analysis in a previous conducted studies and a study that simultaneously examines all measurable indexes in these modalities has not been done so far, in this study, the subject was upright when doing CBCT and the background variables including age, gender, neck circumference, and neck height as independent variables and TgHt, TgLt, PNS-P, SPAS MP/H, and SPAS of examined indexes from lateral cephalometric analysis in patients with apnea were studied, and its association with developing OSA disease was also investigated.

METHODOLOGY

In this descriptive-analytic cross-sectional study, CBCT images of 50 patients (25 patients with OSA and 25 healthy individuals) referring to the Department of Oral and Maxillofacial Radiology, School of Dentistry, Tabriz University of Medical Sciences, were used to determine the indicators of this disease and were compared. In this study, people with OSA, lack of developmental syndromes without medical and surgical problems, and individuals with AHI index at close range together as a patient group were used. In addition, patients with a history of trauma, fractures in the head and face, with pathological problems in the frontal, maxillary, and mandibular sinuses, with a history of orthodontic treatment and orthognathic surgery, and having a systemic disease or intraosseous lesions were excluded from the study.

A completely randomized sampling was performed by the Newtom VGi cone-beam (Verona/Italy) device in the radiology department. The device has an X-ray cone beam, a 1536 × 1920-pixel flat-panel detector, a 360° rotation, an 18 s scan, and a maximum KVp of 110. The data obtained from CBCT was entered into software NNT viewer version 2.21, and finally, the initial and final restoration was done by the software. The radiation conditions of the device are automatically set. In this study, the mean area, mean volume, and total length of the upper airway were measured. Anteroposterior depth and size in the smallest parts of the axial were obtained [Figure 1]. The images taken by CBCT were exported as digital imaging and communications in medicine files and then entered into the Analyze 10.0 (AnalyzeDirect, Overland Park, KS, USA) software for airway analysis.

The results of the study were reported using descriptive statistics methods (mean ± standard deviation and frequency). To compare the quantitative variables in two groups, in the case of normal distribution of these indices (examined using Kolmogorov–Smirnov test), independent samples T-test was used; and in case of non-normal distribution of data, the non-parametric

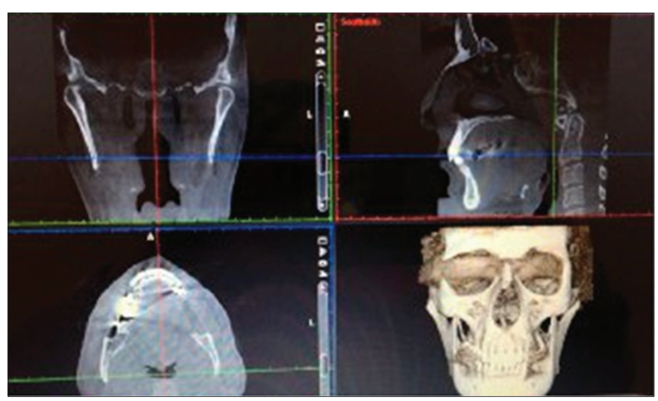

Figure 1: The anteroposterior dimension and the width of the upper airway in the smallest dimension of the axial and sagittal

equivalent of the Mann–Whitney U-test was used. Furthermore, to examine the relationship between qualitative variables (gender) and OSA disease, Chi-square test was used to identify this relationship. To identify the risk factors involved in the development of OSA, logistic regression analysis was conducted. The results of the study were carried out using SPSS version 17 software (Statiscal Package for social sciences, SPSS Inc., Chicago, IL, USA), and a significance level of $P < 0.05$ was considered.

RESULTS

All variables are described separately using mean and standard deviations in each group. In the group with OSA patients, 9 (36.3%) were female and 16 (63.7%) were male. In the group with healthy subjects, 13 (52.4%) were female and 12 (47.6%) were male.

According to the obtained results, the area and length of the upper airway in patients with OSA are higher than healthy subjects, but the volume of airway in healthy people is more than those with OSA. The vertical and horizontal length of soft palate was also higher in patients with OSA than in healthy subjects. The mean of apnea index in patients with OSA was 19.3 ± 28.93. The anteroposterior distance in patients with OSA was lower than normal subjects [Table 1].

To compare the mean of the measured indicators, first of all, the normal values of them should be ensured. To do this, this assumption was tested using the Kolmogorov–Smirnov test. The results showed that all values have normal distribution. Hence, independent samples t-test was used to compare normal values.

In Table 2, the comparison between measured indicators was performed. According to the results, it can be seen

Table 1: Descriptive statistics

Parameters	Mean±SD	
	OSA group	Healthy people group
Upper airway area	4992.12±2160.57	4695.16±1481.72
Upper airway volume	11,984.65±5445.91	13,234.18±7694.54
Upper airway length	47.62±9.92	46.63±6.46
Vertical length of soft palate	33.06±7.78	28.98±4.14
Horizontal length of soft palate	25.53±3.61	23.25±3.34
Apnea index	19.3±28.93	-
Anterior–posterior distance	6.9±3.41	7.84±3.25
Width	20.37±6.1	24.89±6.36
Age	49.33±15.12	38.9±10.59
Neck circumference	40.8±3.31	42.19±3.86
Neck height	8.52±1.36	9.04±0.92

SD: Standard deviation, OSA: Obstructive sleep apnea

Table 2: Comparison of indices in two groups of patients with obstructive sleep apnea and healthy people

Parameters	Mean difference between the two groups	Test statistic	*P*
Upper airway area	269.95	0.519	0.606
Upper airway volume	−1249.53	−0.607	0.547
Upper airway length	0.98	0.38	0.706
Vertical length of soft palate	4.07	2.11	0.042
Horizontal length of soft palate	2.28	2.12	0.04
Anterior–posterior distance	−0.94	−0.91	0.366
Width	−4.52	−2.35	0.024
Age	10.43	2.54	0.015
Neck circumference	−1.38	−1.24	0.221
Neck height*	−0.52	174*	0.222*

*Posterior of mandibular angle to superior of clavicle

Table 3: Logistic regression analysis to estimate the risk of obstructive sleep apnea via indicators

P	EXP(B)	B	
0.032	1.28	0.249	Neck circumference

that, despite the 269.95 unit difference between the upper airway area between healthy subjects and patients with OSA, this difference is not significant. Furthermore, there is 1249.53 and 0.98 unit difference between volume and length of the upper airway in healthy subjects and patients, respectively, which was not statistically significant ($P > 0.05$). There is 4.07 and 2.28 unit difference between the vertical and horizontal length of the soft palate in healthy subjects and the patient, respectively, which both were statistically significant ($P = 0.042$ and $P = 0.04$). The difference of anteroposterior distance between the patients and the healthy people was 0.94, which was higher in the healthy subjects, and this difference was not statistically significant ($P = 0.366$). The difference between the width of the upper airway in patients and healthy subjects was 4.25, and this difference was statistically significant ($P = 0.024$).

Logistic regression analysis was used to estimate the model for predicting the risk of OSA using the measurement of indicators previously mentioned. All variables entered into the model with the Forward LR method, and the results are presented in Table 3. The classification accuracy in this model is 70.7%. This means that it can be said with a confidence of 70.7% that the risk of OSA can be explained using the total of the indices specified in this study. As can be seen, the results were only significant for the neck circumference.

DISCUSSION

Using various imaging techniques, previous studies suggest that an unusual anatomy of the upper airway is a key factor in the development and expansion of OSA[14,17] so that generally people with OSA have smaller upper airways and oval airways compared to those without OSA.[17-19] Furthermore, the results of some studies have found that people with older age, male gender, and upper airway dimensions of <17 mm are known to be at-risk populations in OSA.[14] In addition, according to the results of some other studies, it has been found that some skeletal abnormalities can be considered as risk factors for OSA, including mandibular and maxillary defects, dimension reduction of airway posterior space, and large size of tongue and palate.[20]

The findings of our study indicated that the area and length of the upper airway were higher in patients with OSA than in healthy subjects, but the volume of airway in healthy people was higher than those with OSA. As well as, the vertical and horizontal length of soft palate was more in people with OSA than in healthy people. The anteroposterior distance in patients with OSA was lower than normal subjects. In addition, there was a difference between the vertical and horizontal length of the soft palate in healthy subjects and patients, both of which were statistically significant. There was a significant difference between the width of the upper airway in patients and healthy people.

Furthermore, in Buchanan *et al*., it was found that patients with OSA had significantly smaller mean airways and airway volume, overall air volume, and lower mean airway width than that of healthy control group. In addition, all patients had a longer airway length than the healthy group. Overall, the results of this study revealed that patients with OSA were smaller than the healthy control group, except for the length of the airway, for the rest of the cases that the results of this research were in line with our findings.[13] In another study conducted by Marshall *et al*., it was found that people with OSA had a smaller airway than the control group except for the length of the airway, while there was no significant difference between the mean anterior and posterior dimensions. However, this study has had some weaknesses such as low sample size, retrospective study, and the selection of control group only based on the absence of symptoms of OSA without considering the sleep status of subjects (due to the retrospective nature of the plan).[21]

Since the OSA occurs during sleep, it is better to examine and analyze the anatomy of the upper airways of the patients during their sleep. However, during normal sleep of people, taking the right images of people is very hard and difficult so rarely can be done.[22,23]

However, it is still not clear that how the mechanism of various soft tissue structures mechanically influences the control of the volume of the upper airway dimensions, and how soft tissue structure changes lead to an increase in the dimensions and sizes of the different parts of the upper airway. In addition, various research findings have shown that obesity is one of the most important predisposing factors for OSA.[24] As most previous studies have shown, obese patients with OSA have narrowed upper airways even at awakening.[25] However, the mechanism by which obesity can lead to a narrowing of the upper airway is still unknown.[26]

CONCLUSION

The final results of this study revealed that the area and length of the upper airway were higher in patients with

OSA than in healthy subjects. This means that people with a longer upper airway will be at risk of developing OSA. Furthermore, the vertical and horizontal length of soft palate was higher in people with OSA than in healthy people.

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