Original Article

Comparative Analysis of the Oropharyngeal Airway in Patients Aged Over 40 Years: A Cone Beam Computed Tomography Study

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Abstract

Aim: This study was carried out to compare different measurements of the oropharyngeal airway in patients aged over 40 years on cone beam computed tomography (CBCT) images. **Materials and Methods:** Seven hundred and five patients aged over 40 years were divided into three groups (40–49, 50–59, and ≥60 years). A comparative analysis of oropharyngeal airway (volume, minimum cross-sectional area, minimum anteroposterior distance, and minimum right to left distance) between the groups was carried out on CBCT images acquired for different dental purposes. Data were analyzed using the one-way ANOVA statistical test. **Results:** There were statistically significant differences between the groups in mean value of oropharyngeal airway measurements ($P < 0.05$). In the middle age group of patients aged from 50 to 59 years, the mean value of each measurement was lower than its counterpart in other groups. **Conclusions:** Patients aged from 50 to 59 years had the smallest oropharyngeal airway measurements; therefore, they might be at high risk of developing sleep-related breathing disorders, and further assessment is recommended.

Keywords: Aged over 40 years, cone beam computed tomography, oropharyngeal airway

INTRODUCTION

The upper airway can be divided into three parts: nasopharynx, oropharynx, and hypopharynx.[1] Constrictions in the upper airway may result in sleep breathing disorder like obstructive sleep apnea (OSA).[2-8] Therefore, an evaluation of upper airway anatomy is paramount.

Different imaging modalities have been used for evaluation of the upper airway such as cephalometric radiography, cone beam computed tomography (CBCT), CT, and magnetic resonance imaging.[9] Among these modalities and unlike cephalometric radiography, CBCT is considered a reliable three-dimensional (3D) imaging modality for assessing the airway.[10] Moreover, the scanning time is short, and the radiation dose is low in comparison with normal CT.[9]

CBCT is commonly ordered by dentists for implant site assessment and other dental purposes. If the upper airway is included on the CBCT images, dentists can identify patients at risk of OSA by analyzing different airway parameters on CBCT images such as airway volume, minimum cross-sectional area, anteroposterior distance, and width on smallest axial slice.[8,11-13] Having smaller and narrower airway measurements is associated with OSA.[8,11-13]

In addition to other risk factors for OSA, patients older than 40 years are at risk of developing OSA;[14] however, no previous study has examined the differences in oropharyngeal airway measurements in patients older than 40 years, so this study was conducted.

MATERIALS AND METHODS

Patients

In our retrospective study, images for all patients aged over 40 years who underwent CBCT between January

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2011 and January 2019 for dental implant treatment and other dental purposes at our dental radiology clinic were retrieved and evaluated. Only CBCT images showing the region of oropharyngeal airway with correct patient positioning, normal jaw alignment, and free of pathologies and artifacts were included in the study. The patients included in the study (705) were divided into 3 groups: 207 patients aged 40–49 years (136 females and 71 males), 250 patients aged 50–59 years (160 females and 90 males), and 248 patients aged above 60 years (145 females and 103 males) with a mean patient age of 56 years. The present study is part of a protocol (20/2019) which was approved by our research review board.
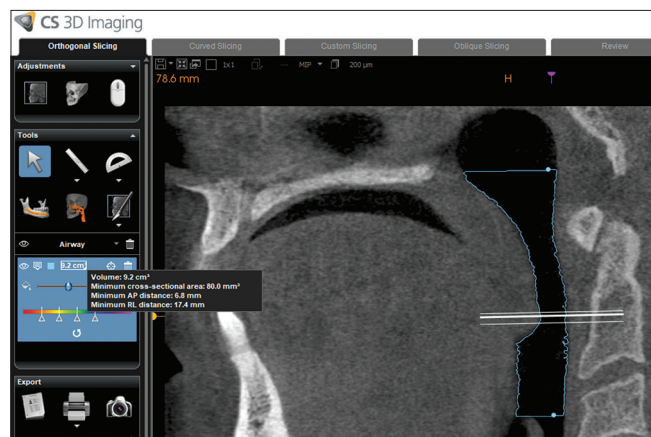
Cone beam computed tomography examination

A KODAK 9500 cone beam 3D system (Carestream, Rochester, NY, USA) with flat panel detector was used to acquire CBCT images. The imaging area of CBCT is a cylinder with a height of 15–20.6 cm and a diameter of 9–18 cm providing isotropic cubic voxels with sides approximating 0.2–0.3 mm. Only cases examined with 0.2 mm were included in the study. The exposure parameters were tube voltage – 90 kV, tube current – 10 mA, and exposure time – 10.8 s.

All examinations were performed by 360° rotation in the occlusal position with the patients standing and closing their teeth.

Images

Using dedicated CBCT software (Kodak CS 3D imaging version 3.8.6, Carestream, Rochester, NY, USA), one calibrated oral radiologist (MA) with 11 years of experience with CBCT was responsible for drawing the path of oropharyngeal airway from posterior nasal spine to the superior border of the epiglottis on a midsagittal section [Figure 1]. Both the upper and lower borders of the oropharyngeal airway were parallel with the Frankfort plane. The software subsequently automatically generated the following values: volume (cm³), minimum cross-sectional area (mm²), minimum anteroposterior distance (mm), and minimum right to left distance (mm). The

Figure 1: Midsagittal cone beam computed tomography section of a 50-year-old patient showing the oropharyngeal airway region with automatically generated measurements

location of the minimum cross-sectional area was also recorded as being cranial or caudal to most anterior inferior corner of the second cervical vertebra. After 4 weeks, the same observer reevaluated the measurements of 100 randomly selected CBCT images.

All images were evaluated on a high-definition liquid crystal display. The window settings were fixed for all cases.

Statistical analysis

Data analysis was achieved via the Statistical Package for Social Sciences software (version 15; SPSS Inc., Chicago, IL, USA). The repeatability of the two sets of measurements was assessed using paired t-tests. Means and standard deviations were used to describe the data. The differences in means of airway measurements were analyzed using one-way ANOVA. *Post hoc* Bonferroni protected pairwise comparisons between the means were performed. A 5% significance level was used for all comparisons.

RESULTS

No statistically significant difference was noted between the first and second set of measurements.

Table 1 shows number, mean value, and standard deviation of all oropharyngeal airway measurements among the three age groups. In addition, *post hoc* Bonferroni test results are presented.

In the middle age group of patients aged 50–59 years, the mean value of each measurement was lower than its counterpart

Table 1: Descriptive statistics of airway measurements among different age groups

Airway measurement	n	Mean	SD
Airway volume (cm³)			
40-49	207	11.646	5.0701
50-59	250	10.839*	4.5389
≥60	248	12.297*	5.1053
Total	705	11.589	4.9326
Minimum cross-sectional area (mm²)			
40-49	207	145.184*	91.7784
50-59	250	117.792*	69.9882
≥60	248	129.127	75.3661
Total	705	129.822	79.4424
Minimum anteroposterior distance (mm)			
40-49	207	9.154*	3.2776
50-59	250	8.260*,□	2.7154
≥60	248	9.026□	3.2982
Total	705	8.792	3.1187
Minimum right-left distance (mm)			
40-49	207	22.026*	6.8101
50-59	250	20.352*	5.4764
≥60	248	21.141	5.7102
Total	705	21.121	6.0057

*/□$P<0.05$, significant difference by the *post hoc* Bonferroni protected pairwise tests. SD – Standard deviation

in other groups. Between the groups, there were statistically significant differences in the mean value of oropharyngeal airway measurements (one-way ANOVA, $P < 0.05$).

Comparing patients aged from 50 to 59 years with the other groups, the mean value of minimum cross-sectional area, minimum anteroposterior distance, and minimum right to left distance was significantly lower than its counterpart in the younger age group of patients aged 40–49 years (*post hoc* Bonferroni test, $P < 0.05$). On the other hand, the mean value of airway volume and minimum anteroposterior distance was significantly lower than its counterpart in the older age group of patients aged ≥60 years (*post hoc* Bonferroni test, $P < 0.05$).

The location of minimum cross-sectional area was above the anterior inferior corner of the second cervical vertebra in 646 patients and below the anterior inferior corner of the second cervical vertebra in 59 patients.

DISCUSSION

In this study, the smallest values of airway measurements were found in patients aged from 50 to 59 years. Therefore, we believe that patients in their fifties are at high risk of developing sleep-related breathing disorders, especially if symptoms of sleep apnea are present. The dentist should pay attention to these symptoms and to airway measurements on their patients' CBCT images. Having small airway measurements in this age group might be an indication for polysomnography.

At the time of conducting CBCT, all patients were in the upright position. To the best of our knowledge, only 3 studies in the literature were conducted using the same methodology.[11-13] In all of these previous studies, airway volume and minimum cross-sectional area were smaller in OSA patients in comparison with controls. Thus, a conclusion can be reached that having small measurements of airway volume and minimum cross-sectional area can result in sleep breathing disorder like OSA.

Although airway volume in the Momany *et al.*'s study[13] was smaller in OSA patients, it was not significantly smaller as shown in the Tikku *et al.*'s and Buchanan *et al.*'s studies.[11,12] This can be due to differences in the study subjects such as age, sex, and craniofacial size. In both of the Buchanan *et al.*'s and Tikku *et al.*'s studies,[11,12] the mean value of the minimum cross-sectional area in OSA patients was <100 mm²; therefore, patients included in our study may not be OSA patients.

The minimum anteroposterior distance and the minimum right-left distance can be measured on the section of minimum cross-sectional area, and contradictory results have been obtained previously.[11-13] Tikku *et al.*[11] reported both values to be significantly smaller in OSA patients; however, only the lateral dimension of the oropharynx was significantly smaller in the Buchanan *et al.*'s study.[12] This might be due to differences in reference standard for identifying patients with OSA, while

as in latter study, polysomnography was the become reference standard; in the Tikku *et al.*'s study,[11] the Epworth Sleepiness Scale and STOP-BANG questionnaire were used as reference. Conversely, Momany *et al.*[13] measured both distances at the anterior inferior corner of the second cervical vertebra, and inconsistent results were shown.

In contrast to previous studies,[11-13] the slice of minimum anteroposterior distance and minimum right-left distance were automatically located and distances were automatically measured by our CBCT software. In most of patients, the slice for measuring these distances is not the slice of minimum cross-sectional area; therefore, a direct comparison with aforementioned studies cannot be made. As with other oropharyngeal airway measurements, these distances were significantly smaller in patients aged 50–59 years. This proves the importance of considering these measurements in an airway analysis.

Finally, we recorded the location of minimum cross-sectional area, and in 59 patients (8%), it was caudal to the anterior inferior corner of the second cervical vertebra. This was only possible by limiting the inferior border of the oropharynx to the upper border of the epiglottis, similar to Buchanan *et al.*[12] Limiting the inferior border of the oropharynx to the level of the anterior inferior corner of the second cervical vertebra might miss the location of minimum cross-sectional area below this border, and this might lead to considering different treatment approaches.[4]

Our current study is the first study to compare oropharyngeal airway measurements in different age groups of patients over 40 years and using a large sample size; however, future studies are needed to correlate the measurements with sleep studies.

CONCLUSIONS

Patients aged 50–59 years have the smallest airway measurements and are probably at the highest risk of developing sleep-related breathing disorders. Further assessment with clinical correlation is recommended.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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