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Survey of the Air Way Volume in Adult Egyptians in Different Classes of Occlusion Utilizing CBCT

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ABSTRACT

Aim: The aim of this work was to survey the total air way volume and the surface area of the most constricted area of the air way in adult Egyptians in different classes of occlusion utilizing the cone beam CT (CBCT).

Patients: 30 patients from those who have done CBCT scan for different indications were randomly selected. 10 had Class I occlusion, 10 had Class II and 10 had Class III. A special software have been used to measure the airway volume and other measurements.

Results: The average airway volume in Class I occlusion was 13.2 cc. The average airway volume in Class II occlusion was 13 cc. The average airway volume in Class III occlusion was 10 cc. The average value of the surface area in the most constricted area of the airway was highest in Class III (129.3mm^2), followed by Class I (119.9mm^2), followed by Class II (106.4mm^2).

Conclusion: Patients having normal occlusion possessed the highest airway volume. The surface area in the most constricted area had a highest value in Class III occlusion and lowest value in Class II. There is no statistically significant relationship between volume of the airway and age or sex.

INTRODUCTION

CBCT has become an increasingly important source of three dimensional (3D) volumetric data in clinical orthodontics since its introduction into dentistry in 1998 [1].

CBCT allows 3-D visualization of the oral and maxillofacial complex from any plane. With the development of CBCT, there has been a drastic reduction in radiation exposure to the patient, which allows its use for safely obtaining three dimensional images of the craniofacial structures. This should allow the clinician to visualize the hard and soft tissues of the craniofacial region from multiple perspectives, which could have far-reaching implications for treatment planning in orthodontics and orthognathic surgery [2,3].

Airway volume and respiratory function are highly relevant to the orthodontic and the maxillofacial specialty. Studies have confirmed that airway problems are significantly related to different types of malocclusion and that nasal obstruction is a major etiological factor for dentofacial anomalies [4].

Most of the airway studies relating airway anatomy and the craniofacial growth and development are limited because of using the two-dimensional lateral or frontal cephalograms which cannot identify the soft tissue contour in the third dimension thus limiting evaluation of areas and volumes. Currently, the advances in computed tomography imaging and the three-dimensional technology allow better visualization of the airway and volumetric analysis [5].

Clinicians can more easily perform the volumetric measurements and also calculate the cross-sectional areas of the airway in three planes of space: Coronal, sagittal, and axial [6]. The axial plane, which is not visualized on a lateral cephalogram, is the most physiologically relevant plane because it is perpendicular to the airflow [7]. CBCT systems have been developed specifically for the maxillofacial region. Accurate and easy evaluation of the airway anatomy has been possible using those CBCT systems [8-12].

PATIENTS AND METHODS

This is a randomized retrospective study. Thirty patients from those who had undergone CBCT for maxillofacial problems were randomly selected to be the sample of this study. Their age ranged between 20 and 39. 15 were males and 15 were females. 10 patients had Class I occlusion (Group A), 10 had Class II (Group B) and 10 had Class III occlusion (Group C).

Patients below 20 years age and those above 40 years were excluded from this study. Also, patients who had performed surgical interventions on the mandible or the maxilla were excluded.

The airway was traced in three planes (sagittal, axial and coronal). The airway anatomical landmarks were determined as follows, cephalic was the hard palate plane, caudal was the upper end of the glottis, ventral was the posterior surface of the tongue, dorsal was the posterior pharyngeal wall, and lateral was the right and left lateral pharyngeal walls.

The total airway volume was measured in cubic centimeters utilizing a specific software (In vivo Dental Anatomag). The ANB angle was measured in all cases so as to correlate the degree of malocclusion with the airway volume. The surface area of the maximum constricted segment was measured in square millimeters.

The relationship between the ANB angle and the airway volume was determined.

RESULTS

The total air way volume in Class I ranged between 6.6cc and 30.8cc. The average was 13.2cc. The total air way volume in Class II ranged between 4.1cc and 26.3cc. The average was 13cc. The total air way volume in Class III ranged between 6.3cc and 25cc. The average was 10cc. Although it was expected that the average total airway volume takes the highest value in Class III followed by Class I and finally Class II, yet, what has been recorded shows the highest value with Class I followed by Class II and finally Class III.

The ANB angle in Class I ranged between 1.5 and 2.8 degrees. The average was 2.0 degrees. The ANB angle in Class II ranged between 4.1 and 9.8 degrees. The average was 6.2 degrees. The ANB angle in Class III ranged between –1.1 and –4.9 degrees. The average was –3.6 degrees.

Within the same class, the highest total airway volume coincided with the lowest ANB angle. In Class I, the highest total air way volume was 30.8cc which coincided with the lowest ANB angle which was 1.5 degrees. Also, the lowest total air way volume was 6.6cc which coincided with the highest ANB angle which was 2.8 degrees. In Class II, the highest total air way volume was 26.3cc which coincided with the lowest ANB angle which was 4.1 degrees. Also, the lowest total air way volume was 4.1cc which coincided with the highest ANB angle which was 9.8 degrees. In Class III, the highest total air way volume was 25cc which coincided with the lowest ANB angle which was –4.9 degrees. Also, the lowest total air way volume was 6.3cc which coincided with the highest ANB angle which was –1.5 degrees. However, this relationship between the total airway volume and the ANB angle was not a fixed finding among all readings.

The surface area in the most constricted area in Class I occlusion ranged between 4.3 and 348.7mm^2. The average was 119.9mm^2. The surface area in the most constricted area in Class II occlusion ranged between 30.4 and 311.8mm^2. The average was 106.4mm^{2}rs. The surface area in the most constricted area in Class III occlusion ranged between 11.1 and 271.1mm^2. The average was 129.3mm^2. This maximum constricted area lied near the oropharynx in most of the cases.

The average value of the surface area in the most constricted area of the airway was highest in Class III (129.3mm^2), followed by Class I (119.9mm^2), followed by Class II (106.4mm^2).

There was no statistically significant relationship between volume of the airway and age or sex (Tables 1-3).

Table (1): Group (A) Class I occlusion.

Age (years)	Sex	Total airway volume (cc)	ANB angle (degrees)	Surface area of the most constricted area (mm^2)
36	Male	11.4	2.1	141.0
21	Male	12.5	1.9	154.6
27	Female	7.7	1.9	90.6
31	Male	13.8	2	4.3
39	Male	10.7	2.3	27.1
26	Male	6.6	2.8	28.4
32	Female	10.4	2.4	129.8
31	Female	30.8	1.5	348.7
29	Female	13.6	1.9	123.8
33	Female	15	1.8	151.4

Table (2): Group (B) Class II occlusion.

Age	Sex	Total airway volume (cc)	ANB angle (degrees)	Surface area of the most constricted area (mm^2)
21	Male	13.7	5	154.5
27	Female	26.3	4.1	30.4
33	Female	8.6	4.5	88.8
38	Female	21.7	9.4	201.2
22	Male	20.8	4.3	311.8
26	Male	9.1	5	73.1
27	Male	5.8	5.6	31.7
39	Female	9.5	5.2	56.6
30	Male	4.1	9.8	56.6
23	Male	11.3	9.3	59.5

Table (3): Group (C) Class III occlusion.

Age	Sex	Total airway volume (cc)	ANB angle (degrees)	Surface area of the most constricted area (mm^2)
22	Male	19.3	–3.5	197.5
35	Male	24.1	–4.7	70.8
33	Female	17.7	–4.3	232.9
31	Female	8.3	–4.1	91.3
21	Female	7.1	–4.5	54.4
22	Male	25	–4.9	271.1
26	Female	10	–1.1	130.9
33	Female	6.3	–1.5	88.5
21	Female	14.8	–3.3	145.2
34	Male	18.3	–4.2	11.1

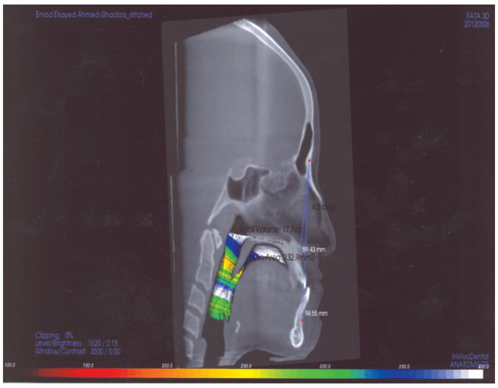

Fig. (1): Patient number (3) in group (C). The ANB is –4.3 degrees, The total airway volume is 17.7cc and the surface area of the maximum constricted area is 232.9mm2.

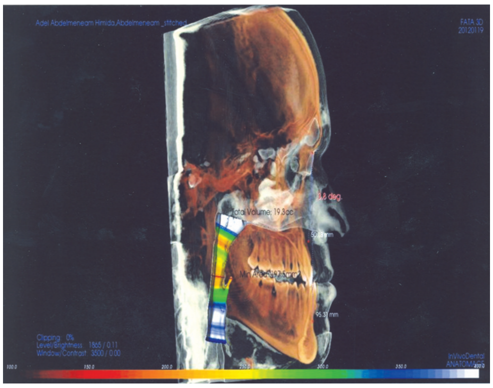

Fig. (2): Patient number (1) in group (C). The ANB is –3.5 degrees, The total airway volume is 19.3cc and the surface area of the maximum constricted area is 197.5mm2.

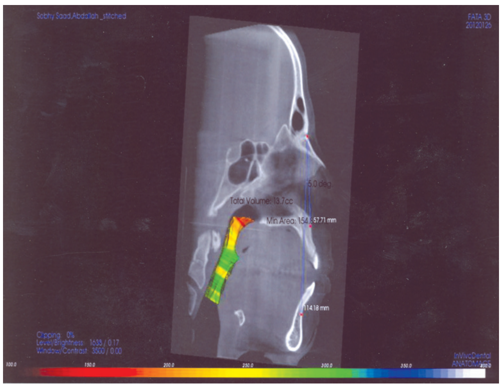

Fig. (3): Patient number (1) in group (B). The ANB is 5 degrees, The total airway volume is 13.7cc and the surface area of the maximum constricted area is 154.5mm2.

DISCUSSION

In a comparison between CT and lateral cephalometric radiographs in assessing the pharyngeal airway space, Abouda et al., 2009 **[5]** found a significant correlation between sagittal area obtained from the radiographs and the volume obtained from CBCT, although the latter showed greater variability in patients with similar airway space in lateral cephalometric radiographs. This is expected since cephalometric analysis of conventional lateral radiographs only measures pharynx height and depth and therefore does not allow cross-sectional (i.e., width) examination **[12]**.

Because CBCT is three-dimensional, it allows clinicians to assess the airway space and surrounding structures, and determine three-dimensional naso-, oro- and hypopharyngeal measurements, such as the most constricted area, volume and the smallest anteroposterior and lateral pharyngeal dimensions in OSAS patients. One can also evaluate changes that might potentially be induced by the treatment modality itself, and identify which patients would benefit from such treatment **[12]**.

In a randomized retrospective study up on 10 patients selected randomly from a pool of 196 subjects seeking dental treatment at the University of California, Hsiag HT et al., 2009 **[13]** demonstrated that 8 of the 10 subjects demonstrated a region of maximum constriction near the oropharynx level. The most restricted cross-sectional area varied from 90mm2 to 360mm2.

In their three-dimensional analysis of pharyngeal airway volume in adults with anterior position of the mandible. Hong JS et al., 2011 **[14]**, measured the pharyngeal airway volumes and areas and compared them with the cephalometric variables. The volume of the upper part of the pharyngeal space was greater in patients with skeletal Class III malocclusion, and the increased volume of the upper part of the pharyngeal airway showed significant correlations with measurements characterizing the anterior position of mandible as indicated by negative correlations with ANB angle.

Dan Grauer et al., **[15]** studied the Pharyngeal airway volume and shape from cone-beam computed tomography and their relationship to facial morphology. They concluded that the average volume of the pharyngeal airway was 20.3cm3 (SD, 7.3cm3), with mean volumes of 8.8cm3 (SD, 2.9cm3) for the superior component and 11.5cm3 (SD, 4.9cm3) for the inferior component. Preliminary bivariate analysis showed no statistically significant relationship between volume of the airway and age or sex. There were other potential influences on airway dimensions and shape. They found a significant difference in the inferior compartment of the airway volume between skeletal Class II and Class I and Class III patients (skeletal Class II inferior compartment airway volume was smaller, p=0.02), but there were no significant differences in airway volume among the long, normal, and short face-height groups. Airway orientation and shape differed between the Class II and Class III groups, with no difference between the vertical groups. Several factors might have contributed to these outcomes.

Many authors [14-17] utilized the CBCT to detect the changes in the air way volume after mandibular setback and after bimaxillary surgery. Pereira-Filho VA et al., 2011 [16] concluded that patients who underwent bimaxillary surgery, upper jaw advancement compensated for changes of the posterior air space brought about by the mandibular setback. Patients who received mandibular setback surgery showed no changes in the posterior air space, and those who underwent maxillary advancement showed a significant increase of the posterior air space and that remained stable during the evaluation period. Park et al., 2012 [17] showed that the volumes of the oropharyngeal and hypopharyngeal airways decreased significantly 4.6 months post-surgery in the mandibular setback group. In the bimaxillary surgery group, the volume of the oropharyngeal airway also decreased. Hong et al., 2011 [14] concluded that the pharyngeal airway showed significant narrowing after both mandibular setback surgery and bimaxillary surgery.

Studies using CBCT have established a correlation between airway space and facial pattern. The oropharyngeal airway space of individuals with Class III anteroposterior skeletal pattern appears to be wider and more flattened displaying a more vertical orientation relative to the sagittal plane [18]. Individuals with Class II anteroposterior skeletal pattern, on the other hand, showed a more anterior superior airspace [19].

Three-dimensional images of the airway allow improved evaluation of sites of airway obstruction, and further studies are needed to clarify the physiologic response to pharyngeal stenosis. Computer software that allows determination of volumes from surface contours is more accurate for these research studies. In addition, it already is possible to use the cranial base surface to superimpose 3D models for different times in the same patient, so that changes in airway volume and orientation relative to this stable reference can be studied before and after surgery [15].

Freitas et al., 2006 [20] concluded that the upper and lower pharyngeal airway width is not associated with Class I or Class II malocclusions. However, Kirjavainen and Kirjavainen, 2007 [4] reported that in Class II malocclusion, there is an association with a narrower upper airway structure even without retrognathia. Although Trenouth and Timms (1999) [21] showed that the oropharyngeal airway was positively correlated with length of the mandible. None of the subjects with short mandibular length in their study had OSA [12].

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