CONE BEAM COMPUTED TOMOGRAPHY ROLE IN SURGICAL TREATMENT PLANNING OF OBSTRUCTIVE SLEEP APNEA PATIENTS

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ABSTRACT

Purpose: To evaluate the accuracy of cone beam computed tomography (CBCT) as a diagnostic tool that can be used (alone or in conjunction with another diagnostic tool) in surgical treatment planning of obstructive sleep apnea (OSA) patients and to determine level of collapse in the upper airway.

Methods: Using a case-control study, 40 patients subjected to upper airway surgery were selected in this study. All patients were subjected to physical, clinical evaluation and Drug Induced Sleep Endoscopy (DISE), for 20 patients surgery was done without CBCT scanning, while 20 patients surgery was done after CBCT scanning and assessing radiographic findings including virtual endoscopy with clinical findings. Both groups were clinically evaluated after six months of the surgery to determine surgical treatment planning success. For all tests P≤0.05 was considered statistically significant.

Results: Group II was more superior over group I in postoperative clinical parameters such as patient satisfaction and AHI reduction.

Conclusion: CBCT is a low dose highly efficient diagnostic tool that is very important in proper evaluation of OSA. Virtual endoscopy is a noninvasive impressive tool for 3D soft tissue simulation.

KEY WORDS: Cone beam computed tomography, Obstructive sleep apnea, Drug induced sleep endoscopy, Virtual Endoscopy.

INTRODUCTION

The definition of OSAS has been changed through last years with the progress of pathological knowledge of the disease.[1-3] At the beginning, OSAS was defined as "average frequency of apneic episodes every hour of sleep", but this definition

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lacks the clinical parameters so, it was replaced by the concept of apnea/hypoapnea index which is considered as a parameter that points out the sleep physiology alterations and shows the severity of the disease.[1] Apnea/Hypoapnea Index (AHI) is given by the number of apneas plus number of hypoapneas for an hour of sleep.[1] Recently, OSAS is defined as "Five or more episodes of apnea or hypoapnea per hour of sleep with associated symptoms or 15 or more episodes per hour of sleep regardless of associated symptoms".[4-6]

OSAS is caused by anatomic and neurological abnormalities.[1] During inhalation, pharynx contracts promoting its collapse. The imbalance between negative pressure which exaggerates airway collapse and contractile activity of the pharynx dilator muscle is the main cause of upper airway obstructions.[4] Pharyngeal collapse etiology is multifactorial,[1] It may be associated with:

a) Anatomical factors as: accumulation of fatty tissues in sub mucosa.

b) Physiological and functional factors as: hypo tonicity of the pharyngeal muscles during sleep.

c) Pathological factors as: sever reduction in the tonicity of pharyngeal muscles.

OSAS is usually asymptomatic as 20-30 % in the middle aged population are suffering from OSA and don't present any clinical symptoms.[4, 7] However, African Americans are more affected.[4, 8]

Clinical manifestations of OSA include the signs and symptoms of upper airway obstruction, insomnia and hypersomnia. Symptoms always begin gradually and may last for long time before referral for evaluation. Obstructive breathing symptoms at night includes: snoring, gasping and choking. Patients complain from interrupted awaking and insomnia with reduction of total sleep time, fragmented sleep or early morning awakenings.[4, 9] However, patients usually under estimate nocturnal symptoms resulting in diagnosis delay until it becomes more obvious at daytime.[4]

Usual daytime symptoms include: headache and dry mouth at early waking up time. However, the most obvious complaints of the patients are chronic fatigue and daytime sleepiness. During early stages of the disease, the patient may fall asleep during activities as office work. During this stage, conflict between hyper somnolence and tiredness may occur. Chronic fatigue is often under evaluated. With the progression of the disease, sleepiness interrupts all daily activities and become unsafe. Accordingly, OSA represents a major cause of motor vehicle crashes.[4, 10].

For years, 2-dimenseional (2D) cephalometric images was valuable to differentiate between OSA and normal patients. However, the complex shape of airway can't be fully evaluated except with 3D images.[11-13] Cone beam computed tomography (CBCT) has the advantage of short scanning time which is a relatively low dose compared with conventional CT, [11, 12] high resolution between bony skeleton, and air spaces which in advance provides ideal visualization to the complex anatomy of pharynx.[12, 14, 15] Reliability and measurements of upper airway space with CBCT shows great accuracy in comparison with images from multidetector CT. [12, 16, 17]

MATERIALS AND METHODS

Forty patients were selected from outpatient sleep clinic in Mansoura University hospital. Full clinical assessment was performed including: Body Mass Index (BMI) and signs and symptoms of OSA. This study included only surgical candidates who refused medical treatment and Continuous Positive Airway Pressure (CPAP).

All candidates were subjected to specific printed questionnaire "Epworth Sleepiness Scale" (ESS) [18]. The scale is composed of 8 questions based on different daily activates asking the patient about the usual chances of dozing or falling asleep during these activates. The patients respond on 4-point

scale (0-3) where 0= Never doze, 1= Slight chance of dozing, 2= Moderate chance of dozing, 3= Hight chance of dozing. According to ESS score, patients are classified into normal (ESS= 0–8), mild to moderate (ESS= 8–15), and severe (ESS= 16–24)[19].

Patients were divided into 2 groups: Group I consisted of twenty patients who were subjected to surgical treatment without CBCT imaging, group II consisted of twenty patients for whom surgery was performed after imaging by CBCT with new quick scan plus technique of 16cm x 13cm FOV (120 KV, 5 mA, 2 sec) and resolution of 0.3 mm voxel size using iCAT FLX V17 machine (Imaging Science International, ISI, PA, USA).

Dual scanning technique was done for group II patients; once at the end of inspiration and at expiratory end. AHI was performed to detect disease severity and on the strength of AHI value, OSA can be classified into mild respiratory alterations (AHI = 5-14 / hour), moderate (AHI = 15-30 / hour) and sever (AHI 30 > / hour). To evaluate upper airway anatomy to detect the possible levels of airway collapse; Drug Induced Sleep Endoscopy (DISE) was performed.

DISE procedures:

The patient lied in a supine position on the operating table. The patients had basic cardio respiratory monitoring (pulse oximetry, blood pressure, electrocardiogram), and oxygen mask on the operating table. The target depth of sedation is the transition from consciousness to unconsciousness (loss of response to verbal stimulation), in another word when the patient chocks and snores. We used to induce sleep using propofol in a dose of (1.5 mg/kg). Propofol is an ultra-short acting hypnotic, enables greater control of the depth of sedation during sleep endoscopy as the anesthetic depth is a key of importance during sleep endoscope so we used slow stepwise induction to avoid over sedation.

Once the patient has reached a satisfactory level of sedation, a 3.5 mm lubricated flexible endoscope was introduced into the nasal cavity. The nasal passage, nasopharynx, velum, tongue base, epiglottis, and larynx were observed. The levels of snoring and/or obstruction were assessed.

Radiographic Assessment:

Raw Dicom data from CBCT scanning were analyzed by specific software. Linear measurements were done by OnDemand3DApp software while volumetric measurements were done by Invivo5 software, including: total airway volume and narrowest Cross-sectional Area (CSA) and the morphology of retropalatal space. (Fig. 1) Virtual endoscopy was performed in 3D Module of the OnDemand3DApp software.
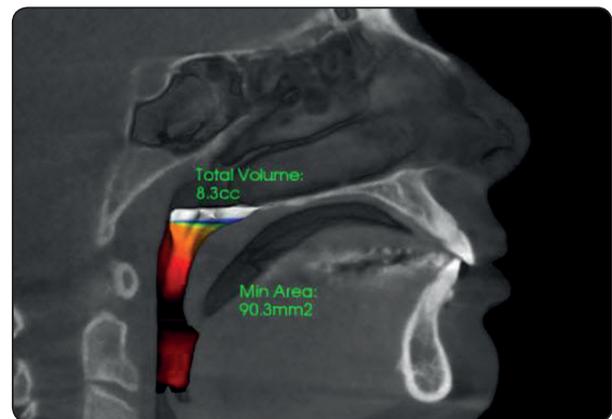

Fig. (1) The total airway volume and narrowest Cross-sectional Area (CSA) measured by InVivo Dental software.

Level of collapse determined by the aid of DISE, sagittal views and virtual endoscopy at both end of inspiration and end of expiration imaging protocols. (Fig.2,3) Surgical treatment plan was determined in group II after proper clinical and radiographic assessment.

Post-surgical Assessment:

Resolution of the symptoms, patient satisfaction questioner (ESS) and AHI measurement were evaluated after six months of the surgery to determine the success or failure of surgical procedure in both groups.
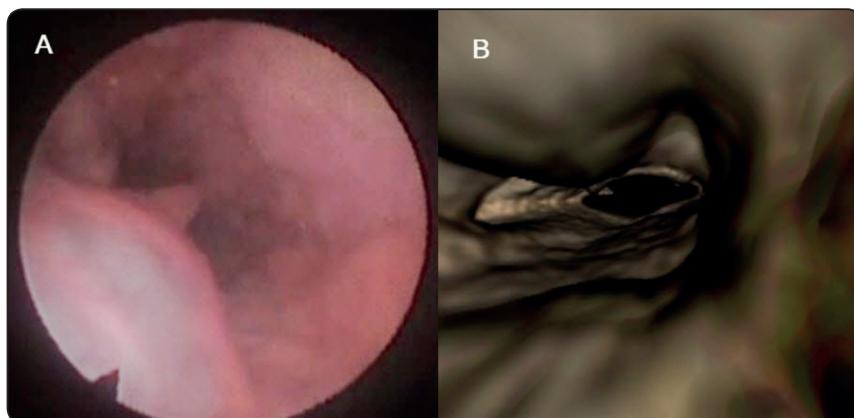
Fig. (2) (A): Pharyngeal airway space view by DISE. (B): Pharyngeal airway space view by Virtual Endoscopy done by OnDemand 3DApp software.
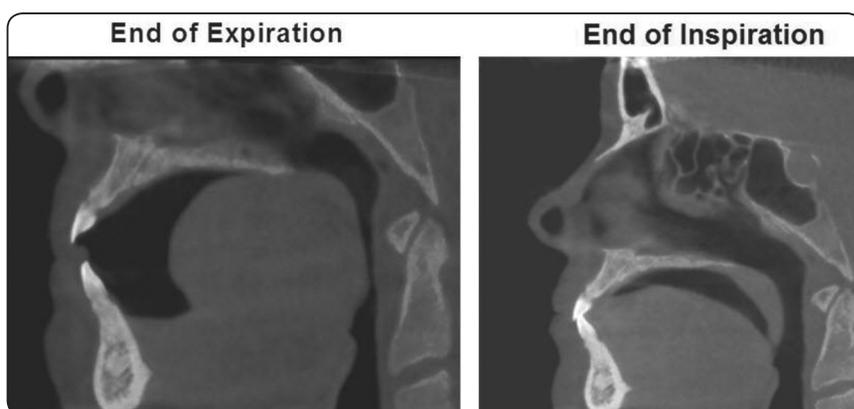

Fig. (3) Determining level of collapse by the aid of CBCT scanning during end of expiration and end of inspiration.

Statistical Analysis

Each individual score of the 8 questions of ESS was recorded and summed to calculate the final ESS score for each patient. Mean and standard deviation (SD) were calculated for each group.

ESS scores for both groups were compared by Chi-square test. While the numerical data for AHI was compared using student's *t* test. For all tests, statistical significance is considered for values $p \leq 0.05$.

RESULTS

The results showed statistical significance in ESS scores in group I while it was highly statically significant in group II. According to ESS Scores classification, group I patient's ESS scores were changed from severe preoperatively to moderate postoperatively. In group II patient's scores were dropped from severe preoperatively to normal postoperatively (Table 1).

TABLE (1) Comparison of patient's satisfaction measured by ESS answered by the patients pre- and post-surgery in group I.

	Pre-Surgery ESS Score	Post-Surgery ESS Score
Group I	14.5 ± 3.8	9.6 ± 1.7
Group II	13.8 ± 4.2**	5.4 ± 2.3**

* P value < 0.05 (statistically significant)

** P value < 0.0001 (high statistical significance)

Table (2) showed severe reduction in AHI measurements in group II patients with high statistical significance in comparison with group I patients postoperatively especially in severe OSA cases. In group I, 12 patients with severe OSA preoperatively has been decreased to only 10, while in group II, there was compete resolution of all 11 sever OSA patients. There was no statistical significance in moderate OSA cases between both groups.

TABLE (2) Comparison of pre-surgical and post-surgical AHI measurements between patients of group I and group II.

AHI	Group I		Group II	
	pre-operative	post-operative	pre-operative	post-operative
Mild	3	7**	2	18**
Moderate	5	3	7	2
Sever	12	10**	11	0**

* P value < 0.05 (statistically significant)

** P value < 0.0001 (high statistical significance)

DISCUSSION

This study is composed of 40 OSA patients, for 20 patients surgery was performed after clinical and radiographic evaluation using CBCT, while other 20 patients were subjected to the surgery after clinical evaluation only. CBCT showed superiority in the diagnosis and treatment planning in combination with clinical assessment to improve patient's satisfaction.

These results corelate with the findings of Momany et al,[12] who concluded that CBCT can provide findings that help earlier referral of suspected patients with OSA. Also, Ogawa et al,[11] were evaluating the cross-section airway configuration of obstructive sleep apnea by CBCT and found that CBCT could distinguish OSA patients from non-OSA patients by evaluating the characteristics of airway in a 3-dimenasional imaging.

Another study comparing parameters obtained from CBCT and sleep questionnaire in OSA patients, [17] concluded that 3D CBCT airway analysis is considered a powerful tool for assessment of the presence and severity of OSA.

Many other studies reached the same results of the significance in using CBCT based 3D analysis for better evaluation of anatomical airway characteristics and morphology which in turn affects treatment planning and final patient's satisfaction after surgery. [15, 20]

Our results showed high significance in imaging patients with low dose CBCT in both end of expiration and end of inspiration which in turn helped in accurate determination of the level of collapse. Subsequently, this could change the surgical decision especially in retroglossal collapse patients. These results are in agreement with work done by Woodson B.T [21] who found that retroglossal collapse appear more frequently during expiration.

CONCLUSION

CBCT is considered a low dose highly efficient diagnostic tool that is essential in conjunction with clinical assessment in proper evaluation of OSA especially in severe cases. Virtual endoscopy is a noninvasive tool for visualization of soft tissue pharyngeal wall.

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