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Obstructive sleep apnea: An oral and maxillofacial radiology perspective

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Abstract
Sleep related disorders can have a drastic negative effect on the quality of life of an individual. Obstructive sleep apnea (OSA) is well recognized condition that is characterized by frequent short periods of collapse of the upper airway, complete or partial obstruction of the airway during sleep, associated with snoring and brief arousals, resulting in sleep disturbance and deprivation. OSA is reported as chronic disease affecting approximately 2-4 % of the adults globally, with middle aged being the most affected. The diagnosis and management of OSA requires a multidisciplinary approach comprising of health professionals of various specialties including dental professionals. The emergence of sleep medicine as a specialty focusing exclusively on sleep-related breathing disorders has incorporated health care professionals of various specialties including pulmonologists, otolaryngologists and dentists in the sleep medicine team. Oral Obstructive sleep apnea exhibits various maxillofacial and upper airway features manifestations such as midface and mandibular hypoplasia, micro pharyngeal ptosis involving tonsils and adenoids, followed by specific radiographic air way findings. Maxillofacial Radiologists play a significant role in identifying patients with OSA with subsequent referral to a sleep clinic. Therefore, Oral Medicine and Radiology Specialists play an important role in recognition of obstructive sleep apnea.

Keywords: Obstructive sleep apnea, snoring, airway, radiologist, hypopharynx

Introduction

Radiology is a broad medical specialty that has undergone tremendous advancements in the recent decade with increasing sub-specializations of radiologists. Dental and Maxillofacial radiology is a subset of Radiology which is considered as a corner stone supporting various other dental specialties. The role of imaging in dental patients ranges from the initial screening to treatment planning and follow up [1, 2]. Specialists in Oral Medicine and Radiology can play a pivotal role in recognition of various non-dental conditions such as Obstructive Sleep Apnea (OSA) through history, clinical examination, and radiographic investigations which is within their scope of practice. Sleep disordered breathing (SDB) is a wide term that includes a group of similar problems manifesting with difficulties in breathing during sleep. These disorders can range from socially disturbing snoring to severe and life-threatening obstructive sleep apnea (OSA). [3] OSA is regarded as the most often reported form of SDB that has gained attention among clinicians including dentists. It was Guilleminault *et al.* in 1976, who first described the term Sleep apnea referring to the Greek term ‘Apnea’ which means ‘without breath’. The manifestations of OSA includes short episodes of cessation in breathing or shallow breathing during sleep. In most instances, the respiratory events are associated with snoring and oxygen desaturations resulting in a brief arousal from sleep. [4, 5] Various other symptoms such as inordinate day doziness, cardiovascular morbidity and mortality are also reported among individuals with OSA. [6] The importance of OSA in the field of dentistry is growing in terms of research and co-management. This narrative review aims to brief the role of Oral Medicine and Radiology specialists in the recognition of Obstructive Sleep Apnea.

Materials and Methods

A computerized database search in PubMed and Google Scholar was conducted using the following search terms: (“Obstructive Sleep Apnea”) and (“Maxillofacial radiology” or

"Dentistry" or "Oral Appliance"). The articles that were published in the English language, from the year 1990 to September 2022 with an emphasis on the dental perspective and radiographic changes in OSA were considered for compilation of the present review. Articles in languages other than English, articles emphasizing the relationship of OSA with other systemic involvement were excluded. Since the literature search was intended only for compilations of a narrative review there were no strict exclusion criteria.

Etiology

The etiology OD OSA is multifactorial and can be attributed to various anatomical and neuromuscular factors. Age, as well as associated conditions like hypertension and endocrine disorders, are important factors. Association with numerous psychogenic factors such as neurobehavioral deficits and mood changes, similar as perversity and depression are reported with OSA. [7] Pham *et al.* explained the biological plausibility in the association between upper airway collapsibility and OSA. Upper airway tube is a rigid structure and narrowing of which would result in increased airway resistance. [8] Obesity is also considered as a predisposing factor for development of OSA as it contributes in accumulation of quantum of fat deposits along the pharyngeal wall and also reduces lung compliance. [9] The oropharyngeal airway occlusion is a common feature of OSA which contributes to a brief disturbance from sleep progressive due to asphyxia, and the condition improves once the normal position is returned back and the airway patency is restored [10].

Previous studies have found the upper airway muscles to contract less forcefully than usual when someone is sleeping, so as to recompense the airway narrowing and increased airway resistance. [11] Reduced mandibular length is also considered as an important predisposing factor to OSA. [12] Other factors include anatomic variations such as tonsillar hypertrophy, retrognathia of either jaw or Macroglossia [13]. Arya *et al.* reported the crucial relationship of the hyoid bone in maintaining the upper airway dimension. The lower part of hyoid bone along with the altered tongue posture can aggravate apnea due to redundant energy needed for elevation of the tongue. [14] Familial history of OSA or snoring, clinically evident large uvula, physical and structural abnormalities, cerebral paralysis, muscular dystrophy, vocal cord palsy, opiate use, chronic smoking, Down's syndrome, hypothyroidism, mouth breathing and other similar conditions that may cause a constriction of the upper airway have been reported as causative factors for OSA [15].

Epidemiology

OSA is more prevalent in Caucasians than Asian populations. The prevalence was reported to be higher especially in the middle-aged population. Literature evidence report OSA to be more prevalent in the age group of 30 to 60 years. Other research indicates that between 0.3 and 4 % of people in their middle years suffer from obstructive sleep apnea. In Asia, a prevalence of 4.1-7.5 % among men and 2.1-3.2 % among women has been reported. However, these is a great disproportion in the rates of prevalence rates reported among various countries. [16] Young *et al.* reported a male predilection of OSA. [10] Another study by Broström *et al.* [12] reported that men with BMI greater than 30 kg/m2 are more to develop to OSA. According to reports, an increase in prevalence of OSA with advancing age has been reported, ranging from 2 % in children to 2.5–6 % in adolescents [17-19].

Clinical features

Sleep Apneas are generally categorized into three types Obstructive, Central and Complex. The Central type of sleep apnea refers to the disorder which is caused due to lack or compensation in the neurological control of the muscles associated with breathing. Another form of SDB, known as complex sleep apnea occurs when frequent central apneas (more than five per hour) remain or emerge when obstructive events are eliminated with positive airway pressure [20, 21].

OSA has a negative impact on the quality of life of affected individuals. These detrimental outcomes include emotional issues as well as disturbed sleep patterns and poor academic performance. Untreated severe OSA can lead to gastrointestinal, cardiopulmonary and neurocognitive disorders [16, 22]. Obesity, body mass index, and neck circumference are the main factors linked to an increase in OSA frequency. A person is considered to be at risk for sleep apnea if they have a body mass index (BMI) exceeding 25, neck circumference that is over 16 inches or the presence of both [23, 24]. Adenotonsilar hypertrophy, which refers to the increase in the size of adenoids and tonsils increases in size resulting in occupying a large area in the nasopharynx region contributing to breathing disorders [25] Drooling, xerostomia, insomnia, apneas, choking or gasping, and diaphoresis are some of the nocturnal signs and symptoms of OSA. [26].

Apnea hypopnea indicator (AHI) score categorizes OSA patients into three groups. The average number of apnea-hypopnea occurrences per hour is less than five (Table 1). [27] Maxillofacial features associated with OSA may include straight or concave profile, narrow palate and large tongue. [28].

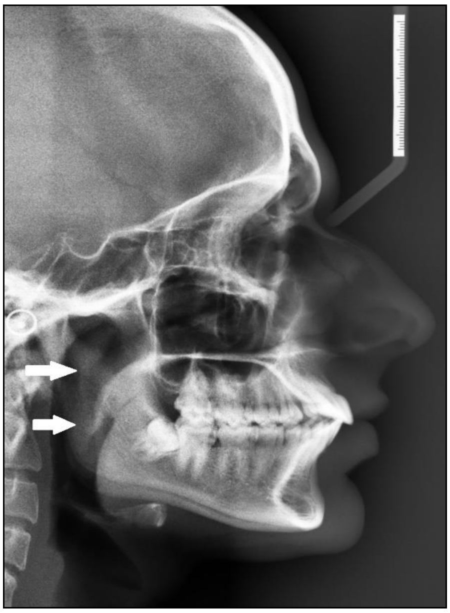

Fig 1: A Lateral Cephalogram showing airway of normal dimension (White Arrow)

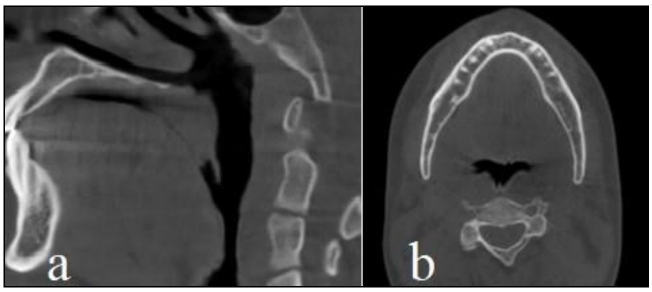

Fig 2: CBCT of an OSA patient demonstrating small upper airway (a. sagittal slice, b. axial slice)

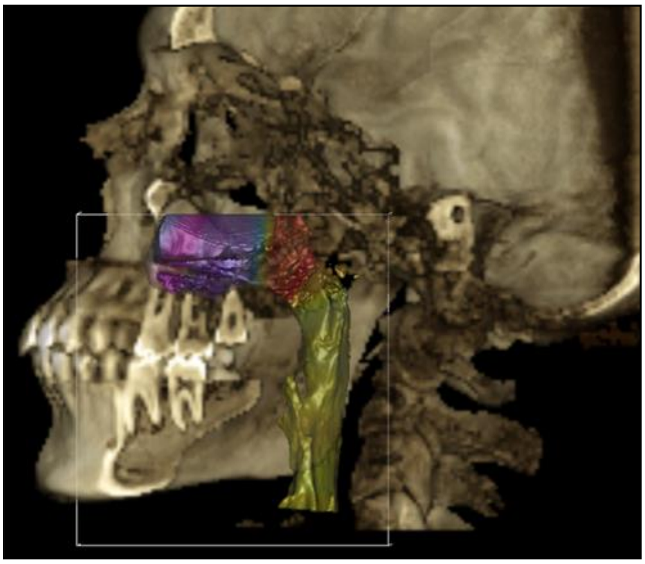

Fig 3: Semi-automated segmentation of upper airway in a 3-D reconstructed CBCT. (Software Planmeca Romexis, Version 5.1.0)

Table 1: Apnea Hypopnea Index scores.

AHI Grade	Score
Mild	5 - 15 events per hour
Moderate	15 - 30 events per hour
Severe	More than 30 events per hour

Table 2: Severity of obstructive sleep apnea based on Oxygen saturation.

Grade	Description
Mild	85% - 90% oxygen saturation
Moderate	80% - 84% oxygen saturation
Severe	Below 80% oxygen saturation

Diagnosis

The well-known and standard approach for diagnosing obstructive sleep apnea is the polysomnographic test. This test offers a quantitative evaluation of the instances of oxygen desaturation and breathing obstruction per hour. It must be noted there are differences between the polysomnographic criteria for diagnosing OSA in children and adults. Mild OSA in children is indicated by an AHI > 1 and an oxygen desaturation 4. Whereas, AHI of 5 (or infrequently 10) denotes mild OSA in adults [29].

Pharyngeal Wall Floppiness is considered as a non-invasive testing modality that is used as a tool in the assessment of Obstructive Sleep Apnea as subjects with OSA exhibit lesser pharyngeal wall slackness compared among healthy subjects. [30].

Several other radiographic imaging modalities within the scope of a maxillofacial radiology, are used as diagnostic aids of OSA.

Lateral Cephalometry

Lateral cephalogram is routinely utilized in maxillofacial radiology for orthodontic purposes. Julià- Serdà *et al.* [31] and Guttal *et al.* [32] inferred that cephalometry in combination with clinical examination and nocturnal oximetry to serve as an useful aid in the evaluation of OSA case as cephalometry provides a quick two dimensional assessment of upper airway but the major disadvantage is that lateral cephalograms can only depict the two dimensional morphology and prone of numerous superimpositions. (Figure 1) According to McNamara, width of the upper pharyngeal airway was reported as 15-20mm while the lower pharyngeal airway width was reported to be 11-14 mm. [18] Maltais *et al.* [33] have reported the successful use of cephalometric analysis to the assess the upper airway patency. It was further verified by Pirilä- Parkkinen *et al.* [34] who stated lateral cephalogram as a valid system for measuring the dimensions of nasopharynx and retropalatal region. However, the airway diameter was prone to change when imaged in standing and lying down positions. [17] Lateral Cephalogram can also be used to assess the Mandible to Hyoid Distance (MHD). Ara *et al.* from their study had reported increased MHD in OSA patients due to inferiorly placed hyoid bone. It was also postulated that patients with lower Upper Airway Diameter (UAD) along with a high Mandible to Hyoid Distance (MHD) to possess high risk for developing OSA [35].

Cone Beam Computed Tomography

Cone Beam Computed Tomography (CBCT) is a 3-dimensional modality that can provide single plane image along the midline. It effectively lessens the overlap of head and neck structures which is challenging to identify and measure certain anatomic entities in a conventional 2-D cephalogram. Also, as CBCT image is not magnified and is recorded directly on a 1:1 scale, it permits accurate dimensional measurements than any other 2-D modalities because magnification is a factor that has to be calculated and compensated during measurements and analysis of 2D radiographic images [36]. Airway analysis from medical Computed Tomography (CT) or CBCT scan data was a time-consuming procedure formerly due to the manual data segmentation and measurement which is a difficult procedure and there exists chances of disproportion in the accuracy. However, the recent automated data segmentation software's are capable of delivering accurate and instant airway analysis. In addition, even though helical CT scans are commonly used and widely accepted for the evaluation of upper airway and associated structures, the high radiation dose and prolonged exposure times associated with CT may not provide the optimal risk-to-benefit ratio for some patients. Whereas CBCT requires very small dose of radiation to deliver similar cross sectional diagnostic images. Hence, in the examination of the OSA patient, a CBCT has a far more favorable risk-to-benefit ratio [37] (Figure 2).

Ogawa *et al.* used CBCT to demonstrate airway imaging in patients under supine position. CBCT in awake patients in the supine position. Their study with Supine CBCT imaging successfully delineated individual with OSA patients from non-OSA individuals. [37] Buchanan *et al.* in their CBCT analysis of OSA patients reported small upper airway in OSA. [38] Shigeta *et al.* used CBCT to evaluate the configuration of the retroglossal airway by studying the axial slices at the level of the anterior-inferior corner of the second cervical vertebra, after considering various factors such as age, gender, and body mass index. They discovered that there were no differences in the retroglossal airway area between obstructive sleep apnea (OSA) patients and non-OSA patients. [39] According to the findings of Mouhanna-Fattal C *et al.*, the posterior space released for the upper airway was larger in the OSA group, whereas the upper airway volume was significantly smaller [40].

Various semi-automated and automated airway analysis software are currently available for the ease of assessment of airways in a CBCT Scan. (Figure 3) Si CAT, ITK-Snap, Invesalius, 3D Slicer, Dolphin, 3D Seg3D etc. are various commercially available software used for airway analysis.

However, these softwares may differ from one other [41, 42].

Management of OSA in a Dental View

The emergence of dental sleep medicine as a specialty focusing on the management of sleep-related breathing disorders has emphasized the role of pulmonologists, otolaryngologists and dentists in the sleep medicine team. [41] Dentists are employed in the management of OSA as a part of the multidisciplinary team. There are various types of oral and orthopedic appliances that are available for the treatment of OSA. The devices can be broadly divided into three categories: mandibular advancement appliances, tongue retainers, and soft palate lifters [43]. There is substantial literature evidence regarding the clinical efficacy of oral appliances in the management of mild to moderate cases of OSA [44, 45].

PAP therapy is considered as the gold standard modality for management for OSA. Various surgical procedures such as nasal and palatal repairs, Maxillo-mandibular advancement surgeries are also available for the management of OSA. However, they are reserved only for the management of severe cases [46].

Conclusion

The role of an Oral and Maxillofacial Radiologist is crucial in identifying individual with a high risk of development of OSA. It is essential for dental practitioners to be aware of the prominent maxillofacial features of OSA and the scope of prescribing necessary imaging modalities along with appropriate referral to a sleep medicine specialist.

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