Role of Dental Radiologists in Diagnosis of Patients with High Risk of Obstructive Sleep Apnea Using Lateral Cephalogram: A Case–Control Study

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Abstract

Introduction: OSA consists of repetitive short episodes of UA collapse with complete (apneas) or partial (hypopneas) obstruction of airway during sleep, associated with snoring and transient arousal, causing sleep fragmentation and insufficient and nonrestorative sleep. Aim: To recognize patients with high risk of obstructive sleep apnea using lateral cephalometric measurements in patients receiving routine dental treatment. Materials and Methods: The study was conducted on 120 patients, which were divided into two groups based on Berlin questionnaire which include 10 questions in 3 categories (snoring, day time drowsiness and hypertension/obesity) the study Group included 60 Patients and 60 normal patients. Digital Lateral Cephalometric analysis was done in all individuals to measure upper air way diameter (UAD), mandibular to hyoid distance (MHD) and to evaluate shape of soft palate (velar), by two observers at two different intervals. The data were statistically evaluated with student’s t test and chi Square test using SPSS version 23.0.0. Results: The study comprised of 120 subjects who were divided into different age groups ranging from 18-65yrs. There were 61 males and 59 females when patients were divided according to gender and had no statistical significance. Based on Berlin questionnaire 51.7% were on high risk and 48.3% were on low risk. The UAD was reduced in study group than in control group and was statistically significant (P = 0.044). The MHD distance was increased in study group when compared with control group and was statistically highly significant (P < 0.001). No significant difference was found between groups when shape of soft palate was compared. Conclusion: Patients with lower UAD and higher MHD values are at high risk of developing OAS, dentist will play a vital role in diagnosis of these patients by thorough clinical examination & by cephalometric analysis.

Keywords: Lateral cephalometry, mandible to hyoid distance, obstructive sleep apnea, snoring, upper airway diameter, velar

INTRODUCTION

Sleep-disordered breathing (SDB) disorder is a group of common problems involving difficulties in breathing during sleep that may range from socially embarrassing snoring to severe and life-threatening obstructive sleep apnea (OSA).[1] It includes simple snoring, upper airway resistance syndrome, and OSA.[2] The most common form of SDB worldwide is OSA. The term sleep apnea was first described by Guillemimault et al. in1976. Apnea in Greek means without breath.[1]

OSA is defined as cessation of airflow with persistent respiratory effort for at least 10 sec due to collapse of the upper airways. It is characterized by repetitive episodes of upper airway obstruction that occur during sleep, usually associated with a reduction in blood oxygen saturation.[1]

The National Sleep Foundation (NSP) sleep in America 2005 Poll found that one in four is at high risk of having sleep apnea based on Berlin Questionnaire and prevalence rate ranging from 2% to 25% in general population, and the prevalence of OSA in Indian population has been reported to be 19.5% in men and 7.5% in women.[3]

The majorities of patients with OSA are undiagnosed and therefore are at risk of upper airway collapse. It is important to identify these patients so that appropriate timely action can be taken.

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Nocturnal polysomnography is the gold standard for the diagnosis of OSA, but cephalometry also plays an important tool to evaluate an upper airway diameter in diagnosis of OSA.[4] It is useful to analyze skeletal and soft tissue characteristics of patient with OSA and has the following advantages:[4]

- Being available in most dental clinics
- Easy to perform
- Low cost
- With minimal exposure to radiation
- Correlates with other investigation.

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e.g., Computed Tomography (CT)

American academy of sleep has recommended the use of oral appliances in the treatment of OSA which has made an interest in dentistry;[5] hence, the role of dental surgeon should not only limit in treating the diseases related to oral cavity but also to make aware of a medical conditions and to take appropriate measures in improving the patients health in general.

As stated “OSA is characterized by partial or complete obstruction of the upper air way during non-REM or REM sleep.”[2]

Hence, the aim of the study was to recognize patients with high risk of OSA using digital lateral cephalogram by measuring upper airway diameter, mandible to hyoid ratio and to evaluate the shape of soft palate in these patients.

MATERIALS AND METHODS

After obtaining ethical clearance and patients consent, study was done on 120 patients who were selected from outpatient department of Al-Badar dental college and hospital Gulbarga who visited for routine dental problem. These patients were divided into two groups: cases and control, based on Berlin Questionnaire[3] which includes 10 questions in 3 categories (snoring, daytime drowsiness, and hypertension/obesity). After thorough clinical examination for facial profile, tonsillar hypertrophy, and size of tongue, occlusion patients were subjected to lateral cephalogram to measure upper airway diameter mandibular plane to hyoid bone distance and to evaluate shape of soft palate.

Digital lateral cephalograms were taken with CS 8100 system and CS imaging software version 7.0.20.4.d2 using all the standard radiographic parameters. Patients were positioned in cephalostat with Frankfort plane parallel to the floor and were asked to swallow once to clear any saliva in the oral cavity and pharynx and then to close their mouth lightly to place their upper and lower teeth in centric occlusion and with their oropharyngeal musculature relaxed. The UAD was measured from the point on the anterior half of the soft palate to the closest point on the outer pharyngeal wall. The mandibular to hyoid ratio was measured by drawing a tangent from gnathion to gonion and by drawing a perpendicular line from that tangent to hyoid bone [Figure 1].

Based on radiologic morphology of soft palate classified according to You et al.,[6] shape of velar (soft palate) were evaluated.

1. Type I leaf shaped
2. Type II rat-tail shape
3. Type III butt shape
4. Type IV straight
5. Type V S shaped
6. Type VI crooked.

Figure 1: The Upper Airway Diameter was measured from the point on the anterior half of the soft palate to the closest point on the outer pharyngeal wall. The mandibular to hyoid ratio was measured by drawing a tangent from gnathion to gonion and by drawing a perpendicular line from that tangent to hyoid bone

Inclusion criteria

- Patients above 18 years of age
- After clinical examination, patients with deviated nasal septum, macroglossia, tonsillar hypertrophy, and malocclusion were included in study.

Exclusion criteria

- Patients not willing to participate in the study
- Patients below 18 years of age
- Patients associated with syndrome
- Patients who have been already diagnosed with OSA.

Statistical analysis

All statistical analyses were conducted using SPSS version 23.0.0 (SPSS Inc., Chicago, IL, USA). Significance for all statistical tests was predetermined at $P < 0.05$. Descriptive statistics was calculated for all measurements. Evaluation of types of soft palate for cases and control was done by Chi-square test. Student t paired test was used to evaluate inter- and intra-observer differences.

RESULTS

Age

The study included 60 OSA patients with 16.7% belonging to age group of 18–25 years, 21.7% patients to age group of 25–35 years, 26.7% to age group of 35–45 years, 30% to age group of 45–55 years, and 5.0% to age group of 55–65 years.
The control group included 60 patients in which 65.0% were belonging to age group of 18–25, 23.3% to age group of 25–35 years, 3.3% to age group of 35–45 years, 8.3% to age group of 45–55 years, and there were no patients belonging to age group of 55–65 [Graph 1].

There was no statistical difference in the distribution of patients according to age groups among study and control group ($P > 0.05$).

The mean age among study group was $30.27 \pm 12.15$ and control group was $28.9 \pm 9.14$, and it was statistically insignificant ($t$-test $= 0.144, P > 0.05$) [Table 1 and Graph 2].

Sex
Among the study group of 60 patients, 20 (8.55%) were females and 40 (9.98%) were males. Among the control group of 60 patients, 39 (11.19%) were females and 21 (11.30%) were males. Sexwise distribution among study and control group had no statistical significance [Graph 3].

Body mass index
Among 60 study group, the body mass index (BMI) was $25.14\pm4.46$, and in control group, it was $23.81\pm3.76$, which was statistical insignificant among cases and controls ($t = 0.278$, $P > 0.05$) [Graph 2].

Risk assessment questionnaire
With regard to risk assessment distribution based on Berlin Questionnaire, 31 (51.7%) were on high risk and 29 (48.8%) were on low risk [Graph 4].

**Comparison of mean values of Upper Airway Diameter and Mandibular plane to Hyoid bone Distance in study and control group.**

The mean value of UAD in study group was $9.50 \pm 8.80$, and in control group, it was $9.06 \pm 4.19$, which was statistically significant ($P < 0.005$) [Table 1].

Among study group, the mean MHD values were $9.06 \pm 4.19$ and mean value among control group was $6.25 \pm 3.30$. The mean MHD value in study group was very high when compared to the control group and was statistically highly significant ($P < 0.001$) [Table 1].

**Comparison of UAD and MHD according to gender**
The mean UAD value for 40 male patients in study group was $9.98 \pm 10.72$ and in 20 female patients was $8.55 \pm 1.90$. The

| Parameter | n     | Mean±SD        | P     |
|-----------|-------|----------------|-------|
| Age       | 60    | 30.27±12.15    | 0.144 (NS) |
| BMI       | 60    | 25.14±4.46     | 0.278 (NS) |
| UAD       | 60    | 9.50±8.80      | 0.044*   |
| MHD       | 60    | 9.06±4.19      | <0.001** |

*Statistically significant ($P<0.05$). **Highly significant ($P<0.001$). SD: Standard deviation, BMI: Body mass index, NS: Not significant, UAD: Upper airway diameter, MHD: Mandibular plane to hyoid bone distance
mean MHD values in 40 male patients in study group were 9.49 ± 4.53, and in 20 female patients, it was 8.20 ± 3.37.

The mean UAD value for 21 male patients in control group was 11.30 ± 2.44, and in 39 female patients, it was 11.19 ± 2.31. The mean MHD value in 21 male patients in control group was 6.01 ± 3.38, and in 39 female patients, it was 6.38 ± 3.29.

When UAD and MHD values were compared between study and control group according to gender, it was statistically insignificant (P > 0.05) [Table 2].

Comparison of UAD in both genders according to age group

Ten male patients in age group of 18–25 years showed mean UAD of 15.6 ± 24.0, 13 patients in age group of 25–35 years showed mean UAD of 8.04 ± 1.67, 16 patients in age group of 35–45 years showed mean UAD of 8.9 ± 1.48, 18 patients in age group of 45–55 years showed mean UAD of 8.491 ± 2.52, and 3 patients in age group of 55–65 years showed mean UAD of 8.7 ± 0.79.

Ten female patients in age group of 18–25 years showed mean UAD of 11.8 ± 0.28, 13 patients in age group of 25–35 years showed mean UAD of 7.69 ± 1.48, 16 patients in age group of 35–45 years showed mean UAD of 7.91 ± 1.0, and 3 patients in age group of 55–65 years showed mean UAD of 0.0.

There was no statistical difference in the distribution of age group when UAD was measured according to gender (P > 0.05) [Graph 5].

Comparison of MHD in both genders according to age group

Ten male patients in age group of 18–25 years showed mean MHD of 6.95 ± 0.49, 13 patients in age group of 25–35 years showed mean MHD of 11.42 ± 1.14, 16 patients in age group of 35–45 years showed mean MHD of 6.43 ± 3.50, 18 patients in age group of 45–55 years showed mean MHD of 7.78 ± 3.50, and 3 patients in age group of 55–65 years showed mean MHD of 0.0.

There was no statistical difference in the distribution of age group when MHD was measured according to gender (P > 0.05) [Graph 6].

Velar (soft palate) variants among study group and control group

Among 60 study patients, 43 patients (71.1%) showed type I (leaf shape) velar morphology, 3 (5.0%) had type II (rat-tail shape) velar, 4 (6.7%) patients had type III (butt) velar, 2 (3.3%) had type IV (straight line) velar, 0 patients had type V (S-shaped) velar, and 8 (13.3%) patients had type VI (crooked shape) velar morphology [Graph 7].

Type I was most commonly seen in study group, followed by type VI, type III, type II, type IV, and type V.

Among 60 control patients, 52 patients (86.7%) showed type I (leaf shape) velar morphology, 2 patients (3.3%) had type II (rat-tail shape) velar, 02 patients (3.3%) had type III (butt shape) velar, 3 patients (5.0%) had type IV (straight line shape) velar, 0 patients (0%) showed type V (“S” shape) velar, and 1 patient (1.7%) had type VI (crook shape) velar [Graph 7].

In control group, the most common type of velar found was type I followed by type IV, type II, type III, type VI, and type V.

Interobserver comparison of airway measurements

The interobserver reliability analysis was done by reobserving 60 lateral cephalograms after 1 month by two observers. UAD
and MHD were measured again, and shape of soft palate was evaluated; the results were statistically analyzed using Student’s t-test, and no significant difference was found with \( P > 0.05 \), showing the reliability of method used and stating that radiographs can be used to predict the sleep apnea [Table 3].

**DISCUSSION**

OSA is multifactorial disease that can lead to upper airway collapse and are potentially fatal with increased risk of hypertension, cardiovascular diseases, stroke and diminish quality of life with prevalence rate of 19.5% in Indian population.\(^{[5]}\) Thorough clinical examination and risk factor analysis help in identifying patients who are at high risk of developing sleep apnea.

Lateral cephalogram is routinely used radiograph for orthodontic purpose. Study done by Maltais et al.\(^{[7]}\) have opined that the use of cephalometric analysis to assess the upper airway anatomy is helpful because it is simple than other methods for measuring airway patency. It was further confirmed by Pirilä-Parkkinen et al.\(^{[8]}\) who stated that lateral cephalogram is valid method for measuring dimension of nasopharynx and retropalatal region.\(^{[7]}\)

In total of 60 study patients, patients were divided into different age groups ranging from 18 to 65 years with mean age of 30.27 ± 12.15 years. This is comparable to the study done by Lavanya et al.\(^{[9]}\)

Majority of our cases which were 18 (30.0%) in number were in age ranged of 45–50 years. Thus, most of patients were in the fourth to fifth decade of life.

Among study group of 60 OSA patients, 40 (66.7%) were male and 20 (33.3%) were female, thus showing male predominance, which is similar to study done by Young et al.\(^{[10]}\)

Obesity is one of the predisposing factors in developing OSA as it contributes in reduction of UAD by increasing the amount of fat deposition in soft tissues of pharynx\(^{[11]}\) and it also affects chest mechanics by weighting the chest wall and reduces lung compliance.\(^{[3]}\) The study done by Broström et al.\(^{[12]}\) states that men who are obese with BMI >30 kg/m\(^2\) are suspected to have OSA.

Berlin Questionnaire\(^{[3]}\) was considered as it help in thorough clinical examination and risk factor analysis, and we found that 51.7% were on high risk while 48% were on low risk; the same assessment was done by Lavanya et al.’s\(^{[9]}\) study.

Studies done by Julià-Serdà et al.\(^{[13]}\) and Guttal et al.\(^{[14]}\) implied that cephalometry in combination with clinical examination, physical examination, and nocturnal oximetry can be useful in diagnosis of OSA patient as cephalometry helps in assessment of upper airway with many advantages and only disadvantage of being not useful in assessment of transverse dimensions. The present study signifies the use of cephalometry in assessing upper airway dimension. The normal upper airway diameter is 15–20 mm (McNamara).

As stated in earlier studies, cephalometric difference was seen between OAS and controls. Battagel et al.\(^{[15]}\) stated that these anatomical difference place the entire facial complex closer to cervical spine and thus contribute to the reduction of space available for airway in both sleep-disordered breathing groups.

Our results showed significantly lower UAD values in the OSA group than in the control group which is similar to studies done by Lavanya et al.,\(^{[9]}\) Szymanska et al.\(^{[16]}\) and Gungor et al.\(^{[4]}\) who found smaller upper airway diameters than the standards set by McNamara\(^{[17]}\) on lateral cephalograms in patients with OSA. Martin et al.\(^{[18]}\) found the decreased upper airway diameter and concluded that these values decreased even more sharply if patients were examined while lying down.

We found significantly higher value of the MHD in the OSA group (9.3 mm) than in the control group (6.23 mm), suggesting that an inferiorly placed hyoid bone is present in patients at a relatively high risk for OSA, which is similar to studies done

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**Table 3: Inter- and intra-observer comparison of airway measurements**

| Group 12 | Parameter | Observer | Mean   | \( n \)  | SD    | SEM   | \( P \) |
|---------|-----------|----------|--------|----------|-------|-------|--------|
| Cases   | UAD       | Observer 1 | 9.5005 | 60       | 8.80463 | 1.13667 | 0.635 (NS) |
|         |           | Observer 2 | 10.0850| 60       | 2.80537 | 0.36217 |        |
|         | MHD       | Observer 1 | 9.0645 | 60       | 4.19330 | 0.54135 | 0.234 (NS) |
|         |           | Observer 2 | 8.1233 | 60       | 4.70699 | 0.60767 |        |
| Control | UAD       | Observer 1 | 11.4097| 30       | 2.40869 | 0.43976 | 0.557 (NS) |
|         |           | Observer 2 | 11.8233| 30       | 2.69171 | 0.49144 |        |
|         | MHD       | Observer 1 | 6.5887 | 30       | 3.60816 | 0.65876 | 0.672 (NS) |
|         |           | Observer 2 | 6.9067 | 30       | 4.02980 | 0.73574 |        |

SD: Standard deviation, SEM: Standard error of mean, NS: Not significant, UAD: Upper airway diameter, MHD: Mandibular plane to hyoid bone distance
by Pracharktam et al.,[19] Bhardwaj et al.,[1] and Armalaite and Lopatiene.[20] They concluded that higher MP-H values might serve as a predictor for differentiating normal individuals and patients with OSA. As hyoid bone is in relationship with tongue position, it is important to determine the position of hyoid bone. Arya et al.[21] stated that hyoid bone plays an important role in maintaining the upper airway dimension as lower position of hyoid bone and tongue posture may aggravate apnea due to extra energy required to elevate the tongue.

When comparison of UAD an MHD was done according to age groups and gender, it was statistically insignificant. But studies done by Gabby and Lavie[22] and Lavanya et al.[9] found significantly higher MHD values in older age group men and middle-aged women and concluded that OAS severity varied with age in both genders.

There was no significant difference in shape of soft palate between OAS and control group, while type I (leaf shaped) velar morphology being common type, which is similar to studies done by Deepa et al.[23] and Patil et al.[24] Soft palate has important role in speech and swallowing. It closes of the nasopharynx during swallowing to prevent nasal reflux. Alteration in shape, size, and length of soft palate may lead to increased risk of OSA.

The treatment options for adult patients with OSA is based on the severity of the sleep disorder, preference of the patient, the patient’s general health, the preference, and experience of the team members. The first and simplest option is behavior modification; this would be followed by insertion of oral devices. Continuous positive airway pressure and surgical options are chosen for patients with moderate to severe OSA.[2]

**Conclusion**

Patients with high risk of OSA were assessed using Berlin questionnaire and was found to have lower UAD and higher MP-H values when measurements were done on lateral cephalogram, and in these patients, leaf-shaped soft palate was common type followed by crooked shaped, which concludes that leaf-shaped soft palate with risk factor and crooked-shaped soft palate without risk factor can cause OSA. Proper history, thorough clinical examination, and lateral cephalometry evaluation help in early diagnosis of OSA patients and preventing them from potentially fatal diseases. Hence, oral radiologist can play an important role in the diagnosis of these patients.

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**Conflicts of interest**

There are no conflicts of interest.

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