A CBCT Study to Assess the Volumetric Analysis of Airway, Craniofacial Morphology and Cervical Vertebral Fusion Anomalies in North Indian Patients with Obstructive Sleep Apnea

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Abstract

Obstructive sleep apnea (OSA) is an under-recognized and under-diagnosed medical condition often termed as a "silent killer" that effects more than 5% of the individuals in the United states as well as 7% worldwide. Symptoms range from daytime sleepiness, loud snoring, and restless sleep. While the "gold standard" of its diagnosis still remains the overnight sleep study also known as polysomnography, a detailed history and focused physical examination along with various skeletal and soft tissue markers, may help in the early diagnosis of the condition. Essential diagnostic records for any Orthodontic treatment consists of a number of skeletal and soft tissue assessments in the form of Orthopantomogram (OPG) and Lateral Gepahlogram which are imperative for the commencement of the treatment. Also, Cone beam CT (CBCT) evaluation is done for certain specific cases. Several modalities exist for treating obstructive sleep apnea, including continuous positive airway pressure, oral appliances, and several surgical procedures. With more and more people becoming vigilant about OSA, there is an ever increasing demand in the medical and dental field to establish a relationship between the Craniofacial pattern, cervical vertebrae with airway volumetric dimensions with Body Mass Index, neck circumference etc. in order to effectively diagnose the syndrome and provide additional methods of diagnosis along with Polysomnography.

Keywords: Obstructive Sleep Apnea (OSA); Orthopantomogram (OPG); Cone Beam CT (CBCT)

Introduction

Obstructive sleep apnea syndrome (OSAS) is a sleep disorder characterized by recurrent episodes of partial or complete collapse of the upper airway during sleep leading to oxygen desaturation and sleep fragmentation. Apnea, derived from the Greek word meaning "without breath", is defined by the American Academy of Sleep Medicine (AASM) as the cessation of airflow for at least 10 seconds [1]. The health consequences of hypoxemia and sleep disruption due to obstructive sleep apnea leads to excessive daytime sleepiness, impaired memory, cognitive dysfunction, effecting work performance, and demoting the health-related quality of life.

OSA is prevalent, in both adult and child with an increase with advancing age. The estimated prevalence is 2% for women and 4% for men in the European population [2,3] with similar data from epidemiologic study from the United States [4,5]. Recent research indicates increasing prevalence with 4% for women and 9% for men [6]. A population-based survey from North India estimated the prevalence of OSAS at 3.6% with 4.9% for males and 2.1% for females [7]. In another study the estimated population prevalence of OSA and OSAS was 9.3% and 2.8% respectively [8].

Predisposing factors like gender, age, narrow airway, craniofacial deformities, muscular hypotony, sleep posture, and fatty deposits in the tissues of the upper airway are some of the important considerations. Studies indicate a co-relation between BMI, Neck circumference and Mallampati index and the severity of OSA [9-11]. Neck circumference has been suggested to be predictive of obstructive sleep apnoea than general obesity. Combining neck circumference with other signs and symptoms may allow the clinical diagnosis or exclusion of sleep apnoea to be made with reasonable confidence [11,12].

The relationship between structure and function along with the upper airway anatomy is an important consideration in the pathophysiology of OSA. Reduced posterior airway space may be associated with abnormally long soft palate, low position of the hyoid bone, and extended head posture [13,15]. It is generally agreed that the jaws are more retrognathic than normal and the vertical dimension of the jaws is increased in patients with sleep apnea [14].

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Consensus exists that patients with sleep apnea have an extended head posture which improves airway space in the pharyngeal area [16-21]. Literature reports states cervical spine development to be related to craniofacial malocclusions [20,22,23]. The fusion anomalies of the cervical column occurred significantly more often in the sleep apnea group compared with subjects with neutral occlusion and normal craniofacial morphology [24,25].

Traditionally, airway assessment was conducted in an orthodontic office on a 2D cephalogram which provided limited information restricted to the sagittal dimension only with no inputs on the important transverse dimension. With the recent advent of CBCT technology into dentistry, the airway can now be assessed with increased accuracy in all dimensions [26-33].

A lacuna of knowledge exists on information related to the North Indian population affected with OSA. Volumetric 3D assessment of airway and its relationship to the craniofacial and cervical morphology has not been reported on this population type. The critical characteristics of neck circumference, BMI and Mallampati index have not been correlated with craniofacial and cervical vertebra morphology with airway dimensions.

Hence, this study was undertaken to assess the relationship between the airway volumetric dimensions with BMI, neck circumference and Mallampati index. The study also aimed to ascertain if co-relation existed between severity of OSA, craniofacial pattern, cervical vertebra fusion and volumetric dimensions of the airway. The differences between a control (Non OSA group) and the OSA affected patients was also studied.

Aims and Objectives

1. To assess the cross-sectional area and volume of airway and establish minimal axial area in patients with mild, moderate and severe obstructive sleep apnea and control group.
2. To assess the skeletal craniofacial parameters and cranio-cervical angulations of patients with mild, moderate and severe obstructive sleep apnea and control group.
3. To evaluate BMI, Neck Circumference and Mallampati Index of patients with mild, moderate and severe obstructive sleep apnea and control group.
4. To evaluate the length and width of soft palate and tongue in patients with mild, moderate and severe obstructive sleep apnea and control group.
5. Evaluate the cervical vertebrae morphology with emphasis on fusion anomalies in patients with mild, moderate and severe obstructive sleep apnea and control group.
6. To evaluate if differences existed between the three OSA affected groups and non OSA (Control group) and if diagnostic parameters for OSA could be identified for North Indian population.

Materials and Methods

The study was conducted at Dept. of Orthodontics and Dentofacial Orthopaedics, of a prominent North Indian Dental College as well as a Sleep Centre in New Delhi was selected for patient’s to undergo overnight sleep study, and finally Dental and Maxillofacial Diagnostics was considered for the various radiological inferences that were to made. The study was commenced after appropriate ethical clearance by the Institutional Ethical Committee (Ref. No: DJD/IEC/01/2009), and obtaining informed consent from each patient prior to the study. A total of 15 pre-diagnosed OSA patients, in the age group of 30 - 50 years with a mean age group of 40 year were included in the study. The patients were diagnosed for OSA with the help of an overnight sleep study by using Polysomnography.

The sample was equally divided into three groups, Group 1, 2 and 3, on the basis of severity of OSA into mild, moderate and severe respectively, with no gender bias. Severity of OSA was established by examining the Apnea-Hypopnea Index (AHI) of patients on the basis of the results of sleep study. AHI of < 15 was considered mild, 15 - 30 as moderate and > 30 as severe Obstructive sleep apnea (Table 1). 05 patients with no airway related issues were randomly selected from the imaging centre. This group was designated as “Group 0” and treated as the control group. Care was taken to ensure they were North Indian but full confidentiality of their personal details was achieved as the imaging centre masked the relevant information.
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<table>
<thead>
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<th>Group (n = 15)</th>
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<th>Severity of OSA</th>
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<tr>
<td>1 (n = 5)</td>
<td>&lt; 15</td>
<td>Mild</td>
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<tr>
<td>2 (n = 5)</td>
<td>15 - 30</td>
<td>Moderate</td>
</tr>
<tr>
<td>3 (n = 5)</td>
<td>&gt; 30</td>
<td>Severe</td>
</tr>
<tr>
<td>0 (n = 5)</td>
<td>-</td>
<td>Control</td>
</tr>
</tbody>
</table>

Table 1: Sample distribution.

General extra and intra oral records

1. Height of the patients was measured using Stadiometer and weight with digital weighing scale (TAYLOR) with high accuracy (Figure 1).
2. Neck circumference (In Inches) of the patients was measured (at the level of cricothyroid cartilage) using a standard roll up non-distensible measuring tape (Figure 2).
3. Intra-Oral photographs were captured with a high precision SLR camera (NIKKON D60) (Figure 3). The photographs were used to score the Mallampati Index.

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**Polysomnography records**

The polysomnographic reports for all the patients were obtained after overnight Polysomnography which provided inputs on AHI, SPO$_2$, PaO$_2$, Total sleep time (REM and NREM) and Apnic and Hypnic events (Figure 4). A total 11 parameters were assessed during the overnight polysomnographic evaluation. The AHI score was obtained from the polysomnography.

![Figure 4: Patient undergoing overnight polysomnography.](image)

**Cone beam computerized tomography (CBCT) records**

The CBCT scans of the study subjects were obtained using CS 3000 (Care Stream 3000) hardware (Figure 5). A standardized field of view (FOV) of 17 cm x 30 cm and voxel size of 300 mm was maintained for all the scans. The patients were positioned upright, with chin rest for the support in maximum intercuspation (MIP). CBCT generated axial, coronal and sagittal sections were captured and analyzed with the help of Xelis 3D software (version 4.0, U. S.) with the minimum thickness of the slice being 0.3 mm and Dolphin3D software (version 11.7, Dolphin Imaging and Management Solutions, Chatsworth, Calif).

![Figure 5: Carestream 3000.](image)
Evaluation of the diagnostic records

General extra and intra oral records

- **Body Mass Index**: The body mass index (BMI), or Quetelet index, is a heuristic proxy for human body fat based on an individual's weight and height. The values for height and weight of each patient were placed in the formulae for the BMI calculator and BMI score was obtained.

- **Neck circumference**: Neck circumference of the patients was measured using a standard roll up measuring tape and tabulated. The measurement was done below the submental/submandibular region, approximately middle of the neck.

- **Mallampati Index**: The intra-oral photographs were assessed to designate the grades of Mallampati index for the patients included in the study (Figure 6).

![Mallampati index](image)

**Figure 6: Mallampati index.**

CBCT evaluation

Craniofacial morphology, airway, tongue, soft palate and cervical vertebra fusion anomalies of each patient were assessed on the Axial, Coronal and Sagittal sections on the DICOM images captured by the CBCT scans.

To measure the transverse, sagittal and vertical dimensions on the CBCT generated lateral cephalogram, Axial Multiplaner Reconstruction (MPR) and Maximum intensity projection (MIP) images were formatted.

These images were studied with the help of a Xelis software and Dolphin 3D and cross-sectional, linear and angular measurements were done with the help of tools provided with the software.

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The Mid-Sagittal Plane was established by coordinating the horizontal and vertical grid in all the three planes on axial, coronal and sagittal section of the 3D images. Once all the three sections were coordinated, the vertical arm of the grid was placed on the three dimensional CBCT image and the tool of MIP was selected to obtain a CBCT generated Lateral Cephalogram.

**Assessment of cervical vertebrae fusion anomalies**

- C1, C2, C3 and C4 were assessed visually for fusion anomalies on the 3D image and the CBCT generated lateral cephalogram. The image was assessed from the right and left lateral along with image rotation for clear observation from the posterior and basal aspect.
- Fusion anomalies were recorded as - a) Fusion of the body of the second and third cervical vertebrae (C2 and C3), b) Block fusion - when two or more vertebrae bodies were fused and c) Occipitalization - when occipitalization of C1 and the occipital bone occurred (Figure 13).

**Assessment of shape of the soft palate**

Soft palate measurements were made on the mid-sagittal slice on the CBCT, for the evaluating the shape of the soft palate (Figure 7a). The shape of the soft palate was assessed form the PNS till the Valleculae. The outline of the soft palate was traced and the shape assessed and classified into any of the six morphological varieties, i.e. “Leaf”, “Rat tail”, “Butt Like”, “Straight Line”, “S-Shaped” and “Crook Shaped” (Figure 8).

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**Figure 7a and 7b: Measurement of soft palate and tongue.**

**Assessment of tongue**

Mid-sagittal section of the DICOM image was assessed for the evaluation of tongue. The length of the tongue was measured as the linear distance from point E (epiglottis) to the tip of the tongue. The width of tongue was recorded as the linear distance between the midpoint of E/TT (tongue length) and the most prominent point on the dorsum of the tongue (Figure 7b).

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**Figure 8: Classification of soft palate.**

**Type – I:** “Leaf-shaped” (lanceolate); the middle portion of the soft palate is elevated to both the nose- and oropharyngeal side.

**Type – II:** “Rat-tail shaped”; the anterior portion is inflated and the free margin has an obvious coarctation.

**Type – III:** “Butt-like shape”; the length of the soft palate in this type is about a third to three-quarters of that of the leaf shape.

**Type – IV:** “Straight line”.

**Type – V:** Distorted soft which presents the “S-shape”.

**Type – VI:** “Crook-shaped” appearance of the soft palate, in which the posterior portion of the soft palate crooks anterosuperiorly.
Cross sectional area assessment of airway

Pharyngeal airway dimensions were measured for all patients at four levels - ranging from the point on the soft palate closest to the dorsal pharyngeal wall to the vallecula of the epiglottis (Figure 9). The areas measured were - a) Soft palate closest to the dorsal pharyngeal wall between anterior and posterior and Valem palati (Ve-PVe), b) Tip of the uvula and posterior border on airway (Uv-PUv), c) Radix linguae to the posterior border (Rl-PRI) and d) From the Valleculea epiglottis to the posterior border (Va-PVa) (Figure 9).

Figure 9: Pharyngeal airway dimensions.

Volumetric assessment of airway

- The DICOM images of the subjects were imported in Dolphin3D software (version 11.7, Dolphin Imaging and Management Solutions, Chatsworth, Calif).
- Upper airway volumes were measured at (1) Nasopharynx (OP) and (2) Oropharynx (NP). In addition, the area of maximum constriction of airway was identified and the constricted volume measured to assess the most compromised airway volume.
- The nasopharyngeal (NP) volume was measured between the last slice before the nasal septum fused with the posterior wall of the pharynx and the palatal plane (which was the superior limit of the OP airway). Hence, the image was manipulated such that the superior border of the NP was defined on the axial slice first and then it was reflected to the sagittal plane (Figure 10).
- The oropharyngeal (OP) volume was defined as volume between the palatal plane (ANS-PNS) extending to the posterior wall of the pharynx and the plane parallel to the palatal plane that passes from the most anterioinferior point of the second cervical vertebrae. This was also established in the similar manner (Figure 11).
- The software capability was extended to identify the region of maximum constriction and a volumetric measure of the same was done in order to ascertain the extent of airway compromise (Figure 12 and 13).

All measurements were conducted by a single investigator. The measurements were repeated randomly for five cases at a 4 week interval by the same operator to check for intra operator errors. No significant intra operator error was found.
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Figure 10: 3D reconstruction of nasopharyngeal airway.

Figure 11: 3D reconstruction of oropharyngeal airway.

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Figure 12a and 12b: Area and volumetric reconstruction of airway.

Figure 13: Measurement: cranio-cervical angle.

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Review of Literature

The orthodontic interest to the airway is related to the dramatic effect that nasorespiratory function has on craniofacial growth and development of the dentofacial complex. It probably dates back to the first description of adenoid hypertrophy. Adenoidecctomy was first performed in Copenhagen by Wilhelm Meyer [34], a Danish physician. Rubin RM [35] in his article described the term Adenoid Facies or Long Face Syndrome which was coined by CV Tomas in 1872, which describe dentofacial changes associated with chronic nasal airway obstruction along with mouth breathing. Osler W [36] coined the term “Pickwickian” after Charles Dickens’s description of Joe in referring to obese, hyper somnolent patients and stated “an extraordinary phenomenon in excessively fat young people is an uncontrollable tendency to sleep” [37].

A population-based survey from North India was conducted by Sharma SK, Kumpawat S, Banga A, Goel A [7] which estimated the prevalence of OSAS at 3.6% (males and females being 4.9 and 2.1% respectively). The prevalence of OSA in the same study was 13.7 percent. However, this prevalence study was conducted in a semi-urban Indian population with a small sample size without adequately studying different socio-economic strata. Another study by Reddy EV, Kadhiravan T, Mishra HK, Sreenivas V, Handa KK, Sinha S, Sharma SK [8] determined the prevalence and risk factors of OSA in middle-aged urban Indian population. The study was conducted as a two-stage, cross-sectional, community-based study in four different socioeconomic zones of the South Delhi district, India, from April 2005 to June 2007. A linear trend was observed in the prevalence of OSA across the socioeconomic strata. OSA is a significant public health problem in the middle-aged Indian population across the socioeconomic spectrum.

Cephalometrics were used to evaluate the posterior airway space by Guilleminault C [38] and Ceylan I and Oktay H [39], whereas Johnston CD and Richardson A [40] conducted a cephalometric study and investigated morphological changes occurring in the pharynx. The nasopharyngeal skeletal dimensions were unchanged but a tendency towards longer and thicker soft palate and narrower oropharynx during adulthood was seen.

Sato K., et al. [41] in their study examined the effectiveness of craniofacial morphology and pharyngeal airway morphology analysis and found significant posterior position and backward rotation of the mandible and stenosis of the nasopharyngeal airway and an elongated soft palate compared with controls. In another study by Lowe AA., et al. [42] interaction between airway and tongue structures were quantified. They concluded that tongue volume increased rapidly than airway volume in subjects with OSA. Grauer D [43] conducted a study to assess differences in airway shape and volume. No differences in airway volumes related to vertical facial proportions were found. Skeletal Class II patients often had forward inclination of the airway, whereas skeletal Class III patients had amore vertically oriented airway.

Sonnesen L and Kjær I [44] were one of the first to examine and compare the cervical column morphology of adults. They found that the most important factor for posterior arch deficiency was mandibular inclination. Arntsen T, Sonnesen L [23] conducted a study in pre-orthodontic children. In their study, new associations were found between cervical column morphology, craniofacial morphology, and head posture.

Liistro G., et al. [45] measured nasal patency, Mallampati Index (MI), neck circumference and body mass index of OSA patients and concluded that high Mallampati score represents a predisposing factor for OSAS, especially if it is associated with nasal obstruction. A similar study was conducted by Nuckton TJ., et al. [46], to assess the clinical usefulness of the Mallampati score in patients with OSA. They concluded that a scoring system will have practical value in clinical settings Kawaguchi Y [47] conducted a study to investigate the significance of neck circumference (NC) on the presence and severity of obstructive sleep apnea (OSA). In conclusion, NC was found to be associated with the severity of OSA independently of visceral obesity, especially in non-obese patients.
Results

Data was subjected to various statistical tests like One-Way Anova, T-Test, Kruskall Wallis Test and Mann Whitney Test. Descriptive statistics were applied to all the groups together which showed that the patients affected with severe OSA had anteclination of maxilla, retrognathic mandible with increased ANB (Table 2). One-way Anova was applied on all the three groups which showed a significant difference (P < 0.05) in the effective length of maxilla and posterior position of maxilla between the mild, moderate and severe groups (Table 3). Mann- Whitney test shows a very high significant difference (P < 0.01) in effective length and posterior position of maxilla in mild and severe groups (Table 4). Mann- Whitney test showed a high significance (P < 0.01) in the effective length of mandible and significant difference (P < 0.05) in saddle angle between mild and moderate groups (Table 5).

### Table 2

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### Table 3: One way anova: maxilla.

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T-Test showed a significant difference (P < 0.05) i.e. at the level of tip of the uvula of the soft palate and the posterior border on airway (SAG2), Radix linguae to the posterior border on airway (SAG3), its corresponding area measurement of the axial section (AREA3) and from the Vallecula epiglottis to the to the posterior border on airway (SAG4) between the mild and severe groups. A Significant difference (P < 0.01) was seen between AREA1, AREA2, AREA3 and AREA4 and (P < 0.05) at SAG1 in severe and control groups (Table 6).

Table 4: Mann-Whitney test: Maxilla.

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<td>.095</td>
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</tr>
</tbody>
</table>

Table 5: Snake Wallis Test: Mandible: Mild vs Moderate.

<table>
<thead>
<tr>
<th>Test Statistics</th>
<th>EL</th>
<th>SNB</th>
<th>SN Go Gn</th>
<th>MPA</th>
<th>GON</th>
<th>SADO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>.000</td>
<td>6.500</td>
<td>10.000</td>
<td>7.500</td>
<td>4.000</td>
<td>2.500</td>
</tr>
<tr>
<td>Wilcoxon W</td>
<td>15.000</td>
<td>21.500</td>
<td>25.000</td>
<td>22.500</td>
<td>19.000</td>
<td>17.500</td>
</tr>
<tr>
<td>Z</td>
<td>-2.611</td>
<td>-1.257</td>
<td>-.524</td>
<td>3.100</td>
<td>-1.776</td>
<td>-2.102</td>
</tr>
<tr>
<td>Asympt. Sig. (2-tailed)</td>
<td>.009</td>
<td>.209</td>
<td>.600</td>
<td>.310</td>
<td>.076</td>
<td>.036</td>
</tr>
<tr>
<td>Exact Sig. [2*(1-tailed Sig.)]</td>
<td>.008</td>
<td>.222</td>
<td>.690</td>
<td>.095</td>
<td>.032</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Inter group comparison: independent T-Test: severe v/s control.

Levant’s Test for Equality of Variances  

<table>
<thead>
<tr>
<th>Levant’s Test for Equality of Variances</th>
<th>F</th>
<th>Sig.</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95% Confidence interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA1 Equal variances assumed</td>
<td>2.291</td>
<td>.169</td>
<td>3.649</td>
<td>8</td>
<td>.007**</td>
<td>-152.4800</td>
<td>41.7843</td>
<td>-248.834 -56.1252</td>
</tr>
<tr>
<td>AREA2 Equal variances assumed</td>
<td>.134</td>
<td>.723</td>
<td>3.860</td>
<td>8</td>
<td>.005**</td>
<td>-165.3600</td>
<td>42.8359</td>
<td>-264.139 -66.5803</td>
</tr>
<tr>
<td>AREA3 Equal variances assumed</td>
<td>3.523</td>
<td>.097</td>
<td>-2.904</td>
<td>8</td>
<td>.020</td>
<td>-152.4200</td>
<td>52.4832</td>
<td>-273.446 -31.3936</td>
</tr>
<tr>
<td>AREA4 Equal variances assumed</td>
<td>1.992</td>
<td>.196</td>
<td>-2.336</td>
<td>8</td>
<td>.048*</td>
<td>-111.7000</td>
<td>47.8194</td>
<td>-221.971 -1.4284</td>
</tr>
<tr>
<td>SAG1 Equal variances assumed</td>
<td>.657</td>
<td>.441</td>
<td>3.436</td>
<td>8</td>
<td>.009**</td>
<td>-4.8200</td>
<td>1.4030</td>
<td>-8.0553 -1.5847</td>
</tr>
<tr>
<td>SAG2 Equal variances assumed</td>
<td>1.607</td>
<td>.241</td>
<td>-2.146</td>
<td>8</td>
<td>.064</td>
<td>-5.8600</td>
<td>2.7307</td>
<td>-12.1570 .4370</td>
</tr>
<tr>
<td>SAG3 Equal variances assumed</td>
<td>.006</td>
<td>.941</td>
<td>-1.728</td>
<td>8</td>
<td>.122</td>
<td>-3.5000</td>
<td>2.0260</td>
<td>-8.1720 1.1720</td>
</tr>
</tbody>
</table>

Table 4: Mann-Whitney test: Maxilla.

a: Not corrected for ties.
b: Grouping Variable: GR.

Table 5: Snake Wallis Test: Mandible: Mild vs Moderate.

a: Not corrected for ties.
b: Grouping Variable: Group.

Table 6: Inter group comparison: independent T-Test: severe v/s control.

Citation: Mayank Gahlot. "A CBCT Study to Assess the Volumetric Analysis of Airway, Craniofacial Morphology and Cervical Vertebral Fusion Anomalies in North Indian Patients with Obstructive Sleep Apnea". EC Dental Science 18.2 (2019): 303-320.
According to the descriptive statistics, Soft Palate increased both in length and width and airway was seen to be compromised severely at the retro-palatal region. Width of the tongue also seemed to have a positive co-relation with the severity of OSA (Table 7). Whereas, Intergroup comparison showed a Statistically significance difference (P < 0.05) in soft palate width (Table 8).

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL</td>
<td>38.640</td>
<td>41.420</td>
<td>45.920</td>
<td>38.800</td>
</tr>
<tr>
<td>SPW</td>
<td>11.760</td>
<td>14.220</td>
<td>15.320</td>
<td>10.030</td>
</tr>
<tr>
<td>TW</td>
<td>70.060</td>
<td>80.520</td>
<td>81.320</td>
<td>65.000</td>
</tr>
</tbody>
</table>

**Table 7:** Descriptive statistics: soft palate and tongue.

**Table 8:** Inter Group comparison: independent T-Test: mild vs moderate.

Discussion

The oropharyngeal airway essentially consists of muscles and soft tissue but lacks a rigid or bony support. It is enclosed along its length by nasal turbinates, hard palate, mandible, hyoid and cervical vertebrae and soft tissues which include the tongue, soft palate, tonsillar pillars, pharyngeal mucosa, muscles, fat pads, epiglottis and blood vessels of the neck.

Katz., et al. and Kawaguchi., et al. [47] conducted separate studies to investigate the significance of neck circumference (NC) on the presence and severity of obstructive sleep apnea (OSA) syndrome independent of obesity. The results of the current study were in concurrence with these studies and showed an increase in the neck circumference with an increase in AHI in all the experimental groups which was statistically significant. Mallampati Index has been used as a guide by anaesthetists and surgeons alike in airway assessment. Liistro., et al. [45] concluded that a high Mallampati score represents a predisposing factor for obstructive sleep apnea syndrome. The results of the current study indicated that the Mallampati index worsened with the increase in severity of AHI.

You., et al. [48] studied variations in velar morphology and classified them into six different types based on the shape related anatomic variations. Literature search did not reveal any previous study where the anatomic shape of the soft palate was correlated with the severity of OSA. Current study concludes that morphology may be responsible for the obstruction due to its increased thickness in the basilar region. Ryan., et al. [49] and Lowe., et al. [42] observed that tongue volume was larger in OSA patients which was associated with reduced airway volumes. In the current study, width of the tongue was found to be significantly increased in the entire OSA group. However, a reduced tongue length was seen in all the OSA groups compared to the control group.

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Solow., et al. [50] measured pharyngeal airway diameters at seven different levels starting from the maxillary tuberosity to the vallecula of the epiglottis. However, in the current study, sagittal airway dimension were measured at four levels and area cross section was assessed in all three OSA groups and compared amongst themselves and against the control. A significant reduction in the width was seen in all 3 OSA Groups where severe OSA group exhibited a significant reduction in mean area cross section at all the four levels.

Various studies have focused on the association between the craniofacial relationships and OSA on the basis of skeletal class I, II and III. The current study makes an attempt to establish association of various craniofacial parameters with the severity of OSA vis a vis the control group. Baik., et al. [51] and Enache., et al. [52] reported positive correlation of retrognathia, micrognathia, and skeletal Class II with Retro palatal (Rp) airway obstruction. On the other hand, Lamaco., et al. [53] found no difference in the maxillary or mandibular prognathism between the two OSA groups studied. Results of the current study showed a statistically significant increase in the ANB values with increasing severity of OSA. The maxillo-mandibular Sagittal difference (ANB) was indicative of skeletal class II pattern and the OSA patients in the moderate and severe group exhibited skeletal mandibular deficiency. Enlow’s Counterpart Principle explains that maxillary length and nasopharyngeal space are counterparts in the process of growth and development. Hence, the reduction in maxillary effective length would significantly affect the nasopharyngeal airway.

Intergroup comparison showed that the mild OSA group exhibited a significant increase in the lower gonial angle which is suggestive of patients exhibiting a vertical growth pattern. This group also showed an ante inclination of maxilla which was statistically significant. Additionally, the study also showed opening of the saddle angle and an increase in ANB in the patients with mild OSA. An increase in saddle angle would denote an upward inclined anterior cranial base and/or posteriorly positioned glenoid fossa.

Aintsena and Sonnesen., et al. [23] assessed cervical vertebrae morphology in non-syndromic patients and patients with OSA and concluded that fusion of the cervical vertebra column is associated with development and function of the craniofacial morphology. Whereas, current study was unable to decipher any cervical vertebrae fusion anomalies in the groups studied. Further studies with large sample size may help in establishing a relationship between the cervical vertebrae fusion anomalies and severity of OSA.

Conclusion

BMI, Neck circumference and Mallampati Index are important diagnostic parameters in the study of sleep related breathing disorders. It may be worthwhile to include these in our orthodontic case assessment sheet in patients suspected to have airway related issues. The length and width of soft palate may be considered as important incriminating factors in effecting OSA in the patients studied. Width of the tongue seemed to have a positive co-relation with the severity of OSA.

Mild OSA group presented with increased cranio-cervical angulation, increased saddle angle and increased ANB due to retrognathic mandible. Maxilla exhibited ante-inclination additionally there was increased gonial angle showing a vertical growth pattern. Patients affected with severe OSA had anatomically reduced maxillary length and retrognathic mandible with increased ANB. Cross sectional area of airway was significantly reduced in the mild group compared to the controls which further worsened with increasing severity of OSA. Clinical features of increased neck circumference, increased body mass index and severe Mallampati index were seen. The soft palate increased both in length and width and the airway was compromised severely at the retro-palatal region.

Bibliography


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