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INFLUENCE OF NECK CIRCUMFERENCE & BMI ON ETIOLOGY OF OBSTRUCTIVE SLEEP APNEA.

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ABSTRACT

Background: A narrow upper airway is associated with obstructive sleep apnea (OSA), currently neck size and obesity is considered to be one of the most important physical characteristic of patients with sleep apnea. Combining neck circumference and body mass may allow the clinical diagnosis or exclusion of sleep apnoea to be made with reasonable confidence. This study examines these issues. **AIM:** The aim of the study is to correlate upper airway and soft tissue measurements with Neck circumference (NC) & BMI (Body Mass Index) using lateral cephalogram to evaluate etiology of obstructive sleep apnoea. **Material and method**- Lateral Cephalogram of 45 subjects were used to measure the pharyngeal airway. The patients were divided into three groups based on the Neck Circumference (NC): Group A: - NC less than equal to 30cm; Group B: - NC 31 to 34 cm; Group C: - NC greater than equal to 35 cm.The population was stratified by Body Mass Index (BMI): Group I: < 23 i.e Lean, Group II: 23 –35 i.e Normal, Group III: > 25 i.e Obese. Student's t-test for paired samples was used to compare the mean values of study variable vital parameters. **Result-** The soft palate and tongue size increased with increasing BMI and NC and the results were statistically significant($p \leq 0.05$). There was reduction IAS and oropharyngeal airway with increasing NC($p > 0.05$) and reduction in SPAS($p \leq 0.10$), MAS($p \leq 0.80$) and IAS($p \leq 0.2$) with increasing BMI. **Conclusion** - The correlation of NC with increase in soft tissue size (soft palate and tongue) suggested that obesity mediates its effects in OSA through fat deposition in the neck.

KEYWORDS: Lateral Cephalogram, NC, BMI, OSA.

INTRODUCTION

Obstructive sleep apnea (OSA) is a sleep-related breathing disorder that involves a decrease or complete halt in airflow despite an ongoing effort to breathe. It occurs when the muscles relax during sleep, causing soft tissue in the back of the throat to collapse and block the upper airway. This leads to partial reductions (hypopneas) and complete pauses (apneas) in breathing that last at least 10 seconds during sleep. Most pauses last between 10 and 30 seconds, but some may persist for one minute or longer. This can lead to abrupt reductions in blood oxygen saturation, with oxygen levels falling as much as 40 percent or more in severe cases. Nasal obstruction secondary to hypertrophied inferior turbinates, adenoidal pad hypertrophy and hypertrophy of the faucial tonsils can cause chronic mouth breathing, loud snoring, obstructive sleep apnea, excessive daytime sleepiness. In this situation, a number of postural changes, such as open mandible posture, downward and forward positioning of the tongue and extension of the head can take place. If these postural changes continue for a long period, especially during the active growth stage, dentofacial disorders at different levels of severity can be seen, together with inadequate lip structure, long face syndrome and adenoidal facies.[1] Abnormalities in the anatomy of the pharynx, the physiology of the upper airway muscle dilator and the stability of ventilatory control are important causes of repetitive pharyngeal collapse during sleep leading to Obstructive sleep apnea (OSA).[2]

There is evidence that OSA patients with a low body mass index (BMI) may have a higher incidence of upper airway abnormalities. Also, in OSA patients, upper airway morphology seems to differ according to Neck size/Circumference or BMI. Obese patients show increased upper airway soft tissue dimensions and non-obese patients demonstrate abnormal craniofacial structure, while intermediate patients have both craniofacial and upper airway soft tissue abnormalities.[3]

Some of the airway compromising conditions of airway are Pierre-Robin syndrome, obesity i.e short thick neck, redundant tissue in the oropharynx, sleep apnea, acromegaly like macroglossia, prognathism etc. It must be recognized, however, that some patients with a difficult airway will remain undetected despite the most careful preoperative airway evaluation.[4]

In our study, the correlation of upper airway and soft tissue measurements with Neck circumference & BMI (Body Mass Index) will be elucidated to evaluate the predictor of sleep apnea.

STUDY SETTING

Patients reporting to Institute who were advised for Lateral Cephalogram either by the Department of Oral Medicine and Radiology or Department of Orthodontics and Dentofacial Orthopedics. A total of 45 patients who were more than 18 years were included in study. However, the patients who were suffering from airway problem, large adenoids and tonsils were excluded from the study. For each patient, written consent was taken and ethical clearance from ethical committee of the institution was obtained.

Subjects were exposed with teeth in centric occlusion, lips relaxed and a fixed anode mid saggital plane distance using standarized technique was used.(Fig 1). Magnification of machine was also taken into consideration. The dorsum of the tongue and pharyngeal airway were coated with Radioopaque dye IOHEX (i.e Iodine 300 mg, Tromethamine 1.2 mg, Edetate Calcium disodium 0.1 mg and water) to enhance the outline of tongue and pharyngeal soft tissue. The patient was asked to swish the dye for 1 second and then swallow. The radiographs were obtained with Kodak, Dental System, France with model no. 8000 C. All the radiographs were traced manually by the same investigator. Various linear measurements of pharyngeal airway passage and soft tissue (soft palate and tongue) dimensions were traced manually with 0.5 mm lead pencil on acetate paper to nearest 0.1mm. The area of the airway and soft tissue i.e Nasopharynx, Oropharynx Hypopharynx, soft palate and tongue was calculated with **Image tool 3.00 software** in pixel square. The pixel square was converted into mm square by multiplying the value with 0.264.

LINEAR MEASUREMENT OF UPPER AIRWAY SPACE AND SOFT TISSUE (Figure 2)

1. **Superior posterior airway space (SPAS)** - is measured from a point on posterior outline of the soft palate to the closest point on the pharyngeal wall. This measurement is taken on the anterior half of the soft palate out line.
2. **Middle airway space (MAS)**- is measured from the point of intersection of the posterior border of the tongue and inferior border of the mandible to the closest point on the posterior pharyngeal wall.
3. **Inferior airway space (IAS)(mm)**- measured between the posterior pharyngeal wall and the point of intersection of tongue with hyoid bone i.e V - LPW: the distance from V to LPW, representing the Inferior airway space.
4. **Tongue length (TGL)(mm)**- measured between tip of the tongue and base of the epiglottis Eb, the deepest point of the epiglottis .
5. **Tongue height (TGH)(mm)**- The linear distance between a point on the most superior curvature of the tongue dorsum and the base of a line drawn perpendicular to the TF-Eb line.
6. **Soft palate length (PNS-P)(mm)**- The linear distance between posterior nasal spine, PNS and P.

MEASUREMENT OF UPPER AIRWAY AND SOFT TISSUE AREA (Figure 3)

1. **Nasopharynx (mm^2):** the area outlined by a line between R and PNS, an extension of the palatal plane to the posterior pharyngeal wall and the posterior pharyngeal wall.
2. **Oropharynx (mm^2):** the area outlined by the inferior border of the nasopharynx, the posterior surface of the soft palate and tongue, a line parallel to the palatal plane through the point Et and the posterior pharyngeal wall.
3. **Hypopharynx (mm^2):** the area outlined by the inferior border of the oropharynx, the posterior surface of the epiglottis, a line parallel to the palatal plane through the point C4 and the posterior pharyngeal wall.
4. **Tongue (mm^2):** the area outlined by the dorsal configuration of the tongue surface and lines that connect TT, RGN, H and Eb.
5. **Soft palate (mm^2):** the area confined by the outline of the soft palate that starts and ends at PNS through P.

CLINICAL ASSESSMENT

Measurement of neck circumference

The neck circumference was measured at cricothyroid level with the measuring tape.

The patients were divided into three groups based on the Neck Circumference (NC):

Group A: - NC less than equal to 30cm;

Group B: - NC 31 to 34 cm;

Group C: - NC greater than equal to 35 cm.

The population was stratified by Body Mass Index (BMI) using cut off points of-
Group I: - < 23- Lean
Group II: - 23 –35- Normal
Group III: - > 25 - Obese

During routine clinical assessment patients were weighed on Health scale weighing machine. Height was measured with a wall fixed height rule (Sterling, An ISO certified unit Health scale)
The BMI of the subjects was calculated by using the following formula:-

$$BMI = \frac{Weight\ In\ Kg.}{(Height\ In\ Mtr.)^2}$$

RELIABILITY AND ERROR ANALYSIS
All the measurement was completed twice, 2 weeks apart, by the two investigators. The mean value of the variables measured on eachof the two occasions were compared using paired *t* tests to detect any systematic error in measurements made.

STATISTICAL ANALYSIS
Student's t-test for paired samples was used to compare the mean values of study variable vital parameters. The statistical test Chi- Square test was used for difference between proportions. All the statistical analyses were performed using appropriate software (SPSS for windows, Release 16.0; SPSS, India). The probability value $p<0.05$ was considered as significant, probability value equal to or less than $p \leq 0.01$ were considered as highly significant.

RESULTS
45 subjects were divided into three groups according to BMI i.e less than or equal to 23 (n=16, 35.6%), between 23-23(n=19, 42.2%) and more than or equal to 25(n=10, 22.2%). (**Table 1)** showed the demographic data based on BMI and found that there was no difference in age between the groups. Similar study was carried out by **Ferguson. K.A (1995)**[5], **Katz I et al**[6], **Hoffstein V**[7], **Davies RJO**[8], **Nabeel JA and Stradling JR.**[9], **Mayer. P et al (1996)**[3] where the relationships between obesity, NC, and upper airway morphology and sleep apnea were evaluated.

Ferguson.K.A et al (1995)[10] evaluated the relationships between neck circumference (NC), body mass index, apnea severity and craniofacial and upper airway soft-tissue measurements from upright lateral cephalometry on patients divided into three different NC groups and found upper airway soft-tissue and craniofacial abnormalities are related to OSA patients. It was found that obese patients showed increased upper airway soft-tissue structures, nonobese patients showed abnormal craniofacial structure and an intermediate group of patients with abnormalities in both craniofacial structure and upper airway soft-tissue structures.

Cephalometric upper airway space and soft tissue variables in different BMI groups were compared **(TABLE 2)** and found that there is decrease in **SPAS, MAS, IAS** with increase in BMI and in patients with BMI >25, there is narrower oropharynx area.

The upper airway soft tissue area of different BMI group was evaluated on lateral cephalogram (**Table 3)** and found that soft palate and tongue size increased with increasing BMI and were different among groups and no relationship was found between upper airway and BMI which is accordance with author **Lowe A. A**[11] **(1995).** The fact that upper airway abnormalities do not correlate significantly with more obese subjects suggests that other pathophysiological mechanisms such as increased upper airway collapsibility, fragmented sleep, ventilatory instability and neurological mechanisms (changes in upper airway dilator muscle activity) may be more important OSA patients. In lean patients, OSA may be attributed to the presence of various skeletal abnormalities, which is in agreement with a study conducted by **Mathur and Douglas N.J.**[12]

The subjects in our study were also divided into three groups according to NC i.e i) less than or equal to 30 (n=12, 26.7%), ii) between 31 to 34(n=16, 35.65%) and iii) greater than equal to 35(n=17, 37.8%) **(TABLE 4)** and the NC was correlated with body mass index and it was found that NC increased progressively from group A to C with increasing BMI and was different among groups which is in accordance with author **Ferguson K.A et al (1995).**[10]

Since the soft palate and the tongue are structures composed of soft tissue with no rigid support, they are greatly affected by gravitational forces. Therefore, in CT scans and other examinations performed in the supine position, these structures move further toward the posterior pharyngeal wall, which results in changes in the dimensional measurements of the upper airway space, as demonstrated by **Lowe et al and**[11] **Abramson et al.**[13] Thus, scan results obtained in supine position is recommended for individuals with OSAS.

Airway size at any of the three levels was measured (superior posterior, middle, or inferior airway space). Cross sectional upper airway measurements of the SPAS, MAS, Nasopharynx and hypopharynx did not relate to NC **(Table 5).** Our study also concluded that there w as reduction IAS and oropharyngeal airway with increasing NC.

(**Table 6)** compared upper airway soft tissue in different NC groups on lateral cephalogram and found that NC was related to the size of tongue and the soft palate size. Tongue cross-sectional and soft palate area increased as NC increased and were different between groups which is in accordance with **Ferguson K.A**[10] **(1995).** Our study also concluded that there was reduction IAS,

Nasopharynx and oropharyngeal airway with increasing NC.

(Table 3 and 6) show relation between BMI, NC, upper airway and soft tissue that with increasing BMI and NC there is increase in soft tissue size. **Ferguson K.A.(1995)**[10] evaluated relationships between neck circumference (NC), body mass, apnea severity and craniofacial and upper airway soft-tissue measurements from upright lateral cephalometry and found that NC is related to obesity, tongue and soft palate size. Patients with larger NC have larger tongue and soft palate with no difference in the upper airway size and NC which is in accordance with our study. **Davies and Stradling**[8] examined the predictive importance of NC, Obesity and lateral cephalometry in patients with OSA and concluded that the relationships between obesity and OSA were secondary to variations in NC related to the degree of fat deposition in the neck.

Obesity occurs in most patients with OSA and is considered to be a major risk factor for its development. The mechanisms whereby obesity contributes to the pathogenesis of OSA are poorly understood. A variety of studies have used upper airway imaging to examine the relationship between obesity and OSA. Our data are consistent with that of **Partinen and associates**[14] where they have demonstrated that upper airway soft-tissue structures increase in size with increasing obesity. **Tsuchiya and coworkers**[15] performed cephalometry and upper airway computed tomography (CT) on patients with OSA and then classified them by cluster analysis on the basis of apnea index and body mass index and found that patients with a low apnea index and a high body mass index had enlarged soft palate whereas patients with a high apnea index and low body mass index had abnormal craniofacial measurements. We have also shown using upper airway cephalometry that patients with high BMI have larger tongue and soft palate and could be considered as predictors of sleep apnea.

TABLE 1 DEMOGRAPHIC DATA OF PATIENTS DEPENDING ON BMI WITH NC, GENDER AND AGE

BMI Group	GROUP I less than 23 (n=16)		GROUP II 23-25 (n=19)		GROUP III more than 25 (n=10)		p Value
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
Age,yr	21.05	2.26	21.83	2.04	22.64	1.75	0.12
GENDER Female	1.78	0.97	2.43	0.98	2.22	0.83	p > 0.05
Male	1.85	0.69	2.20	0.45	1.00	0.00	p > 0.05
BMI	19.95	2.85	23.97	0.64	22.70	2.25	0.001
NC	29.38	3.03	32.06	4.12	36.25	1.96	P < 0.001

The colored region in the table denotes p value ≤ 0.05 as statistical significant or highly significant difference.
Group I- **Less than 23** – lean
Group II- **Between 23-25**- Normal
Group III- **More than 25**- Obese

Table 2 THE MEAN AND STANDARD DEVIATION OF CEPHALOMETRIC UPPER AIRWAY SPACE AND AREA ACCORDING TO THREE DIFFERENT BMI GROUPS

		GROUP I less than 23		GROUP II 23-25		GROUP III more than 25		p Value
	BMI Group	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
Lat ceph	SPAS	13.32	2.75	11.58	1.83	12.91	1.92	0.13
	MAS	12.27	2.78	12.25	2.22	11.64	3.04	0.801
	IAS	14.36	3.58	13.58	3.26	12.18	2.96	0.224
	Nasopharynx (mm^2)	1209.42	194.86	1280.80	264.33	1258.53	236.41	0.648
	Oropharynx (mm^2)	2991.84	556.34	2761.68	570.55	2751.96	434.26	0.508
	Hypopharynx (mm^2)	1732.17	455.81	1721.01	377.69	1869.80	436.16	0.641

- SPAS- Superior posterior airway space
- IAS- Inferior airway space
- MAS- Middle airway space

TABLE 3 COMPARISION OF CEPHALOMETRIC UPPER AIRWAY SOFT TISSUE AREA OF DIFFERENT BMI GROUP

		GROUP I less than 23		GROUP II 23-25		GROUP III more than 25		p Value
	BMI Group	Mean	SD	Mean	SD	Mean	SD	
Lat ceph	Nasopharynx (mm^2)	1209.42	194.86	1280.80	264.33	1258.53	236.41	0.648
	Oropharynx (mm^2)	2991.84	556.34	2891.68	570.55	2761.96	434.26	0.508
	Hypopharynx (mm^2)	1732.17	455.81	1721.01	377.69	1869.80	436.16	0.641
	Soft palate (mm^2)	1215.12	161.06	1326.33	178.28	1395.08	126.33	0.01
	Tongue (mm^2)	10019.98	3917.29	12502.50	1663.86	13837.80	1989.18	0.004

TABLE 4 DEMOGRAPHIC DATA OF PATIENTS DEPENDING ON NC (NECK CIRCUMFERENCE) WITH BMI, GENDER AND AGE

NC Group	GROUP A less than equal to 30 (n=12)		GROUP B 31-34 (n=16)		GROUP C more than equal to 35 (n=17)		p Value
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
Age,yr	21.37	2.42	21.90	2.02	22.25	1.04	0.55
GENDER Male	2.71	0.73	1.25	0.50	1.43	0.53	p< 0.001
Female	2.00	0.71	1.67	0.52	1.00	0.00	p< 0.001
NC cm	25.15	4.23	32.40	0.84	37.06	2.78	0.001
BMI	20.75	3.21	22.11	3.01	26.31	2.48	P < 0.001

TABLE 5 THE MEAN AND STANDARD DEVIATION OF CEPHALOMETRIC UPPER AIRWAY SPACE AND AREA ACCORDING TO THREE DIFFERENT NC (NECK CIRCUMFERNCE) GROUPS

NC GROUP	NC	less than equal to 30		31-34		more than equal to 35		p Value
		Mean	SD	Mean	SD	Mean	SD	
Lateral ceph	SPAS	12.48	1.91	13.10	3.73	13.25	2.12	0.652
	MAS	12.15	2.76	12.40	2.67	11.63	2.62	0.83
	IAS	13.81	3.57	13.60	3.78	13.00	2.51	0.844
	Nasopharynx (mm^2)	1297.56	222.72	1125.66	229.16	1191.26	154.73	0.09
	Oropharynx (mm^2)	2997.95	376.96	2821.67	832.54	2717.60	513.15	0.36
	Hypopharynx (mm^2)	1714.75	391.33	1745.36	484.63	1946.98	473.57	0.41

TABLE 6 COMPARISION OF CEPHALOMETRIC UPPER AIRWAY SOFT TISSUE AREA ACCORDING TO DIFFERENT NC (NECK CIRCUMFERNCE) GROUP

NC GROUP	NC GROUP	less than equal to 30		31-34		more than equal to 35		p Value
		Mean	SD	Mean	SD	Mean	SD	
Lateral ceph	Nasopharynx (mm^2)	1297.56	222.72	1125.66	229.16	1191.26	154.73	0.09
	Oropharynx (mm^2)	2997.95	376.96	2821.67	832.54	2717.60	513.15	0.36
	Hypopharynx (mm^2)	1714.75	391.33	1745.36	484.63	1946.98	473.57	0.41
	Soft palate (mm^2)	1261.39	182.35	1268.61	162.71	1406.37	104.70	0.02
	Tongue (mm^2)	10869.02	3709.32	11025.91	1827.60	14870.32	1730.88	0.01

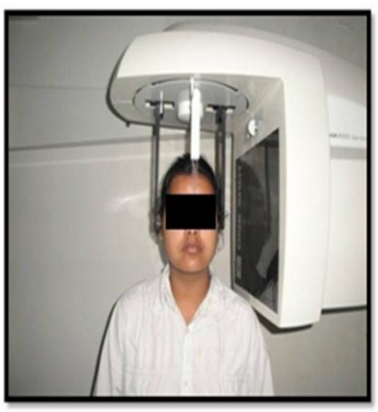

Fig 1 Patient Positioning In Digitalized Lateral Cephalogram Machine

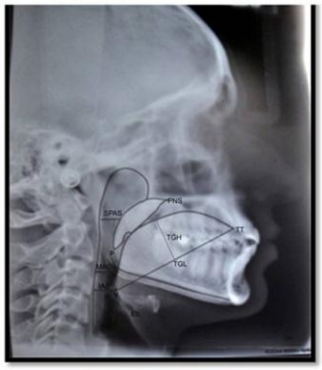

Figure. 2 Cephalometric Upper Airway Soft Tissue Linear measurements.

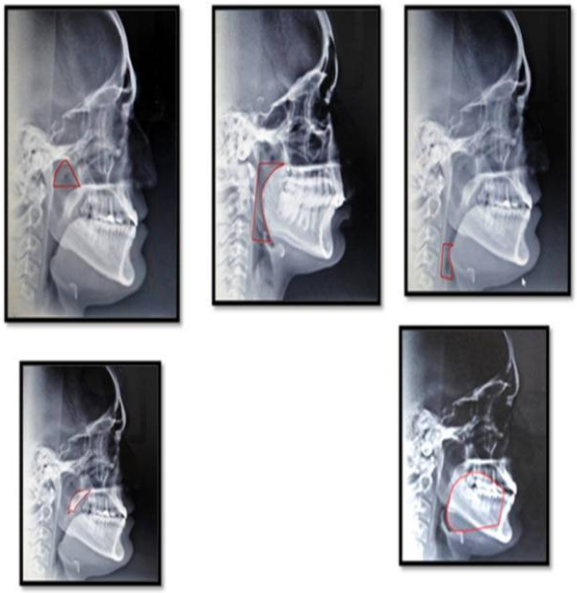

Figure 3 Cephalometric Upper Airway Soft Tissue Area measurements.

CONCLUSION

Neck circumference is a simple clinical measurement that is easy to perform on patients with OSA. The result conclude that patients with increasing NC have large dimensions of upper airway soft tissue (increased soft palate and tongue size) providing predictive information about the severity of OSA and insights into the possible under lying cause of OSA.

Lateral cephalometry is able to provide valuable skeletal information for upper airway morphology but provides no information about the volumetric measurements of the upper airway. In CT scans and other examinations performed in the supine position, soft tissue structures move further toward the posterior pharyngeal wall by gravitational forces, which results in changes in the dimensional measurements of the upper airway space**.** Thus, scan results obtained in supine position is recommended for individuals with OSA.

A narrow upper airway is associated with OSA irrespective of whether the cause is a craniofacial abnormality or increased upper airway soft- tissue size. Patients with high BMI showed soft tissue changes (increased soft palate and tongue size) suggesting upper airway abnormalities in lean patients thus, are more likely to play a more important physiopathogenic role for OSA than in obese or older patients. Further investigation using both static and dynamic imaging techniques like all night polysomnographic recordings, the sleep recording included electroencephalogram (EEG), electrocardiogram (ECG), electrooculogram (EOG), electromyogram (EMG), thoracic respiratory movements, naso-oral airflow and transcutaneous oxygen tension further clarify the pathogenesis of OSA in obese and nonobese patients.

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