Importance of cephalographs in diagnosis of patients with sleep apnea

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Abstract

Introduction: Obstructive sleep apnea (OSA) is considered to be a potentially life threatening disorder, which is characterized by repeated collapse of the upper airway during sleep with cessation of breathing. The cephalometric method despite being a static, two-dimensional evaluation of dynamic three-dimensional structures of the head and neck is useful in diagnosing patients with OSA, as they have shown that significant differences exist between asymptomatic controls and patients with OSA. **Aims and Objectives:** This study is designed to compare and validate the craniofacial morphology in patients with OSA using lateral cephalometry in both upright and supine position. **Materials and Methods:** Sixty subjects participated in the study of which 30 were patients with OSA diagnosed by questionnaire and 30 were healthy control group with age range of 25–45 years. **Results:** The study group demonstrated an increased ANB, mandibular plane angles (GoGn-SN), lower anterior facial height which are statistically significant with a significant $P < 0.05$. Significant decrease in posterior airway space, increased soft palate length, tongue length, and thickness suggesting reduced airway space in supine posture. **Conclusion:** Evaluation of craniofacial morphology in OSA patients using lateral cephalometry helps in recognizing the morphological changes induced by altered sleep pattern and for appropriate treatment planning.

Keywords: Lateral cephalometry, obstructive sleep apnea, retroglossal obstruction, retropalatal obstruction

Introduction

Wellness and illness of an individual is influenced by the biological process of sleep; impaired sleep is a potential health problem, with bio-psycho-social health issues in patients as response related to sleep loss.[1] Obstructive sleep apnea (OSA) is recognized as a potentially life threatening disorder characterized by repeated collapse of the upper airway (UA) during sleep with cessation of breathing.[2] The presence of even a mild degree of sleep-disordered breathing puts the patient at greatly increased risk for the development of hypertension and cardiovascular morbidity having a large toll on the physical, mental, social, and economic health of patients.[3]

Cephalometry has transcended the boundaries of dentistry and today it presents as an important tool for the evaluation of UA and diagnosis of the OSA-hypopnea syndrome.[4] Nocturnal polysomnography is the gold standard for diagnosing OSA, several advanced technologies like computerized tomography, magnetic resonance imaging (MRI) are being used to evaluate sites of obstruction in UA and craniofacial structures.[2] However, the traditional cephalometric method has been the most practical and commonly used.[5] The cephalometric method despite being a static, two-dimensional evaluation of the dynamic three-dimensional anatomical structures of the head and neck is useful. The primary advantages of cephalometry are its low cost, easy access and minimal exposure to radiation.[2] In recent years, American Academy of sleep medicine has recommended oral appliances for the treatment of OSA and this made it as an important area of interest in dentistry.[6] Cephalometric analysis is invaluable tool not only in treatment planning but also in diagnosing individuals with OSA, as abnormal cephalometric dentofacial morphologies such as retrognathia, micrognathia, large ANB angle, long face, steep mandibular plane, inferior positioning of the hyoid bone, long and large soft palate and large tongue, narrowing of the UA have been reported in these patients.

The present study was designed to compare and validate the craniofacial morphology in both upright and supine

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position and also the cervical vertebral column morphology on cephalographs in patients with OSA.

This study is designed in such way that lateral cephalogram which is commonly taken standard radiograph for viewing dental and other soft tissues of cranium, importantly the UA is utilized in visualizing the UA collapse (such as soft palate and tongue thickness, macroglossia, micrognathia) in standard upright position. Then we made patient to supine posture as this is good indicator of soft tissue structure as most of problems of OSA are during sleeping. Thus we compared morphology of soft and hard tissues in OSA in supine and upright postures.

Materials and Methods

Thirty patients with OSA and thirty healthy individuals were included using the data obtained by specialized questionnaire designed specifically for the purpose. Questionnaire is a standard questionnaire given by American Academy of sleep medicine which is modified slightly for easy understanding of local population. Patients selected for the study had one or more of the following signs and symptoms of OSA:

- Snoring
- Daytime sleepiness and fatigue
- Increased body mass index (BMI)
- Increased neck circumference.

Exclusion criteria included, patients with systemic diseases mainly respiratory disorders and patients with developmental disorders such as syndromes.

A written consent was obtained from all the participants for the study. All the patients were subjected to cephometric radiographic examination using the standard protocols. Exposures were made with parameters of 75 KV and 12 mA for 0.50 s exposure time in digital Kodak 8000 orthopantamograph machine, both in upright and supine position [Figures 1 and 2]. Predetermined skeletal and soft tissue parameters were identified and traced for further measurements and analysis [Figures 3 and 4]. During this process of subjection of individuals to lateral cephalometry lead markers one at the level of inferior border of the orbit and other in front of tragus of the ear was placed to avoid error in locating portion in lateral caphalograph in closed mouth position. Tracing of the supine and upright cephalogram is done for skeletal and soft tissue land marks using an indelible pencil [Figures 5 and 6]. The data obtained was subjected to statistical analysis for significance values using *t*-test and Kerl Pearson's correlation.

Figure 1: Patient positioned for upright cephalometry

Figure 2: Patient positioned for supine cephalometry

Figure 3: Upright cephalogram

Results

The mean age in study group and control group is 32.5 years. The mean BMI of the control group was 23.94 kg/m^2 and that of the study group was 26.3 kg/m^2.

Comparison of upright cephalogram between the study and the control group

The results of the cephalometric variables showed a significant difference in the skeletal and soft tissue parameters between study and the control group [Table 1].

Figure 4: Supine cephalogram

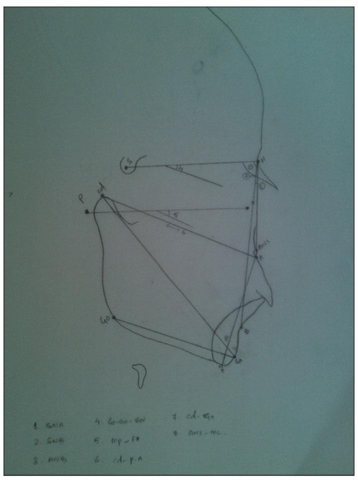

Figure 5: Tracing of hard tissue landmarks

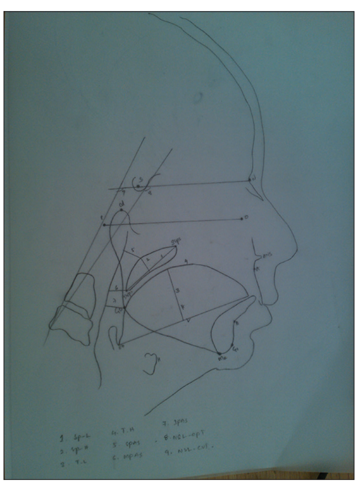

Figure 6: Tracings of soft tissue land marks

The study group revealed retro positioned mandible with large ANB angle. Soft tissue morphology was characterized by thickened tongue and soft palate; the cross-sectional areas of soft palate were enlarged. Anteroposterior pharyngeal airway space at the superior, middle and inferior levels was not significant.

Table 1: Mean comparison between control group and study group in upright

Variables	Upright				*t*	*P*
	Control group		Study group			
	Mean	SD	Mean	SD		
SNA	82.40	4.64	90.73	3.40	−7.929	0.000 S
SNB	77.80	5.84	81.50	4.59	−2.728	0.008 S
ANB	5.80	3.21	9.23	4.83	−3.245	0.002 S
GO-Gn-SN	20.20	5.22	21.87	3.84	−1.408	0.164 NS
FH-MP	21.20	4.33	23.63	4.06	−2.245	0.029 S
Cd-p.A	92.52	8.20	99.65	8.83	−3.240	0.002 S
Cd-Gn	113.31	7.06	121.11	11.42	−3.182	0.002 S
LAFH	66.99	7.08	71.60	6.85	−2.565	0.013 S
SP-T	10.26	1.88	11.62	2.15	−2.614	0.011 S
SP-L	34.30	4.52	37.25	5.46	−2.278	0.026 S
T-H	33.65	1.90	44.10	21.27	−2.680	0.010 S
T-L	69.69	14.21	63.87	21.73	1.227	0.225 NS
SPAS	11.31	3.01	10.01	4.85	1.243	0.219 NS
MPAS	8.64	1.78	9.71	2.91	−1.724	0.090 NS
IPAS	9.08	1.82	8.93	4.19	0.176	0.861 NS
NSL-OPT	110.70	9.38	115.31	8.41	−2.003	0.050 NS
NSL-CVT	113.00	9.43	114.33	9.05	−0.559	0.579 NS

Statistical analysis: Independent sample *t*-test. Statistically significant if $P<0.05$. S: Significant; NS: Nonsignificant; SD: Standard deviation

Comparison of supine cephalogram between the study and the control group

Increased SNA and ANB angles is seen which was statistically significant. Increase in the soft palate length and thickness with statistical significance and increase in tongue length and height which was not significant [Table 2].

Comparison of upright and supine cephalogram in study and control group

The present study demonstrated the soft tissue changes that occurred from upright to supine posture in study and control. The study group showed that with change in posture, soft palate length decreased, thickness increased, tongue length decreased with no significant change in tongue height [Tables 3 and 4].

There was a significant reduction in the posterior airway space behind the soft palate with change in posture in both the groups at all the three levels (superior, middle, inferior). However, a positive correlation for the superior and inferior posterior airway space was evident in the control group and in study group. Cranio-cervical angulation (NSL-OPT; NSL-CVT) showed significant difference with change in posture in study group and control group, and positively correlated.

Table 2: Mean comparison between control group and study group in supine

Variables	Supine				*t*	*P*
	Control group		Study group			
	Mean	SD	Mean	SD		
SNA	86.40	4.82	88.87	4.42	−2.066	0.043 S
SNB	82.40	5.29	83.17	5.57	−0.547	0.587 NS
ANB	4.00	1.44	5.77	2.85	−3.032	0.004 S
GO-Gn-SN	25.50	9.16	30.67	7.81	−2.351	0.022 S
FH-MP	28.50	6.58	31.17	7.67	−1.445	0.154 NS
Cd-p.A	98.86	2.36	99.40	7.64	−0.370	0.713 NS
Cd-Gn	117.53	4.48	120.46	9.09	−1.582	0.119 NS
LAFH	72.97	4.26	73.09	5.81	−0.089	0.930 NS
SP-T	35.92	8.67	13.86	9.50	9.394	0.000 S
SP-L	15.92	19.78	31.87	13.37	−3.659	0.001 S
T-H	59.85	11.22	64.80	23.91	−1.027	0.309 NS
T-L	35.40	8.77	32.21	2.67	1.904	0.062 NS
SPAS	12.62	2.14	14.41	4.83	−1.852	0.069 NS
MPAS	7.58	1.51	7.59	3.02	−0.011	0.991 NS
IPAS	10.22	2.26	9.67	4.44	0.608	0.545 NS
NSL-OPT	105.60	7.28	108.60	11.43	−1.213	0.230 NS
NSL-CVT	106.40	10.23	107.77	6.63	−0.614	0.542 NS

S: Significant; NS: Nonsignificant; SD: Standard deviation

Table 3: Mean comparison between upright and supine in control group

Variables	Control group				*t*	*P*
	Upright		Supine			
	Mean	SD	Mean	SD		
SP-T	10.26	1.88	35.92	8.67	−16.486	0.000 S
SP-L	34.30	4.52	15.92	19.78	4.747	0.000 S
T-H	33.65	1.90	59.85	11.22	−12.921	0.000 S
T-L	69.69	14.21	35.40	8.77	11.205	0.000 S
SPAS	11.31	3.01	12.62	2.14	−2.488	0.019 S
MPAS	8.64	1.78	7.58	1.51	2.371	0.025 S
IPAS	9.08	1.82	10.22	2.26	−3.373	0.002 S
NSL-OPT	110.70	9.38	105.60	7.28	2.837	0.008 S
NSL-CVT	113.00	9.43	106.40	10.23	3.404	0.002 S

S: Significant; SD: Standard deviation

Discussion

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.[7] OSA can be potentially fatal with increased risk of hypertension, cardiovascular diseases, stroke and diminished quality of life with a prevalence rate of 19.5% in Indian urban men population.[8]

Table 4: Mean comparison between upright and supine in study group

Variables	Study group				*t*	*P*
	Upright		Supine			
	Mean	SD	Mean	SD		
SP-T	11.62	2.15	13.86	9.50	−1.304	0.202 NS
SP-L	37.25	5.46	31.87	13.37	2.121	0.043 S
T-H	44.10	21.27	64.80	23.91	−3.643	0.001 S
T-L	63.87	21.73	32.21	2.67	7.794	0.000 S
SPAS	10.01	4.85	14.41	4.83	−3.444	0.002 S
MPAS	9.71	2.91	7.59	3.02	4.656	0.000 S
IPAS	8.93	4.19	9.67	4.44	−0.729	0.472 NS
NSL-OPT	115.31	8.41	108.60	11.43	2.503	0.018 S
NSL-CVT	114.33	9.05	107.77	6.63	2.976	0.006 S

S: Significant; NS: Nonsignificant; SD: Standard deviation

Many studies have demonstrated the orthodontic relevance of naso-respiratory obstruction and its effect on facial growth.[9] In 1990 Davies and Stradling have reported general obesity, altered hyoid position, soft palate length and OSA are probably secondary to increased neck circumferences in their study.[10,11]

According to King[12] increase in diameter of the pharynx is contributed by the forward and downward growth of the face which is in turn affected by the anterior growth of the cranial base and posterior growth of the occipital bone or by the association of both. Battagel *et al*.,[6] stated that these anatomical differences place the entire facial complex closer to the cervical spine and thus contribute to the reduction of space available for the airway in sleep-disordered groups. Among patients with OSA, the sites of obstruction and the narrowing of the UA differed greatly. The retropalatal (posterior to the soft palate) region and retroglossal (posterior to the base of tongue) region were commonly affected sites, and multiple sites of obstruction and narrowing were not rare.[13]

Cephalometry is a two-dimensional representation of a three-dimensional structure, it has been extensively used to quantify the skeletal, dental and the soft tissue relationships of the craniofacial complex.[9] The choice for the cephalometric analysis used in this study was due to its large use in radiological and orthodontic clinics and for it embraces measures in all regions susceptible to obstruction.[14]

In addition to upright cephalometry, supine cephalometry has been introduced to examine the effect of change in body position on the anatomy and function of the UA in patients with OSA.[2] Some studies have shown that a change from upright to supine position altered the cross-sectional area of soft palate and tongue.[15] Supine cephalometry seemed more relevant clinically to examine the airways and surrounding structures because all OSA patients had obstruction in this position.[2] Riley *et al*. employed SNA, SNB, and ANB as variables for evaluating the craniofacial skeleton and reported patients with OSA had smaller SNB and larger ANB angle, which correlates with present study with significant change in ANB angle ($P < 0.004$).[16]

The present study showed retro gnathic mandible, large ANB angle, increase in the soft palate length and thickness, increase in tongue thickness and decrease in posterior airway space which is statistically significant ($P < 0.005$) in the study group which is in accordance with Tangugsorn *et al*.[17] Although the tongue length was greater in majority of patients in study group compared to the control, it was statistically insignificant.

Extended cervical posture has been a compensatory adaptation in patients with airway obstruction. Study group demonstrated similar postural change that was significant ($P < 0.005$).[18]

Battagel *et al*.,[6] and Lowe *et al.*,[5] asserted that the greater alterations in dimensions of UA in OSA patients occur in the oropharynx, which relate to the reduction of the superior and median posterior palatal space that, in the present study was also reduced in OSA subjects with a significant $P < 0.005$. This space has close relation to the dimensions of the soft palate with increased length was related to presence of OSA.

In study group, with change in posture soft palate length decreased, increased tongue height, tongue length decreased with no significant change in soft palate thickness which is in accordance with pae *et al*.[19] the change in cranio-cervical angulation with change in posture was statistically significant in study group, the angulation (NSL-OPT) increased from upright to supine posture in majority of patients and was positively correlated with that of Dobson *et al*.[20]

In addition to changes described above obesity and position of hyoid bone have an influence on the diameter of the airway in OSA patients. Obesity, through neck and soft tissue fat deposition, and increased pressure on the neck of sub mental adipose tissue, may predispose to UA obstruction, Schwartz *et al*.[21] demonstrated a reduction in airway obstruction with reduction of weight. Hyoid bone being located inferiorly leads to tongue being backward influenced by genioglossus caused the collapse of the UA.[22] Anteroposterior pharyngeal structures partially represent the pharyngeal narrowing but lateral pharyngeal structures corresponds to actual pharyngeal narrowing that is depicted on MRI.

Limitations of the study

- Polysomnography is a gold standard for the diagnosis of OSA patients and in our study patients are diagnosed based on the standard questionnaire
- Cephalometry provides information for anteroposterior but not lateral pharyngeal structures that are implicated in the pharyngeal narrowing which can be depicted on MRI
- A longitudinal study more sample would be more accurate and recommended.

Conclusion

Significant differences existed in the craniofacial morphology of patients with OSA and the healthy population with reduced midface length, smaller airway dimensions and retrognathic mandible. Thus, lateral cephalometry served as an important tool in clinical diagnosis of OSA patients demonstrating distinct cranio-facial morphological changes, thereby giving a clue to the site of obstruction based on specific skeletal and soft tissue components.

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Nil.

Conflicts of interest
The authors have obtained the necessary patient consent forms where the patients have given their approval for participation in the investigation, followed by representation in the concerned article. The patients do understand that the authors will ensure that their identities won't be revealed, however anonymity cannot be guaranteed.

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