DOI: http://doi.org/10.4038/cjo.v11i1.5312

Original Article

A Comparative Analysis of Cephalometric data and Drug induced sleep endoscopy in OSA patients – a Sri Lankan perspective

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Abstract
Obstructive sleep apnoea (OSA) is a growing problem, where the diagnosis and management are rapidly evolving. The investigative tools and limited resources in developing countries pose an extra challenge in optimally treating patients with OSA.Polysomnography and drug induced sleep endoscopy are important diagnostic parameters. Cephalometric parameters are an emerging tool in the diagnostic workup, where no data is available in Sri Lankan population where surgery features as a popular treatment option.

Objectives
To identify a correlation between DISE, AHI and cephalometric parameters in a Sri Lankan population and identify common levels of obstruction in the upper airway , which influence treatment outcomes.

Results
CircumferentialVelopharyngeal and oropharyngeal obstruction aremore prevalent levels of obstruction. Statistically significant correlation between oropharyngeal collapse with SNB angle and epiglottic collapse with SNB angle and MP-H distance were seen. No correlation between DISE findings and SNA angles.
No significant correlation between cephalometry and AHI. Post op symptomatic relief based on ESS and VAS score is statistically significant.

Conclusion
Cephalometric findings are complimentary to DISE and AHI findings, but not superior in our population. Extremes from the standard deviations of cephalometric data should be treated with caution when selecting treatment options.

Keywords
Obstructive sleep apnoea, cephalometry, drug induced sleep endoscopy, Apnoea hypopnoea index.

Funding: None
Competing interest: None

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Accepted Date:5th Jan 2022 Published Date: 26th February 2022

Abbreviations:
OSA – Obstructive Sleep Apnoea
AHI- Apnoea hypopnoea index
CPAP – Continuous positive airway pressure
DISE- Drug induced sleep endoscopy
ESS- Epworth Sleepiness score
VAS – Visual analogue scale
SNA - skull base angle of maxilla
SNB - Skull base angles of mandible
MP-H - mandibular plain to hyoid bone
NICE –National Institute of Health Care and Excellence

Introduction

Obstructive sleep apnoea (OSA) is a growing problem that is heavily underdiagnosed and causes a significant disease burden to society, where attention needs to be given to further develop the diagnosis and management.Sleep medicine is an important and emerging branch of medicine in the South Asian subcontinent. The investigative tools and limited resources in developing countries pose an extra challenge in optimally treating patients with OSA.

Polysomnography still plays a main role in the diagnosis of OSA[1], based on the Apnoea Hypopnoea index (AHI) and many other indicesinferred by it. A big part in the diagnostic evaluation entails the physical examination, not only to identify any anatomical obstruction or physiological restriction, but also co morbidities, which ultimately contributes to the final decision of management of OSA. Though CPAP therapy has been considered the gold standard of treatment in OSA[2,3], the emergence of level specific surgical options have shown great efficacy[4].

When considering the anatomical structures, the hard bony framework and the soft tissue structures within[5,6] , both play an important role in the outcome following surgical intervention. The three-dimensional evaluation of thesoft tissue structures with Mullers manoeuvre[7] and Drug Induced Sleep Endoscopy (DISE)[8] have been standard practice with its own limitations. Cephalometry, being a cheap investigation[9], it has multitudeof measurements that could be taken on a two-dimensional plane, between soft tissue structures as well as bony landmarks, where some parameters have tried to associate with OSA[10], and more importantly outcome of surgery[11]. Limited studies are available when it comes to cephalometric analysis with DISE or sleep endoscopy and published data are mainly associated with Caucasian and east Asian populations[12]. This data is limited in the south Asian population, where facial morphisms are quite different to the Caucasians and Chinese[13,14].

Materials and methods

Objectives

The main objective of this study is to find a corelation between DISE, AHI and cephalometric anthropometry in a Sri Lankan population. In addition, the secondary objective is to generate data on common levels of collapse in our population as well as outcomes of management.

Study design

A retrospective cross-sectional study in a tertiary care hospital was performed over the period of 1year. Ethical clearance was obtained as intervention requiring radiation was carried out as a specific component of the study.

Out of 39 total patients who presented,28 patients were included in the study, where all had undergone a level 1 sleep study with an apnoea hypopnoea Index(AHI) over 5/hour. All subjects also underwent Drug induced Sleep Endoscopy prior to treatment with CPAP or surgery. Those excluded were those who did not give written consent for cephalometric analysisor lost in follow up(n = 9) and had AHI below5 (n=2).All patients underwent comprehensive history and examination including anthropometric measurements.

DISEis a fibreoptic nasal endoscopic evaluation which gives a 3-dimensional picture of the velopharyngeal and oropharyngeal , tongue base and epiglottic collapse under pharmacological sedation and spontaneous respiration[15]. This was performed exclusively in the operating theatre by spraying 2% lignocaine with 1:100000 adrenaline as local anaesthesia to the nose. Patient was placed in supine position in a dimmed light environment.In almost all cases ,intravenous propofol infusion was used as the sole anaesthetic agent at the minimum required dose until the target level of anaesthesia wasachieved. This was assessed by loss of verbal response and loss of arousal. Standard nasal endoscope was used to visualise the nasal cavity, postnasal space, upper and lower velum, oropharynx, tongue base and epiglottis. The VOTE classification[16.] was used to grade the degree of obstruction in a 3-point score; 0 denoting <50% obstruction, 1 between 50% and 75% partial obstruction and 2 (>75%)total obstruction. We did note the velum had an anteroposterior,lateral or circumferential collapse and the oropharynx having a lateral or circumferential collapse. The 3-dimensionalcharacteristics of collapseweren't included in the statistical analysis but used only to identify the common patterns of collapse in our population. For analytical purposes 0 (<50%obstruction) was considered as non-obstructive ,while 1and 2were considered to be obstructive in nature.

Level 1 sleep studies were conducted in the sleep lab at the National hospital Sri Lanka prior to any intervention. AHI values were primarily analysed. Sleep patterns, Minimum oxygen saturation, Oxygen desaturation index and other sleep study parameters were taken into consideration when managing the patients. Based on the AHI[17], mild OSA was defined as between 5 to 15/hour, moderate OSA as between 15 to 30/hour and severe OSA as over 30/hour.

All 28 patients underwent were subjected to lateral digital cephalometry in the Department of Radiology, National Hospital. All films were taken at end expiration to prevent errors in calculating hyoid bone level. The teeth were at light occlusion and neutral head position[6]. Digital calculations of the SNA(skull base angle of maxilla) and SNB(Skull base angles of mandible) angles were calculated and MP-H (mandibular plain to hyoid bone) length was measured digitally and verified manually in millimetres to reduce error (Figure 1).SNA angle was defined as the angle from the Sella, at the centre point of pituitary fossa, to nasion and posterior most curve between supradentalle of maxilla and posterior nasal spine. SNB is defined as from the sellar to nasion and to the point of greatest concavity on the anterior surface of mandibular symphysis.MP-H was defined as the distance between the anterosuperior most point of the hyoid up to the mandibular plane.

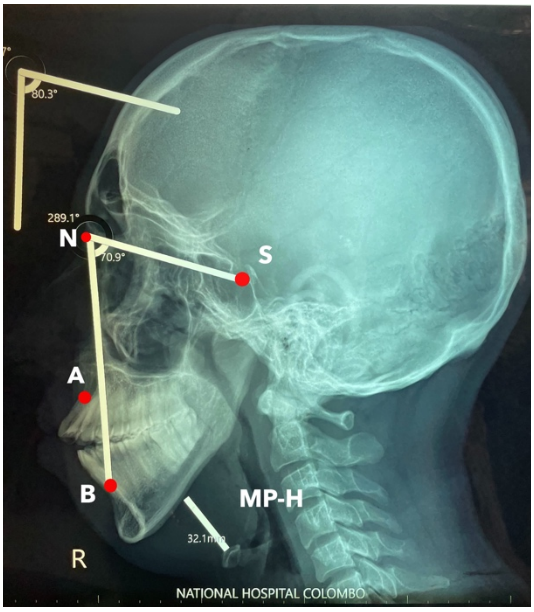

Figure 1: Cephalometric x ray of a patient severe OSA.*Markings of S denotes the pituitary fossa; N denotes the nasion; A denotes Supradentalle ofmaxilla; B denotes concavity of the mandibular symphysis. These points are used to calculate the SNB angle(marked 70 degrees in this example) and the SNA angle (marked 80.3 degrees – slightly displaced above for the purpose of demonstration). The MP-H shows the distance between the anterosuperior most point of the hyoid bone to the mandibular plane.The lines show the digital measurements which were also confirmed manually.*

Normative values of Cephalometry were derived from previously published data in Caucasian population[18,19] (Table 1).

Table 1: normal values of cephalometric measurements

Lateral Cephalogram	Normal values
SNA	81.1 ± 0.66
SNB	78.3 ± 0.65
MP-H	22.5 ± 0.88

A visual analogue scale of 0 to 10 was used to subjectively assess the patient satisfaction pre- and post-treatment, where 0 was denoting on complains and 10 being extremely troublesome OSA.Epworth Sleepiness score[20] was calculated for all participants prior to treatment and after 6 months of intervention(surgery or CPAP).

Statistical analysis

Statistical analysis was performed by using Mann Whitney U test for nonparametric data without the assumption of normal distribution. Due to small sample size , a normal distribution curve was unable to achieve , hence Pearson Coefficient calculation was used to calculate the r value to identify a linear association between variables.

Results and analysis

Observations

28 patients who were included in this study had a Male to female ratio of 8.33:1. The mean age was 44.6 years(28 to 66 years) and BMI ranging from 25 to 47 (mean 31.13).

When considering the levels of collapse ,only one patient had a single level obstruction, where the rest (n=27) had multilevel obstruction. The commonest was at the level of velum(92%). (Figure 2).

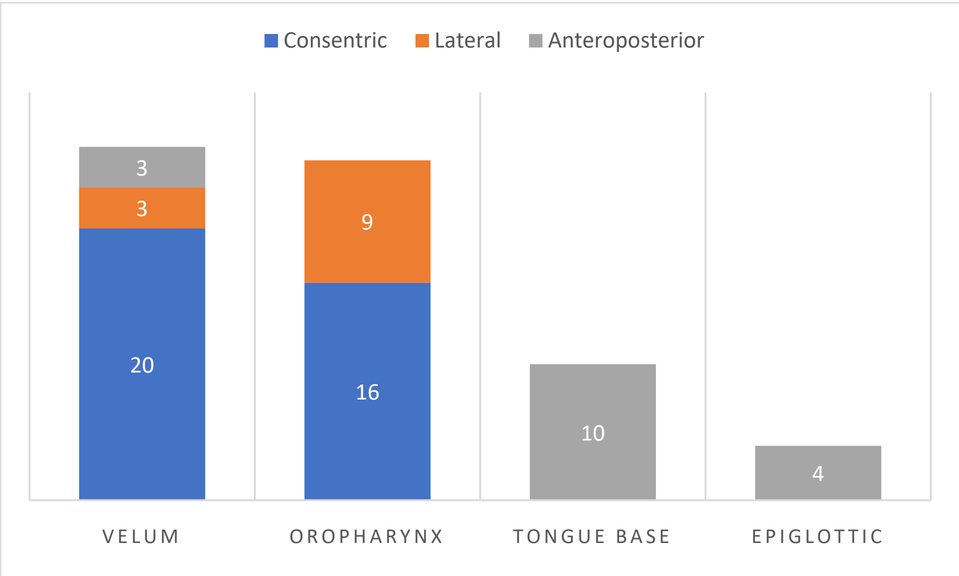

Figure 2: Distribution of DISE findings. *The graph shows the number of subjects with different levels of collapse at velum, oropharynx, tongue base and epiglottic level.*

14 patients underwent surgical intervention including expansion sphincter pharyngoplasty(n=5), relocation pharyngoplasty(n=8), tongue base reduction(n=3), tonsillectomy(n=1) and epiglottopexy(n=1).4 patients underwent septoplasty as a multilevel procedure along with palatal/tongue base surgery and 1 patient underwent partial uvulectomy as a part of the surgical procedure.

Correlation between Pre-treatment and post Treatment ESS

Mean Pre surgical Epworth Sleepiness score (ESS) was 14.83 and post-operative ESS showed a drop of mean ESS to 4.5($p<0.00001$).14 patients who were treated with CPAP also had a statistically significant improvement ($p=0.0034$) on evaluating ESS, where pre-CPAP ESS was 13.15 and post CPAP ESS was 8.15, having a lesser gain than the surgical group.

Correlation between Pre-treatment and post treatment VAS score

The group of patients who underwent surgery had a pre-operative average VAS score of 8.64, which improved to 1.21 post operatively ($P<0.000001$). Similarly, patients who were on CPAP also had an improvement of VAS score from 7.84 to 4.3 ($P<0.001$).

Comparison between DISE findings and Cephalometry

1. At level of Velum

26 patients (92%) had >50% obstruction at the level of velum with only 2 patients with obstruction less than 50%. There was no statistical significance with the SNA and SNB levels, but the statistical significance (P = 0.01) was seen in MP-H values.(Table 2)

Table 2: Association of cephalometry with obstruction at Velum

Velum					
	<50% Obstruction (n=2) Mean with 95% CI		>50% Obstruction (n= 26) Mean with 95% CI		P value
SNA	84.3	1.38	81.2692	2.2	0.06
SNB	80.85	0.9	77.1154	3.41	0.14
MP-H	19	1.1	23.3346	2.44	0.01

2. At level of oropharynx

25 patients had >50% obstruction at the oropharyngeal level. SNB angle decrease was statistically significant (P= 0.032). No significant correlation with SNA angle and MP-h were noted (Table 3).

Table 3: Association of cephalometry with obstruction at Oropharynx

Oropharynx					
	<50% Obstruction (n=3) Mean with 95% CI		>50% Obstruction (n= 25) Mean with 95% CI		P value
SNA	82.63	3.49	81.2692	2.3	0.39
SNB	82.3667	4.58	76.784	2.61	0.032
MP-H	24.5333	6.04	21.08	3.16	0.3

3. At level of tongue base

9 patients had obstruction at tongue base level. There was no statistical significance in cephalometric parameters at the tongue base (Table 4).

Table 4: Association of cephalometry with obstruction at tongue base

Tongue base					
	<50% Obstruction (n=9) Mean with 95% CI		>50% Obstruction (n= 18) Mean with 95% CI		P value
SNA	81.4765	2.75	80.6071	3.11	0.45
SNB	76.8556	3.31	78.33	3.41	0.27
MP-H	20.6556	4.03	21.9667	4.07	0.31

4. At level of Epiglottis

4 patients had epiglottic collapse. There was a significant statistical correlation with SNB angle(p=0.01) and MP-H length (p=0.00017).

Table 5: Association of cephalometry with obstruction at Epiglottis.

	Epiglottis				
	<50% Obstruction (n=4 Mean with 95% CI		>50% Obstruction (n= 24) Mean with 95% CI		P value
SNA	81.4667	2.38	81.6	3.04	0.92
SNB	76.7833	2.71	80.975	4.24	0.01
MP-H	20.2083	3.14	28.9	1.43	0.00017

Comparison between AHI and Cephalometry

21.4% (n=6) were having mild OSA ,39.3% were diagnosed moderate OSA and severe OSA respectively.No statistically significant correlation could be inferred between AHI and cephalometric data.Pearson r calculation revealed r(28) = .187 , p = 0.34(Table 6).

Table 6: Correlation of Cephalometry and AHI

	Degree of OSA based on AHI							
	Mild (AHI 5-15/h)		Moderate (AHI 15-30/h)		Severe (>30/h)			
Measure	Mean	SD	Mean	SD	Mean	SD	r score	P value
SNA	83.5	2.9	82.1727	3.58	81.0545	8.44	.187	0.34
SNB	81.1	3.66	77.0181	4.16	77.3636	4.12		
MPH	23.13	4.56	19.1272	2.799	24.0363	4.165		

Discussion

A patient who presents with complaints of snoring, witnessed obstructive sleep apnoea or daytime somnolence is evaluated by the ENT department by taking a detailed history and thorough clinical examination. Age, BMI , neck circumference and features of systemic comorbidities are also evaluated.On examination, any deviated nasal septum, Tonsil and tongue size is evaluated whileMallampatti score and Friedman Score are calculated. A multi-disciplinary approach consisting of respiratory medicine, nutrition, bariatric surgery and psychiatry are employed in the case of extremes of age, high BMI over 40 and existing comorbidities.

Patients with obvious micrognathia and retrognathia are not further evaluated by the ENT team, but instead referredfor maxillofacialsurgical opinion.MaxilloMandibular Advancement surgery (MMA) has shown to be the main stay of surgery in such patients, which expands the oromaxillary bony framework and also help in creating more soft tissue space, preventing tongue base collapse. Cephalometry plays an important role in the planning of such surgery[21].

It is worth noting that none of the patients in this study had any obvious maxilla mandibular abnormality.

Polysomnography is recommended as an important component of diagnostic workup as per the Clinical practice guidelines by the American Academy of Sleepmedicine[1]. We were able to perform level 1 sleep studies in all subjects to infer the AHI. The incidence of obstructive sleep apnoea is comparable with the only published local data by Undugoda et al (2019)[22]. We do not have any Data to compare findings of DISE and levels of collapse nor are there any cephalometric data done in view of OSA in Sri Lankans. This posed a challenge, as the only comparable data available are published in Caucasian and Chinese populations[14,23,24]. The only study in the South Asian population comparing cephalometry and Awake flexible nasal endoscopy by A. Narayan (2015) also had compared the data referencing literature in Caucasian population[18].

As apart of the management workup Drug Induced Sleep Endoscopy (DISE)were offered to all patients, who didn't need maxillofacial intervention or didn't have a major risk of anaesthetic complications. All participants in our study did fall to this category. Allpatients did undergo DISE. To reduce the interpreter bias, all DISE findings were recorded and verified by the authors and recordings were noted as per the VOTE classification. Majority of the procedures were performed by 2 senioranaesthetists to maintain optimal depth of sedation as excessive propofol usage would give erroneous circumferential collapse of the soft tissue structures due to muscle relaxation.

Following the diagnostic workup all patients were offered CPAP therapy as per the NICE guidelines[25].Unfortunately, compliance was low for CPAP as patients reported difficulty in managing equipment as well as psychosocial factors. Some didn't comply due to the financial burden of owning a CPAP machine. Though the indications for surgery in OSA is secondary to failure of CPAP therapy or as an adjuvant to continuing CPAP therapy[4], 14 patients in our study group opted for a surgical intervention due to non-compliance with CPAP trial. Hence the use of cephalometry, DISE and polysomnography to determine surgical success are more relevant to developing nations with limited resources, when deciding on treatment options and protocols.

Cephalometric analysis was performed digitally by the machine generated software and confirmed accuracy by manual recordings by the author. However similar studies by Koo et al, have used specific orthodontic software which was not accessible to us. Nevertheless, this is considerably cheaper option in comparison to DISE and Polysomnography. Our study did not show any correlation between AHI and cephalometric parameters, though certain limited studies have shown positive correlation with AHI and MP-H length[26,18,9]. Studies have shown narrow SNA and SNB angles have poor soft tissue related surgical outcome[24,27]. However some studies, similar to ours have failed to replicate this finding[9,11].

Banhiranet al. (2013)[23] from Thailand had shown a clear correlation with MP-H length >18mm to be strongly associated with severe OSA with AHI >15/h. Though correlation between MP-H was not shown in our study to be significant, the correlation between Tongue base collapse and epiglottic collapse were statistically significant when compared with high MP-H values in obstructed patients. However, in our study, all subjects had values that were not statistically significant in comparison with the available Caucasian population, which also suggests that surgical outcome with procedures to soft palate, tongue base and epiglottis are comparable to published data.This was replicated in our study where 14 patients who underwent surgical procedure had a statistically significant positive outcome in comparison to CPAP therapy.

Though we could not relate to any adverse outcomes ofabnormal cephalometric data from our study, one could infer that cephalometry acts as an adjuvant diagnostic tool where outcome of surgery or CPAP would be favourable when cephalometric data are within the normal limits. Abnormal SNA and SNB angles as well as Long MP-H values should be treated with caution if conventional surgical approach is considered[18].

The importance of cephalometry has recently being highlighted due to the increased incidence of offering maxillomandibular advancement surgeries to patients with OSA[5,10,26]. This has been more relevant for Chinese populations[28.] opposed to Caucasians, who have higher BMI's. Newer techniques of CT/MRI cephalometry have been described[11,15]where cephalometric and anatomic variations of soft tissue structures are studied in more detail. Hence more detailed studies are needed in relation to our population due to the different craniofacial anatomy in the South Asian population have in comparison to Caucasians and Chinese.

Limitations

A small sample size proved to be a major factor in obtaining more accurate statistical data, partly due to the low presentation of patients for the treatment of OSA. Ethical clearance was not granted for obtaining control cephalometric x-rays in normal subjects to obtain normative values for our population, hence statistical analysis had to be made comparing the data of Caucasians.

Obtaining consent in 9 patients were unsuccessful due to the reluctance of being exposed to radiation or loss in follow up. Due to lack of post procedure polysomnography, we were unable to objectively quantify the success of surgery or CPAP therapy in our population.

Technical hurdles needed to be tackled in establishing a new investigation protocol involvededucating and working closely with the radiographers and radiologists, when developing the use of digital measurements. Manual calculation was performed for all measurements, to reduce the errors in statistics.

Conclusion

The predominant level of obstruction in OSA in our population are the velumand oropharynx. Increased MP-H and decreased SNB angles are associated with epiglottic collapse while decreased SNB angles are associated with oropharyngeal collapse. Statistical significance of MP-H values in velum collapse were associated with epiglottic collapse as all these patients had multilevel pathologies. Cephalometry is complimentary to the management of OSA along with DISE and polysomnography.Patient selection based only on cephalometry is not recommended but could be useful as a cheap adjuvant in selecting patients for selective soft tissue surgical procedures.

Though goals of the study were achieved, further larger scale studies need to be performed to see for correlation on different diagnostic parameters in managing OSA surgically or by CPAP.

Acknowledgements

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Department of ENT, National Hospital of Sri Lanka, Colombo.

Dr.D.K. Wickramasinghe , Registrar Community Medicine, for Statistical analysis.

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