



Brazilian Journal of  
**OTORHINOLARYNGOLOGY**

www.bjorl.org



ORIGINAL ARTICLE

**Correlation between cephalometric data and severity of sleep apnea** ☆, ☆☆

Vanessa Gonçalves Silva<sup>a,\*</sup>, Laíza Araújo Mohana Pinheiro<sup>b</sup>,  
Priscila Leite da Silveira<sup>a</sup>, Alexandre Scalli Mathias Duarte<sup>b</sup>, Ana Célia Faria<sup>b,c</sup>,  
Eduardo George Baptista de Carvalho<sup>b</sup>, Edilson Zancanella<sup>b</sup>, Agrício Nubiato Crespo<sup>b</sup>

<sup>a</sup> Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil

<sup>b</sup> Discipline of Otorhinolaryngology, Head and Neck, Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil

<sup>c</sup> Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo (USP), Ribeirão Preto, SP, Brazil

Received 1 June 2013; accepted 10 November 2013

**KEYWORDS**

Sleep apnea, obstructive;  
Cephalometry;  
Severity of illness index

**Abstract**

*Introduction:* Obstructive sleep apnea syndrome has a high prevalence among adults. Cephalometric variables can be a valuable method for evaluating patients with this syndrome.

*Objective:* To correlate cephalometric data with the apnea-hypopnea sleep index.

*Methods:* We performed a retrospective and cross-sectional study that analyzed the cephalometric data of patients followed in the Sleep Disorders Outpatient Clinic of the Discipline of Otorhinolaryngology of a university hospital, from June 2007 to May 2012.

*Results:* Ninety-six patients were included, 45 men, and 51 women, with a mean age of 50.3 years. A total of 11 patients had snoring, 20 had mild apnea, 26 had moderate apnea, and 39 had severe apnea. The distance from the hyoid bone to the mandibular plane was the only variable that showed a statistically significant correlation with the apnea-hypopnea index.

*Conclusion:* Cephalometric variables are useful tools for the understanding of obstructive sleep apnea syndrome. The distance from the hyoid bone to the mandibular plane showed a statistically significant correlation with the apnea-hypopnea index.

© 2014 Associação Brasileira de Otorrinolaringologia e Cirurgia Cérvico-Facial. Published by Elsevier Editora Ltda. All rights reserved.

**PALAVRAS-CHAVE**

Apneia do sono tipo obstructiva;  
Telerradiologia;  
Índice de gravidade de doença

**Correlação entre dados cefalométricos e gravidade da apneia do sono**

**Resumo**

*Introdução:* A síndrome da apneia do sono apresenta grande prevalência na população adulta. A cefalometria com análise das variáveis morfológicas pode ser um método valioso na avaliação de pacientes com essa síndrome.

*Objetivo:* Correlacionar dados cefalométricos com o índice de apneia-hipopneia do sono, com a finalidade de detectar fatores preditores para a gravidade da síndrome da apneia obstructiva do sono.

☆Please cite this article as: Silva VG, Pinheiro LAM, Silveira PL, Duarte ASM, Faria AC, Carvalho EGB, et al. Correlation between cephalometric data and severity of sleep apnea. Braz J Otorhinolaryngol. 2014;80:191-5.

☆☆Study conducted at the Outpatient Clinic of Sleep Disorders of the Discipline of Otorhinolaryngology, Head and Neck, Faculdade de Ciências Médicas, Universidade Estadual de Campinas (UNICAMP), Campinas, SP, Brazil.

\* Corresponding author.

E-mail: vennis\_gs@yahoo.com.br (V.G. Silva).

1808-8694/\$ - see front matter © 2014 Associação Brasileira de Otorrinolaringologia e Cirurgia Cérvico-Facial. Published by Elsevier Editora Ltda. All rights reserved.

<http://dx.doi.org/10.1016/j.bjorl.2013.11.001>

**Métodos:** Trata-se de um estudo retrospectivo, em que foram analisadas cefalometrias de pacientes em acompanhamento no ambulatório de distúrbios do sono da disciplina de Otorrinolaringologia, de um hospital universitário terciário, no período de junho de 2007 a maio de 2012.

**Resultados:** Foram avaliados 96 pacientes, sendo 45 homens e 51 mulheres. Onze pacientes eram portadores de roncopatia, 20 de apneia leve, 26 de apneia moderada e 39 de apneia grave. A única variável cefalométrica que apresentou correlação estatisticamente significativa com o índice de apneia e hipoapneia foi a distância linear perpendicular do osso hioide ao plano mandibular.

**Conclusão:** As variáveis cefalométricas podem ser úteis no entendimento da síndrome da apneia obstrutiva do sono e uma atenção deve ser dada à variável que mede a distância do hioide perpendicularmente ao plano mandibular.

© 2014 Associação Brasileira de Otorrinolaringologia e Cirurgia Cérvico-Facial. Publicado por Elsevier Editora Ltda. Todos os direitos reservados.

## Introduction

The obstructive sleep apnea syndrome (OSAS) is characterized by pauses in breathing during sleep, micro-arousals and daytime sleepiness. These symptoms are caused by repeated episodes of obstruction at one or more upper airway levels during sleep.<sup>1</sup>

This syndrome has a high prevalence in the adult population, affecting 4% of men and 2% of women.<sup>1</sup> Affected patients have a higher risk of cardiovascular disease, motor vehicle accidents due to daytime sleepiness and may present a significant decline in neurocognitive function.<sup>2</sup>

The pathogenesis of OSAS has been investigated through several structural and physiological methods.<sup>3</sup> An increase in pharyngeal collapse has been postulated as a factor of OSAS pathophysiology. Furthermore, it is known that craniofacial abnormalities and soft tissue characteristics are involved in upper airway patency. However, it is unclear how much the morphology of the craniofacial skeleton and soft tissue characteristics may affect the pharyngeal collapse and contribute to episodes of apnea. Therefore, the etiological significance of the association of the craniofacial skeleton and soft tissues of the oropharynx in OSAS is still controversial.<sup>3-8</sup>

In this context, cephalometry and 3D-CT scanning can assess craniofacial skeleton abnormalities and the characteristics of oropharyngeal soft tissues. Although cephalometry has a limited two-dimensional view, it is a simple and affordable assessment method with less radiation exposure than computed tomography.<sup>3-6</sup>

A meta-analysis of cephalometric studies, reported by Miles et al.,<sup>9</sup> showed the most relevant variables that may be associated with the development and severity of OSAS: the angle between the anterior cranial base and the maxilla (SNA), the angle between the anterior cranial base and the mandible (SNB), the posterior airway space (PAS), the length of soft palate (PNS-P), and the distance from the hyoid bone to the mandibular plane (MP-H). Other studies have also stressed the importance of cephalometric variables in sleep apnea.<sup>10-12</sup>

Many studies have used cephalometric variables, usually associated with data from endoscopic evaluation to assess OSAS development. Although facial skeleton disorders and soft tissue alterations in the oropharynx are described in OSAS patients, any direct association is unclear, and it is still debatable whether the analysis of these cephalometric

morphological variables can be a tool in the assessment of patients with OSAS.<sup>13</sup>

A better understanding of the etiology and pathophysiology of OSAS is extremely important to the selection of the most appropriate treatment. Several therapies have been proposed and studied including the use of an intraoral appliance (IOA), skeletal surgery and soft tissue surgery, as well as a continuous positive airway pressure (CPAP) device.<sup>14,15</sup> In some studies cephalometry has been given an important role in therapeutic decision-making in selecting from various skeletal surgery techniques.<sup>16-18</sup>

This study aimed to evaluate possible correlations between cephalometric data and the severity of the apnea-hypopnea index (AHI).

## Methods

We performed a retrospective, cross-sectional study, in which medical records of 381 patients treated at the Sleep Disorder Outpatient Clinic of the Discipline of Otorhinolaryngology, Head and Neck Surgery of a tertiary university hospital were assessed between June 2007 and May 2012. The following parameters were analyzed: gender, age, AHI, body mass index (BMI) and cephalometric data. Of the total number of selected patients, those with incomplete data, with no cephalometry data and younger than 18 years were excluded. Thus a total of 96 patients remained in the study.

Patients were divided into four groups according to AHI demonstrated by polysomnography: snoring (group 1), mild OSAS (group 2), moderate OSAS (group 3) and severe OSAS (group 4).

Teleradiography (Fig. 1) was considered adequate if performed in a lateral view, with the head in a natural position and barium contrast at the base of the tongue. The following measures were assessed through the cephalometric analysis:

**SNA:** Angle formed between the point sella, nasion and point A. This angle shows the position of the maxilla relative to the anterior cranial base. Therefore, it defines the degree of protrusion or retrusion of the maxilla in the anteroposterior direction. Reference value (RV): 82°.<sup>19</sup>

**SNB:** Angle formed between the point sella, nasion and point B. The magnitude of this angle indicates the position of the mandible relative to the anterior cranial base. Thus, it demonstrates the degree of protrusion or retrusion of the

mandible in the anteroposterior direction. Reference value (RV): 80°.19

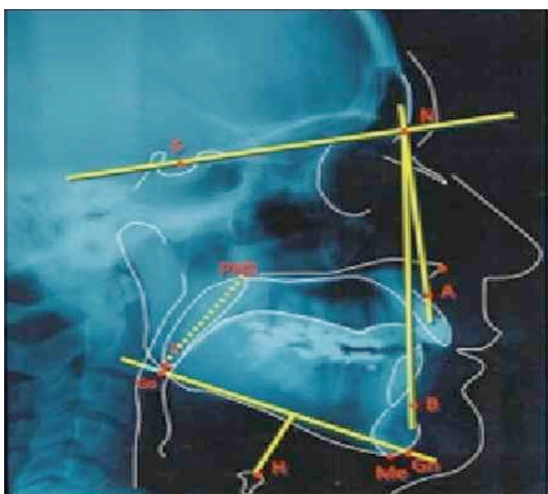
**PAS:** Lower pharyngeal space related to retrolingual air-space. Linear distance between a point on the base of the tongue and another point on the posterior pharyngeal wall, both determined by the length of the B-Go line. Reference value (RV): Men - 19 mm/ Women-15 mm.19

**PNS-U:** Soft palate length, measured from the posterior nasal spine (PNS) to the tip of the uvula (U). Reference value (RV): Men - 34 mm/ Women - 35 mm.19

**Mp-H:** Linear distance along a perpendicular line from point H to the mandibular plane (Mp). Reference value (RV): Men - 19 mm/ Women- 15 mm.19

Data were statistically analyzed using the SAS System, release 9.2, and Tukey's statistical test was used to compare the means of variables between groups, with  $p < 0.05$  being considered statistically significant.

This research was previously approved by the Research Ethics Committee of the institution, under the number 83946.



**Figure 1** Teleradiography. Cephalometric analysis, lateral view, with barium contrast at the base of the tongue.

## Results

A total of 96 patients were evaluated: 45 men and 51 women, with a mean age of 50.3 years (range of 18 to 72 years). Eleven patients had snoring, 20 mild OSAS, 26 moderate OSAS, and 39 had severe OSAS. The male/female ratio remained homogeneous in the subgroups.

The mean BMI in all groups was 28.8 kg/m<sup>2</sup> and the distribution between the groups was as follows: snoring group, mean BMI: 25.04 kg/m<sup>2</sup>; mild OSAS, mean BMI: 28.9 kg/m<sup>2</sup>; moderate OSAS, mean BMI: 28.36 kg/m<sup>2</sup>, severe OSAS, mean BMI: 30.2 kg/m<sup>2</sup>.

The SNA, SNB and PAS values showed no statistically significant correlation with AHI. PNS-P values, although higher in patients with moderate and severe apnea than in snoring

and mild OSAS, were not statistically significantly different. The analysis of MP-H values, on the other hand, showed greater length values in groups 3 and 4 than in groups 1 and 2, and these data are statistically significant ( $p < 0.01$ ) (Table 1).

**Table 1** Mean cephalometric values per group.

Group	1	2	3	4	P value
SNA	82.5	84.5	84.8	82.7	0.185
SNB	79.1	80.3	81.8	79.4	0.211
PAS	8.63	10.0	9.9	9.9	0.731
PNS-U	39.3	38.9	39.4	40.7	0.472
MP-H	21.3	19.3	23.2	25.5	0.0041

SNA and SNB values in degrees; PAS, PNS-U and MP-H values in millimeters.

## Discussion

In the medical literature, several predictors of OSAS have been identified and studied, including: obesity (increased body mass index), older age, increased cervical and abdominal circumference, in addition to the craniofacial disposition and pharyngeal soft tissues.3,19,20

These predisposing and/or etiological factors of OSAS have been extensively investigated by polysomnography, flexible nasal endoscopy, sleep-endoscopy and cephalometry. However, even with the use of all available methods, the precise identification of the airway obstruction site is limited because of the inability to reproduce the sleep state in awake patients.21

It is known that airway patency is influenced by craniofacial configuration, pharyngeal soft tissue characteristics and pharyngeal muscle contraction. There are two hypotheses that attempt to explain upper airway collapse: the neural hypothesis, which implies reduction of the oropharyngeal dilator muscle activity, and the anatomical theory which explains the collapse through the relationship of bony anatomy and soft tissues relaxation during sleep. Deposits of cervical fat may also contribute to the reduction of airway patency.22

Therefore, the structural relationships of the craniofacial skeleton and pharyngeal soft tissue may contribute to airway compromise.

After a comprehensive review, Miles et al.9 indicated that a direct and causal association between the relationship of craniofacial structures and the presence and severity of OSAS is very difficult to find in the literature. In this context, several studies have attempted to establish such a direct association between cephalometric measurements, and the presence and severity of OSAS.3-8 Sforza et al.22 demonstrated that the cephalometric variables that measure the length of the soft palate (PNS-P) and the distance from the hyoid perpendicular to the mandibular plane (MP-H) were associated with the presence of OSAS. Riha et al.23 described a lower position of the hyoid, and found that an increase in MP-H was associated with the presence of OSAS. Partinen et al.24 also found an association of the poste-

rior airway space (PAS) and the distance from the hyoid bone perpendicular to the mandibular plane (MP-H) with OSAS.

Although all these studies have shown an association between variations in cephalometric measurements and the presence of OSAS, few studies have correlated these variables with disease severity, as we did in the present study. This issue remains minimally addressed in the national specialized literature.

In our series, the analyzed cephalometric variables were SNA, SNB, PAS, PNS-U and MP-H. The values of the SNA, SNB, PAS and PNS-U showed no significant correlation with AHI. In agreement with the studies mentioned above, in our study the only variable that correlated with OSAS severity was MP-H. Therefore, attention should be given to the increased distance from the hyoid bone (MP-H), as the muscles of the tongue are partially anchored to the hyoid bone and their height can influence the relationship of soft tissues in the oropharynx.<sup>25</sup>

One might think that this finding would be more consistent if it were associated with decreased posterior airway space (PAS), which did not occur in our sample. However, our data were collected from telerradiographs obtained during the wakened state; during sleep in sleep the location of the hyoid bone is lower-than-normal, and the base of the tongue assumes a more vertical position that would facilitate pharyngeal collapse. However, measured values of MP-H in the literature exhibit some variability perhaps reflecting an imbalance between the action of the supra-hyoid and infra-hyoid muscles and the amount of cervical fat deposition.<sup>22</sup>

In this paradigm, there are many possible explanations for the difficulty of directly associating cephalometric variables with OSAS severity. First, cephalometry is obtained while the individual is awake and standing, which does not reflect changes that occur during sleep with the subject lying down and with relaxed pharyngeal muscles. Second, cephalometry provides information on the anteroposterior pharyngeal dimensions, but not on the laterolateral dimensions and recent studies with magnetic resonance imaging showed a reduction in lateral pharyngeal space in OSAS patients when compared with snoring patients only. Finally, it is possible that the configuration of the upper airway which is elliptical, may predispose to pharyngeal collapse during sleep and this configuration may be more important than the absolute size of the airway.<sup>22-24</sup>

Thus, our study suggests that while there may be a recognizable cephalometric predisposition for sleep-disordered breathing, this is only one of many aspects involved in the physiopathology of OSAS. Future studies should be performed to provide more information about the influence of anatomical variables on upper airway collapsibility.

## Conclusion

The cephalometric variables are useful tools for understanding OSAS. The distance from the hyoid bone to the mandibular plane (MP-H) showed a statistically significant correlation with AHI.

## Conflicts of interest

The authors declare no conflicts of interest.

## References

- Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med.* 1993;328:230-5.
- Shamsuzzaman ASM, Gersh BJ, Somers VK. Obstructive sleep apnea: Implications for cardiac and vascular disease. *JAMA.* 2003;290:1906-14.
- Cillo JE, Thayer S, Dasheiff RM, Finn R. Relations between Obstructive Sleep Apnea Syndrome and specific cephalometric measurements, body mass index, and Apnea-Hypopnea index. *Int J Oral Maxillofac Surg.* 2012;70:278-83.
- Gulati A, Chate RAC, Howes TQ. Can a single cephalometric measurement predict obstructive sleep apnea severity? *J Clin Sleep Med.* 2010;6:64-8.
- Kitamura T, Sakabe A, Ueda N, Shimori T, Udaka T, Ohbuchi T, et al. Usefulness of cephalometry and pharyngeal findings in the primary diagnosis of obstructive sleep apnea syndrome. *Nippon Jibiinkoka Gakkai Kaiho.* 2008;111:695-700.
- Monteith BD. Altered jaw posture and occlusal disruption patterns following mandibular advancement therapy for sleep apnea: A preliminary study of cephalometric predictors. *Int J Prosthodont.* 2004;17:274-80.
- Naganuma H, Okamoto M, Woodson BT, Hirose H. Cephalometric and fiberoptic evaluation as a case-selection technique for obstructive sleep apnea syndrome (OSAS). *Acta Otolaryngol Suppl.* 2002;547:57-63.
- Battagel JM, L'Estrange PR, Nolan P, Harkness B. The role of lateral cephalometric radiography and fluoroscopy in assessing mandibular advancement in sleep-related disorders. *Eur J Orthod.* 1998;20:121-32.
- Miles PG, Vig PS, Weyant RJ, Forrest TD, Rocketti HE. Craniofacial structure and obstructive sleep apnea syndrome: A qualitative analysis and meta-analysis of the literature. *Am J Orthod Dentofacial Orthop.* 1996;109:163-72.
- Cuccia AM, Campisi G, Cannavale R, Colella G. Obesity and craniofacial variables in subjects with obstructive sleep apnea syndrome: comparisons of cephalometric values. *Head Face Med.* 2007;3:41-9.
- Gungor AY, Turkkarhaman H, Yilmaz HH, Yarikitas M. Cephalometric comparison of obstructive sleep apnea patients and healthy controls. *Eur J Dent.* 2013;7:48-54.
- Salles C, Campos PSF, Andrade NA, Daltro C. Síndrome da apneia e hipopneia obstrutiva do sono: análise cefalométrica. *Braz J Otorrinolaryngol.* 2005;71:369-72.
- Verzina JP, Blumen M, Buchet I, Chabolle F. Sleep-Disordered Breathing: Choosing the Right Cephalometric Analysis. *Int J Oral Maxillofac Surg.* 2012;70:1442-8.
- Sundaram S, Bridgman SA, Lim J, Lasserson TJ. Surgery for obstructive sleep apnoea. *Cochrane Database Syst Rev.* 2005;CD001004.
- Lim J, Lasserson TJ, Fleetham J, Wright J. Oral appliances for obstructive sleep apnoea. *Cochrane Database Syst Rev.* 2006;CD004435.
- Faria AC, Xavier SP, Silva SN, Voi Trawitzki LV, Mello-Filho FV. Cephalometric analysis of modifications of the pharynx due to maxillo-mandibular advancement surgery in patients with obstructive sleep apnea. *Int J Oral Maxillofac Surg.* 2013;42:579-84.
- Mayer G, Meier-Ewert K. Cephalometric predictors for orthopaedic mandibular advancement in obstructive sleep apnoea. *Eur J Orthod.* 1995;17:35.
- Marklund M, Franklin KA, Stenlund H, Person M. Mandibular morphology and the efficacy of a mandibular advancement device in patients with sleep apnoea. *Eur J Oral Sci.* 1998;106:914-21.
- Macedo MMC, Colombini NEP, Silva ACP et al. Cefalometria. In: Neto SC, Júnior JFM, Martins RHG, Costa SS. *Tratado de Otorrinolaringologia: Volume I - Fundamentos.* 2ª Ed. São Paulo: Roca Editora; 2011. pp. 1019-48.

20. Pinto JA, Godoy LB, Marquis VW, Sonogo TB, Leal Cde F, Artico MS. Anthropometric data as predictors of Obstructive Sleep Apnea severity. *Braz J Otorhinolaryngol.* 2011;77:516-21.
21. Kim SJ, Kim YS, Park JH, Kim SW. Cephalometric Predictors of Therapeutic Response to Multilevel Surgery in Patients With Obstructive Sleep Apnea. *Int J Oral Maxillofac Surg.* 2012;70:1404-12.
22. Sforza E, Bacon W, Weiss T, Thibault A, Petiau C, Krieger J. Upper Airway Collapsibility and Cephalometric Variable in Patients with Obstructive Sleep Apnea. *Am J Respir Crit Care Med.* 2000;161:347-52.
23. Riha RL, Brander P, Vennelle M, Douglas NJ. A Cephalometric Comparison of Patients with the Sleep Apnea/Hypopnea Syndrome and Their Siblings. *Sleep.* 2005;28:315-20.
24. Partinen M, Guilleminault C, Quera-Salva MA, Jamieson A. Obstructive Sleep Apnea and Cephalometric Roentgenograms. *Chest.* 1988;93:1199-205.
25. Guilleminault C, Riley R, Powell N. Obstructive Sleep Apnea and Abnormal Cephalometric Measurements. Implications for Treatment. *Chest.* 1984;86: 793-4.