Accuracy of cephalometric pharyngeal analysis for diagnosis of obstructive sleep apnea syndrome (OSAS)

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Abstract

The objective of this study was to verify the accuracy of lateral radiographic cephalometry for the diagnosis of obstructive sleep apnea syndrome (OSAS). The sample was composed of 60 patients, all with clinical suspicion of OSAS. A positive polysomnographic diagnosis requires an apnea-hypopnea index [(A+H)I] per hour of sleep equal to or above five events. A positive cephalometric diagnosis requires superior posterior airway space (PASs)<26 mm and/or middle posterior airway space (PASm)<9 mm and/or inferior posterior airway space (PASi)<11 mm. The statistical study verified the accuracy of the cephalometric analysis in relation to the polysomnographic examination (gold standard). The comparison was established with the McNemar and Cohen's Kappa Tests. The sensitivity of the cephalometric analysis was 91.5%. The specificity was 38.5%. The positive predictive value was 84.3%. The negative predictive value observed was 55.6%. False negative results occurred in four situations and false positive in eight situations. The McNemar test showed no statistically significant difference between the results obtained by cephalometry and by polysomnography (p=0.388); and the measure of agreement calculated by Cohen's kappa coefficient was 33.7% (p=0.007), significant for values of p<0.05. The high sensitivity and the elevated positive predictive value of radiographic cephalometry make it a trustworthy tool, capable of diagnosing OSAS patient with a high degree of certainty, and indicating the obstructive site related to the manifestation of the condition. However, the low specificity of radiographic cephalometry and its negative predictive value do not allow its use as an exclusive examination.

Keywords: sleep apnea; cephalometry; snoring.

INTRODUCTION

By definition, obstructive sleep apnea syndrome (OSAS) is characterized by interruption of the naso-buccal air flow for 10 s (while thoracic/abdominal movements continue), repeated at least five times per hour of sleep. The cause of this clinical scenario is the collapse of the superior airways at the nasopharynx, oropharynx and/or hypopharynx.

According to Sgarbi and Sgarbi[1] about 9% of all men between the ages of 40 and 60,

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and 4% of post-menopausal women suffer from OSAS. They also stress the fact that this condition is found among 35% of habitual snorers and that it is impossible to define accurately how common the impairment is, because a large number of OSAS patients die in car accidents (due to daytime somnolence) or of cardiorespiratory failure before the condition has been diagnosed.

There are several factors linked to the collapse of the superior airways. The most important are excessive weight (obesity), alcohol abuse, the use of hypnotic substances, deviation of the nasal septum, hyperplasia of the inferior conchae, the palatine tonsils and/or the pharyngeal pillars, elongation and/or swelling of the soft palate, macroglossia and maxillary and/or mandibular deficiency.

The symptomatology of OSAS patients is rather diversified: nighttime snoring, daytime somnolence, morning headache, polyuria, insomnia, nighttime awakenings, soliloquy, low libido, erectile dysfunction, muscular asteny, emotional alteration (irritability, aggressive behavior, depressive attitude), loss of memory, decrease of concentration, arterial hypertension and heart arrythmia.

Keeping the above characteristics in mind when evaluating the patient can lead to a suggested diagnosis of OSAS. However, in order to reach a conclusive diagnosis of the condition, polysomnography should be employed. A variety of details can be observed: the apnea-hypopnea index (AHI), oxymetry, capnography, oculometry, electrocardiography, myography, snoring, postural aspect during sleep, thoracic/abdominal movements, etc.

After the diagnosis has been made, it is necessary to determine the obstructive sites (through the spacial relationship of the naso-buccal-pharyngeal soft tissues) and the skeletal type of the patient, in order to establish the most adequate therapy. At this point, somnofluoroscopy, fibroscopy, magnetic resonance, computed tomography and lateral teleradiography with cephalometric analysis can be used. These are the most widely used complementary examinations, as they favor the analysis of soft tissues and the skeleton type of the patient.

Cephalometric analysis for OSAS should measure the length, thickness and degree of verticalization of the soft palate, the position of the maxilla and the mandible in relation to the base of the skull, the position of the hyoid bone and the superior, middle and inferior airway space. The data from cephalometric analysis make it possible to determine the probable obstructive sites and the skeletal discrepancies, in order to establish the most adequate treatment plan.

Thus, the objective of the present study was to verify the accuracy of lateral radiographic cephalometry and to compare cephalometric analysis of the posterior airways to polysomnographic examination for the diagnosis of OSAS.

MATERIAL AND METHODS

The sample was composed of 60 subjects, 42 men and 18 women, between the ages of 9 years 5 months and 70 years 6 months, all with clinical suspicion of OSAS. After being informed about the objective of the study, all patients gave permission to use their data, as long as their identities were not revealed. The study was approved by the Ethics Committee of the School of Dentistry, Federal University of Bahia, Brazil.

The diagnosis of OSAS following the polysomnographic examination was based on the AHI per hour of sleep, with a minimum of five events per hour. Furthermore, the following examinations were carried out: oxygen desaturation, capnography, electroencephalogram (EEG), electrocardiogram (ECG), facial electromyogram (EMG), electrooculogram (EOG), tachography and movements of the patient during sleep.

All the radiographic examinations were performed using an Orthophos Plus Ceph unit (Sirona, The Dental Company, Germany), following the technical procedures, and the radiographic images were select according their quality for the purpose of the present study.

For the cephalometric computer evaluation of the posterior airway space, the following items were observed:

1. the superior posterior airway space (PASs) – the distance between the posterior nasal spine (PNS, the most posterior point of the hard palate) and the point where the palatal plane (PP), from the anterior nasal spine (ANS) to the posterior nasal spine (PNS), crosses the posterior wall of the pharynx;

2. the medium posterior airway space (PASm) – the distance between the most inferior point of the soft palate and the posterior wall of the pharynx;

3. the inferior posterior airway space (PASi) – the distance between the point where the plane B-Go (the deepest point of the anterior border of the mandible, a point in the gonion, which corresponds to the bisecting of the gonial angle) crosses the posterior margin of the tongue base and the posterior wall of the pharynx.

The measured sites and the illustrative cephalometric outline are shown in Figures 1 and 2.

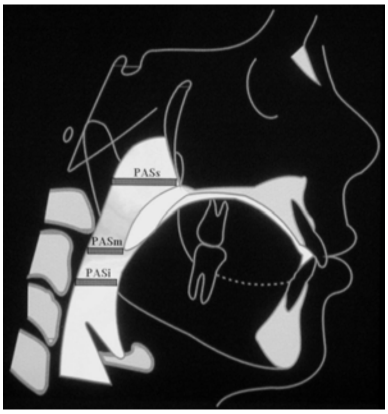

Figure 1 - Measured obstructive sites

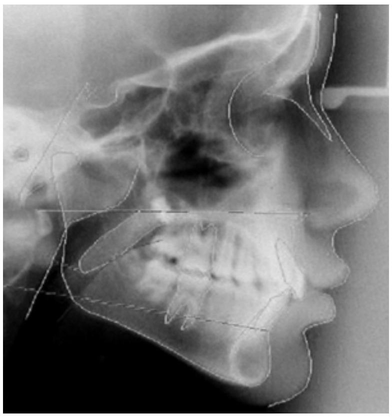

Figure 2 - Cephalometric analysis

The cephalometric diagnosis was considered positive for OSAS if the posterior airway space was reduced in at least one of the three measured levels. The reference values were as follows: PASs, 26 mm; PASm, 9 mm, PASi, 11 mm [2, 3] . Individuals were considered apneic if they presented PASs<26 mm and/or PASm<9 mm and/or PASi<11 mm. The diagnosis was made by two experienced radiologists, who had to agree regarding the cephalometric analysis and the measurements of the obstructive sites.

Statistical analysis verified the accuracy of the cephalometric analysis in relation to the polysomnographic examination (gold standard) for the diagnosis of OSAS by means of the sensitivity, specificity, positive predictive value, and negative predictive value of cephalometry. The comparison was established with the McNemar and Cohen's Kappa Tests, assuming a level of significance of 5%.

RESULTS

The theoretical reference parameters assumed for accuracy determination were defined with the aid of a table with double entries (TABLE 1), where the absolute values determined by the polysomnographic examination (gold standard) are shown in the columns and the results obtained by the cephalometric analysis (test) are shown in the rows.

The first indicator of accuracy is the sensitivity, considered to be the ratio between the number of situations that the gold standard

Table 1 - Parameters for accuracy determination of radiographic cephalometric analysis when compared to polysomnographic examination.

Cephalometry	Polysomnography		
	Positive	Negative	Total
Positive	43 84.3% 91.5%	8	51 85%
Negative	4	5 55.6% 38.5%	9 15%
Total	47 78.3%	13 21.7%	60 100%

indicates as true and the test defines as positive, and the total number of true situations as given by the gold standard. A highly sensitive test identifies a great number of situations for which the gold standard confirms them to be true. In this study, the sensitivity of the cephalometric analysis in relation to the polysomnographic examination was 91.5%.

The specificity is the ratio between the total number of situations that the gold standard confirms to be false and the test indicates as negative, and the total number of situations referred to as false by the gold standard. The specificity in this study was 38.5%.

The positive predictive value is the ratio between the total number of situations that the gold standard confirms to be true and the test indicates as positive, and the total number of positive situations defined by the test. The positive predictive value of the cephalometric analysis in this study was 84.3%.

The negative predictive value is the ratio between the total number of situations that the gold standard determines as false and the test indicates as negative, and the total number of negative situations verified by the test. The negative predictive value observed was 55.6%.

Thus, the positive predictive value is the probability that an individual is classified as apneic by the gold standard, given that the subject is positive by cephalometry. The negative predictive value refers to the probability that an individual is classified as non-apneic by the gold standard, given that the subject is negative by cephalometry.

A false negative is the situation where the test indicates negative and the gold standard confirms positive, which happened in four cases in this sample. A false positive is the situation where the test confirms positive, when the gold standard registers negative, which was observed in eight cases in this sample.

Table 2 presents the comparison between the polysomnographic examination and cephalometry for the diagnosis of OSAS performed using the nonparametric McNemar test.

There were no statistically significant differences between the results obtained by cephalometry and by polysomnography (p=0.388).

Table 2 - Comparison between the OSAS diagnosis by polysomnography and radiographic cephalometry.

Polysomnography	Cephalometry	
	Negative	Positive
Negative	5	8
Positive	4	43
Value of p	0.388	0.388

Note: Significant for values of p<0.05

The measure of agreement calculated by Cohen's kappa coefficient was 33.7% (p=0.007), significant for values of p<0.05.

DISCUSSION AND CONCLUSIONS

Polysomnographic examination is decisive in the diagnosis and establishment of the pattern of pathologies associated with sleep, especially of OSAS. In spite of precise diagnosis, surgical treatment has not presented satisfactory results for patients with this disorder. Yao, Utley and Terris[4] observed that in 50% of the patients who were treated surgically with uvulopalato-pharyngoplasty their symptoms did not improve, which indicating that the treatment did not interfere at the obstructive site. This is proof that polysomnographic examination cannot identify with precision the site associated with the manifestation of the condition.

The possibility of visualizing the posterior airway space enabled Riley and others[3] to use radiographic cephalometry as an auxiliary tool for the diagnosis of OSAS. Various studies followed since then, in attempts to evaluate the amplitude of the posterior airway space and determine the probable obstructive sites as well as to associate the existence of these sites with the skeletal type of the individual.

Many authors have analyzed the skeletal type and established common characteristics of apneic individuals: for example, retrognathic mandible, retropositioned maxilla, increased skull base, hyoid bone in a posterior-inferior position on the level of the cervical vertebrae

C4-C6, increased gonial angle, as well as increased tongue volume, longer and thicker soft palate, and finally, narrowing of the posterior airways at the level of the nasopharynx, oropharynx and hypopharynx. [2,3,5,6,7,8,9,10,11,12,13,14,15,16,17,18]

It could be considered a disadvantage of radiographic cephalometry that lateral teleradiography is performed with the patient in the upright position and awake, whereas the pharyngeal obstruction occurs with the patient in the supine position and asleep. Thus, Pae and others[19] reported that, due to the position of the tongue, there is a reduction of the posterior airway space in computed tomography images made in the supine position, and this postural effect has to be taken into consideration when the extrathoracic airways are evaluated in the upright position. On the other hand, Fontanella and Martinez[20] did not observe significant differences between lateral teleradiographs made in the supine and upright positions.

The extensive use of lateral radiographic cephalometry within the last three decades raises an important question as to the validity of the examination for diagnosing OSAS, based on the identification of probable obstructive sites related to the manifestation of the condition, and, eventually, of replacing the polysomnographic examination.

Observing the accuracy indicators, we found a sensitivity of 91.5% and positive predictive value of 84.3% for cephalometry, compared to the polysomnographic examination. This means that there is a high agreement between the examinations and that radiographic cephalometry has a high probability of identifying individuals who suffer from OSAS.

However, radiographic cephalometry presented a low specificity index of 38.5% and a negative predictive value of only 55.6%. This shows that cephalometry is not capable of identifying satisfactorily healthy individuals among those who were found to be free of the condition by polysomnography. Thus, it can be deduced that cephalometry is not a very accurate procedure to identify individuals without OSAS.

In summary, these indicators show that radiographic cephalometry is capable of identifying with accuracy patients with this condition. However, it cannot identify healthy individuals with the same certainty.

Eight false positive patients were observed. In other words, cephalometry indicated them as positive and polysomnography as negative. However, of these eight individuals, four were under the age of 32, and seven were under the age of 43, probably with a better muscular tonus, which would prevent the collapse of the posterior airways during sleep. Another important fact is that from this false positive subgroup of seven patients under the age of 43, the registered values for PASs, PASm and PASi were very close to the reference values. This means that in the cephalometric examination these patients presented alterations of slight amplitude in the obstructive sites measured.

The results indicated four false negative patients who were considered healthy by cephalometry while polysomnography indicated OSAS. However, one of the individuals did not have the body mass index (BMI) registered in the clinical questionnaire and three of them had BMI between 30 Kg/m and 40 Kg/m, which characterizes morbid obesity, according to Paoli and others.[18] Morbid obesity, according to Lowe and others[21] , and Miró Castillo and others[14] , who evaluated the pharynx of obese and nonobese individuals through computed tomography, reduces the size of the pharyngeal lumen. Because fat does not appear in conventional images, this information cannot be extracted from teleradiography.

In summary, we can ascertain that the high sensitivity and the elevated positive predictive value of radiographic cephalometry make it a trustworthy tool, capable of diagnosing OSAS accurately, and indicating the obstructive site related to the manifestation of the condition. On the other hand, the low specificity of radiographic cephalometry and its negative predictive value do not allow its use as an exclusive examination. Thus, although radiographic cephalometry should be part of a diagnostic evaluation protocol for OSAS, it has to be complemented by examinations such as magnetic resonance or computed tomography, whenever necessary.

Acurácia da análise cefalométrica da faringe para o diagnóstico da síndrome da apnéia obstrutiva do sono (SAOS)

Resumo

Esta pesquisa teve por objetivo verificar a acurácia da cefalometria radiográfica das vias aéreas posteriores para o diagnóstico da SAOS. A amostra constou de 60 pacientes, todos com suspeita clínica de SAOS. Diagnóstico polissonográfico positivo: índice de apnéia-hipopnéia [I(A+H)] por hora de sono igual ou maior que 5 eventos. Diagnóstico cefalométrico positivo: EAPs (espaço aéreo posterior superior) < 26mm e (ou) EAPm (espaço aéreo posterior médio) < 9mm e/ou EAPi (espaço aéreo posterior inferior) < 11mm. O estudo estatístico verificou a acurácia da análise cefalométrica, comparada ao exame polissonográfico (padrão-ouro). A comparação foi estabelecida através dos testes de McNemar e kappa de Cohen. A sensibilidade da análise cefalométrica foi de 91.5%. A especificidade foi de 38.5%. O valor preditivo positivo foi de 84.3%. O valor preditivo negativo foi de 55.6%. Falso negativo = 4 (quatro) situações. Falso positivo = 8 (oito) situações. O teste de McNemar mostrou não haver diferença estatisticamente significante entre os resultados auferidos pela cefalometria e pela polissonografia (p = 0.388), e o nível de concordância calculado por meio do coeficiente kappa de Cohen foi de 33.7% (p = 0.007), significante para valores de p < 0.05. A alta sensibilidade e o elevado valor preditivo positivo fazem da cefalometria radiográfica instrumento confiável, capaz de diagnosticar com alta acurácia pacientes portadores de SAOS, identificando o sítio obstrutivo relacionado à manifestação da condição. Entretanto, a baixa especificidade da cefalometria radiográfica e o seu valor preditivo negativo não permitem admiti-la como exame único.

Palavras-chave: *apnéia do sono obstrutiva; cefalometria; ronco.*

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