KBB Uygulamaları 2024;12(2):62-69

Original Article / *Özgün Makale*

OPEN ACCESS

Cephalometric analysis with magnetic resonance imaging in patients with obstructive sleep apnea syndrome

Tıkayıcı uyku apne sendromu olan hastalarda manyetik rezonans görüntüleme ile sefalometrik analiz

Buğra Subaşı[1], Nadir Yıldırım[1], Gönül Akdağ[2], Şahinde Atlanoğlu[3], Osman Pala[4]

[1]Department of Otolaryngology, Kütahya Health Sciences University Faculty of Medicine, Kütahya, Türkiye
[2]Department of Neurology, Kütahya Health Sciences University Faculty of Medicine, Kütahya, Türkiye
[3]Department of Radiology, Kütahya Health Sciences University Faculty of Medicine, Kütahya, Türkiye
[4]Department of Otolaryngology, Kütahya Evliya Çelebi Training and Research Hospital, Kütahya, Türkiye

ABSTRACT

Objectives: The study aimed to assess soft tissues and bony structures in patients with snoring and obstructive sleep apnea syndrome (OSAS) by magnetic resonance imaging (MRI) cephalometry and to investigate the correlation between the degree of OSAS with cephalometric measures.

Patients and Methods: The prospective study included 137 adult patients (86 males, 51 females; mean age: 44.2±11.8; range 21 to 70 years) admitted with complaints of snoring or witnessed apnea between December 2020 and June 2023. Polysomnography and MRI cephalometry were performed for each patient. According to the polysomnography results, patients were assigned to one of the following groups: simple snorers [apnea-hypopnea index (AHI) <5; n=25], mild OSAS (AHI between 5 and 15; n=37), moderate OSAS (AHI between 15 and 30; n=36), and severe OSAS (AHI >30; n=39). The SNA (sella, nasion-point A), SNB (sella, nasion-point B), submental fat thickness, retropalatal and retro glossal distance, tongue, uvula, basion, and hyoid-related cephalometric measurements were evaluated with MRI cephalometry.

Results: The H-A (hyoid-point A) values were found to be higher in the severe OSAS patients than in other groups (p<0.001, p<0.001 and p<0.05, respectively). The PNS-UT (posterior nasal spine-uvula tip) values of the patients in the severe OSAS group were found to be higher than patients in both the snoring and moderate OSAS groups (p<0.001). The SNB values of the patients in the mild OSAS group were found to be higher than the patients in the snoring group (p<0.05). In the parameters of UW (uvula thickness), PAS-RG (posterior airway space-retroglossal distance), and H-B (hyoid-point B), statistically meaningful differences were found only between the simple snorers group and the group with severe OSAS.

Conclusion: In OSAS patients, some important distances, angles, and lengths can be evaluated by avoiding ionizing radiation with MRI cephalometry.

Keywords: Cephalometry, magnetic resonance imaging, obstructive sleep apnea syndrome, polysomnography, sleep.

ÖZ

Amaç: Bu çalışmada, horlama ve tıkayıcı uyku apne sendromu (TUAS) hastalarında yumuşak dokular ve kemik yapılar manyetik rezonans görüntüleme (MRG) sefalometri ile değerlendirildi ve TUAS derecesi ile sefalometrik ölçümler arasındaki korelasyon araştırıldı.

Hastalar ve Yöntemler: Horlama veya tanıklı apne şikayetiyle Aralık 2020-Haziran 2023 tarihleri arasında başvuran 137 yetişkin hasta (86 erkek, 51 kadın; ort. yaş: 44.2±11.8 yıl; dağılım, 21-70 yıl) prospektif çalışmaya dahil edildi. Her hastaya polisomnografi ve MRG sefalometri ölçümü yapıldı. Polisomnografi sonuçlarına göre hastalar sıralanan gruplardan birine atandı: basit horlama [apne-hipopne indeksi (AHİ) <5; n=25], hafif TUAS (AHI 5-15; n=37), orta TUAS (AHI 15-30, n=36) ve ağır TUAS (AHI >30; n=39). Manyetik rezonans görüntüleme sefalometri ile SNA (sella, nasion-A noktası), SNB (sella, nasion-B noktası), submental yağ kalınlığı, retropalatal ve retroglossal mesafe, dil, uvula, basion ve hyoid ile ilgili sefalometrik ölçümler değerlendirildi.

Bulgular: Ağır TUAS hastalarında H-A (hyoid-A noktası) değerleri diğer gruplarındaki hastalara kıyasla daha yüksek bulundu (sırasıyla p<0.001, p<0.001 ve p<0.05). Ağır TUAS grubundaki hastaların PNS-UT (posterior nazal spin-uvula ucu) değerleri hem basit horlama hem de orta TUAS grubundaki hastalara kıyasla yüksek bulundu (p<0.001). Hafif TUAS grubundaki hastaların SNB değerleri horlama grubundaki hastalara kıyasla yüksek bulundu (p<0.05). Sadece basit horlama grubu ile ağır TUAS grubu arasında; UW (uvula kalınlığı), PAS-RG (posterior hava yolu-retroglossal mesafe) ve H-B (hyoid-B noktası) parametrelerinde istatistiksel olarak anlamlı farklar bulundu.

Sonuç: Tıkayıcı uyku apne sendromu hastalarında MRG sefalometri ile iyonize radyasyondan kaçınarak bazı önemli mesafeler, açılar ve uzunluklar değerlendirilebilir.

Anahtar sözcükler: Sefalometri, manyetik rezonans görüntüleme, tıkayıcı uyku apne sendromu, polisomnografi, uyku.

Received: April 27, 2024
Accepted: May 29, 2024
Published online: June 11, 2024

Correspondence: Buğra Subaşı, MD.
E-mail: drbugrasubasi@hotmail.com

Doi: 10.5606/kbbu.2024.32767

Citation:
Subaşı B, Yıldırım N, Akdağ G, Atlanoğlu Ş, Pala O. Cephalometric analysis with magnetic resonance imaging in patients with obstructive sleep apnea syndrome. KBB Uygulamaları 2024;12(2):62-69. doi: 10.5606/kbbu.2024.32767.

Obstructive sleep apnea syndrome (OSAS) is a significant disease with recurrent blockages in the upper airway, which reduces functional capacity and quality of life and raises the risk of cardiovascular disease, systemic hypertension, stroke, glucose metabolism disorders, traffic accidents, and sudden death.[1,2] The estimated prevalence of OSAS is 2% and 4% for middle-aged (30 to 60 years) females and males, respectively.[3] Loud snoring, excessive daytime sleepiness, witnessed apnea, and irregular sleep quality are the main symptoms of OSAS, but people are generally not aware that these symptoms are related to OSAS.[2] Hypoxemia, hypercapnia, intrathoracic pressure changes, increased sympathetic activity, and sleep fragmentation are observed due to recurrent pauses in breathing during the course of sleep.[1,4] The main pathophysiological mechanism of OSAS is the blockage of the upper airway while sleeping.[5] Obesity, large neck circumference, retro or micrognathia, nasal obstruction, tonsil or adenoid hypertrophy, macroglossia, low-lying soft palate, vocal cord paralysis, pharyngeal region tumors or cysts, high-arched palate, glossoptosis, low hyoid bone, ectopic thyroid, and acromegaly are the main morphological abnormalities that predispose OSAS.[6,7] The diagnosis of OSAS is typically confirmed through polysomnography (PSG), which is accepted as the diagnostic gold standard.[8] However, it cannot show the location of the pathology or predict surgical outcomes reliably.[5,9] In cephalometric analysis, the angle, area, distance, and tissue volumes are measured using reference points of bony and soft tissues on the scans.[10] Magnetic resonance imaging (MRI) enables multiplanar imaging without ionizing radiation and provides a fairly good view of many anatomical regions that might be causing obstruction; therefore, it is a very convenient imaging method to pinpoint the possible causes of OSAS.[7,11] Hence, this study aimed to analyze the value of MRI for cephalometry in patients with simple snoring and OSAS.

PATIENTS AND METHODS

This prospective cohort study was conducted at the otorhinolaryngology clinic of the Kütahya Health Sciences University Faculty of Medicine between December 2020 and June 2023. A total of 137 patients (86 males, 51 females; mean age: 44.2±11.8; range 21 to 70 years) who applied to our department with sleep disorders or witnessed apnea as well as daytime sleepiness and snoring were queried on their symptoms in detail. This cohort included 37 patients with mild OSAS, 36 patients with moderate OSAS, and 39 patients with severe OSAS, as well as 25 patients who were evaluated as having simple snoring and were included as the control groups. Demographic data of the patients of age and sex, as well as cephalometric and PSG data, were recorded on a worksheet. Polysomnography and MRI cephalometry were performed for each patient. Full-night PSG by Alice 6, Diagnostic Sleep System (Philips, Amsterdam, the Netherlands) was performed in the sleep center laboratory. Polysomnography was carried out in the sleep laboratory of the hospital, using the above specified PSG device with at least 16 channels that included six electroencephalography (F4-M1, F3-M2, C4-M1, C3-M2, O2-M1, and O2-M2), two electrooculography, three mentalis/submentalis electromyography, oximeter, body position sensor, snoring signal, nasal pressure/flow signal (thermistor and nasal cannula), respiratory effort (thorax-abdominal) bands, two electromyography (tibialis anterior) electrodes, and electrocardiography (single lead) recording features. Apnea is defined as the cessation of airflow from the mouth and nose for ≥10 sec. Hypopnea is defined as a decrease of ≥30% in respiratory depth lasting longer than 10 sec in airflow accompanied by desaturation or arousal. The number of above-described apnea and hypopnea events per hour is defined as the apnea-hypopnea index. The PSG results were evaluated by the same researcher in accordance with the American Sleep Academy scoring criteria.

Patients were broken down into four groups in accordance with the apnea-hypopnea index (AHI) value as the primary snoring (AHI <5), mild OSAS (AHI between 5 and 15), moderate OSAS (AHI between 15 and 30), and severe OSAS (AHI >30) groups. The patients who had neuromuscular disorders, low sleep efficiency, a previous diagnosis of OSAS with a history of continuous positive airway pressure (CPAP) or intraoral appliance usage, prior surgical treatment for OSAS, and those younger than 18 years of age were not included in the study. Magnetic resonance imaging was taken with a 1.5 Tesla (Signa Explorer; GE Healthcare Inc., Milwaukee, USA) device. A three-dimensional sagittal cube sequence was used. The MRI protocol was as follows: all imaging studies were performed in the supine position using a head and neck coil. The display parameters were as follows: thickness, 1.2 mm; time repetition, 8.3; time of echo, 3.3; recovery time, 400; frequency field of view, 23; phase field of view, 0.85. Cephalometric analysis was performed on the MRI image by the radiologist.

The cephalometric landmarks used in the study are described as follows: nasion (N), anterior most point of the frontonasal suture; basion (Ba), most inferior point of the anterior foramen magnum; sella (S), midpoint of the hypophyseal fossa; anterior nasal spine (ANS), anterior-most point of the hard palate; posterior nasal spine (PNS), most posterior point of hard palate; the tip of uvula (UT); A-point (A), deepest point in the anterior maxillary concavity; B-point (B), deepest point of the anterior mandible concavity; hyoid (H), most anterosuperior point of hyoid (Figure 1).

Cephalometric calculations used for further analysis are described as follows: ANS-PNS, ANS to PNS; S-Ba, S to Ba; Ba-PNS, Ba to PNS; SNA, the angle between S, N, and A; SNB, the angle between S, N, and B; PAS RP, the distance between the soft palate and the posterior pharyngeal wall; PAS RG, the distance between the tongue base and the posterior pharyngeal wall (Figure 2); PNS-UT, the distance between the PNS to the tip of the uvula; UW, uvula thickness; TL, tongue length; TH, tongue height; submental fat thickness (Figure 3); H-A, the distance from H to A; H-B, the distance from H to B (Figure 4).

Statistical analysis

Data were analyzed using IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Mean ± standard deviation (SD), median values (min-max) were given in descriptive statistics for continuous data, and number and percentage values were given in discrete data. The suitability of the data for normal distribution was demonstrated by the Kolmogorov-Smirnov test. In the comparison of continuous data between OSAS groups, one-way analysis of variance (ANOVA) was used for data showing normal distribution, and Kruskal-Wallis variance analysis was utilized for the data that was nonnormally distributed. The Tukey post hoc test was used to determine which groups caused the difference in the variables that were found to be different as a result of ANOVA, and the Kruskal-Wallis multiple comparison test was used to identify the groups that caused the difference in the variables by Kruskal-Wallis variance analysis. For the group comparison of the nominal variables (cross-tables), the chi-square test was used. The relationships between continuous data were examined with the Pearson/Spearman correlation deficiency. A p-value <0.05 was considered statistically significant

Figure 1. Cephalometric landmarks.

N (nasion): Anterior point at frontonasal suture; S (sella): Mid-point of fossa hypophysealis; Ba (basion): Most inferior point on anterior foramen magnum; ANS (anterior nasal spine): Most posterior point of hard palate; PNS (posterior nasal spine): Most posterior point of hard palate; UT (uvula tip): Tip of uvula or soft palate; A (A-point): Deepest anterior point in concavity of anterior maxilla; B (B-point): Deepest anterior point in concavity of anterior mandible; H (hyoid): Most anterosuperior point of hyoid.

Figure 2. Cephalometric measurements. The angle between S-N and N-A (SNA), the angle between S-N and N-B (SNB), retopalatal distance (asterisk), and retro glossal distance (arrowhead).

ANS: Anterior nasal spine: PNS: Posterior nasal spine; Ba (basion): Most inferior point on anterior foramen magnum; N (nasion): Anterior point at frontonasal suture; S (sella): Mid-point of fossa hypophysealis; B (B-point): Deepest anterior point in concavity of anterior mandible; H (hyoid): Most anterosuperior point of hyoid.

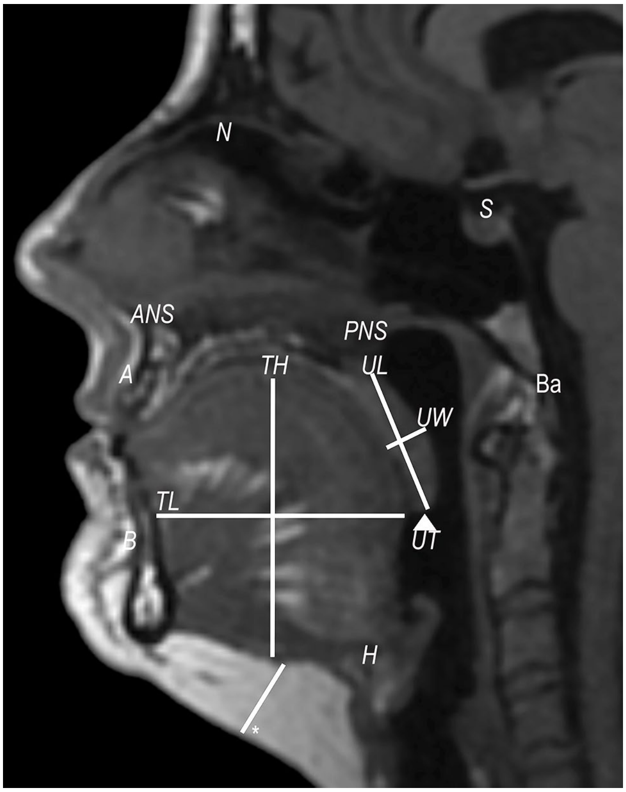

Figure 3. Tongue and uvula-related cephalometric measurements and submental fat thickness.

TL: Tongue length (straight white line); TH: Tongue height (straight white line); UT: Uvula tip; UL: Uvula length (arrowhead); UW: Uvula thickness (straight white line); * Submental fat thickness; ANS: Anterior nasal spine: PNS: Posterior nasal spine; Ba (basion): Most inferior point on anterior foramen magnum; N (nasion): Anterior point at frontonasal suture; S (sella): Mid-point of fossa hypophysealis; B (B-point): Deepest anterior point in concavity of anterior mandible; H (hyoid): Most anterosuperior point of hyoid.

Figure 4. Hyoid-related cephalometric measurements. The distance from H to A (H-A), the distance from H to B (H-B), retropatellar distance, and retroglossal distance.

ANS: Anterior nasal spine: PNS: Posterior nasal spine; Ba (basion): Most inferior point on anterior foramen magnum; N (nasion): Anterior point at frontonasal suture; S (sella): Mid-point of fossa hypophysealis; B (B-point): Deepest anterior point in concavity of anterior mandible; H (hyoid): Most anterosuperior point of hyoid.

RESULTS

The mean age of the control group patients (34.28±9.66 years) was lower than each of OSAS groups [mild OSAS (44.73±11.85), moderate OSAS (45.19±10.00), and severe OSAS (48.97±11.06); $p<0.01$, $p<0.01$, and $p<0.001$, respectively] No statistically significant difference was observed between OSAS groups in respect of mean age ($p>0.05$). The rate of females in the snoring group was higher than in the mild and severe OSAS groups, and the rate of females in the mild OSAS group was lower than in the moderate OSAS group (Table 1).

Similar clustering was determined for the parameters of mean UW, mean PAS RG, and mean H-B values, as statistically significant differences in the mean values were only observed between the simple snorers group values and the severe OSAS group.

The mean H-A value of the severe OSAS group (83.92±6.75) was found to be higher than that the snoring (74.90±6.47), mild OSAS (77.22±6.93), and moderate OSAS (78.81±7.57) groups ($p<0.001$, $p<0.001$, and $p<0.05$, respectively). No difference was determined between the H-A values of the other groups ($p>0.05$).

There was no significant difference in the ANS-PNS, S-Ba, Ba-PNS, SNA, TL, TH, submental fat, and PAS RP values when the groups (snoring, mild OSAS, moderate OSAS, and severe OSAS) were statistically compared with each other ($p>0.05$).

The mean SNB value of the patients in the mild OSAS group (86.41±3.95) was found to be higher than the mean SNB value of the snoring group patients (83.48±3.85). No significant difference was determined between the mean SNB values of the other OSAS groups ($p>0.05$).

Table 1
Comparison of age and sex of patients with snoring, mild OSAS, moderate OSAS, and severe OSAS

	Snoring					Mild OSAS					Moderate OSAS					Severe OSAS					
	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	*p*
Age (year)			34.28±9.66	34	21-57			44.73±11.85	45	23-68			45.19±10.00	43	21-69			48.97±11.06	49	25-70	<0.001
Sex																					<0.003
Male	9	36				29	78.4				20	55.6				28	71.8				
Female	16	64				8	21.6				16	44.4				11	28.2				

OSAS: Obstructive sleep apnea syndrome; SD: Standard deviation.

The mean PNS-UT value of the severe OSAS group patients (42.46±4.03) was found to be higher than that of the patients in both the snoring (36.65±4.03) and moderate OSAS (38.62±4.83) groups, and the PNS-UT value of the mild OSAS group (40.52±4.50) was found to be higher than that of the snoring group.

The mean UW value the severe OSAS group patients (11.20±1.95) was found to be higher than that the snoring group patients (9.83±1.75). No significant difference was determined between the mean UW values of the other groups (p>0.05, Table 2).

A positive correlation was measured between the AHI scores and the H-A (r=0.394, p<0.001) and H-B values (r=0.333, p<0.001; Table 3).

DISCUSSION

Obstructive sleep apnea syndrome is a prominent disease characterized by recurrent upper airway obstruction leading to recurrent arousals and decreased oxygen saturation during sleep. Soft tissue and bone structures surrounding the upper airway can increase extraluminal tissue pressure, causing the pharynx to collapse.[12] Although MRI is mostly used to examine soft tissues, what we addressed in this study was the use of MRI cephalometry in the evaluation of the mentioned angles, lengths, and distances that are conventionally measured by other researchers through X-ray cephalometry. Silva et al.[13] and Sonsuwan et al.[14] found no meaningful correlation between the OSAS scores and the SNA and SNB values. Contrary to those results, Kubota et al.[15] reported that among the nonobese Japanese OSAS patients, SNA and SNB angles were lower in the ones with severe OSAS than those with mild and moderate OSAS. Similarly, Ryu et al.[5] found an inverse correlation between AHI and SNB and concluded that mandibular retrognathia is associated with OSAS severity. Interestingly, another Japanese group found no difference between SNA and SNB values of CPAP user OSAS patients and a control group.[16] In a study conducted by Bayat et al.,[17] the SNB value was lower in the control group compared to the OSAS patient group. In the current study, there was no difference between the SNA measurements of the patients in the snoring and mild, moderate, and severe OSAS groups, and similar to the findings of Bayat et al.,[17] the SNB measurements of the patients in the mild OSAS group were found to be higher than those of the snoring group.

It has been stated in the literature that the hyoid bone is located inferiorly in OSAS patients.[13,14,18,19] The tongue muscles attach to the hyoid bone; therefore, a lower-placed hyoid bone results in a larger tongue mass.

Table 2
Comparison of the cephalometric measurements of patients with snoring, mild OSAS, moderate OSAS, and severe OSAS

	Snoring			Mild OSAS			Moderate OSAS			Severe OSAS			
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
ANS-PNS	47.33±3.89	47.7	40.2-54	48.91±5.62	47.8	38.4-61.3	47.66±3.96	47.7	40.1-54.4	47.69±4.50	47.2	39.6-55.8	0.512
S-Ba	40.59±4.29	40.4	27.8-50	43.04±5.37	43.1	29.2-53.9	41.16±4.93	41.3	30.5-50.7	42.70±3.97	43	32.4-52.1	0.114
Ba-PNS	34.55±3.54	34.2	27.6-43.5	35.95±5.06	35.4	26.1-46.3	35.11±4.89	35.7	22-43	33.66±5.14	34.1	21.4-42.2	0.216
SNA	87.10±4.46	86.5	78.4-96.7	89.25±5.42	89.1	77.6-98.9	89.76±4.37	89.5	80.1-100.2	89.45±4.18	88.7	80.9-98.7	0.139
SNB	83.48±3.85	84.1	75.1-92.4	86.41±3.95	86.3	77.7-95.2	85.02±4.03	84.7	72.4-93.2	85.55±3.51	85.6	74.1-92.3	0.013
PNS-UT	36.65±4.03	36.4	29-43.5	40.52±4.50	40.4	31-49	38.62±4.83	37.9	28.8-54.4	42.46±4.03	42.2	31.8-52.6	<0.001
UW	9.83±1.75	9.6	6-13.4	11.02±1.92	10.5	8.3-14.9	11.03±2.07	11	6.2-15.7	11.20±1.95	11.4	7.1-15.3	0.037
TL	55.17±5.08	55.6	46.5-69.3	58.99±7.25	58	48.5-87.2	55.67±5.73	56.3	37-68.4	56.95±7.01	57.2	44.1-84.2	0.078
TH	65.80±8.41	63.8	52.4-83	67.85±8.08	67.6	54-87.4	68.22±7.69	69.8	47.7-81.5	67.56±7.70	66.8	53.7-85.4	0.680
Submental fat	16.58±4.04	15.5	10.5-28.5	17.37±3.98	16.5	12.1-27.4	17.86±3.86	17.7	10.5-26.5	17.32±3.20	17	12-24.1	0.638
PAS RP	5.84±2.24	5.7	2.2-12	6.27±2.16	5.8	2.3-12.9	5.45±2.02	5.2	2.2-10.5	5.91±2.46	5.6	2.3-12.5	0.480
PAS RG	11.22±3.62	10.2	4.6-18.4	13.15±3.54	12.3	6.6-22.4	12.40±3.40	12.3	4.9-23.4	14.47±3.97	14.2	1.6-23.1	0.005
H-A	74.90±6.47	74.4	64.2-89.5	77.22±6.93	76.5	64.7-92.3	78.81±7.57	78.6	66-93	83.92±6.75	84.4	68.5-99.2	<0.001
H-B	49.50±6.44	49.4	35.5-63.2	52.84±4.99	51.6	46.6-64.4	52.97±5.22	52.9	42.6-63.7	55.43±5.03	56.6	44.2-69.6	0.001

OSAS: Obstructive sleep apnea syndrome; ANS-PNS: Distance between anterior nasal spine and posterior nasal spine; S-Ba: Distance from sella to basion; Ba-PNS: Distance from basion to posterior nasal spine; SNA: The angle formed between the point sella, nasion and point A; SNB: The angle formed between the point sella, nasion and point B; PNS-UT: The distance between the PNS to the tip of the uvula; UW: Uvula thickness; TL: Tongue length; TH: Tongue height; PAS RP: Posterior airway space retropalatal distance; PAS RG: Posterior airway space retroglossal distance; H-A: Distance from the hyoid to the point A; H-B: Distance from the hyoid to the point B; SD: Standard deviation.

Table 3
Correlations between the AHI scores and the H-A and H-B values of the patients

		H-A	H-B
AHI	r*	0.394	0.333
	p	<0.001	<0.001

AHI: Apnea-hypopnea index; H-A: Distance from the hyoid to the point A; H-B: Distance from the hyoid to the point B.

Obstruction occurs in the hypopharyngeal region due to both the effect of gravity when lying supine and the decrease in muscle tone during sleep.[14] In this study, the mean H-A values of patients in the severe OSAS group were higher than those of patients in other groups, whereas the H-B values of the severe OSAS group were only higher than the snoring group. We also found a linear correlation between the AHI scores of the patients and the H-A and H-B values (Table 3). Similarly, Bates and McDonald[20] showed that the AHI and H-B distance were correlated and that the H-B distance lengthened as the AHI became more severe. Tanellari et al.[21] also showed that the average length of H-B distance was higher in OSAS patients than control group patients.

Akpinar et al.[9] investigated cephalometric parameters in OSAS, habitual snorers, and a control group in nonobese Turkish males and reported that the posterior airway space (PAS) was higher in the OSAS group compared to habitual snorers. Sonsuwan et al.[14] noted that the AHI value was inversely correlated with PAS. Ryu et al.[5] and Silva et al.[13] reported no statistically significant correlation between PAS and AHI. In the current study, no highly significant correlations were determined between PAS RP and snoring or OSAS, and the only notable finding was that the mean PAS RG value in the severe OSAS patients was greater than the simple snorers' mean value of the same parameter ($p<0.05$). In support of this appraisal, some researchers have found through dynamic MRI and electromyography that to maintain airway patency, tongue movements during wakefulness are more extensive, particularly in severe OSAS patients compared to control subjects.[22,23]

Bayat et al.[17] and Battagel et al.[24] reported that the soft palate was larger and thicker in OSAS patient than in the control group or simple snorers. Araz et al.[25] also showed that UW, uvula length, and uvula angle were greater in the OSAS group than in the control group in MRI cephalometry, and a relationship was determined between UW and the severity of OSAS.

In the current study, the PNS-UT values of the patients with severe OSAS were higher than both the snoring and moderate OSAS groups, and the UW values in the severe OSAS group were higher than those of the snoring group patients. Sekosan et al.[26] performed surgery in 21 patients with moderate OSAS and analyzed the uvula materials they obtained and the uvula samples taken from five subjects without OSAS. It was concluded that soft palate inflammation in OSAS patients contributes to the volume of the soft palate and to the airway obstruction during sleep. Stauffer et al.[27] compared the uvula samples of OSAS patients who underwent uvulopalatopharyngoplasty with those of a non-OSAS control group. Muscle and adipose tissue were observed to be significantly bulkier in the OSAS group, and it was stated that in OSAS patients, excessive adipose and muscle tissue in the uvula could lead to stenosis of the pharynx.

Obstructive sleep apnea syndrome is a multifactorial disorder, and the most important factors appear to be the narrowing of the upper airway passage at one or more levels by the bony and soft tissue ring around the upper airway. Magnetic resonance imaging provides a very good view of soft tissue and bone structures surrounding the upper airway in multiple planes in patients with OSAS, and patients are not exposed to ionizing radiation.

The limitations of the study are that MRI is more costly and less available in some centers than the conventional X-ray imaging. Additionally, MRI's were taken with 1.5 T MRI while the patients were awake. For ethical reasons, we could not include healthy volunteers without snoring and OSAS in our study as the control group.

In conclusion, the results have shown that the important lengths, angles, and distances can be evaluated with MRI cephalometry in OSAS patients.

Ethics Committee Approval: The study protocol was approved by the Kütahya Health Sciences University Faculty of Medicine Clinical Studies Ethics Committee (date: 30.12.2020, no: 2020-08/11). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, control/supervision, analysis: B.S., N.Y.; Design: B.S., N.Y., G.A., Ş.A., O.P.; Data collection and processing: B.S., N.Y., G.A., Ş.A., O.P.; Literatüre review: B.S., N.Y., O.P.; Writing the article: B.S., N.Y., G.A., Ş.A.; References: B.S., N.Y., O.P.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Garvey JF, Pengo MF, Drakatos P, Kent BD. Epidemiological aspects of obstructive sleep apnea. J Thorac Dis 2015;7:920-9. doi: 10.3978/j.issn.2072-1439.2015.04.52.
2. Punjabi NM. The epidemiology of adult obstructive sleep apnea. Proc Am Thorac Soc 2008;5:136-43. doi: 10.1513/pats.200709-155MG.
3. 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;328:1230-5. doi: 10.1056/NEJM199304293281704.
4. Epstein LJ, Kristo D, Strollo PJ Jr, Friedman N, Malhotra A, Patil SP, et al. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. J Clin Sleep Med 2009;5:263-76.
5. Ryu HH, Kim CH, Cheon SM, Bae WY, Kim SH, Koo SK, et al. The usefulness of cephalometric measurement as a diagnostic tool for obstructive sleep apnea syndrome: A retrospective study. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;119:20-31. doi: 10.1016/j.oooo.2014.07.537.
6. Spicuzza L, Caruso D, Di Maria G. Obstructive sleep apnoea syndrome and its management. Ther Adv Chronic Dis 2015;6:273-85. doi: 10.1177/2040622315590318.
7. Mello Junior CF, Guimarães Filho HA, Gomes CA, Paiva CC. Radiological findings in patients with obstructive sleep apnea. J Bras Pneumol 2013;39:98-101. doi: 10.1590/s1806-37132013000100014.
8. Bloch KE. Polysomnography: A systematic review. Technol Health Care 1997;5:285-305.
9. Akpinar ME, Celikoyar MM, Altundag A, Kocak I. The comparison of cephalometric characteristics in nonobese obstructive sleep apnea subjects and primary snorers cephalometric measures in nonobese OSA and primary snorers. Eur Arch Otorhinolaryngol 2011;268:1053-9. doi: 10.1007/s00405-010-1448-z.
10. Sakat MS, Sütbeyaz Y, Yüceler Z, Kantarci M, Kilic K, Kurt S. Cephalometric measurements with multislice computed tomography in patients with obstructive sleep apnea syndrome. J Craniofac Surg 2016;27:82-6. doi: 10.1097/SCS.0000000000002267.
11. Stuck BA, Köpke J, Maurer JT, Verse T, Kuciak G, Düber C, et al. Evaluating the upper airway with standardized magnetic resonance imaging. Laryngoscope 2002;112:552-8. doi: 10.1097/00005537-200203000-00026.
12. Patil SP, Schneider H, Schwartz AR, Smith PL. Adult obstructive sleep apnea: Pathophysiology and diagnosis. Chest 2007;132:325-37. doi: 10.1378/chest.07-0040.
13. Silva VG, Pinheiro LA, Silveira PL, Duarte AS, Faria AC, Carvalho EG, et al. Correlation between cephalometric data and severity of sleep apnea. Braz J Otorhinolaryngol 2014;80:191-5. doi: 10.1016/j.bjorl.2013.11.001.
14. Sonsuwan N, Suchachaisri S, Chaloeykitti L. The relationships between cephalometric parameters and severity of obstructive sleep apnea. Auris Nasus Larynx 2011;38:83-7. doi: 10.1016/j.anl.2010.04.009.
15. Kubota Y, Nakayama H, Takada T, Matsuyama N, Sakai K, Yoshizawa H, et al. Facial axis angle as a risk factor for obstructive sleep apnea. Intern Med 2005;44:805-10. doi: 10.2169/internalmedicine.44.805.
16. Akashiba T, Kosaka N, Yamamoto H, Ito D, Saito O, Horie T. Optimal continuous positive airway pressure in patients with obstructive sleep apnoea: Role of craniofacial structure. Respir Med 2001;95:393-7. doi: 10.1053/rmed.2001.1058.
17. Bayat M, Shariati M, Rakhshan V, Abbasi M, Fateh A, Sobouti F, et al. Cephalometric risk factors of obstructive sleep apnea. Cranio 2017;35:321-6. doi: 10.1080/08869634.2016.1239850.
18. Kikuchi M, Higurashi N, Miyazaki S, Itasaka Y. Facial patterns of obstructive sleep apnea patients using Ricketts' method. Psychiatry Clin Neurosci 2000;54:336-7. doi: 10.1046/j.1440-1819.2000.00703.x.
19. Borges Pde T, Filho ES, Araujo TM, Neto JM, Borges NE, Neto BM, et al. Correlation of cephalometric and anthropometric measures with obstructive sleep apnea severity. Int Arch Otorhinolaryngol 2013;17:321-8. doi: 10.7162/S1809-977720130003000013.
20. Bates CJ, McDonald JP. The relationship between severity of obstructive sleep apnoea/hypopnoea syndrome (OSAHS) and lateral cephalometric radiograph values: A clinical diagnostic tool. Surgeon 2005;3:338-46. doi: 10.1016/s1479-666x(05)80113-1.
21. Tanellari O, Toti C, Baruti Papa E, Ghanim S, Savin C, Romanec C, et al. The link between obstructive sleep apnea syndrome and cephalometric assessment of upper airways and hyoid bone position. Medicina (Kaunas) 2022;58:1213. doi: 10.3390/medicina58091213.
22. Jugé L, Knapman FL, Burke PGR, Brown E, Bosquillon de Frescheville AF, Gandevia SC, et al. Regional respiratory movement of the tongue is coordinated during wakefulness and is larger in severe obstructive sleep apnoea. J Physiol 2020;598:581-97. doi: 10.1113/JP278769.
23. Mezzanotte WS, Tangel DJ, White DP. Waking genioglossal electromyogram in sleep apnea patients versus normal controls (a neuromuscular compensatory mechanism). J Clin Invest 1992;89:1571-9. doi: 10.1172/JCI115751.
24. Battagel JM, Johal A, Kotecha B. A cephalometric comparison of subjects with snoring and obstructive sleep apnoea. Eur J Orthod 2000;22:353-65. doi: 10.1093/ejo/22.4.353.
25. Araz O, Karaman A, Esdur V, Ucar EY, Subasi ID, Alper F, et al. The association of OSAS and uvula: The role of MRI in this egg-chicken problem in OSAS. Sleep Breath 2020;24:465-70. doi: 10.1007/s11325-019-01879-3.
26. Sekosan M, Zakkar M, Wenig BL, Olopade CO, Rubinstein I. Inflammation in the uvula mucosa of patients with obstructive sleep apnea. Laryngoscope 1996;106:1018-20. doi: 10.1097/00005537-199608000-00021.
27. Stauffer JL, Buick MK, Bixler EO, Sharkey FE, Abt AB, Manders EK, et al. Morphology of the uvula in obstructive sleep apnea. Am Rev Respir Dis 1989;140:724-8. doi: 10.1164/ajrccm/140.3.724.