Original Article

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Utility of Palatal Height in Oral Screening for Obstructive Sleep Apnea: A Correlational Analysis in a Thai Adult Group

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Abstract

Objectives: This study investigated associations between palatal height (PH) and polysomnographic (PSG) parameters in obstructive sleep apnea (OSA) patients. The upper posterior arch width (UPAW) and the scalloped tongue and oral torus distributions across PH were also assessed.

Methods: Gender, age, body mass index, Thai version of the Epworth sleepiness scale score, and PSG parameters were obtained from medical records of 60 adult OSA patients. Scalloped tongue and oral torus were clinically examined. PH and UPAW were measured using digitized models from 3D scans of dental plaster casts. Based on the median PH, participants were stratified into two groups (PH<17.58 mm, n=30; PH≥17.58 mm, n=30). At $p<0.05$, statistical analyses included independent t- or Mann–Whitney *U* tests, chi-square or Fisher's exact tests, and Spearman's rank or Pearson's correlation coefficients.

Results: A significant intergroup difference ($p=0.037$) was detected in UPAW only. In those with a PH<17.58 mm, PH was moderately correlated with nadir oxygen saturation (r=0.557), apnea-hypopnea index (r=−0.536), and respiratory disturbance index (r=−0.419). Severe and moderate scalloped tongues were seen in the PH<17.58 mm and PH≥17.58 mm groups, respectively. A weak correlation (r=0.368, $p=0.048$) was found between UPAW in the PH<17.58 mm group and scalloped tongue. A significant difference in oral torus distribution was observed between groups ($p<0.001$), with the majority of patients in both groups exhibiting no torus.

Conclusions: Although PH alone is not a definitive predictor of OSA severity, it may be simple for dentists to assess and must be interpreted cautiously in light of other factors.

Keywords: craniofacial morphology, obstructive sleep apnea, palatal height, polysomnography, upper posterior arch width

Introduction

Obstructive sleep apnea (OSA) contributes to fatigue, reduced quality of life, and an increased risk of metabolic disorders.[1,2] Dentists can play a role in early detection of patients at risk for OSA[3], given its association with craniofacial abnormalities, such as maxillary constriction, mandibular deficiency, and increased cranial base flexion.[4] In addition, deviations in palatal height (PH) have been reported to adversely affect upper airway dimensions and reduce tongue space, which in turn may contribute to the development of OSA.[4-6] In addition, a comprehensive assessment should incorporate multidimensional analysis to fully understand craniofacial morphology.[7] In particular, evaluation of upper intertooth distances may help identify maxillary constriction, which could be related to upper airway compromise in OSA.[5]

PH can be assessed during routine dental examinations. One study found higher PH in patients with OSA compared to controls[5], although other studies did not confirm this finding.[8,9] Interestingly, among individuals with mild to moderate OSA, reduced PH has been associated with a higher oxygen desaturation index, indicating a deterioration in oxygen saturation levels during sleep.[1] The presence of a scalloped tongue[10] and mandibular torus[9] has also been associated with increased OSA risk. Polysomnography (PSG) is the gold standard for diagnosing OSA, using an apnea–hypopnea index (AHI) and a respiratory disturbance index (RDI). Based on these indices, OSA severity is classified as mild (5-14 events/hour), moderate (15-30 events/hour), and severe (over 30 events/hour).[2,11,12] Nadir oxygen saturation (nadir SpO_2), which indicates the lowest oxygen level during sleep, is another important parameter.[13] In Thai populations, the Thai version of the Epworth sleepiness scale (TESS) is used to assess daytime sleepiness.[14]

Despite several investigations into the relationship between craniofacial characteristics and OSA, the role of PH remains unclear due to some inconsistent findings.[1,5,8] Therefore, this study aimed to investigate the association between OSA patients' PH and parameters derived from their PSG parameters.

Materials and Methods

This cross-sectional study was approved by the Naresuan University Human Research Ethical Committee, Thailand (IRB No. P1-0011). Patients over 20 years of age were selected from individuals diagnosed with mild, moderate, or severe OSA at Naresuan University Hospital Otorhinolaryngology Sleep Clinic between May and November 2024.

Strict inclusion and exclusion criteria were applied to minimize selection bias. Eligible patients were required to present with a permanent dentition and have an AHI and RDI≥5 events per hour, as determined by a somnologist. Patients were excluded if they were undergoing an orthodontic treatment at the time of the study or had previously undergone such treatment; had a completely edentulous mouth or lacked dental landmarks; or had a history of an OSA treatment that could affect arch morphology.

Following the impression of the upper dental arch using irreversible hydrocolloid (Alginor; Lascod, Florence, Italy), a dental cast was fabricated using stone plaster (Type 3 Prestia; Siniat, Chonburi, Thailand). The plaster cast was subsequently scanned using a three-dimensional scanner (3Shape E4; 3Shape Inc., Copenhagen, Denmark). A digitized upper model was then constructed and analyzed using a software program (Orthoanalyzer; 3Shape Inc.). In the digitized model, a line drawn between bilateral upper first molars' central pits was designated as the reference plane, and its distance was considered the upper posterior arch width (UPAW).[15] PH (Figure 1) was defined as the perpendicular distance from the reference plane to the median palatine raphe's deepest point (red point in Figure 1) determined on the digitized model by naked eyes. Based on the median PH value, the overall patients (n=60) were divided into two groups.

Data on gender, age, body weight, body height, and PSG parameters-AHI, RDI, nadir SpO_2, and OSA severity (mild, moderate, or severe)-were obtained from patients' medical records. Daytime sleepiness was assessed using the TESS. Scalloped tongue (none, mild, moderate, or severe) described in a report[10] and oral tori (torus absent or only palatal torus, only mandibular torus, or both palatal and mandibular tori present) were confirmed by oral examinations.

The reliability of PH measurement was evaluated by repeating the assessments by the same examiner after a one-week interval. Intraexaminer reliability was assessed using the intraclass correlation coefficient, with values exceeding 0.80 indicating excellent agreement.

Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA).

Descriptive statistics were used to summarize demographic and clinical data. Continuous variables were compared using independent t- or Mann–Whitney U tests for parametric and nonparametric data, respectively. Categorical variables were analyzed using chi-square or Fisher's exact tests. Correlations were assessed using Spearman's rank or Pearson's product-moment correlation coefficients. No sensitivity analysis was conducted. A $p<0.05$ indicated statistical significance.

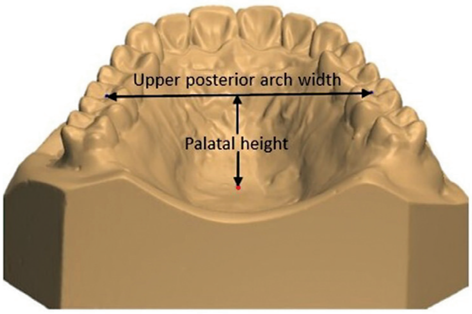

Figure 1: Measurement of the palatal height and upper posterior arch width in a digitized three-dimensional upper dental model. A line drawn between bilateral upper first molars' central pits is designated as a reference plane and its distance is considered upper posterior arch width. Palatal height is the perpendicular distance from the reference plane to the median palatine raphe's deepest point (red point) determined on the digitized model by naked eyes.

Results

The calculated median PH was 17.58 mm. This value was used to divide 60 patients into the group with PH<17.58 mm (n=30) and that with PH≥17.58 mm (n=30). Table 1 shows no significant intergroup difference ($p>0.05$) in gender, age, body mass index, AHI, RDI, nadir SpO_2, or TESS score. The UPAW in the PH<17.58 mm group was significantly narrower ($p=0.037$) than that in the other group.

In the PH≥17.58 mm group, a significant difference in OSA severity distribution was observed ($p=0.007$), with severe OSA being the most common, followed by moderate and mild levels. No such difference was found in the PH<17.58 mm ($p=0.061$).

Both PH groups showed significant intra- and intergroup differences in scalloped tongue severity ($p<0.05$). Severe and moderate scalloping were most frequently observed in the PH<17.58 mm and PH≥17.58 mm groups, respectively.

The presence of torus did not significantly differ between the two PH groups ($p=0.095$) but showed a significant difference within each group ($p<0.001$). In both groups, the majority had no torus, though prevalence was slightly higher in the PH≥17.58 mm group.

In the PH≥17.58 mm group and in the overall sample, no significant correlation was observed between PH and OSA variables (Table 2). In contrast, PH in the PH<17.58 mm group showed a moderately negative correlation with AHI ($r=-0.536$, $p=0.002$) and RDI ($r=-0.419$, $p=0.021$) and a moderately positive correlation with nadir SpO_2 ($r=0.557$, $p=0.001$) (Table 2).

No significant correlation was detected between the UPAW in the overall PH or other variables. UPAW in the PH<17.58 mm group showed a weakly positive correlation ($r=0.368$, $p=0.048$) with scalloped tongue (Table 3).

Discussion

Investigations into the associations between PSG parameters and PH with a more comprehensive multidimensional consideration of UPAW in the OSA patients, along with evaluations of the distributions of scalloped tongue and oral torus between the two PH groups, were conducted in this study. Significant correlations ($p<0.05$) were identified between some PH values and PSG parameters, despite prevailing inconsistencies in the literature regarding the association between PH and OSA.[1,9]

No significant difference ($p>0.05$) in AHI, RDI, nadir SpO_2, or TESS score was observed between the PH groups. However, significant correlations ($p<0.05$) among these parameters were identified within the PH<17.58 mm group, suggesting an effect of reduced PH on respiratory disturbances. In addition, the PH<17.58 mm group possessed a significantly narrower UPAW than the other, illustrating a consistency with findings in some reports.[1,16] An inverse correlation between PH and the oxygen desaturation index has been reported, possibly due to reduced palatal volume and limiting tongue space, which may result in the promotion of posterior tongue position that compromised upper airway patency during sleep. These mechanisms may contribute to increased OSA severity.

Analyses of OSA severity revealed a significant increase in the PH≥17.58 mm group ($p=0.007$). Nevertheless, no significant correlation was found between PH and OSA severity in either group ($p=0.192$). Despite the highest number of patients with severe OSA in the

Table 1: Patients' characteristics stratified by their palatal height (PH).

Patients' characteristics	N	PH<17.58 mm (n=30)	PH≥17.58 mm (n=30)	*p*-value
Gender				
Male	41	18 (60.0%)	23 (76.7%)	0.165[a]
Female	19	12 (40.0%)	7 (23.3%)	
Age* (years)	60	47.29±12.55	48.52±10.83	0.686[b]
Body mass index* (kg/m^2)	60	29.24±6.64	29.55±6.29	0.796[c]
Apnea-hypopnea index* (events/hour)	60	35.23±30.60	42.52±28.27	0.154[c]
Respiratory disturbance index* (events/hour)	60	44.21±40.00	45.39±30.06	0.322[c]
Nadir oxygen saturation* (percentage)	60	77.93±12.74	77.33±12.06	0.790[c]
Thai version of the Epworth sleepiness scale score*	60	7.8±3.73	8.40±4.27	0.564[b]
Upper posterior arch width* (mm)	60	48.76±3.93	50.25±3.57	0.037[c,**]
Severity of obstructive sleep apnea				
Mild	11	8 (26.7%)	3 (10.0%)	0.192[a]
Moderate	16	6 (20.0%)	10 (33.3%)	
Severe	33	16 (53.3%)	17 (56.7%)	
***p*-value**		0.061[a]	0.007[a]	
Scalloped tongue				
None	2	2 (6.7%)	0	
Mild	7	6 (20%)	1 (3.3%)	0.024[d,**]
Moderate	23	7 (23.3%)	16 (53.3%)	
Severe	28	15 (50.0%)	13 (43.3%)	
***p*-value**		0.008[a]	0.002[a]	
Torus				
Torus absent	46	20 (66.7%)	26 (86.7%)	
Only palatal torus present	3	1 (3.3%)	2 (6.7%)	0.095[d]
Only mandibular torus present	7	6 (20.0%)	1 (3.3%)	
Both palatal and mandibular tori present	4	3 (10.0%)	1 (3.3%)	
***p*-value**		<0.001[a]	<0.001[a]	

*The values are expressed in mean±standard deviation.
**Significant intergroup differences at $p<0.05$.
[a]Chi-square, [b]independent t-, [c]Mann–Whitney U, and [d]Fisher's exact tests.

Table 2: Correlations (ρ) between variables and palatal height (PH).

Variable	Overall PH (N=60)		PH<17.58 mm (n=30)		PH≥17.58 mm (n=30)	
	ρ	*p*-value	ρ	*p*-value	ρ	*p*-value
Apnea-hypopnea index	0.043	0.743	-0.536	0.002*	-0.116	0.541
Respiratory disturbance index	0.000	0.997	-0.419	0.021*	-0.051	0.788
Nadir oxygen saturation	0.098	0.456	0.557	0.001*	-0.009	0.962
TESS score	0.111	0.397	0.119	0.529	0.049	0.795
Severity of obstructive sleep apnea	0.012	0.926	-0.349	0.059	0.103	0.587
UPAW	0.103	0.432	-0.195	0.302	0.056	0.767
Scalloped tongue	0.023	0.860	-0.062	0.746	-0.069	0.719

*Significant correlations at $p<0.05$ from two-tailed tests.
Note: All correlations are analyzed by Spearman's rank correlation coefficient, except those between TESS scores and each PH, that between UPAW and the overall PH, and that between UPAW and the PH<17.58 mm groups by Pearson's product–moment correlation coefficient.
Abbreviations: TESS, Thai version of the Epworth sleepiness scale; UPAW, upper posterior arch width.

Table 3: Correlations (ρ) between variables and upper posterior arch width (UPAW) value in each palatal height (PH) group.

Variable	UPAW in each PH group					
	overall PH (N=60)		PH<17.58 mm (n=30)		PH≥17.58 mm (n=30)	
	ρ	*p*-value	ρ	*p*-value	ρ	*p*-value
Apnea-hypopnea index	0.167	0.201	0.065	0.732	0.211	0.262
Respiratory disturbance index	0.184	0.159	0.118	0.534	0.188	0.319
Nadir oxygen saturation	-0.105	0.424	0.046	0.810	-0.206	0.275
TESS score	-0.047	0.724	-0.303	0.103	0.034	0.857
Severity of obstructive sleep apnea	0.194	0.137	0.098	0.608	0.203	0.221
Scalloped tongue	0.243	0.062	0.368	0.048*	0.008	0.967

*Significant correlations at $p<0.05$ from two-tailed tests.
Note: All correlations are analyzed by Spearman's rank correlation coefficient, except that between TESS score and UPAW in the overall PH and that between TESS score and UPAW in the PH<17.58 mm groups by Pearson's product-moment correlation coefficient.
Abbreviation: TESS, Thai version of the Epworth sleepiness scale.

PH≥17.58 mm group, this did not necessarily indicate an association between an increased PH and a greater OSA severity. The anatomical feature alone may not offset other factors contributing to OSA severity.(17) Moderate correlations should then be interpreted with caution. Some possible confounders, such as craniofacial pattern, ethnicity, and body mass index, must also be considered.(1,9,18) A significant intergroup difference (p=0.037) in UPAW was detected. However, the analyses disclosed no significant inter- or intragroup correlation between PH and UPAW, indicating no relationship between them. These may indicate that the observed association reflects a grouping effect rather than a direct linear relationship between the two variables.

Scalloped tongue refers to indentations along the tongue's lateral borders, which are usually caused by repeated pressure against the teeth's lingual surfaces.(10) This condition has been reported to result from palatoglossal disproportion, either independently or in combination with tongue enlargement.(19) It may also be associated with maxillary constriction, which can be indicated by the PH and UPAW.(20) Maxillary constriction is considered a risk factor for OSA.(8,21,22) A high and narrow palatal vault, which is related to a reduced arch width, limits the transverse space available for the tongue and may contribute to the development of scalloped tongue. In this study, the moderate and severe forms of scalloped tongue were more frequently observed in both PH groups, but there was no significant correlation (p>0.05) between them. However, a weakly positive correlation (r=0.368, p=0.048) between UPAW and scalloped tongue was detectable in the PH<17.58 mm group, possibly due to a narrowed oral cavity. Almost all OSA patients in this study possessed scalloped tongues, explicable by rhythmic masticatory muscle activity often associated with respiratory events and cortical arousals in sleep apnea.(23)

Torus is an anatomical variation that may be a risk factor for OSA, and its prevalence varies across countries and ethnic groups.(24) Mandibular torus has been proposed to contribute to limited tongue volume(25) and influence airway patency.(9) Similarly, palatal torus may reduce oral cavity volume and affect tongue position. In this study, the absence of torus was the most common finding in both PH groups. These results suggest that the presence of torus may not be a predominant feature among OSA patients, regardless of palatal morphology.

This study has some limitations. First, its cross-sectional design prevents conclusions about causal relationships. Only associations between variables could be identified. Second, the patients were classified based on their median PH. Using different PH cutoffs and measurement methods may yield different findings, warranting further investigation. Variations in the measurement methods and mean values of PH across diverse populations have been documented.(26-28) Differences in the PH measurement approaches persisted, even in a study conducted in Thailand.(29) Third, all patients were Thai, whose craniofacial characteristics are different from those of other ethnic groups. It may limit the applicability of the results to other populations. Fourth, this study included a relatively small sample size (n=60). No priori power analysis was conducted, due to a suggestion by the central limit theorem that 30 (or more) participants are sufficient for a parametric estimation.[30] This may have limited the ability to detect some smaller, yet clinically relevant, differences.

These findings suggested that PH and UPAW may not be key determinants of OSA severity.[17] The oral cavity proper is a complex three-dimensional structure, and additional anatomical parameters, such as palatal surface area and sagittal dimension, should be considered.[1,7,31] Moreover, evaluations of soft tissue structures[9,21] and cephalometric analyses[5,32,33] may provide a more comprehensive understanding of anatomical factors contributing to OSA.

Conclusions

Within the limitations of this study, it can be concluded that PH alone may not be a reliable predictor of OSA. Significantly moderate correlations between PH and AHI, RDI, and nadir SpO_2 values were observed in patients with PH<17.58 mm. These associations should be interpreted with caution, and PH assessment should be considered alongside other clinical factors, when deciding whether to refer patients for further sleep assessment.

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Conflict of Interest

The authors declare no conflict of interest.

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