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RESEARCH ARTICLE

Morphological assessment of the soft palate and a possible corelation with obstructive sleep apnea – A digital cephalometric study

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ABSTRACT

Background: The available literature on the different morphologies of the soft palate is extremely scarce and has never been classified in an Indian population. We aim to study a corelation between different velar morphologies and probe variations with age, gender, and morphometric assessment based on the length and width. The present study also explores a possible link between snoring and particular velar morphologies as an indicator for the early diagnosis of obstructive sleep apnea syndrome (OSAS). **Aims and Objectives:** (1) To assess the various velar morphological varieties in an Indian population, (2) most prevalent velar patterns according to gender predilection, (3) most prevalent velar patterns according to the age (adult >18 years and pre-adult <18 years), (4) assessment of the length and width of the soft palate, and (5) assessment of predilection for sleep apnea by comparing snoring with particular morphological variants. **Materials and Methods:** Lateral cephalograms were obtained from 299 normal individuals whose age ranged from 5 to 85 years after obtaining clearance from the Institutional Ethical Committee. The velar morphology was classified, and the possibility of a corelation to gender, age, and the length and width of the soft palate was assessed. A snoring questionnaire was given to the relatives of the patients to assess the corelation between it and any particular velar morphology. **Results:** Velar morphology was classified into six types, and we propose an indeterminate type as Type 7 in the classification. The results showed no corelation between particular velar morphologies and age or gender but showed a positive corelation between snoring and Type 6, Type 5, and Type 1 palates. **Conclusions:** The study corroborates the classification suggested by earlier investigators. No significant association was noted with particular velar morphology and age/gender. However, a significant increase in length with respect to Type 5 was noted. The present study for the 1st time in literature derived a positive corelation between snoring and particular velar morphologies (Type 6, Type 5, and Type 1 palates) which may be of use as an early indicator for the early diagnosis of OSAS.

KEY WORDS: Soft Palate; Morphology; Snoring; Digital Cephalometric Radiography

INTRODUCTION

The soft palate hangs like a curtain between the naso- and oropharynx; centrally bearing the uvula on the free posterior edge and laterally blends into the anterior and posterior pillars of the fauces. It has a framework formed of the aponeurosis of the tensor palati muscle, which is adherent to the posterior border of the hard palate and to this fibrous sheet are attached the palatine muscles covered by a mucous membrane, which is squamous on its buccal aspect and ciliated columnar on its nasopharyngeal surface.[1] It plays a significant role during speaking, swallowing, and blowing, the soft palate by closing off the nasopharynx from the buccal cavity.

Over the past decade, lateral cephalometric radiography has been used to quantify several skeletal and soft-tissue

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characteristics of patients. With the advent of digital cephalometry or computed radiography, we can reduce radiation dose exposure to a minimum, convert the diagnostic information of an analog X-ray to digital signals, enhance information from underexposed two-dimensional X-rays, and provide more sensitive, higher-definition, and diagnostically more meaningful images than those provided by conventional radiology, and in real time, process images in such a way as to enable the establishment of a database.[2]

The literature available on various morphologies of the soft palate and its surrounding structures is very scarce, and we have been able to identify only one other earlier study in English literature where You *et al*. have proposed a classification based on the digital cephalometric assessment of the soft palate.[3] Various investigators have previously evinced interest in research pertaining to the measurement of upper airway (UA) structure, speech function, and obstructive sleep apnea syndrome (OSAS).[4-8] Our study aimed at the assessment of variance in soft palate morphology in an Indian population. An attempt is also made to assess the presence of the development of OSAS among the patients by means of a snoring questionnaire, considering the fact that it is an indicator.[9] Although a wide variety of parameters have been put to test in the assessment of OSAS, our literature review has revealed that no studies were undertaken to check the association between a particular soft palate morphology and snoring in patients.

Recently, OSA in the juvenile population has received attention.[10] It has been suggested that UA patency while asleep is relevant to the craniofacial growth pattern. Orthodontists may be the first specialists to detect some of the clinical symptoms of OSA when children visit them for orthodontic treatment, and orthodontists can evaluate the trend of the craniofacial development as the child grows. Moreover, evaluating cephalometric radiographs may be useful for selecting which patients with OSA are potentially suitable for oral appliance therapy and which appliance to use.[11]

Aims and Objectives

1. To assess the various velar morphological varieties in an Indian population
2. Most prevalent velar patterns according to gender predilection
3. Most prevalent velar patterns according to age (adult >18 years and pre-adult <18 years)
4. Assessment of the length and width of the soft palate
5. Assessment of predilection for sleep apnea by comparing snoring with particular morphological variants.

MATERIALS AND METHODS

A total of 299 digital cephalograms were taken from normal Indian individuals (110 male and 189 females ranging from 5 to 85 years) who were referred to the Department of Oral and Maxillofacial Radiology of Kannur Dental College, Hospital and Research Centre, India, between August 2016 and August 2017. Following criteria were followed for the selection of patients.

Inclusion Criteria

1. Normal healthy patients
2. Only patients more than 5 years and <85 years were included in the study.

Exclusion Criteria

1. Patients with cleft lip and cleft palate were not included in the study
2. Patients with oral submucous fibrosis were not included in the study.

The lateral cephalograms were taken on a Soredex CRANEX® Excel Ceph (Soredex; Orion Corporation, Helsinki, Finland) with the tube potential optimized at 80 kV.

Digital images were acquired using Digora® (Soredex, Helsinki, Finland) equipment, and photostimulable phosphor (PSP) imaging plate of dimensions 18 cm × 24 cm cephalometric was used after clearance from the Institutional Ethical Committee. The plates were scanned at 360 dpi resolution. At this resolution, the pixel size results in a matrix of 1440 × 1920 pixels with 8-bit quantifying gray levels. This resulted in a spatial resolution of around 6 lp/mm.

All the radiographs obtained were interpreted by a senior faculty member in maxillofacial radiology and were classified into six types following the classification suggested by You *et al*.[3]

The length of the soft palate was evaluated by measuring the linear distance from the posterior nasal spine to the tip of the uvula of the resting soft palate. In addition, the width of the soft palate was also ascertained at the largest dimensions.

A predilection for developing OSAS was evaluated by giving a snoring questionnaire to the close relatives of the patient, and the disease was suspected with or without daytime hypersomnolence or chronic fatigue. In the case of married patients, the spouse gave information regarding the same. The presence of snoring was evaluated to check for corelation with any particular morphological pattern.

All statistical procedures were performed using SPSS software v10.0 (SPSS, Inc., Chicago, IL). The patients were divided into pre-adult and adult age groups, and the Chi-squared test was applied to evaluate any significant relationships between morphological variance with gender and age.

The comparison of the length between different shapes of the soft palate was evaluated using Kruskal–Wallis test followed by the Mann–Whitney U-test to find out among which pair of groups there exists a significant difference. The comparison of width of the soft palate and different shapes of the soft palate was also evaluated using Kruskal–Wallis test. The presence of snoring and its corelation with different shapes of the soft palate was evaluated with the Chi-squared test. The level of Significance was based on $P < 0.05$.

Table 1: Sample distribution according to the shape

Shape	*n* (%)
Type 3	16 (5)
Type 6	47 (16)
Type 1	81 (27)
Type 2	60 (20)
Type 5	17 (6)
Type 4	66 (22)
Type 7	12 (4)
Total	299 (100)

Table 2: Gender distribution in the study sample

Shape	Males		Females		χ^2	*P*-value
	n	%	*n*	%		
Type 3	5	2	11	4	9.542	0.145
Type 6	14	5	33	11		
Type 1	33	11	48	16		
Type 2	17	6	43	14		
Type 5	11	4	6	2		
Type 4	26	9	40	13		
Type 7	4	1	8	3		
Total	110	37	189	63		

Table 3: Assessment of velar morphology and its prevalence in adult and pre-adult group

Shape	≤18 years		>18 years		χ^2	*P*-value
	n	%	*n*	%		
Type 3	4	1	12	4	5.927	0.431
Type 6	11	4	36	12		
Type 1	15	5	66	22		
Type 2	12	4	48	16		
Type 5	1	0	16	5		
Type 4	14	5	52	17		
Type 7	0	0	12	4		
Total	57	19	242	81		

RESULTS

The six different types suggested by You *et al*. have been confirmed in our study. In addition, we see another shape which cannot be attributed to a known shape and have decided to call it indeterminate or a Type 7.

All the 299 patients evaluated were categorized according to the classification.

Type 1: It showed that the center of the soft palate elevated to both the nasal and oral aspects and radiographically appeared “leaf shaped” (81 [27%] cases)

Type 2: It showed that the soft palate showed the anterior portion which was inflated and the free margin had a thinning/coarctation that radiographically appeared as having a “rat-tail shape” (60 [20%] cases)

Type 3: Soft palate showed a shorter and fatter appearance, and the width had almost no distinct difference from the anterior portion to the free margin, radiographically appeared as a “butt-like” shape (16 [5%] cases)

Type 4: It showed that the soft palate presented a “straight line shape” (66 [22%] cases)

Type 5: The distorted soft palate, presented the S-shape (17 [6%] cases)

Type 6: It revealed a “crook” appearance of the soft palate, in which the posterior portion of the soft palate crooks anteriosuperiorly (47 [16%] cases)

Type 7: It revealed an indeterminate radiographic appearance which could not be attributed to any previously described shape and was not similar to each other to designate it as a separate shape (12 [4%] cases).

A comparison was carried out according to the shape and gender to assess if certain shapes could be directly attributed to a gender variation. No significant association was observed between shape and gender ($P > 0.05$). [Tables 1 and 2]. The sample distribution was also assessed according to the different types and in the adult and pre-adult group [Table 3]. No significant association is observed between

Table 4: Comparison of length between different shapes by employing the Kruskal–Wallis test

Shape	*n*	Mean	Standard deviation	Standard error	Minimum	Maximum	Kruskal-Wallis Chi-square	*P*-value
Butt	16	2.37	0.59	0.15	1.31	3.53	8.021	<0.001*
Crook	47	3.36	0.60	0.09	0.91	4.68		
Leaf	80	3.33	0.58	0.06	1.36	4.51		
Rat-tail	60	3.26	0.62	0.08	1.25	4.48		
S-shaped	17	3.54	0.47	0.11	2.27	4.01		
Straight	66	3.34	0.53	0.07	2.21	4.56		
SU	12	2.95	0.72	0.21	1.59	4.23		

*Denotes significant difference, SU: Shape unclassified shape and the pre-adult or adult age group ($P > 0.05$). Next, we attempted a comparison of length between different shapes by employing the Kruskal–Wallis test followed by Mann–Whitney U-test [Table 4]. A higher mean length was recorded in the Type 5 followed by Type 6, Type 4, Type 1, Type 2, Type 7, and Type 3, respectively. The difference in the mean length between them is found to be statistically significant ($P < 0.001$). To find out among which pair of groups there exists a significant difference, we carried out the Mann–Whitney U-test [Table 5]. The difference in the mean length is found to be statistically significant between Type 3 and Type 7 ($P < 0.05$) as well as Type 3 and all the other shapes ($P < 0.001$), Type 6 and Type 7 ($P < 0.05$), Type 1 and Type 7 ($P < 0.05$), Type 2 and Type 7 ($P < 0.05$), Type 5 and Type 7 ($P < 0.05$) as well as Type 4 and Type 7 ($P < 0.05$). No statistically significant difference is observed between the different shapes with respect to the width ($P > 0.05$) [Table 6]. A statistically significant association is observed between shape and snoring habit ($P < 0.001$) [Table 7].

Table 5: Comparison of length between different shapes by Mann-Whitney test

(I) Shape	(J) Shape	Mean difference (I-J)	Z	*P*-value
Butt	Crook	−0.986	−4.698	<0.001*
	Leaf	−0.960	−4.798	<0.001*
	Rat-tail	−0.893	−4.447	<0.001*
	S-shaped	−1.167	−4.324	<0.001*
	Straight	−0.972	−4.833	<0.001*
	SU	−0.582	−2.253	0.024*
Crook	Leaf	0.026	−0.340	0.734
	Rat-tail	0.094	−0.568	0.570
	S-shaped	−0.180	−1.444	0.149
	Straight	0.015	−0.350	0.727
	SU	0.404	−2.420	0.016*
Leaf	Rat-tail	0.067	−0.341	0.733
	S-shaped	−0.207	−1.718	0.086
	Straight	−0.012	−0.098	0.922
	SU	0.378	−2.116	0.034*
Rat-tail	S-shaped	−0.274	−2.278	0.023*
	Straight	−0.079	−0.303	0.762
	SU	0.310	−2.176	0.030*
S-shaped	Straight	0.195	−1.947	0.052
	SU	0.584	−2.170	0.030*
Straight	SU	0.389	−2.078	0.038*

*Denotes significant difference, SU: Shape unclassified

DISCUSSION

In our study, Type 1 (leaf shaped) was the most frequently occurring shape. We have found that the Type 6 was crook-shaped variety in 12% of the adult age group and the Type 5 was S-shaped palate (17 [6%] cases). In gender comparison, we could not associate any particular association with a particular shape. In comparison between an adult and pre-adult group, we could not associate any particular shape with the patients. A higher mean length is recorded in Type 5 followed by Type 6, Type 4, Type 1, Type 2, Type 7, and Type 3, respectively. Significant association is found between shape and snoring habit ($P < 0.001$).

Type 1 (leaf shaped) was the most frequently occurring shape in our study, which is in accordance with the earlier studies by You *et al.*,[3] who have described it as being the classic velar morphology in the literature. We have performed the study on a larger sample group when compared to the earlier investigators and have found that the Type 6 was crook-shaped variety in 12% of the adult age group which was not noted by You *et al*. The Type 5 was S-shaped palate (17 [6%] cases) which has been referred to as a hooked appearance by Pépin *et al*.[9] They hypothesized that velopharyngeal collapse occurs with a hooked shape due to the reduced dimensions and suggested that such patients have a high risk for OSAS. In gender comparison, we could not associate any particular association with a particular shape. In comparison between an adult and pre-adult group, we could not associate any particular shape with the patients. Subtelny studies revealed that the average dimensional growth in the length was most rapid between 1.5 and 2 years of age which plateaued and then resumed after 5 years of age.[4] There were no reports in the literature on rapid growth after this age; hence, we could not group them into different stages such as pediatric, adolescent, adult, and geriatric populations. However, we did not get a significant association between any particular velar morphology and the adult and pre-adult groups. In this study,

Table 6: Comparison of width between different shapes: (Kruskal-Wallis test)

Shape	*n*	Mean	Standard deviation	Standard error	Minimum	Maximum	Kruskal-Wallis Chi-square	*P*-value
Butt	16	1.20	0.37	0.09	0.45	1.79	4.543	0.604
Crook	47	3.91	18.64	2.72	0.4	129		
Leaf	81	1.24	0.26	0.03	0.44	1.82		
Rat-tail	60	1.21	0.31	0.04	0.57	1.83		
S-shaped	17	1.20	0.31	0.08	0.5	1.63		
Straight	66	1.18	0.32	0.04	0.53	2.08		
SU	12	1.36	0.40	0.12	0.55	2.12		

SU : Shape unclassified

Table 7: The sample distribution according to shape and snoring

Shape	Present		Absent		χ^2	*P*-value
	n	%	*n*	%		
Butt	1	0	15	5	124.238	<0.001*
Crook	23	8	24	8		
Leaf	9	3	72	24		
Rat-tail	0	0	60	20		
S-shaped	14	5	3	1		
Straight	0	0	66	22		
SU	0	0	12	4		
Total	47	16	252	84		

*Denotes significant association

we have also tried to assess the velar length and width of the soft palate and tried to look for a corelation between these parameters and particular velar varieties. A higher mean length is recorded in Type 5 followed by Type 6, Type 4, Type 1, Type 2, Type 7, and Type 3, respectively. The difference in the length of the soft palate has to be longitudinally studied over different age groups with a larger sample size in future studies to note if there is a gradual growth of the soft palate with age or if there is a change into different morphological patterns with the passage of time. There was however no significant association between velar width and the different shapes.

Considering snoring as an indicator for OSAS, a significant association is found between shape and snoring habit ($P < 0.001$). We can conclude that people with snoring habits are less likely to have a straight shape, rat-tail shape, leaf shape, or a SU shape palate and are more likely to have Type 6, Type 5, or Type 1 shape. The importance of this finding is the fact that a maxillofacial radiologist may be able to play a vital role in the early diagnosis and prevention of OSAS by looking for particular velar morphologies which may be more predisposed for OSAS. This method of using a digital cephalogram as an adjunct to the clinical examination can help. However, further studies are required on a larger sample size with the aid of apnea plus hypopnea index (number of apnea/hypopnea episodes/h) and using polysomnography,[12] which has been considered the gold standard in OSAS assessment. Both orthodontists and maxillofacial radiologists may be the first specialists to detect the early clinical and radiographic effects of developing OSAS. Early orthodontic treatment planning may be initiated against this. In our study, we found only an 18-year-old female who had a Type 5 S-shaped palate with snoring. Further research may be performed on a larger sample size in the pre-adult group.

Literature on the morphological assessment of the soft palate is extremely scarce, and we have seen that a digital cephalogram can be a cost-efficient and fast method of assessing the same.[2] It has been routinely used in the specialty of orthodontics and dentofacial orthopedics as an invaluable pre-treatment assessment modality. The different morphological varieties of the soft palate have been largely ignored in the past until You *et al*. proposed a classification for the same.[3] The morphological and morphometric assessment of the soft palate has never been attempted in the literature in an Indian population. The lateral cephalograms taken on the Digora® (Soredex, Helsinki, Finland) equipment and PSP imaging plate allowed the optimization and contrast improvement which allowed better visualization of the soft palate when compared to its appearance on a conventional radiograph.

CONCLUSIONS

It is impossible to reliably differentiate between chronic snorers and people with sleep apnea based on a digital cephalogram alone. Cephalometric radiographs provide only two-dimensional static images that do not take into account any dynamic functional processes. Despite these limitations, cephalometrics can be considered as a valid preliminary screening method to study the craniofacial hard- and soft-tissue morphology in snoring patients who are risk for developing OSAS. The available literatures on morphology of the soft palate have reported very few studies on morphological assessment of the soft palate and have often reported the shape of the soft palate as being only of one type. However, our study has applied an earlier classification[3] to the Indian population and confirmed significant variations in the morphological patterns among the subjects. For the 1st time in literature, our study has found a statistically significant association between particular velar morphology and snoring habits. This may pave the path for further research on the early diagnosis and management of velopharyngeal incompetency.

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