https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 27(4s) (December 2024); 14284-14291
Research Article

Assessment of variation in Soft palate Morphology and Velopharyngeal incompetence using Cone-Beam Computed Tomography in Tamil Nadu population - a retrospective study

Obuliy Bhavithira Saravanan[1], Sudhaa Mani[2*], Yasmeen Ahamed Sahuthullah[3], Sivaraman Sivakumar[4], Ambiga Pazhani[5], Narendar Ramesh[6]

[1]Post graduate, Department of Oral Medicine and Radiology, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode
[2*]MDS, Professor and Head, Department of Oral Medicine and Radiology, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode
[3]MDS, Associate Professor, Department of Oral Medicine and Radiology, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode
[4]MDS, Reader, Department of Oral Medicine and Radiology, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode
[5]MDS, Reader, Department of Oral Medicine and Radiology, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode
[6]MDS, Professor, Department of Oral and Maxillofacial Surgery, Vivekanandha Dental College for Women, Elayampalayam, Tiruchengode

ABSTRACT:
BACKGROUND: The soft palate is an anatomical feature that influences the speech and respiration while the patient is swallowing. Soft palate dysfunctions are typically observed in patients with cleft palate and obstructive sleep apnoea. Understanding the morphological variations of the soft palate can aid in improved patient management and also serving as a predictor of the patient's age and gender.
AIM: The present study aimed at investigating the variations in soft palate morphology in age groups and gender, thereby assessing Velopharyngeal incompetency using CBCT in Tamil Nadu population.
MATERIALS AND METHODS: The study sample consisted of 70 CBCT scans of individuals aged between 15 and 45 years. The velar morphology was examined and grouped into six types. Data was analysed by using statistical software SPSS version 27.0. One-way analysis of variance (ANOVA) was carried out to assess the association of morphological variants among age groups and shape of soft palate. The probability value $p \leq 0.05$ was considered as significant.
RESULT: The most frequent type of soft palate was Crook shaped (37.14%). The mean VL and VW values were significantly higher in males while PD and Need's ratio were higher among females, insignificantly associated with the types of soft palate.
CONCLUSION: The soft palate morphology may aid in assessment of velopharyngeal insufficiency using CBCT. This study found no evidence of sexual dimorphism.

KEYWORDS: Velar morphology, Velopharyngeal incompetency, CBCT

Received: 10/12/2024 *Accepted: 19/12/2024*

DOI: https://doi.org/10.53555/AJBR.v27i4S.7236

© 2024 The Author(s).
This article has been published under the terms of the Creative Commons Attribution-Noncommercial 4.0 International License (CC BY-NC 4.0), which permits noncommercial unrestricted use, distribution, and reproduction in any medium, provided that the following statement is provided. "This article has been published in the African Journal of Biomedical Research"

INTRODUCTION

The term "soft palate" refers to the posterior fibro-muscular region of the palate that connects to the "hard palate." Three elements come together to produce the palate: the frontonasal process, the two palatal processes, and the primitive palate. Later, to create the hard palate, the mesoderm in the palate goes through intra-membranous ossification. The soft palate still exists at the most posterior part of the tooth, where the ossification does not go. During swallowing, the soft palate separates the mouth from the oropharynx without changing the way you breathe. It plays an essential role in blocking food and other substances from entering the nasal passages during swallowing and it participates in velopharyngeal closure.[1],[2]

With further voice quality alteration, velopharyngeal closure aids in the proper pronunciation of consonants. In order to produce different sounds and understandable speech, the nasal and oral cavities must be coupled and uncoupled because the entire vocal tract is a resonating cavity. Velopharyngeal incompetence develops when the usual spatial relationship or coupling between the velum and nasopharynx is disrupted. This produces three common speech characteristics secondary to increased transmission through the nasal cavity: hypernasality, nasal emission, and reduced aspiration and frication.[3],[4]

Cleft lip and palate, enlarged adenoids, OSAS, snoring, inadequately maintained maxillary dentures, and skeletal craniofacial malocclusion are only a few of the causes of soft palate dysfunction. The identification and effective treatment of these challenging situations are aided by knowledge of the soft palate's typical structure and morphological variation. Velopharyngeal insufficiency can be brought on by the wide range of soft palate morphological changes. The different soft palate variations also allow us to determine a person's age and gender.[5],[6]

Two types of evaluation are used to obtain a thorough assessment of velopharyngeal function: Clinical and Radiographic. Clinically, intraoral examination and speech production characteristics can be performed. Both static methods, such as cephalometric radiography, pharyngeal computed tomography (CT), and magnetic resonance imaging (MR), and dynamic methods, such as video fiberoptic pharyngeal studies, fast CT, and fast MR imaging, can be used to image the upper airway. Cone Beam Computed Tomography (CBCT), a recent advancement in radio diagnostic technology, is now commercially produced and widely used in patient care and dentistry teaching settings. In comparison to lateral cephalogram, which provides a two-dimensional picture of an item, it has additional advantages over other radio diagnostic procedures in that it provides a three-dimensional view of an object and accurate landmark recognition. The linear measures obtained from CBCT scans of the dento-maxillofacial region do not significantly differ from actual direct measurements of anatomic features in this region.[6],[7]

Hence, this study was conducted to assess the variation in soft palate morphology and Velopharyngeal incompetency using CBCT and also to find its association with Need‘s ratio (NR), Velar Width (VW), and Pharyngeal Depth (PD) in different morphological velar types among the population of Tamil Nadu.

MATERIALS AND METHODS

This retrospective study was conducted in the Department of Oral Medicine and Radiology of our institute over a duration of 3 months. Data was collected from various CBCT centres in Tamil Nadu. Study sample consisted of 70 CBCT scans of healthy individuals within the age range of 15- 45 years were retrospectively selected from the CBCT database. Scans of patients below 15 years and above 45 years of age and scans of patients showing any pathologies, developmental defects, trauma, or injury affecting the maxilla extending to the soft palate of the maxillary jaw including cleft palate, soft palate syndromes and fractures of the head and neck were excluded from the study. All the scans were analysed and categorized into six types according to the soft palate morphology as put forward by Agarwal *et al.,* namely; Leaf shape, Rat tail shape, S- shape, Butt shape or Crook shape by an oral and maxillofacial radiologist. [Figure 1 to 6]

While interpretation, the scans in the sagittal sections were observed keeping the mid-sagittal plane in centre.

During resting position of soft palate,

Two points were marked from the posterior nasal spine (PNS) to the tip of the uvula of the resting soft palate and the linear distance was measured: Velar length (VL) [Figure 7].

Thickest section of velum: Velar width (VW) was measured [Figure 8].

Two points were marked on the posterior surface of the nasal spine and posterior pharyngeal wall and the palate and the linear distance was measured: Pharyngeal Depth (PD) [Figure 9].

Linear distance between the posterior pharyngeal wall and the dorsum of the tongue on a line joining gonion to the supramentale in sagittal view was measured: Posterior Airway Space [Figure 10]

Nasopharyngeal and oropharyngeal areas were measured in axial view. [Figure 11 and 12]

The measurements were carried out for each digital scan using Invesalius 3.1 software, by the same examiner twice with the interval of 3 weeks, and the mean value so obtained was considered. The Need’s ratio was calculated for all the subjects by the division of Pharyngeal Depth by Velar Length.

Interpretations of scans for soft palate morphology were made, and the following six shapes were identified, i.e., Rat tail, Butt shape, Leaf shape, Handle shape, S-shape, and Crook shape [Figure 8].

Sample size estimation

The sample size was calculated using a power analysis by G*power, version 3.0.1 (Franz Faul University,Kiel,

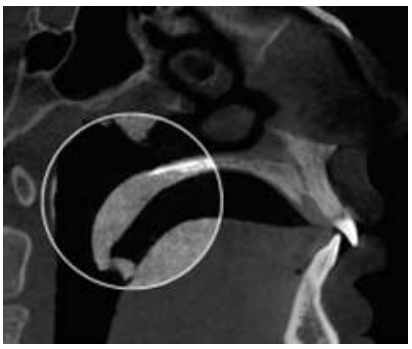


FIGURE 1. Leaf shaped

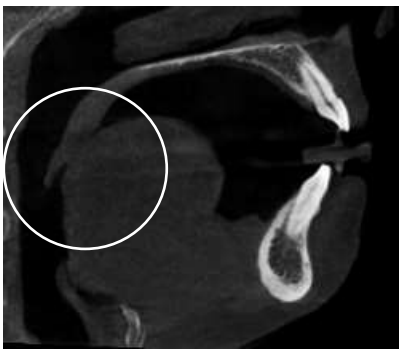


FIGURE 2. Rat Tail shaped



FIGURE 3. S-shaped

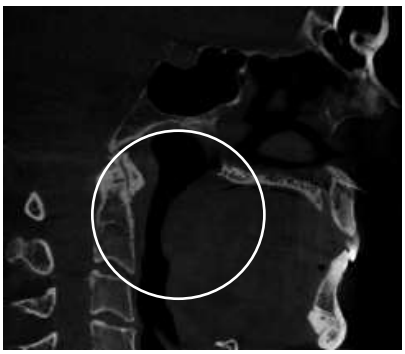


FIGURE 4. Butt shaped



FIGURE 5. Crook shaped



FIGURE 6. Handle shaped

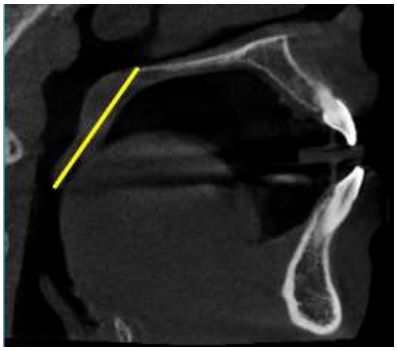


FIGURE 7. Image showing velar length

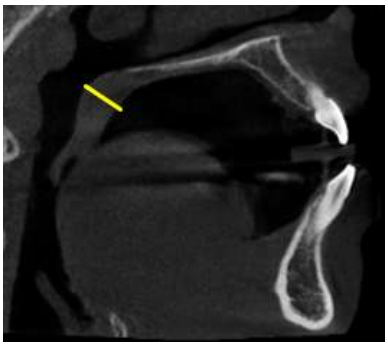


FIGURE 8. Image showing velar width

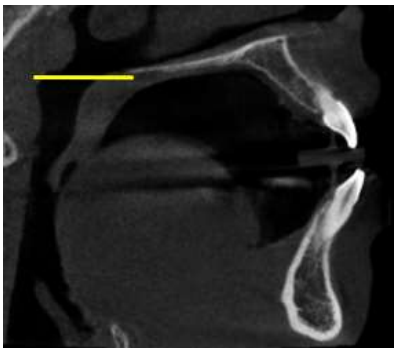


FIGURE 9. Image showing pharyngeal depth

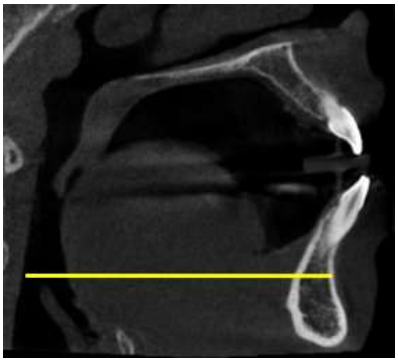


FIGURE 10. Image showing posterior airway space

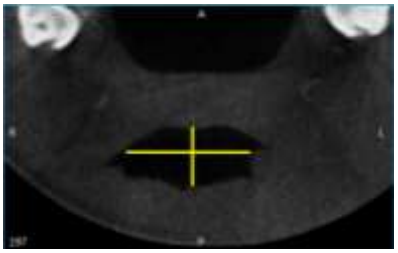


FIGURE 11. Image showing Nasopharyngeal area

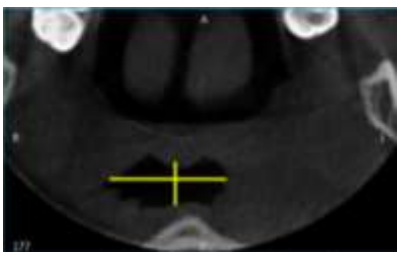


FIGURE 12. Image showing Oropharyngeal area

Germany). A sample size of 70 subjects (35 in each group) would yield 80% power to detect significant differences, with an effect size of 0.42 and a significance level of 0.05.

STATISTICAL ANALYSES

Data was entered in the excel spreadsheet. Mean, standard deviation, and percentages were calculated from the data. Statistical analyses included both descriptive and inferential methods. The data was analysed by using statistical software SPSS version 27.0. Continuous variables were expressed as mean ± standard deviation while the results on categorical measurements were presented in numbers (%). The Chi-Square test was used to observe the association of gender with shape of soft palate. One-way analysis of variance (ANOVA) was carried out to assess the association of morphological variants among age groups and shape of soft palate. Z-test was used to identify the relationship between male and female in different morphological variants. The probability value $p \leq 0.05$ was considered as significant while $p \leq 0.001$ was considered as highly significant.

RESULTS

In this study, 70 subjects that included 35 males (50%) and 35 females (50%) were studied for evaluation of the morphological variants and types of soft palate observed in CBCT images. All the scans were interpreted for soft palate morphology.

The crook shape was the most common (26; 37.14%) in our subjects and it was recognized in 13 females and in 13 males. The second common type of soft palate was rat tail shape (17; 24.28%) reported in 8 males and in 9 females and followed by butt shaped (13; 18.57%) noted in 8 males and in 5 females. The least common type of soft palate was leaf shaped (2; 2.85%) obtained in 2 males and 0 females. These differences in morphological types of soft palate between sexes were not statistically significant ($p>0.05$). Moreover, it was observed statistically that sex was not the significant factor that impacted the shapes of soft palate. Thereby, concluding that sex determination cannot be conducted with respect to variation in shapes of soft palate [Graph 1]. Crook shape and Butt shape were identified in almost all age groups [Table 1]. Rat tail shape wasn't recognized in age groups 2 and 10 (20- 25 and 60-65 year) while leaf shape was present only in group 4 (30-35 year) and group 6 (40-45 year) respectively. The statistical agreement by using one way analysis of variance (ANOVA) showed that the mean differences among all the six age groups for morphological types were highly significant, which concludes that types of soft palate, can be determined according to the age.

The mean velar length was smallest in leaf shape and pharyngeal depth was the smallest in S shape while maximum in crook shape and rat tail shape soft palates, respectively [Table 2]. The mean velar width was the shortest in rat tail shape and maximum in handle shape, whereas the Need's ratio was found to be the lowest in S-shape and the highest in rat tail shape velar morphology. The Need's ratio ranged from 0.69 to 0.85, had 95.0% confidence interval. The statistical agreement based on one-way analysis of variance (ANOVA) highlighted that the mean differences in morphological variants: velar length velar width, pharyngeal depth and Need's ratio were not significant ($p>0.05$) among morphological types of the soft palate. The nasopharyngeal and oropharyngeal levels were greatest with leaf shaped morphology while the Posterior airway space was greatest for handle shaped morphology. However, all these three parameters were lowest with butt shaped morphology. So, it was concluded that types of soft palate cannot be identified by calculating velar length, velar width, pharyngeal depth and Need's ratio.

Morphological variants were found to be significantly different among male and female (Graph 2). The mean velar length (36.42 mm) and velar width (8.32 mm) were higher among males as compared to mean velar length (30.95 mm) and velar width (7.50 mm) among females but the pharyngeal depth (27.19 mm) and Need's ratio (0.75 mm) were lower among males than the mean pharyngeal depth (28.18 mm) and Need's ratio (0.81 mm) among females. The nasopharyngeal and oropharyngeal levels were greater for females (312.93 mm and 262.22 mm respectively) than males (251.16 mm and 194.95 mm respectively) while the inverse relationship was observed with posterior airway space (80.55 mm and 76.83 mm respectively) [Table 3]. The statistical agreement projected that the mean differences between male and female for morphological variants: velar length ($p>0.05$) weren't significant among different age groups [Table 4]. This concluded that velar length and pharyngeal depth increases with age while Need's ratio and velar width had no significance.

DISCUSSION

Planning a successful therapy requires a thorough evaluation of the soft palate architecture. For many years, patients at the chair side were classified as having soft palates using random methods. Even though numerous studies have suggested particular clinical checks, diagnostic casts, radiographic techniques, and various combinations, a precise assessment of soft palate morphology is still difficult to achieve. When it comes to precisely identifying the structure of the soft palate, radiographic technologies have an edge over other techniques.

In our investigation, we identified several different varieties of soft palates, including handle, rat-tail, leaf-like, crooked, straight-line, butt, and s-shaped. The most

TABLE 1 Distribution and association of types of soft palate with age

AGE GROUPS	Mean age (year) at different shape of soft palate					
	Leaf shaped (n=2)	**Rat tail shaped (n=17)**	**S-shaped (n=7)**	**Butt shaped (n=13)**	**Crook shaped (n=26)**	**Handle shaped (n=5)**
15-20	-	19	18	15.5	15	-
20-25	-	-	-	21	21.8	-
25-30	-	26	27.5	30	26	27
30-35	32	33	-	32	33	-
35-40	-	37.33	-	38	-	-
40-45	45	44	44	43.5	43.5	44
45-50	-	48.5	-	47.5	47.63	50
50-55	-	52	-	-	53	51
55-60	-	60	-	57.5	59.5	-
60-65	-	-	62.33	62	63.33	62
F VALUE	NA	264.43	NA	52.34	318.82	NA
P VALUE	NA	p<0.001*	NA	p<0.001*	p<0.001*	NA

*The mean differences are highly significant at the 0.001 level of significance. Statistical Test Used: ANOVA
NA-Not Applicable, as there were only 4 samples in all, and only 1 sample in each age group.

TABLE 2 Comparison in types of soft palate with different morphological variants

SOFT PALATE		MEAN (mm) OF MORPHOLOGICAL VARIANTS						
TYPES	**N=70**	**VELA -R LENG - TH**	**VEL - AR WID -TH**	**PHARY - NGE -AL DEPTH**	**NEE-DS RAT-IO**	**POSTERIOR AIRWAY SPACE**	**NASOPH - ARYN- GEAL LEVEL**	**OROPHA – RYN-GEAL LEVEL**
LEAF SHAPED	2	30.042	8.352	25.371	0.84	79.424	421.25	376.182
RAT TAIL SHAPED	17	35.595	7.3911	30.3920	0.85	77.0188	280.331	193.2479
S-SHAPED	7	36.3738	7.8748	24.65288	0.69	82.7225	340.333	269.6399
BUTT SHAPED	13	34.03762	7.479231	27.3812	0.83	75.84323	208.8696	151.3914
CROOK SHAPED	26	36.8524	8.25185	27.2788	0.75	77.9173	284.089	221.336
HANDLE SHAPED	5	34.2664	9.1528	26.7724	0.80	89.2252	346.414	351.9906
F VALUE		1.3169	1.2253	2.033	1.372	2.544	56.0151	72.243
p VALUE		0.068	0.075	0.0878	0.0832	0.0711	0.0427*	0.016*

* The mean differences are not significant at the 0.05 level of significance. [Degrees of freedom are 5 and 115].
Statistical Test Used: ANOVA

TABLE 3 Comparison of mean differences in different morphological variants between male and female

MORPHOLOGICAL VARIANTS	GENDER	MEAN±SD	MD	Z VALUE	p VALUE
VELAR LENGTH	MALE	36.4207±5.3502	4.466	5.289	0.026*
	FEMALE	30.9548±4.0818			
VELAR WIDTH	MALE	8.325±1.8347	0.817	2.087	0.0406*
	FEMALE	7.5083±1.412			
PHARYNGEAL DEPTH	MALE	27.1919±6.209	0.995	0.679	0.4993
	FEMALE	28.1875±6.0480			
NEEDS RATIO	MALE	0.756±0.1760	0.110	4.353	0.031*
	FEMALE	0.816±0.1946			
POSTERIOR AIRWAY	MALE	80.552±7.1861	3.720	2.264	0.0268*
	FEMALE	76.832±6.5489			
NASOPHARYNGEAL LEVEL	MALE	251.160±128.045	61.772	2.053	0.0440*
	FEMALE	312.932±123.692			
OROPHARYNGEAL LEVEL	MALE	194.958±110.421	67.263	8.3613	0.0214*
	FEMALE	262.221±133.661			

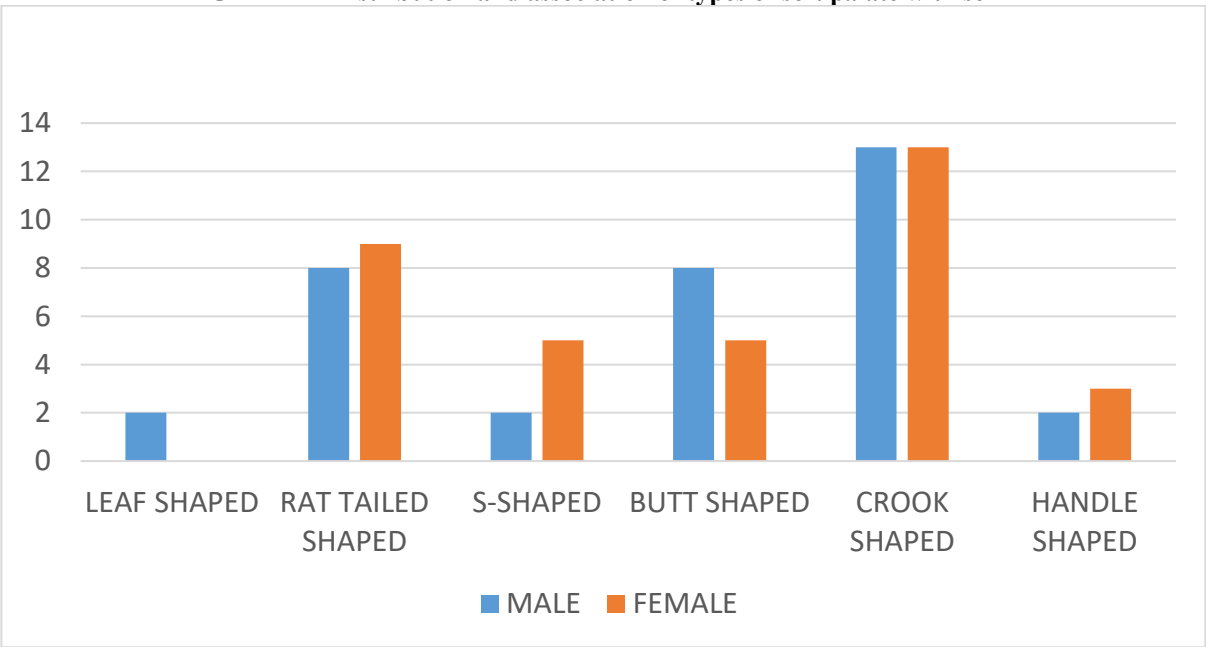
*The mean difference is highly significant at the 0.003 and 0.001 levels of significance.
*The mean difference is not significant (insignificant) at the 0.05 level of significance. [Degrees of freedom are 119; MD-Mean Difference]
Statistical Test Used: Z Test

TABLE 4 Comparison in age groups with different morphological variants

AGE GROUP		MEAN (mm) OF MORPHOLOGICAL VARIANTS						
GROUP	N=70	VELA-R LENG-TH	VEL - ARWID -TH	PHARYNG - EAL DEPTH	NEED -S RATI -O	POSTERIOR AIRWAY SPACE	NASOPH-ARYN -GEAL LEVEL	OROPHA-RYN-GEAL LEVEL
15-20	5	33.933	7.0172	22.2158	0.652	75.567	281.106	186.62
20-25	5	35.6544	8.2168	24.0702	0.688	75.7026	234.73	189.80
25-30	6	34.615	9.2372	26.4822	0.7833	78.1902	261.694	223.369
30-35	5	33.2926	7.0374	27.4364	0.824	81.4752	238.454	159.625
35-40	4	34.34	6.442	26.9023	0.791	75.575	270.430	208.35
40-45	10	34.8548	7.0075	29.8531	0.875	80.6438	263.361	228.189
45-50	14	36.8433	8.4828	28.9873	0.7964	80.0379	304.582	241.379
50-55	7	37.8571	7.6804	28.796	0.7643	76.0251	253.068	184.389
55-60	5	37.482	9.534	28.2624	0.756	79.8732	340.330	242.193
60-65	9	35.77	7.9281	28.437	0.8133	79.4207	327.667	253.839
F VALUE		0.6138	2.559	0.9219	0.7399	0.62817	0.4737	0.38226
P VALUE		0.7805	0.0148*	0.5128	0.6709	0.76845	0.8866	0.93918

*The mean differences are not significant at the 0.05 level of significance. [Degrees of freedom are 5 and 115] Statistical Test Used: ANOVA

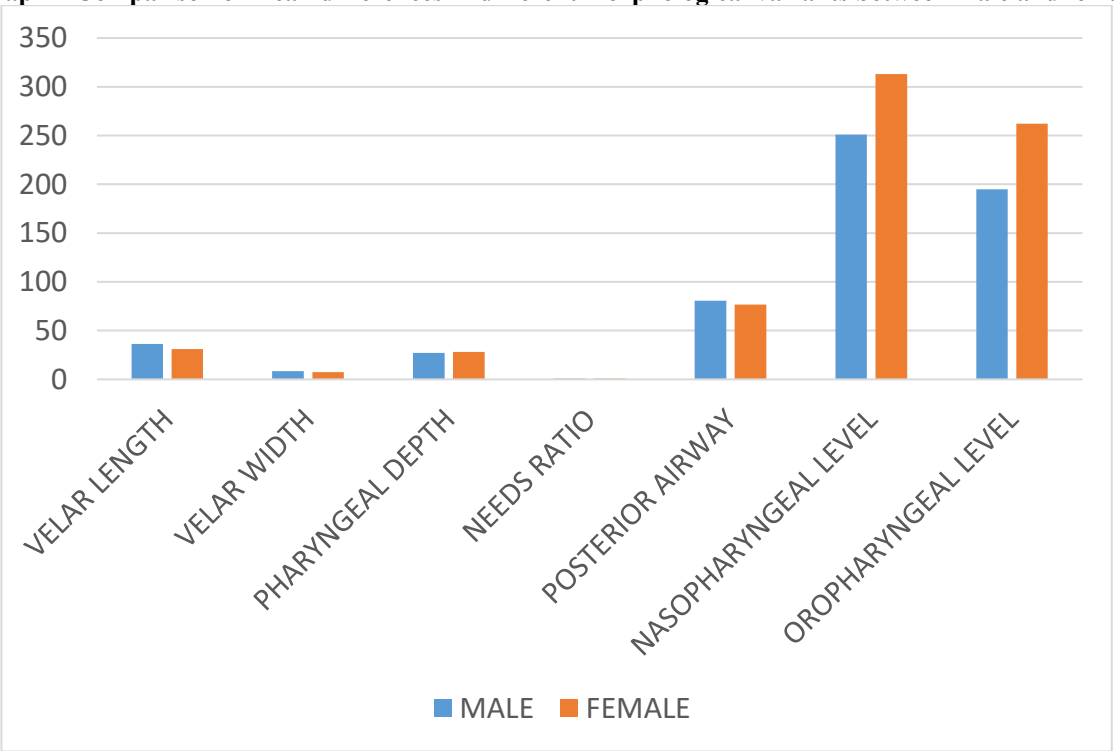
GRAPH 1 Distribution and association of types of soft palate with sex



Statistical test used: Chi Square Test

prevalent shape of soft palate in the population of Tamil Nadu was found to be Crook shape (26 cases; 37.14%) which contains crooks that hang anteriorly and superiorly, while according to Agrawal et al.[7] and Upadhyay et al.[8] it was Rat tail shape (28-37%). In studies, conducted by Verma et al.[2] and You M et al.[5] the common type found was leaf shaped (48.7%), however in the current study it had the lowest prevalence. A peculiarity observed while studying the type of soft palate morphology was that despite Crook-shape having the highest prevalence among the current study population it is less common as reported by other studies 3-3.3%. Additionally, statistical research showed that sexual dimorphism in soft palate shapes was not significant. Accordingly, it is impossible to establish a person's sex based on variations in soft palate form, which is consistent with the findings of Agrawal et al.[7] In the studies done by You et al.[5], and Verma et al.[2], a linear shape was identified in 10% and 8.7% of cases respectively, this particular shape was not identified in our study. S-shaped soft palate was seen in 10% of our cases which was in congruence to the findings of Agrawal et al.[7] (9.9%), while it was observed in 4.7% cases in study done by Verma et al.[2], 3.5% of cases were detected in study done by You et al.[5], inferencing that Tamil Nadu population have greater chances of having Obstructive Sleep Apnoea Syndrome (OSAS). A significant increase in velar length with increase in age was noted in our study. It was consistent with the findings of previous studies done by Agrawal et al.[7], Verma et al.[2], Johnston & Richardson and Taylor et al [9,10]. In the study done by

Graph 2 Comparison of mean differences in different morphological variants between male and female



Kollias and Krogstad, increase in velar length was equal among males and females.[11] While in our study, this was significantly greater in males (36.42±5.35) as compared to females (30.95±4.08), which is in accordance with the results of the study done by Agrawal et al.[7] and Verma et al.[2] During speech, swallowing and pronunciation, velopharyngeal closure helps in the separation of nasal cavity from oral cavity. If this closure does not take place, VPI occurs. According to Subtelny, the risk of VPI increases when Need's ratio becomes greater than 0.70. Need's ratio varies with variations in shapes of soft palate i.e., in the present study Need's ratio was maximum in Rat tail shape (0.85) as compared to other previous studies in which S-shaped soft palate accounted for maximum Need's ratio. Thus, indicating that Tamil Nadu population, who have Rat tail shaped soft palate, have a greater chance towards VPI. In our study, Need's ratio was more in females as compared to males, which is in accordance with the study done by Agrawal et al.[7] and Verma et al.[2], Thus highlighting that, females are more prone for VPI than males.

The dimensions of posterior airway space in the present study ranged from 75.84 to 89.22 which was in contrast to the study conducted by Pepin et al.[12] on obstructive sleep apnoea syndrome (OSAS), (13-19 mm). He stated that the increased dimensions of Posterior airway space was said to be directly proportional to soft palate hooking and the incidence of OSAS. However, our findings regarding the oropharyngeal and nasopharyngeal levels were in congruence to his study where he deduced that when a patient with OSAS had an oropharyngeal area greater than 150 mm^2, the relative risk for soft palate hooking was increased 15 fold and that a reduction in oropharyngeal area was observed in the group of patients with OSAS. Hence, correlation of these three parameters with soft palate hooking and the incidence of Obstructive sleep apnoea syndrome becomes the need of the hour.

LIMITATIONS

The present study's primary limitation was a small sample size. In order to better understand the morphological differences of the soft palate and their relationship with velar length, pharyngeal depth, and Needs ratio, further studies with a larger sample size are advised. The absence of clinical evaluation of the patient and the lack of data connecting the increase in needs ratio to the patient's history of snoring were additional study limitations.

REFERENCES

1. Moore K.L., Agur AM., Essential clinical anatomy. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2002.
2. Verma P., Verma K.G., Kumaraswam KL., Basavaraju S., Sachdeva SK., Juneja S., 2014. Correlation of morphological variants of the soft palate and Need's ratio in normal individuals: A digital cephalometric study. Imaging Sci Dent. 44(3), 193-98.
3. Johns D., Anatomy and Physiology of the Velopharyngeal Valving Mechanism. Dallas, Texas: Department of Plastic Surgery, University of Texas Southwestern Medical Center Grand Rounds, 2001.
4. Iglesisas, A., and Morris H., 1980. Simultaneous assessment of pharyngeal wall and velar displacement for selected speech sounds. J. Speech Hear. Res. 23. 429.

5. You M., Li X., Wang H., Zhang J., Wu H., Liu Y., 2008. Morphological variety of the soft palate in normal individuals: a digital cephalometric study. Dentomaxillofacial Radiol. 37(6). 344–9.
6. Johns DF., Rohrich RJ., Awada M., 2003. Velopharyngeal incompetence: A guide for clinical evaluation. Plast Reconstr Surg. 112(7). 1890–8.
7. Agrawal P., Gupta A., Phulambrikar T., Singh SK., Sharma BK., Rodricks D., 2016. A focus on variation in soft palate morphology using cone-beam computed tomography with an assessment of need's ratio in central Madhya Pradesh population. J Clin Diagn Res. 10. ZC68–71.
8. Upadhyaya C., Neupane I., Sapkota B., Srivastava S., 2017. Morphological Diversity of Soft Palate in Nepalese Population: A Retrospective Cephalometric Study. Orthod J Nepal. 7(1). 18–22.
9. Johnston CD., Richardson A., 1999. Cephalometric changes in adult pharyngeal morphology. Eur J Orthod. 21(4). 357-62.
10. Taylor M., Hans MG., Strohl KP., Nelson S., Broadbent BH., 1996. Soft tissue growth of the oropharynx. Angle Orthod. 66(5). 393-400
11. Kollias I., Krogstad O., 1999. Adult craniocervical and pharyngeal changes--a longitudinal cephalometric study between 22 and 42 years of age. Part II: Morphological uvulo-glossopharyngeal changes. Eur J Orthod. 21(4). 345-55.
12. Pépin JL., Veale D., Ferretti GR., Mayer P., Lévy PA., 1999. Obstructive sleep apnea syndrome: hooked appearance of the soft palate in awake patients--cephalometric and CT findings. Radiology. 10(1). 163-70.