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Original Article:

Morphometry of the Palate and Pharyngeal Airway- A Computed Tomographic Study

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Abstract: Background: The morphometry of the palate and pharyngeal airway has a crucial role in the development of disorders like apnea. Therefore the present study aims to explore the shape and dimensions of the palate and the pharyngeal airway. Materials and Methods: The study was carried out on normal sagittal and axial sections of head and neck in 100 CT images. Results: The average length of the hard and soft palates measured 4.49±0.38 and 3.44±0.61cm respectively. The anteroposterior dimension of the soft palate was 0.90±0.33 cm. The velopalatine angle measured 130.23±9.98º. The luminal areas were 4.59±1.81, 2.058±1.09 and 2.99±1.08 cm in naso, oro and laryngo pharynx respectively. The soft palate showed varied shapes which were classified as a straight line, leaf-like, rat-tail, distorted S, crooked and butt like. Conclusion: The present study attempts to provide a normal database to understand the anatomy of the soft palate and pharyngeal airways.
Key Words: Palate, Morphometry, Computed tomography, Pharyngeal airway, Apnea

Introduction:
The palate comprises of bony (hard palate) and soft tissues (soft palate). The hard palate is a partion between the nasal and oral cavities while the soft palate is a fibro-musculo-glandular curtain. It hangs from the posterior margin of the hard palate, sloping down and back between the oro and nasopharynx.(1)
The soft palate plays an important in phonation, deglutition, respiration, pronunciation and velopharyngeal competence.(2,3)
The dysfunctions of the soft palate are commonly observed in conditions like cleft lip /palate, enlarged adenoids, poorly retained maxillary denture, skeletal craniofacial malocclusion and obstructive sleep apnoea (OSA).(3-5)
The morphometric analysis of the palate and the pharyngeal airway has therefore gained greater importance and can be conducted using radiography. CT scan is one such important and reliable tool for better assessment of the soft palate and the surrounding structures.(6,7)
The diversity in the radiographic images of the palate has been less recognized. A number of studies in the past have focussed on the dimensional analysis of the palate and its surrounding structures.(8,9) However, the measurements like the velopalatal angle, the luminal areas of the naso, oro and laryngo pharynx have been seldom discussed.
The present study is therefore designed to extensively analyze the normal morphometry of the palate, shape of the soft palate and measurements of the luminal areas of the pharynx which would provide a normal database to understand the anatomy of the palate and the pharyngeal airway.

Methods
The present observational study was carried out on normal sagittal and axial sections of head and neck in 100, 64/16 slice Brilliance CT images, (Philips) of adults procured from the department of Radiology & Radiodiagnosis, Kasturba Medical College, Manipal during the year 2016. The CT images with any pathology of the head and neck regions or with previous surgeries were excluded from the study. The parameters were measured using Meddiff Pacs System.

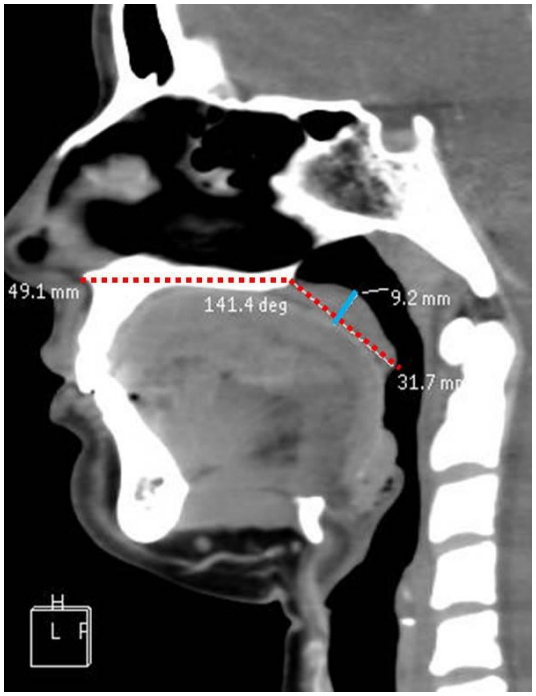

Figure 1: Showing the parameters measured: Length of the hard & soft palate (Red dotted lines), AP dimension (Width) of the soft palate (Blue line), Velopalatal angle.

The following parameters were considered: Length of the hard palate, soft palate i.e., distance from the posterior nasal spine to the tip of the uvula, maximum thickness of the soft palate (antero-posterior dimension), the velo-palatal angle i.e., the angle formed between the hard and the soft palate, angulation between the distal part of the uvula and the longitudinal axis of the soft palate if hooking is present (Figure 1). Further, the luminal area of the airway at the level of nasopharynx (at the level of hard palate; A), oropharynx (20 mm caudal to A), and laryngopharynx (50 mm caudal to A) was also measured (Figure 2).(5) The shape of the soft palate was also identified and classified (Figure 3).

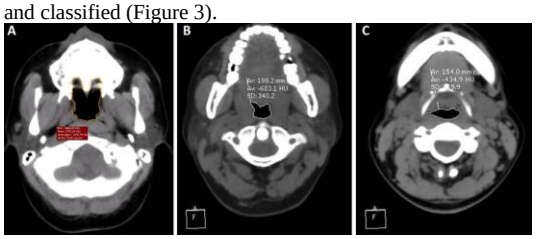

Figure 2: Showing the luminal areas of the pharynx measured. A: Nasopharynx (At the level of hard palate), B: Oropharynx (20mm caudal to A), C: Laryngopharynx (50mm caudal to A)

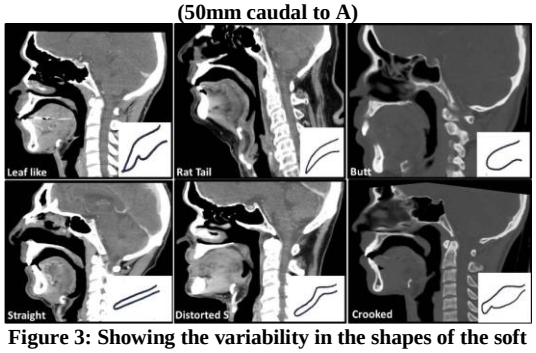

Figure 3: Showing the variability in the shapes of the soft palate

SPSS version 16 was used for the statistical analysis. Kolmogorov-Smirnov test was applied to check the uniform distribution of the data and Levene's test for their homogenecity. The mean parameters were compared between males and females using unpaired t test. p value<0.05 was considered statistically significant.

Results

CT images of 100 adults were included in the study, of which 60 were males and 40 were females. Their age group ranged from 21 to 82 years with a mean age of 50.59±16.67. The average length of the hard palate was 4.49±0.38 cm while that of the soft palate was 3.44±0.61cm. The anteroposterior dimension (thickness) of the soft palate was 0.90±0.33 cm. The velopalatal angle measured 130.23±9.98º. The luminal areas of the naso, oro, and laryngo pharynx were 4.59±1.81, 2.058±1.09 and 2.99±1.08 cm respectively.

The comparison of the parameters between male and females showed a significant increase in the length of the hard palate in males. The length of the soft palate and the antero-posterior dimension (thickness) of the soft palate although showed an increase in males, the findings were however not significant statistically. On the contrary, the velo-palatal angle was greater in females than males but the difference was not significant. The luminal areas of the naso and laryngopharynx was significantly more in males compared to females (Table 1).

Table 1: Comparison of the parameters measured in males and females. *p<0.05

Parameters measured (cm)	Male (Mean±SD) (N=60)	Female (Mean±SD) (N=40)	p value
Length of the hard palate (HP)	4.568±0.406	4.384±0.334	0.02*
Length of the soft palate (SP)	3.459±0.642	3.417±0.581	0.74
Antero-posterior dimension (thickness) of the soft palate	0.952±0.411	0.827±0.147	0.06
Velopalatal angle	128.76±9.788	132.45±9.979	0.07
Luminal area of the Nasopharynx	4.95±1.655	4.08±1.93	0.018*
Luminal area of the Oropharynx	2.143±1.193	1.932±0.942	0.353
Luminal area of the Laryngopharynx	3.215±1.109	2.668±0.97	0.013*

The shape of the soft palate when identified and classified indicated Rat-tail to be the most common type and was found in 30 cases. This was followed by Leaf-like and Crooked Shaped (18 cases each), Distorted S Shaped (13 cases), Butt-like (12 cases) and Straight-line shaped (9 cases) (Table 2, Figure 3).

Table 2: Variability in the shapes of the soft palate in males and females.

Shape of the soft palate	Males		Females	
	(N=60)	%	(N=40)	%
Leaf	9	15	9	22.5
Rat –tail	20	33.3	10	25
Butt-like	9	15	3	7.5
Straight line	4	6.7	5	12.5
Distorted S	6	10	7	17.5
Crooked	12	20	6	15

Discussion

Radiologic studies of the palate morphology may facilitate to diagnose a variety of neurologic, inflammatory and neoplastic disorders of the adult soft palate. The dimensions of the palate and the luminal areas of the pharynx have been studied. These studies reveal that there is an increase in the length and the thickness of the soft palate with age in both the genders. This increase is significantly more in males.(10,11) The present study also revealed greater length and thickness of the soft palate in males. The difference, however, were not significant statistically. The length of the hard palate was significantly higher in males compared to females. Additionally, in the current study, the velopalatal angle when measured showed higher values in females compared to males. The findings, however, were not significant statistically.

Previously authors have studied the velopalatal angle in human fetuses and tried to correlate the changes in the angulation with an increase in the gestational age (GA). They have reported that the angulation between hard and soft palate did not vary much with an increase in GA.(12,13) However there is a scarcity in the existing literature regarding the variability of the velopatalal angle in adults. The difference in the velopalatal angle may be attributed to the different shapes of the soft palate. The decrease in the velopalatal angulation (up to 30 degrees) can result in hooking of the soft palate.(5) This may be a predisposing factor for disorders like OSA.

The normal function of the soft palate is frequently not achieved even after soft palate defect closure in cleft palates. The variation of the soft palate morphology may be a new explanation for the surgical failure.(4,14) Therefore the findings of the present study may be useful during procedures like cleft reconstruction. It may also be beneficial in the aetiological research of OSA.

Previously authors have also studied the morphology of the soft palate and the luminal areas of the pharynx in OSA and snoring patients.(5) Similar attempt was made in the present study but on normal adult individuals. Results showed considerable differences i.e., remarkably higher values of the luminal areas (naso, oro, and laryngo pharynx) were observed in comparison to the pharynx in OSA and snoring patients.

A reduction in the oropharyngeal area was commonly observed in patients with OSA as depicted in the previous study. The cross-sectional area of the laryngopharynx, however, did not show any significant difference. The reduction in the oropharyngeal area was further accentuated by the hooking of the soft palate as observed by the previous authors. In such situations, the changes in the activity of the palatine muscles may trigger the upper airway collapse.(5)

In the present study, the luminal areas of the pharynx when compared between males and females showed significantly larger lumen of the naso and laryngo pharynx in males compared to females. The lumen of the oropharynx, however, did not show any statistical difference. These findings could not be compared with other studies. This is because, there is a scarcity in the existing literature on the luminal areas of the pharynx in normal adult individuals.

The variations in the shape of the soft palate is a common cause for the different dimensions of the soft palate as indicated by the previous studies.(4,9,15,16) You et al had studied and classified the shapes of the soft palate into six different types. They included leaf-like, rat tail, butt shaped, straight, distorted S-shaped and crooked shaped.(4) Other authors have also attempted to classify the same (Table 3). The most common shape of the soft palate as observed in the present study was rat tail. This finding was similar to Praveen et al.(9) However, in the other studies, leaf-shaped was identified to be the most common type.(2,4,15,16)

Table 3: Shape of the soft palate as represented by various studies

Studies	Shape of the Soft Palate (%)					
	Type I: Leaf	Type II: Rat-tail	Type III: Butt	Type IV: Straight	Type V: Distorted 'S'	Type VI: Crooked
You et al[4] (n=200)	53	18.5	13.5	10	3.5	1.5
Praveen et al[9] (n=80)	10	55	8.75	18.75	2.5	05
Deepa et al[15] (n= 120)	38	23	10.8	09	10	6.6
Verma et al[16] (n= 300)	48.7	31	04	8.7	4.7	03
Present study (n=100)	18	30	12	09	13	18

The hooked appearance of the soft palate indicates a high risk of OSA as postulated by Pepin et al.(5) You et al explained that the hooked appearance of the soft palate corresponds to the S-shaped in their classification.(4) In our study, S-shaped soft palate was observed in 13% of the cases.

The soft palate hooking can lead to a sudden and major reductions in the oropharyngeal dimensions, thus increasing upper airway resistance and transpharyngeal pressure gradient resulting in the pharyngeal collapse.(5)

Pre-surgical evaluation of the palate morphology is essential and will aid in the success of the surgery. A detailed knowledge of the anatomical features of the pharyngeal airway is also imperative for future developments in the successful surgical therapy of the region concerned.

Conclusion

The present study may serve as a normal database for the morphology of the palate and the luminal areas of the different parts of the pharynx which would be helpful for the clinicians and surgeons during different diagnostic and therapeutic procedures of the pharynx.

Conflict of Interest: None

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