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Evaluation of Soft Palate Morphological Types in Cone Beam Computed Tomography Using Need's Ratio

Konik Işınlı Bilgisayarlı Tomografide Yumuşak Damak Morfolojik Tiplerinin Need's Oranı Kullanılarak Değerlendirilmesi

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ABSTRACT

Objectives: The aim of this study is to determine the soft palate morphology in several age and gender groups and to find its relationship with Need's ratio, Velum Length, Velum Width and Pharyngeal Depth with using Cone Beam Computed Tomography (CBCT).

Materials and Methods: 122 CBCT scans were analyzed for velar morphology and classified into different types. Velum Length, Velum Width, and Pharyngeal Depth were measured on CBCT. Need's ratio was calculated by dividing Pharyngeal Depth to Velum Length.

Results: Of all the types of soft palates in the study, rat tail shaped was most commonly found. While the mean soft palate length and width were higher in males, the Need's ratio was higher in females. There was a significant relationship between the mean velar length and various age groups and the values increased with increasing age. There was no significant difference between the mean velar width and Need's ratio between age groups.

Conclusion: Morphometric analysis of the soft palate in the CBCT scan helped us understand the diversity in types of palate morphology. This study may be a source for research on the etiological causes of velopharyngeal insufficiency and Obstructive sleep apnea syndrome.

Keywords: *Cone-Beam Computed Tomography, Morphology, Soft palate*

ÖZET

Amaç: Bu çalışmanın amacı, Konik Işınlı Bilgisayarlı Tomografi (KIBT) kullanarak çeşitli yaş ve cinsiyet gruplarında yumuşak damak morfolojisini belirlemek ve Need's Oranı, Velum Uzunluğu, Velum Genişliği ve Faringeal Derinlik ile ilişkisini bulmaktır.

Gereç ve Yöntemler: 122 KIBT taraması velar morfoloji açısından analiz edildi ve farklı tiplere göre sınıflandırıldı. KIBT'de Velum Uzunluğu, Velum Genişliği ve Faringeal Derinlik ölçüldü. Need's oranı, faringeal derinliğin velum uzunluğuna bölünmesiyle hesaplandı.

Bulgular: Çalışmadaki tüm yumuşak damak tipleri arasında en yaygın olarak sıçan kuyruğu şekli bulundu. Erkeklerde ortalama yumuşak damak uzunluğu ve genişliği daha fazla iken, Need's oranı kadınlarda daha yüksekti. Ortalama damak uzunluğu ile çeşitli yaş grupları arasında anlamlı bir ilişki vardı ve değerler yaş arttıkça arttı. Yaş grupları arasında ortalama damak genişliği ve İhtiyaç oranı arasında anlamlı bir fark yoktu.

Sonuç: KIBT taramasında yumuşak damağın morfometrik analizi damak morfolojisi türlerindeki çeşitliliği anlamamıza yardımcı oldu. Bu çalışma velofaringeal yetmezlik ve Obstrüktif uyku apne sendromunun etiyolojik nedenleri konusunda yapılacak araştırmalara kaynak olabilir.

Anahtar Kelimeler: *Konik Işınlı Bilgisayarlı Tomografi, Morfoloji, Yumuşak damak*

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Introduction

The soft palate or velum is a mobile muscle flap situated behind the hard palate that separates the oral and nasal parts of the pharynx.[1,2] It participates in velopharyngeal opening and closing by taking part in most oral functions such as blowing, sucking, deglutition, respiration, and pronunciation.[1]

The velopharyngeal mechanism includes the posterior and lateral pharyngeal walls, the velum, and a muscular valve named the velopharyngeal port. By separating the oral and nasal cavities, the velopharyngeal mechanism forms a sphincteric system between the velar and pharyngeal regions.[3] Failure of the velopharyngeal mechanism to function causes velopharyngeal insufficiency (VPI).[4,5] Cleft palate, grown adenoids, obstructive sleep apnea (OSA) and skeletal malocclusions are usually reasons for VPI.[1,6,7] Therefore, examination of soft palate shape, length, and width is important to assess for velopharyngeal regurgitation.

The association between velum length (VL) and pharyngeal depth (PD) can determine velopharyngeal function.[8] PD divided by VL is named Need's ratio (NR). According to Subtelny,[8] the NR should be in the range of 0.6–0.7 in normal individuals.

Various studies have been conducted using the lateral cephalogram to examine the morphological variations of the velum. You et al.[6] observed that the soft palate configuration occurs in various ways in normal individuals and classified morphological variations into six velar shapes; Type 1: Leaf-shaped, 2: Rat-tail, 3: Butt-like, 4: Straight-line, 5: S-shaped, 6: Hook-shaped. According to Pepin et al.'s 9 research, a soft palate that is "Hooked or S-shaped" is a risk factor for Obstructive Sleep Apnea Syndrome (OSAS).

According to the literature review, Cone Beam Computed Tomography (CBCT) studies are limited to examining soft palate morphological types. Thus, the purpose of this research is to ascertain the different morphological velum types in CBCT according to several age and gender specific groups and to detect their relation with Need's Ratio (NR), Velum Length (VL), Velum Width (VW), and Pharyngeal Depth (PD).

Metarials and Methods

This retrospective study was conducted with a study sample consisting of a total of 122 CBCT scans of age range 15–77 years who applied to the Istanbul Medipol University School of Dentistry Department of Dentomaxillofacial Radiology for various reasons between 2015 and 2021. Patients under the age of 15, patients with cleft palate, soft palate syndromes, systemic disease, and head and neck fractures were excluded. This current study was accepted by the Research Ethics Committee of the Istanbul Medipol University (E-10840098-9047). Soft palate morphologies were analyzed into seven types according to their radiographic appearance[6,11] (Fig. 1-a, 1-b, 1-c, 1-d, 1-e, 1-f, 1-g). The VL was measured as the straight distance from the posterior nasal spine to the end of the soft palate (Fig. 2-a). The VW measurement is a straight measurement of the thickest part perpendicular to soft palate length (Fig. 2-b). PD is linearly measured from the posterior nasal spine to the posterior pharyngeal wall[10](Fig. 2-c). NR was calculated by dividing PD by VL for all cases. The CBCT images were obtained using an i-CAT 17-19 Imaging System (Imaging Sciences International, Inc., Hatfield, PA, USA) with a tube potential of 120 kVp and 20.27 mAs, a field of view of 16×6 cm, a voxel size of 0.25, and an exposure period of 14.7 seconds. The patients were placed on the CBCT device in a vertical position with the horizontal plane parallel to the ground and the head and chin stabilized.

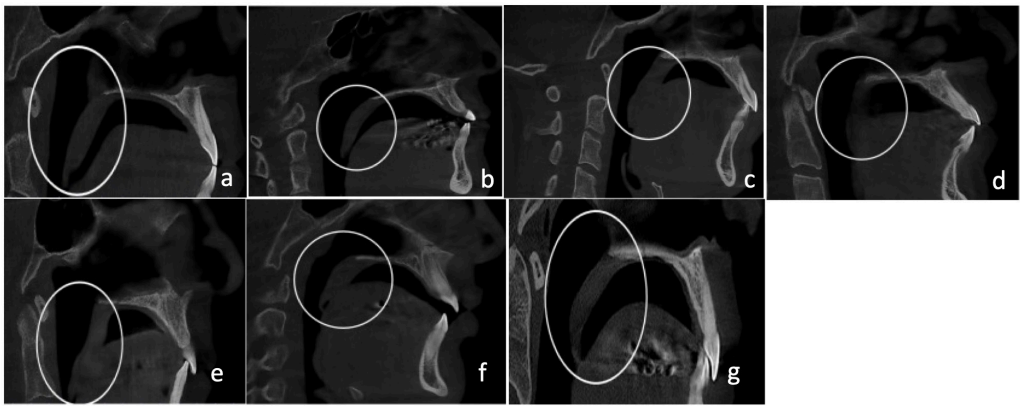

Figure 1. Leaf shape of velum (a), Rat Tail shape of velum(b), Butt shape of velum(c), Straight line shape of velum(d), S-shape of velum(e), Crook shape of velum(f), Handle shape of velum(g).

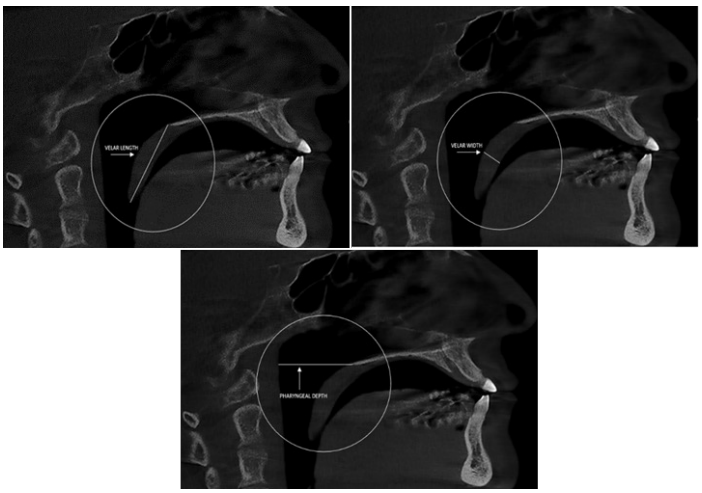

Figure 2. Image showing velar length(a), velar width(b), pharyngeal depth(c).

The data was analyzed using the IBM® SPSS® Statistics 22 statistical software. The Kolmogorov-Smirnov and Shapiro-Wilks tests were used to evaluate the parameters' consistency for the normal distribution, and it was determined that the parameters were consistent for the normal distribution. The one-way ANOVA test was used to compare the parameters among more than two groups in the comparison of quantitative data. If the variances of the groups were homogeneous, the Tukey HDS test was used, and if they were not, the Tamhane's T2 test was used. The Student t-test was applied to compare the parameters of two groups. To compare qualitative data, a chi-square analysis was performed. The $p<0.05$ level was used to determine significance.

Results

This study was carried out with a total of 122 subjects, 61 (50%) males and 61 (50%) females, aged between 15 and 77. The mean age is 41.11±15.88 years (Table[1]).

The rat tail shape (type two) was most prevalent (74, 60.7%) in the current study, followed by the butt shape (type three), (14, 11.5%). Leaf shape (type one), (10, 8.2%) was the third most common soft palate type. The new morphological type handle found in the study by Agrawal et al.[11] was nine (7.4%) in this study. S-shaped was the least common type of soft palate (3.3%), (Table 1).

Table 1. Distributions of demographic characteristics

		n	%
Gender	Male	61	50
	Female	61	50
Age	15-20	18	14.8
	21-30	19	15.6
	31-40	17	13.9
	41-50	32	26.2
	51-60	24	19.7
	61 and above	12	9.8
Soft Palate Types	Type 1	10	8.2
	Type 2	74	60.7
	Type 3	14	11.5
	Type 4	5	4.1
	Type 5	4	3.3
	Type 6	6	4.9
	Handle	9	7.4

There is a statistically considerable diversity among the age groups in terms of the distribution of soft palate types (p:0.029; p<0.05). The incidence of Type teo and Type three in the 41–50 age group is remarkably higher than in the 15-20 age group. It is not statistically significant among other age groups (p:0.007; p<0.05). According to statistical data, gender was not an important factor affecting soft palate shape (p>0.05). Therefore, it is concluded that gender cannot be determined from soft palate types (Table 2).

Table 2. Evaluation of soft palate types according to gender and age

		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Handle	p
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
Gender	**Male**	7 (%11.5)	30(%49.2)	9 (%14.8)	3 (%4.9)	3 (%4.9)	4 (%6.6)	5 (%8.2)	0.288
	Female	3 (%4.9)	44(%72.1)	5 (%8.2)	2 (%3.3)	1 (%1.6)	2 (%3.3)	4 (%6.6)	
Age	**15-20**	2 (%11.1)	7 (%38.9)	1 (%5.6)	1 (%5.6)	0 (%0)	5 (%27.8)	2 (%11.1)	0.029*
	21-30	3 (%15.8)	11(%57.9)	2 (%10.5)	0 (%0)	1 (%5.3)	0 (%0)	2 (%10.5)	
	31-40	1 (%5.9)	10(%58.8)	2 (%11.8)	2 (%11.8)	0 (%0)	1 (%5.9)	1 (%5.9)	
	41-50	1 (%3.1)	24 (%75)	5 (%15.6)	1 (%3.1)	1 (%3.1)	0 (%0)	0 (%0)	
	51-60	2 (%8.3)	15(%62.5)	3 (%12.5)	1 (%4.2)	0 (%0)	0 (%0)	3 (%12.5)	
	61+	1 (%8.3)	7 (%58.3)	1 (%8.3)	0 (%0)	2 (%16.7)	0 (%0)	1 (%8.3)	

Chi-square test *p<0.05

A statistically significant result was obtained when the mean VW was compared according to the soft palate types. The mean VW of Type three was found to be significantly higher than Type two and Type four (p_1:0.004; p2:0.005; p<0.05). The mean VW of Type six was found to be significantly higher than Type four (p_1:0.037; p<0.05). There is no statistically considerable discrepancy among the means of VL, PD and NR according to velum types (p>0.05) (Table 3).

Table 3. Correlation of mean velar length, velar width, pharyngeal depth, and Need's ratio with morphological types of soft palate

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Handle	p
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
VL	34.83±4.85	38.54±4.77	38.69±5.14	36.85±3.55	39.9±6.08	34.4±2.7	35.88±5.43	0.084
VW	10.40±1.5	10.01±1.83	11.86±3.57	8.69±1.53	10.59±2.08	11.41±2.07	10.19±2.42	0.043*
PD	24.92±1.49	26.06±3.27	26.42±4.06	24.65±2.66	26.44±2.21	25.73±3.49	26.71±2.77	0.827
NR	0.73±0,.[1]	0.68±0.1	0.69±0.09	0.67±0.1	0.68±0.12	0.75±0.09	0.76±0.11	0.280

Oneway ANOVA test, VL: Velar Length, VW:Velar Width, PD: Pharyngeal Depth, NR: Need's Ratio *p<0.05

VL and VW mean values were significantly higher in males (p:0.002; p<0.05)- (p:0.008; p<0.05). There was no important diversity among the mean PD of females and males (p>0.05). The mean NR is notably higher in females (p:0.023; p<0.05), (Table 4).

While the mean VL and PD are statistically considerable among age groups (p<0.05), there is no considerable correlation between the mean VW and NR (p>0.05). The VL of the 15-20 and 21-30 age groups was concluded to be notably lower than the other age groups. The mean PD of the 15-20 age group was found to be notably lower than that of the 51–60 and over 61 age group. The mean PD of the 31–40 age group was found to be significantly lower than that of the over-61 age group. There was no statistically remarkable diversity among other age groups (p>0.05), (Table 5).

Table 4. Correlation of mean velar length, velar width, pharyngeal depth, and Need's ratio with gender

	Male	Female	p
	Mean±SD	Mean±SD	
VL	39.17±5.16	36.48±4.26	0.002*
VW	10.82±1.82	9.78±2.42	0.008*
PD	26.17±3.14	25.82±3.2	0.541
NR	0.67±0.09	0.72±0.11	0.023*

Student t test VL: Velar Length, VW: Velar Width, PD: Pharyngeal Depth, NR: Need's Ratio *p<0.05

Table 5. Correlation of mean velar length, velar width, pharyngeal depth, and Need's ratio with age groups

	15-20	21-30	31-40	41-50	51-60	61+	p
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
VL	34,55±4,48	35,34±3,5	36,12±4,87	39,38±5,35	39,89±3,43	40,8±3,91	0,000*
VW	10,2±1,68	9,59±1,47	10±1,81	10,79±3,01	10,35±2,29	10,6±1,34	0,533
PD	24,28±2,88	25,57±2,46	24,98±3,6	25,87±3,47	27,29±2,31	28,39±2,57	0,002*
NR	0,72±0,13	0,73±0,09	0,7±0,12	0,67±0,1	0,69±0,08	0,7±0,07	0,316

Oneway ANOVA test < VL: Velar Length, VW:Velar Width, PD: Pharyngeal Depth, NR: Need's Ratio *p<0.05

Discussion

There are several methods to assess velopharyngeal morphology and function, such as videofluoroscopy, nasopharyngeal endoscopy, lateral cephalometrics, magnetic resonance imaging (MRI), and computed tomography (CT). The benefits of CBCT scanning include minimal superimposition of structures, correct identification of landmarks, and better visualization. Therefore, various morphological measurements of the soft palate were obtained using CBCT to assess pharyngeal and soft palate morphology in the median sagittal plane.

In this study and Dahal et al.'s[12] study the most prevalent velum shape found was type two (60.7%

cases, 42.4% cases), whereas You et al.[6], Niu et al.[13], Kumar and Gopal[14] and Verma et al.[15] found that type one (leaf shape) was the most prevalent in their researches. Type six was seen at 4.9% and it was found only in the 15–20 and 31–40 age groups. Agrawal et al.[11] found that the new soft palate shape, which they defined as the handle shape, was found at 7.4% in the current study.

OSAS is characterized by recurrent occlusion of partial or complete airway obstruction as a result of the collapsing back of the pharyngeal walls while sleeping.[16-18] Nighttime sleep deprivation due to reduced airflow results in excessive sleepiness during the daytime. Common symptoms of OSAS include attention deficit disorder, daytime sleepiness, headache, and loss of activity. OSAS is also associated with cardiac, pulmonary, and nervous system diseases.[19] Pepin et al.[9] reported that the risk of OSA is high in patients with a soft palate morphology defined as type five (S-shaped). In this study Type five (S-shaped) velar shape was found in 3.3% of cases. Comparative studies were conducted by You et al.[6] and Guttal et al.[20]. They found that Type five (S-shaped) accounts for 3.5% and 1.5% of cases respectively.

The separation of the oral and nasal cavities occurs through the velopharyngeal port. The most important muscle for velopharyngeal closure is the levator veli palatini.[1] If the velopharyngeal port does not fulfil its function, VPI occurs.[3] Hoopes et al.[21] suggested that the VL/PD is 1.35 in normal adults. Schendel et al.[22] and Simpson and Austin[23] concluded in their cephalometric study that a NR greater than 1 is an indicator of VPI. According to Subtelny[8], NR greater than 0.7 causes VPI. In this study, the average NR, which is higher in females than in males, was reported as 0.72 in females. This result contrasted with the results of Simpson and Colton,[10] Hoopes et al.[21] and Subtelny,[8] while being similar to the results of Guttal et al.[20] Thus, as in the study of Verma et al.,[15] it was concluded that women have a higher risk of VPI than men.

In the current study, there is an increase in VL with increasing age. Similar findings were found in studies done by Verma et al., 15 Johnston and Richardson 24 and Taylor et al.[25]

In this study, males mean velar length was statistically significantly higher than females. However, the increase in VL was equal for men and women in Kollias and Krogstad's study.[26]

This study provides important information to healthcare professionals such as dentists, otolaryngologists and speech therapists by examining the diversity of soft palate types and their potential contribution to clinical practice. This information can help better guide patients' diagnosis and treatment processes and identify health problems early.

The limitations of this study include the inability to clinically evaluate the patients. The correlation between the increase in NR and the presence of OSA in the patient could not be evaluated. Studies should be conducted to compare CBCT imaging with other imaging modalities, with a larger sample size and clinical examination.

Conclusion

In this study using CBCT, the most common type two and other soft palate morphological types were emphasized. The risk of developing VPI is higher in women and in the 15–20 and 21–30 age groups. It has been observed that those with the handle type have a higher risk of developing VPI. The statistical findings in this study may be helpful in investigating the etiological causes of velopharyngeal insufficiency and obstructive sleep apnea.

Conflict of interest

None of the authors of this article has any relationship, connection or financial interest in the subject matter or material discussed in the article.

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