ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.17567/currresdentsci.1484849

Evaluation of Variations in Morphology and Morphometry of the Hard Palate Using CBCT Images: A Radio-Surgical Perspective

CBCT Görüntüleri Kullanılarak Sert Damağın Morfolojisi ve Morfometrisindeki Varyasyonların Değerlendirilmesi: Radyo-Cerrahi Bir Bakış Açısı

Melda Pelin AKKİTAP[1]

[1] Department of Oral and Maxillofacial Radiology, Biruni University, Faculty of Dentistry, İstanbul, Türkiye

ABSTRACT

Objective: This retrospective study aims to unveil the changes in morphology and morphometric features of hard palate on cone-beam computed tomography (CBCT) images and evaluate its age- and gender- related variations in a Turkish subpopulation.

Methods: The present investigation analyzed CBCT of 300 individuals aged between 19 and 71 retrospectively. Measurements of palate dimension (length, breadth, and height) and palate inclination (superior, parallel, and inferior) and the calculation of palatine index (leptostaphylline, mesostaphylline, and brachystaphylline) and palatine height index (chamestaphylline, orthostaphylline, and hypsistaphylline), were quantified and statistically evaluated.

Results: The mean length, breadth, and height of hard palate were found as 48.79±3.8 mm, 39.67±3.43 mm, and 12.79±3.01 mm, respectively. The palatine index was mostly brachystaphylline (99.67%), followed by leptostaphylline (0.33%) and mesostaphylline (0%). The palatal height index was mostly orthostaphylline (58.33%), followed by chamestaphylline (28%) and hypsistaphylline (13.67%). A significant difference between genders was not detected in the palate inclination, palatine index and height index compared to other parameters ($p>0.05$). The largest palate breadth and inferiorly inclined palate are mostly observed in those aged ≥25 years than in those aged ≤24 years (P=.015 and P=.010, respectively; P<.05).

Conclusion: The results of present investigation will provide useful radio-anatomical data for the prevention of possible complications of surgical procedures.

Keywords: Morphometry, Morphology, Hard Palate, Cone-Beam Computed Tomography

ÖZ

Amaç: Bu retrospektif çalışmanın amacı, konik ışınlı bilgisayarlı tomografi (CBCT) görüntülerinde sert damağın morfolojisi ve morfometrik özelliklerindeki değişiklikleri ortaya koymak ve Türk alt popülasyonunda yaşa ve cinsiyete bağlı varyasyonları değerlendirmektir.

Yöntemler: Mevcut araştırmada 19 ila 71 yaşları arasındaki 300 bireyin CBCT'si retrospektif olarak analiz edildi. Damak boyutunun (uzunluk, genişlik ve yükseklik) ve damak eğiminin (üst, paralel ve alt) ölçümleri ve palatin indeksi (leptostafilin, mezostafilin ve brakistafilin) ve palatin yükseklik indeksinin (kamestafilin, ortostafilin ve hipsistafilin) hesaplanması kantifize edildi ve istatistiksel olarak değerlendirildi.

Bulgular: Sert damağın ortalama uzunluğu, genişliği ve yüksekliği sırasıyla 48,79±3,8 mm, 39,67±3,43 mm ve 12,79±3,01 mm olarak bulundu. Palatin indeksi çoğunlukla brakistafilin (%99,67), ardından leptostafilin (%0,33) ve mezostafilin (%0) idi. Palatal yükseklik indeksi çoğunlukla ortostafilin (%58,33), ardından kamestafilin (%28) ve hipsistafilin (%13,67) idi. Diğer parametrelere kıyasla damak eğimi, palatin indeksi ve yükseklik indeksinde cinsiyetler arasında anlamlı bir fark tespit edilmedi (P>,05). En geniş damak genişliği ve aşağı eğimli damak çoğunlukla ≥25 yaşındakilerde, ≤24 yaşındakilere göre gözlenmektedir (sırasıyla P=,015 ve P=,010; P<,05).

Sonuç: Mevcut araştırmanın sonuçları cerrahi prosedürlerin olası komplikasyonlarının önlenmesi için yararlı radyo-anatomik veriler sağlayacaktır.

Anahtar Kelimeler: Morfometri, Morfoloji, Sert Damak, Konik Işınlı Bilgisayarlı Tomografi

INTRODUCTION

The hard palate consists of the palatal process of maxilla and the horizontal lamina of palatal bone and forms the roof of the mouth by separating the nasal cavity superiorly and the oral cavity inferiorly.[1-3] It serves as a guide in dentistry for surgical procedures such as extraction of maxillary molar teeth, placement of orthodontic mini-implants, surgical interventions to cysts and tumours, and graft harvesting

Geliş Tarihi/Received 15.05.2024
Revizyon Talebi/Revision Requested 28.08.2024
Son Revizyon/Last Revision 03.11.2024
Kabul Tarihi/Accepted 12.11.2024
Yayın Tarihi/Publication Date 24.07.2025

Sorumlu Yazar/Corresponding author: Melda Pelin Akkitap
E-mail: pelinakkitap@hotmail.com

Cite this article: Akkitap MP. Evaluation of Variations in Morphology and Morphometry of the Hard Palate Using CBCT Images: A Radio-Surgical Perspective. *Curr Res Dent Sci.* 2025;35(2): 232-236.

from the palatal region.[4-7] In this respect, a detailed knowledge about the palatal morphology and morphometry may guide surgical approaches in the palatal area and help decrease the neurovascular surgical injuries and failures in anaesthesia techniques.

Cone-beam computed tomography (CBCT) is the preferred radiological technique for detailed evaluation of bone structures in the craniofacial region. CBCT examinations provide serious advantages in terms of obtaining diagnostic information without superposition, providing precise and accurate three-dimensional information about the relationship with adjacent anatomical structures, and being superior in terms of image quality.[4,8-10] In the literature review, there are only few useful studies examining palatal morphology and morphometry with CBCT[1,4,8-13], although most previous studies on this topic were performed on dry skulls.[14-22]

Due to the lack of sufficient data about the morphological and morphometric analysis of the hard palate using CBCT, especially in Turkey, the present investigation aims to evaluate the morphology and morphometry of palatal bone on CBCT images according to demographic characteristics of a Turkish subpopulation.

METHODS

The design of this retrospective radiological study was reviewed and approved by the Research Ethics Committee of Biruni University Faculty of Dentistry (Date: 24.01.2024, protocol number: 2024/27-86). CBCT images of patients who admitted to the Department of Oral and Maxillofacial Radiology in Faculty of Dentistry, Biruni University between July 2019 and December 2019 were retrospectively assessed.

The CBCT records of approximately 1137 patients were examined, but only 300 patients fully met the eligibility criteria. CBCT scans showing all maxillary molars bilaterally from patients over 18-year-old from both genders were included in the sample. CBCT images with pathological maxillary deformities, history of orthognathic surgery, and poor quality images that could compromise appropriate evaluation of the region of interest were excluded.

All CBCT scans were collected with the patient in a standing position using a Sirona Galileos Comfort Plus device (Dentsply Sirona, York, PA, USA), which was operated at 98 kVp and 6 mA with a rotation time of 36 seconds, voxel size 250 µm and field of view 150 × 150 mm. The CBCT images were evaluated in all 3 planes (coronal, axial and sagittal) using Sidexis software (Dentsply Sirona).

A single observer (MPA) investigated and double-checked the CBCT images. Intra-observer agreement on the parameters was determined according to the calculation of Cohen's kappa value and re-evaluation of 30 randomly selected CBCT images at an 8-week interval. All Kappa values were calculated to be higher than 0.90.

All CBCT scans were manually reoriented for standardization before the evaluation. In the coronal plane, the vertical reference line of the software was positioned along the median sagittal plane, which divides the head into right and left sections and intersects the nasal septum. In the axial plane, bilateral zygomatic structures were positioned at the same angle and the same level, while the Frankfort plane served as the true horizontal axis in the sagittal plane. The qualitative and quantitative analysis of the hard palate morphology and morphometry was carried out according to Miranda-Viana et al.[4], Premkumar[14], and Sarilita and Soames[15] methodologies. Palatal length was measured as the distance between the Orale, which is located in the middle of the line passing through the socket edges of both maxillary central incisors in posterior region, and the staphylion, which is located at the base of the posterior nasal spine (Figure 1a), whereas the palatal breadth was calculated as the maximum arch distance relative to the line drawn between the maxillary second molars (Figure 1b).[4,14,15] In the evaluation of the palatal height, the distance obtained between the socket edges of the maxillary second molars in the palatal surface was considered (Figure 1c).[1,14,15] A horizontal line extending towards the anterior and posterior nasal spines was considered to evaluate the inclination of hard palate. According to the inclination of this line relative to the horizontal plane, the hard palate was categorized as follows: superiorly inclined (Figure 2a); parallel (Figure 2b); and inferiorly inclined (Figure 2c).[4]

Figure 1. Measurement of the palatal length **(a)**, breadth **(b)**, and height **(c)**.

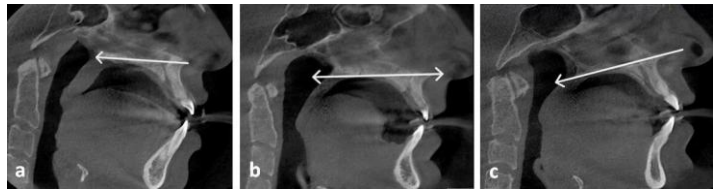

Figure 2. Evaluation of the superiorly **(a)**, parallel **(b)**, and inferiorly **(c)** inclined hard palate.

The palatine index calculation was performed according to the palatine breadth to length ratio expressed as a percentage, while the palate height index calculation was performed according to the palatine height-to-breadth ratio expressed as a percentage. The palatine index was grouped as follows: leptostaphylline (narrow palate:<80), mesostaphylline (intermediate type:80–84.9), and brachystaphylline (wide palate:≥85). The palate height index was divided into chamestaphylline (low palate:<28), orthostaphylline (intermediate type:28–39.9), and hypsistaphylline (deep palate:≥40).[1,4]

Statistical analysis was conducted by using the IBM SPSS® Statistics software version 25.0 (IBM SPSS Corp.; Armonk, New York, USA). The Kolmogorov-Smirnov statistical test for the analysis of histograms is presented. The descriptive characteristics of collected data were offered as mean and standard deviation (Mean±SD) and median (Min–Max: minimum–maximum). 2x2 Pearson Chi-Square Test was used in the comparison of qualitative data. The comparison between the means of a normally distributed interval dependent variable for two independent groups was performed by using Independent Samples T-Test. The statistically significant difference was set at $P<.05$.

RESULTS

This retrospective study analyzed the CBCT images of 300 patients, including 172 females aged 19 to 63 years (mean age 35.36±8.59 years) and 128 males aged 25 to 71 years (mean age 37.39±7.89 years). Considering that the normal age of skeletal maturity is 25, the patients were divided into over 25 years of age and under 25 years of age. Table 1 demonstrates the distribution of patients by age and gender.

The values of all parameters are shown in Table 2. The palatal length, breadth, and height were 48.79±3.8 mm, 39.67±3.43 mm, and 12.79±3.01 mm, respectively. 207 individuals showed inferiorly inclined

palates, 90 patients had superiorly inclined palates, and 3 individuals had parallel palates. The palatine index were mostly brachystaphylline (99.67%), followed by leptostaphylline (0.33%) and mesostaphylline (0%). Considering the palatal height index, most of the patients were orthostaphylline (58.33%), followed by chamestaphylline (28%) and hypsistaphylline (13.67%).

Table 1. Distribution of patients by age group and gender.

Demographic Features		N / Mean±SD	% / Median (Min-Max)
Age (years)	≤24	10	(3.33)
	≥25	290	(96.67)
	Total	36.23±8.35	35 (19-71)
Gender	Female	172	(57.33)
	Male	128	(42.67)

N: number, SD: standard deviation, Min: minimum, Max: maximum

Table 2. Descriptive statistics of the study parameters

Parameters		N / Mean±SD	% / Median (Min-Max)
Palate dimension	Length	48.79±3.8	48.6 (31.09-65.16)
	Breadth	39.67±3.43	39.6 (29.21-50.01)
	Height	12.79±3.01	12.41 (5.6-31.21)
Palate inclination	Superior	90	(30)
	Parallel	3	(1)
	Inferior	207	(69)
Palatine index	Leptostaphylline	1	(0.33)
	Mesostaphylline	0	(0)
	Brachystaphylline	299	(99.67)
Palatine height index	Chamestaphylline	84	(28)
	Orthostaphylline	175	(58.33)
	Hypsistaphylline	41	(13.67)

The parameter values according to the age groups and gender of the patients are given in Table 3. Significant differences were detected between males and females in all parameters except for the palate inclination, palatine index and height index. The higher values of palatal length, breadth, and height were calculated in males compared to females (P <.001; P<.05). Considering the gender distribution of palate inclination, palatine index and palatine height index, there was not significant difference in the distribution of parameters between males and females (P >.05). When compared the patients aged ≤24 and ≥25, the largest palatal breadth and inferiorly inclined palate are mostly observed in those aged ≥25 years than in those aged ≤24 years (P=.015 and P=.010, respectively; P<.05).

DISCUSSION

The palatal bone is an important region of the cranium and many clinical procedures in dentistry such as dentofacial orthopedics, implant surgery, maxillary orthodontic protraction and operative management of oral pathology in maxillary region require a surgical approach to the hard palate.[1,14,15] In this regard, the anatomy and morphological variation of the hard palate have still been of interest in several studies. However, the literature review shows that there is a lack of comparable research on the morphology and morphometry of hard palate using CBCT images and most of the studies on this subject have been conducted on dry skulls, investigating skull skeletons with unknown gender[16-19] and gender-specific.[20-22]

The present study included CBCT scans of 300 patients and determined the palate length, breadth, and height as 48.79±3.8 mm, 39.67±3.43 mm and 12.79±3.01 mm, respectively. A similar study investigating CBCT scans of 175 patients documented 48.8±3.9 mm palate length, 36.2±3.8 mm palate breadth and 11.6±2.4 mm palate height.[1] According to previous studies conducted on skull skeletons, the mean values ranges between 47.10±3.34 to 52.3±3.2 mm for the palate length and 36.26±2.55 to 47.10±3.34 mm for the palate breadth but these studies provided no data regarding the palate height.[16-19]

In present study, it was found that the palatal length, breadth, and height were significantly different between genders (P <.001; P <.05). In accordance with the present study, another CBCT study demonstrated that males have a higher mean palatal length, breadth, and height compared to females.[1] In a study on the Turkish population using CBCT images, the palate length and breadth were found to be larger in males than females.[11] Furthermore, there are several studies on dry skulls which noted gender-related significant differences in palatal length and breadth.[20-22] This demonstrates that males have larger skulls than females.[23] According to the result of the present study, the palate breadth was larger in the patients aged ≥25 regardless of gender, which is congruent with the study conducted by Kaplanoğlu et al.[11].

In regard to the palate inclination, 207 patients showed inferiorly inclined palates, 90 patients had superiorly inclined palates, and 3 patients had parallel palates in present investigation. In addition, no significant difference was found between the palate inclination and genders akin to the results from a study by Miranda et al[4]. Also, Miranda et al.[4] found that 127 patients had inferiorly inclined palates, 122 patients had parallel palates, and 49 patients has superiorly inclined palates on CBCT images.

Table 3. Parameter values and comparisons according to the age groups and gender of the patients.

Parameters		Age					Gender				
		≤24		≥25		P	Female		Male		P
		N / Mean±SD	% /Median (Min-Max)	N /Mean±SD	% / Median (Min-Max)		N / Mean±SD	% /Median (Min-Max)	N /Mean±SD	% / Median (Min-Max)	
Palate dimension	Length	49.37±6.85	47.07 (41.02-65.16)	48.77±3.67	48.62 (31.09-57.64)	.628[a]	47.82±3.49	47.81 (31.09-65.16)	50.11±3.81	50.01 (40.5-57.64)	<.001[a*]
	Breadth	37.08±2.63	35.92 (34.63-42.15)	39.76±3.42	39,61 (29.21-50.01)	.015[a*]	38.61±3.03	38,8 (29.21-46.42)	41.1±3.42	41.32 (29.6-50.01)	<.001[a*]
	Height	13.03±2.26	13.2 (9.63-16.35)	12.78±3.03	12.41 (5.6-31.21)	.794[a]	11.95±2.85	12 (5.6-31.21)	13.91±2.85	14 (7.61-22.8)	<.001[a*]
Palate inclination	Superior	4	(40)	86	(29.66)	.010[b*]	50	(29.07)	40	(31.25)	.879[b]
	Parallel	1	(10)	2	(0.69)		2	(1.16)	1	(0.78)	
	Inferior	5	(50)	202	(69.66)		120	(69.77)	40	(67.97)	
Palatine index	Leptostaphylline	0	(0)	1	(0.34)	.852[b]	1	(0.58)	0	(0)	.388[b]
	Mesostaphylline	0	(0)	0	(0)		0	(0.00)	0	(0)	
	Brachystaphylline	10	(100)	289	(99.66)		171	(99.42)	128	(100)	
Palatine height index	Chamestaphylline	1	(10)	83	(28.62)	.344[b]	60	(34.88)	24	(18.75)	.002[b]
	Orthostaphylline	8	(80)	167	(57.59)		96	(55.81)	79	(61.72)	
	Hypsistaphylline	1	(10)	40	(13.79)		16	(9.30)	25	(19.53)	

***N:** number, **SD:** standard deviation, **Min:** minimum, **Max**: maximum.*

**Statistically significant at level P<.05 (Independent-Samples T test[a] and Chi-Square test[b])*

Considering the palatine index, brachystaphylline (99.67%) was mostly observed, followed by leptostaphylline (0.33%), and mesostaphylline (0%). In a similar CBCT study, Araby et al.[1] reported that most patients were leptostaphylline (76.6%), followed by mesostaphylline (12%), and brachystaphylline (11.4%). Also, Kaplanoğlu et al.[11] stated that 92.8% of the Turkish patients were mostly leptostaphylline. On the other hand, the results of current study are conformed to those of some authors using dry skulls in their studies[17,24] but differ from other studies with dry skulls[16,18].

Regarding the gender distribution of the palatine index, this study demonstrated there was no statistically significant difference between genders (*P*>.05). This is consistent with the observation of a previous study on Turkish population using CBCT images[11], but another study involving dry skulls of the Turkish population reported that there was a significant difference between males and females.[25]

In present study, most patients were orthostaphylline (58.33%), followed by chamestaphylline (28%), and hypsistaphylline (13.67%) and no significant gender-related differences were found (*P*>.05). These results are similar to those of a study involving CBCT images conducted by Araby et al.[1], in whose study, most of patients were orthostaphylline (59.4%), followed by chamestaphylline (26.3%) and hypsistaphyline (14.3%). Furthermore, this is consistent with the observation of Sarilita and Soames[15], but D'Souza et al.[24] stated that chamestaphylline was mostly observed (87.5%).

In conclusion, the present study contributes significant information about the hard palate morphology and morphometry, which will be useful for the treatment planning and prevention of possible complications during oral surgical procedures. Also, the results of this study are expected to be guide for future studies on the morphological and morphometric variation in hard palates of Turkish patients using CBCT images

Ethics Committee Approval: Ethics committee approval was obtained from Biruni University Local Ethics Committee (Date: 24.01.2024, Number: 2024/27-86).

Informed Consent: Informed consent was not obtained due to the retrospective nature of this study.

Peer-review: Externally peer-reviewed.

Author Contributions: **C**oncept - M.P.A.; Design - M.P.A.; Supervision - M.P.A.; Resources - M.P.A.; Data Collection and/or Processing - M.P.A.; Analysis and/or Interpretation - M.P.A.; Literature Search - M.P.A.; Writing Manuscript - M.P.A.; Critical Review - M.P.A.

Conflict of Interest: The author has no conflicts of interest to declare.

Financial Disclosure: The author declared that this study has received no financial support.

Etik Komite Onayı: Etik kurul onayı Biruni Üniversitesi Yerel Etik Kurulu'ndan (Tarih: 24.01.2024, Sayı: 2024/27-86) alınmıştır.

Hasta Onamı: Bu bir retrospektif çalışma olduğu için hasta onamı alınmamıştır.

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Fikir - M.P.A.; Tasarım – M.P.A.; Denetim – M.P.A.; Kaynaklar – M.P.A.; Malzemeler – M.P.A.; Veri Toplama ve/veya İşleme – M.P.A.; Analiz ve/veya Yorum – M.P.A.; Literatür Taraması – M.P.A.; Yazma – M.P.A.; Eleştirel İnceleme – M.P.A.

Çıkar Çatışması: Yazar, çıkar çatışması olmadığını beyan etmiştir.

Finansal Destek: Yazar, bu çalışma için finansal destek almadığını beyan etmiştir.

REFERENCES

1. Araby YA, Alharbi AS, Kolarkodi SH, Almosyteer AS. Morphometric analysis of the hard palate using cone beam computed tomography in a Saudi population. *Saudi Dent J.* 2023;35(3):270-274.
2. Lacerda-Santos JT, Granja GL, de Freitas GB, Manhães LRC Jr, de Melo DP, Dos Santos JA. The influence of facial types on the morphology and location of the greater palatine foramen: a CBCT study. *Oral Radiol.* 2022;38(3):337-343.
3. Fonseka MCN, Hettiarachchi PVKS, Jayasinghe RM, Jayasinghe RD, Nanayakkara CD. A cone beam computed tomographic analysis of the greater palatine foramen in a cohort of Sri Lankans. *J Oral Biol Craniofac Res.* 2019;9(4):306-310.
4. Miranda-Viana M, Freitas DQ, Gomes AF, Prado FB, Nejaim Y. Classification and Morphological Analysis of the Hard Palate in Cone-Beam Computed Tomography Scans: A Retrospective Study. *J Oral Maxillofac Surg. 2021*;79(3):695.e1-695.e13.
5. Bahşi İ, Orhan M, Kervancıoğlu P, Yalçın ED. Morphometric evaluation and clinical implications of the greater palatine foramen, greater palatine canal and pterygopalatine fossa on CBCT images and review of literature. *Surg Radiol Anat.* 2019;41(5):551-567.
6. Cantarella D, Dominguez-Mompell R, et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. *Prog Orthod.* 2017;18(1):34.
7. Tavelli L, Barootchi S, Ravidà A, Oh TJ, Wang HL. What is the safety zone for palatal soft tissue graft harvesting based on the locations of the greater palatine artery and foramen? A systematic review. *J Oral Maxillofac Surg.* 2019;77:271.e1-271.e9.
8. Abeleira MT, Outumuro M, Diniz M, Limeres J, Ramos I, Diz P. Morphometry of the hard palate in Down's syndrome through CBCT-image analysis. *Orthod Craniofac Res.* 2015;18(4):212-20.
9. Jung BA, Wehrbein H, Heuser L, Kunkel M. Vertical palatal bone dimensions on lateral cephalometry and cone-beam computed tomography: implications for palatal implant placement. *Clin Oral Implants Res.* 2011;22(6):664-8.
10. Yu C, Ahn HW, Kim SH. Three-dimensional morphological evaluation of the hard palate in Korean adults with mild-to-moderate obstructive sleep apnea. *Korean J Orthod.* 2018;48(3):133-142.
11. Kaplanoğlu K, Esen G, Servi T. A Retrospective Investigation of the Hard Palate Morphometry with 416 Cone-Beam CT Images. *Int J Acad Med Pharm.* 2022;4(2):25-29.
12. Aoun G, Nasseh I. The Length of the Greater Palatine Canal in a Lebanese Population: a Radio-anatomical Study. *Acta Inform Med.* 2016;24(6):397–400.
13. Ferrario VF, Sforza C, Colombo A, Dellavia C, Dimaggio FR. Three-dimensional hard tissue palatal size and shape in human adolescents and adults. *Clin Orthod Res.* 2001;4(3):141-7.
14. Premkumar S. *Textbook of Craniofacial Growth*. 1st. ed. India, JP Medical Ltd; 2011.
15. Sarilita E, Soames R. Morphology of the hard palate: a study of dry skulls and review of the literature. *Rev Arg Anat Clin.* 2015;7(1):34–43.
16. Jotania B, Patel SV, Patel SM, Patel P, Patel S, Patel K. Morphometric analysis of hard palate. *Int J Res Med.* 2013;2(2):72–75.

17. Kulkarni V, Ramesh BR. Palatometry in South Indian skulls and its clinical implications. *Int J Anat Res.* 2017;5(1):3362–3366.
18. Rao MJ, Vanilia BHS, Yesender M. Morphological and morphometric analysis of the hard palate and the greater palatine foramen in dry adult south indian skulls. *Int J Anat Res.* 2017;5(4):4441–4444.
19. Gujar SM, Oza SG. Morphometric analysis of hard palate and its clinical importance. *Natl J Clin Anat.* 2018;7(1):36–40.
20. Jacob M, Bindhu S, Avadhani R. Sex determination from hard palate measurements using palatine index with reference to its clinical implications. *IJCAP.* 2016; 3(2):186–188.
21. Kumar A, Ajmani ML, Heming T. Morphological and morphometric study of hard palate in Indian population. *IJBR.* 2016;7(11):778–784.
22. Wahane AM, Nandanwar RA. A study of palatal indices and foramina in the hard palate of adult human skulls in central india región. *Int J Anat Res.* 2019;7(2):6397–6403.
23. Huang X, Hu X, Zhao Y, Wang Y, Gu Y. Preliminary comparison of three-dimensional reconstructed palatal morphology in subjects with different sagittal and vertical patterns. *BMC Oral Health.* 2020;20(1):1–12.
24. D'Souza AS, Mamatha H, Jyothi N. Morphometric analysis of hard palate in south indian skulls. *Biomed Res.* 2012;23(2):173–175.
25. Ortug A, Uzel M. Greater palatine foramen: assessment with palatal index, shape, number and gender. *Folia Morphol. (Warsz)* 2019;78(2):371–377.