RESEARCH

# A Retrospective Investigation of the Hard Palate Morphometry with 416 Cone-Beam CT Images

**Kadir Kaplanoğlu[1], Gülru Esen[1], Tayfun Servi[3]**

[1] Adıyaman University Faculty of Dentistry Department of Dentomaxillofacial Radiology, Adıyaman/Turkey
[2] Adıyaman University Faculty of Medicine Anatomy Department Adıyaman/Turkey
[3] Adıyaman University Collece of Education Department Chair of Measurement and Statistics, Adıyaman/Turkey

**Abstract:** The hard palate separating the oral and nasal cavities constitutes the application area of clinicians in many fields, such as forensic anthropology, orthodontic surgeries, palate implants, staphylorrhaphy, and obstructive sleep apnea syndrome treatment. In this respect, expert knowledge on regional morphometry constitutes a basis for many different clinical areas and plays a significant role in the success of orthodontic and dental implants. Studies conducted in this region are usually on a limited number of cranial skeletons, gender unknown. In this retrospective study, we aimed to reveal the morphometric features of this clinically important structure by using a significant number of Cone-Beam CT (Computed Tomography) images obtained from individuals of certain age and gender. The current study analyzed Cone-Beam CT images of 416 individuals aged between 18 to 67 retrospectively. By measuring the palate length and width, the palatal index was obtained, which helped determine the palate types. A angle was calculated to find the palate thickness. The statistical analysis showed that 92.8% of 416 people had a narrow palate. A difference between men and women was observed in all parameters except the palatal index. In the age groups above and below 25 years, b, c, x, y parameters were different. Moreover, the A angle varied significantly between men and women. Considering all the participants in the two age groups, while the A angle did not show a significant difference, a statistically significant difference arose between men and women. These data, obtained from 416 Cone-Beam CT images, will contribute to the setting of a broad standard and will be useful data for many different disciplines such as forensic anthropology, maxillofacial surgery.

## INTRODUCTION

Hard palate is the bone structure that forms the front part of the palate. It is a critical element in the human skull skeleton and separates the oral and nasal cavities. It is constituted by the processus palatinus of the maxillae and the lamina horizontalis of the os palatinum [1-4]. Morphometric measurements, structural changes, and differences in palate indices in the hard palate are substantial in palate surgery and maxillary surgery [2-6]. Detailed knowledge of the normal structure and dimensions of the region is required both to design better instruments for some procedures (such as nasopharyngoscopy and nasogastric intubation) and to carry out meticulous manipulations. Dentists, anesthesiologists, and maxillofacial surgeons should be familiar with the hard palate morphometry to perform the correct maxillary nerve block during the procedures such as maxillary tooth extraction, maxillary dental implants, orthognathic surgery and cleft palate surgery [7, 8]. It is known that anesthesia given through the incisive canal is the most painful and traumatic anesthesia in the upper jaw. Considering the incisive canal morphology is crucial in surgical interventions on the maxilla[9-11]. The palate shape is suggested to have a 90% accuracy in gender determining. In this respect, the morphometric structure of the hard palate is vital in determining gender in forensic dentistry[1]. Knowing the bone boundaries of the region is a critical issue in skull base surgeries, anterior approaches, transnasal and transoral procedures, endoscopic and robotic surgeries [12].

Studies on this subject have emphasized that the hard palate is associated with racial, ethnic and regional [5-7] differences as well as gender differences [12-14]. Anatomical studies focus on morphometric measurements of structures in the human body and their correlations. Very little morphological or metric analysis has been done in this area. There is no comprehensive study focusing on people, particularly those living in the Anatolian region. Existing a few studies have been conducted on a limited number of skull bones of unknown gender [2, 3, 8] .

There is much disagreement in the current scientific literature regarding the ideal location of orthodontic implant placement in the palate. Some authors report that the mid-palatal suture of the palate is the perfect site, while others prefer the paramedian region as the insertion site. There is also disagreement about the exact positioning in the paramedian region [4]. A mid-palatal line is preferred while placing screws in the applications made on the maxillary palate [15]. The palate thickness is not the same at every point of the structure, and thus it requires evaluation on numerous three-dimensional

*Received* : 01/12/2022
*Received in revised form* : 02/20/2022
*Accepted* : 03/18/2022
*Available online* : 06/21/2022

*Keywords:*

*Hard palate*
*Morphometry*
*Gender*
*Incisive canal*

Corresponding Author:
Gülru Esen
E-mail; gbakay@adiyaman.edu.tr
ORCID; 0000-0002-8848-3988
http://dx.doi.org/10.47009/jamp.2022.4.2.6
*Int J Acad Med Pharm,*
2022; 4(2); 25-29

sections passing through different points [4, 16, 17]. This situation poses a problem in routinely measuring palate thickness. A practical method that is easy to use is needed. For this purpose, we developed a practical method to evaluate palate thickness on Cone-Beam CTs routinely taken in the clinic. In our study, we defined it as A angle.

## MATERIALS and METHODS

The study started after obtaining the relevant University Non-Interventional Clinical Studies Ethics Committee Approval, dated 18.05.2020, under number: 2020/05-10. The study retrospectively analyzed the Cone-Beam CT (Computed Tomography) diagnostic records of patients who applied to the Dentistry Faculty Initial Examination Clinic between 03.12.2018 and 31.03.2020 and had no lesion or impacted tooth in their routine panoramic radiography or intraoral examination. In the examined regions, the images of the patients with incisive canal cysts, follicular cysts, periapical lesions, impacted teeth, supernumerary teeth, without maxillary central incisors and maxillary second molars, and undergoing orthodontic treatment were excluded. Tomography images taken with Planmeca ProMax3DMid ProFace brand dental Cone-Beam CT device were evaluated using Planmeca Romexis 4.6.2.R licensed software program.

The following parameters were measured in Cone-Beam CT images:

**a:** The distance between the most superior-posterior point and the most inferior-posterior point of the incisive canal (fig. 1)

**b:** The distance between the most superior-posterior point of the incisive canal and the most posterior point of the hard palate (PNS = posterior nasal spine) (fig. 1).

**c:** The distance between the most inferior-posterior point of the incisive canal and the PNS (fig. 1)

**A angle:** The angle between the lines b and c (fig. 2)

**x:** palate length: The distance between the Orale point and the staphylon point (PNS). (Orale point: The midpoint of the line merging the posterior edges of the alveoli of the upper first incisors) (Figure 3)

**y:** palate width: The distance between the inner margins (endomolar) of the upper second molar tooth alveoli. (Figure 4)

**Palatal Index:** palate width / palate length X 100 [2,3]

A normal distribution test was carried out on data to determine whether they had a normal distribution. After confirming the normal distribution, the data summarized with frequency and descriptive analysis. The parameters' comparisons were made with independent samples t test and also correlation analysis was applied to determine the relationship between the variables in the data. A P value less than 0.05 was considered statistically significant and all statistical analysis were performed by using the SPSS software program.

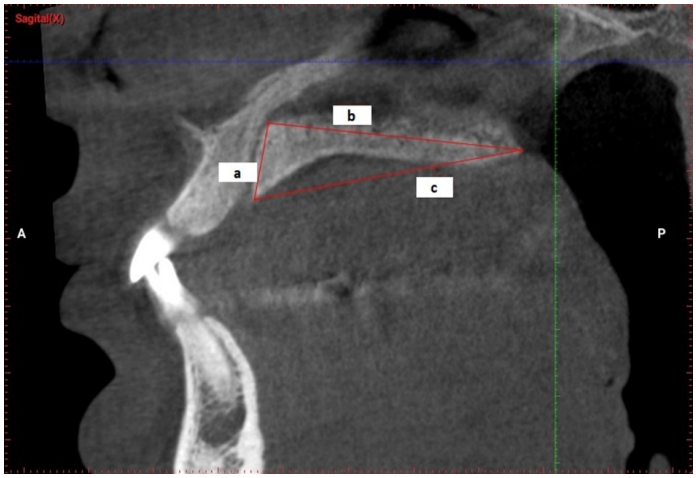


**Fig.1.** a, b and c parameters in sagittal plan

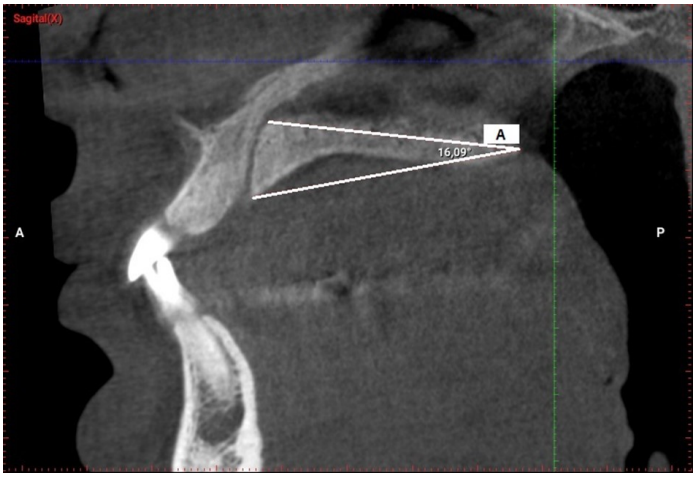


**Fig.2.** A angle

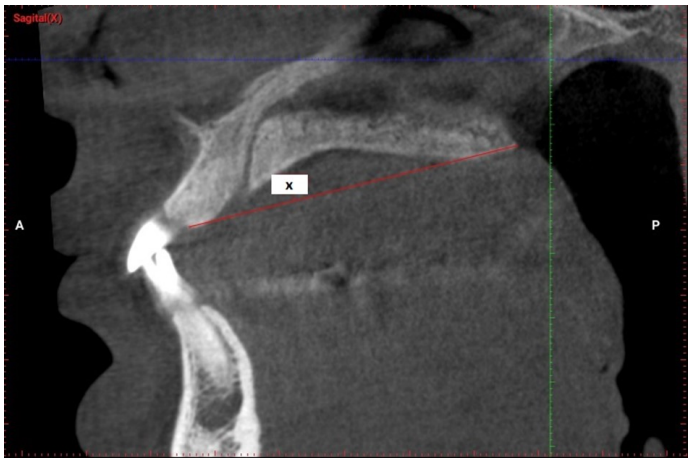


**Fig.3.** Palatal length

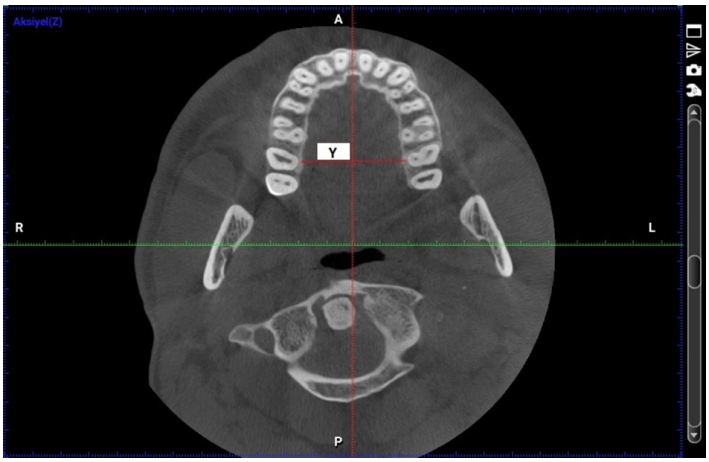


**Fig.4.** Palatal width

## FINDINGS

The study retrospectively analyzed the Cone-Beam CT images of 416 individuals, including 222 women and 194 men aged 18 to 67 years old. Considering that skeletal maturity age is generally 25, the patients were examined by dividing into two age groups, those over and under 25. Table 1 shows the distribution of people by age and gender. The data values and comparisons of 222 women and 194 men by gender are in Table 2. Significant differences were observed between men and women in all data except for the palatal index. That was also the case while grouping people by gender as those over and under 25 years old (Tables 4 and 5). However, when compared the individuals aged over and under 25 regardless of gender, A angle, the palatal index, and 'a' value did not differ significantly (Table 3).

In female participants, only a significant difference was observed in the y value between those over and under 25 years old (Table 6). As for the male participants, the number of significantly different parameters increased between the two age groups. A angle, b, c, and y parameters showed significant differences between the groups (table7). Table 8 shows the summary of the correlations between parameters.

According to the palatal index (PI), the measured palates were classified as leptostaphyline (narrow), mesostaphyline (medium), and brachystaphyline (wide)[2, 3]. Leptostaphyline (PI≤ 79,9%) were 386 people, Mesostaphyline (PI=80-84.9%) were 25 people, and Brachystaphyline (PI≥ 85%) were 5 people. By this classification, 92.8% of the 416 people in the study had a narrow palate. While 90.1% of women had narrow palates, 7.7% had medium, and 2.3% had wide palates. Similarly, 95.9% of men had narrow palates, and 4.1% had medium palates.

## DISCUSSION

The hard palate plays a significant role as an integral of the craniofacial complex. Its development is directly linked to the

**Table 1.** Distribution of participants by age group and gender

| | Gender | | sum |
|---|---|---|---|
| | Female(F) | Male(M) | |
| **Below 24 years** | 77 | 65 | 142 |
| **Over 25 years** | 145 | 129 | 274 |
| **Sum** | 222 | 194 | 416 |

**Table 2.** Parameter values and comparisons according to the gender of the participants

| Parameters | Female(n=222) Mean±SD | Male (n=194) Mean±SS | P value |
|---|---|---|---|
| **A angle** | 15,08±2,55 | 16,77±2,76 | 0.000* |
| **Palatal index** | 71,89±6,13 | 71,10±5,28 | 0.162 |
| **a** | 10,47±1,61 | 12,19±1,89 | 0.000* |
| **b** | 35,61±2,58 | 37,67±2,94 | 0.000* |
| **c** | 39,18±2,72 | 41,56±3,21 | 0.000* |
| **x** | 49,72±2,79 | 52,41±3,41 | 0.000* |
| **y** | 35,65±2,52 | 37,17±2,51 | 0.000* |

Abbreviation: SD, Standart deviation

**Table 3.** Parameter values and comparisons according to the age groups of the participants

| Parameters | Age≤24(n=142) Mean±SD | Age≥25(n=274) Mean±SS | P value |
|---|---|---|---|
| **A angle** | 16,16±2,92 | 15,72±2,69 | 0.125 |
| **Palatal index** | 71,03±5,65 | 71,78±5,81 | 0.212 |
| **a** | 11,32±2,03 | 11,25±1,90 | 0.709 |
| **b** | 36,04±2,70 | 36,85±3,02 | 0.008* |
| **c** | 39,66±2,99 | 40,62±3,23 | 0.003* |
| **x** | 50,44±3,34 | 51,25±3,36 | 0.020 |
| **y** | 35,73±2,50 | 36,68±2,63 | 0.000* |

Abbreviation: SD, Standart deviation

**Table 4.** Parameter values and comparisons according to age≤24 and gender of the participants

| Parameters | Female(n=77) Mean±SD | Male (n=65) Mean±SS | P value |
|---|---|---|---|
| **A angle** | 15,15±2,52 | 17,36±2,92 | 0.000* |
| **Palatal index** | 71,28±5,82 | 70,74±5,47 | 0.574 |
| **a** | 10,41±1,63 | 12,41±1,92 | 0.000* |
| **b** | 35,42±2,50 | 36,78±2,77 | 0.003* |
| **c** | 38,82±2,69 | 40,65±3,04 | 0.000* |
| **x** | 49,32±2,81 | 51,76±3,45 | 0.000* |
| **y** | 35,07±2,40 | 36,51±2,41 | 0.001* |

Abbreviation: SD, Standart deviation

**Table 5.** Parameter values and comparisons according to age≥25 and gender of the participants

| Parameters | Female(n=145) Mean±SD | Male (n=129) Mean±SS | P value |
|---|---|---|---|
| **A angle** | 15,04±2,57 | 16,47±2,63 | 0.000* |
| **Palatal index** | 72,21±6,29 | 71,29±5,19 | 0.185 |
| **a** | 10,51±1,60 | 12,08±1,88 | 0.000* |
| **b** | 35,71±2,63 | 38,12±2,93 | 0.000* |
| **c** | 39,37±2,72 | 42,02±3,20 | 0.000* |
| **x** | 49,93±2,77 | 52,74±3,35 | 0.000* |
| **y** | 35,95±2,53 | 37,50±2,50 | 0.000* |

Abbreviation: SD, Standart deviation

**Table 6**. Parameter values and comparisons of female participants by age group

| Parameters | Age≤24(n=77) Mean±SD | Age≥25(n=145) Mean±SS | P value |
|---|---|---|---|
| **A angle** | 15,15±2,52 | 15,04±2,57 | 0.770 |
| **Palatal index** | 71,28±5,82 | 72,21±6,29 | 0.282 |
| **a** | 10,41±1,63 | 10,51±1,60 | 0.643 |
| **b** | 35,42±2,50 | 35,71±2,63 | 0.425 |
| **c** | 38,82±2,69 | 39,37±2,72 | 0.150 |
| **x** | 49.32±2,81 | 49,93±2,77 | 0.123 |
| **y** | 35,07±2,40 | 35,95±2,53 | 0.012* |

Abbreviation: SD, Standart deviation

**Table 7.** Parameter values and comparisons of male participants by age group

| Parameters | Age≤24(n=65) Mean±SD | Age≥25(n=129) Mean±SS | P value |
|---|---|---|---|
| **A angle** | 17,36±2,92 | 16,47±2,63 | 0.036* |
| **Palatal index** | 70,74±5,47 | 71,29±5,19 | 0.497 |
| **a** | 12,41±1,92 | 12,08±1,88 | 0.248 |
| **b** | 36,78±2,77 | 38,12±2,93 | 0.003* |
| **c** | 40,65±3,04 | 42,02±3,20 | 0.005* |
| **x** | 51,76±3,45 | 52,74±3,35 | 0.060 |
| **y** | 36,51±2,41 | 37,50±2,50 | 0.009* |

Abbreviation: SD, Standart deviation

**Table 8**. Correlation table of variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **1.A angle** | 1 | | | | | | |
| **2.Palatal index** | -0,061 | 1 | | | | | |
| **3.a** | -,292** | ,818** | 1 | | | | |
| **4.b** | -,334** | -,218** | ,171** | 1 | | | |
| **5.c** | -,431** | -,138** | ,372** | ,882** | 1 | | |
| **6.x** | -,528** | -0,007 | ,433** | ,730** | ,847** | 1 | |
| **7.y** | ,628** | -0,072 | 0,070 | ,297** | ,294** | ,326** | 1 |

**. Correlation is significant at the 0.01 level (2-tailed)

harmonious development of the face and the execution of functional activities in the orofacial region [6, 18]. The palate structure varies among individuals according to the craniofacial growth pattern and various genetic and environmental factors [13]. Hard palate assessments have broad applications in forensic anthropology, orthodontic surgery, palate implants, staphylorrhaphy, and obstructive sleep apnea syndrome treatment [14]. Few literature studies are available on this subject, investigating a limited number of skull skeletons with unknown gender. In a study on the Anatolian population, the measurements performed on 86 skull skeletons of unknown gender found the palate width 3.58 ± 0.33 cm and the palate length 4.62 ± 0.39 cm. The same study determined 58.1% leptostaphyline, 17.4% mesostaphyline, 24.4% brachiostaphyline palate structure according to the type of palate [2]. Researchers reported the palatal index value as 77.94 ± 9.68 on average. Another study investigating 50 skull skeletons, documented 3.33 ± 0.28 cm palate width and 4.31 ± 1.28 cm palate length [3]. The same study found a mean palatal index value of 77.62 ± 8.14 and underlined 60% leptostaphyline palate structure observation. Similar data reported in both studies is noteworthy. In our study we determined the palate length 50,976 mm and the palate width 36,361 mm in 416 individuals. In our classification according to palate types, 92.8% leptostaphyline palate type was observed. The study by Ortuğ and Uzel reported observing 50% (n=19) of brachiostaphyline palate type in men and 43.8% (n=21) of leptostaphyline palate type in women in the measurements on the skull bones belonging to 43 men and 54 women[8]. Since their study emphasized palate types according to gender, comparing it with other non-gender-based studies conducted in the Anatolian population was not possible. In our study we observed that 91.1% of women and 95.9% of men had leptostaphyline palate type.

In the literature, it is possible to see various studies on unknown-gender skull skeletons in different geographies. Jotania et al. reported the mean palate length and width as 49.74 and 37.75 mm, respectively, in their study [5]. They emphasized that 70% of the 60 skull bones in the study were of the leptostaphyline palate type. Likewise, in their research, Rao et al. reported that the palate length was 49.87 ± 3.54, and the palate width was 34.42 ± 2.09 mm. In the study conducted on 58 skull skeletons, they observed 95% leptostaphyline palate type [6]. Gujar and Oza performed palate measurements on 50 skull skeletons and found the mean palate length and width values of 47.10 ± 3.34 mm and 36.26 ± 2.55 mm, respectively [19]. They stated that the measurements made on these limited materials indicated leptostaphyline type palate structure at a rate of 68%. Another study announced the values of mean palate length and palate width as 40.4 mm and 44.2 mm, respectively, and stated that 179 (86.9%) of 208 skull skeletons measured had a brachiostaphylin palate [14]. Although this study by Kulkarni and Ramesh was in the same geographical region, it is noteworthy that it reported different values from other studies in terms of both average values and palate type. The present study determined the palate length and width as 50,976 mm and 36,361 mm, respectively. In terms of palate type, our study with 92.8% leptostaphyline palate type differs from the study of Kulkarni and Ramesh.

The literature also has gender-specific studies on the skull. In their research covering the skulls of 50 men and 37 women, Kumar et al. , reported 52.5 mm palate length and 36.51 mm palate width for men [7]. The same research stated that these values were 48.1 and 32.33 mm in women, respectively, and there was a statistically significant difference. The study, conducted on 86 skull skeletons, emphasized that 62% of men and 58.13% of women had a leptostaphyline palate structure. In our study we found that both the palate length and the palate width were significantly different in men and women. Several separate studies also documented gender-specific significant differences between males and females in palate length and palate width [12, 20, 21].

As seen, the data obtained from available materials is insufficient to represent the universe. Perhaps this is the reason why different studies conducted in the same geographical region may report different results. Today, the data obtained by imaging methods are more respected rather than bone measurements. Our research has a sample group that represents the universe with 416 Cone-Beam CT images. In the literature, studies conducted with Cone-Beam CT have been observed to focus principally on palate thickness.

A study with Cone-Beam CT, has found that the mid-palatal suture and the anterolateral region of the palate provide sufficient bone height for orthodontic implant placements, and the anterior palate and mid-palatal suture regions are suitable locations for implant placement for optimal primary stability of orthodontic implants [4]. The same study has emphasized that the palate bone height in women is lower than in men.

According to the results of the Cone-Beam CT measurements obtained at some reference points, another study determined that the palate bone thickness decreased from the midline to the lateral in both genders [17]. The same study reported that the palate total thickness decreased from front to back at all points in men, and that was a similar case in women, except for some reference points. In a study by Aleshkina et al. it has been announced that the palate thickness varies gender-specifically and is thicker in men than in women [22]. The authors also found that the thickest points were the anterior one-third of the palate. A angle, defined as the palate thickness on the midline in the current study, represents the palate thickness from anterior to posterior in the reference of the upper and lower points of the posterior edge of the canalis incisivus. The value obtained from 416 people is 15,87°. Although this angle was significantly different between women and men, it did not show a statistically significant difference in individuals over and under 25 years old. However, when only male participants were the point, the A angle was significantly lower in the group aged 25 and over. The parameter a, which has a highly positive correlation with this angle, is substantial because it forms the posterior edge of the incisive canal. Although this posterior margin length with a mean value of 11,27 mm did not differ between age groups, it showed a statistically significant difference between genders. Besides the correlation of this posterior margin length with the b and c values forming the A angle, its positive correlation with x (palate length) draws attention. All three studies above reported that incisive canal length showed a significant difference between genders but did not change with age. In our study we also found that the a parameter corresponding to the canal's posterior wall length did not change with age, but it showed a significant difference between the genders.

Although studies examining incisive canal morphometry exist in the literature [9, 10, 23] these studies use a reference line passing through the middle of the canal for an average length calculation. However, the irregular shape of the channel requires more delicate measurements.

### *Conclusion*

Determining the anatomical values of the hard palate will also make important contributions to other scientific disciplines. These data, which we obtained from 416 Cone-Beam CT images, will contribute to the determination of a wide standard and guide the development of implants used in regional surgery; It will be guiding and useful data for surgeons, anatomists, forensic physicians and anthropologists. In addition, this study will provide a basis for oral developmental anomaly studies by determining the palatal index in the normal range. Our study also serves as a guide for future studies on incisive channel. The fact that the number of materials in our study is a representative number of the universe makes our study more reliable than the studies done so far and brings clarity to the studies that give contradictory results.

### *Conflict of interest*

The authors declare that there are no conflict of interests.


### *Financial disclosure*

The authors declared that this study has received no financial support.

## *REFERENCES*


1. Ayman GM, Ayssar AT, Othman AA, Mohammed ZA, Ahmad AA. Morphometric study of the hard palate and its relevance to dental and forensic sciences. *Internat onal Journal of Dent stry*. 2019;2019.
2. Gozil R, Sakul BU, Çalguner E, Uz A. Morphometry of the hard palate and shapes of palatine torus and transverse palatine sutura. *Turkiye Klinikleri Journal of Dental Sciences*. 1999;5:149-153.
3. Yilmaz S, Ertekin T, Nisari M, Sagiroglu A, Acer N, Ulger H H. Morphometry of the hard palate and shapes of transverse palatine sutura. *Bozok Medical Journal*. 2017;7:29-34.
4. Chhatwani S, Rose-Zierau V, Haddad B, Almuzian M, Kirschneck C, Danesh G. Three-dimensional quantitative assessment of palatal bone height for insertion of orthodontic implants-a retrospective CBCT study. *Head & Face Medicine*. 2019;15:9.
5. Jotania B, Patel SV, Patel SM, Patel P, Patel S, Patel K. Morphometric analysis of hard palate. *Int J Res Med*. 2013;2:72-75.
6. 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. *International Journal of Anatomy and Research*. 2017;5:4441-4444.
7. Kumar A, Ajmani ML, Heming T. Morphological and morphometric study of hard palate in Indian population. *International Journal of Biomedical Research*. 2016;7:778-784.
8. Ortug A, Uzel M. Greater palatine foramen: assessment with palatal index, shape, number and gender. *Folia Morphologica*. 2019;78:371-377.
9. Gönül Y, Bucak A, Atalay Y, Acay MB, Caliskan A, Sakarya G et al. MDCT evaluation of nasopalatine canal morphometry and variations: An analysis of 100 patients. *Diagnostic and Interventional Imaging*. 2016;97:1165-1172.
10. Hakbilen S, Magat G. Evaluation of anatomical and morphological characteristics of the nasopalatine canal in a Turkish population by cone beam computed tomography. *Folia Morphologica*. 2018;77:527-535.
11. Lake S, Iwanaga J, Kikuta S, Oskouian RJ, Loukas M, Tubbs RS. The incisive canal: a comprehensive review. *Cureus*. 2018;10:e3069.
12. Jacob M, Bindhu S, Avadhani R. Sex determination from hard palate measurements using palatine index with reference to its clinical implications. *Indian Journal of Clinical Anatomy and Physiology*. 2016;3:186-188.
13. Khatiwada S, Chaulagain R, Khan GA, Sapkota SM, Sudhin BNA. Morphometric Analysis of Hard Palate on Nepalese Population. *Journal of Karnali Academy of Health Sciences*. 2020;3.
14. Kulkarni V, Ramesh BR. Palatometry in South Indian skulls and its clinical implications. *Int J Anat Res*. 2017;5:3362-3366.
15. Camci H. Selecting the proper screw for the case: review. *Turkiye Klinikleri Journal of Dental Sciences*. 2017;23:126-129.
16. Ozan O, Orhan K, Turkyilmaz I. Correlation between bone density and angular deviation of implants placed using CT-generated surgical guides. *Journal of Craniofacial Surgery*. 2011;22:1755-1761.
17. Yu S-K, Cho Y, Seo Y-S, Kim J-S, Kim DK, Kim H-J. Radiological evaluation of the bone and soft tissue thicknesses of the palate for using a miniscrew-supported maxillary skeletal expander. *Surgical and Radiologic Anatomy*. 2021;43:1001-1008.
18. 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. *Journal of Oral and Maxillofacial Surgery*. 2021;79:695.e1-695.e13.
19. Gujar SM, Oza SG. Morphometric analysis of hard palate and its clinical importance. *National Journal of Clinical Anatomy*. 2018;7:36-40.
20. Wahane AM, Nandanwar RA. A study of palatal indices and foramina in the hard palate of adult human skulls in central india región. *International Journal of Anatomy and Research* 2019;7:6397-6403.
21. Orish C, Ibeachu PC. Craniometric indices of Nigeria skulls. *Int J Anat Appl Physiol*. 2016;2:6-13.
22. Aleshkina O, Suetenkov D, Dydykin S, Vasil'ev Y, Paulsen F, Firsova I et al. Determination of sex dimorphisms of the thickness of the hard palate in adolescence using computed tomography: Pilot study. *Annals of Anatomy-Anatomischer Anzeiger*. 2021;238:151764.
23. Acar B, Kamburoğlu K. Morphological and volumetric evaluation of the nasopalatinal canal in a Turkish population using cone-beam computed tomography. *Surgical and Radiologic Anatomy*. 2015;37:259-265.