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Original Article

Evaluation of hard palate asymmetry in turkish population

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Abstract

Aim: In a sample of the Turkish population, we aimed to evaluate differences in hard palate asymmetry by sex, the direction of right-left dominance, and how hard palate asymmetry and morphometric measurements are shaped with age.

Materials and Methods: The present study was conducted on 3-dimensional computed tomography images of the head and neck region belonging to 172 (88 males, 84 females) individuals aged between 20-89 years. In this study, the distances between the Incisive foramen-Greater palatine foramen, Greater palatine foramen-Posterior nasal spine on the right and left sides with regard to the hard palate were measured. The asymmetry ratio was determined as a percentage using the asymmetry index. Furthermore, the angle values between the Incisive foramen-Posterior nasal spine-Greater palatine foramen on the right and left sides were measured on the lines between the measured points and compared with each other.

Results: The measured parameters were compared between sexes, higher linear measurement parameters were found in males; angular values and the asymmetry index were close to each other, and no difference was found between them. When a comparison was made between the sides, the difference was revealed only in the measurement of the Greater palatine foramen-Posterior nasal spine, and the right side was larger. In all cases, the right side was larger in 79 cases in the Incisive foramen-Greater palatine foramen asymmetry index, and in 93 cases, the asymmetry was to the left. In the Greater palatine foramen-Posterior nasal spine asymmetry index, it was found that the asymmetry was to the right in 61 cases, and the asymmetry was to the left in 111 cases.

Conclusion: This study provided important data on the hard palate morphology of the Turkish population. It also presented anthropological references for hard palate measurements of the Turkish population. Using 3-dimensional computed tomography images, we determined the greater palatine foramen's location according to the posterior nasal spine and incisive foramen. Determining the greater palatine foramen's location according to anatomical structures will contribute to determining the location of the greater palatine foramen in surgical interventions to be performed in this region.

Keywords: Asymmetry; greater palatine foramen; incisive foramen; posterior nasal spine; symmetry

INTRODUCTION

The perfect balance between the right and left sides is not the reality of the individual body structure. Human antimeres are naturally asymmetrical, and the mentioned small difference provides an individual with a unique appearance. Beauty is not closely related to symmetry. Actually, perfectly symmetrical faces are not as attractive as slightly asymmetrical ones (1).

The numeral difference between the left and right of a measurement performed between the same points is called asymmetry. Asymmetry is a common finding in human craniofacial bones and is also present in patients and healthy individuals. Although every person shares many traits with other people, there are enough asymmetrical differences to make every person unique. Variations in the size, shape, and relationship of facial structures are significant for providing every individual with his/her own identity (2). Differences in the right and left sides, which occur at varying degrees in the population, may interfere with normal dental function and aesthetic appearance or may be too insignificant to be detected by external observation. In biology, symmetry is not always regarded as a perfect match between two measurements. Sometimes, various degrees of asymmetry on the craniofacial skeleton are regarded as normal (3-5).

Many hard palate asymmetry studies have been conducted on cadavers, skulls, and radiological images (6-8). Excessive hard palate asymmetry can cause abnormal dental function and change facial aesthetics. The correction of dental or skeletal asymmetry is the main goal and one of the most difficult treatment targets not only for orthodontics (9,10) but also for orofacial and plastic surgeons. To assess asymmetry in the head region, different methods, including measurement

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directly on skulls (7), on the posteroanterior direct head radiograph (11,12), computed tomography (CT) (13), on a tooth mold (14), on a photograph (15), and directly on the face (16), have been used. Studies conducted using radiographs show that adults with aesthetic faces have different skeletal asymmetries that cannot be detected by visual inspection (12). In this case, soft tissue minimizes the underlying skeletal shape and size differences (17,18).

The maxillary nerve and its tributaries provide sensory innervation to the maxillary teeth, the palate, the nasal cavity, the sinuses and, subsequently, the skin of the midface (19). The anterior (greater) palatine nerve supplies the main sensory innervation to the palate. It branches off the maxillary nerve and passes through the greater palatine canal to the surface on the hard palate from the greater palatine foramen (Gpf), and continues anteriorly, ending just short of the front incisors (20). The anterior palatine nerve block was first described in 1927 (21). This procedure can be performed using two intraoral approaches.

1- High tuberosity approach

2- Greater palatine canal approach (22)

Secondly, it is associated with a higher success rate and a lower incidence of complications (23). However, this method's major clinical challenge is to locate the Gpf accurately (23). Moreover, when aiming to mobilize the greater palatine artery during oroantral fistula closure, palatal flaps with mucoperiosteal pedicles (22) or palatal mucosa graft collection for periodontal recommendations (24), the correct Gpf localization is required. All of the above mentioned issues underscore the need to thoroughly understand the anatomy and anatomical variability of the Gpf and its associated landmark.

A detailed morphometric analysis of local populations is important to facilitate safe and effective surgical palate approaches. Therefore, the current study's main aim was to investigate aspects of hard palate asymmetry in Turkish population. To assess hard palate asymmetry, several anatomical landmarks in different palate regions were used to determine whether there was a deviation towards the right or left side from the selected reference points in the midline. Additionally, the Gpf was localized to multiple anatomical landmarks in Turkish adult head and neck CT images.

MATERIALS and METHODS

This research was conducted retrospectively on head and neck computed tomography (CT) images obtained from the hospital's "Picture Archiving and Communicating System" (PACS) in the Radiology Department. Patients with any pathology in head and neck CT; patients with any tumors or fractures were not included in the study. Metabolic bone conditions that may affect bone tissue in patients were not questioned, such as osteoporosis. CT images were obtained with a multidetector 128 slice SOMATOM Definition AS Siemens (Siemens Healthcare, Erlangen, Germany) computed tomography device using the following parameters:120 kV, effective mAs=143 mAs, slice thickness=1 mm, matrix=512x512, collimation=128x0.6 slice increment=0.7 pitch =0.8 FOV (Field of View) (250-300). A 3D reconstruction was created from the scanned axial images using the RadiAnt DICOM Viewer 2020.1 version program. The images were posted to the Image J analytical software. Approval was acquired from the Clinical Research Ethics Committee of Suleyman Demirel University, Faculty of Medicine.

In the current research, distances between the anthropological landmarks of the hard palate of 172 cases (88 males, 84 females) aged between 20-89 years (mean age 53.56 ± 17.22) were investigated. The cases aged between 20-29 years were grouped as the 3rd decade, the cases aged between 30-39 years were grouped as the 4th decade, the cases aged between 40-49 years were grouped as the 5th decade, the cases aged between 50-59 years were grouped as the 6th decade, the cases aged between 60-69 years were grouped as the 7th decade, the cases aged between 70-79 years were grouped as the 8th decade, and the cases aged between 80-89 years were grouped as the 9th decade. In this study, the hard palate measurements were made based on the reference points previously utilized by Skrzat et al. (25) and Moreira et al. (7). The reason for using the same reference points described by Moreira et al. is that the method is repeatable, yields clear results, and provides the angle measurement on the length measurement lines related to the hard palate (7). The following points were utilized (Figure 1):

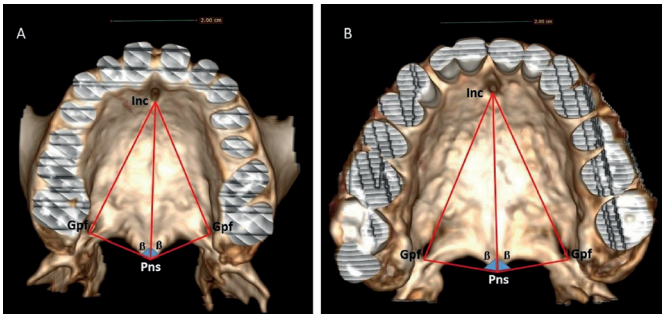

Figure 1. Hard palate measuring points. A- Photographs of a 39-year-old female patient's hard palate. B- Photographs of a 49-year-old male patient's hard palate. Inc: Incisive foramen, Pns: Posterior nasal spine, Gpf: Greater palatine foramen, ß: The angle between the Inc-Pns-Gpf

Incisive foramen (Inc): the posterior margin of the Inc

Posterior nasal spine (Pns): the most posterior and median point of the Pns

Greater palatine foramen (Gpf): the median point of the posterior margin of the Gpf

The following parameters were measured linearly:

- The Distance Between the Incisive foramen-Posterior nasal spine (Inc-Pns)

- The Distance Between the Incisive foramen-Greater palatine foramen (Inc-Gpf) (on the right and left sides)

- The Distance Between the Greater palatine foramen-Posterior nasal spine (Gpf-Pns) (on the right and left sides)

The following parameters were measured angularly on the right and left sides.

- The Angle Between the Incisive foramen-Posterior nasal spine-Greater palatine foramen (Inc-Pns-Gpf) (ß)

The asymmetry index was computed in accordance with the following formula of Rossi et al. (8). This formula has also been used by Moreira et al. (7) and Dursun et al. (26). in the literature.

$$\text{Asymmetry index} = \frac{\text{Right side} - \text{Left side}}{\text{Left side}} \times 100$$

- Incisive foramen-Greater palatine foramen Asymmetry index (A. in. Inc-Gpf)

- Greater palatine foramen-Posterior nasal spine Asymmetry index (A. in. Gpf-Pns)

Statistical Analysis

Statistical analysis was carried out using SPSS Inc. SPSS for Windows 20.0 program. The minimum, maximum, mean and standard deviation values of the measured parameters were determined. The data in the present study were normally distributed. The independent samples t-test was conducted to make a comparison between the sexes and sides. The one-way ANOVA was performed in the comparison between decades. In the groups for which a difference was detected in the analysis of variance, the advanced analysis was performed in post hoc analysis using Tukey's comparison method. Pearson's correlation analysis was used for correlation analysis. The statistical significance level was accepted to be $p<0.05$.

RESULTS

The hard palate related parameters and the maximum, minimum and average values and standard deviations of these parameters were found (Table 1). When the measured parameters were compared between sexes, the mean values of males were observed to be higher in the linear measurement parameters, and there was a statistically significant difference between them ($p<0.001$, Table 2).

Table 1. The length and angular measurements, asymmetry index of the hard palate

Parameters	N	Minimum	Maximum	Mean	Standard deviation
Inc-Pns (mm)	172	31.67	49.05	39.48	3.18
Inc -Gpf (right) (mm)	172	31.87	44.48	38.37	2.65
Gpf-Pns (right) (mm)	172	13.15	20.88	16.98	1.51
Inc -Gpf (left) (mm)	172	31.19	44.85	38.40	2.73
Gpf-Pns (left) (mm)	172	13.33	19.71	16.66	1.43
Ip-Pns-Gpf (right)	172	55.65°	88.15°	73.03°	5.25°
Ip-Pns-Gpf (left)	172	58.71°	86.37°	73.56°	5.58°
A. in. Inc-Gpf (%)	172	-8.17	10.46	-.019	2.83
A. in. Gpf-Pns (%)	172	-33.89	14.66	-2.12	6.73

Inc: Incisive Foramen, Pns: Posterior Nasal Spine, Gpf: Greater Palatine Foramen, A. in: Asymmetry Index

Table 2. Comparison of measurements of the hard palate between sexes

	N	Inc-Pns (mm)	Inc -Gpf (right) (mm)	Gpf-Pns (right) (mm)	Inc -Gpf (left) (mm)	Gpf-Pns (left) (mm)	Inc-Pns-Gpf (right)	Inc-Pns-Gpf (left)	A. in. Inc-Gpf (%)	A. in. Gpf-Pns (%)
Male	88	40.32	39.21	17.49	39.24	17.28	73.03°	73.58°	.01	-1.41
Female	84	38.60	37.49	16.44	37.52	16.01	73.04°	73.55°	-.05	-2.87
P		<.001	<.001	<.001	<.001	<.001	.985	.970	.896	.156

Inc: Incisive Foramen, Pns: Posterior Nasal Spine, Gpf: Greater Palatine Foramen, A. in: Asymmetry Index

The mean angular values and the mean values of the asymmetry index were very close to each other, and there was no significant difference between them (Table 2). When the comparison between the sides was made, a significant difference was revealed only in the Gpf-Pns measurement ($p = 0.044$), and the right side was larger (Table 3).

The mean values of the measured parameters according to decades were calculated (Table 4). In the comparison between decades, a difference was found in linear measurements and the Inc-Pns-Gpf angle measurement on the right side. No difference was found between the asymmetry indices and in the Inc-Pns-Gpf angle on the left side (Table 4).

Table 3. Comparison of measurements of the hard palate between sides

	N	Mean	Std. Deviation
Inc-Gpf (mm)			
Right	172	38.37	±2.65
Left	172	38.40	±2.73
P		.922	
Gpf-Pns (mm)			
Right	172	16.98	±1.51
Left	172	16.66	±1.43
P		.044	
Inc-Pns-Gpf			
Right	172	73.03°	±5.25°
Left	172	73.56°	±5.58°
P		.366	

Inc: Incisive Foramen, Pns: Posterior Nasal Spine, Gpf: Greater Palatine Foramen

Table 4. Comparison of measurement of hard palate according to decades

Group (years)	N	Inc-Pns (mm)	Inc -Gpf (right) (mm)	Gpf-Pns (right) (mm)	Inc -Gpf (left) (mm)	Gpf-Pns (left) (mm)	Inc-Pns-Gpf (right)	Inc-Pns-Gpf (left)	A. in. Inc-Gpf (%)	A. in. Gpf-Pns (%)
20-29 (3. decade)	11	37.38	36.70	16.21	36.49	15.50	73.06°	73.37°	.68	-4.68
30-39 (4. decade)	29	38.23	36.34	16.35	36.52	16.11	69.89°	71.01°	-.44	-1.61
40-49 (5. decade)	36	39.35	38.25	16.91	38.31	16.54	73.17°	73.99°	-.15	-2.47
50-59 (6. decade)	32	40.17	39.19	16.97	39.15	16.77	73.86°	74.02°	.21	-1.47
60-69 (7. decade)	26	40.12	38.94	17.37	38.80	17.02	73.21°	73.03°	.43	-2.31
70-79 (8. decade)	23	40.76	39.96	17.72	40.15	17.42	74.30°	75.23°	-.44	-1.78
80-89 (9. decade)	15	39.22	38.60	17.16	38.63	16.85	74.75°	74.99°	-.020	-1.97
P		.014	<.001	.014	<.001	.002	.025	.131	.846	.899

Inc: Incisive Foramen, Pns: Posterior Nasal Spine, Gpf: Greater Palatine Foramen, A. in: Asymmetry Index

Table 5. Correlation of age and hard palate parameters

		Age (20-89 years)	Inc-Pns	Inc-Gpf (right)	Inc-Gpf (left)	Gpf-Pns (left)	Gpf-Pns (right)	Inc-Pns-Gpf (right)
Age (20-89 years)	Pearson Correlation (r)	1						
	Sig. (2-tailed)							
	N	172						
Inc-Pns	Pearson Correlation	.213**	1					
	Sig. (2-tailed)	.005						
	N	172	172					
Inc-Gpf (right)	Pearson Correlation	.333**	.849**	1				
	Sig. (2-tailed)	.000	.000					
	N	172	172	172				
Inc-Gpf (left)	Pearson Correlation	.315**	.838**	.919**	1			
	Sig. (2-tailed)	.000	.000	.000				
	N	172	172	172	172			
Gpf-Pns (left)	Pearson Correlation	.305**	.417**	.483**	.488**	1		
	Sig. (2-tailed)	.000	.000	.000	.000			
	N	172	172	172	172	172		
Gpf-Pns (right)	Pearson Correlation	.268**	.348**	.398**	.414**	.726**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.000		
	N	172	172	172	172	172	172	
Inc-Pns-Gpf (right)	Pearson Correlation	.193*	-.423**	.102	-.019	-.033	-.103	1
	Sig. (2-tailed)	.011	.000	.182	.800	.672	.178	
	N	172	172	172	172	172	172	172

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed). Very weak correlation or no correlation if r <0.2, weak correlation between r=0.2-0.4, moderate correlation between r=0.4-0.6, high correlation between r=0.6-0.8, very high correlation r>0,8. Inc: Incisive foramen, Pns: Posterior nasal spine, Gpf: Greater palatine foramen

In the post hoc analysis performed for the parameters with a difference between decades, a difference was found between decades 3-8, 4-5, 4-6, 4-7, and 4-8 in the Inc-Gpf on the right side, between decades 3-5, 3-8, 4-6, 4-7, and 4-8 in the Inc-Gpf on the left side, between decades 3-7, 3-8, and 4-8 in the Gpf-Pns on the left side, between decades 4-8 in the Gpf-Pns on the right side, between decades 4-8 in the Inc-Pns, and between decades 4-6, 4-8, and 4-9 in the Inc-Pns-Gpf on the right side. As can be understood from the post hoc analysis, the difference originates mostly from the 3rd and 4th decades.

The correlation analysis of the parameters for which a difference between decades was found with age was performed, and there was a weak correlation in linear parameters, while no correlation was found in the Inc-Pns-Gpf angle measurement on the right side (Table 5).

The asymmetry index represents a percentage expression. In the calculations, negative values show that the palate's left side values are larger, while positive values show that the right side values are larger. The maximum, minimum, mean values and standard deviations of the asymmetry

index data related to the palate are presented in Table 1, the mean values by sex are presented in Table 2, and the mean values by decades are presented in Table 4. In the A. in. Inc-Gpf in all cases, it was found that the right side was larger in 79 cases, i.e. the asymmetry was to the right, and the left side was larger in 93 cases, i.e. the asymmetry was to the left. In the A. in. Gpf-Pns, it was determined that the right side was larger, i.e. the asymmetry was to the right in 61 cases, and the left side was larger, i.e. the asymmetry was to the left in 111 cases. No case showing exact symmetry in both asymmetry indices was found.

DISCUSSION

Revealing the parameters related to the hard palate in Turkish individuals aged between 20-89 years and knowing the presence of asymmetry and the degree and direction of asymmetry will be a guide in the diagnostic and treatment of diseases in the research to be carried out on the palate. It is also important for dentists, oral and maxillofacial surgeons to know the localization of the Gpf. Furthermore, it is of great importance to identify the location of the Gpf for palatal donor tissue and greater palatine nerve block anesthesia (27).

When the linear measurement parameters were compared between the right and left sides, a statistically significant difference was detected only in the Gpf-Pns measurement (Table 3). Moreira et al. (7) could not reveal a statistically significant difference between the measurement values of the sides. Likewise, Awad et al. (27) and Kizilkanat et al. (28) could not detect the difference between the right and left sides in linear measurements. In this study, the mean Gpf-Pns was found to be 16.98±1.51 mm on the right side and 16.66±1.43 mm on the left side upon examining the linear measurement results. Moreira et al. (7) found these values to be 17.70 mm on the right side and 17.55 mm on the left side in Brazilian adults aged between 25-55 years, Kızılkanat et al. (28) found these values to be 17.72 mm and 17.37 mm, respectively, in skulls of unknown age, and Awad et al. (27) found these values to be 16.55 mm and 16.48 mm, respectively, in Egyptian adults aged between 22-65 years. Moreover, the location of the Gpf was determined to vary in various ethnic populations. The mean distance from the Gpf to the palatal midline was indicated to be 15.4 mm in the Nigerians (29), 16 mm in the Chinese (30), 16.1 mm in the Thais (31), and 16.2 mm in the Koreans (32). In this study, upon examining the Inc-Gpf measurements, the mean was found to be 38.37±2.65 mm on the right side and 38.40±2.73 mm on the left side. Moreira et al. (7) found it to be 41.35 mm and 41.43 mm, respectively, in Brazilian adults aged between 25-55 years, and Awad et al. (27) found it to be 38.06 mm and 37.96 mm, respectively, in Egyptian adults aged between 22-65 years. We think that the reason why our Gpf-Pns and Inc-Gpf results were closer to the results obtained by Awad et al. (27) may be the fact that our study was conducted on CT like the study carried out by Awad et al. (27), and the age range was closer to that in our study.

Moreira et al. (7) determined a difference between sexes only in Inc-Gpf in the adult group aged between 25-55 years, and the mean values of males were higher than those of females. Awad et al. (27) found males' mean values to be higher in both Gpf-Pns and Inc-Gpf, and the difference between sexes was statistically significant. In the studies conducted by Sheta et al. (33) and Lima et al. (34), the researchers found higher mean values in males in the Inc-Gpf measurement and the differences between sexes were statistically significant. Similar to the literature, in this study, when a comparison was made between sexes, the mean values of all linear parameters were revealed to be higher in males, and a statistically significant difference between sexes was determined ($p<0.001$) (Table 2).

In the comparison between decades, a significant difference was found in linear measurements. In the post hoc analysis, we thought that this difference mostly originated from the 3rd and 4th decade. The reason for this might be that the development of the palate structure was completed in the 4th decade. A weak correlation was determined in the correlation of linear measurements with age. Although we thought that the hard palate development was completed in the 4th decade, we found its correlation with age to be weak due to the fact that the growth in the 3rd and 4th decades was quite low and the development was completed in the advanced ages (Table 5).

When the right and left measurement results of Inc-Pns-Gpf, which is the angular measurement parameter, were compared, no statistically significant difference was detected ($p=0.366$). Nevertheless, according to the Inc-Pns-Gpf right and left angle measurement results, no case that showed complete symmetry was found in our study. In their research, Moreira et al. (7) detected complete symmetry in Inc-Pns-Gpf in 13.51% of the cases. In the research carried out by Moreira et al. (7), the angular measurements were more symmetrical than the length measurements. In contrast, the Inc-Gpf parameter showed the best symmetry in our study (Table 3). When the angular parameter values in our study were compared between sexes, no statistically significant difference was detected.

In our study, we measured and evaluated the measurement points developed by Moreira et al. (7) on 3D-CT images using the Image-J program to evaluate asymmetry. We used the term asymmetry index to express the ratio of asymmetry as a percentage. The asymmetry index was computed and evaluated by Pns-Gpf and Inc-Gpf. When using the asymmetry index data, the presence of asymmetry was evaluated using the absolute values of negative values.

In this study, we determined the mean Pns-Gpf asymmetry index value to be 5.43% and the mean Inc-Gpf asymmetry index to be 2.29%. Similar to our study, Moreira et al. (7) revealed the mean Pns-Gpf asymmetry index to be higher than the mean Inc-Gpf asymmetry index in all age groups. The reason for the higher Pns-Gpf asymmetry index may be the variational location of the Pns on the sagittal plane.

In our study, in evaluating the Inc-Gpf asymmetry index, the left side was detected to be larger in 93 of 172 cases, while the right side was larger in 79 cases. In the Pns-Gpf asymmetry index, the left side was revealed to be larger in 111 of 172 cases, and the right side was larger in 61 cases. According to the aforementioned results, left-sided asymmetry was more dominant in this study. In their research, Moreira et al. (7) revealed more left-sided asymmetry. Some authors detected more right-sided asymmetry (12,35,36), whereas other authors found more left-sided asymmetry (14,37,38).

In the literature, various authors have utilized various degrees of limitation for the purpose of determining the limit of asymmetry. If there was a difference between the distances measured by Sutton (16) to the median plane, he accepted it as asymmetry. If there was a difference higher than 0.5 mm between the measurements made by Chebib and Chamma (14), they accepted it as asymmetry. Trpkova et al. (4) accepted differences more than 1 mm, Farkas and Cheung (18) accepted differences more than 2 mm, and Vazquez et al. (39) accepted differences more than 5 mm as asymmetry.

Since the asymmetry index represents a percentage expression, in their research carried out on various age groups, Moreira et al. (7) demonstrated that there was 15.44% symmetry in the Pns-Gpf asymmetry index and 27.41% symmetry in the Inc-Gpf asymmetry index when they accepted values of 1% and above as asymmetry. In the current study, when we accepted the asymmetry index value of 1%, we found symmetry in 42 cases (24.42%) in the Inc-Gpf and symmetry (8.14%) in 14 cases in the Pns-Gpf. When we accepted the asymmetry index value of 2% and higher as asymmetry, we determined that there was symmetry in 93 cases (54.07%) in the Inc-Gpf and 33 cases (19.19%) in the Pns-Gpf. When Moreira et al. (7) accepted the asymmetry index value of 2% and higher as asymmetry, they found 26.42% symmetry in the Pns-Gpf and 48.79% symmetry in the Inc-Gpf. The age distribution of cases in the study carried out by Moreira et al. (7) ranged from the fetal period to the elderly period. The cases in our study consist of the cases aged between 20-89 years. We think that the reason why the results are not parallel to each other originates from differences in age distribution.

The presence of asymmetry in a person should not always be regarded as an abnormal situation requiring treatment. The asymmetry between the bone structures may be tolerated with soft tissues to a certain extent, and asymmetry mirrored on the appearance adds character to the human face aesthetically (11). It is challenging to determine the normal and abnormal limits of asymmetry. Generally, treatment options should be considered according to clinicians' experience in facial balance and the patient's perception of asymmetry (40).

LIMITATIONS

This study had several limitations. Firstly, the nature of the study was retrospective. Secondly, technical parameters of CT imaging could not be optimized because the study was retrospective. Thirdly, the study had a relatively small sample size. There is a need for further large-scale studies in this area.

CONCLUSION

Morphometric measurements also need to be tested and verified in local samples due to increased human variation and inter-racial interactions. Different results have been reported between races, suggesting differences in hard palate morphology. This study provided important data on the hard palate morphology of the Turkish adult population. It also provides anthropological references for hard palate measurements in the Turkish adult population.

We determined the location of the Gpf according to the Pns and Inc by using 3D-CT images. The neurovascular bundles passing through Gpf are important structures that must be accessed for local anesthesia and some surgical procedures. The failed Gpf injection can cause strabismus, iatrogenic intravascular injections, ptosis, diplopia, iatrogenic nasopharyngeal injections, nerve injuries, and anesthetic failure. Determining the location of the Gpf according to anatomical structures will contribute to determining the location of the Gpf in surgical interventions to be performed in this region.

Competing interests: The authors declare that they have no competing interest.

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Ethical approval: Approval was obtained from the Clinical Research Ethics Committee of Suleyman Demirel University, Faculty of Medicine, for this study (Date: 05.06.2020, Decision No: 132).

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