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Morphometric Analysis of Greater Palatine Canal via Cone-Beam Computed Tomography

SUMMARY

Background/Aim: *The morphology of the greater palatine canal (GPC) should be determined preoperatively to prevent possible complications in surgical procedures required maxillary nerve block anesthesia and reduction of descending palatine artery bleeding. The purpose of this investigation was to evaluate the GPC morphology.* ***Material and Methods:*** *In this retrospective cross-sectional study, cone-beam computed tomography images obtained for various causes of 200 patients (females, 55%; males, 45%) age ranged between 18 and 86 (mean age±standard deviation=47±13.6) were examined. The mean length, mean angles of the GPC and anatomic routes of the GPC were evaluated.* ***Results:*** *The mean length of the GPC was found to be 31.07 mm and 32.01 mm in sagittal and coronal sections, respectively. The mean angle of the GPC was measured as 156.16° and 169.23° in sagittal and coronal sections. The mean angle of the GPC with horizontal plane was measured as 113.76° in the sagittal sections and 92.94° in the coronal sections. The mean GPC length was longer in males than in females.* ***Conclusions:*** *The results of this study showed that the most common pathway of the GPC was "first inferior, and then anterior-inferior direction" in sagittal plane and "first medial-inferior, then inferior direction" in coronal plane.*

Key Words: Greater Palatine Canal, Anatomy, Anesthesia, Cone-Beam Computed Tomography

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Introduction

Knowledge of the greater palatine canal (GPC) anatomy is very important for dentists, oral surgeons and otolaryngologists. Some complications may occur during several procedures such as local anesthesia in dental implant placement, orthognathic and sinonasal surgery; decreasing bleeding risk in osteotomy and fractures[1-6]. The GPC connects the oral cavity and the pterygopalatine fossa (PPF), contains descending palatine artery, minor palatal nerve, major palatal nerve and its posterior inferior lateral nasal branches[1,7]. Major and minor palatal nerves emerge on the hard palate by their foramina[8]. Depositing the anesthetic solution to the PPF via the major palatine foramen (MPF) is the most common technique for achievement of maxillary block. Injecting local anesthetic solution into the GPC provides vasoconstriction for endoscopic sinus surgery[2]. The achievement of infraorbital nerve block provides maxillary regional anesthesia due to the nerve located at the deep of the PPF[2, 3, 6].

Maxillary nerve block anesthesia may cause many complications such as the penetration of the orbital and nasal cavities, proptosis, blindness depending on the ophthalmic artery vasoconstriction, intracranial extension, intravascular injection, nasopharynx penetration, neural tissue damage and lack of anesthesia[3, 9]. Knowledge of the anatomy, the mean length and angle of the GPC play important roles during these procedures. The anatomical structure of the GPC can be determined by cone-beam computed tomography (CBCT)[10]. On the other hand, clinicians' knowledge of the GPC's mean length and angle might be useful before the surgical procedures[10].

To our best knowledge, there are only three published articles about the GPC morphology imaging with CBCT, and no published article with previous work conducted in the Turkish population.

The aim of this retrospective study was to determine the length, angle and the pathways of the GPC.

Material and Methods

The protocol of this study was approved by Ankara University's Faculty of Dentistry Clinical Research Ethics Committee (2014/36290600-109) and written informed consent was obtained from all patients. This study followed the Declaration of Helsinki on medical protocol. In total 200 CBCT images which were obtained between January 2012 and August 2012 at our Radiology Clinic, retrospectively. All evaluations were conducted by a dentomaxillofacial radiologist, approximately 50 cm away from the screen. Thirty percent of radiographic images were reexamined one month later by the same observer for intraobserver agreement.

Inclusion criteria of the study was as follows: patients older than 18 years, no artifacts in the maxillary region which would affect the quality of the image and without any pathology in the maxillary region[11].

The adequacy of the sample size was statistically analyzed with power analysis and the sample size was found to be adequate (Power value = 0.958).

CBCT images were obtained by ProMax 3D Mid (Planmeca Oy, Helsinki, Finland) using these exposure parameters: 90 kVp, 12 mA, scanning time of 13.85 seconds and 0.4 mm voxel size. The field of views (FOVs) used were 20×10 and 20×17 cm. Scanning was performed by fixing the patient's jaw and head support apparatus while the patient was standing. Images were examined in 24-inch Philips medical monitor with NVDIA Quadro FX 380 graphics card and 1920×1080-pixel resolution by using the original programme, Romexis® 2.7.0. (Planmeca Oy, Helsinki, Finland). Patients' age and sex were recorded.

Measurements

"On the axial view, the long axis of the incisive canal and the internal occipital protuberance were made parallel to sagittal plane and this axial section was chosen as the reference view for reconstruction of the sagittal and the coronal slices. The coronal and sagittal images were reconstructed as 0.4 mm slice interval/thickness. The measurements were established on the central sagittal and coronal section of the incisive canal and the internal occipital protuberance.

In sagittal sections, the superior limit of the GPC was determined as anterior-inferior point of foramen rotundum (FR); inferior limit was identified as hard palate projection of the MPF[10]. In coronal sections, the superior limit of the GPC was determined as the medial-inferior point of FR, inferior limit was identified as hard palate projection of the MPF[12]. The GPC length (Figure 1) and angle (Figure 2) were measured from the canal elbow in both sagittal and coronal sections[10]. The angle between the inferior part of the GPC and horizontal line (Figure 3) was measured from the canal elbow in both sagittal and coronal sections[13].

Anatomic pathways of the GPC were classified in sagittal sections (Figure 4) as described by Howard-Swirzinski *et al.*[10]:

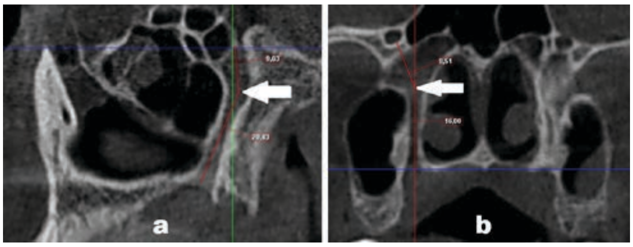

Figure 1. Measurements of the length of the GPC in sagittal (A) and coronal (B) sections. Elbow of the GPC was displayed by arrows.

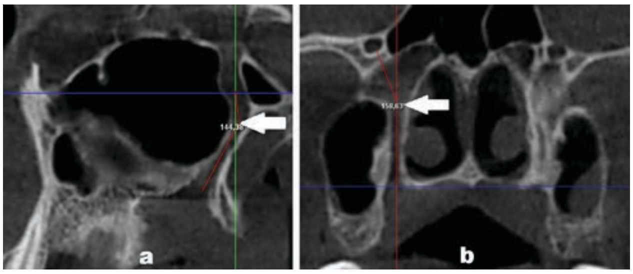

Figure 2. Measurements of the angle of the GPC in sagittal (A) and coronal (B) sections. Elbow of the GPC was displayed by arrow.

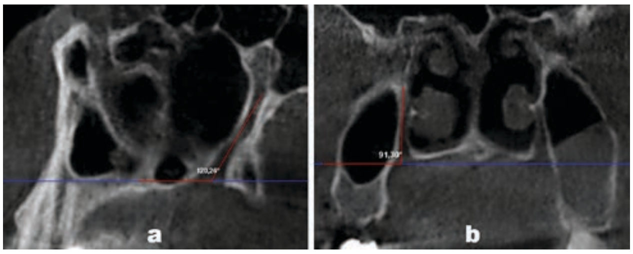

Figure 3. Measurements of the angle of the GPC with horizontal plane in sagittal (A) and coronal (B) sections.

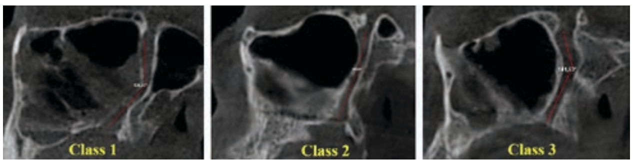

Figure 4. The GPC pathway classifications in sagittal sections. Class 1: "first inferior, then anterior-inferior direction"; Class 2: "direct anterior-inferior direction"; Class 3: "first posterior-inferior, then anterior-inferior direction".

- Class 1: "first inferior, then anterior-inferior direction"
- Class 2: "direct anterior-inferior direction"
- Class 3: "first posterior-inferior, then anterior-inferior direction"

Anatomic pathways of the GPC were classified in coronal sections (Figure 5) as described by Howard-Swirzinski *et al.*[10]:

- Class a: "direct inferior direction"
- Class b: "first medial-inferior, then inferior direction"
- Class c: "first inferior, then medial-inferior direction"

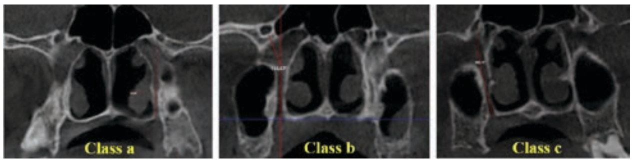

Figure 5. The GPC pathway classifications in coronal sections. Class a: "direct inferior direction"; Class b: "first medial-inferior, then inferior direction"; Class c: "first inferior, then medial-inferior direction".

All variables were examined in the right and left sides, respectively.

Statistical analysis

Data were statistically analyzed by using SPSS for Windows software version 19.0 (SPSS Inc., Chicago, IL, USA). The relationship between categorical variables were statistically analysed with chi-square test and t-test and ANOVA were used for comparison of the mean measurements. According to ANOVA test, when presence of the difference between the groups, a Scheffe multiple comparison test was performed to determine which groups are different from each other. The length and angle measurements; standard deviation, minimum and maximum values were calculated with descriptive analysis. Right and left measurements were compared for symmetry analysis. After determining the average around the age distribution is symmetric, patients included in this study were divided into three groups: 18-40 years old (N=62, 31%), 41-50 years old (N=59, 29.5%) and 51-86 years old (N=79, 39.5%). All analyzes were performed at the 95% confidence interval.

Results

In total 200 patients aged between 18-86 years old (mean age ± standard deviation: 47.2 ± 13.6) and consisted of 90 male (45%) and 110 female (55%) patients were included in the study. A total of 400 canal morphologies were evaluated.

Length and angle measurements of the GPC

The mean lengths of 400 GPC were found to be 31.07 mm and 32.01 mm in sagittal and coronal planes, respectively. The mean angles of GPC were found to be 156.15° and 169.23°, and also the mean angles of the GPC with horizontal plane were 113.76° and 92.94°in sagittal and coronal planes, respectively. The statistically significant difference ($p<0.05$) was found between right and left sides in the angle of the GPC with horizontal plane. The mean right angles of this parameter were higher than left angles. No statistically significant difference was detected between the other measurements of right and left sides. Details are shown in Table 1.

Table 1. Statistical analyses and comparisons of the right and left GPC measurements

Measurements	Side	Mean	SD	Minimum	Maximum	t	P value
The GPC length (sagittal) (mm)	Right	31.20	3.21	24.30	43.13		
	Left	30.94	3.15	23.59	41.40	1.96	0.06
The GPC length (coronal) (mm)	Right	32.03	3.00	24.81	40.69		
	Left	31.99	2.92	24.63	40.00	0.36	0.72
Angle of the GPC (sagittal) (°)	Right	155.96	9.40	126.11	180.00		
	Left	156.35	8.43	138.16	177.00	-0.61	0.54
Angle of the GPC with horizontal plane (sagittal) (°)	Right	113.95	5.50	95.00	132.74		
	Left	113.57	5.73	97.22	133.00	1.15	0.25
Angle of the GPC (coronal) (°)	Right	169.68	8.24	146.72	180.00		
	Left	168.79	9.07	142.88	180.00	1.49	0.14
Angle of the GPC with horizontal plane (coronal) (°)	Right	93.87	5.06	85.00	113.20		
	Left	92.01	3.98	79.92	116.06	4.96	0.00*

*Statistically significant at $p<0.05$ level. GPC: Greater palatine canal. SD: Standart deviation

There was a statistically significant difference ($p<0.05$) between females and males for the GPC length. The mean length of the GPC was longer in males than in females. No significant difference ($p>0.05$) between females and males was detected for angle measurements (Table 2). Furthermore, no significant measurement difference ($p>0.05$) was found between the age groups (Table 3).

Table 2. Comparison of the measurements by gender (SD: Standard deviation)

Measurements	Side	Gender	N	Mean	SD	t	P value
The GPC length (sagittal) (mm)	Right	Female	110	29.66	2.36	-8.62	0.00*
		Male	90	33.09	3.11		
	Left	Female	110	29.40	2.60	-9.08	0.00*
		Male	90	32.83	2.72		
The GPC length (coronal) (mm)	Right	Female	110	30.57	2.51	-9.01	0.00*
		Male	90	33.82	2.56		
	Left	Female	110	30.55	2.60	-9.20	0.00*
		Male	90	33.75	2.26		
Angle of the GPC (sagittal) (°)	Right	Female	110	155.81	10.31	-0.26	0.80
		Male	90	156.15	8.20		
	Left	Female	110	156.04	8.62	-0.57	0.57
		Male	90	156.73	8.23		
Angle of the GPC with horizontal plane (sagittal) (°)	Right	Female	110	113.52	5.57	-1.20	0.23
		Male	90	114.46	5.41		
	Left	Female	110	113.58	5.75	0.03	0.97
		Male	90	113.55	5.73		
Angle of the GPC (coronal) (°)	Right	Female	110	170.29	8.05	1.16	0.25
		Male	90	168.93	8.45		
	Left	Female	110	169.35	8.96	0.96	0.34
		Male	90	168.11	9.20		
Angle of the GPC with horizontal plane (coronal) (°)	Right	Female	110	93.95	4.76	0.26	0.80
		Male	90	93.78	5.43		
	Left	Female	110	91.64	3.41	-1.47	0.14
		Male	90	92.47	4.56		

*Statistically significant at $p<0.05$ level. GPC: Greater palatine canal. SD: Standart deviation

Table 3. Comparison of the measurements by the age groups (SD: Standard deviation)

Measurements	Side	Age groups	N	Mean	SD	F	P value
The GPC length (sagittal) (mm)	Right	18-40 years old	62	31.04	3.41	0.82	0.44
		41-50 years old	59	30.90	3.13		
		51-86 years old	79	31.55	3.12		
	Left	18-40 years old	62	30.92	3.68	1.08	0.34
		41-50 years old	59	30.49	3.03		
		51-86 years old	79	31.29	2.77		
The GPC length (coronal) (mm)	Right	18-40 years old	62	31.88	2.93	1.53	0.22
		41-50 years old	59	31.61	3.14		
		51-86 years old	79	32.47	2.93		
	Left	18-40 years old	62	31.90	3.08	1.11	0.33
		41-50 years old	59	31.61	3.06		
		51-86 years old	79	32.34	2.69		
Angle of the GPC (sagittal) (°)	Right	18-40 years old	62	154.66	7.32	0.89	0.41
		41-50 years old	59	156.31	10.68		
		51-86 years old	79	156.72	9.83		
	Left	18-40 years old	62	155.74	8.73	0.63	0.53
		41-50 years old	59	155.89	8.51		
		51-86 years old	79	157.18	8.18		
Angle of the GPC with horizontal plane (sagittal) (°)	Right	18-40 years old	62	114.96	5.73	2.95	0.06
		41-50 years old	59	112.60	5.65		
		51-86 years old	79	114.15	5.06		
	Left	18-40 years old	62	114.26	5.77	1.23	0.29
		41-50 years old	59	112.65	5.53		
		51-86 years old	79	113.70	5.82		
Angle of the GPC (coronal) (°)	Right	18-40 years old	62	169.61	8.56	0.16	0.85
		41-50 years old	59	169.25	8.54		
		51-86 years old	79	170.05	7.83		
	Left	18-40 years old	62	168.70	8.81	0.01	0.99
		41-50 years old	59	168.81	9.78		
		51-86 years old	79	168.85	8.82		
Angle of the GPC with horizontal plane (coronal) (°)	Right	18-40 years old	62	93.68	4.49	0.15	0.86
		41-50 years old	59	94.16	5.43		
		51-86 years old	79	93.80	5.25		
	Left	18-40 years old	62	91.79	3.86	0.13	0.87
		41-50 years old	59	92.11	3.51		
		51-86 years old	79	92.10	4.41		

GPC: Greater palatine canal. SD: Standart deviation

Classification of the GPC

Pathways of the GPC in the sagittal and coronal planes are shown in Table 4. The most common pathway of the GPC was Class 1 (72.25%, N=289) in the sagittal plane and Class b (57%, N=228) in the coronal plane.

Table 4. The distribution of the GPC pathways in sagittal and coronal plane

		Right GPC		Left GPC		Total	
	Class	N	%	N	%	N	%
Sagittal	1	138	69.0	151	75.5	289	72.25
	2	40	20.0	34	17.0	74	18.5
	3	22	11.0	15	7.5	37	9.25
Coronal	a	58	29.0	68	34.0	126	31.50
	b	110	55.0	118	59.0	228	57.00
	c	32	16.0	14	7.0	46	11.50
	Total	200	100.0	200	100.0	400	100.0

GPC: Greater palatine canal.

Class 1 was the most common pathway of all the age groups in sagittal plane. Class b was the most common pathway of the all age groups in coronal plane.

No statistically significant difference was found between the genders for the classification of the right and left GPC in sagittal plane (p>0.05). The most common pathway of the right GPC was found to be Class 1 in both females (68.2%) and males (70%). The most common pathway of the left GPC was Class 1 in both females (80%) and males (70%).

No statistically significant difference was found between the genders for the classification of right and left GPC in coronal plane (p>0.05). The most common pathway of right GPC was found to be Class 1 in both females (54.5%) and males (55.6%). The most common pathway of left GPC was found to be Class 1 in both females (57.3%) and males (61.1%).

Discussion

The anatomical structure of craniofacial complex depends on various factors such as age, gender and race; its symmetry may vary from individual to individual. Head and zygomatic arch sizes of females have been reported as smaller than in males. Midsagittal curvature, top third of the face, nose, eyes and palate has been shown to be statistically different between females and males[14-16].

In the literature, the length and anatomic pathways of the GPC have been investigated with cadaver, computed tomography (CT) and CBCT studies for different populations[5, 10, 17]. In the previous studies, the mean length of the GPC was found to be between 29-40 mm; the mean angle of the GPC (sagittal plane) was found to be between 148°-160°; the mean angle of the GPC (sagittal plane) with horizontal plane was found to be between 112°-122° [2, 5, 10, 12, 14, 19, 20].

The superior limit of the GPC was selected as different anatomical points -such as FR, orbital floor, foramen sphenopalatine, infraorbital fissure, pterygoid canal- by different authors[2, 5, 10, 12, 13, 18, 19]. The anesthetic solution must be deposited to the FR level of the maxillary nerve for an efficacious anesthesia[5]. Thus, the FR was selected as the superior limit of the GPC.

To our best knowledge, there are only two published articles about the GPC length via CBCT[10, 12]. Howard-Swirzinski *et al.* evaluated the length of the GPC in sagittal sections of 500 patients. Superior limit of the GPC was selected as pterygoid canal and the mean length of the GPC was found to be 29 mm±3 mm[10]. Sheikhi *et al.* examined the length of the GPC in sagittal sections of 138 patients. The superior limit of the GPC was selected as pterygoid canal and the mean length was recorded as 31.8 mm, no statistically significant difference was found between three age groups (18-24 age, 25-40 age, 41 and over age). The results of our study were different from other CBCT studies. Different results may have arisen from radiological methods, the choice's superior limit of GPC, sample size, age groups and various ethnic characteristics[2, 20]. In accordance with previous studies, the length of the GPC was found to be shorter in females than in males[12, 17, 18].

In this study, the mean angles of the GPC were found to be 156° and 169° for sagittal and coronal sections, respectively. These results were compatible with the previous studies[10, 13].

The anatomic pathways of the GPC have been classified by different investigators and methods. In clinical practice, injection from the MPF to the PPF might be difficult, because of the anatomical variations, especially in coronal plane[10]. Wang *et al.* studied 100 dried skulls and reported that the long axis of the GPC opened to the oral cavity 90.5% anteriorly and 9.5% vertically[21].

In this study, the anatomical pathways of the GPC were classified as similar with Howard-Swirzinski's study[10]. The GPC travelled most frequently (72.3%) in first inferior, than anterior-inferior direction in sagittal plane, it travelled most commonly (57%) in first medial-inferior, than inferior direction in coronal plane. Our results for the sagittal plane were compatible with Sheikhi's study[12], conversely Howard-Swirzinski's[10]. On the other hand, our results for coronal plane were not consistent with the previous studies[10, 12]. These differences may be explained by the selection of different superior limits of the GPC. No statistically significant difference was detected between genders and age groups for the GPC types.

This study presents a number of limitations. We investigated and classified the GPC morphology in sagittal and coronal planes, not in three-dimensional classification. Another limitation of the study is the lack of palatal soft tissue thickness measurements due to CBCT's deficiency in the soft tissue imaging. Therefore, the thickness of the palatal mucosa must be added to the distance of the injection depth[5].

In conclusion; the mean GPC lengths were longer in males than in females and it was found to be approximately 31-32 mm. The mean angles of GPC were measured as 156° and 169°, and also its mean angles with horizontal plane were 114° and 93° in sagittal and coronal planes, respectively. The most common pathway of the GPC was "first inferior, then anterior-inferior direction" in sagittal plane and "first medial-inferior, then inferior direction" in coronal plane.

Conclusions

The results of this study showed that the most common pathway of the GPC was "first inferior, and then anterior-inferior direction" in sagittal plane and "first medial-inferior, then inferior direction" in coronal plane.

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