The Anatomical Position and Size of Greater Palatine Foramen and Canal in an Iranian Sample Using Cone Beam Computed Tomography

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Research

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Abstract

Introduction

Detection of exact location of greater palatine foramen and its anatomical variations are vital prior to posterior maxillary surgeries and gingival grafts. The aim of this study is to determine the anatomical position and size of the greater palatine canal (GPC) and foramen (GPF) using cone beam computed tomography (CBCT) scans.

Materials and methods

In this descriptive-analytic study, CBCT images of 148 patients were assessed. To determine the anatomical foramen position, the posterior maxilla area was divided into five regions on the axial view (A: from the mesial surface of the second molar to the center of the second molar, B: from the center of the second molar to its distal, C: from the mesial surface of the third molar to the center of the third molar, D: from the center of the third molar to the distal of the third molar, E: distal to the third molar.). The length of the canal was investigated on both coronal and sagittal views. Independent and paired T-test were used to analyze the data.

Results

Among 80 females -68 males, the anatomical position of the GPF was mainly located in region E on the left (55%) and the right (50%), and then, respectively, in region D and region C. The mean diameter of GPF was 4/48 mm on the left and 4/63 mm on the right side (P-value = 0/01). The average length of the canal on the coronal view was 29.46 mm on the left side and 29.75 mm on the right (P-Value = 0/005). The average length of the canal on the sagittal view was 29.62 mm on the left and 30.02 mm on the right (P-value = 0/001).

Conclusion

The anatomical position of the GPF was primarily located distal to the third maxillary molar. CBCT is a valuable diagnostic tool for evaluation of vital anatomic landmarks in the maxillofacial region prior to surgeries and interventions.

Introduction

The pterygopalatine fossa (PPF) is a pyramidal area between the maxilla, sphenoid and palatine bone that contains the maxillary artery, its branches and the accompanying vein, the trigeminal nerve and its branches including the maxillary nerve (1). The Greater Palatine Canal (GPC) is a canal in the posterior maxilla containing the greater palatine and lesser palatine nerves which further enters the hard palate. This canal is one of the most critical maxillary landmarks due to its vascular and nerve fibers (2) and serves as an anatomical pathway connecting the oral cavity and PPF. The canal is typically used to inject

local anesthesia prior to posterior maxillary surgeries, affecting the nerves that extend through the palatine trigeminal path(3).

A direct access to the PPF, including the sphenopalatine ganglion, pterygopalatine ganglion, infraorbital nerve, internal maxillary artery and pterygoid venous plexus is provided by GPC. The most common method for a maxillary nerve block is the GPC block. The GPC block is used in all palatal interventions, where severe palate anesthesia is required, including periodontal surgery, abscess drainage, and even oral surgery such as tooth extraction(4, 5). GPF blocks are also effective for anesthesia and for controlling bleeding during paranasal sinus surgery (6). Mendel first introduced this method in 1917 (5) and applied injections into the GPC. To succeed in this method, at least two-thirds of the length of the needle must be inserted into the canal to deliver the anesthetic substance to the trunk of the maxillary nerve.

Complications such as proptosis, constriction of ophthalmic arteries, the spread of infection into the skull, intravascular injection, penetration of the nasopharynx, damage to nerve tissues, and unsuccessful anesthesia are possible to occur if the anesthetic needle passes through the nasal cavity and eye (7, 8). Therefore, having sufficient knowledge of location, anatomy and average length of the GPC is crucial to avoid these problems.

Today, Cone beam computed tomography (CBCT) imaging is widely used due to its high-quality images of bone structures in the head and neck region (9-11). CBCT is capable of producing high-resolution images. In addition, various studies have shown that in determining the morphology of the maxilla and mandible, including position of nasopalatine canal (NPC) and the position of the inferior alveolar canal and the exact location of the radiopaque implant to the bone (12,13). To the best of our knowledge, there are no studies assessing GPC in Iranian population. Therefore, the aim of this study is to assess the anatomical position of the GPF and the size of the Greater Palatine Canal using CBCT images.

Materials And Methods

Methods and Material:

This study was approved by research committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.RIDS.1396.4618).

Sample size:

This descriptive cross sectional study was performed on data from CBCT examinations of 148 patients referred to three Oral and maxillofacial radiology departments from 2015 to 2019 (one clinic in Tehran, Iran and two clinics in Khorramabad, Iran).

Evaluation of CT scans:

CBCT scans were obtained using NewTom VGi (Verona, Italy, kvp: 110, FOV: 12 × 8, voxel size: 125μ), Sordex, Scanora 3D (Helsinki, Finland, (kvp: 90, FOV: 7.5 × 10, mA: 8, voxel size 200 μm), and Planmeca 3D imaging (Helsinki, Finland, kvp: 84, FOV: 23 × 16, mA: 14, voxel size 200 μm). Images were evaluated

using Ondemand 3D application version No 1.0.1 in a standardized position with maxillary occlusal plane parallel to the horizontal axis. Demographic information including age and gender were recorded. All measurements taken from the CBCT scans were completed by one experienced oral and maxillofacial radiologist.

Inclusion criteria:

- CBCT scans of patients over 18 years of age
- Scans must have been full-volume containing complete maxilla and pterygopalatine fossa with second and third molars on both sides
- Images must have been of adequate resolution/diagnostic quality.

Exclusion Criteria:

- Toothless individuals.
- Any scan that did not satisfy any of the requirements listed in the inclusion criteria.
- Any scan with “radiographic noise” or patient movements that did not allow measurements to be recorded in the planning software.

The following items were evaluated on CBCT scans:

- 1) Anatomical position of the GPF on the right
- 2) Anatomical position of the GPF on the left
- 3) Size of the GPF on the right
- 4) Size of the GPF on the left
- 5) Average length of the GPC on the right
- 6) Average length of the GPC on the left.

In order to investigate the anatomical position of the GPF, the posterior maxilla was divided into the five following areas at the level of the Cementoenamel junction (CEJ) of tooth, on axial views (Figure-1) and the position of the foramen was located from A to E:

A: from the mesial surface of the second molar to the center of the second molar

B: from the center of the second molar to its distal

C: from the mesial surface of the third molar to the center of the third molar

D: from the center of the third molar to the distal of the third molar

E: distal to the third molar.

by scrolling up the axial views towards the greater palatine foramen, same locations from A to E were marked. In addition the foramen diameter was measured on axial views at the level of the palate (Figure-2).

On sagittal and coronal views the length of the greater palatine canal was measured connecting the upper and lower limits. Initially, the anatomical regions greater palatine foramen (GPF), greater palatine fossa and pterygopalatine fossa (PPF) were identified. Then the shortest line connecting the highest point of the PPF to the GPF and considered it as the length of the canal. If the canal was not completely straight, a curvilinear measurement was applied. Figure-3 shows the anatomical variations of the canal and how the length of the greater palatine canal was measured on the coronal view. On the sagittal view, the upper limit of PPF was marked posterior to the eye socket, and the lower limit was marked at GPF in the palatine bone (Figure-4).

Statistical analysis:

All data were entered into a database system and evaluated using SPSS® for Windows version 26 (SPSS Inc., Chicago, IL, USA, 2012). Data analysis was performed with descriptive statistics. The level of significance was set at $p = 0.05$. Independent and non-independent t-tests were used to analyze the data and their significance. For all measurements an intraclass correlation (ICC) was measured to assess the intraoperator reliability.

Results

Intra-Operator Reliability

Measures for the first and second replicates of 20 patients were recorded and intra-class correlation coefficients (ICC) were established for all measurements. Most measures demonstrated a high degree of reliability between the first and second replicates with ICC values exceeding from 0.73 to 0.99.

Demographic Data

Within the 148 assessed CBCT scans, the gender distribution was 80 female and 63 male. The age range of subjects in this study varied from 35 to 85 years old with mean of 64.33 ± 10.61 for females and 65.16 ± 10.88 for males.

The anatomical position of the Greater Palatine foramen:

The position of this foramen was examined in five anatomical areas, the results of which are reported by gender on the left and right of each patient in Tables-1 to -3. The highest prevalence of the greater palatine foramina in both genders on both the right and left sides was located in area E.

Table 1: Position of the left greater palatine foramen

			Position of the left greater palatine foramen					Total
			A	B	C	D	E	
Gender	Male	count	5	15	8	14	26	68
	Within%		3.37	10.13	5.41	9.45	17.57	45.95
	Female	count	3	8	16	24	29	80
	Within%		2.04	5.41	10.81	16.23	19.59	54.05
Total	count		8	23	24	38	55	148
	Within%		5.41	15.54	16.22	25.68	37.16	100

Table 2: Position of the right greater palatine foramen

			Position of the right greater palatine foramen					Total
			A	B	C	D	E	
Gender	Male	count	6	12	10	14	26	68
	Within%		4.05	8.10	6.75	9.45	17.56	45.95
	Female	count	2	11	16	27	24	80
	Within%		1.36	7.44	10.85	18.25	16.22	54.05
Total	count		8	23	26	41	50	148
	Within %		5.41	15.54	17.6	27.70	33.78	100

Table 3: Position of the greater palatine foramen on both right and left

		Position of the greater palatine foramen					Total
		A	B	C	D	E	
Right	Count	8	23	26	41	50	148
	Within%	2.70	7.77	8.78	13.85	16.89	50
Left	Count	8	23	24	38	55	148
	Within%	2.70	7.77	8.11	12.84	18.58	50
Total	Count	16	46	50	79	105	296
	Within%	5.41	15.54	16.89	26.69	35.47	100

The greater palatine canal diameter:

The diameter of this canal was examined on the axial view. The largest diameter of this canal was detected in males on the right and the lowest diameter was detected in females and on the left (Table 4).

Table 4: Diameter of the greater palatine canal. L: left, R: right, T: Total

	Gender	Frequency	Minimum diameter (mm)	Maximum diameter (mm)	Average diameter (mm)	P-Value
R	Male	68	3.13	6.77	4.65	0.995
	Female	80	2.32	6.55	4.63	
L	Male	68	2.67	7.02	4.49	0.773
	Female	80	2.60	6.80	4.47	
T	Right	148	2.60	7.02	4.63	0.010
	Left					

The Greater Palatine Canal Length:

To measure the length of the greater palatine canal, both sagittal and coronal views on both sides were examined. The data in each view were reported separately in Tables-5 and -6. The average length of this canal on the sagittal view on the right was 30.02 mm and 29.62 mm on the left side, but these values were lower on both sides on the coronal view than on the sagittal view. The highest canal length on both sagittal and coronal views was reported in males on the right, and the lowest canal length in both views was reported in females on the right.

Table 5: The length of the greater palatine canal in the sagittal view. L: left, R: right, T: Total

Gender		Frequency	Minimum diameter (mm)	Maximum diameter (mm)	Average diameter (mm)	P-Value
R	Male	68	23.42	43.91	30.06	0.473
	Female	80	23.04	43.33	29.99	
L	Male	68	23.70	39.88	29.75	0.677
	Female	80	23.32	39.34	29.51	
T	Right	148	23.04	43.91	30.02	0.001
	Left					

Table 6: The greater palatine canal length in the coronal view. L: left, R: right, T: Total

Gender		Frequency	Minimum diameter (mm)	Maximum diameter (mm)	Average diameter (mm)	P-Value
R	Male	68	22/74	43/13	29/93	0.534
	female	80	22/61	42/65	29/59	
L	Male	68	23/28	39/02	29/63	0.579
	female	80	23/80	39/49	29/32	
T	Right	148	22/61	43/13	29/75	0.005
	Left	148	23/28	39/49	29/46	

Discussion

Several studies have recently examined anatomical landmarks and their structural diversity to advance better and more accurate surgical treatments (2,14,15). One of the most important landmarks of the maxilla is the greater palatine foramen, which has recently attracted attention. In line with previous studies, the present study showed that the GPC has many anatomical variations and dimensions (1,3). Despite numerous studies on this canal, information about its size and anatomical variations, and morphology in races, especially in the Iranian population, is scarce.

The GPC length:

In the present study, the average canal length on the left was 29.75 mm in males and 29.51 mm in females, and on the right, this amount was 30.06 mm in males and 29.99 mm in females. In a study by Razavi et al., the average length of the greater palatine canal was 31.34 mm in women and 28.89 mm in men (16). On the coronal view, the average length of the greater palatine canal was 29.75 mm on the right and 29.46 mm on the left. Also, the average canal length on the left was 29.63 mm in men and 29.32 mm in women, and on the right, this amount was 29.93 mm in men and 29.59 mm in women. A study by Georges Aoun et al. reported that the length of the greater palatine canal on the sagittal view was 35.02 mm on the right and 35.01 mm on the left. The shortest canal length in this study was reported to be 20.82 mm, and the maximum was 41.60 mm (17). The results of this study were inconsistent with our results, which may be due to ethnic-racial differences.

The GPF size:

In the present study, the size (diameter) of the Greater Palatine foramen was also measured, with an average diameter of 4.48 mm on the right and 4.63 mm on the left. Also, the average size of the Greater Palatine foremen on the left was 4.49 mm in men and 4.47 mm in women, and on the right, 4.65 mm in men and 4.63 mm in women.

In the study of Georges Aoun et al., The mean diameter of the Greater Palatine foramen was 5.63 mm on the right and 5.72 mm on the left. These results show a one-millimeter difference compared to our results, which is clinically negligible (17). In another study in 2020, the mean median-distal diameter of the Greater Palatine foramen was measured 3.67 mm on the right and 3.64 mm on the left. This is also clinically negligible due to the slight difference of about 1 mm(18).

The GPF anatomical position:

In the present study, the most general position of the Greater Palatine foramen on the right and left were in the distal third molar (region E) and then between the center and the distal of the third molar. Also, the highest position of the Greater Palatine foramen in men was on the right and left in the distal third molar, while in women, it was positioned in the distal of the third molar on the left and close to the third molar on the right. Contrary to the results of our study, Carla Ikuta et al. reported the highest prevalence of the anatomical position of the Greater Palatine foramen between the mesial part of the third molar to its

center (53%) and then from the center of the third molar to its distal (39%) and then the distal of the third molar (19%).

Also, a study by Georges Aoun et al., the highest position of the Greater Palatine foramen was between the mesial to the distal of the third molar (41.38%) and then in the distal of the third molar (29.31%), which was not consistent with our results (18). The most common location of the Greater Palatine foramen was in the posterior region of the third molar, followed by in front of the center-to-distal of the third molar. The recorded dimensions of the foramen diameter in the axial view were higher in men than in women and more on the left than on the right. Also, in the present study, the mean canal length was higher in men than women and higher on the right than on the left. These variations are in consensus with previous studies (17-19)

Conclusion

In general, the GPC was located distal to the third molar (>50%) in Iranian population. However, due to the anatomic variations of GPF and GPC, careful assessment of this region is suggested prior to any surgery of intervention.(20)

Limitations:

Due to the limited number of samples, it is recommended to conduct studies with a larger sample size in this field to obtain more accurate results.

Abbreviations

GPC: grater palatine canal, GPF: grater palatine foramen, CBCT: cone beam computed tomography, PPF: pterygopalatine fossa, NPC: nasopalatine canal, CEJ: Cementoenamel junction, ICC: intraclass correlation

Declarations

Ethics approval and consent to participate:

The study protocol was approved by the institutional review board of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR.SBMU.RIDS.1396.4618).

Consent for publication:

All authors consent to publication of this manuscript.

Availability of data and materials:

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests

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Authors' contributions:

Valizadeh S designed and supervised the study process. Ahmadi S.M performed data acquisition and investigation. Valizadeh S and Ghazizadeh Ahsaie M and Vasegh Z participated in the data analysis and interpretation. Jamalzadeh N drafted the manuscript. Ghazizadeh Ahsaie M revised the manuscript. All the authors have reviewed and approved the final article.

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Figures

Figure 1

Criteria for examining the position of the Greater Palatine foramen on axial views (A: at the level of CEJ and B: at the level of foramen). A: from the mesial surface of the second molar to the center of the

second molar,B: from the center of the second molar to its distal, C: from the mesial surface of the third molar to the center of the third molar, D: from the center of the third molar to the distal of the third molar,E: distal to the third molar.

Figure 2

assessment of the diameter of the greater palatine foramen in the axial view

Figure 3

Greater Palatine canal measurement on coronal view

Figure 4

Greater Palatine canal measurement on sagittal view