Evaluation of Greater Palatine Canal and Foramen Anatomical Variation on Cone-beam CT Radiography

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Introduction: A known method for maxillary nerve block is through the greater palatine canal (GPC). Poor knowledge about the anatomy might result in undesired conditions such as perforation of the arteries, nerve damage and blindness. This study aimed at determining variations of the GPC and greater palatine foramen (GPF) on cone beam computed tomography (CBCT) images. **Materials and Methods:** This cross-sectional descriptive study was carried out at Islamic Azad University dental school and private clinics of Isfahan in 2018. A total of 92 CBCT images of adults over 18 years old were evaluated and GPC length, GPF diameter and its distance to the anterior nasal spine (ANS), posterior nasal spine (PNS) and mid-maxillary suture (MMS) were measured. The data were analyzed using SPSS 18. **Results:** The mean distance of GPF to ANS (47.96 mm in men and 45.36 mm in women), to PNS (18.9 mm in men and 17.21 mm in women), and to MMS (15.93 mm in men and 14.73 mm in women), as well as the diameter of the GPF (6.07 mm in men and 5.01 mm in women) were significantly higher in men on both right and left sides (P<0.05). The mean GPC length in men and women was 34.36±2.5 and 31.39±1.9 mm, respectively, which was significantly larger in men. The more common canal pathway in sagittal plane was inferior/inferior-anterior (70%) in both genders. The inferior/inferior-anterior pathways were more common in both genders in coronal plane; however, this difference was not significant (P>0.05). **Conclusion:** Since the maxillary nerve block technique might cause irreparable complications through GPC, it is very important to know the position of the foramen and the canal direction. Therefore, it is advisable to use CBCT in order to better understand the GPF and GPC anatomy.

Keywords: Cone Beam Computed Tomography; Greater Palatine Canal; Greater Palatine Foramen; Maxillary Nerve Block

Introduction

The greater palatine canal (GPC) plays an important role in maxillofacial surgery (1). Above the maxillary surface of the palatine bone, there is a deep vertical groove that connects with the maxillary bone and forms the GPC that ends at the greater palatine foramen (GPF), which is formed by the vertical plate of the palatine bone and the palatine process of the maxilla (1, 2). The maxillary nerve is derived from the trigeminal ganglion, leaving the middle cranial fossa through foramen rotundum and entering the pterygopalatine cavity (2-4).

The GPC is the common way to access pterygopalatine fossa for anesthesia of the maxillary branch of the trigeminal nerve; therefore, local anesthesia must be administered with insertion two thirds of the needle from the GPF (2, 3). Maxillary nerve block provides the anesthesia of the hemimaxilla containing teeth, palatal and gingiva soft tissue, midfacial skin, maxillary sinus and oral cavity (3, 5). This technique causes nasal hemostasis due to the vasoconstriction effects on maxillary artery which is necessary in various procedures such as endoscopic sinus surgery, palatal free vascular flaps and septorhinoplasty (2, 6). Therefore, the ability to fine the correct location of the GPF and GPC and awareness of canal length is essential for oral and maxillofacial surgeons, otolaryngologists, periodontists and clinicians who work in the specialized fields of dentistry (2, 7, 8). Moreover , it might be helpful for determining gender in forensic medicine (8). Poor knowledge of the location and anatomy of the GPF increases the risk of damage to the greater palatine nerve and artery such as perforation of the orbit, blindness and intracranial infection (9-11).

With the advancement of medical imaging, CT scan and cone beam computed tomography (CBCT) systems, determining the position of the GPC and GPF more accurately and anatomical variations of them is possible (2, 3).

The purpose of this study was to investigate the diameter and position of the GPF, GPC, canal length and direction relative to anatomical landmarks on CBCT radiography in an Iranian population in Isfahan.

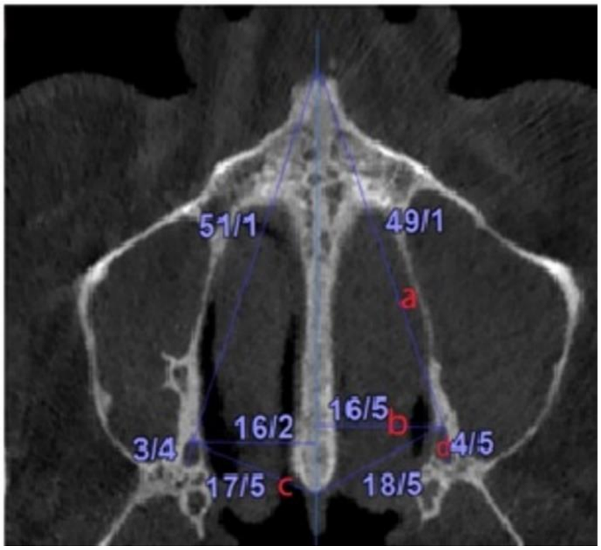

Figure 1. Axial view. a: GPF to ANS distance; b: GPF to MMS distance; c: GPF to PNS distance; d:GPF diameter

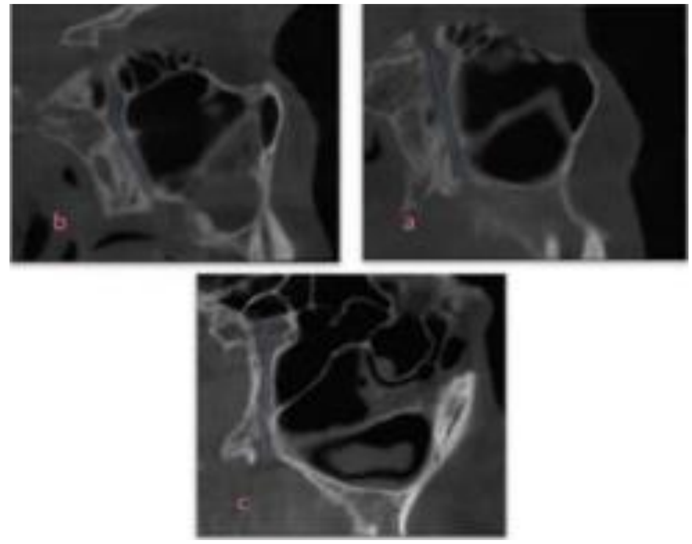

Figure 2. Sagittal view. *A*) Inferior-anterior route; *B*) Inferior/inferior-anterior route; *C*) Inferior route

Materials and Methods

Sample collection

This study has been approved by ethical board at the Islamic Azad University (Khorasgan branch). A total of 92 CBCT images, including 46 females and 46 males over 18 years old, were randomly collected from the archive of Depatment of Oral Radiology of Isfahan Azad University and private offices in Isfahan. The exclusion criteria were the existence of any pathology and/ or deformity in the maxillofacial region.

Graphies were prepared using the Galileos-Sirona CBCT machine (Bensheim-Germany).

Parameters of the CBCT imaging

The parameters were adjusted based on the patient's size and the recommendation by the manufacturer. Technical parameters were 85 KVp, 10-42 mA, 14 s exposure time with 2-6 s effective exposure time, 0.3×0.3×0.3 mm^3 voxel size and 2.5 minutes reconstruction image time.

Two dimensional images in panoramic, cross-sectional and axial planes and computer-reconstructed three-dimensional images of the maxillary bone were examined.

CBCT assessment

The CBCTs were assessed by two researchers separately in a proper environment. The mean diameter of the GPF and its distance to the anterior ANS, PNS and MMS in both right and left parts were evaluated and the results were compared between genders. The mean length of the GPC and its direction were measured and compared between the two genders as well.

Axial view was used to assess GPF diameter. The diameter was measured from the largest part and the distances from landmarks were measured from the anteriormost point of the foramen using the measure tool in millimeters (Figure 1).

Sagittal view and right side of the images were used to evaluate GPC length and sizes were recorded. In order to evaluate GPC route, images were examined in both sagittal and coronal views and the samples were divided into following groups according to the results:

Sagittal view

The canal travels all the way inferior- anterior (Figure 2A).

The canal first travels inferior and then inferior- anterior (Figure 2B).

The canal travels all the way inferior (Figure 2C).

Coronal view

The canal first travels inferior- lateral and then inferior- medial (Figure 3A).

The canal first travels inferior- lateral and then inferior (Figure 3B).

The canal first travels inferior- lateral, then inferior and the rest goes inferior- medial (Figure 3C).

The canal travels all the way inferior (Figure 3D).

All measurements were performed under the supervision of a maxilllofacial radiologist and were repeated after two weeks.

Statistical analysis

The measurements were analyzed by SPSS software 18, using Independent t- test, Chi-square test and Mann-whitney test.

Table1. The comparison of GPF diameter

GPF diameter	Gender	Number	Mean ± SD	*P*-value
Left	Male	46	6.02±1.27	0.005
	Female	46	5.10±1.40	
Right	Male	46	6.13±1.14	0.000
	Female	46	4.91±1.18	

Table2. The comparison of GPF to ANS distance

GPF to ANS distance	Gender	Number	Mean ± SD	*P*-value
Left	Male	46	47.80±3.99	0.001
	Female	46	45.17±2.96	
Right	Male	46	48.13±3.99	0.001
	Female	46	45.56±2.79	

Table3. The comparison of GPF to PNS distance

GPF to PNS distance	Gender	Number	Mean ± SD	*P*-value
Left	Male	46	18.80±1.80	0.000
	Female	46	17.22±1.33	
Right	Male	46	19.01±2.02	0.000
	Female	46	17.21±1.53	

Table4. The comparison of GPF to MMS distance

GPF to MMs distance	Gender	Number	Mean ± SD	*P*-value
Left	Male	46	15.75±1.38	0.000
	Female	46	14.66±1.51	
Right	Male	46	16.11±1.34	0.000
	Female	46	14.81±1.47	

Results

The present study was conducted on 92 CBCT images of 46 females and 46 males in Isfahan in 2018.

GPF analysis: Statistical analysis showed that the mean diameter of right and left GPF in men was significantly larger than women (*P*<0/05) (Table 1). The mean distance of GPF to right and left ANS in men was significantly higher than women (*P*<0/05) (Table 2). The mean distance of GPF to right and left PNS was significantly higher in men in comparison with women (*P*<0/05) (Table 3) and the mean distance of GPF to right and left MMS was significantly higher in men than women (*P*<0/05) (Table 4).

GPC length analysis: The mean length of right and left GPC was significantly larger in men compared to women (*P*<0/05).

GPC direction in sagittal plane: Statistical analysis demonstrated that the most canal direction in the sagittal plane was inferior/inferior-anterior in both genders. The GPC directions in sagittal plane were significantly different among men and among women (*P*<0/05); however, the difference was not significant between the two genders (*P*>0.05) (Figure 4).

GPC direction in coronal plane: The canal direction with the highest frequency in coronal plane was inferior-lateral/ inferior-medial in both genders. There was no significant difference in GPC directions in coronal planes between men and women (*P*> 0.05) (Figure 5).

Discussion

Nowadays with the advent of advanced CBCT imaging, high resolution 3D images can be used to examine maxillofacial hard tissue (2, 3, 12). In the present study, the position and anatomy of the GPF and GPC were examined and compared among genders in order to provide useful information to reduce complications during maxillary nerve block in medical and dental procedures.

The mean GPF diameter measured in both men and women on both sides was consistent with the results of the study performed by Aoun *et al.* (6.39±1.28 mm) (13). The values of mean GPF diameter, mean GPF distance to ANS point, mean GPF distance to PNS point, mean GPF distance to MMS and mean GPC length were significantly higher in men in comparison with women which might be due to larger size of the male skull than female (14).

The mean GPC length measured in this study corroborate the results of the evaluations performed by Tomaszewska *et al.* (32.6±2.8 mm in men and 29.6±2.5 mm in women), Aoun *et al.* (35.02±3.89 mm); however, Asha *et al.* reported different outcomes (28.46±3.37 mm in men and 24.94±2.12 mm in women) (15-17).

The mean GPF to PNS distance distance obtained in this study was in accordance to the results of Viveka and Kumar (right and left, 17.78±1.78 mm and 17.44±2.02 mm, respectively) (18). The mean GPF to ANS distance in the present study supports the outcomes reported by Aoun *et al.* (49.49±3.84 mm and 49.02±4.10 mm, 47.33±2.98 mm and 47.29±3.29 mm; right and left sides in men and women respectively) (13). The mean GPF to MMS distance was different from the results of Asha *et al.* which might be due to the differences in the point of origin (17). Asha *et al.* used the middle of the canal in measurements while in the present study; the anteriormost point of the canal was selected as the origin (17). The mean GPF to MMS distance on the right side was consistent with the study of Viveka and Kumar (16.72±2.61 mm), however the results of left side were different (20.03±3.38 mm) (17, 18). Variations of GPF might depend on the fusion time of the interpalatine suture (2).

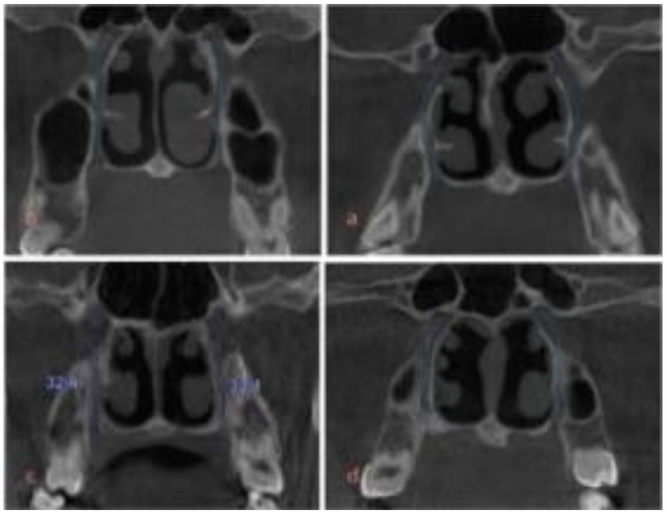

Figure 3. Coronal view. A) Inferior-lateral/ inferior-medial route; B) Inferior-lateral/ inferior route; C) Inferior-lateral/ inferior/ inferior-medial route; D) Inferior route

A significant difference was shown in the prevalence of canal pathways in sagittal plane between men and women separately ($P<0.05$). The most common canal pathway in sagittal plane was inferior/inferior-anterior which was in agreement with the results of the study conducted by Tomaszewska *et al*., Asha *et al*., Sheikhi *et al*. (13-15). On the other hand, the outcome was different from two studies performed by Weaam *et al*. and Howard-Swirzinski *et al*. that both reported the anterior- inferior pathway as the most common direction in sagittal plane(19, 20).

There was no significant difference in the prevalence of GPC pathways in men and women in coronal plane ($P>0.05$). The most frequent GPC pathway was inferiorFigure lateral/ inferior-medial in coronal plane, which was in accordance with the studies Tomaszewska *et al.* and Asha *et al.* and was different from the outcomes of Sheikhi *et al.* (inferior lateral/ inferior pathway), Weaam *et al.* (inferior pathway) and Howard-Swirzinski *et al.* (inferior pathway) (15, 19, 20). There was no significant difference in the prevalence of GPC pathways in coronal and sagittal planes between men and women in the present study ($P>0.05$).

It is essential to have enough knowledge about the position and anatomy of GPF and its relation to anatomical landmarks, GPC length and pathway as well in order to increase the success of maxillary nerve block anesthesia and avoid complications. Although the present study has provided informations about the anatomic variations of GPF and GPC in an Iranian population, further investigations containing larger sample size and samples of other populations are required to obtain more useful outcomes on GPF and GPC anatomical variations.

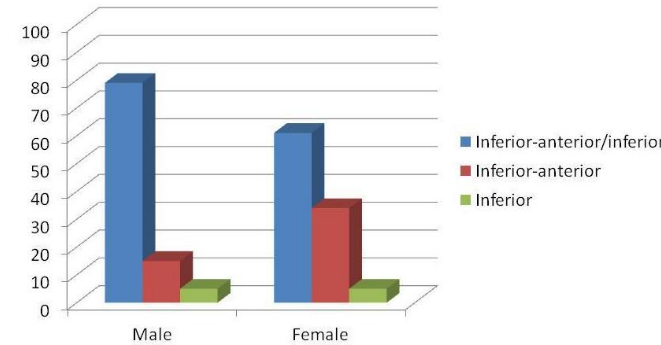

Figure 4. GPC pathways frequency in sagittal plane

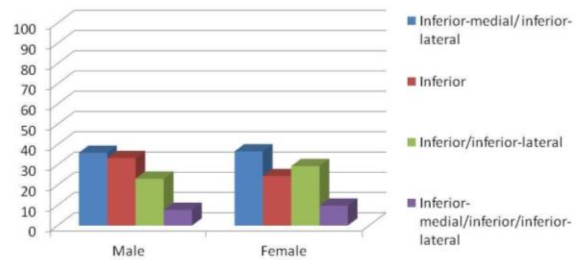

Figure 5. GPC pathways frequency in coronal plane

Conclusion

The diameter of GPF and its distance to ANS, PNS, MMS and GPC length is significantly higher in men. The most common GPC direction in sagittal plane was inferior and then inferior-anterior. In coronal plane, the canal travels inferior- lateral first and then travels the rest of the route in inferior- medial path.

Conflict of Interest: 'None declared'.

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