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Research Article

Anatomical Variations of the Path and Length of the Greater Palatine Canal in an Iranian Population Using Cone Beam Computed Tomography

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ABSTRACT

Purpose: This study aimed to assess the anatomical variations of the path and length of the GPC using cone beam computed tomography (CBCT) scans. **Methods**: In this descriptive cross sectional study, 96 CBCT scans of patients (32 males and 64 females) were retrieved from the archives of the Radiology Department of Hamadan University of Medical Sciences and evaluated. Both the right and left GPCs were studied in the coronal and sagittal planes and their path and length were determined using NNT Viewer software. We used spss 22 soft ware for data analysis and descriptive (frequency tables) and analytic (chi square,mann-whitney tests)statistics were used if required to explain the results. **Results**: The mean length of the GPC was 33±2.87 mm (range 26.1 to 39.88 mm). In the coronal plane, straight inferior path (49%) was the most common anatomical path of the GPC. In the sagittal plane, anterior-inferior path (32.3%) was the most common pattern. **Conclusion**: The GPC was longer in our Iranian population compared to the mean values reported for other races. Knowledge about the length and path of the GPC can help the clinicians in effective administration of anesthesia. In case of availability, CBCT data can greatly help in determination of the length and path of the GPC.

Keywords: Greater Palatine Canal; Cone-Beam Computed Tomography; Anatomical Variations

INTRODUCTION

Anatomy of the greater palatine canal (GPC) has long been an interesting topic for dentists, maxillofacial surgeons and otorhinolaryngologists. Knowledge in this regard is mandatory for the surgeons prior to local anesthetic injection in this area, dental implant placement, osteotomy, orthognathic surgery or sinonasal surgery in this region 1-6. This region includes the palatine artery (third branch of the maxillary artery), greater palatine nerves (maxillary branch of the trigeminal nerve) and posterior-inferior lateral nasal nerves. Maxillary nerves provide sensory innervation to all the maxillary teeth, palatal and gingival tissues, skin of the mid-face, nasal cavity and sinuses. The maxillary nerve block in the pterygopalatine fossa causes desensitization of all the afore-mentioned structures in the same side as the blocked nerve. A common approach for this nerve block is via the GPC. In this approach, the needle is inserted into the greater palatine foramen and proceeds to reach the inferior part of the pterygopalatine fossa and then the anesthetic agent is injected 1. Injection of anesthetic agent into the GPC can cause vasoconstriction during endoscopic surgery 1. For this purpose, the needle is inserted into the canal but does not enter the fossa to prevent arterial perforation 1.

In case of requiring anesthesia of the maxillary region, the needle should be inserted more deeply to reach the infraorbital nerve, which is located deep in the pterygopalatine fossa 1, 4, 5. Thus, knowledge about the anatomy and mean length of the GPC is imperative for successful results. Moreover, traumatization of palatine artery and palatine nerves must be avoided to prevent hemorrhage and nerve damage 7.

In some cases, regional block may fail due to excessive tissue resistance during anesthetic injection because of anatomical variations. This study aimed to determine the mean length of the GPC and its most common anatomical path in a group of Iranian patients using CBCT.

MATERIAL & METHODS

This descriptive cross-sectional study was conducted on 96 CBCT scans of adults patients over 18 years of age who had presented to the Radiology Department of Hamadan University of Medical Sciences, School of Dentistry to obtain CBCT scans for dental implant treatment planning, orthodontic treatment or third molar surgery during 2015. The CBCT scans of trauma patients and patients who had lesion in this area were not included since the anatomy of the region of interest could have been deranged. The sample size was calculated to be 96 CBCT scans considering standard deviation of 3 and d=0.6

All CBCT scans had been taken by NewTom 3G CBCT units (Verona, Italy) in this unit, experimentation were made in supine position. So, patients head positions could standardize easier than sitting of standing. For ideal visualization of the anatomy of our region of interest, only CBCT scans with 9” and 12” field of view were included. The NNT Viewer software was used for observation and determination of the length and path of the GPC.

two experienced oral and maxillofacial radiologist evaluated the anatomical path and measured the length of the GPC in the right and left sides (a total of 192 canals) on coronal and sagittal and in same case on paracornial and parasagittal sections on a monitor with 1440×900 pixels resolution in the same condition because of the isotropic nature of acquision of the CBCT, we could make paracorronal and parasagittal plane to best CBCT vision. We did this method several times to achieve the best vies for CBCT evaluation. The width of reconstructed coronal and sagittal sections was 130 mm, the slice thickness was 0.5 mm and the interval was 0.5 mm.

In the coronal plane, the pterygopalatine fossa and GPC are located lateral to the nasal cavity where the sphenoid sinus and clinoid processes can be observed (figure 1). In the sagittal plane, the fossa and GPC can be seen posterior to the maxillary sinus (figure2). The greater palatine nerve is branched from the pterygopalatine ganglion, which is located approximately at the center of pterygopalatine fossa. To measure the canal length, its inferior limit was the orifice of the greater palatine foramen in the palate (mucosal thickness was not included). Since determination of the center of pterygopalatine fossa was difficult and could cause measurement errors, the distance from the foramen in the palate to the floor of the sphenoid sinus (as the superior limit) was measured; half of this length was considered as the length of the GPC. This distance was measured using the ruler of the software as the straightest line passing through the center of canal and reaching the center of foramen in the palate. The canal path was determined on both coronal and sagittal sections in the right and left sides. The canal had a straight, medial or lateral path in the coronal plane. (figure3) Also, it had an anterior or posterior path in the sagittal plane. The canal path was determined by measuring the angle of deviation from the straight path using the caliper of the software (Figure 4) and divided into two groups of primary and secondary deviation angle. The primary deviation angle was defined as deviation of canal from the straight path since the beginning while the secondary deviation was defined as deviation of canal from the straight path occurring close to the palate. In this study, among many canal and sagittal section of each patients, only one or two section, whole of done.

RESULTS

In this study, 96 CBCT scans of 32 males (33.33%) and 64 females (66.67%) were evaluated. Patients' age ranged from 18 to 73 years. ICC between two observered was good (0.78). Table 1 shows the frequency of different canal paths in the right and left sides in the coronal plane. As shown in Table 1, the most common path of the GPC in the left side in the coronal plane was straight from the superior reference point to the inferior point. The least common path was a descending straight path from the superior reference point and the canal then continued laterally to reach the hard palate. The same was true for the GPC in the right side.

Table 2 shows the frequency of different canal paths in the right and left sides in the sagittal plane. The most common path of the GPC in the left side in the sagittal plane was anterior-inferior path while the least common path was the descending posterior path. The most common path of the GPC in the right side in the sagittal plane was the anterior-inferior path while the least common path was descending straight path of the canal from the superior reference point and then the canal continued posteriorly or descended anteriorly at first and then continued its path posteriorly.

The mean canal length in the left side was 31.32±3.7 mm on coronal and 31.8±3.57 mm on sagittal sections in the left side. These values were 34.32±4.18 mm and 34.56±3.8 mm, respectively in the right side. On both coronal and sagittal sections, the canal in the right side was slightly longer than that in the left side.

Table 3 shows the mean canal length on coronal and sagittal sections in the right and left sides based on the age group of patients. As shown in Table 3, canal length in the coronal plane in the right and left sides was longer in the age group of 30 to 60 years compared to other age groups. The same was true for canal length measured in the sagittal plane.

Table 4 shows the mean canal deviation angle on sagittal and coronal sections in the right and left sides in males and females. The smallest canal deviation angle in the coronal plane in the left side was noted in males and females over 60 years of age while the largest angle was noted in males and females between 30 to 60 years. In the right side, the smallest angle was noted in males between 30 to 60 years and females under 30 years. The largest angle was noted in males under 30 years and females between 30 to 60 years. In the sagittal plane, the smallest angle was noted in males under 30 years and females over 60 years in the left side, and males and females under 30 years in the right side. The largest angle was noted in males between 30 to 60 years and females under 30 years in the left side and males and females over 60 years in the right side. The smallest angle was noted in males between 30-60 years and females under 30 years.

In the coronal plane, the mean canal length was 33.5±4.04 mm in the right and 33.19±4.25 mm in the left side in males. These values were 30.95±3 and 30.39±2.99 mm in females, respectively. In the sagittal plane, the mean canal length was 35.86±4.06 mm in the right and 35.80±3.81 mm in the left side in males. These values were 33.91±3.51 mm and 33.57±4.18 mm, respectively in females.

The mean primary angle was 12.18±4.83° in the left and 10.78±4.68° in the right side in the coronal plane. These values were 14.11±5.45° and 13.10±6.44°, respectively in the sagittal plane. The mean secondary angle was 11.43±6.15° in the left and 10.05±4.73° in the right side in the coronal plane. These values were 14.95±6.38° and 13.98±6.96°, respectively in the sagittal plane. The highest mean angle on coronal and sagittal sections belonged to the secondary deviation angle in the left side in the sagittal plane while the smallest angle belonged to the secondary deviation angle of the right side in the coronal plane.

Table 5 shows the mean deviation angle (primary and secondary) in the right and left sides on sagittal and coronal sections based on gender. As seen in Table 5, the largest angle in males was secondary deviation angle in the left side in the sagittal plane while the smallest angle was the secondary deviation angle in the left side in the coronal plane. In females, the smallest angle was the secondary deviation angle in the right side in the coronal plane while the largest angle was the secondary deviation angle in the right side in the sagittal plane.

DISCUSSION

The use of GPC for local anesthesia is beneficial. Wong and Sved 4 and Lepere 5 mentioned that maxillary nerve block is required for palatal surgery, periodontal surgery of the maxillary teeth, the Caldwell-Luc procedure, restorative treatments of one-fourth of the maxillary teeth, extraction of several maxillary teeth or diagnosis of local infections. Adequate hemostasis and depth of anesthesia are also important for endoscopic surgery of the sinuses, septorhinoplasty and posterior epistaxis 1, 8. According to Wong and Sved 4, maxillary nerve block is most problematic when there is swelling of the palate around the greater palatine foramen. Greater palatine nerve block, similar to all maxillary nerve blocks, may have complications such as intravenous injection of anesthetic agent, nasal bleeding, diplopia, nerve damage, failure of anesthesia due to wrong angle of needle, insufficient penetration of needle, not finding the greater palatine foramen and inadequate depth of anesthesia due to intravenous injection of anesthetic agent 3, 5, 9. Thus, it would be ideal if the clinicians have access to CBCT data of patients preoperatively to study the anatomy of the region and minimize the risk of these complications. Our study assessed the anatomical variations in path and length of the GPC using CBCT scans. The results showed that the mean length of the left GPC in the coronal plane in different age groups was in the range of 30.54 to 32.93 mm. This range was 31.2 to 33.03 in the right side. The mean canal length in the left and right sides was 1.5 to 2mm longer in 30-60 year olds compared to other age groups. In the sagittal plane, the left canal length was in the range of 32 to 34.5 mm. This range was 34 to 35.5 mm in the right side. The left canal length in females was slightly less than that in males in the coronal plane (30.95 mm versus 33.5 mm). In the sagittal plane, the left canal length was 2 mm smaller in females than males.

Table 1. Frequency of different canal paths in the right and left sides in the coronal plane

Path	Left side		Right side	
	Number	Percentage	Number	Percentage
Straight	50	52.1	44	45.8
Straight-laterally	1	1	2	2.1
Straight-medially	3	3.1	4	4.2
Laterally-straight	13	13.5	12	12.5
Laterally	23	24	26	27.1
Laterally-medially	4	4.2	5	5.2
Medially	2	1.2	3	3.1

Table 2. Frequency of different canal paths in the right and left sides in the sagittal plane

Path	Left side		Path	Right side	
	Number	Percentage		Number	Percentage
Anterior-posterior	6	6.2	**Straight**	29	30.2
Straight	29	30.2	**Straight-anterior**	15	15.6
Straight-anterior	15	15.6	**Straight-posterior**	1	1
Straight-posterior	2	1.2	**Anterior-straight**	6	6.2
Anterior-straight	6	6.2	**Anterior**	31	32.2
Anterior	31	32.3	**Anterior-posterior**	1	1
Posterior-posterior	4	3.6	**Posterior-straight**	5	5.2
Posterior	1	1	**Posterior-anterior**	4	2.1
-	-	-	**Posterior**	4	4.2

Table 3. Mean canal length on coronal and sagittal sections in the right and left sides based on the age group of patients

Age group	Coronal plane		Sagittal plane	
	Left side Mean (SD)	Right side Mean (SD)	Left side Mean (SD)	Right side Mean (SD)
Under 30	30.54 (3.04)	31.20 (3.14)	34 (5.12)	34.12 (3.42)
30-60	32.93 (4.41)	33.03 (4.15)	34.55 (3.7)	35.42 (4.47)
Over 60	30.96 (3.73)	31.46 (3.52)	32.83 (3.52)	34.83 (3.32)

Table 4. Mean canal deviation angle on sagittal and coronal sections in the right and left sides in males and females

Gender	Age	Coronal plane		Sagittal plane	
		Left side Mean (SD)	Right side Mean (SD)	Left side Mean (SD)	Right side Mean (SD)
Males	**Under 30**	7.17 (6.01)	6.56 (6.20)	7.7 (5.94)	8.35 (5.85)
	30-60	6.73 (5.41)	6.05 (4.98)	8.72 (7.84)	7.08 (6.08)
	Over 60	4.44 (2.56)	5.84 (3.46)	7.7 (6.67)	12.66 (4.25)
Females	**Under 30**	6.72 (3.92)	5.67 (4.57)	8.58 (8.46)	9.13 (7.33)
	30-60	7.01 (5.54)	6.62 (4.8)	9.96 (8.13)	8.01 (7.56)
	Over 60	4.44 (2.56)	8.02 (3.86)	7.7 (6.67)	12.66 (4.25)

Table 5. Mean canal deviation angle (primary and secondary) in the right and left sides on sagittal and coronal sections based on gender

Gender	Section	Primary		Secondary	
		Left side Mean (SD)	Right side Mean (SD)	Left side Mean (SD)	Right side Mean (SD)
Males	**Coronal**	10.21 (1.99)	9.24 (3.28)	10.08 (3.99)	10.45 (5.44)
	Sagittal	14.59 (5.69)	11.68 (5.52)	15.91 (7.99)	11.88 (6.39)
Females	**Coronal**	12.82 (5.31)	11.44 (5.06)	11.94 (6.78)	9.86 (4.45)
	Sagittal	13.81 (5.39)	13.96 (6.89)	14.51 (5.57)	14.99 (7.09)

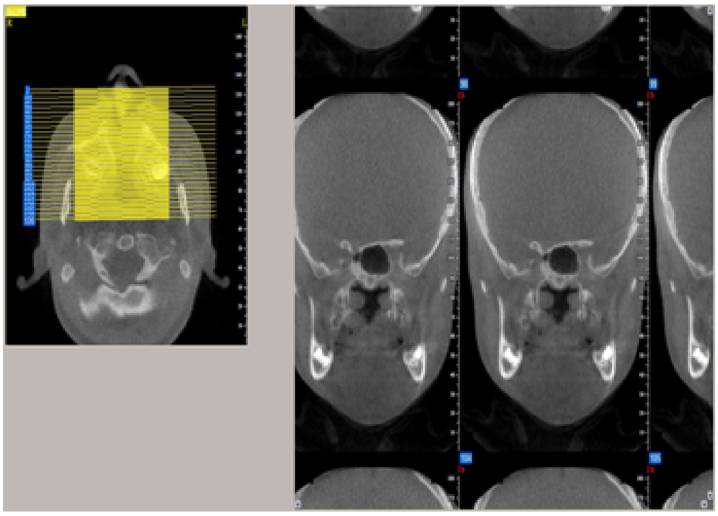

Figure1. Showed the greater palatine canal in coronal view where the sphenoid sinus and clinoid process are observed.

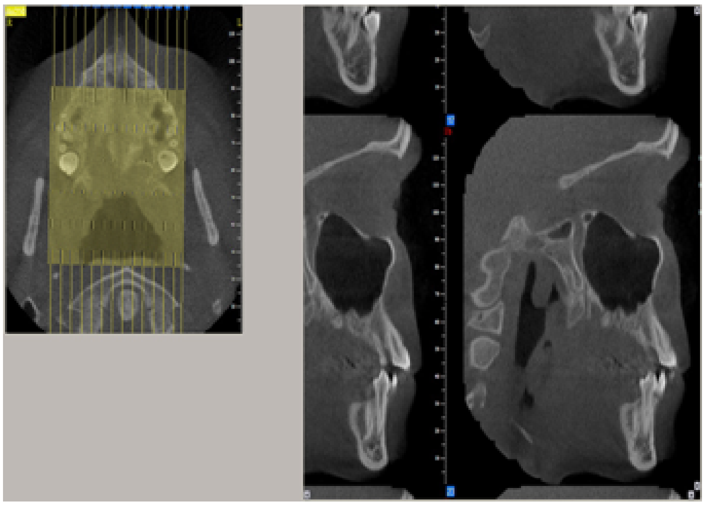

Figure2. Showed the greater palatine canal in the sagittal view, posterior to the maxillary sinus.

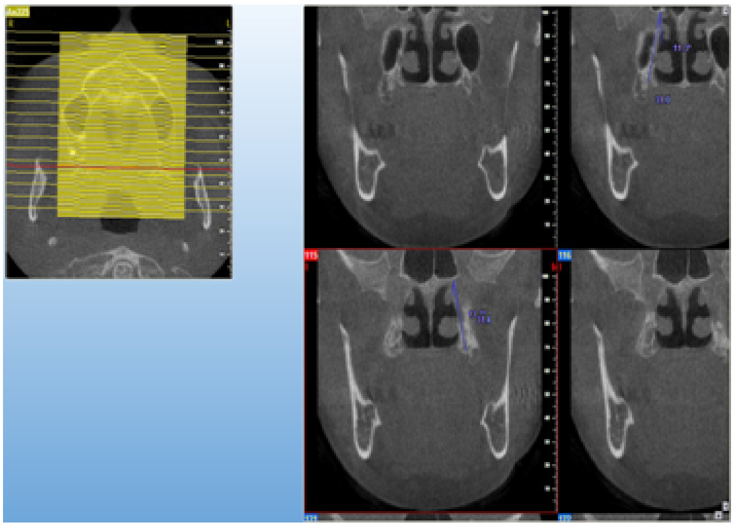

Figure3. Showed the measurement way in the coronal view.

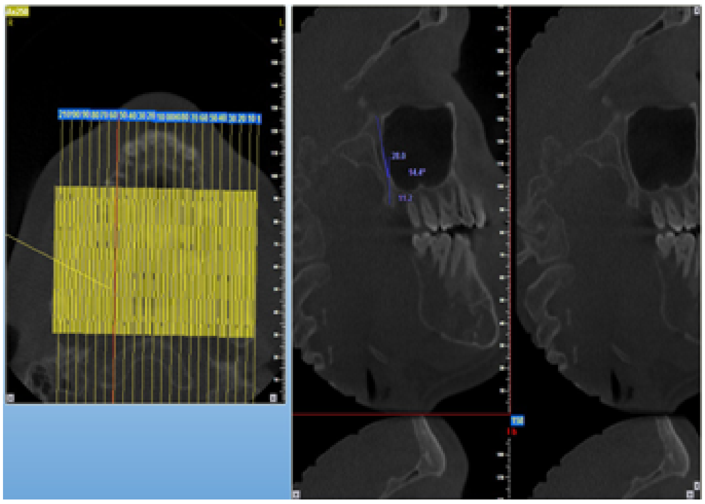

Figure4. Showed the measurement way in the sagittal view.

The suggested depth of insertion of needle into the GPC at each side is 25 mm for hemostasis in sinus surgery and 32-39 mm for maxillary anesthesia 1, 4, 5, 10. A long canal may result in failure of anesthesia while short canals even with the use of a standard needle may result in complications. Thus, knowledge about the mean canal length can be beneficial for surgeons. In our study, the mean canal length in 95% of participants was 33±2.87 mm (range 26.1 to 39.88 mm), which was longer than the value reported by Howard-Swirzinski et al 7 (29±3 mm). The most common path in the sagittal plane was anterior-inferior path in both studies but the path was different in the coronal plane in the two studies. These differences between the two studies are probably due to the different study populations and race of patients. Also, the mean canal length in our study was greater than that reported by McKinney et al 11 (19.36±2.76 mm). This can be due to different study populations and different methodologies since they measured the canal length from the hard palate to the floor of the orbit while we measured the canal length from the hard palate to the floor of the sphenoid sinus. The mean canal length in our study was greater than that reported by Hwang et al 12 (13.8±2) and Methathrathip et al 3 (29.7±4.2 mm). Methathrathip et al. 3 measured the canal length on dry skulls of Thai people, which may explain the difference in the results. Douglas et al, 1 in their study on Australians reported the mean GPC length to be 18.5 mm, which was also higher than our obtained value. This difference may be attributed to different study populations, race of patients and methodology. These comparisons show that the mean GPC length in the Iranian population is higher than that of other races.

Rapdo-gonzales et al. 13 From the 77 GPF analyzed,76 were located on level 2. Average posterior GPF distance was 6.59 ± 3.27 mm on right side and 7.35 ± 3.40 mm on left side. Several measurements to determine the position and dimensions of the GPF presented significant values (p = 0.05). GPC length was 12.31 ± 1.96 mm on right side and 12.52 ± 2.15 mm on left side, statistically significant differences were detected between genders only on right canal (p = 0.004). Sagittal and coronal reference lines presented significantly higher values for men except for the S3 (p=0.062) and C1 (p=0.067) in the left GPC.

Georges Aoun et al. 14 indicated In a sagittal plane, the average length of the greater palatine canal was 30.62 (30.64 mm on the right and 30.60 mm on the left).

In our study, patients over 18 years of age were selected since skeletal maturation of the maxillofacial region is completed by this age. Maturation of the maxillofacial region can significantly affect the length of GPC. Also, canal length was greater in 30-60 year olds in our study, which may indicate that skeletal development affects the length of this canal up to the age of 30 years. In those over 60 years, resorption of bones in the skull and face may explain shorter length of this canal. Also, our study showed that canal in the right side was slightly longer than that in the left side, which indicates that the two sides of the human body are not symmetric. Canal length in females was shorter than that in males, which is expected since males are often taller than females.

The coronal angle in females was smaller than that in males in both sides; this factor has not been compared in males and females in previous studies and assessment of this parameter was a strength of our study. A previous study measuring GPC length based on computed tomography scans reported a range of 27-40 mm, which was close to our obtained range. Slight difference may be attributed to the superior reference point and inclusion/exclusion of the thickness of soft tissue in measurement.

The most common path of the GPC in the left side in the coronal plane was straight from the superior reference point to the inferior point. The least common path was a straight descending path from the superior reference point and the canal then continued laterally to reach the hard palate. The same was true for the GPC in the right side. The most common path of the GPC in the left side in the sagittal plane was anterior-inferior path while the least common path was the descending posterior path. The most common path of the GPC in the right side in the sagittal plane was the anterior-inferior path while the least common path was the descending straight path of the canal from the superior reference point and then the canal continued posteriorly or descended anteriorly at first and then continued its path posteriorly. These findings indicate that after needle insertion into the foramen, it would better enter the canal posteriorly. However, considering the individual differences in canal length and path in different individuals, the best way is to study the CBCT data of patients prior to any intervention in this region if CBCT scans of patients are available. Future studies with larger sample sizes are required to further confirm our results. Also, the soft tissue thickness should be considered in future studies and higher number of observers should assess the images.

CONCLUSION

The GPC is longer in the Iranian population compared to the mean values reported for other races. Thus, care must be taken with regard to the selection of the correct site and depth of needle insertion in the Iranian patients. If available, CBCT scans of patients must be reviewed prior to any intervention to determine the length and path of the GPC.

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