Original Article

# CBCT Evaluation of the Position of Palatal Neurovascular Bundle and the Greater Palatine Foramen in an Iranian Population

**Mehrdokht sadat Safavi[1], Maryam Tehranchi[2], Shahriar Shahab[3], Saeed Mahdipour Ganji[4], Ferial Taleghani[5]**

[1] Dentist, Private Office, Tehran, Iran
[2] Assistant Professor, Department of Periodontology, School of Dentistry, Shahed University, Tehran, Iran
[3] Assistant Professor, Department of Radiology, School of Dentistry, Shahed University, Tehran, Iran
[4] Periodontist, Private Office, Tehran, Iran
[5] Associate Professor, Department of Periodontology, School of Dentistry, Shahed University, Tehran, Iran

## Abstract

**Background and Aim:** Traumatization of the palatal neurovascular bundle (NVB) is a potential complication of soft tissue graft harvesting from the palate. Thus, it is imperative to have adequate knowledge about the position and path of the NVB. This study assessed the position of palatal NVB and the greater palatine foramen (GPF) in an Iranian population using cone-beam computed tomography (CBCT).
**Materials and Methods:** This retrospective, cross-sectional study evaluated CBCT scans of 128 patients. The position of the GPF relative to molar teeth, the distance between the depth of NVB and the cementoenamel junction (CEJ) of canine to second molar teeth, and the distance between the GPF and the alveolar ridge, the posterior nasal spine (PNS), and the median maxillary suture (MMS) were all assessed. Statistical analysis was performed by the Chi-square test, Pearson's correlation coefficient, and ANOVA.
**Results:** In 64% of the cases, the GPF was located close to the apex of the third molar in both females (49.4%) and males (50.6%), irrespective of age. The mean distance between the depth of the NVB and the CEJ of the canine to second molar teeth was 9.56, 12.36, 14.69, 14.98 and 16.01 mm, respectively. The mean distance between the GPF and the alveolar ridge, PNS, and MMS in edentulous patients was 2.23±0.65, 16.88±1.19, and 15.89±1.20 mm, respectively.
**Conclusion:** Third molar is the best anatomical landmark to determine the position of the GPF. The distance between the palatal NVB and the CEJ increases from the anterior towards the posterior region.
**Key Words:** Cone-Beam Computed Tomography, Connective Tissue, Palate, Alveolar Process

Corresponding author:
Ferial Taleghani, Associated Professor, Department of Periodontology, School of Dentistry, Shahed University, Tehran, Iran

*drtaleghani2020@yahoo.com*

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## Introduction

Sub-epithelial connective tissue graft (SCTG) is an ideal gold-standard soft tissue graft for treatment of gingival recessions (1). It is increasingly used in patients with esthetic demands for increasing the soft tissue thickness, treatment of gingival recession, ridge augmentation, and papillary reconstruction (2).

Langer et al, (3) in 1980 were the first to use SCTG to correct depressions of an edentulous ridge. It was later used in 1982 for denuded root coverage (4). In 1985, predictable results of SCTG were reported for root coverage of over 90% of Miller's class I and II root resorptions (5). Since the greater palatine artery (GPA) and the greater palatine nerve are adjacent to the palatal donor site in SCTG, it is critical for dental clinicians and surgeons to pay utmost attention to the position of the palatal neurovascular bundle (NVB) and the greater palatine foramen (GPF) in graft harvesting from this area to prevent traumatization of the NVB and GPF, and subsequent hemorrhage and paresthesia. The NVB includes an arteriole, a venule, and the greater palatine nerve, that exit through the GPF and travel anteriorly in an osseous groove (6). Reiser et al. (7) reported that the position of the NVB in the palatal vault had averagely 7, 12 and 17 mm distance from the cementoenamel junction (CEJ) of premolar and molar teeth.
The greater palatine canal is connected to the oral cavity via the GPF. According to a review article, the most common position of the GPF is adjacent to the maxillary third molar (8). Another study reported the most common position of the GPF to be between the second and third molars (48%) (9). According to the literature, the position of the GPF may vary depending on the race and gender of individuals. To date, the position of the GPF has been evaluated in many different populations such as the African, American, Brazilian, and European populations (8). Since the skull in males is larger than that in females, the difference in the position of the GPF between males and females is expected (8).
Computed tomography (CT) and cone-beam computed tomography (CBCT) enable imaging of the teeth, gingiva, and periodontal tissues. These images can be saved and printed out. Also, numerous measurements can be made on CT and CBCT scans. CBCT has several advantages over CT such as lower patient radiation dose, higher image quality, easier availability, and lower cost [6,10]. The position and topography of the NVB have been evaluated on cadavers. However, limited studies have assessed the position of the NVB using CBCT. Thus, further studies are required on the position of the NVB using CBCT to find the safest zone of the palate for graft harvesting. This study aimed to assess the position of the NVB and the GPF in an Iranian population using CBCT. The authors believe that this study is the first on this topic in Iran and on the Iranian population.

## Materials and Methods

This cross-sectional study was conducted at the Periodontology Department of Shahed University during 2018-2019. It should be noted that all CBCT scans had been requested by the attending clinician/surgeon of patients for diagnostic/therapeutic purposes not related to this study. The study protocol was approved by the ethics committee of Shahed University (IR.SHAHED.REC.1397.025).
In this study, 128 patients (64 males and 64 females; 67 ≤ 40 years and 61 > 40 years, were evaluated. The sample size was calculated to be 128 according to relevant previous studies [11,12] considering $\alpha$ = 0.05, effect size (w) of 0.31, power (1-$\beta$) of 0.81, and degree of freedom equal to 4 using the G-Power version 3.1.9.6 software. A total of 128 eligible patients who met the inclusion criteria and required CBCT scans for third molar extraction, maxillary sinus assessment, or implant placement in the maxilla, and presented to three oral and maxillofacial radiology clinics were enrolled.
A wooden tongue depressor was placed between their teeth to separate the tongue from the palate, and CBCT scans were obtained by NewTom Giano (Verona, Italy) CBCT scanner with the exposure settings of 110 kV, 3.6 s and 10 x 8 cm field of view.
The images were evaluated in coronal view by Image Work NNT Viewer version 8 software. The measurements were recorded in datasheets separately for each patient.
The position of the GPF in the palate was evaluated three-dimensionally, and the position of the NVB was assessed on coronal sections. The distance between the depth of the NVB and the CEJ of canine to second molar teeth was also measured separately for each tooth. The

position of the GPF relative to the maxillary molars in dentate patients, and the distance between the GPF and the alveolar ridge, posterior nasal spine (PNS), and median maxillary suture (MMS) was measured in edentulous patients. The inclusion criteria were as follows:
(I) Age over 21 years
(II) Absence of pathologies or developmental defects in the maxilla
(III)Requiring maxillary CBCT scan upon request of the attending clinician/surgeon
The exclusion criteria were:
(I) History of surgery in the palate
(II) Previous history or current presence of any condition in the palate
(III) Recent use of removable denture or orthodontic appliance in the maxilla
(IV) Intake of medications causing gingival hypertrophy
(V)Crowding, rotation, or severe spacing in maxillary teeth
All patients were voluntarily enrolled after signing informed consent forms.
The following parameters were evaluated on CBCT scans:
(1) Position of the GPF relative to the maxillary molars, which was categorized as (A) mesial to the second maxillary molar, (B) from the mesial surface of the $2^{nd}$ molar to the distal surface of the $2^{nd}$ molar, (C) between (Interproximal) the $2^{nd}$ and $3^{rd}$ molars, (D) from the mesial surface of the $3^{rd}$ molar to the distal surface of the $3^{rd}$ molar, and (E) distal to the $3^{rd}$ molar (Figure 1).

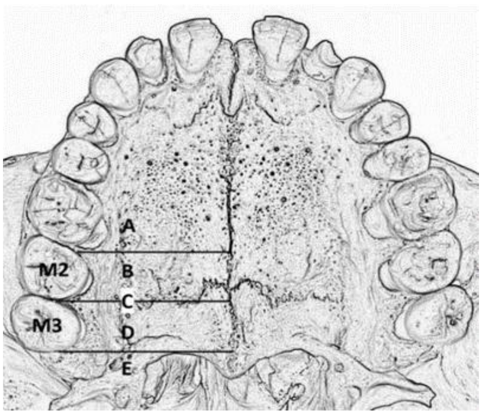


**Figure 1.** Position of the greater palatine foramen in dentate patients

(2) Position of the GPF in edentulous patients: In edentulous patients, the distance between the GPF and the alveolar ridge, PNS and MMS was measured and recorded (Figure 2).

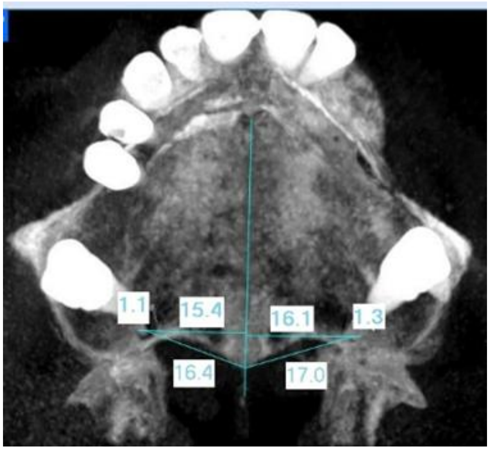


**Figure 2.** Position of the greater palatine foramen in edentulous patients

(3) The distance between the depth of the NVB and the CEJ of canine to second molar teeth on coronal views was measured separately for each tooth (Figure 3).


**Figure 3.** Measuring the distance between the depth of the neurovascular bundle and the cementoenamel junction

All measurements were made by an experienced observer. In order to assess the intra-observer reliability, the measurements were repeated after 2 weeks.
The collected data were analyzed using SPSS version 24 at 95% confidence interval and $P<0.05$ level of significance. Descriptive statistics were reported as mean, standard deviation,

frequency and percentage. Statistical analysis was performed by the Chi-square test, Pearson's correlation coefficient, and ANOVA.

## Results

*Position of the NVB:*

Table 1 shows the mean and standard deviation of the distance between the NVB and the CEJ. Accordingly, the mean distance was minimum at the site of canine tooth (9.56±1.14 mm). Comparison of the mean distances revealed that the values increased from the canine towards the posterior teeth, and the maximum distance (16.01±2.47 mm) was noted at the second molar site. Also, the difference between the positions of the NVB in the study population was significant after confirming the normality assumption ($P< 0.005$).

*Distance between the GPF and the alveolar ridge, PNS, and MMS in edentulous patients:*

Table 1 shows the mean distance between the GPF and the alveolar ridge, PNS and MMS in edentulous patients. Also, the difference in the mean distance between the GPF and the alveolar ridge, PNS and MMS was significant in edentulous patients after confirming the normality assumption (ANOVA, $P<0.005$).

*Position of the GPF:*

According to Table 2, position D was the most common position of the GPF (64.8%, Figure 2). Also, according to Table 2, position D had the highest frequency in females (49.4%) and males (50.6%). Position D had the highest frequency in patients > 40 (43.4%) and < 40 years (56.6%).

*Relationship between the GPF position and gender in the left and right sides:*

According to the Chi-square test, there was no statistically significant correlation between the right and left GPF position and gender (Table 3, $P>0.05$).

*Correlation between GPF position in the left and right sides and age of patients:*

According to the Chi-square test, there was no statistically significant correlation between the right and left GPF position and age of patients (Table 4, $P>0.05$).

## Discussion

The palatal mucosa is the most common site for harvesting a SCTG for denuded root coverage. Considering the potential complications, the NVB is the most important anatomical structure in this region that needs to be protected. Thus, adequate knowledge about the position and path of the GPA is imperative (6). This study assessed the position of the GPF and the NVB using CBCT to determine a safe zone for graft harvesting.

Several methods may be employed to assess the palatal mucosa such as the trans-gingival sounding, ultrasound, CBCT, and CT; among which, CBCT has advantages such as lower patient radiation dose, higher image quality, higher patient convenience, lower cost, the ability to save the images, and enabling numerous measurements by the software programs (13). Correct determination of the position of the GPF is important especially for nerve block injections prior to palatal surgical procedures (10).

Methathrathip et al. (14) reported that the location of the GPF was next to the third molar tooth in 60.2% of males and 71.9% of females. Klosek and Rungruang (15) reported that the GPF was close to the apex of the second and third molars in most cases, which was in line with our findings. Yilmaz et al. (10) reported that the position of the GPF was adjacent to the third molar tooth in 63% of males and 56% of females, which was in agreement with the current findings. Fu et al. (16) showed that the GPF was between the second and third molars in 66% of the cases. However, their study was conducted on cadavers, which is different from our methodology. In this study, position D (adjacent to the third molar) was the most frequent position of the GPF in both females (49.4%) and males (50.6%).

The maximum distance between the NVB and the CEJ was noted at the second molar site (16 mm); while, the minimum distance was noted at the site of canine (9.5 mm). In a study by Yilmaz and Ayali [6] the maximum distance was noted at the site of first molar (14.02 mm); while, the

**Table 1.** Position of the NVB in the study population and the mean distance between the GPF and the alveolar ridge, PNS and MMS in edentulous patients (n=44)

| Variable | | Mean | SD | Maximum | Minimum | P value |
|---|---|---|---|---|---|---|
| **Tooth** | Canine | 9.56 | 1.14 | 12.58 | 8 | 0.000 |
| | First premolar | 12.36 | 1.55 | 25.17 | 8.7 | |
| | Second premolar | 14.69 | 2.10 | 21 | 9.5 | |
| | First molar | 14.98 | 1.95 | 20.90 | 11.88 | |
| | Second molar | 16.01 | 2.47 | 22.7 | 10.95 | |
| **Distance from GPF** | Alveolar ridge | 2.23 | 0.65 | 3.53 | 1.10 | 0.000 |
| | Posterior nasal spine | 16.88 | 1.19 | 19.67 | 14.35 | |
| | Median maxillary suture | 15.89 | 1.20 | 18.15 | 13.43 | |

**SD: Standard deviation**

**Table 2.** Position of the GPF according to age, gender and laterality

| Variable | | Position | | | | |
|---|---|---|---|---|---|---|
| | | B | C | D | E | Unclear |
| | | Number (percentage) | Number (percentage) | Number (percentage) | Number (percentage) | Number (percentage) |
| **Gender** | **Female** | 0 | 6 (%54.5) | 41 (%49.4) | 4 (%33.3) | - |
| | **Male** | 1 (%100) | 5 (%45.5) | 42 (%50.6) | 8 (%66.7) | - |
| **Age (yrs.)** | **40≤** | 1 (%100) | 6 (%54.5) | 47 (%56.6) | 6 (%50) | - |
| | **40>** | 0 | 5 (%45.5) | 36 (%43.4) | 6 (%50) | - |
| **Side** | **Right** | 1 (%0.8) | 11 (%8.6) | 83 (%64.8) | 12 (%9.4) | 21 () |
| | **Left** | 1 (%0.8) | 10 (%7.8) | 79 (%61.7) | 15 (%11.7) | 23 (%18) |

**Table 3.** Relationship between GPF and gender in the right and left sides

| | | Side | Position of GPF | | | | | Total | P value |
|---|---|---|---|---|---|---|---|---|---|
| | | | Unclear | B | C | D | E | | |
| **Gender** | **Male** | **Right** | 12 | 1 | 6 | 41 | 4 | 64 | 0.581 |
| | **Female** | | 9 | 0 | 5 | 42 | 8 | 64 | |
| **Total** | | | 21 | 1 | 11 | 83 | 12 | 128 | |
| **Gender** | **Male** | **Left** | 12 | 1 | 6 | 38 | 7 | 64 | 0.804 |
| | **Female** | | 11 | 0 | 4 | 41 | 8 | 64 | |
| **Total** | | | 23 | 1 | 10 | 79 | 15 | 128 | |

**Table 4.** Correlation between GPF position and age of patients in the left and right sides

| | Correlation Coefficient | N | P value |
|---|---|---|---|
| **Age** | 1.000 | 128 | . |
| **Right GPF** | 0.038 | 107 | 0.701 |
| **Left GPF** | 0.007 | 105 | 0.942 |

minimum distance was noted at the site of canine tooth (10.8 mm). The minimum distance in their study was similar to that in our study. In our study, this distance was measured between the CEJ and the depth of the greater palatine groove while Yilmaz et and Ayali (6) measured the distance between the CEJ and the coronal part of the NVB.

A study conducted on 25 skulls of human cadavers to assess the path and branching of GPA revealed that the distance between the CEJ of canine to second molar and the GPA was 9, 11.1, 13.5, 13.7 and 13.9 mm, respectively, and this distance increased from the canine towards the second molar (17). Tomaszewska et al, (8) in a systematic review assessed the use of anatomical landmarks to determine the position of the GPF on 1200 CT scans of the skull and 1500 dry skulls. They concluded that the mean distance between the GPF and the MMS was 15.9±1.5 mm. The distance from the GPF to the alveolar ridge and PNS was 3±1.2 mm and 17±1.5 mm, respectively. Also, the GPF was adjacent to the maxillary third molar in 74.7% of the cases. They concluded that maxillary molars were the best landmarks for estimation of the position of the GPF. In edentulous patients, the alveolar ridge, MMS, and PNS were the most suitable points for identification of the position of the GPF [8]. In our study, the mean distance from the GPF to the alveolar ridge, PNS, and MMS in edentulous patients was 2.23±0.65 mm, 16.88±1.19 mm, and 15.89±1.20 mm, respectively, which were close to the values reported by Tomaszewska et al [8]. Thus, the GPF can be well detected on coronal CBCT views, and according to the results, the GPF is often adjacent to the third molar tooth. In edentulous patients, the position of the GPF can be estimated with the help of MMS, distance from the alveolar ridge, and the PNS. The maximum and minimum distances between the NVB and the teeth were noted at the second molar and canine teeth, respectively. This finding can greatly help in SCTG harvesting from the palate.

## Conclusion

The GPF is located next to the third molar tooth in most patients. The distance between the palatal NVB and the CEJ increases from the anterior towards the posterior region, which can help in graft harvesting from the palate. The third molar tooth is the best anatomical landmark to determine the position of the GPF. However, in edentulous patients, some supplemental anatomical landmarks such as the MMS, and distance between the alveolar ridge and the PNS can be used to identify the correct position of the GPF.

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