**Original Article**

# Evaluation of the Position and Course of the Posterior Superior Alveolar Artery by Cone-Beam Computed Tomography in an Iranian Population

**M. Panjnoush [1], Z. Ghoncheh [2]✉, H. Kaviani [2], M. Moradzadehkhiavi [3], N. Shahbazi [4], MJ. Kharrazifard [5].**

[1] Associate Professor, Dental Research Center, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran AND Department of Oral and Maxillofacial Radiology, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[2] Assistant Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry, International Campus, Tehran University of Medical Sciences, Tehran, Iran
[3] Associate Professor, Department of Oral and Maxillofacial Pathology, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[4] Dentist, Private Office, Tehran, Iran
[5] Research Member, Dental Research Center, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran

**Abstract**

**Background and Aim:** Understanding the vascular anatomy of the maxillary sinus plays an important role in the success of sinus grafting and determining the location of lateral osteotomy. The aim of the present study was to localize the posterior superior alveolar artery (PSAA) and to measure the distance from this vascular canal to the maxillary sinus floor and alveolar crest by cone-beam computed tomography (CBCT).

**Materials and Methods:** This study was conducted on 600 CBCT scans. The distance from the inferior border of the PSAA to the maxillary sinus floor and alveolar crest was measured and the position of this vascular canal was evaluated. The distance from the vascular canal to the maxillary sinus floor was also compared in dentulous and edentulous patients. The results were analyzed by repeated measures ANOVA and Tukey's post-hoc test.

**Results:** The PSAA was detected on 150 scans. The intraosseous position of the canal was seen in 51.30% of the cases. There were insignificant differences among the distances from the vascular canal to the maxillary sinus floor in different dental areas. However, there were significant differences in the distances from the vascular canal to the alveolar crest in different regions ($P<0.001$).

**Conclusion:** In this study, the PSAA was detected in 25% of the cases. The smallest distance between the vascular canal and maxillary sinus floor was observed in the first premolar and first molar regions, respectively. Determining the position of the PSAA by CBCT is useful for reducing perioperative bleeding; therefore, CBCT is recommended as a routine imaging technique prior to sinus lifting.

**Key Words:** Cone-Beam Computed Tomography, Maxillary Artery, Maxillary Sinus

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✉ Corresponding author: Z. Ghoncheh, Assistant Professor, Department of Oral and Maxillofacial Radiology, School of Dentistry, International Campus, Tehran University of Medical Sciences, Tehran, Iran

*Z-Ghoncheh@sina.tums.ac.ir*

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## Introduction

Dental implant placement in the maxilla is challenging when the maxillary sinus is extended into the alveolar ridge. In many cases, the maxillary alveolar ridge has adequate height and width, but the extension of the maxillary sinus into the alveolar ridge prevents implant placement in the posterior maxilla due to the lack of a sufficient bone support [1].

Sinus lifting is a popular bone augmentation

procedure for increasing the bone height in atrophic maxillary ridges before implant placement. At present, this procedure is considered a safe surgical technique with a high success rate [1-5].

Several techniques are used for the assessment of maxillary sinuses such as panoramic radiography, computed tomography (CT), and cone-beam computed tomography (CBCT). Panoramic radiography is a commonly used imaging modality in dentistry. However, due to the overlapping of adjacent anatomical structures, this method cannot provide precise information about the sinus structure. CT and CBCT can provide beneficial information about the sinus structure by capturing sectional and three-dimensional (3D) images [1,6,7]. During the recent years, CBCT scans have been increasingly used as a diagnostic tool in oral and maxillofacial surgeries. This imaging technique is advantageous due to its cost-effectiveness, shorter scan time, higher resolution, excellent spatial resolution, and lower patient radiation dose compared to conventional CT [1,8].

The blood supply of the maxillary sinus is derived from two branches of the maxillary artery, namely the posterior superior alveolar artery (PSAA) and the infraorbital artery (IOA). The oral mucosa and the external wall of the maxillary sinus are supplied by these two arteries. The PSAA divides into two branches of gingival and dental arteries. The dental artery branch of the PSAA forms an anastomosis with the IOA [1,9-12]. Traumatization of the PSAA during the sinus lift surgery causes a mild to severe hemorrhage and impairs the surgeon's access to the surgical field leading to possible perforation of the sinus membrane. Thus, the location of this artery should be considered during the operation [1,8,9,13-15]. The aim of this study was to assess the position of the PSAA and to measure the distance from the inferior border of the artery to the maxillary sinus floor and alveolar crest on CBCT scans obtained from an Iranian population.

## Materials and Methods

This cross-sectional retrospective study was conducted on 600 CBCT scans of the patients presenting to our oral and maxillofacial radiology clinic during 2010-2011. The PSAA was detected in 150 cases. None of the patients had any history of trauma, surgery or pathological lesions in the posterior maxilla.

The CBCT scans had been obtained by Planmeca Promax 3D imaging system (Planmeca OY, Helsinki, Finland) with a 0.16-mm voxel size and an 8×8-cm field of view (FOV). In all CBCT systems, the 8×8-cm FOV is considered suitable for imaging the maxilla. The exposure settings included 84 kilovoltage peak (kVp), 16 milliamperes (mA), and exposure time of 16 seconds. Conversion to 3D images was performed by using Planmeca Romexis® version 2.6 software program (Planmeca OY, Helsinki, Finland). After reconstruction of the panoramic-like image, cross-sectional views were obtained with 2-mm slice intervals. The location of the PSAA was assessed in the premolar and molar regions by measuring the following distances (Figure 1):

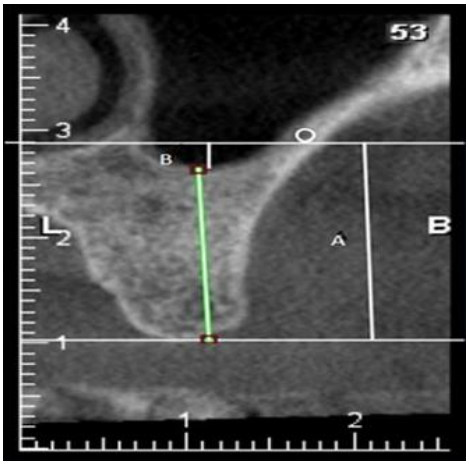


**Figure 1.** (A) Vertical distance from the alveolar crest to the inferior border of the posterior superior alveolar artery (PSAA). (B) Vertical distance from the maxillary sinus floor to the inferior border of the PSAA

A. The vertical distance from the inferior border of the PSAA to the alveolar crest.

B. The vertical distance from the inferior border of the PSAA to the maxillary sinus floor.

Moreover, the mediolateral position of the PSAA relative to the external wall of the maxillary sinus was determined as follows:

a. Intrasinus position: Beneath the sinus membrane

of the external maxillary sinus wall.
b. Intraosseous position: Within the external maxillary sinus wall.
c. Superficial position: Beneath the periosteum of the external maxillary sinus wall.
Different mediolateral positions of the PSAA are shown in Figure 2.
The vertical distance from the PSAA to the maxillary sinus floor was also measured and compared in dentulous and edentulous regions.

The data were analyzed by using SPSS version 22 software program (IBM Co., Chicago, IL, USA). All the measurements were compared in six different dental regions by using repeated measures analysis of variance (ANOVA). The distance from the PSAA to the alveolar crest at each site was compared with the other two sites by Tukey's post-hoc test. P-values less than 0.05 were considered statistically significant.

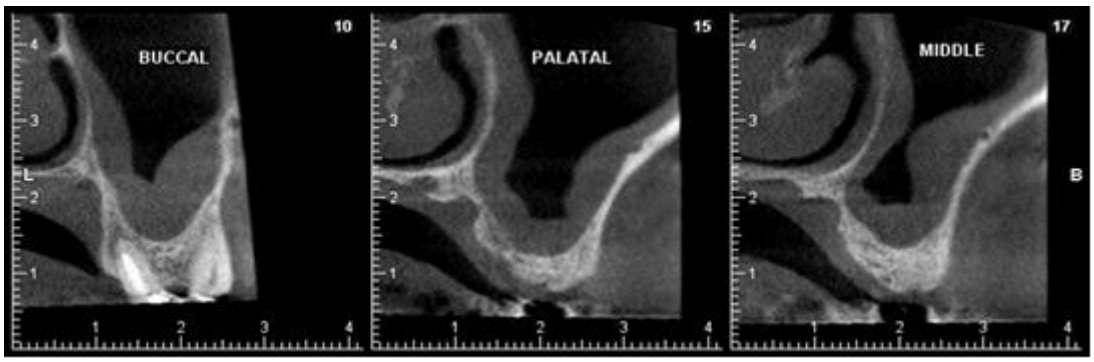


**Figure 2.** Different mediolateral positions of the posterior superior alveolar artery (PSAA): Intrasinus (Palatal), intraosseous (Middle), superficial (Buccal)

## Results

Six-hundred CBCT scans were examined, and the PSAA was identified on 150 scans (25%; 95% confidence interval (CI): 22-28). Of the 150 scans on which the PSAA was detected, 75 scans belonged to men and 75 scans belonged to women. The patients had a mean age of 47.80 years (from 15 to 79 years old). As shown in Table 1, the smallest vertical distance from the vascular canal to the maxillary sinus floor was detected in the first premolar region, while the greatest distance was found to be in the first molar area. Despite the differences in the distances from the vascular canal to the maxillary sinus floor in different dental regions, these differences were not statistically significant (P=0.130; Table 1). On the other hand, the smallest vertical distance from the vascular canal to the alveolar crest was detected in the first molar region, while the greatest distance was found to be in the first premolar area (Table 2). The differences in the distances from the vascular canal to the alveolar crest in different sites were statistically significant (P<0.001). The pairwise comparisons of different dental regions also showed significant differences (P<0.001).
As shown in Table 3, the mediolateral position of the PSAA was variable relative to each tooth. The vascular canal was intraosseous in the first premolar (69.11%) and second premolar regions (58.94%), and intrasinus in the first molar area (65.91%). The mediolateral position of the canal was intraosseous in 51.31% of the cases and intrasinus in 48.69% of the cases, regardless of the dental region. The superficial position of the artery could not be detected in this study.
Table 4 shows the vertical distance from the PSAA to the maxillary sinus floor in dentulous and edentulous patients. There were no significant differences in the distances from the PSAA to the maxillary sinus floor between dentulous and edentulous patients or between the right and left sides of the jaw (P>0.05). There were significant differences in the distances from the inferior border of the PSAA to the alveolar crest, but no

significant differences were found in the distances to the maxillary sinus floor or with regard to the mediolateral position of the PSAA in different dental regions (P>0.05, Tables 3 and 5).

**Table 1.** Vertical distance from the posterior superior alveolar artery (PSAA) to the maxillary sinus floor

| Dental region | n | Mean(mm) | SD | Range(mm) | P-value* |
|---|---|---|---|---|---|
| First premolar | 136 | 4.82 | 2.45 | 0.00-14.10 | 0.039 |
| Second premolar | 285 | 5.17 | 2.44 | 0.00-14.10 | |
| First molar | 267 | 5.82 | 2.39 | 0.00-18.20 | |

**SD=Standard Deviation, * P-values less than 0.05 are considered statistically significant**

**Table 2.** Vertical distance from the posterior superior alveolar artery (PSAA) to the alveolar crest

| Dental region | n | Mean(mm) | SD | Range(mm) | P-value* |
|---|---|---|---|---|---|
| First premolar | 136 | 20.81 | 2.96 | 10.60-30.70 | <0.001 |
| Second premolar | 285 | 18.22 | 2.92 | 8.50-29.30 | |
| First molar | 267 | 15.54 | 2.76 | 5.80-26.60 | |

**SD=Standard Deviation, * P-values less than 0.05 are considered statistically significant**

**Table 3.** Position of the posterior superior alveolar artery (PSAA) in the external wall of the maxillary sinus

| Dental region | Intrasinus (%) | Intraosseous (%) | Total | P-value* |
|---|---|---|---|---|
| First premolar | 42(30.89) | 94(69.11) | 136 | 0.002 |
| Second premolar | 117(41.06) | 168(58.94) | 285 | |
| First molar | 176(65.91) | 91(34.09) | 267 | |
| Total | 335(48.69) | 353(51.31) | 688 | |

*** P-values less than 0.05 are considered statistically significant**

**Table 4.** Vertical distance (mean±standard deviation) from the posterior superior alveolar artery (PSAA) to the maxillary sinus floor in dentulous and edentulous regions of the right and left sides of the maxilla

| Dental region | Dentulous(mm) | Edentulous(mm) | P-value* |
|---|---|---|---|
| Right first molar | 6.00±2.82 | 5.28±3.59 | 0.198 |
| Right second premolar | 4.99±3.23 | 4.82±3.86 | 0.792 |
| Right first premolar | 5.28±3.57 | 3.47±3.44 | 0.05 |
| Left first premolar | 5.43±3.26 | 4.43±3.53 | 0.236 |
| Left second premolar | 5.60±3.30 | 5.12±3.62 | 0.441 |
| Left first molar | 5.91±3.53 | 6.23±3.38 | 0.602 |

*** P-values less than 0.05 are considered statistically significant**

**Table 5.** Vertical distance from the posterior superior alveolar artery (PSAA) to the alveolar crest in dentulous and edentulous regions of the right and left sides of the maxilla

| Dental region | n | Mean(mm) | SD | Range(mm) | P-value* |
|---|---|---|---|---|---|
| Right first premolar | 67 | 21.24 | 4.04 | 8.20-30.70 | 0.810 |
| Left first premolar | 60 | 20.38 | 4.32 | 10.60-30.7 | |
| Right second premolar | 143 | 18.66 | 3.79 | 8.50-28.50 | 0.72 |
| Left second premolar | 142 | 17.79 | 4.45 | 6.90-29-30 | |
| Right first molar | 140 | 15.34 | 3.81 | 4.20-26.60 | 0.2 |
| Left first molar | 127 | 15.74 | 3.99 | 5.80-26.10 | |

**SD=Standard Deviation, * P-values less than 0.05 are considered statistically significant**

## Discussion

Knowledge of the anatomy and blood supply of the maxillary sinus is of utmost importance in surgical procedures such as implant placement, sinus augmentation, and sinus lifting. The blood supply of the maxillary sinus is derived from two branches of the maxillary artery, namely the PSAA and IOA [9,10]. Out of 600 CBCT scans evaluated in this study, the PSAA was detected on 150 scans. According to our results, the most common position of the canal was intraosseous, and this finding was consistent with that of Güncü et al [16] but different from that of Jung et al [1], which could be related to racial differences of the study populations. These results suggest that the intraosseous vascular canal in the area of first and second premolars may run medially relative to the lateral wall of the maxillary sinus in the first molar area.

In a study by Chitsazi and colleagues [17], the PSAA was observed in 71% of the cases, and its location was mainly intraosseous. This finding was also reported by Shahidi et al [18]. They also reported that in 93% of the cases, the artery was located inside the maxillary sinus [18]. Tehranchi et al [19] reported that the PSAA had an intraosseous position in 47% of the cases. In a study by Kim et al [20] which was conducted in 2011 on a South Korean population, the average prevalence of the PSAA on CT images was 52%, and it was higher in males (64%) than in females (40%). Moreover, they reported that the prevalence of the PSAA on CT images was higher, and the diameter was larger in males. The PSAA in the cited study was more close to the alveolar crest in the molar area [20].

Dental implants are often placed in the first molar region, a frequent site for sinus elevation. The information rendered by CBCT in terms of the presence and location of the PSAA minimizes the risk of hemorrhage due to traumatization of the PSAA during surgery [1].

In our study, the superficial position of the canal was not detected on any of the scans, which is different from the results reported by Jung et al [1], Ilgüy et al [10], and Güncü et al [16]. The difference between our results and those of Jung et al [1] and Ilgüy et al [10] was due to the probable racial differences among the studied populations. The difference between our results and those reported by Güncü et al [16] might be due to ethnic variations as well as different methodologies and techniques. Although the results related to the vascular canal's position in our study were similar to those reported by Elian et al [21], the techniques were different (CBCT versus CT scans); the former method has been used in many of the recent studies [17,18,22]. In the cited study, the intraosseous position of the vascular canal was seen in 52.9% of the cases in comparison to the 51.31% frequency in our study. On the other hand, the mean distance of the artery from the alveolar crest was different in these studies. In our study, the vertical distance of the PSAA from the alveolar crest was measured in different dental sites; however, in the mentioned study, the average distance was reported [21].

In the current study, the smallest distance between the inferior border of the PSAA and the maxillary sinus floor was detected in the first premolar region (4.82±2.45 mm), while the greatest distance was found to be in the first molar area (5.82±2.39

mm), which was not in agreement with the results found by Jung et al [1]. They reported the smallest distance in the molar region (7.58±3.19 mm) and the greatest distance in the first premolar site (9.20±3.22 mm). In the Iranian race, the alveolar height may decrease if the time interval between tooth extraction and implant placement is prolonged, and this can lead to the extension of the maxillary sinus into the alveolar ridge as also demonstrated by Haghanifar et al [22]. On the other hand, in the study by Lee et al [23], no significant differences were observed in the distances from the maxillary sinus floor to the PSAA in different dental regions. However, the distance increased as the canal passed through the posterior dental region [23]. Despite the difference in the methodologies of these studies (usage of CT versus CBCT), their results were in agreement with those of our study.

The distance from the inferior border of the PSAA to the alveolar crest was also measured in the present study; the minimum distance was detected in the first molar site (15.54±2.76 mm), while the maximum distance was found to be in the first premolar area (20.81±2.96 mm). These findings agree with the results of the studies by Mardinger et al [6] and Haghanifar et al [22]. Haghanifar et al [22] reported the smallest distance in the region of first molar (16.92±4.45 mm) and the greatest distance in the first premolar area (22.54±5.49 mm). Our results were also in line with those of Kim et al [9]. They reported the shortest distance in the second molar area (15.45±4.04 mm) and the maximum distance in the second premolar site (18.9±4.21 mm) [9]. Jung et al [1] found the smallest distance to be in the first molar region (14.79±4.04 mm) and the greatest distance in the first premolar site (18.92±4.86 mm); which is in agreement with our findings.

The distances from the inferior border of the vascular canal to the maxillary sinus floor and alveolar crest were compared in men and women, and no significant differences were found in this regard; which confirms the findings of the studies by Jung et al [1] and Kim et al [9]. However, this finding is in contrast to the results reported by Haghanifar et al [22] and Tehranchi et al [19], which may be attributed to the usage of different imaging modalities. Finally, the present study is the first to separately assess the distance from the inferior border of the PSAA to the maxillary sinus floor in dentulous and edentulous areas.

## Conclusion

Based on our findings, the PSAA was detected in 25% of the cases, and the smallest distances between the vascular canal and maxillary sinus floor were observed in the first premolar and first molar regions, respectively. This study also demonstrated that the preoperative assessments of the position of the PSAA by CBCT are beneficial for reducing the risk of perioperative bleeding.

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