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Comparison of the Posterior Superior Alveolar Artery in the Maxillary Sinus between Edentulous and Dentate Patients Using Cone-Beam Computed Tomography

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Abstract

Background and Aim: The posterior superior alveolar artery (PSAA) is a branch of the maxillary artery. This study compared the anatomical position of the PSAA in the maxillary sinus between edentulous and dentate patients using cone-beam computed tomography (CBCT).

Materials and Methods: This descriptive study evaluated 280 maxillary sinus CBCT scans of edentulous and dentate patients. Visibility, vertical diameter, location and type of artery, horizontal distance from the PSAA to the sinus internal wall, distance from the artery to the sinus floor, distance from the artery to the alveolar crest, and distance from the alveolar crest to the sinus floor were studied on coronal sections using SIDEXIS 3D software. Data were analyzed by the Chi-square, Spearman rank correlation coefficient, and independent t tests.

Results: The artery type was mainly type I, with no difference between males and females or edentulous and dentate patients (P>0.05). PSAA was primarily located in the second molar area in dentate patients. The horizontal distance from the PSAA to the sinus internal wall, PSAA vertical diameter, distance from the alveolar crest to the sinus floor, and distance from PSAA to the maxillary sinus floor were not different in different age groups (P>0.05). Vertical diameter of PSAA and distance from PSAA to the maxillary sinus floor were not different between edentulous and dentate groups (P>0.05).

Conclusion: The distance from the PSAA to the sinus internal wall and to the alveolar crest, and the distance from the alveolar crest to the sinus floor were smaller in edentulous patients.

Keywords: Maxillary Sinus; Edentulous; Cone-Beam Computed Tomography

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Introduction

Nowadays, with the increasing use of dental implants for replacement of the missing teeth, particularly in the posterior region of the maxilla, it is crucial to have a comprehensive understanding of bone anatomy, the maxillary

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sinus, and vital anatomical structures such as the nerves and arteries in this area [1,2]. In order to ensure safe manipulation of the maxillary sinus, it is crucial to have a good understanding of its blood supply. The maxillary sinus receives blood from two primary sources: the posterior superior alveolar artery (PSAA) and the infraorbital artery [3,4].

PSAA is one of the maxillary artery branches that enters the maxillary bone from the tuberosity area and supplies the blood flow to the posterior teeth with its intraosseous branches and the maxillary gingiva with its superficial branches. The infraorbital artery anastomoses with the PSAA and creates a common artery in the anterior-lateral membrane of the maxillary sinus. It is crucial to avoid any damage to this artery in maxillary sinus surgeries [5]. Determining the exact position and diameter of the PSAA is imperative before any surgical procedure. Enlargement of the maxillary sinus with age, resorption of the alveolar crest, and surgical procedures performed in this area increase the risk of damage to this artery [1,6].

Maxillofacial presurgical imaging is crucial to detect possible maxillary sinus abnormalities and pathologies. The treatment plan may require alterations, and surgical interventions in the maxillary sinus may yield a more favorable prognosis after using 3D imaging modalities. Cone-beam computed tomography (CBCT) is a 3D imaging modality that can reveal anatomical structures around the desired area for dental implant placement with a submillimeter resolution. It helps to determine the exact anatomy of the maxillary sinus [7]. Tavakoli Harandi et al. [8] reported the most common location of the PSAA in the maxillary sinus to be in the first molar area, and intraosseous type (type I) was reported as the most common type. In addition, the average distance from the artery to the medial wall, and the mean vertical diameter were the highest in the third molar area. Pandharbale et al. [9] observed PSAA on CBCT images of 70% of the cases. In another study conducted by Vasegh et al. [10], the most common type of PSAA canal was intraosseous.

This study aimed to determine the prevalence of PSAA in the maxillary sinus in two groups of edentulous and dentate patients using CBCT.

Materials and Methods

This study was approved by the Dental Research Ethics Committee of the Dental Research Center, College of Dentistry, Islamic Azad University, Isfahan (Khorasgan) branch (IR.IAU.KHUISF.REC.1400.042). In this descriptive analytical study, CBCT images of 280 maxillary sinuses (140 maxillary sinuses in dentate patients and 140 sinuses in edentulous patients) were studied in 73 females and 67 males. The sample size was calculated to be 63 patients (126 maxillary sinuses) in each group, assuming alpha=0.05, beta=0.2, study power of 80%, and detection of a difference maximally equal to half of the standard deviation using the following formula:

$$n = \frac{2\sigma^2\left(z_{1-\alpha/2}+z_{1-\beta}\right)^2}{\delta^2}$$

Considering 10% possible dropouts, 70 patients were considered for each group (140 maxillary sinuses).

Th inclusion criteria were optimal quality CBCT scans with no artifacts visualizing the entire maxillary sinuses bilaterally, age over 18 years, and for dentate patients, losing at least one tooth from first premolar to second molar area [11]. CBCT scans of patients with a history of trauma or fracture of the maxilla, and those with pathological lesions in the maxillary sinus were excluded from the study. The enrolled patients were between 18-72 years.

In this study, the following variables were measured: presence of PSAA canal, type of PSAA canal, location of PSAA canal, horizontal distance from the PSAA to the sinus internal wall, vertical diameter of the artery, vertical distance from the PSAA to the maxillary sinus floor, vertical distance from the alveolar crest to the maxillary sinus floor, and distance from the PSAA to the alveolar crest.

All scans were obtained using Sirona-Galileo CBCT scanner (Sirona Dental Systems GmbH, Bensheim, Germany) with the exposure parameters of 85 kVp and 21 mAs, with a total exposure time of 2–4 s, depending on patient. SIDEXIS software version 4.1 (3D Viewer; Sirona, Germany) in an Intel Core i7-4460 at 3.20 GHz (Intel Corp, Santa Clara, CA) PC workstation running Windows 10 professional SP-2 (Microsoft Corp, Redmond, WA) was used to study the reconstructed multiplanar images in the axial, sagittal, and coronal planes.

First, the coronal images from the posterior to the anterior maxilla were assessed to see if the PSAA could be observed. Regarding dentate patients, the nearest dental area was selected and recorded to determine the location of the artery. In case of observing the artery, as mentioned earlier, the type of artery position relative to the sinus membrane and the lateral wall of the maxillary sinus was classified into one of the three following types (Figure 1):

Type I: The artery is intraosseous

Type II: The artery is below the Schneiderian membrane

Type III: The artery is on the outer cortex of the lateral wall

After determining the type of artery, on the same coronal view cross-section, the distance between the lower border of the PSAA and the edge of the alveolar crest (to the center of the interdental alveolar crest in dentate areas) (Figure 2b), the maxillary bone height from the sinus floor to the alveolar crest (Figure 2c), the distance between the notch slit of the PSAA to the internal wall of the maxillary sinus (Figure 2d), the distance between the lower border of the PSAA to the middle of the maxillary sinus floor (Figure 2a) and the diameter of the PSAA were measured by the software ruler with 100 mm accuracy.

The data were analyzed by the Chi-square test, Spearman rank correlation coefficient, and independent t-test, using SPSS version 26 at 0.05 level of significance.

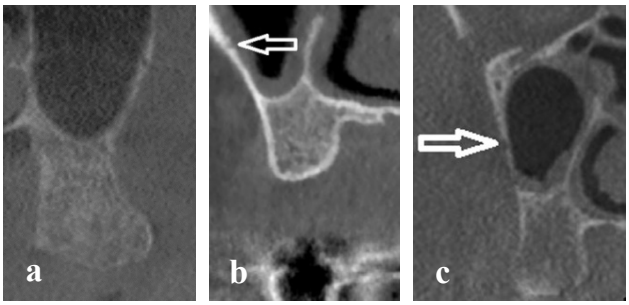

Figure 1. Coronal view of the maxillary sinus and PSA: (a) Type I (intraosseous type), (b) Type II (below the Schneiderian Membrane), and (c) Type III (outer cortex of the lateral wall)

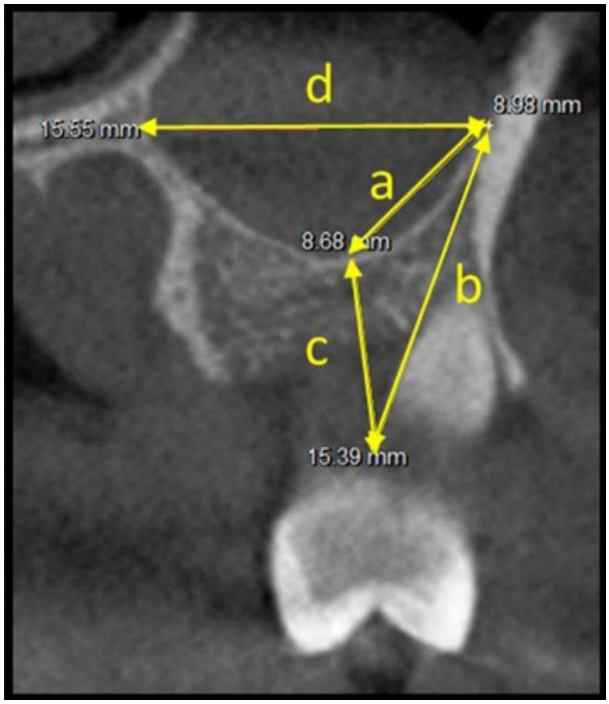

Figure 2. Distances measured on the coronal cross-sectional image of the maxillary sinus and PSAA

Results

In evaluating the demographic information, the frequency distribution of gender in edentulous and dentulous patients was almost the same (P=0.072). The mean age was 37.40±11.14 years in the dentate group and 50.55±12.43 years in the edentulous group. The mean age of the patients in the dentate group was significantly lower than the mean age of the edentulous group (P<0.001). Of all patients, 24 (16.9%) were under 30 years, 74 (53.2%) were between 31-50 years, 39 (27.7%) were between 51-70 years, and 3 patients (2.2%) were over 71 years. Patients between 31-50 years had the highest frequency.

The PSAA canal in the maxillary sinus was visible on images of 107 sinuses of the dentate patients (77%). It was observed on the images of 101 sinuses of the edentulous patients (72.7%). The frequency distribution of the presence of PSAA canal was almost the same between edentulous and dentate patients (P=0.407). The frequency distribution of the PSAA canal between male and female patients was not significantly different (P=0.888). The frequency of presence of PSAA in the maxillary sinus was not significantly different between males and females in dentate (P=0.563) or edentulous patients (P=0.639).

In evaluating the frequency distribution of the PSAA type in the maxillary sinus in males and females, the type of artery was mainly type I (intraosseous) (54.8%); among which, 59 patients (28.4%) were from the dentate group and 55 patients (26.4%) were from the edentulous group. No significant difference was found in the frequency distribution of the artery type between females and males in the two groups (P=0.868). No significant difference was found between the edentulous and dentate patients in the four age groups regarding the frequency of observing the PSAA in the maxillary sinus (P>0.05).

Based on the results reported in Table 1, no significant difference was found in the mean horizontal distance from the PSAA to the sinus internal wall (P=0.278) and vertical distance from the alveolar crest to the maxillary sinus floor (P=0.324) between dentate males and females. Nevertheless, the mean vertical diameter of the artery (P=0.009), vertical distance from the PSAA to the maxillary alveolar crest (P=0.040), and the distance from the artery to the maxillary sinus floor (P=0.003) in females were significantly lower than the corresponding values in males. As shown in Table 1, comparison of the mean coronal view variables between males and females in the edentulous group showed that only the distance between the artery and the maxillary sinus floor was lower in the edentulous female group than in the male group (P=0.004). No significant difference was found between males and females in other variables (P>0.05). Evaluating the relationship between age and horizontal distance from the PSAA to the sinus internal wall, vertical diameter of the artery, distance from the alveolar crest to the sinus floor, and distance from the artery to the maxillary sinus floor in different age groups showed no significant difference between the edentulous and dentate groups (P<0.05). Based on the results in Table 2, no significant difference was found between the two groups of edentulous and dentate patients in the mean vertical diameter of the artery (P=0.092) and vertical distance from the PSAA to the maxillary sinus floor (P=0.555). The mean horizontal distance from the PSAA to the internal wall of the maxillary sinus (P<0.001), mean vertical distance from the alveolar crest to the maxillary sinus floor (P=0.023), and the distance from the artery to the alveolar crest (P=0.044) in dentate patients were significantly greater than those in the edentulous group.

As shown in Table 3, the relationship between the location of the artery and gender of patients showed that the location of the PSAA in the maxillary sinus was more commonly in the second molar area on both sides (right and left) in males and females. Furthermore, there was no significant difference in the frequency distribution of the location of PSAA in males and females (P>0.05). The maximum frequency of all three types of PSAA was related to the second molar area. The frequency distribution of the PSAA canal location (first molar, second molar, and third molar area) in the three artery types had no significant difference (P=0.870) (Figure 3).

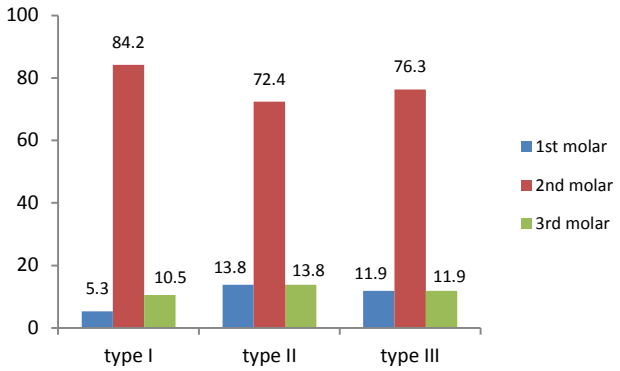

Figure 3. Comparing the frequency distribution of artery location (first molar, second molar, and third molar) with different types of PSAA canal on CBCT coronal images of the dentate group

Table 1. Mean of the variables measured on CBCT images in edentulous and dentate males and females

Variable	Dentate group					Edentulous patients			
	Gender	Number	Mean	Standard deviation	P-value	Number	Mean	Standard deviation	P-value
Horizontal distance from the PSAA to the sinus internal wall (mm)	Female	46	11.79	3.22	0.401	63	13.27	2.76	0.278
	Male	55	12.28	2.59		44	13.89	3.05	
Vertical diameter of PSAA (mm)	Female	46	1.14	0.53	0.320	63	0.98	0.32	0.009
	Male	55	1.24	0.49		44	1.22	0.53	
Vertical distance from the PSAA to the alveolar crest (mm)	Female	46	16.44	4.37	0.212	63	17.19	3.46	0.040
	Male	55	17.40	3.07		44	18.66	3.80	
Vertical distance from the alveolar crest to the maxillary sinus floor (mm)	Female	46	8.91	4.00	0.134	63	9.64	2.98	0.324
	Male	55	7.77	3.56		44	9.03	3.39	
Distance from the PSAA to the maxillary sinus floor (mm)	Female	46	7.53	3.68	0.004*	63	7.55	3.36	0.003
	Male	55	9.63	3.47		44	9.63	3.71	

Table 2. Descriptive values of variables measured on CBCT coronal sections

Variables	Group	Number	Mean	Standard deviation	P-value
Horizontal distance from the PSAA to the sinus internal wall (mm)	Dentate	107	13.53	2.89	<0.001
	Edentulous	101	12.05	2.89	
Vertical diameter of PSAA (mm)	Dentate	107	1.08	0.46	0.092
	Edentulous	101	1.91	0.51	
Vertical distance from the PSAA to the alveolar crest (mm)	Dentate	107	17.80	3.65	0.044
	Edentulous	101	16.96	3.73	
Vertical distance from the alveolar crest to the maxillary sinus floor (mm)	Dentate	107	9.39	3.15	0.023
	Edentulous	101	8029	3.79	
Distance from the PSAA to the maxillary sinus floor (mm)	Dentate	107	8.41	3.64	0.559
	Edentulous	101	8.67	3.70	

Table 3. Relationship between the location of artery and gender

Location of the maxillary sinus	PSAA location	Gender		P-value
		Male	Female	
Right	First molar	1(0.9)	5 (4.7)	0.268
	Second molar	15(14.0)	30(28.0)	
	Third molar	5(4.7)	4(3.7)	
Left	First molar	3(2.8)	3(2.8)	0.591
	Second molar	19(17.8)	18(16.9)	
	Third molar	1(0.9)	3(2.8)	

Discussion

The present study assessed the CBCT scans of 280 maxillary sinuses in edentulous and dentate groups. No significant difference was found in gender between the two groups of edentulous and dentate patients, which was consistent with the studies by Vasegh et al. [10] and Velasco-Torres et al. [12]. However, Fayek et al. [13] showed that the PSAA canal could be detected in 92.0% of the sinuses. Variations in the results can be due to differences in sample size, resolution of images due to using different scanners, racial differences, and observers' accuracy.

In the present study, higher number of arteries were observed in the second molar area and then in the third and first molar areas in the dentate group, and there was no difference in gender or type of artery. Moreover, the type of artery was mainly type I (intraosseous), then type II (below the sinus membrane), and finally type III (outer cortex of the lateral wall). In addition, no significant difference was reported in the type of artery between males and females or between edentulous and dentate groups. This result aligns with other studies [8, 10, 14].

Based on the results of the present study, the diameter of the PSAA in dentate males was significantly larger than that in dentate females. However, this parameter was not significantly different in males and females in the edentulous group. Fayek et al. [13] and Kim et al. [2] assessed dentate patients and showed that the mean diameter of the PSAA was higher in males.

In the present study, the horizontal distance from the artery to the internal wall of the maxillary sinus was lower in the edentulous group. Therefore, the distance decreases with tooth loss. This parameter was not significantly different in different age groups and between males and females in either group. This result was consistent with the findings of Vasegh et al. [10] and Chitsazi et al. [14]. However, Velasco-Torres et al. [12] showed that the mediolateral width of the sinus increased with tooth loss, which is different from the results of the present study, and may be related to the difference in the study populations and race.

The distance from the artery to the alveolar crest was lower in the edentulous group. Hence, it decreased with tooth loss but increased with age in the dentate group. Nevertheless, it decreased in the edentulous group by age, which can be due to the loss of vertical height of the edentulous ridge with age. The distance was significantly less in the dentate females compared to males. However, this parameter did not differ significantly in terms of gender in the edentulous group, which is consistent with the results of Velasco-Torres et al. [12] and Vasegh et al. [10].

In the present study, the distance from the artery to the maxillary sinus floor was not significantly different between the edentulous

and dentate groups and between different age groups. The distance was significantly smaller in females in both groups than males. This result was consistent with the findings of Fayek et al. [13]. However, Velasco-Torres et al. [12] showed that the distance from the artery to the sinus floor was shorter in edentulous patients than in dentate patients due to the differences in the study populations and race.

The distance between the sinus floor and alveolar crest was lower in the edentulous group, indicating a decrease in this distance in this group. However, this distance between males and females and different age groups was not different in the edentulous and dentate patients.

The visibility of the artery, the horizontal distance from the PSAA to the sinus internal wall, the vertical diameter of the artery, the distance from the alveolar crest to the sinus floor, and the distance from the artery to the maxillary sinus floor had no difference in different age groups. In dentate females, the diameter and vertical distance from the artery to the maxillary alveolar crest and distance from the artery to the sinus floor were significantly smaller compared with males. However, the edentulous group showed significantly smaller distance between the artery and the maxillary sinus floor in the female group than in the male group.

Conclusion

In the edentulous group, the distance from the artery to the sinus internal wall, the distance from the artery to the alveolar crest, and the distance from the alveolar crest to the sinus floor were smaller than the corresponding values in the dentate group. However, the visibility of the artery, artery diameter, artery type, and distance from the artery to the sinus floor were not significantly different.

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