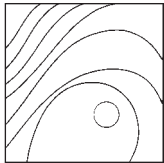


Location of Posterosuperior Alveolar Artery and Correlation with Maxillary Sinus Anatomy



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The blood supply to both the lateral wall of the maxillary sinus and the overlying membrane originates from the posterosuperior alveolar artery (PSAA) and the infraorbital artery. The purpose of the present study was to evaluate the anatomic characteristics of the PSAA in a large number of subjects of the Lebanese population. Images of 696 sinuses were analyzed using cone beam computed tomography (CT). Coronal, axial, and sagittal CT images were evaluated for the presence of an osseous canal in the lateral wall of the sinus, and the prevalence, position, and location of the canal were studied and presented. (Int J Periodontics Restorative Dent 2015;35:e60–e65. doi: 10.11607/prd.2418)

Thorough knowledge of the anatomy of the sinus blood supply is imperative before performing any all sinus lift and bone grafting procedures in the maxillary sinuses. All measures need to be taken to ensure good vascularization of the graft and to avoid excessive bleeding during procedures, especially those needing a lateral surgical approach.

In their report of the Sinus Consensus Conference of 1996, Jensen et al¹ stated that “sinus augmentation has evolved into a predictable surgical modality for increasing the existing height with bone of sufficient quality to allow for the successful placement of dental implants.”

In 2008, Pjetursson et al² stated that the main indication for maxillary sinus floor augmentation via the lateral approach is a reduced residual bone height, which cannot accommodate standard implant placement. This approach has been shown to be a predictable method to increase the volume of bone for the purpose of implant placement.^{3–5} The blood supply to both the lateral wall of the maxillary sinus and the overlying mucosal membrane originates from the posterosuperior alveolar artery (PSAA) and the infraorbital artery. When performing an osteotomy in the lateral wall of the sinus, it is possible to damage the vascular supply in the lateral wall, resulting in intraoperative

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bleeding that may be mild to severe. When the intrabony course of the vessels is known, the osteotomy can be properly planned to avoid damage to the vessels and to maintain perfusion of the entire bone segment and bone graft.⁶

Many studies were conducted to detect the prevalence of the PSAA using computed tomography (CT) scans of the maxillary sinus, but the results were based on a limited number of cases; some anatomic studies of human cadavers were also aimed at examining the PSAA in the lateral wall of the sinus.

The purpose of the present study was to characterize the prevalence, position, and location of the PSAA, and to calculate the distance between the PSAA and the highest point of the buccal alveolar crest using cone beam computer tomography (CBCT) in a large number of cases, and to discuss its importance and the correlation with the sinus floor augmentation procedure.

Method and materials

Imaging modes

The scans used in this study were acquired with an I CAT CBCT machine (Imaging Sciences International) in the Department of Oral and Maxillofacial Imaging, School of Dentistry, Lebanese University (Beirut, Lebanon).

The patients were referred for multiple purposes and were randomly selected for the study; the field-of-view (FOV) of the studies was chosen according to the indications.

Almost two thirds of the scans were acquired for prosthetic and implant assessment and planning. The remaining scans were obtained for orthodontic or other reasons (pathology, trauma, sinusitis, etc). A total of 401 CBCT studies covering the entire volume of the maxillary sinuses were examined for the study, and 53 patients who exhibited a pathologic appearance of the maxillary sinus were excluded.

Study population and indications

The study included 348 patients: 159 male patients (45.69%) and 189 female patients (54.31%).

The mean age of patients was 44 years, with the youngest being 5 years old and the oldest 82 years old at the time of the investigation. Patient demographics are summarized in Table 1. A total of 696 sinuses were analyzed between January 2008 and December 2012. All patient data were anonymized following the request of the ethics committee.

Data acquisition and statistical analysis

The images were viewed with proprietary software (ICAT Vision) using the multiplanar reconstruction module. All images were assessed at an examination workstation that consisted of two monitors and a personal computer (Intel Pentium D CPU 3.60GHz, 3.60 GHz, 3.25 GB of RAM running a Microsoft Windows

Table 1 Study population		
Age (y)	Male	Female
0–20	17	24
21–40	53	73
41–60	63	79
61–85	26	13
Total	159	189
No. of patients	348	

XP Professional Version 2002, SP3). Monitors were 19-inch EIZO units with a resolution of 1,280 × 1,024 pixels and a contrast of 700:1 (Eizo Nanao). All hardware components were technically approved for radiologic diagnostics. The room containing the examination workstation was equipped with window shades and dimmable light for standardized low-lit ambience illumination.

The images were analyzed by three examiners who were experienced in dental and oral radiology (one periodontist [W.H.] and two oral radiologists [E.Y., I.N.]). The examiners were allowed to adjust the brightness and contrast of the images and to use the zoom function provided by the visualization software.

Images of 696 sinuses were examined for the presence of an intraosseous canal in the lateral wall of the sinus (Fig 1). In coronal views, the canal was described as a circular or oval low-density structure that is fully or partially embedded in the thickness of the lateral wall of the maxillary sinus; it has to be seen along the sinus border while scrolling the axial views. To confirm the radiographic presence of the canal, we examined the axial and coronal

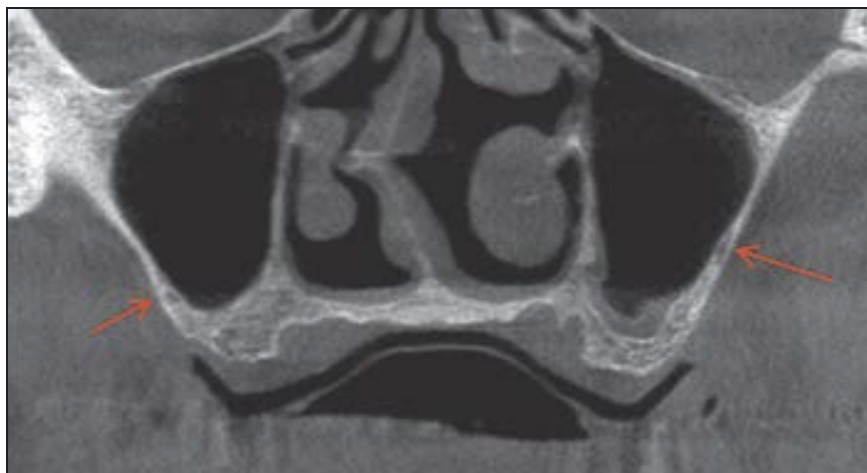


Fig 1 Coronal view showing the PSAA canal in the lateral wall.



Fig 2 Distance from the inferior border of the PSAA to the crest of the alveolar ridge.

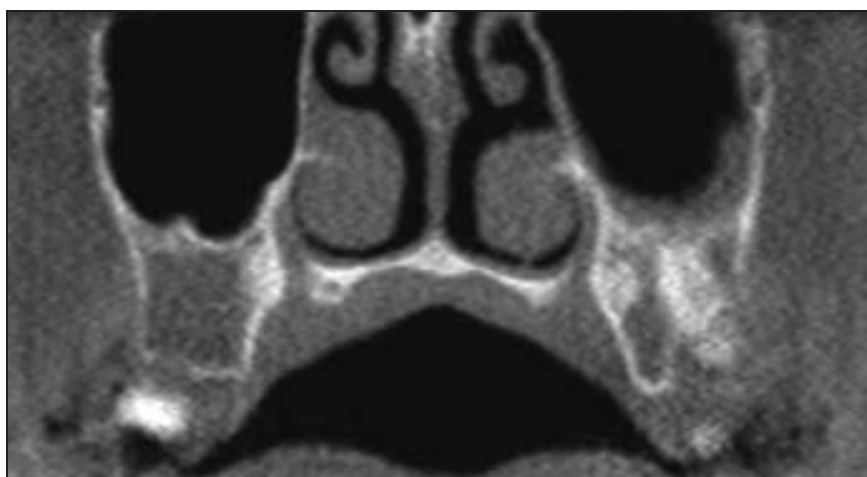


Fig 3 Coronal section showing the location and diameter of PSAA in a mediolateral orientation: less than 1 mm on the right side and more than 1 mm on the left side.

images because it helped us rule out any possible artifact generated while reconstructing CT images.

After confirming the presence of the canal, measurements were taken to record the diameter of the canal and the distance from its lower border to the most external point of the alveolar crest. Radiographically, two possibilities may present, depending on the shape of the crest; if the crest has a more squared shape, the distance measured will be between the inferior

aspect of the PSAA and the angle of the crest. If the crest is curved, the distance measured will be between the inferior aspect of the PSAA and the most inferior contact point between the straight line and the bone. The measurements were acquired in millimeters using the proprietary software measuring tool and were gauged up to two decimal points (Fig 2).

The mean values and standard deviations of the measuring results were calculated.

The diameter of the canals was measured in a mediolateral direction, and the cases were distributed into three categories based on the diameter of the canal: (1) less than 1 mm; (2) between 1 and 2 mm; and (3) more than 2 mm (Fig 3).

The radiographic location of the intraosseous canal in relation to the lateral wall was recorded as well and divided into three categories; (1) between the sinus membrane and the osseous wall; (2) within the thickness of the osseous wall; and

(3) on the external aspect of the lateral wall (Fig 3).

The prevalence of the canal was analyzed with regard to age, sex, site (right or left), and presence of teeth (dentate or edentulous).

Patient data obtained, scan data, and assigned scores were recorded in a Microsoft Excel 2010 database (Microsoft). Statistical analysis was performed with the software SPSS Statistics 17.0 for Windows (SPSS).

Results

A total of 696 maxillary sinuses were examined; the bony canal was radiographically identified in 348 sinuses, with 171 (49.1%) cases exhibiting the canal on the right side and 177 (50.1%) on the left side, for an overall average of 50%. No statistically significant difference was found between the right and left sides (Table 2).

The subjects were divided into dentate and completely edentulous groups; 290 cases (83.33 %) were found to have least two teeth in the posterior maxillary region and were considered dentate subjects. In the absence of all teeth in the posterior maxillary region, the subject was considered edentulous; 58 cases (16.67 %) were completely edentulous. The distance between the canal and the alveolar crest was between 10 and 20 mm in 68.6% of dentate subjects and 79.4% in the edentulous group (Tables 3 and 4); the distance between the PSAA and the alveolar crest was found to be shorter in the edentulous group than dentate group.

Table 2 Prevalence of radiographically detectable PSAA in the maxillary sinus wall

	PSAA (n)	%
Right sinus	171	49.1
Left sinus	177	50.9
Total	348	50
No. of sinuses	696	100.0

PSAA = posterosuperior alveolar artery.

Table 3 Distance between PSAA and alveolar crest in dentate patients

	0–10 mm	10–20 mm	20–30 mm	Total
Right	4	91	44	139
Left	1	101	39	141
%	1.8	68.6	29.6	100

PSAA = posterosuperior alveolar artery.

Table 4 Distance between PSAA and alveolar crest in edentulous patients

	0–10 mm	10–20 mm	20–30 mm	Total
Right	1	26	5	32
Left	3	28	5	36
%	5.9	79.4	14.7	100

PSAA = posterosuperior alveolar artery.

Table 5 Diameter of PSAA

	< 1 mm	1–2 mm	> 2 mm	Total
Right	121	48	1	32
Left	116	58	3	36
%	68.1	30.7	1.2	100

PSAA = posterosuperior alveolar artery.

The diameter of the canal was less than 1 mm (category 1) in 237 cases (68.10%), 1 to 2 mm (category 2) in 107 cases (30.75%), and 2 to 3 mm (category 3) in four cases (1.15%). No statistically significant difference was found between the right and left sides. The results of

the diameter categories are presented in Table 5.

The canal was located between the sinus membrane and the osseous wall (category 1) in 97 cases (27.88%), within the thickness of the intraosseous wall (category 2) in 241 cases (69.25%), and on the

Table 6 Location of PSAA in relation to the lateral sinus wall

	Intraosseous	Between the bone and the mucosa	Outside the bone	Total
Right	118	48	5	171
Left	123	49	5	177
%	69.2	27.9	2.9	100

PSAA = posterosuperior alveolar artery.

outer aspect of the lateral wall (category 3) in 10 cases (2.87%). Right and left sides were compared as well and a statistically significant difference was found (Table 6).

Discussion

The lateral window technique has proven to be predictable and highly successful, providing direct access and visibility to the sinus; however, various complications were reported during sinus floor augmentation, including, but not limited to, sinus membrane perforation, antral pathoses such as sinusitis or mucocoele formation, and oroantral communication. According to Katranji et al,⁷ the major intraoperative complication is bleeding in the surgical field associated with the interruption of a large vessel in the sinus wall.

In 2008, Ella et al⁸ stated that the vascular supply of the maxillary sinus including all major blood vessels needs to be outlined because of the potential risk of intraoperative bleeding during sinus augmentation surgery.

This study examined the PSAA and the alveolar crest in 348 Lebanese patients. The canal was radiographically identified in more than 50% of CT images examined, equally between the right and left side. In

the majority of cases, the canal was between 1 and 2 cm superior to the alveolar crest. Previous studies achieved almost the same results.

Elian et al⁹ studied 50 CT images to determine the detection rate of the PSAA and the distance from the inferior border of the PSAA to the alveolar ridge. The radiographic detection rate of the PSAA was 52.9%, and the mean \pm standard deviation distance from the inferior border of the artery to the alveolar crest was 16.4 ± 3.5 mm.

Mardinger et al¹⁰ also examined the existence of the PSAA in 180 maxillary sinuses using CT scan. The detection rate was 55%, and the mean distance from the residual alveolar ridge to the artery in the first molar area was 16.9 ± 4.46 mm.

Kim et al¹¹ conducted research on the Korean population and found that, among 87 CT scan images, the detection rate of artery was 52% and the distance from the buccal residual alveolar ridge to the artery was 17.7 ± 4.2 mm.

The result of the present study is very similar to the expression ratio of the PSAA in previous studies, but the slightly lower detection rate could be attributed to differences in the sample population in this study.

Before external sinus floor augmentation, and using the currently available methods of presurgical

evaluation (CBCT), it is possible to identify the location of the intraosseous artery in at least 50% of cases. The alveolar ridge is subject to progressive atrophy with teeth loss and age, which can lead to changes in the blood supply to that area.

In this study, the number of subjects in the edentulous group was 58 patients or 116 maxillary sinuses. Intraosseous arteries were identified in both sinuses in 68 edentulous subjects (58.6%), indicating a possible correlation between the edentulous region and the prevalence of PSAA, compared with 48.3% of the dentate patients.

In an anatomic study conducted by Traxler et al,¹² an intraosseous anastomosis between PSAA and infraorbital artery was found in all specimens.

The distance between the canal and the alveolar crest was between 10 and 20 mm (category 2) in 68.6% of dentate patients (mean 16.9 mm) and 79.4% (mean 14.7 mm) of the edentulous patients; similar results were published by Solar et al⁶ and Elian et al.⁹ The significant difference between dentate and edentulous patients was probably the result of the progressive atrophy of the alveolar ridge.

During a sinus lift procedure using lateral window techniques, the inferior osteotomy will be placed 2 to 3 mm superior to the estimated floor of the sinus, and the superior cut will be made approximately 15 mm from the alveolar crest (to place an implant of 13 mm). In addition, two vertical cuts will be made to connect the superior and inferior cuts. The vertical cuts are suspected

to transect the artery if the distance between the bony canal and the alveolar crest is less than 15 mm. Therefore, depending on the desired length of the implant to be placed, a preparation of the lateral window that is closer to the crest of the alveolar ridge should be considered.¹³ Special attention should be given to avoid such an accident because damage of the bony vessel can cause intense bleeding and obscuring of vision, and may lead to perforation of the sinus membrane.¹⁴

The diameter of the bony canal, as recorded in our study, was smaller than 1 mm (category 1) in 68.1% of the sinuses, but it is more than 1 mm in 31.9%. Accordingly, if the risk of severe bleeding is reduced in canals smaller than 1 mm, the possibility of having surgical complications is higher in larger canals and needs to be taken into consideration in almost one-third of all external sinus lift procedures.

Conclusion

This retrospective study using CBCT images of 696 maxillary sinuses analyzed the prevalence, location, and radiographic diameter of PSAA in relation to the lateral sinus wall in 348 patients divided into dentate and edentulous groups.

Considering the results of this study, the PSAA must be examined with CBCT before external sinus lift is performed, because there is a 50% probability of detecting it radiographically with CT images.

The results of this study showed that the distance between the PSAA and the alveolar crest was found to be shorter in edentulous subjects than in dentate subjects.

Therefore, in edentulous patients, especially because the distance between the PSAA and the alveolar crest is shorter than in dentate patients, a preparation of the lateral window that is closer to the crest of the alveolar ridge should be considered.

Regardless of the race or sex of patients, performing CBCT before maxillary sinus floor augmentation provides valuable information about the anatomy of the sinus, including the location of blood vessels. Intraoperative and postoperative complications can thus be successfully avoided, and if necessary, appropriately managed.

Acknowledgments

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