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Evaluation of the Posterior Superior Alveolar Artery Using Cone Beam Computed Tomography

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Summary

Background:

Maxillary posterior tooth region is an important area with respect to periapical surgery, implant placement, and sinus lifts. Posterior superior alveolar artery (PSAA) is located on the lateral wall of maxillary sinus and may become injured during such surgical procedures. Therefore, knowledge of the subject is essential to a clinician.

The goal was to determine the anatomical relationship of posterior superior alveolar artery to the floor of maxillary sinus and alveolar crest.

In our study we attempted to present the locations and course of posterior superior alveolar artery (PSAA) using cone beam computed tomography (CBCT) imaging.

Material/Methods:

CBCT scans of 50 patients (30 males, 20 females) who had undergone computed tomography imaging were analyzed. We assessed the visibility and location of vascular canal/notch of posterior superior alveolar artery on cross sectional images and measured the distances from lower margin to the floor of maxillary sinus and alveolar crest in the 1st molar and 2nd molar regions. Unpaired t-test was carried out in the analysis to determine the level of significance.

Results:

Maxillary PSAA was visualized in 36 patients (70%). Mean diameter of the vessel was 0.63 mm. Mean distance between PSAA and alveolar crest was the shortest in the 2nd molar region. The mean distance between PSAA and floor of maxillary sinus was 9.96 mm.

Conclusions:

Periapical surgeries, implants and maxillary sinus lift are performed on routine basis. PSAA is an important structure in the posterior maxillary region; the clinician should be aware of its location and course. CBCT is an excellent tool to localize the PSAA because of it provides finer details at low exposure and less radiation. It should be recommended in clinical practices.

MeSH Keywords:

Cone-Beam Computed Tomography • Dental Implants • Maxillary Sinus

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Background

Maxillary sinus is a vital structure located in the maxillary bone; hence, it is necessary to understand the anatomy and recognize anatomical landmarks around the maxillary sinus. The roof of the alveolar process, which is formed by the floor of maxillary sinus, is clinically important. Maxillary sinus grows exponentially until permanent teeth erupt by the age of 20; however, the sinus floor descends

with removal of posterior maxillary teeth [1]. Replacement of posterior maxillary teeth is a critical issue due to failure of distal extension and development of defective, constricted alveolar bone. [2]

Vascular supply to both lateral walls of the maxillary sinus originates from the posterior superior alveolar artery (PSAA) and the infraorbital artery (IOA), which are branches of maxillary artery. Both arteries give off extraosseous

and intraosseous branches, which subsequently anastomose around the maxillary sinus [3]. The course of the intraosseous branch of the PSAA on the buccal wall of the sinus could be classified into one of two types: straight (S) (78.1%) or U-shaped (21.9%) [3].

Surgical procedures performed through the lateral wall include: open sinus lift, Caldwell-Luc surgery, and Le Fort I osteotomy. Osteosynthesis for the treatment of maxillary fractures may also involve this artery. Surgical manipulation around this artery during these procedures may lead to hemorrhage [4]. Although bleeding may not be a life-threatening complication, as only a minor vessel is involved, it may obscure the field of vision during surgery [1,5].

There is a high success rate when implantation is combined with bone grafting in the posterior maxillary area; it is advantageous in cases of insufficient residual alveolar bone [6]. Implants constitute the current trend in dentistry and implant insertion with direct or indirect sinus [TN: word missing] is common. During this procedure PSAA can easily get injured or traumatized.

PSAA is a crucial structure located on the lateral wall of maxillary sinus. (Figure 1) Enlargement of maxillary sinus with age and resorption of alveolar crest, or surgical procedures performed in this area are associated with increased risk of damage [TN] [7]. Cone beam computed tomography (CBCT) technology provides numerous advantages, such as reduced costs, decreased radiation dose and availability of 3D maxillofacial imaging, compared to conventional computed tomography (CT) [2].

In previous studies authors used OPG, PNS and CT scans to visualize the PSAA [8]. It is very difficult to visualize oral and maxillofacial structures in two dimensions due to their anatomy and superimpositions [9]. CT examination provides finer details at the expense of high radiation dose and higher cost per scan. The aim of the study was to determine the visibility and course of the posterior superior alveolar artery (PSAA) using cone beam computed tomography (CBCT) imaging. (Figure 1)

Material and Methods

This cross-sectional study was conducted at the Department of Oral Medicine and Radiology, Mahatma Gandhi Vidyamandir's Karmaveer Bhausaheb Hiray Dental College Nashik, Maharashtra, India. The scans of patients who had undergone CBCT examination for various reasons were randomly selected from the data stored in the CBCT machine Sirona Orthophos XG 3D (Bensheim, Germany) with the following specifications: the images were scanned at 85 kVp and 5–7 mA, using focal point of 0.5 mm, voxel size of 0.1 mm and FOV (field of view) with the standard diameter of 8×8 cm (maximum). CBCT scans of both [...] arches and the maxillary arch were selected for the study. Inclusion criteria were as follows: CBCT scans of maxilla showing complete maxillary bilaterally. CBCT scans without optimum image quality and scans with artifacts, scans showing gross pathology in the maxilla distorting normal anatomy, periodontal bone loss, signs of previous surgery



Figure 1. Location of the posterior superior alveolar artery canal – intraosseous.

(i.e. wiring or plates), or sclerotic bony walls of the maxillary sinus were excluded from the study.

CBCT scans of 50 patients, 30 males and 20 females, aged from 18 to 60 years were selected. Scans of both dentulous and edentulous patients were subject to analysis. The visibility and location of vascular canal/notch of posterior superior alveolar artery were evaluated in cross-sectional and longitudinal CBCT images. A radiologist specializing oral and maxillofacial imaging examined the presence of the artery and its location on the lateral wall of maxillary sinus. For greater reliability, the observer assessed the canal or notch twice while examining the scans. PSAA was identified in the 1st and 2nd molar areas, centrally to individual teeth. Its course was classified as intraosseous or submembranous. A caliper tool provided with the CBCT software was used to measure the diameter of the canal.

The distances were measured in the 1st molar and 2nd molar areas – 1) from PSAA inferior margin to the middle of maxillary sinus floor (a), 2) from PSAA inferior margin to the middle of the interdental alveolar crest (b), 3) from the floor of maxillary sinus to the center of alveolar crest (c), 4) from PSAA notch to the medial wall of the sinus (d) (Figure 2)

The distances were measured in cross-sectional CBCT images using the caliper tool. Moreover, we measured the 1st and 2nd molar regions in the scans of the edentulous group.

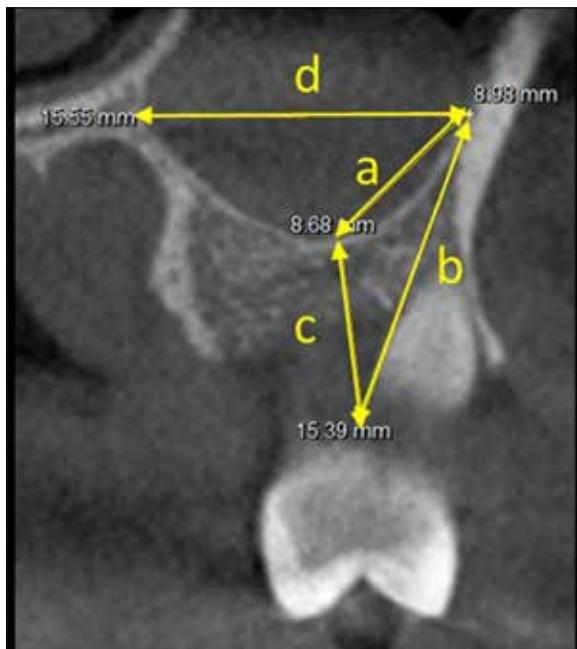


Figure 2. Distances measured in a cross-sectional CBCT image). a – from the inferior border of PSAA canal to the middle of maxillary sinus floor; b – from PSAA canal to the middle of interdental alveolar crest; c – from the floor of maxillary sinus to the center of alveolar crest; d – from PSAA notch to the medial wall of the sinus.

Statistical analysis

All the data was gathered and inserted into Microsoft Excel file; Instat software was used for statistical analysis. The unpaired t-test was used in the analysis to test for the level of significance. P-values less than 0.05 were considered significant.

Results

Fifty bilateral maxillary sinus CBCT scans (100 sinuses) were subject to evaluation. Mean age of study participants was 39 years (range: 18–60 years). Maxillary posterior superior alveolar artery (PSAA) was visualized in 36 patients, 24 male (30) and 12 female (20). Mean diameter of the posterior superior alveolar artery was 0.63 ± 0.38 mm. Mean diameter amounted to 0.58 mm on right side and 0.70 mm on left. Correlation of the mean diameter on right and left side was not statistically significant as the p-value amounted to 0.08.

Mean distance from PSAA canal/notch to the floor of maxillary sinus was the shortest in the 2nd molar region (9.49 mm). Mean distance in the right 1st molar area was 9.95 ± 3.79 mm and 9.96 ± 3.25 mm in the 2nd molar area. On left side mean distance in the 1st molar area amounted to 10.48 ± 3.21 mm and 9.49 ± 3.12 mm in the 2nd molar area (Table 1). Mean distance between vascular canal/notch

Table 1. Distances from the inferior margin of PSAA to the middle of maxillary sinus floor.

	Location	Mean	SD	P-value	Range
Right	1 st molar	9.95	3.79	0.984	4.77–18.38
	2 nd molar	9.96	3.25		2.5–17.11
Left	1 st molar	10.48	3.21	0.25	4.7–12.36
	2 nd molar	9.49	3.12		0.89–15.94

Table 2. Distances from inferior margin of PSAA to the middle of interdental alveolar crest.

	Location	Mean	SD	P-value	Range
Right	1 st molar	17.19	4.6	0.97	10.46–31.6
	2 nd molar	17.17	3.68		9.8–25.9
Left	1 st molar	17.75	3.81	0.42	10.8–24.06
	2 nd molar	17.00	3.28		10.16–24.5

Table 3. Distances from the floor of maxillary sinus to the center of alveolar crest.

	Location	Mean	SD	P-value	Range
Right	1 st molar	9.97	3.89	0.60	4.23–23.23
	2 nd molar	9.54	3.06		4.23–14.99
Left	1 st molar	9.84	3.53	0.95	4.14–16.51
	2 nd molar	9.79	3.56		1.57–19.02

Table 4. Distances from PSAA canal to the medial wall of maxillary sinus.

	Location	Mean	SD	P-value	Range
Right	1 st molar	14.64	4.06	0.65	6.92–24.23
	2 nd molar	14.28	2.80		8.76–20.18
Left	1 st molar	15.50	3.35	0.56	9.11–22.13
	2 nd molar	15.04	2.76		9.79–20

and alveolar crest was measured. On the right side mean distance in the 1st molar area was 17.19 ± 4.60 mm and 17.17 ± 3.68 mm in the 2nd molar area. On left side mean distance in the 1st molar area was 17.75 ± 3.81 mm, while in the 2nd molar area it amounted to 17 ± 3.28 mm (Table 2).

The distance from the floor of maxillary sinus to the middle of the alveolar crest was determined. On the right side mean distance was 9.47 ± 3.89 mm; on the left – 9.81 ± 3.06 mm. Comparing the dimensions obtained on the right and the left side yielded no significant difference ($P=0.907$) (Table 3). On the right side the distance from PSAA canal/notch to the medial sinus wall in the 1st molar area was 14.64 ± 4.06 mm and 14.28 ± 2.80 mm in the 2nd molar area. On the left side mean distance in the 1st molar area amounted to 15.5 ± 3.35 mm and 15.04 ± 2.76 mm in the 2nd molar area. (Table 4)

Discussion

The anastomosis between posterior superior alveolar artery (PSAA) and infraorbital artery (IFO) provides blood supply to the maxillary sinus membrane, periosteal tissues and the anterolateral wall of the sinus. Localization of those vessels must be taken into consideration before bone resection from the lateral wall of maxillary sinus [10].

PSAA may complicate surgical formation of a bony window on the lateral wall of maxillary sinus due to bleeding that might obscure the visual field or interfere with fixation of bone graft material [1].

PSAA and IOA may reach maximum diameters of 2 mm and 2.7 mm, respectively [11]. Mean diameter of PSAA canal in our study was 0.63 mm, ranging from 0.2 mm to 1.7 mm. Visualization of PSAA or image detail is defined by the voxel size of CBCT apparatus – the smaller the voxel size, the higher the resolution and better the discernibility of the artery on the sinus wall or within the bone. In this study voxel size of 0.1 mm was used. In previous studies Yoshida et al. and Sato et al. used voxel sizes of 0.1 mm [12,13], while Ilgüy et al. [5] used 0.2-mm voxel size.

In total of 50 scans, 30 male and 20 female, were analyzed. PSAA was visualized in 24 male (80%) and 12 female (60%) patients. The prevalence of PSAA canal in this study was higher than in previous studies by Güncü et al. (64.5%) [3], Mardinger et al. (55%) [14], and Elian et al. (52.9%) [15]. Higher rate of visualization of the canals (80%, 60%) in our study may be due to higher resolution of CBCT compared to traditional CT imaging.

There were no statistical differences between p-values for PSAA canal-to-sinus floor ($p=0.905$) and PSAA canal-to-alveolar crest ($p=0.210$) measurements in male and female populations.

In his study of CBCT images Kang et al. [16] measured the distance from inferior margin of PSAA to the alveolar crest. There was no significant difference amongst males and females.

In this study we compared measurements in the right 1st molar region between groups of males and females. There were no statistical differences between the values of PSAA canal/notch-to-sinus floor and PSAA-to-alveolar crest measurements. Comparing the right and the left side, PSAA was visualized on right side in 70% and on left side in 60% of cases. Mean diameter on right side was 0.73 mm and 0.70 mm on left side.

In our study the mean distance between PSAA canal/notch and sinus floor amounted 9.96 mm, ranging from 4.7 mm to 17.11 mm. In a study by Hur et al. [17] that measured distances from the sinus floor to the intraosseous branch in first molar area, the minimum distance was 2.5 mm. Authors concluded that PSAA might become injured during surgical procedures.

According to scientific literature reports, average distance between PSAA and the alveolar crest amounted to 19 mm, ranging between 16.4 mm and 16.9 mm. The mean vertical distances reported by Jung et al. [18] in premolar and molar areas were 18.92 mm and 14.79 mm, respectively. This study the mean demonstrated distances in the 1st and 2nd molar areas were 17.19 mm and 17.17 mm, respectively. Mean distances between PSAA canal/notch and the medial wall of maxillary sinus in right and left sides amounted to 14.67 mm and 15.5 mm, respectively; no statistical difference were noted ($p=0.65$)

PSAA provides blood supply to maxillary sinus membrane. Complete preservation of the sinus membrane during surgery may be difficult due to the presence of septa in the maxillary sinus, as they may impede formation and elevation of the bony window [17]. Prevalence of sinus septa ranges between 16% and 27% [19–22]. It should be taken into consideration during elevation of the sinus floor.

The results of our study show a risk of bleeding from PSAA during surgery in the posterior maxillary area. It may not be a life-threatening complication, but may obscure the field of view and lengthen the procedure [14]. Hence, it is necessary to gain thorough knowledge regarding the

anatomy, location and distances between PSAA and the structures of interest.

Preoperative CT examination is essential for localization of intraosseous anastomoses. Moreover, piezoelectric surgical inserts may aid in reducing vessel and membrane lacerations [23]. A vestibular extraosseous anastomosis runs below the zygomatic process [11]. Taking into consideration the results of our study as well as previous literature reports, we underscored use of CBCT imaging instead of CT before planning surgical procedures in posterior maxillary areas. CBCT provides higher visualization rates and relatively better images with less radiation exposure and lesser costs. In many cases previous CBCT imaging studies can be used, as their position will not change with time.

Sample size could have been the limitation of the study. Authors proposed further research on larger sample including both dentulous and edentulous patients, as well as

patients from various age groups. Scans from different CBCT machines and different FOV's may be compared

Conclusions

CBCT is superior to computed tomography with regard to PSAA visualization. PSAA may be effortlessly identified as having intraosseous or submembranous course; all the measurements were efficiently performed with CBCT.

In the recent years CBCT scanning has been routinely performed for many procedures, as it constitutes an excellent diagnostic tool. We should examine for the presence and location of posterior superior alveolar artery while planning surgical procedures, implant insertions, or maxillary sinus lifts in the maxillary posterior areas, in order to avoid unnecessary complications and to provide the best possible treatment.

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