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Original Article

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Assessment of the prevalence and spatial distribution of the posterior superior alveolar artery within the maxillary sinus wall utilizing CBCT imaging

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ABSTRACT

BACKGROUND & OBJECTIVE: The posterior superior alveolar (PSAA) artery plays a crucial role in supplying blood to the lateral wall of the maxillary sinus. This artery is of particular significance while performing procedures that involve the maxillary sinus. Our current study aimed to localize this artery and record its distance from a particular landmark: the maxillary sinus floor in patients reporting to a dental teaching hospital.

METHODOLOGY: This cross-sectional study was conducted in the Department of Periodontology at Lahore Medical & Dental College. A total of 85 cone-beam computed tomography (CBCT) images were analyzed to document the presence and precise location of the posterior superior alveolar artery (PSAA).

RESULTS: This study visualized 170 maxillary sinuses of 55 males and 30 females. The PSAA was visualized in 84.1 % of the sinuses. Further analysis revealed that in 54.1% of cases (n = 92), the artery was located intraosseously; in 21.2% (n = 36), it was situated below the sinus membrane; and in 8.8% (n = 15), it was found on the outer surface of the lateral wall of the maxillary sinus.

CONCLUSION: Our study validates the diverse locations of the PSAA relative to the maxillary sinus's lateral wall, with no notable differences observed between genders. Additionally, it highlights the effectiveness of CBCT as a reliable method for pre-surgical evaluation of the maxillary sinus and its associated blood vessels.

KEYWORDS: Cone-Beam Computed Tomography, Maxillary Sinus.

INTRODUCTION

The maxillary sinuses are air-filled cavities that occupy the maxillary bone. These cavities are subject to encroachment by various oral pathologies such as tumors, cysts, and inflammatory lesions. Moreover, these sinuses may be subject to surgical manipulation in cases of facial fractures, orthognathic surgeries, and the Caldwell-Luc approach to remove displaced dental roots [1].

Chronic loss of teeth in the posterior maxilla can result in pneumatization of the maxillary sinus with subsequent loss of alveolar ridge dimensions. This, in turn, poses a challenge to implant placement in this region, often necessitating augmentation procedures and lateral approach sinus lift [2]. Performing sinus augmentation requires a thorough knowledge of the anatomical landmarks surrounding the maxillary sinus, particularly the posterior superior alveolar artery (PSAA) that passes along its lateral wall.

Severing the artery during lateral approach sinus lift can lead to significant intraoperative bleeding, increasing surgical morbidity and patient discomfort [3]. Although damage to this artery does not lead to life-threatening hemorrhage, it can lead to obscuring of the surgical site view and, at times, may require ligation to attain hemostasis [4]. Moreover, bleeding due to damage to this artery can cause trouble in the placement of bone grafts and visualization of the Schneiderian membrane, leading to membrane perforation [5].

The maxillary sinus receives a substantial blood supply from branches of the maxillary artery, including the posterior superior alveolar artery (PSAA), sphenopalatine artery, and infraorbital artery [1]. As the posterior superior alveolar artery

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travels anteriorly along the lateral wall of the maxillary sinus, it forms an anastomosis with the infraorbital artery and gives rise to multiple intraosseous and extraosseous branches [6].

Cone beam computed tomography (CBCT) has gained popularity in recent years as a significant diagnostic and planning tool for implant placement. It provides high-resolution details regarding alveolar bone morphology, anatomical landmarks, and various pathologies [7]. A number of studies have been carried out to study the location and prevalence of PSAA in various populations. However, limited data is available from the South Asian population. Our study utilizes CBCT as a tool to locate the PSAA and trace its course along the lateral wall of the sinus in a selected Pakistani population.

METHODOLOGY

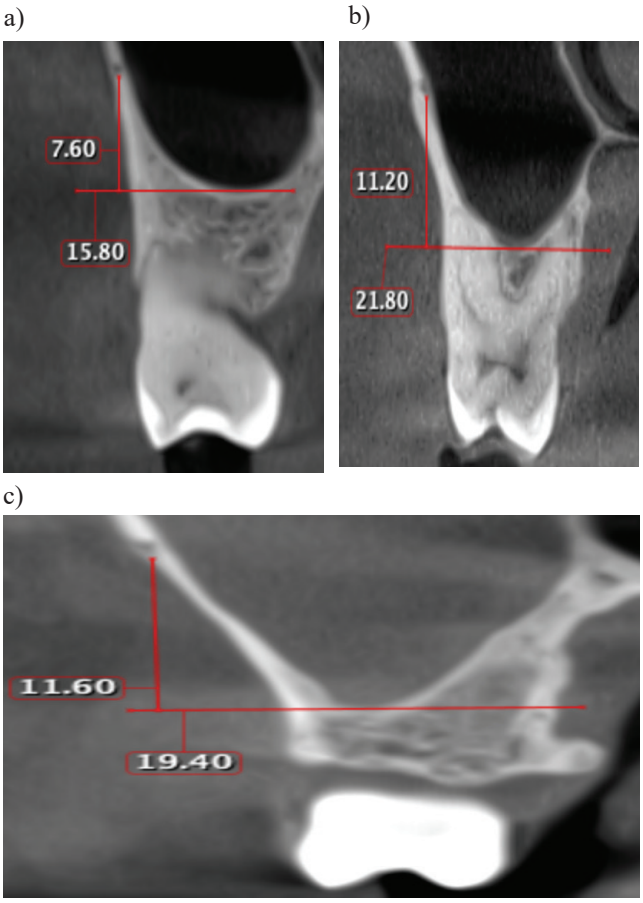
This study was conducted in the Department of Periodontology, Lahore Medical and Dental College, Lahore. After receiving ethical approval (Ref. No. LMDC: FD/3529/24) on 15th January 2024 from the institutional review board, data collection was done between February 2024 and August 2024. A sample size of 85 was determined using the WHO sample size calculator based on a 95% confidence interval and an expected proportion of 20%. Relevant data was recorded from scans of dentate patients who had undergone CBCT evaluation for different dental procedures during the past 5 years (2019 – 2023) using the convenience non-probability sampling technique.

All these patients had consented to using their data for research and academic purposes. Planmeca Romexis viewer was used to view the scanned images. All images were acquired using scanning parameters of 90 kV, 3 mA, and an exposure time of 12.092 seconds. The voxel size was 200 µm, and the field of view measured 11 cm × 8 cm. Scans exhibiting compromised image quality, artifacts, maxillary pathologies, or evidence of prior surgical manipulation were excluded from the study. All patients aged 20 to 75 years who had undergone CBCT evaluation in the Department of Periodontology were included in this study. Patients with complete edentulism, congenital anomalies, a history of maxillary trauma, or previous maxillary surgery were excluded from the study.

Each CBCT scan was studied on a coronal view to identify the presence/absence of PSAA After being identified, the artery was classified based on its location about the lateral wall of the maxillary sinus that is; intraosseous, sub-membranous, and external to the cortex (Figure-I). Next, the distance from the lowest margin of the posterior superior alveolar artery (PSAA) to the lowest point of the maxillary sinus floor was measured for each identified artery using the measuring tool in the Planmeca software (Figure-I). A single trained examiner conducted each of these measurements and then counter-checked them with a second trained examiner to ensure reproducibility and remove biases.

Data was described and categorized according to age, gender, and sinus locations. Our results were described as frequencies, percentages, and graphs. Mean+SD was calculated for the continuous variables. T-test was used to check the difference in continuous variables according to the gender & chi-square test. Fisher's Exact test was used to check the difference in ordinal & nominal variables according to the age group. A 95% confidence interval was used to assess the significance level. The data was entered and analyzed by using SPSS software version 22.

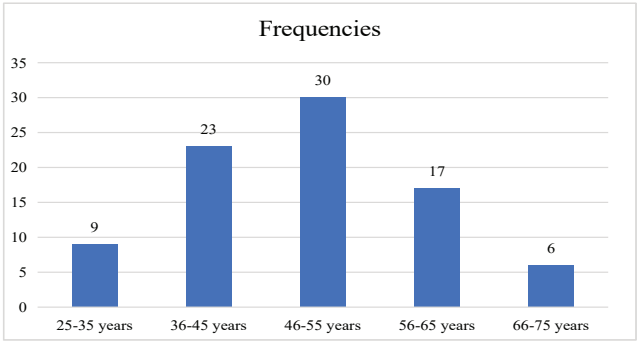
RESULTS



Our study comprised a total of 85 patients, aged between 25 to 75 years as shown in Figure-I.

Figure-I: Location of PSAA (a) intraosseous (b) sub membranous (c) External to the cortex, and measuring the distance from the lowest point of the sinus floor to the lower border of PSAA

Figure-II: Age-wise distribution of our study population.



The gender-wise presentation comprised 55 male and 30 female patients. Bilateral PSAA was seen in 67 patients (78.8 %); 42 were male and 25 female. Unilateral PSAA was visualized in 11 patients (12.9 %), eight males and 3 females. In 7 patients (8.2 %), five males and 2 females, PSAA was not detected at all. The difference in the prevalence of PSAA was not statistically significant among males and females (p-value = 0.814) (Table- I).

Table-I: Distribution of PSAA according to gender and side.

Gender	Bilateral n(%)	Unilateral n(%)	None n(%)	Total n(%)	P-value
Male	42(49.4)	8(9.4)	5(5.9)	55(64.7)	0.814
Female	25(29.4)	3(3.5)	2(2.4)	30(35.3)	
Total	67(78.8)	11(12.9)	7(8.2)	85(100)	

***P-value calculated using Fisher's Exact Test.**

This artery was identified in 145 sinuses, whereas 25 sinuses (total n = 170) did not show any course of the artery on CBCT. (Table-I) Of the arteries identified, 55.3% (n=94) were present in intraosseous locations, 21.2 %(n=36) were submembranous, and 8.8%(n=8) of arteries were present external to the cortex. The intra-osseous type was the most prevalent in both males and females (Table-II).

Table-II: Distribution of PSAA based on gender.

Gender	Locations				Total	P-value
	Intra osseous n(%)	Sub membranous n(%)	External to cortex n(%)	None n(%)		
Male	60(35.3)	23(13.5)	9(5.3)	18(10.6)	110	0.857
Female	34(20.0)	13(7.6)	6 (3.5)	7(4.1)	60	
Total	94(55.3)	36(21.2)	15(8.8)	25(14.7)	170	

***P-value calculated using the chi-square test.**

On average, the distance of the PSAA from the maxillary sinus floor in our population ranged from the lowest value of 1.32 mm to as far as 16.23 mm. On the right side, the mean distance was 6.93mm (SD, 2.94), and 6.98mm (SD, 2.20) on the left side, which was statistically insignificant (Table-III).The mean vertical distance from the lowest point of the sinus floor to the PSAA was 6.96 mm, with a range of 1.32 mm to 16.23 mm.

An Independent t-test was used to compare the difference in the average distance between the two genders. Our results showed no significant difference (P= 0.97, 0.44) (Table-IV).

Table-III: Distance between floor of the maxillary sinus to the inferior border of PSAA.

Side	Gender	
	Male Mean ±SD (mm)	Female Mean ±SD (mm)
Left (n = 72)	7.11 ± 2.59	6.61 ±2.73
Combine Mean	6.93 ± 2.94 Range = 3.80 – 11.54	
Right (n = 73)	6.99 ±2.10	6.97 ±2.41
Combine Mean	6.98 ±2.20 Range = 1.32 – 16.23	

Table-IV: Independent sample t-test was used to see the mean difference in both sinuses according to the gender.

Sinus	Gender	n	Mean± Std. Deviation	Mean diff	95% CI of the difference		P-value
Right	Male	46	6.9983 ±2.10550	0.025	-1.108	1.148	0.97
	Female	27	6.9726±2.41630				
Left	Male	46	7.1100±2.59402	0.491	-0.795	1.795	0.44
	Female	26	6.6181±2.73543				

DISCUSSION

Pre-operative imaging of the maxillary sinus before any surgical intervention is essential to rule out any sinus pathology and locate various anatomical landmarks [8]. The maxillary sinus is richly innervated with anastomosing blood vessels along its lateral wall. Therefore, robust planning is required during surgery to avoid iatrogenic damage to these blood vessels, particularly the posterior superior alveolar artery [9]. CBCT has emerged as one of the best imaging techniques to visualize the maxillary sinus and its landmarks [4].

This study identified PSAA in 84.1% of maxillary sinuses and was most commonly seen in an intraosseous location (54.1%). Our results fall in the range of those found by other authors who reported successful visualization of PSSA in 91.6% of patients (Ang KY et al., 2022) [1] and 89.3 % (Ilgu¨y et al., 2013) [10]. However, our results were higher than those reported by some other authors: 64.5% (Guncu et al., 2011) [11] and 52% (Kim et al., 2011) [12]. These observed differences may be attributed to the difference in viewing software and the type of machine used. Moreover, the diameter of the PSAA is another significant factor, as smaller-caliber vessels may not be detectable even on CBCT scans [1].

Our study did not report any gender-wise difference in the prevalence of PSAA, which corresponds with the findings of other authors as well (Ang KY et al, 2022) [1] and (Ilgu¨y et al., 2013) [10].

More importantly, our study utilized the maxillary sinus floor as an anatomical landmark to measure the distance from PSAA, which has been previously used by other

authors as well (Ang KY et al., 2022)[1] and (Kawakami et al., 2019)[8]. The sinus floor is easier to visualize owing to its transparency, unlike the alveolar ridge, which is subject to variations due to its different resorption patterns in every patient.

In this study, the average distance between the sinus and the lower border floor was 6.96 mm (1.32mm -16.23). Our results fall within the range reported by other authors, including Bedeloğlu and Yalçın (2020)[13] and Fayek et al. (2021)[14]. However, other studies indicate a higher distance range [1,15], which may be attributed to ethnic differences. The shortest distance reported in our study is similar to that found in other studies (0-1.2mm) by Bedelog ̆lu and Yalc ̧ in 2020 and Apostolakis and Bissoon (2014) [13,16]. Moreover, this study shows no statistical difference in the distance between both genders, a finding that is consistent with other studies; Pandharbale et al. (2016)[17]; Yang and Kye (2014)[18]; and Tran et al. (2021)[19].

One limitation of our study is the relatively small sample size and the uneven gender distribution within the sample population. Additionally, including subjects from diverse ethnic backgrounds in future studies may help identify potential genetic variations in the anatomical course of the PSAA within the maxillary sinus.

CONCLUSION

Our study highlights the variable positions of the PSAA in relation to the lateral wall of the maxillary sinus, with no significant differences observed based on gender or side. To reduce potential complications and improve patient outcomes, 3D imaging scans should be performed prior to surgical procedures involving the maxillary sinus.

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Authors' Contribution:

Maha Maqbool: Substantial contributions to the conception and design of the work.
Ahmad Danyal : Acquisition and analysis of data for the work.
Zubair Ahmad Khan:: Interpretation of data for the work.
Muhammad Haseeb: Drafting the work.
Usman Manzoor: Reviewing it critically for important intellectual content.
Nuvaira Ijaz: Final approval of the version to be published.