

# Prevalence and morphological variations of maxillary sinus septa in different age groups: a CBCT analysis

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**BACKGROUND:** There are limited data from Saudi Arabia on the prevalence and characteristics of maxillary sinus septa.

**OBJECTIVE:** Determine the prevalence and morphological characteristics of septa in the maxillary sinus and their relationship to gender and age using cone beam computed tomography (CBCT).

**DESIGN:** Cross-sectional

**SETTING:** CBCT images acquired from the maxillofacial radiology department in a dental school.

**PATIENT AND METHODS:** CBCT scans of 1010 maxillary sinuses from 505 patients were analyzed to determine the prevalence, location, type, and orientation of maxillary sinus septa. Descriptive statistics, chi-square tests and t tests were used to analyze the data.

**MAIN OUTCOME MEASURES:** The prevalence, location, type, and orientation of maxillary sinus septa.

**SAMPLE SIZE:** 1010 sinuses from 505 patients.

**RESULT:** Approximately 46% of the studied patients had maxillary septa, which were present in 370 (37%) sinuses. About 64% of the septa were present on the right side and 85.7% of all septa were mediolaterally oriented. The mean height of the septa was 6.06 mm (0.84) in the right sinuses and 5.70 mm (0.93) in the left sinuses. Multiple septa were found in 101 patients (20%). Among males, 58.5% had septa compared to 34% of females ( $P<.001$ .) A significant positive association was found between age and the presence and number of septa,  $P<.001$ .

**CONCLUSIONS:** Maxillary sinus septa were highly prevalent with various heights and directions among the studied sample. Careful assessment of different anatomic variation must be conducted prior to any maxillary sinus augmentation, particularly in older patients.

**LIMITATIONS:** Cross-sectional evaluation of CBCT images from one dental school patient population; thus, the findings cannot be generalized to other populations.

**CONFLICT OF INTEREST:** None.

During the last two decades dental implants have become a commonly used option to replace missing teeth.<sup>1,2</sup> Severe pneumatization of the maxillary sinus and/or severe alveolar bone loss may hinder the use of dental implants. To address this issue, maxillary sinus augmentation was introduced to increase the bone volume for optimal implant placement.<sup>3</sup> Hence, having a thorough understanding of the anatomy of the maxillary sinus and its anatomical variations are important to the development of an appropriate surgical plan.<sup>4,5</sup>

The maxillary sinus is the largest of the paranasal air sinuses. It has a pyramidal shape with its apex facing the zygomatic arch and its base facing the nasal wall. Underwood's septa, another term for maxillary sinus septa, are anatomic variations that may be present in the maxillary sinuses.<sup>6</sup> These septa are cortical plates of bone that could be present in any region of the sinus and divide the sinus into multiple compartments.<sup>7-9</sup> The prevalence of maxillary sinus septa ranges between 9.5-69%.<sup>4,10-15</sup>

The presence of septa is associated with an increased risk of Schneiderian membrane perforation during sinus augmentation procedure.<sup>16</sup> These septa may complicate augmentation procedures and thus require modification of the surgical technique.<sup>7,8,17</sup> A possible modification involves cutting and removing the septa to facilitate bone grafting, or modifying the design of the buccal window without fracturing the septa by making two access windows or W-shaped windows, depending on the septa location.<sup>5,10</sup>

Accurately identifying the presence and location of maxillary sinus septa in presurgical radiographs is crucial to properly select the surgical technique and avoid complications. Both orthopantomography and cone beam computed tomography (CBCT) are used to evaluate the anatomy of the maxillary sinuses. CBCT provides high-resolution 3D images with a relatively low effective dose and overcomes limitations of traditional 2D techniques, especially with respect to superimposition and magnification. Hence, subtle structural differences can be identified and assessed more precisely.<sup>4,18,19</sup> When comparing the prevalence of septa in CBCT versus conventional radiological techniques, some studies have observed inaccurate results in panoramic radiographs, with up to 50% false-negatives being found.<sup>8,20,21</sup> Therefore, it is advisable to use CBCT when evaluating maxillary sinuses.

In the literature, the prevalence of maxillary sinus septa varies widely in studies from different countries. For example, the prevalence was 27% in a study from Korea, 44% in a study from Brazil and 69% in a study from South Africa.<sup>11,13,14</sup>

Furthermore, most of the studies included elderly patients with missing maxillary teeth who had CBCT scans for dental implants and their respective results cannot be generalized, as recently reviewed.<sup>12</sup> There are limited data on the investigation of maxillary sinus septa, using CBCT, in Saudi Arabia. Therefore, this study was undertaken to assess the prevalence and morphological characteristics of septa in the maxillary sinus and their relationship to gender and age using CBCT imaging.

## PATIENTS AND METHODS

This cross-sectional study was conducted at the Faculty of Dentistry, King Abdulaziz University. CBCT scans of Saudi patients from the Department of Oral and Maxillofacial Radiology were screened. The exclusion criteria included the following: (1) history of trauma or surgery to the face, (2) developmental anomaly, (3) previous maxillary sinus surgery, (4) maxillary sinus pathology, and/or (5) poor quality of CBCT images. Only images obtained using the same CBCT unit and the same scan settings were selected. The study was approved by the Research Ethics Committee at the Faculty of Dentistry, King Abdulaziz University (No. 126-10-18).

All CBCT scans were acquired using i-CAT Next Generation Cone Beam Computed Tomography (Imaging Sciences International, LLC, Hatfield, PA, USA). All selected CBCT scans were acquired with the following settings: 120 KvP, 5 mAs, 0.4-mm voxel size, 0.80-mm slice thickness and 0.5-mm slice increments. The i-CAT Vision software (version 1.8.1.10) was used to perform the analyses. The absence or presence of maxillary sinus septa was determined using the axial, sagittal, and coronal planes. The prevalence and location of septa in the CBCT scans were registered. To evaluate septum height, a line was drawn at the approximate base of the septa to the highest point. Only septa of 2.5 mm or more were recorded. All measurements were performed twice by the same investigator and the average measurement was recorded.

Sinuses were divided into three anatomical locations (**Figure 1**): (1) anterior: in the area between the first and second premolars, (2) middle: in the area between the first and second molars and (3) posterior: in the area distal to the second molar.<sup>22</sup> Septa were further categorized as primary septa if they appeared to be related to a maxillary tooth root or secondary septa if they appeared in the edentulous area (**Figures 1 and 2**). The extent of the sinus septa was categorized as either complete or partial (**Figure 3**). A complete septum is when the septum originates from one wall and extends to reach the opposing wall, vertically or horizontally. A

partial septum, on the other hand, is when the septum does not reach the opposing side. The orientation of septa was recorded as having a mediolateral or antero-posterior direction (**Figure 4**).

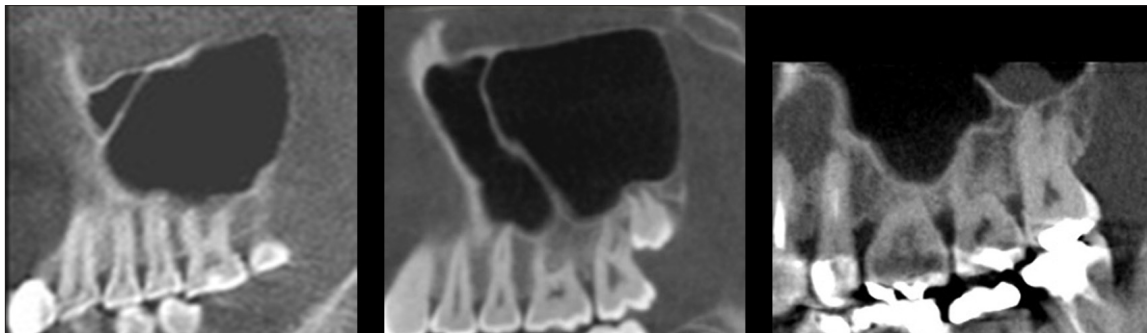
**Statistical analysis**

Statistical analysis was performed using the IBM SPSS for Windows, version 20 (IBM Corp, Armonk, NY, USA). Sample size was determined from Krejcie and Morgan's sample size table.<sup>23</sup> Frequencies, percentages for categorical and means for continuous variables were calculated. The prevalence, height, location and orientation of the septa was compared between the right and left sinuses. The relationship of septa with respect to age

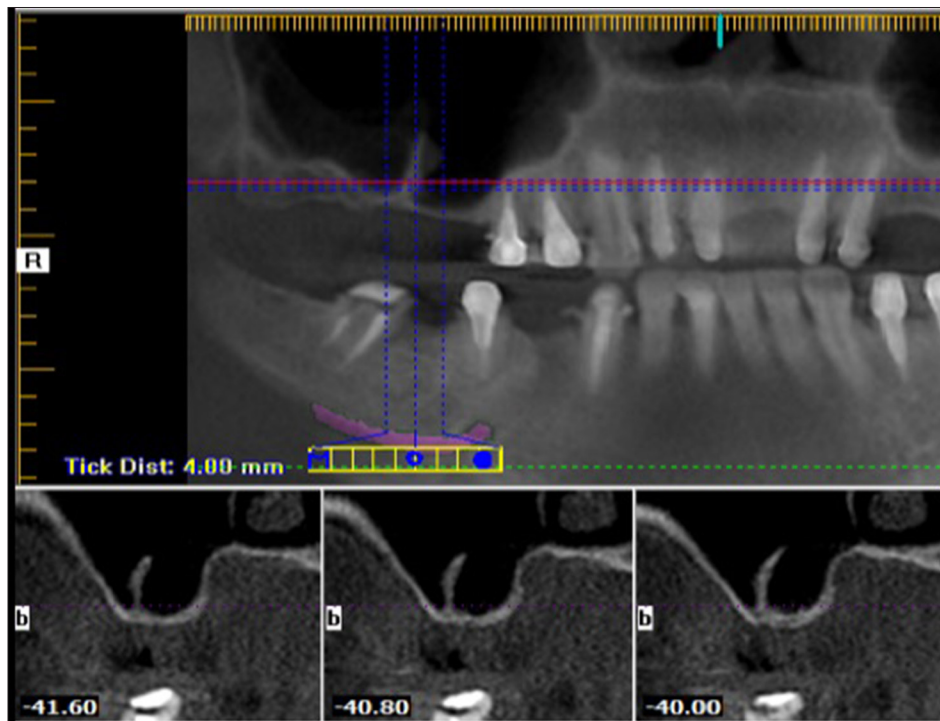
and gender was also evaluated using the chi-square test and the t test for continuous data. A *P* value of less than .05 was considered statistically significant. The final sample consisted of 505 CBCT scans from patients who fulfilled the inclusion/exclusion criteria with a total of 1010 maxillary sinuses.

**RESULTS**

Of 800 CBCT scans screened, 505 individuals (246 males and 259 females, of age range from 18-69 years) fulfilled the inclusion/exclusion criteria (total of 1010 maxillary sinuses). Twenty-five (5%) were completely edentulous, 333 (65.9%) were partially edentulous and 147 (29.1%) were dentate. The number of those who



**Figure 1.** Sagittal CBCT views showing various septa locations (all are primary septa, from left to right: anterior, middle and posterior).



**Figure 2.** Sagittal view (top) and coronal sections (bottom) showing a secondary septum in the right molar area

SEPTA IN THE MAXILLARY SINUS

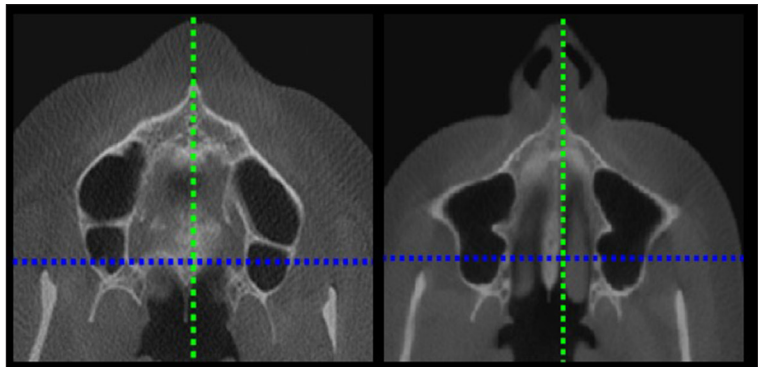
presented with one or more septa was 232 (45.9%). Of the completely edentulous, 17 (68%) individuals had one or more septa compared to 158 (47.4%) of the partially edentulous and 47 (38.8%) of the dentate ( $P<.001$ ). **Table 1** presents the unilateral and bilateral distribution of septa. There were 118 (23.3%) subjects with septa only in the right sinus, which included 96 (19%) with one septum and 22 (4.3%) with two or more septa. Close to 8% of the subjects had septa only in the left sinus and about 15% had septa in both sinuses. **Table 2** shows that the prevalence of septa differed significantly between males, 58.5% and females, 34.0% ( $P<.001$ ). The table also shows that multiple septa are more common in males.

There was a significant positive association between age and number of septa ( $P<.001$ ). The prevalence was highest (61.4%) among individuals who were 45 years or older, and lowest (7.3%) was among patients who were 25 years of age or younger (**Table 3**). A total of 370 septa were found in the subjects. The septa were more prevalent in the right sinus compared to the left ( $P<.001$ ), where 238 septa (64.3%) were identified on the right side and 132 septa (35.6%) were found on the left side. The maximum number of septa in the same sinus was 3 on the right side and 2 on the left side.

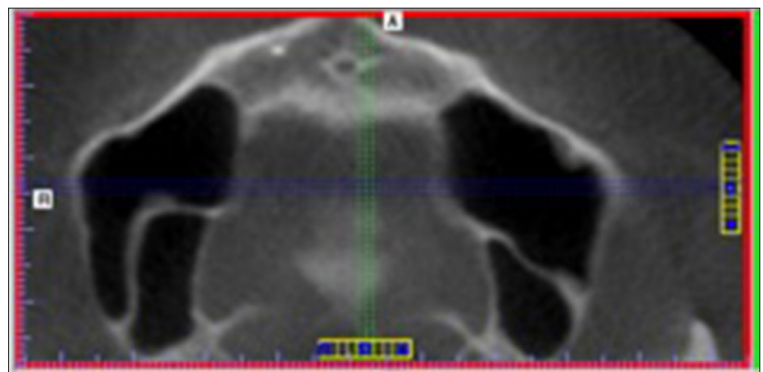
The septum height on the right sinus ranged from 3.14 to 8.42 mm with a mean of 6.06 mm (0.85). The height of the septum on the left sinus ranged from 2.61 to 7.58 mm with a mean of 5.70 mm (0.93), and the difference between the two was statistically significant ( $P<.001$ ). Evaluation of septa location revealed that the middle area (between the first and second molars) were the most prevalent compared to other locations. Most of the sinus septa were oriented in mediolateral direction in both right (87.0%) and left (83.3%) sinuses (**Table 4**). Most of the septa were classified as partial and only 18 (7.6%) septa showed complete morphology, which divided the sinus into two cavities, and primary septa were found more often than secondary septa, as shown in **Table 4**.

**DISCUSSION**

Maxillary sinus septa were observed in 45.9% of patients, which is consistent with previous reports that showed the prevalence of septa ranging between 9.5-69%.<sup>4,10-12</sup> Furthermore, septa were more prevalent in the right sinus compared to the left sinus, and the maximum number of septa in a single sinus was higher in the right (3 septa) compared to the left (2 septa). Several previous studies have shown similar findings;<sup>8,24</sup> however, others have reported more septa in the left sinus.<sup>13,25,26</sup> In the present study, approximately 15% of subjects displayed



**Figure 3.** Axial CBCT views of two patients showing bilateral complete septa (left) and bilateral partial septa (right).



**Figure 4.** Coronal CBCT view of a patient showing bilateral septa with anteroposterior and mediolateral orientation, right and left sinuses, respectively.

**Table 1.** Subjects with septa in only the right sinus, left sinus or bilaterally.

Location of septa	Septa prevalence	Septa distribution	
		1	≥2
Right sinus only (unilateral)	118 (23.3)	96 (19.0)	22 (4.3)
Left sinus only (unilateral)	40 (7.9)	35 (6.9)	5 (1.0)
Both sinuses (bilateral)	74 (14.7)	41 (8.1)	33 (6.6)
Total	232 (45.9)	172 (34.0)	60 (11.9)

Data are number (%)

**Table 2.** Distribution of septa in males and females.

	Septa prevalence	Total number of septa per subject			
		1	2	3	4
Males (n=246)	144 (58.5)	82 (56.9)	39 (27.1)	20 (13.9)	3 (2.1)
Females (n=259)	88 (34.0)	49 (55.7)	28 (31.8)	11 (12.5)	0 (0.0)

Data are number (%)

**Table 3.** Distribution of maxillary septa stratified by age.

Age (years)	n	Prevalence	Total number of septa per subject			
			1	2	3	4
<25	110	8 (7.3)	3 (2.7)	3 (2.7)	2 (1.8)	0 (0.0)
25–34.9	104	47 (45.2)	31 (29.8)	12 (11.5)	4 (3.8)	0 (0.0)
35–44.9	125	75 (60%)	44 (35.2)	18 (14.4)	11 (8.8)	2 (1.6)
>45	166	102 (61.4)	53 (31.9)	34 (20.5)	14 (8.4)	1 (0.6)
<b>Total</b>	<b>505</b>	<b>232 (45.9)</b>	<b>131 (25.9)</b>	<b>67 (13.3)</b>	<b>31 (6.1)</b>	<b>3 (0.6)</b>

Data are number (%).

**Table 4.** Location, orientation, morphology and type of maxillary sinus septa.

	Right (n=238)	Left (n=132)	Total Septa (n=370)
<b>Location</b>			
Anterior	13 (5.5)	10 (7.6)	23 (6.2)
Middle	148 (62.2)	85 (64.4)	233 (63.0)
Posterior	77 (32.3)	37 (28.0)	114 (30.8)
<b>Orientation</b>			
Anteroposterior	31 (13.0)	22 (16.7)	53 (14.3)
Mediolateral	207 (87.0)	110 (83.3)	317 (85.7)
<b>Morphology</b>			
Partial	220 (92.4)	127 (96.2)	347 (93.8)
Complete	18 (7.6)	5 (3.8)	23 (6.2)
<b>Type</b>			
Primary	123 (51.7)	73 (55.3)	196 (52.9)
Secondary	115 (48.3)	59 (44.7)	174 (47.1)

Data are number (%).

bilateral septa. It is important to note that the presence or absence of septa in one sinus is not indicative of the condition in its antimere, as 85% of the subjects exhibited unilateral septa.

Septa were more frequent in males than in females, which is consistent with several previously published studies.<sup>8,13,25,27</sup> In males, the maximum number of septa in a patient was four while the maximum number was three in one female patient. The mean maximum bite force in males was shown to be significantly higher than in females,<sup>28</sup> which could explain the difference in septa prevalence based on gender. However, it is important to note that Park et al<sup>29</sup> found the prevalence of septa to be higher among females and Neychev et al, found no correlation between gender and the presence of septa.<sup>30</sup>

Previous studies have found that there was a positive association between age and the presence of septa. This was also true in the current findings, where 7.3% were found in patients who were younger than 25 years of age versus 61.4% in patients who were 45 years or older. Furthermore, the maximum number of septa was 4 in older patients and 3 in younger patients.

In the present study, 52.9% of the septa were classified as primary while 47.9% were secondary. However, the prevalence of septa was highest among completely edentulous persons. These findings are in agreement with some previous reports<sup>9,13</sup> but differ from others who found more septa in dentate individuals.<sup>25,29</sup> However, the determination of primary and secondary septa based on the presence or absence of teeth is debatable. Septa that develop during the growth and development of the middle face are primary (congenital) septa, while septa that develop after tooth loss due to pneumatization of the sinus are considered secondary (acquired).<sup>31,32</sup> Therefore, only longitudinal studies before and after tooth extraction can ascertain if the septa are congenital or acquired.

The presence of septa was significantly higher in the middle region in both the right and left sinuses which is consistent with most of the previously reported data as reviewed by Malec et al.<sup>10</sup> However, our results are inconsistent with Neychev et al, who found the septa to be more common in the anterior or posterior regions based on the dentate status.<sup>30</sup> The orientation of the majority of maxillary sinus septa in the current study were mediolateral, and the anteroposterior oriented septa were infrequent, which is also consistent with previous studies.<sup>4,19,29,33</sup> The prevalence of complete septa is rare and most if not all septa are partial.<sup>10,22</sup> This is confirmed in the present study, with almost 94% of septa being classified as partial. In the current study, the mean height of septa was 6.06 mm (0.84) in the left sinus and 5.70 mm (0.93) in the right sinus. These results

were consistent with the findings of Park et al.<sup>29</sup>

The prevalence of septa in the maxillary sinuses is relatively high, and the success of surgical treatment is influenced by the presence of septa. Therefore, preoperative 3D imaging provides the opportunity to modify the surgical approach whenever necessary and can help decrease the risk of perioperative and postoperative complications.<sup>4,11</sup> Multiple septa create difficulties during the sinus elevation process and may require modification of the access window.<sup>34</sup> In the present study few cases had more than one septa in the same sinus (12%), while most of the cases had one septum in the same sinus (25.9%). The maximum number of septa found in the same sinus

was three (0.8%) and in the same patient, the maximum was four (0.6%), which is consistent with other studies.<sup>22,24</sup>

A limitation of this study is that it was a cross-sectional evaluation of CBCT images from a dental school patient population; thus, the findings cannot be generalized to other populations. Based on the results of this study, it can be inferred that there is a high prevalence of maxillary sinus septa with diverse anatomical variation in the height, morphology, type and location. Hence, it is crucial to thoroughly evaluate the morphology of the maxillary sinus prior to any implant related surgery to avoid unnecessary risks especially during sinus augmentation procedures.

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