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Original article

Evaluation of maxillary sinus septa using cone-beam computed tomography in a Turkish population

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ABSTRACT

Background: *A comprehensive understanding of maxillary sinus anatomy is essential for successful maxillofacial surgical interventions. The presence of bony septa along the inner surface of the sinus significantly increases the risk of Schneiderian membrane perforation during sinus floor elevation procedures for dental implant placement.* ***Purpose:*** *This study aimed to evaluate the frequency, localization, and lateralization of maxillary sinus septa using cone-beam computed tomography (CBCT) prior to sinus surgery.* ***Methods:*** *Cone-beam computed tomography images of 750 patients (353 men, 397 women) were included in this study. Cases with sinus septa were analyzed based on gender, anatomical location (anterior, middle, posterior), and lateralization (unilateral or bilateral). All data were recorded and statistically analyzed to determine prevalence rates.* ***Results:*** *The average age of the patients was 35 years. A total of 1,500 maxillary sinuses (right and left) were examined, and 275 sinus septa (32%) were identified in 240 patients. Of these, 60 septa (22%) were located in the anterior region, 140 (51%) in the middle, and 75 (27%) in the posterior region.* ***Conclusion:*** *In this study, sinus septa were present in 32% of patients in the Turkish population. Recognizing and detecting maxillary sinus septa with CBCT is important for preventing complications during surgical procedures.*

Keywords: *anatomic variation; cone-beam computed tomography; maxillary sinus septa; sinus lift surgery*
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INTRODUCTION

Anatomically, the maxillary sinus is a wide space with a thin wall located between the alveolar, infratemporal, and facial surfaces of the maxilla and the orbital floor. The dimensions, morphology, and wall thickness of the maxillary sinus can exhibit individual variability. At the same time, the sinuses on both sides of a person may differ from each other.[1] The anatomical presence of septa within the maxillary sinus has a significant impact on the planning and execution of sinus-related surgical procedures.[2] Therefore, knowing the anatomical structure of the maxillary sinus is extremely important during preoperative planning for maxillofacial surgery.

In 1910, when Underwood described the maxillary sinus anatomy in detail, he first mentioned the maxillary sinus septa and defined these septa as clinically insignificant anatomical variations.[3] Maxillary sinus septa are cortical bone barriers of varying number, thickness, and length, and they can divide the sinus into two or more spaces.[4,5]

The importance of anatomical changes in the maxillary sinus has increased with the widespread use of endoscopy in the detection and treatment of sinus diseases and the introduction of sinus augmentation procedures in individuals receiving dental implants. According to the classification proposed by Malec et al.[6] in 2014, septa within the maxillary sinus are categorized as primary or secondary. Primary septa develop concurrently with maxillary bone formation, whereas secondary septa arise due to uneven pneumatization of the sinus floor following tooth loss.[7,8] It is thought that primary septa form from remnants left over from the incomplete fusion of cavities during sinus development.[9] Septa rarely divide the maxillary sinus into completely separate compartments, and these compartments may have their own ostia for drainage.[10]

Maxillary sinus septa may present different anatomical variations, including localization, morphology, and

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direction. If the septum is at the level of the first and second premolars, it is termed anterior septum; if it is between the mesial of the first molar and the distal of the second molar, it is called middle septum; and if it is between the distal of the second molar and the posterior sinus wall, it is referred to as posterior septum. Regarding direction, septa may be classified as transverse (extending medio-laterally), sagittal (extending antero-posteriorly), or atypical (not fitting either category).[11,12]

Planning implant procedures in these areas using computed tomography (CT) is extremely important for detecting and preventing potential complications in the presence of septa.[13,14] In this respect, recognizing anatomical differences in the maxillary sinus is valuable for the success of surgical procedures. This study aims to assess the prevalence, anatomical location, and lateralization of maxillary sinus septa using cone-beam CT (CBCT) prior to maxillary sinus surgery, as well as to explore the association between these variations and factors such as age, gender, and dental status.

MATERIALS AND METHODS

In this retrospective study, CBCT scans of 1,500 maxillary sinuses from 750 patients who presented to the Faculty of Dentistry at Dicle University between January 2017 and December 2022 were analyzed. According to the G*Power analysis (85% confidence, 1−α; 85% test power, 1−β; and d = 0.1 effect size), the study was planned to include a minimum of 1,440 samples. This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Dicle University Faculty of Dentistry Deanery Clinical Research Ethics Committee (Date: 29/11/2023, Protocol code: 2023-44).

Patients over the age of 18 whose image resolution permitted examination of the relevant areas were included in the study. Patients with blurred images due to movement during tomography, intrabony lesions preventing anatomical evaluation, history of sinus-related surgical procedures, jaw fractures, or other anomalies were excluded.

Cone-beam computed tomography imaging was performed using an iCat device (Imaging Sciences International, Hatfield, PA, USA) with the following irradiation settings: 20.27 mA, 120 kVp, and an exposure time of 14.7 seconds. All CBCT images were examined by two researchers, each with at least 10 years of experience, using the same monitor. Cohen's kappa coefficient (κ) for interobserver agreement was calculated as 0.85, indicating an excellent level of agreement. The study was conducted in four separate sessions, each spaced 15 days apart. Additionally, all images were reviewed twice.

The images were evaluated using the iCAT-Vision software (Imaging Sciences International, Hatfield, PA, USA) on axial, sagittal, and coronal sections with a section thickness of 0.2 mm. The CBCT images were examined to determine the presence, number, and location of septa, and they were recorded separately for the right and left maxillary sinuses of each patient. To clearly define septa localization, the sinuses were divided into anterior (mesial to the distal part of the second premolar), middle (between the distal part of the second premolar and the distal part of the second molar), and posterior (distal to the distal part of the second molar), following the protocol used by Qian et al.[15] in non-edentulous patients (Figure 1).

In cases where anatomical reference points were absent due to missing teeth, the method described by Rancitelli et al.[4] and Toprak et al.[16] was applied. Based on this method, the maximum distance between the anterior and posterior sinus walls was measured on the panoramic image obtained from tomography. Half of this distance was used to define the middle sinus region, whereas the remaining two quarters were designated as the anterior and posterior regions, respectively (Figure 2). The relationship between age, gender, and dental status with maxillary sinus septa variations was recorded for statistical analysis.

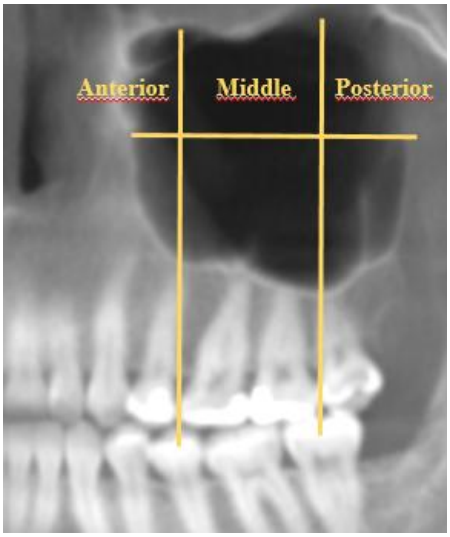

Figure 1. Method used to determine septa location in patients with dentition.

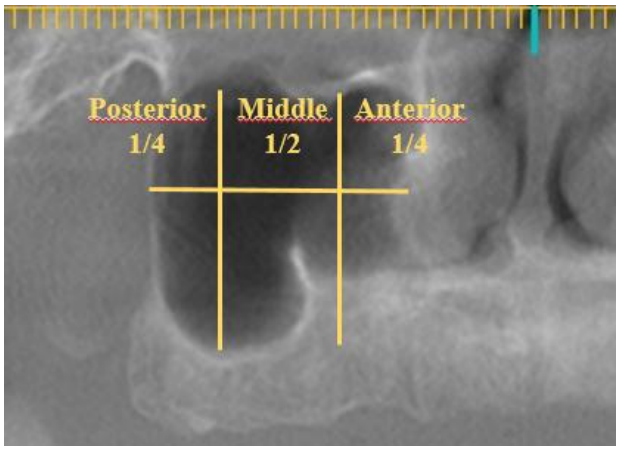

Figure 2. Method used to determine septa location in patients with edentulism.

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Statistical analyses were conducted using IBM SPSS Statistics, version 21.0 (IBM Corp., Armonk, NY, USA) for Windows. Sample size estimation was performed using G*Power.[17] Cohen's kappa analysis was used to assess the agreement between the two researchers. Continuous variables were expressed as mean ± standard deviation and categorical variables were reported as frequencies and percentages. The chi-square (χ^2) test was used to compare qualitative variables between groups. All hypotheses were two-sided, and statistical significance was set at $p \leq 0.05$.

RESULTS

In the study, 1,500 maxillary sinuses were examined in a total of 750 individuals, 397 (53%) of whom were women and 353 (47%) men. The ages of the cases ranged from 18 to 75, with a mean of 35 ± 4.2. Considering the dentition status of the patients, 314 (42%) were fully dentulous, 251 (33%) were partially edentulous, and 185 (25%) were completely edentulous (Table 1).

A total of 275 septa were detected, with at least one septum present in 240 (32%) of the 750 patients included in the study (Figures 3–4). Of these, 145 septa were observed in women and 130 in men (Table 2). No statistically significant relationship was found between septa prevalence and patient gender ($p = 0.940$).

Although a unilateral sinus septum was observed in 205 of 240 patients (85%), bilateral sinus septa were observed in 35 (15%) patients (Table 3). A statistically significant difference was found in terms of whether the septa were single or multiple ($p = 0.0001$). The 275 sinus septa were mostly seen in the middle region of the maxillary sinus. Of these, 60 were detected in the anterior (22%), 140 in the middle (51%), and 75 in the posterior (27%) (Table 4). A

Table 1. Distribution of patients according to gender and dentition status

Parameters	Women	Men	Total
Patients	397 (53%)	353 (47%)	750 (100%)
Fully Dentulous	150 (48%)	164 (52%)	314 (100%)
Partially Edentulous	136 (46%)	115 (54%)	251 (100%)
Completely Edentulous	95 (51%)	90 (49%)	185 (100%)

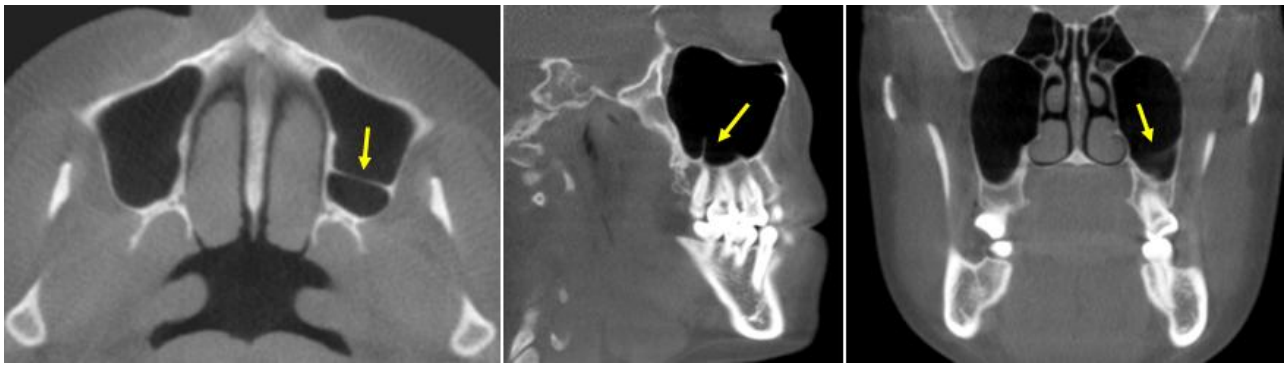

Figure 3. Cone-beam computed tomography scans showing unilateral maxillary sinus septa. Axial, coronal, and sagittal plane images of the same patient. Yellow arrows indicate the septa.

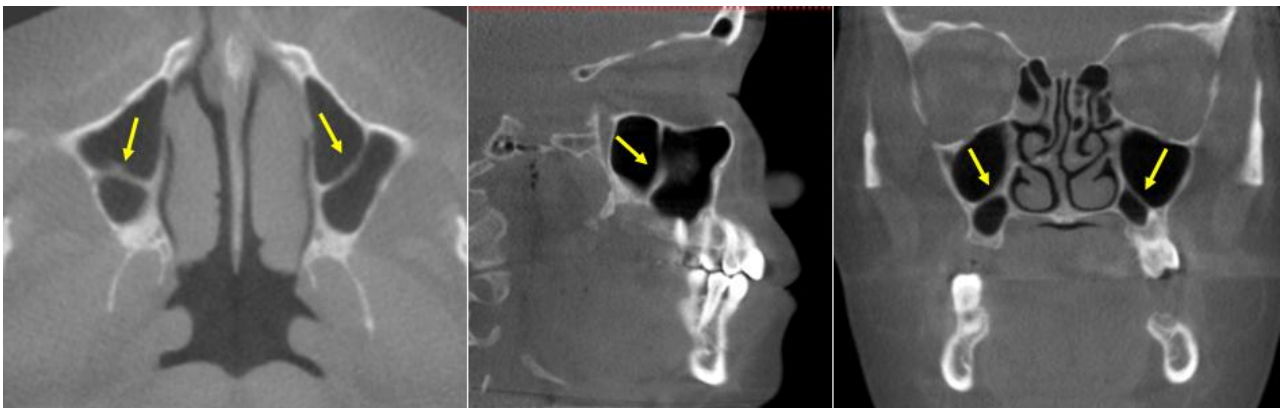

Figure 4. Cone-beam computed tomography scans showing bilateral maxillary sinus septa. Axial, coronal, and sagittal plane images of the same patient. Yellow arrows indicate the septa.

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statistically significant difference was found regarding the distribution of sinus septa localizations (p = 0.0001).

Sinus septa were seen bilaterally in 20 of 397 women (5%) and unilaterally in 105 patients. They were seen bilaterally in 15 of 353 men (4.2%) and unilaterally in 100 patients. When examined unilaterally, it was determined that men had more septa on the left, whereas women had more on the right (Table 5). When the prevalence of maxillary sinus septa was examined, there was no statistically significant difference between gender and lateralization of septa (unilateral vs. bilateral) (p = 0.517).

DISCUSSION

The anatomical boundaries of the maxillary sinus are defined by several structures, including the lateral wall of the nasal cavity, the infratemporal and facial surfaces of the maxilla, the orbital floor, the palatine process, and the alveolar portion of the maxilla.[18] In surgeries to be performed in the maxillary sinus region, preoperative determination of the anatomical structures and variations of the maxillary sinus is of critical importance. This is because anatomical or pathological formations in the maxillary sinus can seriously challenge even experienced surgeons performing the operation.[14,19] Therefore, in surgeries planned for the maxillary sinus region, it is extremely important to determine the anatomical formations and variations of the sinus preoperatively.

In the literature, studies on determining the prevalence and characteristics of maxillary sinus septa have been conducted anatomically on cadavers, clinically during sinus augmentation operations, or radiologically using panoramic radiography or CT.[20] It is known that bilateral extraoral radiographs, such as panoramic or plain radiographs, are not sufficient for precise observation of morphological structures or pathological changes in the maxillary sinus.[21] On the other hand, CBCT images are more useful in terms of avoiding the superposition of other structures and providing clearer and more realistic imaging, as they capture images from different angles.[11,22,23] Therefore, in our study, we conducted evaluations using CBCT.

Different studies examining the prevalence of maxillary sinus septa using CBCT have been reported in the literature. For example, Tadinada et al.[24] found the sinus septa rate to be 59.7% in their study (Farmington, USA), whereas

Table 2. Sinus septa distribution in men and women

Gender	CBCT	MSS (−)	MSS (+)	p
Women (n = 397)	794	649	145	0.940
Men (n = 353)	706	576	130	
Total (n = 750)	1500	1225	275	

MSS – Maxillary sinus septa; CBCT – Cone-beam computed tomography; χ^2 test (Chi-Square) = 0.006; *p > 0.05, no significant difference; p ≤ 0.05, significant difference.

Table 3. Sinus septa appearing singly or in pairs

Parameters	Total	Septa	p
Single sinus septa	275	205	0.0001***
Multiple sinus septa	275	35	

χ^2 test (Chi-Square) = 87.90; *p > 0.05: no significant difference; *p ≤ 0.05: significant; **p ≤ 0.01: very significant; **p ≤ 0.01: highly significant.

Table 4. Prevalence and localization of maxillary sinus septa (n = 1,500)

Septa Localization	Anterior	Middle	Posterior	Total	p
Septa number	60	140	75	275	0.0001***
Percentage (%)	22	51	27	100	

χ^2 test (Chi-Square) = 36.02; *p > 0.05: no significant difference; *p ≤ 0.05: significant; **p ≤ 0.01: very significant; **p ≤ 0.01: highly significant.

Table 5. Evaluation of 240 maxillary sinus septa in terms of gender and laterality

Gender	Laterality			p
	Unilateral (n = 205)		Bilateral (n = 35)	
	Right	Left		
Men (n = 115)	42	58	15	0.517
Women (n = 125)	59	46	20	
Total (n = 240)	100	105	35	

χ^2 test (Chi-Square) = 0.420; *p > 0.05: no significant difference; p ≤ 0.05: significant.

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Mudgade et al.[25] reported a rate of 66.7% (Maharashtra, India). In studies conducted by reformatting CT, Takeda et al.[26] found the presence of sinus septa in 34.6% (Kobe, Japan) and Qian et al.[15] in 48.2% (Shanghai, China).

Although Wang et al.[20] found the sinus septa rate to be 46.9% in their CT-based evaluation (Beijing, China), Talo Yıldırım et al.[27] reported a prevalence of 29.7% in their study of 1,000 maxillary sinuses using CBCT (Elazığ, Türkiye). When Durmuş[2] examined the maxillary sinuses of 446 patients with CBCT, he found the septa rate to be 30.2% (Şanlıurfa, Türkiye). In their study of CBCT images from 350 patients, Lacin et al.[28] found a prevalence of 40.2% (İzmir, Türkiye). Hungerbühler et al.[29] detected sinus septa in 163 of 600 maxillary sinus images (27.1%) (Zurich, Switzerland), most commonly in the middle third and in the coronal direction.[29]

Studies in the literature show that the prevalence of maxillary sinus septa varies between 13% and 40%. In our study, the prevalence of sinus septa was 32% in the patient population, consistent with the literature. We believe that the variation in rates may be related to differences in the populations studied, the criteria used to define septa, and the sample size.

There exist studies investigating the etiology of maxillary sinus septa.[3,30,31] Although Neychev et al.[3] reported that septa form due to different stages of tooth eruption, Neivert (cited in Mirdad et al.[31]) suggested that septa consist of finger-like protrusions originating from the embryological protrusion of the ethmoid infundibulum.

As a result of examining the anatomical localization of maxillary sinus septa, Takeda et al.[26] reported that a single unilateral septum was the most frequently observed type, with most septa located centrally within the maxillary sinus. Qian et al.[15] found that 34.9% were localized in the anterior region, 41% in the middle region, and 24.1% in the posterior region. In their study, Taleghani et al.[32] reported septa distribution rates of 52.6% in the anterior, 34.8% in the middle, and 32.6% in the posterior region. Kılınç et al.[8] determined the rates as 25.8% anterior, 29.9% middle, and 44.2% posterior. In his study, Durmuş[2] reported 45.2% of the septa in the middle region, 28.1% in the posterior, and 26.7% in the anterior. In the study by Güneş et al.,[9] 81 septa (25.1%) were in the anterior region, 153 (46.8%) in the middle, and 88 (27.3%) in the posterior region. Toprak et al.[16] examined 600 maxillary sinuses from 300 patients and found a total of 208 septa in 132 patients (44%). Of these, 42 (20.19%) were in the anterior, 124 (59.62%) in the middle, and 42 (20.19%) in the posterior region. A review of the literature shows that sinus septa are most commonly located in the middle region.[16] In our study, we found 60 septa in the anterior (22%), 140 in the middle (51%), and 75 in the posterior region (27%).

Durmuş[2] found only one septum in 93.3% of patients with septa, whereas more than one septum was found in 6.7%. Güneş et al.[9] observed single septa in 93.7% and multiple septa in 6.3% of patients. Toprak et al.[16] reported that 77 patients (58.3%) had unilateral septa, and 55 (41.7%) had bilateral septa. Wang et al.[20] found that 399 sinuses (33.5%) had one septum, and 279 (46.9%) had one or more. Mirdad et al.[31] reported that 49 patients (35.25%) had bilateral septa. In our study, a single sinus septum was observed in 85% of patients, whereas multiple septa were identified in 15%.

The presence of maxillary sinus septa presents challenges during sinus lifting procedures in atrophic arches. Therefore, it is extremely important to determine the presence of septa before any surgical procedure is initiated. This allows surgeons to adjust their technique and take the necessary precautions to reduce the risk of complications such as Schneiderian membrane perforation.[8,33,34]

Maxillary sinus septa show wide anatomical variation in prevalence, localization, morphology, and size. In our study, the prevalence of maxillary sinus septa was 32% in the Turkish population. Septa were detected more frequently in women and on the unilateral side. However, no significant difference was found between the number of septa and gender or lateralization. As a result, detailed knowledge of maxillary sinus anatomy is important to help prevent complications during surgical procedures in this region.

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