Research Article / Araştırma Makalesi

Location, Size, and Prevalence of the Maxillary Sinus Septa: Comparison of Panoramic Radiography and Cone-Beam Computerize Tomography

Maksilller Sinus Septasının Yeri, Yüksekliği ve Prevelansı: Panoramik Radyografi ve Konik Işınlı Bilgisayarlı Tomografi Karşılaştırması

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Abstract

Background: The purpose of the study was to evaluate the maxillary sinus septa in patients with various dental arch statuses with panoramic and Cone-Beam Computerize Tomography (CBCT).
Materials and Methods: In the panoramic radiography and CBCT scans of 400 patients aged 16-86 years, 800 maxillary sinuses on both sides were retrospectively examined. In addition, the height and location of the septa were evaluated with CBCT.
Results: The septa rate was determined as 51.8% with panoramic radiography and 66.8% with CBCT. The septa were more commonly found in dentate patients than edentulous patients. The septa are generally localized at the middle part of the maxillary sinus and the height was approximately 7.31mm.
Conclusions: Maxillary sinus septa can be found in the anterior, middle and posterior regions and in dentate, partially edentulous and edentulous patients. Detailed information about the height, location, and morphology of the septa is important to reduce complications in maxillary sinus surgical procedures.

Key Words: Maxillary sinus septa, panoramic radiography, CBCT

Öz

Amaç: Bu çalışmada, panoramik ve konik ışınlı bilgisayarlı tomografi (KIBT) ile çeşitli dental ark durumlarına sahip hastalarda maksiller sinüs septasının değerlendirmesi amaçlandı.
Materyal ve Metod: 16-86 yaş aralığında 400 hastanın panoramik radyografi ve KIBT taramalarında her iki tarafta 800 maksiller sinüs retrospektif olarak incelendi. Ayrıca maksiller sinus septasının yüksekliği ve yeri KIBT ile değerlendirildi.
Bulgular: Panoramik radyografide septa oranı %51,8, KIBT'de %66,8 olarak belirlendi. Septalar dişli hastalarda dişsiz hastalara göre daha sık bulundu. Septalar, maksiller sinüsün genellikle orta kısmında izlendi ve yaklaşık 7,31 mm yüksekliğinde tespit edildi.
Sonuç: Maksiller sinüs septası ön, orta ve arka bölgede ve dişli, kısmen dişli ve dişsiz hastalarda bulunabilmektedir. Maksiller sinüs cerrahilerinde komplikasyonları azaltmak için septanın yüksekliği, yeri ve morfolojisi hakkında detaylı bilgi önem arz etmektedir.

Anahtar Kelimeler: Maksiller sinüs septası, panoramik radyografi, KIBT

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Introduction

The maxillary sinuses (MS), known as the largest paranasal sinuses, are pyramid-shaped air-filled cavities located on both sides of the maxilla and lined with epithelial tissue. These sinuses serve several functions, including reducing the weight of the skull, modulating voice resonance, providing protection against facial impacts, insulating the eyes and tooth roots from temperature changes, humidifying and warming inhaled air before it reaches the bronchi and lungs, and contributing to the growth of the maxilla (1). The characteristics of the maxillary sinuses, such as wall thickness, shape, and size, vary among individuals and can even differ between the left and right sides of the same person (2). The deepest part of the sinus floor, which is convex in shape, is often in the area of the first molars (3). The deepest part of the sinus floor, often situated around the first molars, exhibits a convex shape. Within the maxillary sinuses, there may be septa composed of cortical bone, which act as barriers of varying number, thickness, and length, potentially dividing the sinuses into multiple sections (4, 5). The study of anatomical variations in the MS has gained significance due to the integration of endoscopy in diagnosing and treating diseases affecting these sinuses, as well as the application of maxillary sinus augmentation procedures in dental implant treatments (6).

The maxillary sinus septa (MSS) can be categorized into primary and secondary septa. Primary septa, also known as congenital septa, are observed on all walls of the maxillary sinus and form during the developmental stages of the midface. It is believed that primary septa result from the incomplete fusion of the sinus cavities during the formation of the sinuses. On the other hand, secondary septa are anatomical formations found at the base of the sinus, and their presence is associated with varying degrees of resorption in different regions of the alveolar bone following tooth loss (7). This theory is supported by the observation that the level of the sinus floor differs in front of and behind the MSS (8). It is noteworthy that septa rarely divide the maxillary sinus into completely separate compartments, and each compartment typically maintains its own ostium for drainage (9).

Understanding the anatomical variations in the MS holds significant importance in ensuring the success of surgical procedures. It allows for accurate surgical planning and helps prevent possible complications (10). The objective of the present study is to assess the prevalence of MSS using panoramic radiography and cone-beam computed tomography (CBCT) and to compare the effectiveness of these two imaging techniques. Additionally, the present study aims to evaluate the location and dimensions of the MSS using CBCT.

Materials and Methods

This study was approved by the Ethics Committee of Necmettin Erbakan University Faculty of Dentistry with the date of 28.04.2022 and the decision number of 2022/17-135.

In this study, panoramic and CBCT scans of patients aged 16-86 years who applied for various dental reasons to Necmettin Erbakan University Faculty of Dentistry between January 2021 and January 2022 were examined.

All images were obtained using a Morita Veraviewepocs 2D panoramic unit (J Morita MFG Corp., Kyoto, Japan) with parameters of 60-70 kVp, 5-7 mA, and 6-8 s exposure time, and 3D Accuitomo 170 (J Morita MFG Corp., Kyoto, Japan) unit with parameters 90 kVp, 5 mA and 15-18 s exposure time according to the manufacturer's recommended protocol.

Patients included in this study were selected based on specific criteria. Panoramic and cone-beam computed tomography (CBCT) scans lacking patient information such as age and gender, as well as those belonging to patients with head trauma, poor image quality, absence of maxillary sinus visualization, presence of artifacts, and errors in positioning and magnification were excluded. Only diagnostically acceptable images were considered for analysis.

A total of 500 CBCT scans were initially collected. However, only the images of 400 patients who fulfilled the defined criteria and had accompanying panoramic images were included in the evaluation. A single radiologist with two years of experience assessed these images. To determine intra-observer agreement, the same observer re-evaluated 100 patients with a three-week interval between assessments.

In panoramic imaging, only the presence or absence of MSS was evaluated. However, in CBCT imaging, additional assessments were made regarding the size and localization of the septa within the MS. To precisely define the positions of the septa in patients with dentition, the MS were divided into three regions based on the protocol established by Kim et al. (11) These regions included the anterior region (located more mesial to the distal aspect of the second premolar), the middle region (situated between the distal aspect of the second premolar and the distal aspect of the second molar), and the posterior region (positioned more distal to the distal aspect of the second molar) (Figure 1).

In cases where there were missing teeth and no clear reference points, the method described by González-Santana et al. (12) and Rancitelli et al. (13) was employed to determine the septa's location.

This technique involved measuring the maximum distance between the anterior and posterior walls of the sinus in the panoramic image obtained from the CBCT scan. Half of this distance was designated as the middle region, while the remaining one-fourth portions were determined as the anterior and posterior regions. The locations of the sinus septa were then recorded based on these divisions (Figure 2).

To assess the height of the septa, a line (a-b) was drawn approximately at the base of the septa. Subsequently, a second line (c-d) was drawn from this line to the most coronal part of the septa, and the height was measured (Figure 3).

Statistical Analysis

Statistical analyses were performed using the SPSS version

21 (SPSS, Chicago, Ill., USA) software program. To assess intra-observer reliability, the Cronbach's alpha test was used for repeat measurements of the radiologist. The Pearson chi-square test was performed for statistical analysis among age groups, gender, localization, and measurements ($p<0.05$). Independent samples t-test was used in normally distributed pairs, and ANOVA test was used for multiple comparisons.

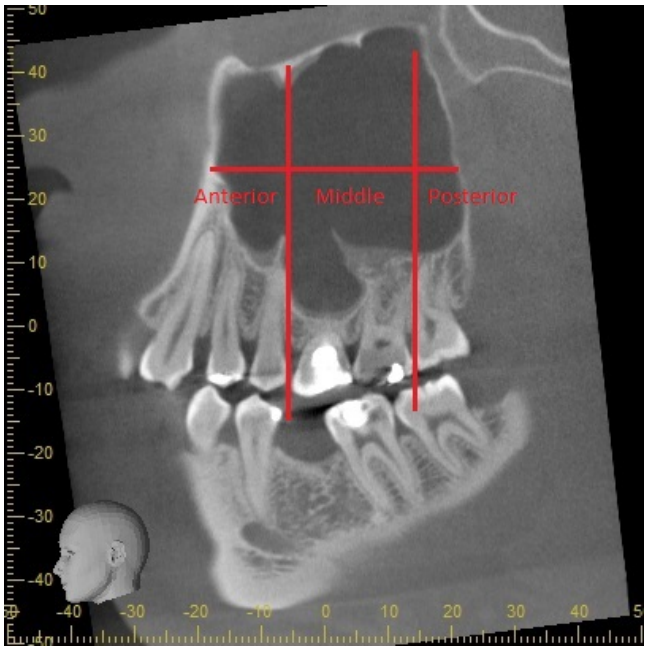

Figure 1. Method used to determine septa localization in dentate patients

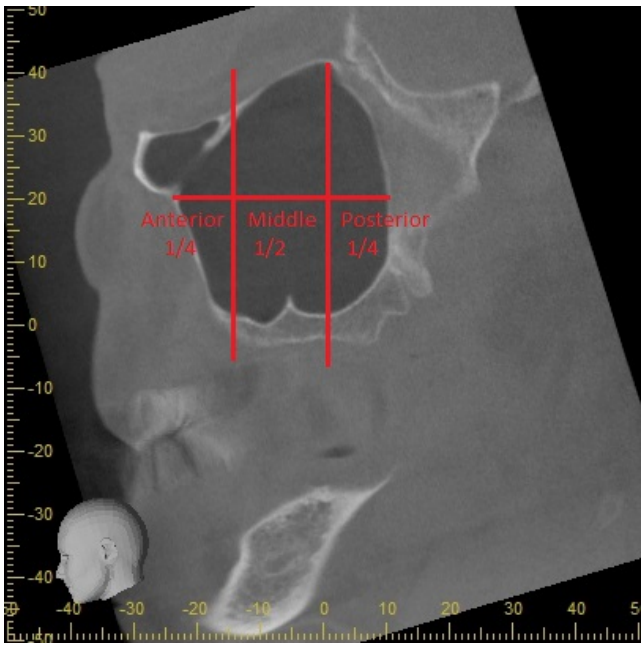

Figure 2. Method used to determine septa localization in edentulous patients

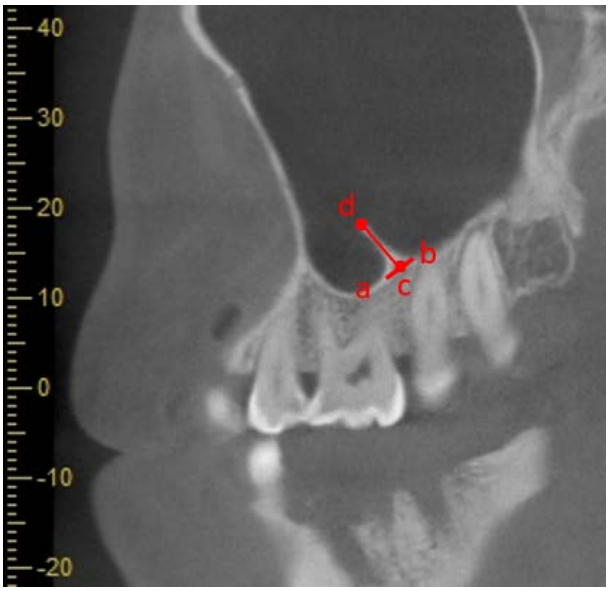

Figure 3. Measuring technique of septa heights

Results

The intra-observer consistency was found 0.96 (Cronbach's alpha value) between the two measurements.

400 patients (46,2±15,09) who met the criteria were evaluated. 200 of these patients were female (43,75±14,67), and 200 were male (48,66±15,15).

Bilateral septa were identified in 22% of the subjects, while unilateral septa were present in 31%. Panoramic radiography revealed the presence of septa in 51.8% of cases. Among these, 56.52% were classified as primary septa, and 43.48% as secondary septa. In Cone Beam Computed Tomography (CBCT) scans, septa were observed in 66.8% of the patients. Within this group, on the right side, 10.1% of septa were located in the anterior region, 52.4% in the middle region, and 14.2% in the posterior region. The length of septa on the right side ranged from a minimum of 1.45mm to a maximum of 32.71mm, with an average length of 7.035mm. On the left side, the distribution was 10.9% in the anterior region, 44.9% in the middle region, and 15.4% in the posterior region. The lengths of left-sided septa varied, with the shortest being 1.99mm, the longest 36.26mm, and the average 7.043mm. Septa lengths in dentate, partially edentulous, and edentulous patients are shown in Table 1 by region.

The analysis of septal presence across different age groups and genders revealed no statistically significant variation ($p>0.05$) as shown in Tables 2 and 3. Furthermore, the investigation into the occurrence of unilateral and bilateral septa in relation to dental status also yielded no statistically significant differences ($p>0.05$), as documented in Table 4. However, when assessing the presence of septa in connection with dental status, a significant distinction was observed among the various dental status groups ($p<0.05$), which is detailed in Table 5.

The septa height on the right sinus was measured an average of 7.035mm. The septa height on the right sinus was measured an average of 7.043mm. Upon comparison of the

lengths of the right and left septa, it was ascertained that the differences were not statistically significant (p=0.973), as indicated in Table 6. The anterior, middle and posterior region septa heights were found to be 6.3mm, 7.3mm and 6.7mm, respectively. Similarly, an evaluation of the lengths of the anterior, middle, and posterior regions revealed no statistically significant disparities(p=0.188), detailed in Table 7.

Table 1. Septa heights by region

Dental status		Septum location, n			Mean septum high±SD, mm		
		Anterior	Middle	Posterior	Anterior	Middle	Posterior
Right	Dentate	11	51	17	5,73±3,1	7,57±3,35	6,83±6,15
	Partially edentulous	9	69	18	6,43±2,93	7,54±4,23	6,57±2,58
	Edentulous	7	21	3	5,98±3,35	5,62±2,05	9,25±1,37
Left	Dentate	14	42	16	8,52±8,77	8,01±4,47	6,16±3,55
	Partially edentulous	10	57	16	4,17±1,49	7,38±3,68	7,11±6,16
	Edentulous	5	21	9	5,79±0,68	5,91±2,71	6,09±3,92

Table 2. Cross tabulation for age groups and septa

Age groups	Septa	Without septa	Total
15-30	56	21	77
31-60	160	87	247
61+	51	25	76
Total	267	133	400

χ2 =1.677, s.d.=2, p=0.432

Table 3. Cross tabulation for gender and septa

Gender	Septa	Without septa	Total
Female	129	71	200
Male	138	62	200
Total	267	133	400

χ2 =0.912, s.d.=1, p=0.339

Table 4. Cross tabulation for dental status and bilateral-unilateral septa

Dental status	Bilateral septa	Unilateral septa	Without septa	Total
Dentated	36	44	48	128
Partially edentulous	38	61	104	203
Edentulous	14	19	36	69
Total	88	124	188	400

χ2 =7.688, s.d.=4, p=0.104

Table 5. Cross tabulation for dental status and septa

Dental status	Septa	Without septa	Total
Dentated	102	26	128
Partially edentulous	122	81	203
Edentulous	43	26	69
Total	267	133	400

χ2 =14.310, s.d.=2, p=0.001

Table 6. The result of Independent T-test between right and left sides

	Mean	Std. Dev.	F	Sig.(2-tailed)
Right Side	7.035	3.78	2.843	0.973*
Left Side	7.043	4.51		

** Significant level <0.05*

Table 7. The result of the one-way ANOVA test, mean values of anterior, middle, and posterior regions and significance level

	Mean	*Std. Dev.*	*F*	*Sig.*
Anterior	*6.30*	*5.0*	*1.681*	*0.188**
Middle	*7.30*	*3.78*		
Posterior	*6.70*	*4.57*		

** Significant level <0.05*

Discussion

Previous studies investigating the identification and characteristics of maxillary sinus septa (MSS) have employed various approaches, including anatomical examinations on cadavers, clinical observations during sinus augmentation procedures, or radiological assessments using panoramic radiography or cone-beam computed tomography (CBCT) (6, 10). Among these methods, CBCT is preferred for determining the presence of sinus septa due to its high-resolution imaging capabilities, particularly for bone structures.

Panoramic radiography can also be used to detect the presence of MSS, but it has been observed that panoramic radiography may yield inaccurate results when compared to CBCT (14). This is because panoramic radiography can produce multiple radiopaque lines caused by superimpositions, leading to potential misdiagnosis (9, 14). Although panoramic radiography is routinely utilized for patient evaluations in our clinic, computed tomography is requested when deemed necessary. Given the extensive use of panoramic radiography in clinical settings, it was considered appropriate to include panoramic radiography in the evaluation of MSS.

In studies conducted according to the number of sinuses, the prevalence of MSS varies between 13% and 35.3%. In studies conducted according to the number of patients, the prevalence varies between 21.6% and 66.7% (5, 10, 11, 15, 16). While Krenmair et al. (15, 17) determined the rate of 27.7% during the clinical sinus augmentation operation in their studies to determine the rate of sinus septa, they determined the rate of 36.6% in their study on cadavers. In anatomical studies on cadavers, Underwood (4) detected a rate of 33.3% of septa, and Ulm et al. (18) found 31.7%. With the evaluations made on the computed tomography image that has not been processed, Krennmair et al. (15) found the rate of sinus septa to be 16%, while Oh et al. (19) found it to be 24%. In studies performed with the reformatting of computed tomography, Velasquez-Plata et al. (20) detected the presence of MS septa at a rate of 24%, and Kim et al. (11) at a rate of 26.5%. In the present study, the rate of MS septa was 66.8% as a result of the evaluation with CBCT, and this rate was 51.8% as a result of the panoramic radiographic evaluation. The presence of septa at different percentages in panoramic radiography and CBCT evaluations in our study may be attributed to the possibility of false negative results in panoramic radiography.

As a result of the examination of the anatomical localization of the MS septa, Valezquez-Plata et al. (20) found 24% of the septa in the anterior region, 41% in the middle region, and 35% in the posterior region; on the other hand, Kim et al. (11) found that 25.4% were localized in the anterior region, 50.8% in the middle region, and 23.7% in the posterior region. Krennmair et al. (15) determined that 70% of the sinus septa were in the premolar region in edentulous maxillae, and they attributed the higher prevalence of septa in this region to secondary septa formed in this region due to the loss of molars and premolars at different times. The results obtained in this study support the literature information.

As a result of the comparison of the prevalence of MSS in dentate, and edentulous patients, the rate of 31.76% was determined in edentulous patients, while this rate was determined as 22.61% in dentate patients (11). The reason for this can be shown that the edentulous area usually contains secondary septa. However, in this study, unlike other studies (6, 11), more septa were detected in the dentate patients. The reason for this can be considered as examining different populations.

It was observed that the height of the MSS differed according to the localization, the mean sinus septa height was 1.63 mm in the anterior region, 3.55 mm in the middle region, and 5.46 mm in the posterior region (11, 18). In this study, the mean sinus septa height was calculated as 6.29mm, 7.31mm and, 6.69mm in the anterior, middle, and posterior regions, respectively.

Determining the size and localization of the MSS present in the sinus before sinus augmentation surgery is important in terms of modifying the basic sinus augmentation surgery technique according to the determined features. If the operation is performed without knowing the presence of MSS, or if the location of the MSS is known and the surgical technique is not modified accordingly, the possibility of perforation in the sinus membrane is high (10). To minimize the complications that may occur due to the MSS, if the septa size is less than 3 mm, it is recommended that the osteotomy lower incision be applied to the sinus wall should be made at least 3 mm above the sinus floor. It was stated that if the septa height is more than 3 mm, the osteotomy to be made on the sinus wall should be made as two separate windows with vertical incisions in front of the septa and behind the septa (21, 22).

Zahrani et al. (23) conducted a study where they examined 1010 sinuses in a group of 505 patients. They found that septa were present in approximately 46% of the patients included in their study. The length of the septa in the right sinus was measured to be around 6mm, while in the left sinus, it averaged around 5mm. On the other hand, Jung et al.(24) focused their research on 134 patients who were edentulous, and they found that the prevalence of septa in this group was approximately 37.3%. In the present study, a higher rate of septa was found in the maxillary sinuses of 66.8% of the patients. These variations in findings can be attributed to differences in the populations being studied and the sample sizes used.

Zahrani et al. (23) had a larger sample size and included a diverse group of patients, which may have contributed to the observed differences in septal prevalence and lengths. Each patient has unique dental conditions and anatomical characteristics that can influence the presence and dimensions of septa in their maxillary sinuses.

Conversely, Jung et al. (24) specifically focused on patients who were edentulous, which could explain the relatively lower prevalence of septa in their findings. When teeth are missing, the jawbone undergoes changes that can affect the shape and structure of the maxillary sinuses. Therefore,

these differences in findings highlight the importance of considering the specific population being studied and the sample size when interpreting the prevalence and dimensions of septa within the maxillary sinuses.

Alhadi et al. (25) evaluated 633 panoramic images. They observed septa in 180 cases (69.5%) unilaterally and in 79 cases (30.5%) bilaterally. In terms of localization, the highest prevalence was in the anterior region with 146 cases (42.94%), followed by the middle region with 126 cases (37.05%), and the posterior region with 68 cases (20%). In the current study, the highest prevalence was observed in the middle region. This disparity could be attributed to differences in the populations being studied.

Wang et al. (26) assessed sinus septa in CBCT images. They found that the prevalence of septa was 50.2% in patients with full dentition, 44.2% in those with partial dentition, and 41.7% in edentulous patients. In this study, respective rates were observed of 67%, 51%, and 52%. The highest septa recorded in their study measured 33 mm in height, with an average height of 9.66 ± 7.54 mm. In this study, the highest septum measured 36.26 mm in height, with an average height of 7.043 mm. These differences may be attributed to variations in the study populations and methodologies.

These findings are based on a cross-sectional analysis of CBCT images from only one group of dental faculty patients; as a result, one of the limitations of the study is that it cannot be generalized to other groups.

Conclusion

The anatomical variability of the maxillary sinus septa (MSS), including its prevalence, morphology, localization, and dimensions, necessitates a thorough understanding of the maxillary sinus (MS) structure prior to surgical intervention to mitigate the risk of complications. Given the limitations of panoramic radiography in accurately identifying septa within the maxillary sinus, which often leads to both false-positive and false-negative interpretations, it is crucial to employ cone-beam computed tomography (CBCT) for a comprehensive assessment of the sinus in the context of maxillary sinus surgical procedures. This approach ensures the acquisition of precise and reliable diagnostic data, essential for effective surgical planning and execution.

Ethical Approval: *This study was approved by the Ethics Committee of Necmettin Erbakan University Faculty of Dentistry with the date of 28.04.2022 and the decision number of 2022/17-135.*

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Concept: A.A.
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Design : A.A.
Data acquisition: C.N.Y., A.A.
Analysis and interpretation: A.A., C.N.Y.
Writing manuscript: A.A., C.N.Y.
Critical revision of manuscript: A.A.

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