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CONGRESS PROCEEDING

Evaluation Of Paranasal Sinus Septa Types, Orientations, And Angles Using Cone Beam Computed Tomography

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Abstract

Purpose: This study aimed to determine the characteristics of the paranasal sinus septa and evaluate the gender differences using cone beam computed tomography (CBCT).
Materials and Methods: : CBCT images of 300 patients were used in this study. The number, types, and orientations of septa and the angle between the septa and the midline was measured separately on the right and left side of the maxillary, frontal and sphenoid sinuses. Coronal, axial, and sagittal sections were used for evaluations. CBCT scans were taken with Newton 3G and the images were evaluated with the NNT software program.
Results: As a result of the study, it was determined that the most common type of septa in the maxillary sinus was 1 septum on one side with a rate of 28.3%. While the incidence of 1 septa on one side was the highest in the frontal sinus at 28%, and also 3 septa were found on one side with a rate of 1.3%. In the sphenoid sinus, 31% of cases with 2 septa on one side and 1 septa on the other side had the highest prevalence. There was no significant difference between men and women in terms of septa orientations and angles (p0.05).
Conclusions: CBCT is frequently used to determine anatomical structure and variations. These results provide us with information about the anatomical characteristics and variations of the evaluated population. It is important to evaluate anatomical variations with CBCT, which provides 3-dimensional imaging using low-dose radiation, to reduce the risk of complications before surgical intervention and to perform safe sinus surgery.

Key words: Paranasal sinuses; CBCT; Septa types

Introduction

Accurate diagnosis and treatment planning is necessary for a satisfactory result in every field of dentistry. Imaging methods used in this field are complementary to this process and are an important tool for treatment planning. However, all two-dimensional (2D) imaging methods suffer from the same inherent limitations which include distortion, magnification, and superimposition leading to the misrepresentation of anatomic structures. For this reason, 3D imaging methods such as Computed Tomography (CT) or Cone Beam Computed Tomography (CBCT) are used to identify the exact anatomical structures of the head and neck area. Maxillofacial cone beam CT has been available for dental and maxillofacial imaging for more than 20 years. CBCT has several advantages over CT, including reduced radiation dose, higher spatial resolution, and lower equipment cost. CBCT provides valuable information about not only the region of interest (eg, implant treatment planning, impacted teeth, detection of periapical pathologies) but also the structures included in the overall exposed tissue volume. During the CBCT image acquisition, paranasal sinuses, cervical spine, airway, and intra and extracranial structures can also be included in the images according to the desired field of view (FOV).[1]

The paranasal sinuses are air-filled spaces lined with soft, pink mucosa located within the bones of the skull and face. The paranasal sinuses are the four paired sets of airfilled cavities of the craniofacial complex composed of maxillary, frontal, and sphenoid sinuses

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and ethmoid air cells. It can exhibit anatomical variations such as asymmetry, hyperplasia, septa, orientations and exostosis. [2]

The presence of anatomical variation such as septa within the maxillary, frontal and sphenoid sinus increased the iatrogenic injury of the internal carotid artery or optic nerve and sinus membrane perforation during the surgical operations. [2]

This study aimed to determine the characteristics of the paranasal sinus septa and evaluate the gender differences using cone beam computed tomography (CBCT).

Methods

A total of 300 CBCT images who referred to Near East University Faculty of Dentistry (Nicosia, Turkish Republic of Northern Cyprus) for different reasons such as paranasal sinus infections, orthodontic planning, pre-dental implant evaluation, impacted wisdom tooth surgery, planning before LeFort I osteotomy and obstructive sleep apnea syndrome between January 2008 and July 2012, were used in this study. CBCT scans were obtained with Newton 3G (at 120 kVp, 3-5 mA, and using 9 or 12-inch FOV) and the images were evaluated using the NNT software program.

136 (45.3%) male and 164 (54.7%) female patients, aged between 9 and 83 (mean age 40), were included in the study. Patients were divided into 4 main age groups: ≤18 (6.3%), 19-35 (42.3%), 36-60 (35%), and >61 (16.3%). The study protocol was prepared following the principles defined to include all regulations and revisions in the Declaration of Helsinki. Access to the data used is limited to the principal investigator(s). Written informed consent was obtained from the patients before the imaging.

The number, types, and orientations of septa and the angle between the septa and the midline was measured separately on the right and left side of the maxillary, frontal and sphenoid sinuses. Coronal, axial, and sagittal sections were used for evaluations.

Results

Maxillary, frontal, and sphenoid sinus septa types were classified into 10 groups according to the number of septa in the right and left sinus. Table 1. shows the frequency of septa types in each sinus. As a result of the study, it was determined that the most common type of septa in the maxillary sinus and frontal sinus were 1 septa on one side with a rate of 28.3% and 28% respectively. In the sphenoid sinus, 31% of cases with 2 septa on one side and 1 septa on the other side had the highest prevalence. The least common one was 3 septa on both sides (0%) for maxillary sinus, 3 septa on one side (1.3%) for frontal sinus, and the absence of septa on both sides (0.7%) for sphenoid sinus. No statistically significant differences were found between the male and females according to septa type (p>0.05). When the maxillary, frontal and sphenoid sinus septa numbers are examined in the right and left sinus, it is seen that there is no significant difference between age groups (p>0.05). No statistically significant difference was found between the age groups in terms of the number of septa in the right-left comparisons (p>0.05). In addition, the differences in the septa types of the maxillary, frontal and sphenoid sinuses between age groups were examined in the right and left sinus and no statistically significant difference was found (p>0.05).

The results of the study indicate that maxillary sinus septa are most commonly oriented mediolaterally, while frontal and maxillary sinus septa are oriented anteroposteriorly. There was no significant difference between females and males in terms of septa orientations and angles (p>0.05). There was no statistically significant difference between age groups in terms of their orientation (p>0.05) of the right and left maxillary, frontal and sphenoid sinuses. In right-left comparisons, significant differences were found in septa orientation in other sinuses except maxillary sinus (p<0.05). For the frontal sinus, the ratio of septa orientation being anteroposterior in the 36-60 age group was higher in the right frontal sinus than in the left (p<0.05). No significant difference was found in other age groups (p>0.05). In the 19-35 age group, the right sphenoid sinus septa orientation was found to be significantly higher than the left anteroposterior orientation in the sphenoid sinus (p<0.05). No significant difference was found in other age groups (p>0.05) (Table 3).

Table 1. Prevalence of septa types in the maxillary, frontal, and sphenoid sinus

	Septa Types		
	Maxillary Sinus	**Frontal Sinus**	**Sphenoid Sinus**
No septa on both side	85 (28.3%)	25 (10.5%)	2 (0.7%)b
1 septa on one side	85 (28.3%)a	67 (28%)a	76 (25.3%)
2 septa on one side	16 (5.3%)	22 (9.2%)	21 (7%)
1 septa on both sides	66 (22%)	41 (17.2%)	61 (20.3%)
2 septa on both sides	9 (3%)	19 (7.9%)	19 (6.3%)
2 septa on one side and 1 septa on the other side	33 (11%)	32 (13.4%)	93 (31%)a
3 septa on one side	1 (0.3%)	3 (1.3%)b	3 (1%)
3 septa on one side and 1 septa on the other side	4 (1.3%)	8 (3.3%)	12 (4%)
3 septa on one side and 2 septa on the other side	1 (0.3%)	13 (5.4%)	10 (3.3%)
3 septa on both sides	0 (0%)b	9 (3.8%)	3 (1%)

Table 2. Mean values and standard deviations of right and left maxillary, frontal and sphenoid sinus septa angles

Septa Angle		**M (Mean s.d)**	**F (Mean s.d)**	**p value**
Maxillary Sinus	Right	78.29 (23.98)	84.7 (21.72)	p>0.05
	Left	79.82 (29.96)	81.82 (21.06)	
Frontal Sinus	Right	103.51 (64.46)	96.44 (64.67)	p>0.05
	Left	88.12 (172.3)	77.6 (65.7)	
Sphenoid Sinus	Right	117.52 (51.2)	112.72 (53.97)	p>0.05
	Left	111.9 (51.34)	114.36 (51.38)	

Discussion

Paranasal sinuses are of great importance in dentistry because they affect the growth and development of facial structures. Imaging of the paranasal sinuses is essential for the evaluation of anatomical variations, the diagnosis of pathologies, the detailed anatomy of the region before sinus surgery, and the prediction of complications in surgery. [2] Maxillary sinus septa are an important anatomical variation that poses a problem for implant placement and sinus augmentation. [3]

The presence of septa increases the risk of sinus membrane perforation. Separation of the Schneiderian membrane from the septa in the septa region may be difficult, but if it has been long after tooth extraction and the sinus has formed a downward fold, the distinction can be much more difficult. [3] For this reason, the anatomy of the region was investigated with various imaging methods, especially in cases requiring sinus augmentation. In the literature, panoramic radiography [4,5] computed tomography [4–8] and CBCT [9,10] have been used to identify maxillary sinus septa.

In their study comparing the accuracy of panoramic radiography with CT in determining the maxillary sinus septa, González-Santana et al. [4] reported that 2 (11.8%) septa detected in CT could not be detected in panoramic radiography.

Similarly, in another study investigating the reliability of panoramic radiography, Kasabah et al. [5] reported that 12 of 24 septa seen on CT could not be diagnosed in panoramic radiography, and false positive diagnosis was made in 8 of 26 cases where no septa

Table 3. Statistical analysis of septa orientations of the maxillary, frontal and sphenoid sinuses, incidence rates in age groups, and right-left differences

Age Groups	Maxillary Sinus						p value	Right-Left
	Right Septa Orientations			Left Septa Orientations				
	0	1	2	0	1	2		
18	11 (57.9%)	7 (36.8%)	1 (5.3%)	7 (36.8%)	12 (63.2%)	0 (0%)	p>0.05	p>0.05
19-35	59 (46.5%)	68 (53.5%)	0 (0%)	58 (45.7%)	69 (54.3%)	0 (0%)		
36-60	44 (41.9%)	59 (56.2%)	2 (1.9%)	48 (45.7%)	55 (52.4%)	2 (1.9%)		
61	23 (46.9%)	24 (49%)	2 (4.1%)	23 (46.9%)	26 (53.1%)	0 (0%)		
Total	137 (45.7%)	158 (52.7%)	5 (1.7%)	136 (45.3%)	162 (54%)	2 (0.7%)		
	Frontal Sinus							
18	6 (35.3%)	0 (0%)	11 (64.7%)	4 (23.5%)	1 (5.9%)	12 (70.6%)	p>0.05	p>0.05
19-35	27 (25.2%)	3 (2.8%)	77 (72%)	34 (31.8%)	3 (2.8%)	70 (65.4%)		
36-60	18 (23.4%)	0 (0%)	59 (76.6%)	25 (32.5%)	0 (0%)	52 (67.5%)		**p<0.05**
61	13 (34.2%)	0 (0%)	25 (65.8%)	15 (39.5%)	1 (2.6%)	22 (57.9%)		p>0.05
Total	64 (26.8%)	3 (1.3%)	172 (72%)	78 (32.6%)	5 (2.1%)	156 (65.3%)		
	Sphenoid Sinus							
18	3 (15.8%)	2 (10.5%)	14 (73.7%)	1 (5.3%)	4 (21.1%)	14 (73.7%)	p>0.05	p>0.05
19-35	20 (15.7%)	22 (17.3%)	85 (66.9%)	24 (18.9%)	29 (22.8%)	74 (58.3%)		**p<0.05**
36-60	20 (19%)	13 (12.4%)	72 (68.6%)	16 (15.2%)	20 (19%)	69 (65.7%)	p>0.05	
61	9 (18.4%)	6 (12.2%)	34 (69.4%)	11 (22.4%)	7 (14.3%)	31 (63.3%)		p>0.05
Total	52 (17.3%)	43 (14.3%)	205 (68.3%)	52 (17.3%)	60 (20%)	188 (62.7%)		

were found on CT. Therefore, they stated that panoramic radiographs are not reliable in the diagnosis of septa.

Park et al.[7] examined the anatomy of the septum of the maxillary sinus with 3D CT, and examined 200 patients and 400 sinuses. Septa was observed in 37% of the patients. They reported that 47.7% (53) of them were on the right side and 52.2% (58%) were on the left side. They did not find a significant difference between age groups (45-55 and 56-65) and genders in terms of incidence.

Shen et al.[8] investigated the prevalence and localization of maxillary sinus septa in the Taiwan population in their study on CT images of a total of 423 patients, including 207 men and 216 women. They divided the patients into 3 groups according to their age, as 30>, 30-59 and 60-89, and found that the prevalence of septa in the 30-59 age group was higher than in the other groups.

According to a study conducted by Neugebauer et al.[9] on CBCT data of 1029 patients, the prevalence of septa was determined as 47% (484). Its incidence in the sinuses was reported as 33.2% (683). They found no significant difference in the prevalence of septa in terms of age and gender. In another study, Toprak and Ataç,[11] determined that 44% (132) patients and 31.17% of the maxillary sinus had septa. Of these 132 patients, 77 (58.3%) had septa in only one sinus (unilateral), and 55 (41.7%) had septa in both sinuses (bilateral). The septa were more common in male patients, but no significance was revealed. According to our study findings, maxillary sinus septa are found in 54.5% of the sinuses (54.3% in the right maxillary sinus, 54.7% in the left maxillary sinus). Septa was detected in 53.3% of the sinuses in men and 55.5% of the sinuses in women. In total, septa were found in 71.7% of the patients (73.5% in men, 70.1% in women). No significant difference was found between men and women in terms of the prevalence of maxillary sinus septa. Lee et al.[6] found that the septa prevalence was higher in males than females, contrary to our findings.

In our study, septa were found in higher prevalence than most of the previous studies. We think that this result depends on the technique and diagnostic criteria used in the study. Septa below 2.5 mm were not considered in most studies. In CTs, the spatial resolution is nonisotropic. Therefore, diagnosing thin septa on CT images becomes difficult.[9] Since CBCT with isotropic resolution was used in our study, it is thought that this is the reason why septa were detected in higher prevalences compared to studies using CT. Higher prevalence of the septa in the CBCT studies based on the thin slice interval.[10]

When septa types were examined, Neugebauer et al.[9] reported that the presence of a single septum on one side was the most common type with 24.6%, while the presence of one septa in each sinus was observed with 13.7% in the second row. In our study, similar to the study of Neugebauer et al.[9] the type with a single septum on one side was found with the highest rate (28.3%), while the type with one septum on both sides (22%) came in second place. There were no cases with 3 septums on both sides. In most previous studies, it has been reported that the orientation of all septa in the maxillary sinus is mediolateral (buccopalatinal).[5–7] Only Park et al.[7] reported that the septa orientation was seen as mediolateral in 96.3% and anteroposterior in 3.6%. In our study, similar to this study, mediolateral orientation was found in 96.9% and anteroposterior orientation was found in 3.1%. Another parameter of our study is the septa angle between the sinus septa and the sutura palatina media. Park et al.[7] determined that this angle is 76.29° on the right side and 83.94° on the left side. In our study findings, the mean angle was 81.9° on the right side and 80.9° on the left side. Septa angles do not show a significant difference according to gender and age groups. Since the prevalence of septa is very high in our population, 3D evaluation should be performed before implant surgery in patients who are thought to have sinus augmentation.

The sphenoid sinus septa are usually not located in the midline and deviate to one side of the sinus and form two unequal compartments. Besides this, some of the sphenoid sinus septa get attached to the bony canals of the optic nerve, internal carotid artery, maxillary nerve, and/or vidian nerve which may cause serious complications such as severe bleeding, and blindness during the transsphenoidal surgery.[12] The prevalence, type, orientation and angle of the sphenoid sinus septum were also evaluated in our study. In their study on 60 patients, Idowu et al.[13] reported that 95% of the patients had an intersphenoid septum and only one patient did not have a septum. They reported that 29 of 120 sinuses had multiple septa.

Banna and Olutola[14] in their study evaluating the sphenoid sinus of 70 adults, reported that 61% of the patients had a single septum, 14% had 2 septums, 12.8% had more than 2 septums, and 11.4% had no septa. Jaworek et al.[15] in their study on paranasal sinus CT scans of 207 patients reported that 41% of the patients had a single septum, 33% had 2 septa, 22% had 3 septa, and 4% had 4 septa. In our study findings, there were no septa in the sphenoid sinus of 2 patients (0.7%). In the right sphenoid sinus, 1, 2, and 3 septa are seen in 48.7%, 26.7%, and 7%, respectively. In the left sphenoid sinus, 1,2 and 3 septa are seen in 52%, 27.3% and 3.3%, respectively. It was determined that the number of septa and the types of septa did not differ in gender and age groups.

It was determined that 68.3% of the septa orientations on the right and 62.7% on the left were in the anteroposterior direction and did not differ between men and women. In the 19-35 age group, the probability of right sphenoid sinus septa orientation to be an-

teroposterior was found to be higher than the left. Septa angle was found as 114.91° on the right and 113.28° on the left, and no significant difference was detected in gender and age groups. The sphenoid sinus septum is usually not located in the middle, it deviates to one side and forms 2 unequal sinus cavities. Since septums are often associated with the optic nerve and ICA, care should be taken if removal of the septum is required during endoscopic sinus surgery.[12]

Conclusion

CBCT is frequently used to determine anatomical structure and variations. These results provide us with information about the anatomical characteristics and variations of the evaluated population. It is important to evaluate anatomical variations with CBCT, which provides 3-dimensional imaging using low-dose radiation, to reduce the risk of complications before surgical intervention and to perform safe sinus surgery.

Author Contributions

All authors contributed to the study conception and design. The preparation of the project was done by Kaan Orhan and S.A. Data collection was done by S.A. Selecting patient data, evaluating images, making measurements, writing publication were done by S.A. and M.M.G. The article has been revised by K.O. and S.A., and the final manuscript has been read and approved by all authors.

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Conflict of Interest

Not applicable.

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