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Maxillary Sinus Abnormalities Detected by Dental Cone-Beam Computed Tomography

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Abstract

Background: The aim of the present study was to detect maxillary sinus abnormalities in asymptomatic patients using the cone beam computed tomography (CBCT).

Methods: 193 patients were included in the study forming 386 CBCT images for detection of maxillary sinus abnormalities. The correlation of abnormalities with age, gender, the sinus wall affected and proximity of the lesions to the floor of maxillary sinus were recorded and analyzed by using mean, standard deviations and Chi-Square tests.

Results: Incidental abnormalities of maxillary sinus were 73%. The mucosal thickening was the most common abnormality (41.4%) followed by polyps (16%), Increased dimensions of the sinus (10.2%), Decreased dimensions of the sinus (8.3%). Bubbles inside sinus (8.3%), Partial opacification (8%), Complete opacification (5%).There was significant difference between the genders. There was a moderate significant relation between classification of periapical lesions and sinus abnormalities (P-value=0.045). There was no statistically significant difference between age groups and between the side and sinus abnormalities for CBCT scans.

Conclusion: The higher incidence of maxillary sinus abnormalities among a symptomatic patients denotes that, the oral radiologists should evaluate the CBCT images with full examination of maxillary sinus and be aware of these sinus abnormalities. This will lead to early detection, treatment and follow up of sinus abnormalities.

Keywords: Maxillary sinus; Abnormalities; Cone-beam computed tomography

Background

Maxillary sinus is the paranasal sinus that impacts most on work of the dentists and the maxillofacial surgeon when treatment requires bone grafting in this area. Full understanding of the anatomic and functional relationships between the maxillary sinus and upper posterior teeth is important when dealing with chronic inflammatory diseases and surgery planning. The maxillary sinus is a pneumatic space. It is the largest bilateral air sinus located in the body of the maxilla and opens in the middle nasal meatus of the nasal cavity with single or multiple openings. It measures about 8 × 4 mm at birth, and situated with its longer dimension directed anteriorly and posteriorly [1]. It develops at the third month of intrauterine life, in the place existing between the oral cavity and the floor of the orbit. It develops as evagination of the mucous membrane of the lateral wall of the nasal cavity at the level of the middle nasal meatus forming a minute space that expands primarily in an inferior direction into the primordium of the maxilla Figure 1. The maxillary sinus enlarges variably and greatly by pneumatization until it reaches the adult size by the eruption of the permanent teeth [2].

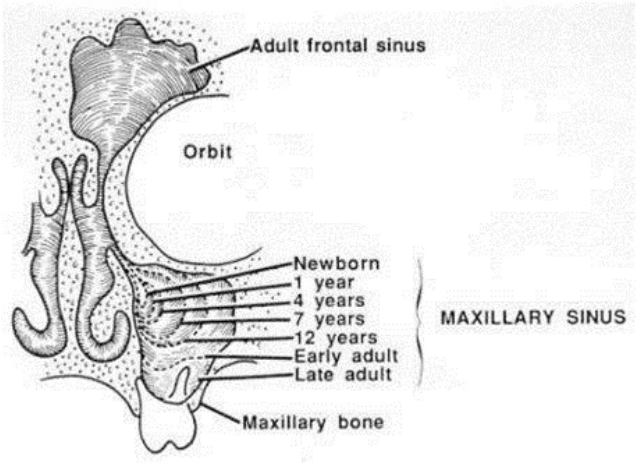

Figure 1: Development of maxillary sinus.

A significant difference in the bone height of the sinus floor exists between dentulous and edentulous individuals. Anatomic variations within the sinus, such as septa, mucosal thickening of the sinus floor

increase the risk of the sinus membrane perforation during pre-implant surgery in posterior maxilla [3]. Failure to detect incidental abnormalities is associated with the limited ability and experience of oral radiologists when interpreting volumetric images and negligence when undertaking a systematic visual scrutiny of the whole image, including the dentoalveolar region and all adjacent structures of the maxilla-mandibular complex [4]. The use of CBCT technology in clinical practice provides a number of advantages for maxillofacial imaging compared with conventional CT. CBCT is well suited for imaging the craniofacial area. It provides clear images of highly contrasted structures and is extremely useful for evaluating bone [5,6].

CBCT can accurately capture, display and provide 3-dimensional visualization of maxillofacial anatomy and pathology. In maxillary sinus floor elevation procedure, it is important to be acquainted with different anatomic and pathologic findings in sinus, to minimize the risk of postoperative complications [3]. In a study done by Cha et al., using CBCT as a tool for examinations, the abnormalities found were signs of acute sinusitis (7.5%), retention cysts (3.5%), and polypoid mucosal thickening (2.3%) [7]. In other studies, the prevalence of flat mucosal thickening ranged from 23.7% to 38.1%, polypoid mucosal thickening ranged from 6.5% to19.4%, signs of acute sinusitis was 3.6%, and partial and total opacification were 12% and 7%, respectively [8,9]. In spite of other previous studies reported the detection of incidental abnormalities in CBCT scans in patients referred to as orthodontic and other dental purposes [8], the prevalence of abnormalities is not already known in large samples of scans of patients who underwent to be examined for other oral and dental complains. The aim of the present study was to detect maxillary sinus abnormalities in asymptomatic patients using the cone beam computed tomography (CBCT).

Methods

The study sample includes CBCT images at Riyadh colleges of dentistry and pharmacy (RCs DP), Riyadh, Saudi Arabia, between 2014 and 2015. 193 patients were included in the study, forming 386 cases (right and left side for each patient) .The study was approved by the Ethical Committee of the Research Center of RCsDP. Informed, written consent was obtained from each patient prior to imaging, including a clause for using the images for research purposes. The cases included were the patients that had been referred for CBCT diagnosis for dental implants, maxillofacial surgery, oral pathology, etc. Age gender, and indication for the exam were recorded.

For statistical analysis, patients were classified into six age groups: (1) 12-19; (2) 20-29; (3) 30-39; (4) 40-49 and (5) 50-59; (6) 60-69; (7) 70-79 years of age.

All images were evaluated for detecting any abnormalities in the maxillary sinus. The abnormalities that were included: (1) increased thickness of the lining mucous membrane, (2) presence of dome shaped elevations, (3) fluid level or any other abnormality that may be encountered in the sinus.

Inclusion criteria

The study included the CBCT images for patients more than 12 years of age and CBCT scans of bilateral maxillary sinus where gender, age and indication for scanning had been recorded.

Exclusion criteria

The images for patients less than 12 years of age were excluded from the study because of their incomplete sinus development. The CBCT scans with known cases of maxillary pathologies were excluded from the study. Images of low resolution quality were also excluded.

The measurements were performed using a CBCT machine (Galileos, Sirona)and CBCT images were analyzed using software. Images were obtained at 85 kV, 5-7 mA and 14 s with a voxel size of 0.3 mm, F.O.V15 × 15 × 15, (Sirona, Germany).

Diagnosis of the maxillary sinus abnormalities (Right and left side) was performed on a 1:1 scale, using three orthogonal slice views (axial, coronal and sagittal). To identify the presence or absence of sinus abnormalities we use a yes/no scale. The abnormalities had been classified as: (1) increased or decreased dimension of the sinus, (2) partial or complete opacification of the sinus cavity, (3) increased thickening of the mucosa (MT), (4) polypoidal-mucosal thickening (PT) and (5) Retention cyst. When the MT was more than 3 mm the sinus pathology was considered [10]. Any dome shape radiopacity in these maxillary sinus was considered as PT. The diagnosis of an abnormality was registered for the right and left sinuses separately of each patient.

The detection of which wall of the maxillary sinus was affected with each abnormality was also recorded as the anterior, posterior, upper, lower, lateral and or medial walls of the sinus on right and left sides separately.

The diagnoses of periapical lesions in the upper posterior teeth was recorded and proximity of the lesions to the floor of maxillary sinus was classified as follow: class I (near to the sinus floor), class II (in contact with the sinus floor) and class III (overlapping the sinus floor). This classification were done on the bases of the proposal of OBERLI et al. [11].

Statistical analysis

Statistical analysis was done using SPSS version 21. Descriptive statistic done by using mean and standard deviations for the scale variable age .Frequencies for other nominal variables such as gender, sinus abnormalities, walls of right and left maxillary sinus and classification were done. Chi-Square test was conducted to test the significant relations between nominal variables mentioned above. P-value was significant if less than 0.05.

An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency among raters. kappa value of, 0.40 was considered to be poor agreement, 0.40-0.59 fair agreement, 0.60-0.74 good agreement and 0.75-1.00 excellent agreement.

Results

There were 193 patient included in the study, 120 (62.2%) of which were females and 73 (37.8%) were males .Their ages ranged from 10 to 75 years (mean= 35.85, SD=17.19). There were 140 Patients (73%) with maxillary sinus abnormalities (280 maxillary sinuses) and 53 Patients (27%) with no abnormalities. There was significant difference between the genders, showing a greater occurrence of sinus abnormality in Females (57.9%) versus in Males (42.1%) (p-value 0.04<0.05) using Chi-Square test Table 1. The inter-rater reliability for CBCT scans was considered from a substantial degree to excellent degree of agreement for all types of maxillary sinus abnormalities (kappa is 0.67 for mucosal

thickening, kappa is 0.79 for polyps, kappa is 0.81 for opacifications, kappa value is 0.90 for others, p<0.000).

Variables	Sex		Total	Chi-Square	P-value
Abnormality	Female N (%)	Male N (%)			
Yes	81(57.9%)	59(42.1%)	140	4.04	0.04 Significant
No	39(73.6%)	14(26.4%)	53		
Total	120	73	193		

Table 1: Frequency of occurrence of Sinus abnormalities among male and female.

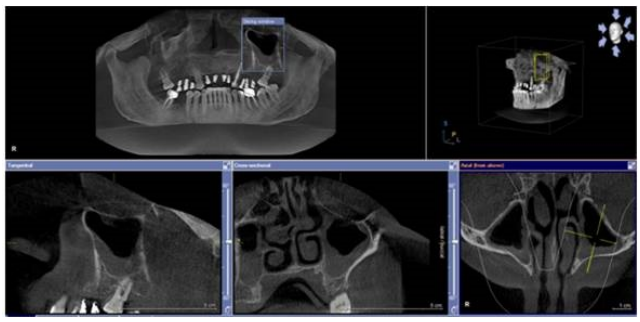

Figure 2: Cone beam computed tomography scan showing increased mucosal thickness of maxillary sinus.

The radiological findings of maxillary sinus abnormalities showed that the Increased thickness of mucosal lining was the most common sinus abnormalities among all cases which was found in 116 (41.4%) Figure 2, followed by polyps 45 (16%), Increased dimensions of the sinus 29 (10.2%) , Decreased dimensions of the sinus 23 (8.3%) , Bubbles inside sinus 23 (8.3%) , Partial opacification of the sinus 22 (8%), Complete opacification of the sinus 14 (5%) Figure 3, Retention cyst 8 (2.8%) Figure 4.

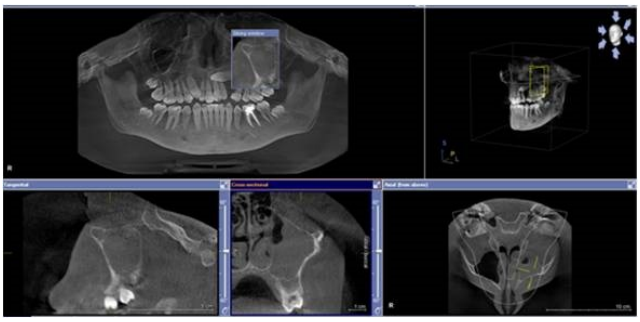

Figure 3: Cone-beam computed tomography scan showing opacification of maxillary sinus.

Figure 4: Cone-beam computed tomography scan showing retention cyst in maxillary sinus.

There was no statistically significant difference between the side and sinus abnormalities. There was no significant relation between abnormalities and Right Side (Chi-Square=11.9, P-value=0.1). There was no significant relation between abnormalities and Left Side (Chi-Square=9.8, P-value=0.2) Table 2.

Pathological finding	Right - Side	Left- Side	Total number of sinuses (%)
Retention cyst	6 (4.2%)	2 (1.3%)	8 (2.8 %)
Bubbles inside sinus	9 (6.4%)	14 (10%)	23 (8.3%)
Complete opacification of the sinus	9 (6.4%)	5 (3.5%)	14 (5%)
Partial opacification of the sinus	7 (5%)	15 (11.5%)	22 (8%)
Polyps	18 (13%)	27 (19%)	45 (16 %)
Increased thickness of mucosal lining	63 (45%)	53 (37.7%)	116 (41.4%)
Decreased dimensions of the sinus	11(7.8%)	12 (8.5%)	23 (8.3%)
Increased dimensions of the sinus	17(12.2%)	12 (8.5%)	29 (10.2%)
Test Statistic : Chi-Square test	11.9	9.8	
P-value	0.1	0.2	

Table 2: The frequency of the occurrence of abnormalities in Maxillary Sinus.

Among 140 patients who had maxillary sinus abnormalities, they were categorized into 7 age groups. Age group (12 to 19 years)and (20-29 years) each of them represents highest percent of abnormalities (21.4%) among other age groups, While the lowest percent (1.4%) of having abnormalities appeared for age group (70-79 years). There was no statistically significant difference between different age groups for CBCT Scans Table 3.

The cross tabulation between classification of periapical lesions and different maxillary sinus abnormalities showed that, there was a moderate significant relation between classification of periapical lesions and abnormalities (Chi-square test=26.7, P-value=0.045). Class I is the most classification category (53%), followed by Class II (30.3%) and Class III (16.7%) Table 4.

Variables		Abnormality		Total	Chi- Square	P-value
		Yes	No			
Age Groups	10-19 Years	30(21.4%)	15(28.3%)	45	X^2 = 2.8	0.83 Not significant
	20-29 Years	30(21.4%)	11(20.8%)	41		
	30-39 Years	29(20.7%)	10(18.9%)	39		
	40-49 Years	17(12.1%)	8(15.1%)	25		
	50-59 Years	18(12.9%)	4(7.5%)	22		
	60-69 Years	14(10%)	5(9.4%)	19		
	70-79 Years	2(1.4%)	0(0.0%)	2		
Total		140(100%	53(100%)	193		

Table 3: Descriptive statistics of age and frequency of sinus abnormalities in different age groups.

Abnormalities	Classification			Total	Chi- test	P-value
	Class I	Class II	Class III			
Retention cyst	2(25%)	4(50%)	2(25%)	8 (100%)	26.7	0.045 moderate Significant
Bubbles inside sinus	12(52.1%)	6(26%)	5(21.9%)	23 (100%)		
Complete opacification of the sinus	0 (0%)	5 (35.7%)	9 (64.3%)	14 (100%)		
Partial opacification of the sinus	16 (72.7%)	5 (22.7%)	1 (4.6%)	22 (100%)		
Polyps	34(75%)	9(20%)	2(4.5%)	45(100%)		
Increased thickness of mucosal lining	64 (55.1%)	41- 35.30%	11- 9.60%	116 (100%)		
Decreased dimensions of the sinus	10 (43.6%)	7 (30.4%)	6 (26%)	23 (100%)		
Increased dimensions of the sinus	10 (34.6%)	8 (27.5%)	11 (37.9%)	29 (100%)		
Total	148 (53%)	85-30.30%	47-16.70%	280(100%)		

Table 4: The frequency of Periapical lesion of the sinus inferior wall and different abnormalities.

The frequency distribution of walls affected of maxillary Sinus among abnormalities are represented in Table 5. On the left side, frequency distribution From highest to lowest were the lower wall (42.1%), Anterior wall (36.6%), Medial wall (32.9%),Lateral wall (27.1%).Upper wall (15.7%) and Posterior wall (15%) . On the right side, frequency distribution From highest to lowest were Lower wall (40%), Anterior wall (37.1), Posterior wall (30%) lateral and Medial (22.9%) each and upper wall (18.6%). Lower wall is the most wall affected in both sides with total number 115 times (42%.1) for left side, and 40% for Right side. Upper wall is the least one affected in both sides with total 48 times (18.6%) for Right side and (15%) for Left side Table 5.

	Anterior wall	Posterior wall	Upper wall	Lower wall	Medial wall	Lateral wall
Right Side	52 (37.1%)	42 (30%)	26 (18.6%)	56(40%)	32 (22.9%)	32 (22.9%)
Left Side	51 (36.6%)	22 (15%)	22 (15.7%)	59 (42.1%)	46 (32.9%)	38 (27.1%)
Total	103	64	48	115	78	70

Table 5: The Distribution of walls affected of maxillary Sinus among abnormalities.

Discussion

In this study 193 patients were included to detect any abnormalities within the maxillary sinus in asymptomatic patients using cone beam computed tomography (CBCT). The present study showed that the incidence of maxillary sinus abnormalities was 73% which was different from other studies. Rege et al. found 68.2% prevalence of mucosal pathologies [12]. The study carried out by Ritter et al. using CBCT showed incidental findings in the maxillary sinus was 56.3% [13]. In other study the occurrence of sinus abnormality was 46.8% [8].This may be referred to the difference in the indications of CBCT scans, which were included in the study, variation in the sampling criteria, and the effect of the climate among differences geographical areas [14].

Regarding the genders, there was a significant difference between the genders, showing a greater occurrence of sinus abnormality in Females (57.9%) versus in Males (42.1%) which are different findings from other studies with the males have more frequency of sinus abnormalities [13,15].

We detected that the second decade represents highest percent of abnormalities with no statistically significant difference between different age groups for sinus abnormalities which is similar to the finding of Rege et al. that reported no influence of age on the occurrence of sinus abnormalities [16]. This is in contrast to the Raghav, et al. finding that the patients in the third decade showed more pathologies in the maxillary sinus [17] and also Ritter et al. finding in which the patients more than 60 years more found to be affected [13].

In our study the Mucosal thickening was the most frequently observed abnormality (41.4%) followed by polyps (16%), Increased dimensions of the sinus (10.2%) Decreased dimensions of the sinus (8.3%) Bubbles inside sinus (8.3%) and Retention cyst (2.8%) which are similar to reported results of Raghav, et al. [17]. These findings are different from other studies that found the retention cyst to be the second most common maxillary sinus abnormality [16]. The retention cyst when plain panoramic radiography was used was ranged from 1.4% to 9.6% [18]. Other study using sectional exams obtained by CT and MRI reported a prevalence of 12.4% [19]. The variations in the results among different studies may be referred to different imaging modalities, the differences geographical areas, and variation in sample size [13,20]. The opacification of the sinus was ranged from 5% to 8 % as partial and complete opacification of the sinus respectively . This finding is close to the results of other study that the incidence of occurrence was 7.8% [12]. This opacification may occur with the infection and sinusitis. Opacification can also be found in sinus abnormalities other than sinusitis, such as mechanical trauma and hemorrhage [21].

Regarding the sinus walls, the lower wall of the sinus is the most wall affected in both sides with 42% for left side, and 40% for Right side. These findings are coincide with the result of Rege et al. that may related to a possible odontogenic involvement [16]. The accuracy of detecting periapical lesions is higher with CBCT but these findings should be taken with caution, as chronic periapical lesions detected by a CBCT exam might present low potential for evocating sinusal inflammatory signs and symptoms [22,23]. Different imaging modalities had been widely used for diagnosis of maxillary sinus abnormalities in previous researches and studies and demonstrated a wide range of occurrence from 10.9% up to 69.1% with the majority between 30% and 50% [22]. However , the use of MRI show higher levels of sinus abnormalities than CT scans because of its better sensitivity detection of soft-tissue pathologies [19]. Recently, CBCT is used in many studies for detecting incidental maxillary sinus abnormalities. CBCT as a new 3D imaging modality could be of a great clinical value not only in screening, but also in planning paranasal surgery. Some of the studies reported on the useful application of CBCT for intraoperative imaging of the paranasal sinus [24,25]. The development of CBCT equipment has resulted in better image quality for diagnoses, exposure to lower radiation doses, easier operation and lower cost than CT and maxillary sinus abnormalities can be demonstrated easily on the CBCT images. The early detection of maxillary sinus abnormalities will lead to early treatment and will decrease the incidence of complications. The present study was limited that the nature of fluid cannot be identified as they were blood or pus which appear radiologically the same but still our study shows that the use of CBCT scans is making a great help in early diagnosis of maxillary sinus abnormalities in asymptomatic patients.

Conclusion

The higher incidence of maxillary sinus abnormalities among a symptomatic patients denotes that, the oral radiologists should evaluate the CBCT images with full examination of maxillary sinus and be aware of these sinus abnormalities. This will lead to early detection, treatment and follow up of sinus abnormalities.

Declarations

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Not applicable

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Availability of data and materials

All data collected and analyzed during this study are included in the published article and are available upon request.

Authors' contributions

EE: Collect the data and revised the images with anatomical explanations. EI: Revised CBCT images data. YE: Analyzed the data and performed the statistics. HA, NA, NA, KM: Collect the data. All authors contributed to preparation of the data used in this paper and revised the manuscript critically. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests and no conflicts of interests to disclose.

Consent for publication

The patients gave their informed consent to publish their CBCT images. The consent form is available to the Editor-in-Chief upon request.

Ethics approval and consent to participate

All patients agreed to participate in this study and consented to their CBCT images and to be published. This study was approved by the Ethical Committee of the Research Center of RCsDP

(IRB: FIRP/2015/120) The consent form is available to the Editor-in-Chief upon request.

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