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Radiographic Assessment of Maxillary Sinus Pathologies Using Cone Beam Computed Tomography (CBCT): Prevalence and Distribution Analysis

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Aim: This study aimed to evaluate the prevalence and distribution of pathological findings in the maxillary sinus using Cone Beam Computed Tomography (CBCT) and to analyze their association with demographic factors and dental conditions.
Materials and methods: A retrospective study, one hundred forty-one CBCT images (65 males and 76 female) aged between 8-81 years, their maxillary sinuses were evaluated for presence or absence of any pathological lesion in three planes.
Results: The pathological findings were present in 56.03% of participants. Normal findings were more common on the right side, mucosal thickening scored the highest pathological findings with a prevalence of 43.26% followed by polypoidal mucosal thickening 31.2%, partial and complete opacification were less common. A notable association was found between maxillary sinus pathologies and molar teeth conditions on the right and left side.
Conclusion: The variations that associated with maxillary sinus pathology need a thorough examination. CBCT is recommended to provide an accurate diagnosis and to improve the quality of treatment.

Key words: Quality of treatment, Maxillary sinus pathology, mucosal thickening, CBCT.

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Introduction

The maxillary sinus is an air-filled cavity located within the maxillary bone of the human skull and is one of four paired paranasal sinuses along with the others being the frontal, ethmoid, and sphenoid sinuses. [1]

There is a major difference among individuals in the height of the sinus floor. Sinus anatomical variations, such as septa and sinus floor mucosal thickening raise the risk of sinus membrane perforation in the posterior region of maxilla during surgery for pre-implantation.[2] The importance of maxillary sinuses to dentist is related to their close proximity to the teeth and dental structures, so increased risk of maxillary sinusitis has been reported with periapical abscess, periodontal diseases, dental trauma, tooth extraction, and implant placement. [3] Maxillary sinus pathology that associated with dental infections are points of respect in the field of dentistry and it includes a variety of conditions that related to the sinus which have or haven't combination with dental and periodontal infections.[4,5] The pathologies of maxillary sinuses classified into intrinsic pathologies that originating from walls of the sinus and extrinsic pathologies that originate from outside the sinus, like mucosal thickening, mucosal polypoid, partial or complete opacification, in addition to some other findings either associated with impacted teeth, or root stumps, retention cysts, antroliths, exostosis, oro-antral fistulas, and further a benign or malignant lesions. [6]

The radiographical examination of maxillofacial pathologies offers an accurate diagnostic knowledge which is influential for establishing a final clinical decision with greater quality of treatment.[7] Cone Beam Computed Tomography (CBCT) considered a good alternative to conventional CT scanners and two-dimensional radiography due to its sharpness, practicality, low cost, low radiation dose, and because of its ability to visualize both bone and soft tissue in multiple views. [8,9,10] The suitable slice orientation selected to evaluate the anatomical area required with high diagnostic accuracy compared to conventional radiographs.[11] CBCT is beneficial in identifying the adequate knowledge about the possible anatomical variation, sinus health, incidental pathologies, and measurement of sinus membrane thickness. [12,13,14] The imaging of sinuses preoperatively is highly recommended to estimate the relationship between dental pathologies and sinus abnormalities, however the distribution of pathological lesions in maxilla raises caution of their existing within maxillary sinus. [14,15,16] The present study aims to evaluate the prevalence and distribution of pathological findings in the maxillary sinus using cone beam computed tomography (CBCT) and to analyze their association with demographic factors and dental conditions.

Materials and Methods

Study design and setting

A retrospective study performed by a radiologist in radiology clinic at University of Baghdad/ College of Dentistry/ Department of Oral Diagnostic Sciences. One hundred forty-one CBCT images (65 males and 76 female) retrieved from the archives of the clinic from January 2023 to May 2024.

Sample selection (subjects)

Inclusion criteria include patient attended the clinic for CBCT imaging for various purposes. Exclusion criteria include any images of low quality of resolution or artifacts that impair sinus visualization, and any patient with surgical intervention involving the sinus.

Data collection and outcome measurements

Data collected and evaluated. The patient's age range was 8-81 years and it was classified into six age groups (<20, 20-29, 30-

39, 40-49, 50-59, and >60). About 282 maxillary sinuses (right and left) were evaluated by specialist radiologist for presence or absence of any pathological lesion in three planes (axial, coronal, and sagittal) as in figure 1 such as:

1. Mucosal thickening: observed as a thick radiolucent bands more than 3 mm on any wall of sinuses.
2. Polypoid mucosal thickening: observed as soft tissue bulging within sinus walls.
3. Opacification: observed as radiodense sinus either complete or partial with a recognized air-fluid level.

Ethical consideration

Informed consents were already obtained from all the patients attended the clinic according to the protocol of hospital. All procedures that performed in the studies involving human participants were in accordance with the ethical standards of the 1964 Helsinki Declaration. This study approved by the ethical committee/College of Dentistry/University of Baghdad (project no. 937724 in 29/8/2024).

Statistical analysis

The statistical analysis was done by using Microsoft excel version 2010 and GraphPad Instant program. A distribution and statistical analysis for age groups, gender, maxillary sinus side, presence and absence of pathological findings and their relation with molar teeth conditions were performed using chi-square test (P-value significant at $p<0.05$).

Results

One hundred forty-one CBCT images of patients were retrieved from the archive and MS evaluated. Out of a total of 141 individuals, 65 were male (46.1%) and 76 were female (53.9%). The chi-square test yielded a p-value of 0.935, indicating that the difference in gender distribution was not statistically significant ($p>0.05$). Age group distribution of participants shows that the majority were between 20-29 years old (45 case, 31.91%), followed by those under 20 (31 case, 21.99%), and 30-39 years old (26 case, 18.44%). Smaller percentages were noted in the age groups 40-49 (8 case, 5.67%), 50-59 (16 case, 11.35%), and over 60 (15 case, 10.64%). The chi-square test yielded a highly significant p-value of 0.0001, indicating a significant difference in age group distribution ($p<0.001$).

Pathological findings were present in 56.03% of participants, with 46.1% having findings in the right maxillary sinus (MS) and 43.26% in the left MS. The chi-square test revealed a p-value of 0.0154, indicating a significant prevalence of pathological findings ($p<0.05$). as shown in table 1.

Table 1: Distribution and Statistical Analysis of overall prevalence of pathological findings in the maxillary sinus

Presence/absence of pathological findings	N (%)			P Value
	Right MS	Left MS	Overall findings	
Overall pathological findings	56 (46.1%)	61 (43.26%)	79 (56.03%)	**0.0154***
No pathological findings	85 (60.28%)	80 (56.74%)	62 (43.97%)	

Chi-square test, n: number of subjects, %: frequency, MS: Maxillary Sinus, * P-value significant at p<0.05

The absence or the presence and the types of pathological findings in the right and left maxillary sinus was shown in table 2. Normal findings were more common on the right side (60.28%) compared to the left (56.74%). Thickening of the sinus membrane was observed in 16.31% (right) and 26.95% (left). The presence of polypoidal mucosal thickening was relatively equal (16.31% right, 14.89% left). Partial and complete opacification were less common. The chi-square test indicated a significant difference with a p-value of 0.0369 ($p<0.05$).

Table 2: Distribution and statistical analysis of pathological findings in the maxillary sinus (right and left)

Presence/absence of pathological findings	N (%)		P Value
	Right MS	Left MS	
Normal MS	85 (60.28%)	80 (56.74%)	0.0369*
Mucosal thickening	23 (16.31%)	38 (26.95%)	
Polypoidal mucosal thickening	23 (16.31%)	21 (14.89%)	
Partial opacification	5 (3.55%)	2 (1.42%)	
Complete opacification	5 (3.55%)	0 (0%)	
Total	141 (100%)	141 (100%)	

Chi-square test, n: number of subjects, %: frequency, MS: Maxillary Sinus, * P-value significant at p<0.05

Pathological findings varied across age groups. The highest prevalence of normal sinus findings on the right side was in the 20-29 age group (17.73%) comparing to (17.02%) on the left side at the same age group, while highest prevalence of pathological findings was recorded in age group 50-59 years, the chi-square test in right side yielded a significant p-value of 0.0180, indicating a significant difference in pathological findings among age groups (p<0.05). In the left side the age group 20-29 years show the highest prevalence of pathological findings, the chi-square test showed a non-significant p-value of 0.1172, indicating no significant difference in pathological findings among age groups (p>0.05). as shown in table 3.

Table 4 compares the prevalence of pathological findings between genders. Normal findings were slightly more common in females on both the right (31.91%) and left (32.62%) sides. Thickening was higher in females on the left side (14.18%) compared to males (12.77%). Polypoidal mucosal thickening were equally prevalent among males on both sides (7.80%). Partial and complete opacifications were less common, with no significant differences between genders (p>0.05 for all comparisons).

Table 5 explores the relationship between pathological findings and the condition of molars. Mucosal thickening was more frequent in the left MS with edentulous conditions (4.26%) and roots inside the sinus (4.96%). Polypoidal thickening was more common with roots inside the right MS (2.84%). Partial and complete opacifications were rare, with isolated cases associated with specific dental conditions.

Discussion

In the present study the overall prevalence of pathological findings was 56.03% that is in accordance with studies conducted by Ritter et al.[17] that showed 56.3%, and closed to the results of Chandran, et al.[15] and Kihara et al.[18] studies that showed the same percentage 58%. Other studies showed relatively less prevalence of pathologic findings than that found in the present study Cha et al.[19] shows 24.6% and Lim and Spanger [20] show 27.5%, the variations among the studies could be due to sample size studied that selected according to specific criteria considering as pathology in these studies, while Rege et al.[21] reported 68.2% larger than overall prevalence of our study which might be related to greater number of possible included cases.

Table 3: Distribution and statistical analysis of pathological findings in the maxillary sinus according to age group in right and left side.

Right side							
Age group	Pathological findings n. (%)						
	Normal MS	Mucosal thickening	Polypoidal Mucosal thickening	Partial opacification	Complete opacification	Grand Total	P value
<20	20 (14.18%)	3 (2.13%)	5 (3.55%)	0 (0%)	3 (2.13%)	31 (21.99%)	0.0180* P-value significant at p<0.05
>60	11 (7.8%)	2 (1.42%)	2 (1.42%)	0 (0%)	0 (0%)	15 (10.64%)	
20-29	25 (17.73%)	7 (4.96%)	11 (7.8%)	2 (1.42%)	0 (0%)	45 (31.91%)	
30-39	17 (12.06%)	4 (2.84%)	0 (0%)	3 (2.13%)	2 (1.42%)	26 (18.44%)	
40-49	7 (4.96%)	0 (0%)	1 (0.71%)	0 (0%)	0 (0%)	8 (5.67%)	
50-59	5 (3.55%)	7 (4.96%)	4 (2.84%)	0 (0%)	0 (0%)	16 (11.35%)	
Grand Total	**85 (60.28%)**	**23 (16.31%)**	**23(16.31%)**	**5 (3.55%)**	**5 (3.55%)**	**141 (100%)**	
Left side							
<20	18 (12.76%)	9 (6.28%)	4 (2.84%)	0 (0%)	**0 (0%)**	31 (21.99%)	0.1172 NS P-value non-significant at p>0.05
>60	9 (6.28%)	4 (2.84%)	1 (0.71%)	1 (0.71%)		15 (10.64%)	
20-29	24 (17.02%)	8 (5.67%)	13 (9.22%)	0 (0%)		45 (31.91%)	
30-39	15 (10.64%)	9 (6.28%)	1 (0.71%)	1 (0.71%)		26 (18.44%)	
40-49	5 (3.55%)	1 (0.71%)	2 (1.42%)	0 (0%)		8 (5.67%)	
50-59	9 (6.28%)	7 (4.96%)	0 (0%)	0 (0%)		16 (11.35%)	
Grand Total	**80 (56.74%)**	**38 (26.95%)**	**21 (14.89%)**	**2 (1.42%)**		**141 (100%)**	

Table 4: Distribution and Statistical Analysis of Pathological Findings in the Maxillary Sinus (Right & Left) According to Gender

pathological findings	Right MS		Left MS		P value
	Total number	(%)	Total number	(%)	
normal	**85**	60.28%	**80**	56.74%	
Female	45	31.91%	46	32.62%	**P**= 0.55
Male	40	28.37%	34	24.11%	
Mucosal thickening	**23**	16.31%	**38**	26.95%	
Female	15	10.64%	20	14.18%	**P**= 0.33
Male	8	5.67%	18	12.77%	
Polypoidal mucosal thickening	**23**	16.31%	**21**	14.89%	
Female	12	8.51%	10	7.09%	**P**= 0.76
Male	11	7.80%	11	7.80%	
Partial opacification	**5**	3.55%	**2**	1.42%	
Female	3	2.13%	**0**	**0%**	**P**= 0.14
Male	2	1.42%	2	1.42%	
Complete opacification	**5**	3.55%	0	0%	
Female	1	0.71%	**0**	**0%**	
Male	4	2.84%	0	0%	
Grand Total	**141**	**100%**	**141**	**100%**	

Table 5: Distribution of Side-Finding with Condition of Molars in Maxillary Sinus (Right and Left)

Pathology	Maxillary sinus	edentulous	root inside	Endo.	implant	P.A lesion	Ortho.	Tooth bud
Mucosal Thickening	Right	4 (2.84%)	3 (2.13%)					
	Left	6 (4.26%)	7 (4.96%)		2 (1.42%)	2 (1.42%)		
Polypoidal mucosal thickening	Right	1 (0.71%)	4 (2.84%)	2 (1.42%)	1 (0.71%)			
	Left	2 (1.42%)	3 (2.13%)					
Partial Opacification	Right	1 (0.71%)					2 (1.42%)	
	Left	1 (0.71%)						
Complete opacification	Right				1 (0.71%)			1 (0.71%)
	Left							

Regarding right and left side, out of 141 patients, 46.1% having findings in the right maxillary sinus (MS) and 43.26% in the left MS as against overall 43.97% in which no pathologic findings were detected in right and left side MS, Chandran, et al.[15] study show 42% with no pathologic findings. When the mucosa of maxillary sinus showed thickening, a pathology is suspected which may followed by a failure of implant or acute sinusitis, in this study mucosal thickening scored the highest pathological findings with a prevalence of 43.26% (16.31% in the right and 26.95% in the left) similar to Kihara et al.[18] who found 43%, Shiki et al.[22] (49%) and Dobele et al.[23] (48.5%), Sanaullah et al.[12] also found the most prevalent finding was mucosal thickening, with an overall prevalence of 35% pathology, the right and left sides was non-significant statistically regarding to mucosal thickening. Another study conducted by Mudgade et al.[7] reporting an overall prevalence of mucosal thickening was found to be 29.3%. The variation of the results might be caused by the classification system applied in different studies, or differences in measurement criteria. In our study, polypoidal thickening was secondly observed with a prevalence of 31.2% (16.31% right, 14.89% left) in harmony with Chandran et al.[15] studies who reported 36.7%. Other studies results were with lower prevalence, Raghav et al.[24] showed 7.2% prevalence for polypoidal mucosal thickening and Kihara et al.[18] reported 15%. Any variation among different studies could be associated with various definitions of polypoidal thickening of mucosa.

Partial and complete opacification were less common prevalence, 4.97% (right 3.55%, left 1.42%) of partial type was found in our study sample that was closed to Lim and Spanger [20] they revealed a 2.3% of total prevalence, furthermore Sanaullah et al.[12] reported 5% prevalence of partial opacification in in the right sinus and 3.5% in the left sinus. Regarding to complete opacification it was the least found 3.55% (right 3.55%, 0% left) Sanaullah et al.[12] found 4% of completely radio-opacified sinuses in the right, and 3.5% in the left, Chandran et al.[15] reported only 0.7% and Dobele et al.[23] found 2.9% prevalence among their participants, the climate during the patient's collection period might affect the variations of the studies result in addition to the diversity in the geographic regions of population.

Regarding to age group the relation indicates that the age group 50-59 years had the highest prevalence of pathologies in the right side 68.75% (represented as mucosal thickening and polypoidal mucosal thickening respectively), most prevalence

was in age group 20–29 years in the left side 46.66% (represented as polypoidal mucosal thickening and mucosal thickening respectively). A study by Alotaibi [3] observed that the most frequent pathological findings allover was in middle age group between 30 to 50 years. Chandran, et al.[15] also notice that overall prevalence of pathologic was in age group of 30–39 years form (50%) of the subjects. These variations seem to be as a result of different age distribution of patient age groups included in different studies. A remarkable difference was also observed in overall relevance of findings to gender where in female patients on both the right (31.91%) and left (32.62%) sides have no pathologies versus male patients where the prevalence scored (28.37%) on the right and (24.11%) on the left side, On the contrary Chandran, et al.[15] reveal that 48.2% of female patients and 34.3% of male patients were pathology free. Mucosal thickening was higher in females compared to males, polypoidal mucosal thickening were equally prevalent among males and females. Partial and complete opacifications were more in males than females, with no significant differences between genders ($p>0.05$ for all comparisons). Alotaibi [3] reported a significant difference in genders, with a higher existence of pathological findings in males 66.7% against 33.3% females, while Malik et al.[25] found a higher frequency of pathological findings in males, but the result was not statistically significant. This contradiction can be reverting to demographic differences.

For realization the link of dental health and the pathology of sinus, the odontogenic condition should have identified as a predisposing factor for maxillary sinus disorders. [26,27] This study explored the association of sinus pathologies with the condition of molar teeth. Mucosal thickening scored the highest pathological findings in relation to roots inside the sinus (4.96%) and edentulous patients (4.26%), with (1.42%) related to dental implant and periapical lesions in the left side. While polypoidal thickening was more common with roots inside the right side (2.84%). Partial and complete opacifications were rare. Altwaijri et al.[27] study show that the periapical findings were recognized in 22.4 % on the right side and 28.7 % on the left side. Pathologies concerning to dental implant were less common, showing 1.9 % in right side and 0.7 % in left side, while odontogenic cyst form the smallest rate of 0.2 % in both right and left side.

Conclusion

There are lot of variations associated with maxillary sinus pathology that need a thorough examination. CBCT is recommended to provide an accurate diagnosis and to improve the quality of treatment.

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Data availability

Data can be shared upon reasonable request.

Ethics approval and consent to participate

Informed consents were already obtained from all the patients attended the clinic according to the protocol of hospital. All procedures that performed in the study involving human participants were in accordance with the ethical standards of the 1964 Helsinki Declaration. This study approved by the ethical committee/College of

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Competing interest

The authors have no conflict of interest to declare publication

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Figure1: CBCT images of maxillary sinus pathologies: a-coronal view of polypoidal mucosal thickening in the both MS, b- coronal view of mucosal thickening in the left MS, c- axial view of complete opacification of right MS, d- axial view of partial opacification in the left MS.