ORIGINAL RESEARCH

Occurrence of Abnormalities and Anatomical Variations in Maxillary Sinus detected by CBCT

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ABSTRACT

AIM: The current study aims to determine and investigate maxillary sinus abnormalities and anatomical variations in patients, by using Cone Beam Computed Tomography. **MATERIALS AND METHODS:** The cross sectional study was carried out in the Department of Oral Medicine and Radiology, Meenakshi Ammal Dental College and Hospital, Chennai and it consisted of 100 subjects from age groups of 14- 65 years. Scanning of Maxillary sinuses was performed with Planmeca Proface Cone Beam 3D imaging system and assessed using Romexis software. **RESULTS:** The mean revealed that right sinus had an increased mesio lateral width, the left sinus had an increased superoinferior and anteroposterior length and the volume of the right sinus was comparatively increased than left sinus. The most common finding was the mucosal thickening (37.5%), followed by antral septa (24.6%), opacification (12.9%),and sinus hypoplasia(9.6%), polyps(4%), inflammatory cysts(2.9%), fracture(0.7%) and aplasia (0.7%) were all statistically significant. Following this, the sexual dimorphism of the maxillary sinus also proved to be statistically significant. **CONCLUSION:** The obtained results highlight that the maxillary sinus exhibits a number of abnormalities as well as anatomical variations which might in turn predispose to a chronic sinus infection. In addition to this, it also proves that the incidence of maxillary sinus pathologies which are detectable in CBCT images are not only taken for evaluation of Sinus infections but also for other dental purposes, thereby insisting their importance in Diagnostic radiology.

KEYWORDS: Maxillary Sinus, Abnormalities, Anatomical Variations, Cone Beam Computed Tomography, Sinus Pathology

INTRODUCTION

Cone Beam computed tomography is a widely recognized advancement in the recent years in terms of diagnostic imaging in dentistry. Being a three dimensional imaging modality, pioneered by Mozzo et al 1998 and Aral et al 1999. It is custom-designed for the evaluation of hard tissues in the craniofacial area and has been in use since 1998. However, an interpretation of CBCT images requires familiarity with the anatomy of the area under investigation, an understanding of the spatial relationships of the image volume, a sound knowledge of the possible diseases, anatomical variations and abnormalities which affect the maxillofacial area and, finally, competence when formulating a differential diagnosis.[1,2]

The study aims to determine and investigate maxillary sinus abnormalities and anatomical variations in patients, by using Cone Beam Computed Tomography. The objective of the study is to determine the ***frequency*** of the maxillary sinus abnormalities and variations, to find the ***type*** of such disorders and to locate their ***site*** of occurrence within the sinus, to determine the distance between the floor of the sinus and the roots of the upper first molar and to classify them accordingly, and in addition, to correlate between the maxillary sinus disorders and their proximity to the apex of maxillary first molar tooth, to compare the sinus dimensions and the volume in males and females and to establish a sexual dimorphism using the obtained parameters.[3]

MATERIALS AND METHODS

The cross sectional study was carried out in the Department of Oral Medicine and Radiology, Meenakshi Ammal Dental College and Hospital, Chennai. The study population consisted of 100 subjects from age groups of 14- 65 years. Ethics Research Committee approved the study. Right and Left Maxillary sinuses were scanned with Planmeca Proface Cone Beam 3D imaging system.

Selection Of Subjects: The study was conducted among the outpatients who visited Department of Oral Medicine and Radiology, Meenakshi Ammal Dental College and Hospital, Chennai. The study population consisted of 100 subjects from age groups of 14- 65 years out of which 55 were females, and 45 were males. CBCT images were taken for subjects had been referred for diagnosis and

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treatment planning which included Orthodontics, Endodontics, Maxillofacial Surgery, ENT and dental implants. The involved patients who were included in the current study had, at least, one sinus related history with or without any medication intake.

Inclusion Criteria: Inclusion criteria comprised of CBCT exams which showed the entire maxillary sinuses bilaterally or, at least, the four sinus walls, independently of whether the whole maxilla and other anatomical structures are visualized or not.

Exclusion Criteria: Exclusion criteria comprised of patients under 14 years of age, because of their incomplete sinus development. Images of low resolution quality and those in which the presence of metallic artifacts impaired sinus visualization was excluded.

Methods: Patients who fulfilled the above mentioned criteria were informed about the study and a signed consent form was obtained. The enrolled subjects were interviewed, clinically examined and details were recorded in a prepared case sheet proforma.

All individuals were made to wear lead apron and thyroid collar and exposed using CBCT machine.

The screening procedure was undertaken to identify the presence/absence of sinus abnormality and orthogonal views of coronal, axial, sagittal scans.

The classification criteria to detect the presence of an abnormality included identification of atleast one of the following deviations from the normality.

1. Increased/decreased dimension of sinus
2. Radiographic density changes in cortical bone of sinus
3. Partial or complete opacification of sinus cavity
4. Increased thickening of mucosa greater than 3mm in any of the walls.

The data was analysed using descriptive statistics, and the linear dimensions and volume changes were detected by Romexis Software, however the sinus volume was calculated by substitution of the formula:

Volume of maxillary sinus = length x breadth x height x 1/3 [50]

Statistical Analysis: The data that was obtained was tabulated and analysed with SPSS 16.0 version.

RESULTS

The CBCT examinations of 100 patients were included in the study, 55 of which were female and 45 of which were male. Their ages ranged from 14 to 65 years (mean: 39.5). The exams had been undertaken for diagnostic purposes, such as implant planning, endodontic exam, surgical planning, oral disease diagnosis, TMJ dysfunction, orthodontic diagnosis, traumatology and ENT referral.

The collected data was analysed with SPSS 16.0 version. To describe about the data descriptive statistics the cross tabulation, frequency analysis, percentage analysis were used for categorical variables and the mean & standard deviation were used for continuous variables. To find the significant difference between the bivariate samples in independent groups, Unpaired Sample T-Test was used. To find the significance in categorical data Chi-Square test was used. In both the above statistical tools the probability value .0005 was considered as significant level.

The mean of dimensional analysis of the right and left sinus revealed that the right sinus has an increased medio lateral width, the left sinus has an increased superoinferior and anteroposterior length and the volume of the right sinus is comparatively increased than the left sinus. The most common finding being the mucosal thickening (37.5%), followed by antral septa (24.6%), opacification (12.9%), and sinus hypoplasia(9.6%), polyps(4%), inflammatory cysts (2.9%), fracture(0.7%) and aplasia (0.7%) were all statistically significant. The Levene's test revealed 95% of confidence interval of difference. The cross tabulation and the Chi squared test of the maxillary sinus abnormalities were statistically significant (Table 1).

			RL		Total
			Right	Left	
TYPE	Sinus polyps	Count	5	6	11
		% of Total	1.8%	2.2%	4.0%
	Antral septa	Count	34	33	67
		% of Total	12.5%	12.1%	24.6%
	Aplasia	Count	1	1	2
		% of Total	.4%	.4%	.7%
	Fracture	Count	1	1	2
		% of Total	.4%	.4%	.7%
	Hypoplasia	Count	13	13	26
		% of Total	4.8%	4.8%	9.6%
	Inflammatory cysts	Count	3	5	8
		% of Total	1.1%	1.8%	2.9%
	Mucosal thickening	Count	55	47	102
		% of Total	20.2%	17.3%	37.5%
	Mucous retention cyst	Count	4	7	11
		% of Total	1.5%	2.6%	4.0%
	Odontogenic cysts	Count	2	6	8
		% of Total	.7%	2.2%	2.9%
	Opacification	Count	17	18	35
		% of Total	6.3%	6.6%	12.9%
Total		Count	**135**	**137**	**272**
		% of Total	49.6%	50.4%	100.0%

Table 1: Right And Left Sinus Cross Tabulation

Distribution of wall location of other abnormalities maxillary sinus within the geometric volume of the sinus (Table 2) and the Distribution of wall location of other abnormalities maxillary sinus within the geometric volume of the sinus (Table 3) revealed that the floor of the sinus was more commonly involved. Frequency of periapical lesion classification in relation to the proximity of the sinus floor and type of inflammatory abnormalities (Table 4) revealed that in Class I, II and III there were 203, 33 and 13 numbers of abnormalities respectively and the cross tabulation of the above data also proved to be statistically significant. Following this, the mean dimensions and volumes of the right and left sinus were compared between males and females (Graph 1), which

Sinuses	Medial	Floor	Lateral	Roof	Anterior	Posterior
Right	23	45	23	9	4	2
Left	17	33	14	7	3	3
Total	40	78	37	16	7	5

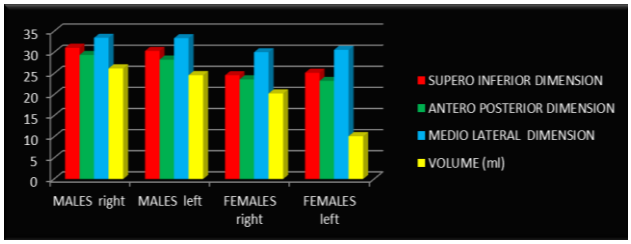
Table 2: Distribution of wall location of mucosal thickening of maxillary sinus within the geometric volume of the sinus

Sinuses	Medial	Floor	Lateral	Roof	Anterior	Posterior
Right	2	7	-	1	-	1
Left		8	-	4	-	1
Total	2	15	-	5	-	2

Table 3: Distribution of wall location of other abnormalities maxillary sinus within the geometric volume of the sinus

Abnormality	Classification			Total
	Class I	Class Ii	Class Iii	
None	88	6	4	98
Mucosal Thickening	84	16	8	108
Opacification	22	9	1	32
Retention Cyst	9	2	-	11
Total	203	33	13	**249**

Table 4: Frequency of periapical lesion classification of proximity of the sinus floor and type of inflammatory abnormalities.



Graph 1: Mean values of the dimensions and volume of right and left sinus in males and females

revealed that the dimensions and volume of the sinus in males was comparatively larger than that of females, and thus the sexual dimorphism of the maxillary sinus proved to be statistically significant.

Hence from the above obtained results, it is evident that maxillary sinus exhibits a number of abnormalities as well as anatomical variations which might, in turn, predispose to a chronic sinus infection. Thus the above study proves the incidence of maxillary sinus pathologies which are detectable in Cone Beam CT images that are not only taken for Sinus infections but also taken for other dental purposes, thereby insisting their importance in Diagnostic radiology.

DISCUSSION

Several studies have reported a great variability in the prevalence of abnormalities in the maxillary sinuses when multiplanar images are used. CT scanning studies revealed that approximately 30% of cases and CBCT studies reported a prevalence ranging from 24.6% to 56.3%. In our study, we detected anatomical variations and abnormalities in almost all of the cases. Discrepancies in abnormality rates occur due to several factors, namely dissimilarities in sampling criteria, variations in image interpretation and diagnostic criteria and influence of the climate among differences geographical areas.

In our study we found higher prevalence of abnormalities than *Ritter et al.* (2011), probably due to the fact that we investigated a greater number of possible causes of alterations in maxillary sinus, such as odontogenic lesions, benign and malignant lesions, acquired and congenital lesions, bone related, traumatic and iatrogenic lesions.[16] *Rege et al.* evaluated the occurrence of maxillary sinus abnormality using CBCT, and reported that mucosal thickening was the most prevalent abnormality (66%), followed by retention cyst (10%), and opacification (7.8%).[1] In another study, *Ritter et al*, *Phothikhun et al* and *Pazera et al* showed that mucosal thickening was the most frequent pathology in the maxillary sinus.[16,30] In *Smith's* study, mucosal thickening was found in 19.4%. It is generally associated with some kind of irritation, such as odontogenic pathology or allergic phenomena. Non vital posterior maxillary teeth, periodontal abscesses, retained roots, embedded or impacted teeth, extensively carious teeth and oro-antral fistulae could be etiological factors in pathologies of odontogenic origin.[26] In our study, we found out mucosal thickening in about 37.5 % cases and it was also the most prevalent abnormality recorded. *Rak et al* reviewed 128 MRI images of paranasal sinuses and found out that 3mm of mucosal thickening was significantly related to clinical symptoms.[34] In our study, our reference range of mucosal thickening was 3mm which was measured using the Romexis measurement tool.

Gracco et al concluded that age is a significant predictor of mucosal thickening, in a way that subjects aged 41–60 years showed a 40.1% higher odds-ratio than those aged 12–18 years.[30] However, *Lesserson et al*. and *Tatil et al.* reported that no correlation was found between age and sinus abnormalities. We detected no influence of age on the occurrence of sinus abnormalities. While our sample covered a wide range of ages, it did not include patients under 14-years old because the formation of their Maxillary Sinus is still incomplete and certain abnormalities such as mucosal thickening and opacification are common findings in early childhood and are not indicative of sinus disease.[26] *Nam and Lee and Min et al.* in their study have reported incidences of 36.3% and 38% for the asymptomatic Korean population using CT. Studies based on the panoramic imaging found the prevalence of mucosal changes in the maxillary sinus of 12% for Mucosal thickening.[24,25]

Maloney and Doku et al stated that 10-12% 0f sinusitis cases have an odontogenic source.[23] *Obayashi et al* found out that 71.3% of cases of dental infection were associated with changes in maxillary sinus.[23,25,26] In our study, we had classified the level of upper maxillary molar relationship in accordance with the floor of sinus that also revealed significant results. The cross tabulation (Table:2) between the classification of periapical lesions

and types of abnormality (mucosal thickening, opacification and retention cyst) showed that there was no difference in the distance of periapical lesion classification according to presence and type of inflammatory abnormality.

In our study, septation of maxillary sinus was the most common CBCT finding which had not been recorded in any other specific study. In a recent study, *Beaini et al.* concluded that CBCT could be a useful method in the evaluation of such anatomical variations.[26] *Cho et al.* reported that 41.8% of patients had opacification in at least one paranasal sinus. The ethmoid (28.4%) and maxillary (27.8%) sinuses were among the most frequently involved ones.[26] In our study, opacification was found in about 12.9 % (6.3% in Right side and 6.6% in the Left side) and it was also categorised as whether it was partial or complete. Patients who were present with such abnormality revealed in clinical examination that they had loss of sensation of smell, pain the sinus region during bending and unexplained pain in the upper molar teeth. However, sometimes opacification can also be found in abnormalities other than sinusitis, such as mechanical trauma, barotraumas and hemorrhage.

Uthman A.T in 2011 and *Amusa YB et al* in 2011 studied 24 dried skulls of Nigerians. The height, width, depth and volume of each of the sinuses were determined. In all the paranasal sinuses, the right side was found to be larger than the left except for the maxillary sinus where the left side was found to be larger.[35] In our study, the mean value of the two parameters namely the superoinferior dimension and the anteroposterior dimension was found to be larger in the left sinus (Right : SI: 26.99mm, AP: 31.26mm; Left: SI: 27mm, AP: 31.71mm), however the mediolateral dimension and the volume sinus was found larger in the right sinus (Right: ML: 31.26mm, Volume: 7.72ml; Left: ML: 31.71mm, Volume: 7.68ml) *Shahbazian et al.* study revealed symmetric morphology of maxillary sinus in 83% of patients, while the remaining patients (17%) showed a predominant asymmetric morphology. Moreover, *Ohba et al.* radiologically compared the depth of the sinus floor and did not observe statistical differences between the right and the left sides.[29]

The floor of the sinus was the most affected location within the sinus, which would suggest a possible odontogenic involvement. However, considering that the CBCT increases the accuracy of detecting periapical lesions, these results should be interpreted with caution, since incipient and chronic periapical lesions detected by a CBCT examination might present low potential for evocating sinusal inflammatory signs and symptoms. The low prevalence of abnormalities in the upper sinus wall may also have been influenced by the limited visualization of this region due to the small FOV (6 cm) commonly used for this examination. In our study, the floor of sinus was involved in about 93 cases and the rest of the walls of sinus were involved to a lesser extent comparatively.

In our study, mucous retention cysts was found in about 4% of cases and it was the fifth most common finding, the first 4 being Mucosal thickening (37.5%), antral septa(24.6%), opacification (12.9%),and sinus hypoplasia (9.6%). Other study using sectional examinations obtained by CT and MRI reported a prevalence mucous retention cysts in of 12.4%. According to *Karamody and Bassiouny* maxillary sinus hypoplasia can be seen in ranges between 1.73 and 10.4% of symptomatic patients. The radiographs (panoramic, intraorals or Water's projection) demonstrate Maxillary Sinus Hypoplasia with full or partial radiopacity engaging maxillary sinus or sinuses.[28] CBCT is cheaper, largely available in dental offices and lead to relatively lower radiation dose in comparison with CT. The silent sinus syndrome is a spontaneous unilateral maxillary atelectasis with complete or partial opacification of the sinus. According to *Hourany et al* Silent sinus syndrome is a rare disorder, but it is probably under-diagnosed because of a lack of recognition. The typical patient with silent sinus syndrome, is an adult in the third to fifth decades of life who presents with spontaneous, painless, and occasionally progressive enophthalmos and hypoglobus.[31] Thickening of the sinus walls is probably related to chronic inflammation and not to underlying developmental hypoplasia. Surgical or other trauma to the maxilla and sinus ostium may play a role in the pathogenesis of this condition. In our study, about 9.6% of subjects had Sinus Hypoplasia. However other clinical symptoms were not confirmatory of Silent sinus syndrome.

Antral septa was defined as a pointed bone structure and maxillary sinus exostosis as a rounded bone structure, both originated from any maxillary sinus wall (*Naitoh et al. 2009).*[36] It is important to emphasize that antral septa, detected in almost half of the CBCT examinations evaluated, might increase the risk of sinus membrane perforation during the maxillary sinus floor elevation surgery (*Tatum 1986; Betts & Miloro 1994; Krennmair et al. 1999; Van den Bergh et al. 2000)*. The accidental perforation of this membrane can lead to development of acute or chronic sinusitis, as well as subsequent bone graft resorption (*Abrahams et al. 2000; Aimetti et al. 2001*). Furthermore, antral septa can difficult the lifting of the bone plate and of the sinus membrane during surgery (*Tidwell et al.1992*). In our study, the no of subjects who presented with antral septa were 67 (right sinus: 34, left sinus: 33) which was comparable with studies given by the previous authors. Out of the total number of patients, there was histologically proven Sinus Aspergillosis, Sinus Keratocystic Odontogenic tumor, Infected cyst of Maxillary sinus, Mucormycosis of Maxillary sinus, Plexiform Neurofibromatosis causing sinus hypoplasia and Osteopetrosis causing aplasia of maxillary sinus.

Henceforth, the current study is conclusive of the aims and Objectives mentioned. However a larger sample size would put light in revealing more number of maxillary sinus pathologies.

CONCLUSION

The higher occurrence of abnormalities in asymptomatic Maxillary Sinus emphasizes how important it is for a dentomaxillofacial radiologist to undertake a comprehensive interpretation of the whole volume acquired in CBCT images, including the entire Maxillary Sinus. This may be considered in the individual clinical context of signs and symptoms, reducing the risk of overestimat ion of the real impact of radiographic findings.

Although oral radiologists or dentists are not expected to treat conditions outside of professional knowledge and expertise, they are not exempt from the moral responsibility of identifying these potential pathologies of maxillary sinus in the CBCT scan image. If any concerns are present, then it could be beneficial to the patient, and they can be thus referred to the concerned specialist for treatment of such pathologies.

On the whole, oral radiologists and dentists should make appropriate use of the current Advancement in Orofacial Diagnostics in order to be attentive to these findings in order to provide comprehensive health care for their patients.

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