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Interrelationship between Dental Pathology and Maxillary Sinus Pathology –A CBCT Study

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Abstract

Purpose: To find the interrelationship between maxillary sinus pathology and dental pathology: a CBCT study.

Methodology: A cross sectional study was perfomed .A total of 36 patients were included in this study which were divided into two groups: Group 1- Sinusitis of Non Odontogenic Origin. Group 2-Sinusitis of Odontogenic Origin

The patient ages ranged between 7 and 82 years of both male and females were included. Subjects for the study were selected through detailed case history, clinical examination and radiographic screening. Radiographic screening with OPG and PNS . Subjects who fulfilled the given clinical and radiographic criteria were subjected to **CBCT(CBCT MACHINE-KODAK).** Patients referred from **ENT DEPT** which were Diagnosed cases of Maxillary sinusitis were evaluated for any odontogenic infection and were subjected to CBCT .

Results: Root relation in Group 2 (Sinusitis of odontogenic origin) for cbct was significant i.e roots penetrating sinus and in close proximation can lead to sinus changes CBCT findings of sinus changes in relation to root were significant for group 1 and 2 in more significant for group 2. Root relation to sinus floor was insignificant for Group 1 (Sinusitis of non odontogenic origin)and 2 (Sinusitis of non odontogenic origin)in OPG and PNS. In our study 57.1% of cases in Group 1 and Group 2 in which root penetrating the sinus have mean distance of 1-2.9 mm and CBCT findings stated that Haziness was significant in Group 2 patients.(odontogenic origin). In our study maxillary second premolar and first molar are most commonly involved.

Conclusion: Sinusitis of odontogenic origin can lead to changes in sinus when compared to sinusitis of non odontogenic origin ie dental pathology and periapical infection can lead to max sinus changes .Relation of root

to sinus is better visualized in CBCT than in PNS and OPG . CBCT is more sensitive imaging modality as compared to OPG and PNS

Keywords: Cone-Beam Computed Tomography, Maxillary Sinus, odontogenic,

Introduction

The development of maxillary sinus in closed proximity to the oral cavity resulted in anatomic reality where the disease from each of the area would affect each other. [1]

The pyramid of antrum of Highmore is lying on its side with base formed by lateral wall, facial wall, orbital wall the pterygomaxillary wall and the palatal wall all narrowing into a vertex which is located into a zygomatic process. **(Fig 1)**

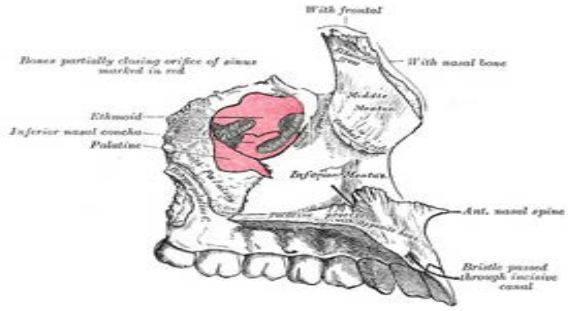


Fig 1: Anatomy of maxillary sinus

This physiological and anatomical leads us to look for the impact of maxillary sinus pathology into for different walls mentioned above. Of these we will be focusing on pathology which impacts on the facial wall and the palatal floor.**(Fig 2)**

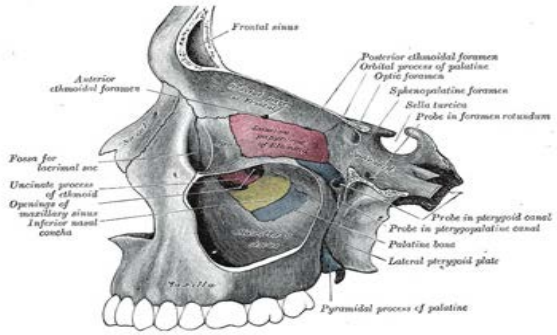


Fig 2-Anatomy of maxillary sinus

Eberhardt JA (1992)16 stated that the imaging of periapical radiograph and of Waters Waldron view have been classically associated with the imaging and radiographic interpretation of maxillary sinus disease. These methods evolved further by modalities like Tomography and some invasive techniques like sonography. Ultimately the CBCT (Cone Beam Computed Tomography) was developed as a part of the reconstruction and reformatting modalities made possible by information technology and high speed computers.[2]

Dentofacial pain in the danger triangle of face usually causes a diagnostic problem with emergency action required. The oral physician has to a certain whether the pain is coming from the maxillary dental complex or form the deeper structure like floor of orbit ,maxillary sinus infections of parotid or spreading infection of mastoid process. The differentiating factor becomes easier if three dimensional scan of anatomical and pathological process can be imaged. The first historical reference of spread of periapical inflammation to the maxillary sinus was describedin Bauer in 1943.[3] The three dimensional visualization of anatomy of maxillary sinus ultimately cannot be seen by a diagnostician by two dimensional radiography of Intraoral periapical radiography, OPG (Orthopantomogram) PNS (Paranasal sinus) view The tomography adds the element of movement and slight haziness in selected areas. All this was overcome by the development of CT (Computed Tomography) scans and subsequently its new avatar “The CBCT”. CBCT has created the imaging revolution which gives amazing diagnostic information to have an accurate treatment plan.. [2]

Michelle M et al (2011) in his study examined Eighty-two CBCT scans previously identified as showing maxillary sinus pathosis were examined and concluded that One hundred thirty-five maxillary sinusitis instances

with possible odontogenic origin were detected. Of these, 37 sinusitis occurrences were from non-odontogenic causes, whereas 98 instances were tooth associated with some change in the integrity of the maxillary sinus floor .The average amount of mucosal thickening among the sinusitis cases was 7.4 mm.[4] Maxillary first and second molars were 11 times more likely to be involved than premolars, whereas either molar was equally likely to be involved. The root most frequently associated with odontogenic sinusitis is the palatal root of the first molar followed by the mesio-buccal root of the second molar and concluded that changes in maxilla sinuses appear associated with periapical pathology in greater than 50% of the cases and CBCT scan could provide identification of changes in maxillary sinus.

Mehra P U et al (2007) conducted a study using CBCT to delineate the radiographic characteristics of maxillary sinusitis, and concluded that odontogenic causes can lead to changes in maxillary sinus. [5]

Arias-Irimia et al (2010) in A recent meta-analysis evaluated the frequency of the different odontogenic conditions that may lead to maxillary sinusitis, which most commonly manifests itself as chronic maxillary sinusitis. According to the findings, iatrogenic conditions, and in particular tooth extractions, are more frequent than other etiological factors.[6]

Huang and Brunsvold(2006) stated that the close proximity between the first molar roots and the floor of the sinus represents an issue not only for endodontic procedures, but also for periodontal surgery and dental prosthetic therapy.[7]

Costa et al (2003)19stated that direct spread of dental infections into the maxillary sinus is possible due to the close relationship of the maxillary posterior teeth to the maxillary sinus. If a periapical dental infection or dental/oral surgery procedure violates the schneiderian membrane integrity, infection will likely spread into the sinus, leading to sinusitis. The low incidence of sinusitis concerning cysts is mainly due to the fact that during their development, they push the sinus structures causing them no damage unless an infection accounts or the ostium obstructs preventing the natural drainage of the sinus.[8]

Abrahams et al (1996) have observed that sinusitis incidence on patients with periodontal disease is double to that on patients without periodontal disease. The relationship between the inflammation of the periapical tissues and the damage to the sinus membrane ended up in the known syndrome of “Endo-antral syndrome” .[9]

Freisfeld et al. (1993) the vertical relationships between the roots of maxillary teeth and the sinus inferior wall have been classified before. They suggested three types of vertical relationships (class 0: teeth roots not contact the sinus floor; class 1: teeth roots contact the sinus floor, but not project on sinus cavity; class 2: teeth roots project into the sinus cavity).[10]

Aim of the Study : To find the interrelationship between maxillary sinus pathology and dental pathology: a CBCT study.

Objectives of the Study

(1) Characterization and evaluation of Odontogenic pathologies affecting maxillary sinus.

(2) Characterization and evaluation of maxillary sinus pathologies causing diseases in upper posterior teeth.

(3) Comparison of CBCT with conventional radiography in evaluation of maxillary sinus pathologies and concurrent dental pathologies

Materials Used For Clinical Examination

(1) Dental chair with provision of artificial illumination

(2) A pair of sterile gloves

(3) Disposable mouth mask

(4) Mouth mirrors and straight and periodontal probe

(5) Sterilized tweezer

(6) Sterilized cotton

(7) 0.2% Chlorhexidine gluconate solution and water

Fig. 3: Materials used for clinical examination

For Radiographic Examination

OPG Machine-Planmeca Proline Xcexposure

Fig. 4: OPG

Fig. 5:CBCT kodak machine CS 9300

CBCT KODAK MACHINE,

(Fig 3,4,5)

CS 9300 with following specifications- **SENSOR TYPE IFT**

Scanning time	12-28 sec
Voxel size	90-500
FOV	5x5,8x8,10x10,17x6,17x13.5,17
Reconstruction time	Less than 2 min

Source of Data

Patient attending OPD at Peoples Dental Academy Patients refered from ENT department of Peoples Hospital Bhopal

Methodology

A total of 36 patients were included in this study. The patient ages ranged between 7 and 82 years of both male and females were included.

Inclusion criteria- Subjects for the study were selected throughdetailed case history, clinical examination and radiographic screening. 36 Patients who fulfilled the criteria for the study were divided into 2 groups-

Group 1-sinusitis of non odontogenic origin

Group 2-sinusitis of odontogenic origin

Group 1-Patients presenting with sinus symptoms /diagnosed with sinus pathologies

Group 2-Patients presenting with odontogenic symptoms

Exclusion criteria

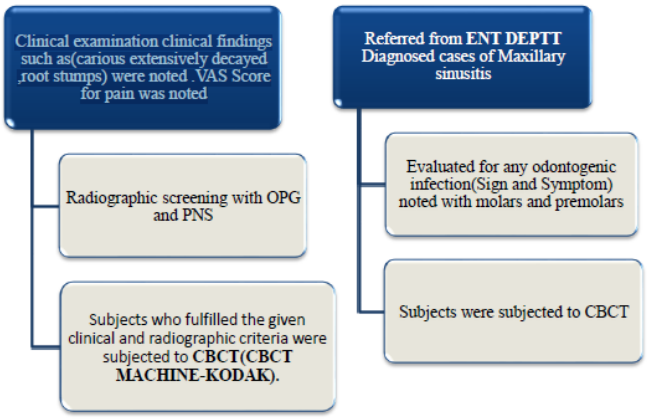
1. Pregnant patients
2. Patients with Maxillofacial Trauma

In the clinical examination clinical findings such as (carious, extensively decayed, root stumps) were noted .VAS Score for pain was noted. After the clinical examination subjects were referred for radiographic screening which OPG / PNS were taken by (OPG Machine-Planmeca Proline Xcexposure Time- 4.9 to 18 sec as indicated)and then the subjects who fulfilled the

given clinical and radiographic criteria were subjected to CBCT(CBCT MACHINE-KODAK CS 9300).

While patients diagnosed with max sinusitis from ENT (Ear nose and throat) Department of Peoples Hospital were further evaluated for any odontogenic infection noted with molars and premolars and such subjects were also subjected for CBCT imaging. ?

Flow chart: depicting methodology by which patients were screened for CBCT



Diagnostic Criteria for Sinusitis

Sinusitis of odontogenic origin: a soft-tissue density mass within the sinuses is a sinusitis of odontogenic origin if it fulfills the following criteria: carious tooth, tooth with defective restoration, or extraction site with or without radiographically evident periapical lesion and mucosal thickening limited to the area of the tooth or extraction site in question.[4](Fig 6)

Sinusitis of non-odontogenic origin: A soft-tissue density mass within the sinuses is a sinusitis of non-odontogenic origin if it fulfills the following criteria: teeth are non-carious, have coronal and/or endodontic restorations of good quality without radiographically evident periapical lesion or if extracted, intact or healing socket and mucosal thickening is not limited to any tooth. [4] **(Fig 7a,b).**

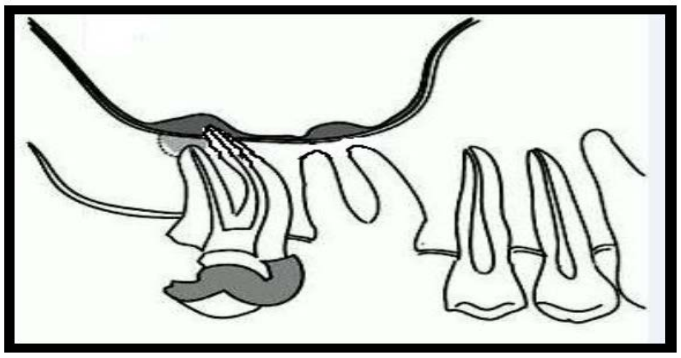


Figure 7 a: Sinusitis of odontogenic origin

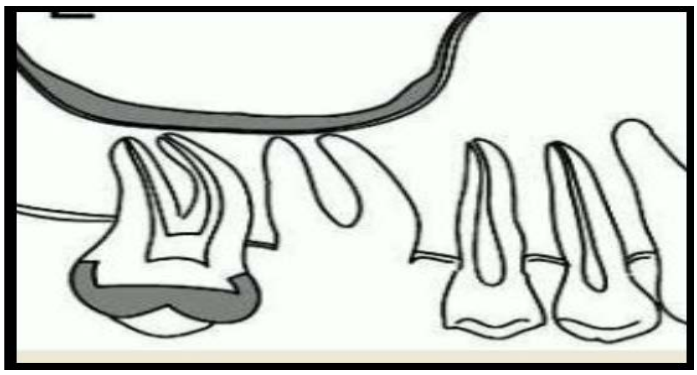


Figure 7 b: Sinusitis of non odontogenic origin

Sinusitis of undetermined origin: a soft-tissue density mass within the sinuses is a sinusitis of undetermined origin if it fulfills the following criteria: carious tooth, tooth with defective restoration, presence of a periapical lesion, or a disrupted socket and mucosal thickening is not limited to any tooth.[4] (Fig 8)

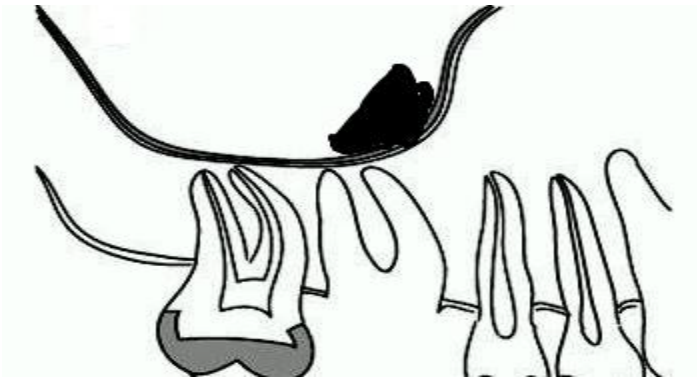


Figure 8: Sinusitis of undetermined origin

Indications for CBCT examination and the corresponding clinical diagnoses of the adjacent teeth (maxillary molars and premolars) were assessed on the basis of patient records and radiographic changes noted in OPG and PNS.

All subjects who fulfill the following criteria were subjected for further evaluation for CBCT.**CBCT was done at Geeta Digital Imaging Centre In Bhopal**

Fig. 9

CBCT Of the patient were analyzed on the following basis

A. Mucosal thickening which was further classified as **basal wall involved or all walls involved**

B. Opacification-which was interpreted as **Complete and incomplete**

C. Haziness-which was also interpreted as **complete and incomplete**

D. **Relation of root tip** of (maxillary first premolar, second premolar, first molar and second molar) to the **sinus floor (Fig 9)**

A. Root Tip Below The Sinus	B. Root Tip In Contact With The Sinus Floor	C. Root Tip Penetrating Into The Sinus
0-Contact	0-No Contact	1.1-2.9mm
1-No Contact	1-In Contact	2.3-4.9 mm
3.5 and above		

The root tip of the tooth found in most approximation of the sinus or was found penetrating sinus was considered mainly. Lines were drawn on the cross sectional images between the deepest point of the maxillary sinus floor and the root tips of the maxillary first and second premolars and first, second and third molars, and the distances were measured using built-in measurement tools.**(Fig 10)** To quantify intra-observer agreements, CBCT images were randomly selected from the sample and analyzed twice by the main observer.

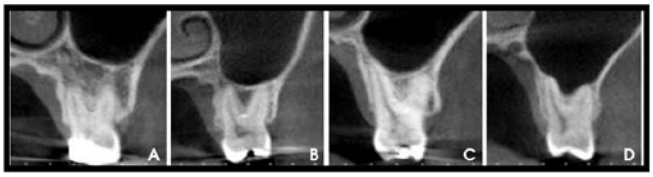


Figure 10 CBCT images show 4 types of vertical relationships between the root of the maxillary molars and the sinus floor. A. Type 0, the root is separate from the sinus floor. B. Type 1, the root is in contact with the sinus floor. C. Type 2, the root is projecting laterally along the sinus cavity, but is outside the sinus borders. D. Type 3, the root is projecting into the sinus cavity.

There was a period of 1 month between readings. Another observer also measured the same images to verify inter-observer reliability.

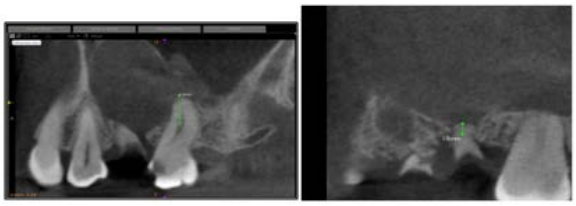


Fig. 11: Measurement of CBCT Images

Results

Our study consisted of total 36 patients that reported to PDA (Peoples Dental Academy) OMR (Oral medicine and Radiology) of which 13 were male and 23 were female patients. 24 subjects completed the required study protocol for sinusitis of non odontogenic origin (Group 1).

12 subjects completed the required study protocol for sinusitis of odontogenic origin Group 2 and no patients was included in Group 3. Average or Mean value of duration of pain (in days) and VAS (visual analogue scale) score for male and female for **Group 1** in table 1 and for Group 2 in table 2.

DURATION	GENDER	NO OF SUBJECTS	GENDER	VAS FOR PAIN
15.09 DAYS	AVERAGE MALE	11	AVERAGE MALE	6.2
13.36 DAYS	AVERAGE FEMALE	11	AVERAGE FEMALE	6.7

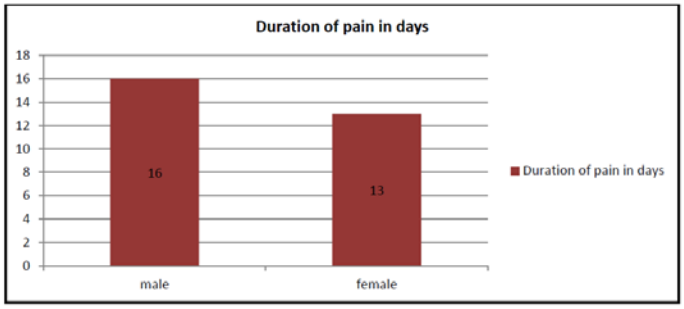
Table 1: Duration of pain for male and female for Group 1 patients

DURATION	GENDER	NO OF SUBJECTS	GENDER	VAS FOR PAIN
15 DAYS	AVERAGE MALE	2	AVERAGE MALE	3.5
5.0 DAYS	AVERAGE FEMALE	12	AVERAGE FEMALE	6.5

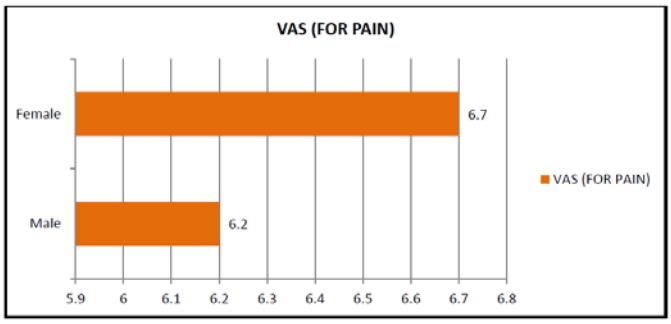
Table 2: Duration of pain for male and female for Group 2 patients

In graph 1 and 2 average value of duration of pain in (days) and VAS score is noted for both male and female in Group 1

GRAPH 1

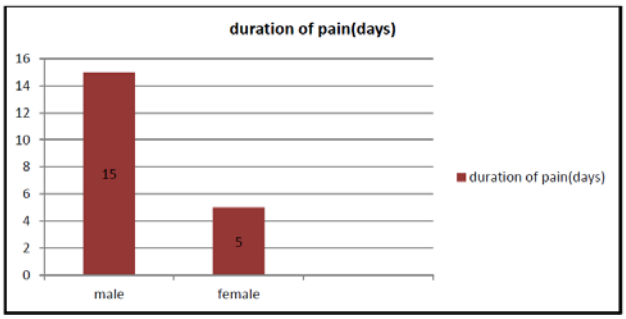


GRAPH 2

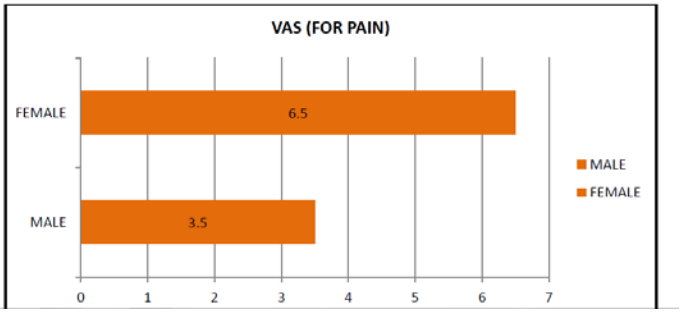


In graph 3 and 4 average value or mean of duration of pain in (days) and VAS score is noted for both male and female in Group 2 patients.

GRAPH 3

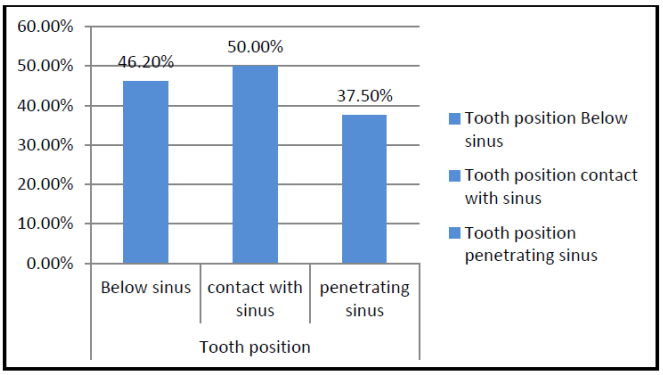


GRAPH 4

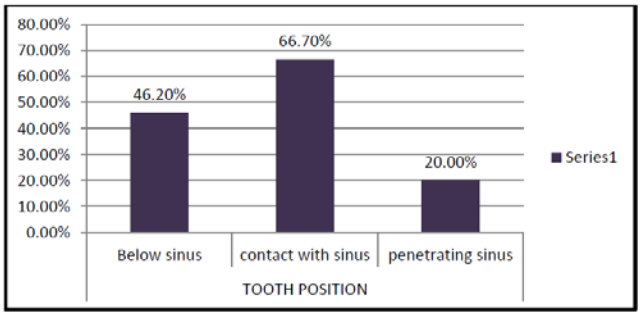


The following **graphs 5,6** depicts relation of root to the sinus in OPG, and CBCT in Group 1 patients.

GRAPH 5



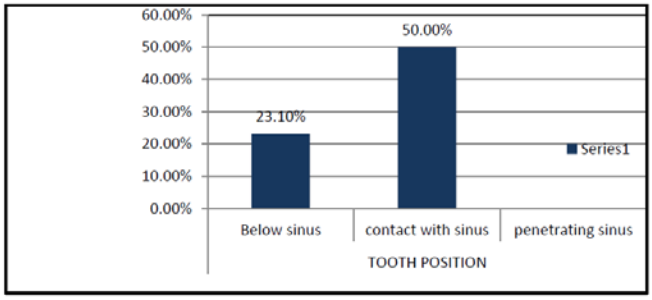
GRAPH 6



The following graphs **7,8.** depicts relation of root to the sinus in OPG,PNS and CBCT in Group 2 patients.

In Table 3 and 4 relation of root to sinus changes is noted in CBCT for Group 1 and Group 2 patients.

GRAPH 7



GRAPH 8

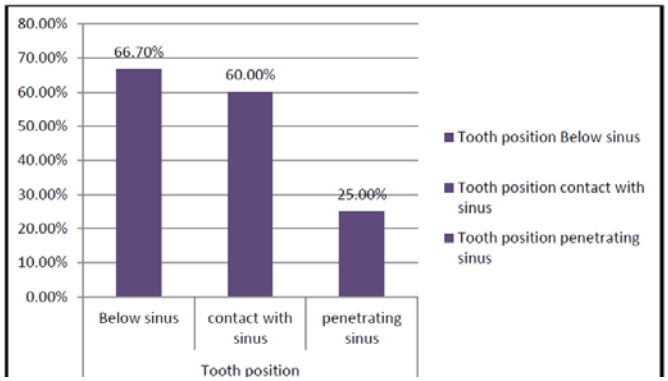


Table 3

TOOTH POSITION	Haziness	Opacification	Mucosal thickening
Below sinus	30.80%	8%	15.40%
Contact with sinus	0.00%	0.00%	0.00%
Penetrating sinus	40.00%	0.00%	60%

Table 4

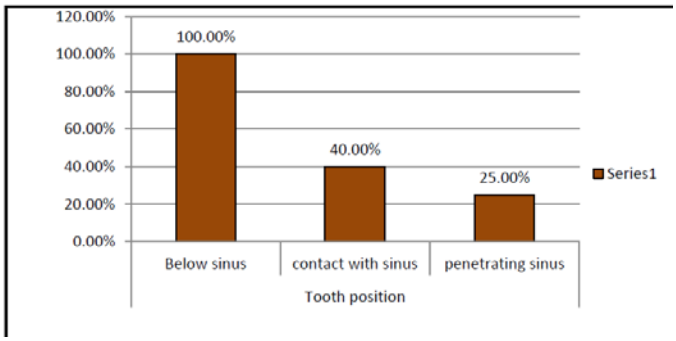
	Haziness	Opacification	Mucosal thickening
Below sinus	30.80%	8%	15.40%
Contact with sinus	0.00%	0.00%	0.00%
Penetrating sinus	40.00%	0.00%	60%

Table 3 and 4 relation of root to sinus changes is noted in CBCT for Group 1 and Group 2 patients.

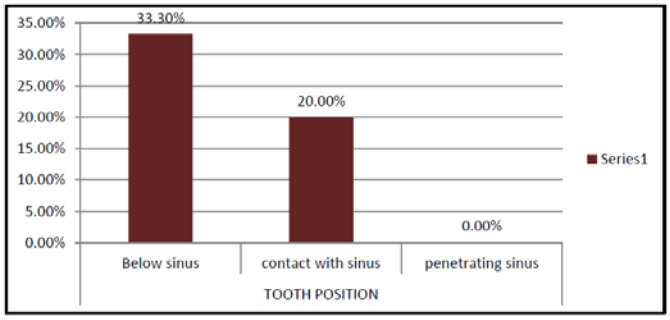
Graph 9 and 10 shows CBCT findings of mucosal thickening for Group 1 and Group 2 patients.

Graph 11 and 12 shows CBCT findings of haziness for Group 1 and Group 2 patients.

GRAPH 9

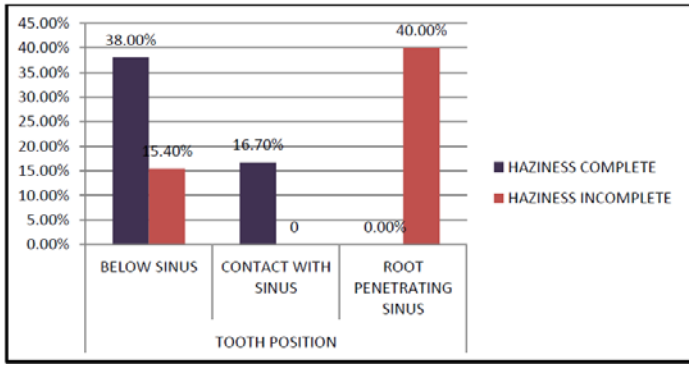


GRAPH 10

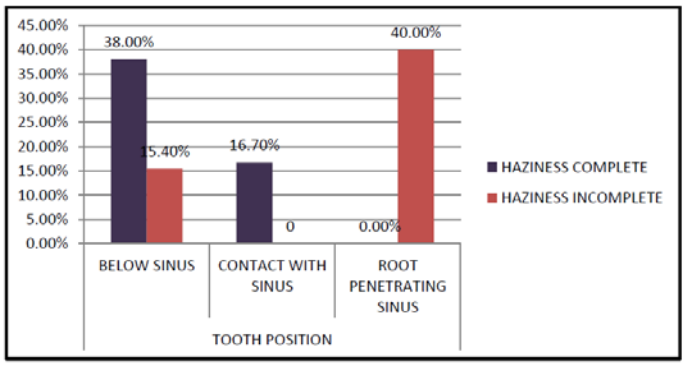


Graph 13 and 14 shows CBCT findings of opacification for Group 1 and Group 2 patients.

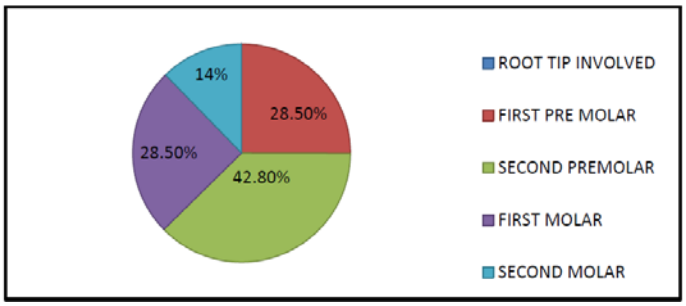
Graph 13



Graph 14



Graph 15 depicts MOST COMMONLY INVOLVED TOOTH



Discussion

In our study we evaluated duration of pain (in days)for both male and females of Group 1 and Group 2 patients and found that duration (in days) was more in males and less in females in both the groups interpreting the fact that females turn to dental office much earlier than males.

Similarly we also evaluated VAS score for pain in both males and females in Group 1 and Group 2 patients and found that VAS score for pain was more in females when compared to males concluding the fact that females have low threshold of pain when compared to males. In our study we found that Root relation to sinus floor was insignificant for Group 1 (Sinusitis of non odontogenic origin)and 2 (Sinusitis of odontogenic origin)in OPG and PNS when compared to CBCT in which it was significant(p value =0.21) in group 2 patients i.e sinusitis of odontogenic origin while in group 1 patients (p value= .092) which was non-significant. These findings correlated with the findings of **Bassam A. Hassan et al (2009)** who concluded in his study that both periapical radiographs and orthopantomograms are not reliable in determination of exact relationship between the apex of tooth root and the maxillary sinus floor.[11] Periapical radiography is slightly more reliable than orthopantomography in determining this relationship. Overall correlation between OPG and CBCT assessments scores independently of tooth type was 50%, 26% and 56.1% for(class 1) in which the root penetrated the sinus wall (class 2) at least one root tip is against the sinus wall ,(class 3) there were no contact between the root and the sinus floor and this was most frequently observed with the first premolar Reports indicate that CBCT images provide clinically relevant information not found in periapical images. **Bornstein. R et al (2013)** in A recent study used CBCT as the reference imaging modality(gold standard) to compare the accuracy of periapical and panoramic radiography in detecting periapical lesions. This study concluded that CBCT had better diagnostic accuracy than periapical and panoramic radiography. Panoramic images were the least sensitive in detecting lesions.[12]

Similar to our studies **Arbel Sharan et al (2005)** found that in 80 subjects with 422 maxillary roots, there was high agreement of 86% to 96% between CT scans and OPG images for roots that did not project on the sinus floor. While only 39% of the roots that projected on the sinus cavity in OPG images showed protrusion into the sinus on CT scans. [13].Their results also demonstrate that OPG images cannot provide the clinician with sufficient information about the true relationship between the sinus floor and root tips when the root is projected on the sinus. We also found in our study that CBCT findings of sinus changes in relation to root were significant for Group 1 and 2 i.e (p value for group 1 was .028) and Group 2 (p value=.021) is highly significant for group 2 cases i.e sinusitis of odontogenic origin and it was noted that roots penetrating the sinus or in contact with sinus floor may cause much more changes in sinus concluding the fact that there exist significant association of root tip to sinus changes.

This interpretation was supported by the study conducted by **Michelle Maillet,(2011)** in which he found that out of One hundred thirty-five maxillary sinusitis instances with possible odontogenic origin were detected. [4] Of these, 37 sinusitis occurrences were from nonodontogenic causes,

whereas 98 instances were tooth associated with some change in the integrity of the maxillary sinus floor concluding the fact that changes in the maxillary sinuses appear associated with periapical pathology in greater than 50% of the cases and also laid stress on the fact that Cone-beam computed tomography (CBCT) provides detailed three-dimensional images of the structures scanned. The use of CBCT scans in endodontic practice could allow for improved treatment planning of surgical procedures by showing the size and location of the lesion in relation to other anatomic structures. Computed tomography scanning has become the standard in medicine for visualizing the maxillary sinuses because of the ability to visualize both bone and soft tissue in multiple views with thin sectioning[4] Because an unresolved sinusitis may be exacerbated by an untreated dental condition, having both axial and coronal views allows the clinician to assess the relationship of a periapical lesion to a sinus floor defect and any resultant changes in the soft tissue of the sinus. In our study 57.1% of cases in Group 1 and Group 2 in which root penetrating the sinus have mean distance of 1-2.9 mm and CBCT findings stated that Haziness was significant(p=.022) in Group 2 patients (odontogenic origin)and in Group 1 was non-significant(p=0.21).

Eberhardt JA et al (1994) In his study measured mean distances between maxillary posterior teeth apices and the maxillary sinus floor and between the apices and the adjacent lateral bony surfaces using CT display data from 12 autopsy specimens and 38 human subjects, the apex of the maxillary second molar mesio-buccal root was found to be closest to the sinus floor (mean: 1.97 mm) and farthest from the buccal bony surface (mean: 4.45 mm), whereas the apex of the maxillary first premolar buccal root was found to be closest to the adjacent lateral bony surface (mean: 1.63 mm) and farthest from the sinus floor (mean: 7.05 mm) highlighting the fact that knowledge of the anatomical relationship between the maxillary sinus floor and the maxillary posterior teeth root tips is important for the preoperative treatment planning of maxillary posterior teeth. [2] In view of the proximity of the maxillary sinus floor and maxillary root tips, clinicians must be particularly cautious when performing dental procedures involving the maxillary posterior teeth

Dominik Brullman et al(2011) stated that there was a pronounced association between periodontitis and radiological signs of sinusitis. Basal mucosal wall thickening was more likely in patients with decayed and non-vital teeth compared to patients with sound teeth.In this study, it was found that CBCT examinations revealed a correlation between visible basal mucosa in the maxillary sinus and decayed posterior maxillary teeth or periodontitis.[14]

Based on a study by **Maloney and Doku et al (1968)** in several reports had indicated that only 10% to 12% of sinusitis cases have an odontogenic source .However, more recent works based on computed tomography images have shown that sinusitis of odontogenic origin is not a rare condition; rather, as high as 86% of sinusitis cases have a potential odontogenic source.[15]

Obayashi et al (2004) 30 found that 71.3 % of cases of dental infection were associated with changes in the maxillary sinus. [15]In our study maxillary second premolar(42.8%) and first molar(28.5%) are most commonly involved teeth while according to **Michelle Maillet et al(2011)** it was found that Of the 98 odontogenic cases, 3 occurrences were first premolars, 8 were second premolars, 55 were first molars, and 34 were second molars.[4]

Bassam A et al(2009)6 in his study revealed, independently on applied radiographic method, that the maxillary first premolar tooth did not perforate the sinus

wall in most cases while first and second molars were the most frequent teeth to penetrate the maxillary sinus wall. [11]

Yun-Hoa Jung et al (2012) in his study stated that In the buccal roots of the maxillary molars, a root protruding into the sinus occurred most frequently. A root projecting laterally along the sinus cavity was most common in the palatal roots of the maxillary first molars. The mesio-buccal roots of the maxillary second molar were closest to the sinus. The mesio-buccal roots of the first molars were closest to the cortical plate. [17]. It was reported that out of 159 maxillary premolars and molars treated with periapical surgery, aperture of the wall or floor of the maxillary sinus occurred in 18 percent of cases. The authors also stated that the introduction of foreign bodies into the maxillary sinus during surgery could cause thickening of the sinus mucosa and symptoms of maxillary sinusitis. The below table 5 depicts the comparative assessment of various other studies with our studies.[17]

FINDINGS	*Eberhadt et al 1994*	*Obyashi et al 2004*	*Brullmann et al 2010*	*Cent Kilic 2010*	*Michel et al 2011*	*OUR STUDY*
SINUSITIS OF NON-ODONTOGENIC ORIGIN	60%	12%	25%	42%	27.5%	68.5%
SINUSITIS OF ODONTOGENIC ORIGIN	40%	86%	74%	57%	72.5%	34.2%
OPG	-	-	-	-		Non significant
PNS	-		Non significant			Non significant
CBCT	Significant		Significant	Significant	Significant	Significant
ROOT RELATION (mean distance)	1.97 mm	1-9 mm		2.1mm		1-2.9 mm

Table 5

Conclusion

Dental pain originating from the maxillary sinuses can pose a diagnostic problem.

Periapical lesion development eliciting inflammatory changes in the mucosal lining can cause the development of a sinusitis. Odontogenic sinusitis can be identified as a localizedthickening of the mucous membrane of the maxillary sinus associated with a carious or heavily restored tooth with a periapical lesion or extraction site.

Among the cases 33.3% of the cases were Group 2 i.e patients with sinusitis of odontogenic origin and 66.66% were of Group 1 patient'si.e sinusitis of non odontogenic origin. Sinusitis of odontogenic origin can lead to changes in sinus when compared to sinusitis of non odontogenic origin i.e dental pathology and periapical infection can lead to maxillary sinus changes in Patients with sinusitis, over half of the cases appear to be associated with odontogenic pathology. Periapical infection with Roots penetrating the sinus can cause much more changes in maxillary sinus than roots in contact and below sinus. Second premolar(75%) and first molar(28%) are more commonly involved. Relation of root to sinus is better visualized in CBCT than in PNS and OPG .CBCT is more sensitive imaging modality as compared to OPG and PNS,because of the complex anatomy of the oral and maxillofacial region, it is difficult to visualize important anatomical features due to the superimposition of structures.

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