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Research Article

PREVALENCE OF ANATOMICAL VARIATIONS OF OSTEOMEATAL COMPLEX AND ITS CORRELATION WITH INCIDENTAL MAXILLARY SINUS PATHOLOGIES USING CONE-BEAM COMPUTED TOMOGRAPHY: AN OBSERVATIONAL STUDY

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ABSTRACT

Various studies have shown that Incidental maxillary sinus pathologies are observed in routine Cone-beam Computed tomography scans (CBCT) and anatomical variations in osteomeatal complex may be one of the predisposing factors. A cross-sectional observational study was carried out to determine the prevalence of anatomical variation of osteomeatal complex (OMC) in incidental maxillary sinus pathologies and the correlation of anatomic variations of OMC with maxillary sinus pathologies using Cone-beam Computed tomography (CBCT) images. 100 full volume CBCT scans obtained were retrospectively evaluated for maxillary sinus pathologies then the same scans were analyzed for anatomical variations of OMC. Data was subjected to analysis. Results show that prevalence of variation in the uncinat process, concha bullosa, ethmoid bulla, Haller cells and agger nassi cells, were found to be statistically significant ($p < 0.05$). Correlation between maxillary sinus pathology with variations in uncinat process ($p = 0.001$), ethmoid bulla ($p = 0.05$) and agger nassi cells ($p = 0.009$) were significant.

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INTRODUCTION

The maxillary sinus is the paranasal sinus that impacts the most of work of the Dentists and the Maxillofacial surgeons when treatment is planned for implant placement, and various maxillofacial surgeries related to sinus region. Maxillary sinus pathologies are asymptomatic and are incidentally found on Cone-beam Computed tomography scans. A conceptual 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 opening of the maxillary sinus osteomeatal complex (OMC) is located high in the medial sinus wall (fig 1). Compromised maxillary sinus drainage system is associated with a higher risk of postoperative sinusitis, and is a significant area in examining patients with sinus complaints. The imaging investigation of the anatomical variation of the osteomeatal complex is important in assessing the predisposing factors for inflammatory changes of the sinuses (Raluca A *et al*, 2016; Jyothi A *et al*, 2013). These changes of the sinuses are a common problem encountered in clinical practice and may cause complications when implant and maxillofacial surgeries related to the area is planned. Several authors

(Khojastepour L *et al*, 2015; Stallman J *et al*, 2004) have assessed the relationship between anatomic variants of osteomeatal complex and the incidence of sinus pathologies.

Several previous studies (Nitnavakarn B *et al*, 2005; Patel AK *et al*, 2015; Fadda G L *et al*, 2012; Adeel M *et al*, 2013; Turna O *et al*, 2014; Budu V *et al*, 2015) concluded that pneumatization of the concha bullosa, the deviated position of the uncinat process and the asymmetrical ethmoid roof, hypertrophy of Haller cells and agger nassi cells of OMC revealed significant association with sinus pathologies (Ritter L *et al*, 2011; Aziz A *et al*, 2006; Stammberger H *et al*, 1995; Mathew R *et al*, 2013). Various studies of these anatomical variations have been conducted using Computer Tomography to detect the correlation with sinus inflammation. Few studies have been conducted using CBCT as imaging tool (Raluca A *et al*, 2016; Jyothi A *et al*, 2013; Khojastepour L *et al*, 2015).

Cone Beam CT images, with its high-quality bone definition, is considered advancement to CT and can provide thin slicing and multi-planar cross-sectioning, a very good approach for scanning the maxillary structures, especially regarding the paranasal sinuses and the implications of their position, shape and variations in the inflammatory pathology.

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Therefore this study was planned with the aim to assess the prevalence of anatomical variants of the osteomeatal complex, and to determine the correlation of these variations with incidental maxillary sinus pathologies by using CBCT images.

MATERIALS AND METHODS

A cross sectional observational study was planned and approved by the Scientific Approval Committee (SAC) of the institute. Study included a total of 100 scans obtained from a private CBCT centre. Consent was obtained from the private imaging centre. The scans were obtained from Kodak Carestream machine (CS 9300, Carestream software) kVp: 76-100, mA: 12 mA, Rotation Time: 18.6 second, Resolution 90 μm to 300 μm , Slice thickness 0.09 mm to 0.3mm. Full volume scans (17 x13 cm) visualizing the sinuses bilaterally were examined by two radiologists specialized in maxillofacial radiology in coronal, axial and sagittal sections. Out of 100 scans 40 were selected as per inclusion criteria

All the patients had been referred for CBCT diagnosis and treatment planning, which included dental implants, maxillofacial surgery, orthodontics, endodontic, periapical pathologies etc. Age, gender and indication/purpose for scanning were retrieved from the patients' records.

Inclusion criteria

1. All CBCT scans visualizing right and left maxillary sinuses were included.
2. CBCT scans showing unilateral or bilateral incidental maxillary sinus pathologies were included in the study.

Exclusion criteria Patients under 16 years of age were excluded because of their incomplete sinus development. Images of low resolution quality and those in which the presence of metallic artifacts impaired sinus visualization were excluded from the study.

CBCT Analysis of OMC Anatomic Variants

In the present study, the concept developed by Stammberger & Kennedy, was adopted which defines osteomeatal complex as a functional unit of the anterior ethmoid complex representing the final common pathway for drainage and ventilation of the frontal, maxillary and anterior ethmoid sinus (Stammberger H et al, 1995) (fig 1).

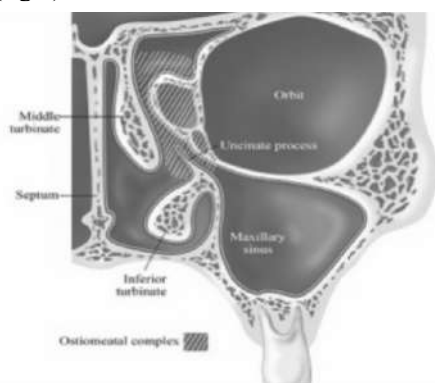


Fig 1 Osteomeatal complex is a functional unit of the anterior ethmoid complex situated between the middle turbinate and lateral nasal wall in middle meatus (Patel AK et al, 2015)

The basis of evaluation of coronal, axial, sagittal sections of maxillary sinus CBCT includes evaluation of the following osteomeatal complex anatomic units-

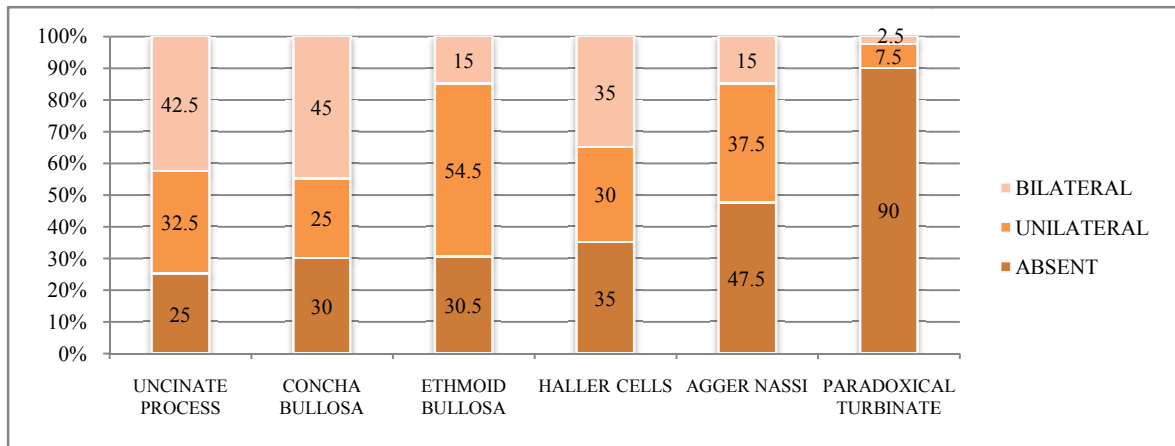
- Uncinate process- The uncinate process is a key bony structure in the lateral nasal wall. Together with the adjacent ethmoid bulla, the anterior one third is usually in the plane of adjacent lateral nasal wall, whereas posterior third is usually incline medially with configuration of adjacent ethmoid bulla. Variation mainly depends on horizontal and vertical placement and insertion of free end of uncinate process and shape.
- Ethmoid bulla- The ethmoid bulla is usually largest and most constant anterior ethmoid air cell, its appearance varies considerably, based on extent of pneumatization. An enlarged ethmoidal bulla may obstruct the infundibulum or the middle meatus.
- Concha bullosa- The middle concha bullosa is a result of pneumatization of the osseous plate due to ethmoidal extension. The concha pneumatization may occur at several degrees, from that affecting only the bulbous portion (distal) or lamellar portion (proximal), or the true variant where there is pneumatization of both portions.
- Haller cells- Haller cells is the pneumatization of the anterior ethmoid cells into the roof of the maxillary sinus extending into the floor of the orbit.
- Agger nassi cells- Agger nassi cells are the most anterior ethmoid cells and extend anteriorly into the lacrimal bone. They are located in the anterior floor of the frontal sinus, on the drainage pathway of the frontal sinus.
- Paradoxical turbinate- Paradoxical middle turbinate occurs if the convexity of the middle turbinate is directed towards the medial wall of the maxillary sinus.

Criteria for analyzing Maxillary sinuses pathologies included were any radiopacities and mucosal thickening. Prevalence and correlation of anatomical variations of osteomeatal complex with incidental maxillary sinus pathologies and the frequency of variations was compared between male and females and in relation to age. Data was collected in data collection form and was descriptively analyzed using frequency and chi-square test and Pearson correlation.

RESULTS

100 CBCT scans, including 40 females and 60 males, with the age range of 18 to 60 years were initially assessed. Out of 100 scans, 40 were selected as per inclusion criteria including 25 males and 15 females with mean age of 45 year. In 40 scans, 45% were (18) with unilateral maxillary sinus pathologies and 55 % (22) with bilateral maxillary sinus pathologies. The anatomical variants were noted in both groups. The correlation of the anatomic variants among each gender group did not show any statistical significance ($p>0.05$) (Table 2).

The most common OMC anatomic variant in our study was the uncinate process (75%), followed by pneumatization in middle concha (70%) and ethmoid bulla (69.5%), Haller cells (65%), agger nassi cells(52.5%) and paradoxical turbinate(10 %). (Graph 1)



Graph 1 Prevalence of variations in bilateral and unilateral maxillary sinus pathologies

In unilateral pathologies, ethmoid bulla (54.5%) followed by agger nassi cells (37.5%) were seen to be more prevalent, whereas in bilateral pathologies highest prevalence was seen with variation in concha bullosa (45%) followed by the uncinete process (42.5%) and haller cells (35%) (Graph 1).

In our study, prevalence of these anatomical variations found to be statistically significant ($p < 0.05$) (Table 1) and significant correlation was found between maxillary sinus pathologies and anatomical variation of uncinete process ($p = 0.001$), ethmoid bulla ($p = 0.000$) and agger nassi cells ($p = 0.009$), concha bullosa ($p = 0.019$), haller cells ($p = 0.099$), whereas gender and age had no significant correlation with these anatomical variations. (Table 2)

Table 1 Prevalence of anatomic variations of Osteomeatal complex in incidental maxillary sinus pathologies

OMC variations	Present (n=40)	Absent (n=40)	p value
Uncinate process	30	10	$p = 0.035$
Concha bullosa	28	12	$p = 0.006$
Ethmoid bulla	23	17	$p = 0.049$
Haller cells	26	14	$p = 0.042$
Agger nassi cells	21	19	$p = 0.000$
Paradoxical turbinate	4	36	$p = 0.000$

n = Total no. of scans
 (*chi-square test)
 $p < 0.05$, frequency statistically significant)

Table 2 Correlation of OMC variations* with age, gender and maxillary sinus pathologies

Variations	Age	Gender	Maxillary sinus pathology
Uncinate process	$p = 0.167$	$p = 0.538$	$p = 0.001^*$
	$r = 0.120$	$r = -.100$	$r = 0.525^*$
Concha bullosa	$p = 0.275$	$p = 0.164$	$p = 0.019$
	$r = 0.159$	$r = -.224$	$r = 0.212$
Ethmoid bulla	$p = 0.71$	$p = 0.684$	$p = 0.000^*$
	$r = 0.055$	$r = -.066$	$r = 0.547^*$
Haller cell	$p = 0.345$	$p = 0.557$	$p = 0.099$
	$r = 0.084$	$r = 0.096$	$r = 0.265$
Agger nassi cells	$p = 0.080$	$p = 0.408$	$p = 0.009^*$
	$r = 0.126$	$r = -0.135$	$r = 0.409^*$
Paradoxical turbinate	$p = 0.081$	$p = 0.527$	$p = 0.689$
	$r = 0.239$	$r = -0.103$	$r = -.065$

(* p value < 0.05 Significant
 r value is Pearson's correlation)

DISCUSSION

The purpose of the present study is to assess the prevalence of anatomical variation of osteomeatal complex, and to determine its correlation with the incidental maxillary sinus pathologies.

Analyzing the results of present study which included 40 CBCT scans, 25 were of males and 15 of females with age ranging from 18 to 65 years and a mean age of 45 years. We observed that there were no significant differences between distribution of patients according to age and gender groups and the presence of anatomical variation (Table 2).

The most prevalent OMC variation in present study was uncinete process (75%), followed by concha bullosa (70%), ethmoid bulla (69.5%), Haller cells (65%), agger nassi cells (52.5%) (Graph1). The least prevalent was paradoxical turbinate, which appeared in only 10% of cases. The prevalence of variations of OMC was found to be statistically significant ($p < 0.05$) (Table 1). The result of review of studies about the prevalence of anatomic variation of osteomeatal complex in previous studies was done by various authors (Table 3). Most of these studies were based on CT except a few on CBCT.

Table 3 Anatomical variations of Osteomeatal complex and their prevalence in previous studies

Variations	Present study (CBCT)	Raluca A. Khojastpourl et al (CBCT)	L. et al (CT)	Jyothi et al. (CT)	Fadda et al (CT)
Uncinate process	75%	88%	54.8%	1%	85%
Concha bullosa	70%	42%	67.3%	26%	69%
Ethmoid bullosa	69.5%	62%	-	3%	-
Haller cells	65%	27%	68%	8%	68%
Agger nassi cells	52.5%	93.2%	93.2%	4%	93.2%
Paradoxical turbinate	10%	8%	10%	4%	10%

- Uncinate process-One of the most important parts in the path of mucus drainage in the osteo-meatal unit, is the uncinete process. Owing to its abnormal shape or position, it can become a very important favoring factor in the appearance of sinus pathologies. In present study, these variations in position like insertion of uncinete process in ethmoid bulla, ethmoid roof, agger nassi cells or with middle concha or in shape like hypertrophy and pneumatization of process were depicted in 75% of the scans. It mainly consists of variation in the shape in half

of the group, followed by deviation in the insertion (fig 4). Prevalence and correlation with maxillary sinus pathology of anatomic variation of uncinete process was found to be statistically significant ($p < 0.05$) (table 1 and 2). Similar results were seen in Khojastepour L. et al (54%) and Raluca et al (88%) using CBCT, and some previous studies (Fadda G L et al, 2012) done using CT. In contrast, study done by Jyothi AC et al did not show significant (1%) uncinete process variations. In our study, 42.5 % of bilateral pathologies showed the variations in uncinete process where as 32.5% in unilateral pathologies almost similar to previous study (Graph 1) (Khojastepour L et al, 2015; Fadda G L et al, 2012).



Fig 2 Cone beam computed tomography coronal section showing hypertrophy of Haller cells.

- Concha bullosa- The middle concha bullosa is a result of pneumatization of the osseous plate due to ethmoidal extension. The appearance is that of an air space of the middle concha surrounded by an oval bony rim (fig 3 a/b). Khojastepour et al found 67.3 % prevalence with 39% unilaterally and 60% bilaterally. In present study we found 70% prevalence with 45% in bilateral and 25% in unilateral pathologies found to be statistically significant in correlation with maxillary sinus pathologies ($p < 0.05$) (table 2). Few studies reported lower incidence of pneumatization, this discrepancy in the incidence may be dependent on the criteria of pneumatization of different researchers and also the method of analysis. (Jyothi A et al, 2013; Stallman J et al, 2004; Patel AK et al, 2015)



Fig 3 a

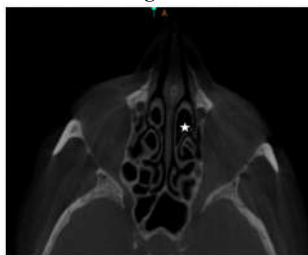


Fig 3 b

Fig 3 Cone beam computed tomography sections showing pneumatization of middle turbinate. (a-in coronal section / b-axial section)

- Haller cells - Haller cell is seen in the pneumatization of the anterior ethmoid cells into the roof of the maxillary sinus extending into the floor of the orbit (Jyothi A et al, 2013). Prevalence of Haller cells is remarkably variable, ranging 3 % to 78%. The result of some studies revealed a correlation between the presence of Haller cells and sinus pathologies (Jangam D et al, 2016; Khojasetpour L et al, 2016; Fadda G L et al, 2012; Arun K et al, 2015), which is in concordance with the present study ($p < 0.05$)(table 2), in which the prevalence of Haller cells is 65%. 35% in bilateral pathologies and 30% in unilateral pathologies (graph 1) (fig 2) and in contrast Vlad B et al, Jyothi et al showed less prevalence. Other studies found no significant correlation between Haller cells and sinus pathologies (Bolger WE et al, 1991; Lloyd DM et al, 1991). The variability in these cells could be due to inconsistency in definition of Haller cells, mean age, race, size, and the imaging protocol.
- Ethmoid bulla- It is the largest and the most constant anterior ethmoid air cell. An enlarged ethmoid bulla may obstruct the infundibulum or the middle meatus. In the present study, prominent ethmoid bulla was found in 69.5% of which 54.5% was found in unilateral pathologies and 15% were seen in bilateral pathologies and the results were statistically significant when correlated with maxillary sinus pathologies (table 2) (fig 4). Results were in concordance with Fadda et al (42%) and Arun AK et al (38%), whereas contrast results were seen by Vlad B et al and Jyothi et al who found less prevalence i.e. 10.93% and 3% respectively.



Fig 4 Cone-beam computed tomography sections showing hypertrophy of ethmoid roof on right side and pneumatization of superior end of uncinete process on left side.

- Agger nasi cells-Agger nasi cells are the most anterior extramural ethmoid cells, located antero-superior to the insertion of middle turbinate. Hypertrophy of the agger nasi cell was present (fig 6) in 52.5% in the present study, and were found to be significant in correlation with maxillary sinus pathologies ($p < 0.05$), results were comparable with results of Raluca et al and Khojaastpour et al. Much less prevalence for these variations however was reported by Jyothi et al and Vlad B et al. The variability reported in the prevalence of cells could be related both to its small size and different definitions assigned to this anatomic variation. Most of the hypertrophy agger nasi cells detected in current study were unilateral (47.5%) this variation was more bilateral among the cases investigated by previous authors (Khojastepour L et al, 2015; Fadda G L et al, 2012).
- Paradoxical turbinate- It is described as a convexity pointing towards the middle meatus and is reported as a

possible cause for closed OMC which may lead to mucosal pathologies (Fig 6). But in our study though the pathologies were seen unilaterally and bilaterally the prevalence of paradoxical turbinate was 10 % (Graph 1), with no statistical significant correlation with maxillary sinus pathologies (Table 2). The rates of this variation in previous studies varied from 4% to 40%. (Raluca A *et al*, 2016; Patel AK *et al*, 2015; Fadda G L *et al*, 2012; Adeel M *et al*, 2013; Turna O *et al*, 2014; Budu V *et al*, 2015; Lloyd DM *et al*, 1991).

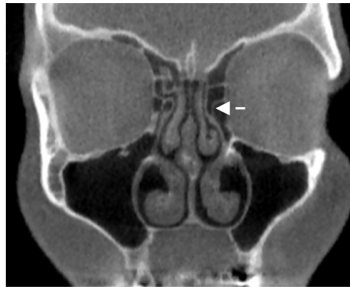


Fig 5 a



Fig 5 b

Fig 5 a/b Cone-beam computed tomography section showing superior insertion of left uncinat process to ethmoid bulla.



Fig 6 Cone-beam computed tomography section showing bilateral paradoxical turbinate and hypertrophy of left agger nasi cell.

were not able to identify the nature of fluid. Controls were not used for comparison. Prospective study on larger population with a bigger sample size and which include patients with sinus pathologies needs to be done. Standardization of definitions of osteomeatal complex needs to be done to get uniformity in results of studies. CBCT is the best tool for scanning the maxillary structures and paranasal sinuses including OMC, due to its high-quality bone definition, thin slicing and multi-planar cross-sectioning and low patient dosage.

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CONCLUSION

Amongst the anatomical variations in OMC, the most prevalent was the uncinat process followed by concha bullosa and ethmoid bulla. OMC anatomical variations in incidental maxillary sinus pathologies are high, they may be considered as predisposing factors along with other etiologies for sinus pathology. We would like to conclude that, Oral and Maxillofacial Radiologists, Dentists, Medical Practitioners, Maxillofacial and ENT surgeons should be able to recognize and be aware of variations of OMC and its role in sinus pathologies. Sinus pathologies also are hindrances for implant placement and sinus lift procedures. Reporting of CBCT should include these anatomical variations of OMC. In our study, we

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