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Original Research Article

Clinical significance of paranasal sinuses and its anatomical variations using 3D cone beam computed tomography: a retrospective study

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ABSTRACT

Background: Paranasal sinuses are a group of four paired air filled spaces surrounding the nasal cavity. During the developmental process, anatomical variations can occur in consequence of intra and extramural migration of the ethmoidal air cells, over pneumatization or hypoplasia of the sinuses and bulging of the neurovascular structures to the sinuses, thereby affecting the drainage pathways, causing chronic infections and complications during functional endoscopic sinus surgery (FESS). The aim of the study was to study the clinical significance of paranasal sinuses and it's anatomical variations using CBCT.
Methods: A retrospective study was carried out at Meenakshi Ammal Dental College, Chennai, from June 2018 to November 2018 using 100 CBCT images of 50 males and 50 females, with their age group ranging from18-60 years. Radiographic assessment of paranasal sinuses and it's variations were accurately characterized using customized Planmeca Romexis software and the data was analysed statistically.
Results: It is found that agar nasi cells were found to be higher 79% followed by Kuhn cells 45%, onodi cells 23% and haller cells 12%. Concha bullosa was found in 39%. Nasal septum was deviated to right in 31% and to the left in 36%. Maxillary sinus septa in 21%, sphenoid sinus pneumatization in 23%,maxillary sinus pneumatization in 2%, and crista galli pneumatization in 7% of the study population. And the results based on gender, the p value is found to be highly significant.
Conclusions: CBCT is the best tool for imaging the paranasal sinuses including osteo meatal complex, due to its high quality bone definition, thin slicing, multi planar cross-sectioning and low patient dosage.

Keywords: Cone beam computed tomography, Paranasal sinuses, Anatomic variations

INTRODUCTION

The paranasal sinuses (Figure 1A) are air filled spaces lined with soft, pink mucosa located within the bones of the skull and face. The mucosa lining the sinuses makes mucus that is cleared out of the sinus cavities and drains into the nasal passage. Clinical and surgical importance of variations in paranasal sinuses should be investigated.[1] Sinusitis may be caused by sinonasal cavity anatomic variations. The osteomeatal unit (Figure 2A) can be narrowed or obstructed by these variations. The paranasal sinuses are separated from the orbital and cranial fossae by very thin bone lamina. Anatomic variations of this region must be understood in detail, otherwise serious complications, such as cerebrospinal fluid leakage, meningitis or blindness may occur during surgery. Conventional dental imaging methods such as: panoramic and lateral cephalometric radiography are generally used for planning of orthodontic and maxillofacial surgical treatment.[1] Nevertheless, conventional radiology has several limitations including providing only a two-dimensional assessment of the skeletal configuration and the fact that structural superimposition does not allow precise exploration of the sinus region. With the advantage of three-dimensional imaging, clinicians are able to observe anatomical structures clearly. Cone beam computed tomography (CBCT) is a useful method for the evaluation of the paranasal sinuses. CBCT is regarded as equivalent to computed tomography (CT) in obtaining diagnostic information. Moreover, CBCT has some advantages compared to CT, such as a shorter imaging time, low cost, and low radiation exposure.[2]

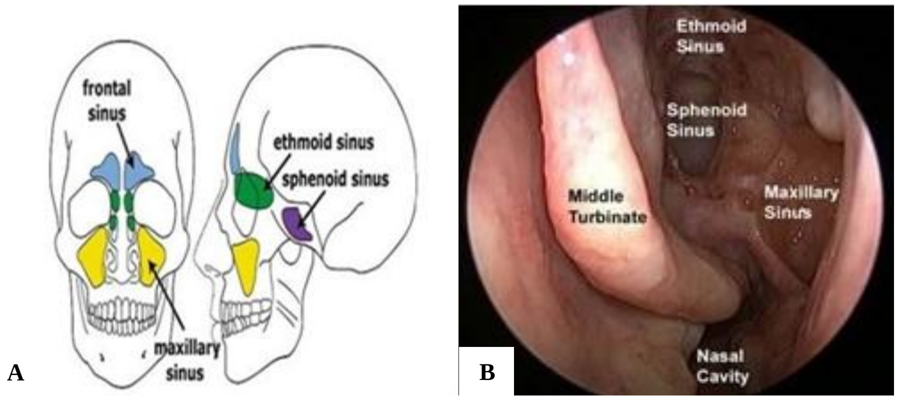

Figure 1: (A) Paranasal sinuses; (B) endoscopic views of paranasal sinuses.[11,13]

Figure 2: (A) Osteomeatal complex; (B) cadaveric view of osteomeatal complex; (C) pictorial representation of osteomeatal complex.[12,13]

METHODS

A retrospective study was carried out at Meenakshi Ammal Dental College, Chennai, from June 2018 to November 2018, using 100 CBCT images of 50 males and 50 females, with their age group ranging from18-60 years referred for different oral and dental diagnostic purposes. Patients under 18 years of age are excluded from the study because of incomplete sinus development. The indications for CBCT examinations were implant planning or oral surgery procedure planning (removal of impacted third molars), orthodontic planning. Trauma cases and patients with cleft lip and palate and facial deformity are excluded from the study. Two oral and maxillofacial radiologists independently evaluated the presence of anatomical variations of paranasal sinuses in CBCT images. An assessment of paranasal sinuses and it's variations were accurately characterized in axial, coronal and sagittal sections using Planmeca Mid Proface machine with customized Planmeca Romexis software and the data was analysed statistically using SPSS software and Chi square test was used to find the statistical significance.

RESULTS

It is found that agar nasi cells (ethmoidal air cells) were found to be higher 79% followed by Kuhn cells (frontoethmoidal cells) 45%, onodi cells (sphenoethmoidal cells) 23% and haller cells (Infraorbital ethmoid cells) 12%. Concha bullosa was found in 39% of the study population. Nasal septum was deviated to the right in 31% and to the left in 36% of the study population. And the results based on gender, the p value is found to be highly significant ($p<0.01$). Maxillary sinus septa were found in 21% in which 8% of the study population, it was unilateral and 13% of the study population, it was bilateral. Maxillary sinus pneumatization in 2% of the study population. Sphenoid sinus pneumatization was found in 23% of the study population, and crista galli pneumatization in 7% of the study population (Table 1).

Table 1: Representation of anatomical variations in percentage.

Anatomical variations		%
1)	Agar nasi cells	79
2)	Kuhn cells	45
3)	Onodi cells	23
4)	Haller cells	12
5)	Concha bullosa	39
6)	Nasal septum deviation	67
7)	Nasal septum deviated to right	36
8)	Nasal septum deviated to left	31
9)	Maxillary sinus septa	21
10)	Maxillary sinus septa-unilateral	8
11)	Maxillary sinus septa-bilateral	13
12)	Sphenoid sinus pneumatization	23
13)	Maxillarysinus pneumatization	2
14)	Crista galli pneumatization	7

Table 2: Representation of anatomical variations based on gender.

Anatomical variation		Male	Female
1)	Agar nasi cell	35	44
2)	Kuhn cell	23	22
3)	Onodi cell	18	14
4)	Haller cell	6	6
5)	Concha bullosa	21	18
6)	Nasal septum deviated to right	16	15
7)	Nasal septum deviated to left	14	22
8)	Maxillary sinus septa	11	10
9)	Sphenoid pneumatization	15	8

Results based on gender, 35 male and 44 female have agar nasi cell, 23 male and 22 female have Kuhn cell, 18 male and 14 female have onodi cell, 6 male and 6 female patients have haller cells, 21 male and 18 female have concha bullosa, 16 male and 15 female have nasal septum deviated to right and 14 male and 22 female patients have nasal septum deviated to left. Maxillary sinus septa was found in 11 male and 10 female. Sphenoid sinus pneumatization was found in 15 male and 8 female (Table 2).

DISCUSSION

Knowing the importance of anatomical variations of various paranasal sinuses prevents complications during sinus surgical procedures. The detailed significance of various variations are given.

Agar nasi cells (Figure 3A represents the CBCT image, 3B represents endoscopic image) are most consistent, anterior of ethmoidal air cells, located anterior to the vertical attachment of middle turbinate to the skull base. Prevalence rate of about 15-92%. Its clinical significance is in case of extensive pneumatization, enlarged ANC narrow the drainage pathway of frontal sinus causing chronic sinusitis.

Spheno ethmoid cells (onodi cell) (Figure 4A represents CBCT image, 4B-cadaveric image and 4C-pictorial represtation) are formed by lateral and posterior pneumatization of the most posterior ethmoid cells over the sphenoid sinus with prevalence rate of (highly variable) 3.4%-51% (highly variable). Clinical significance are risk of injury to the optic nerve when performing the sphenoid sinus surgery. The mean minimum of bone thickness between onodi cell and optic nerve was reported as 0.08 mm by Thanaviratanaich et al in a cadaveric study. Isolated mucoceles in an onodi cell may compress the optic nerve and cause optic neuropathy.

Infraorbital ethmoid cell (Haller's cell) (Figure 5A represents CBCT image, 5B-Endoscopic image) are anterior ethmoidal air cells located along the medial portion of the orbital floor lateral to the maxillary infundibulum. Classified as small, medium, large. The clinical significance is negative effect on maxillary sinus ventilation. Evidence of medium and large size cells attribute to increase the risk of maxillary sinus mucosal disease.

Kuhn cells (frontal cells/ frontoethmoidal cells) (Figure 6A represents CBCT image, 6B represents cadaveric image) are group of anterior ethmoidal cells. There are four types mainly, type I- Single cell above the agar nasi cell, type II- two or more cells above the agar nasi cell, type III- single cell extending from the agar nasi cell into the frontal sinus, type IV- isolated cell within the frontal sinus (loner cell). In this, type III and type IV have higher chances of frontal sinusitis.[3]

Concha bullosa (Figure 7A-represents CBCT image, 7B-represents Endoscopic image) is the pneumatization of the inferior bulbous portion of the turbinate. Prevalence rate of about 14-53.6%. Classified according to the location: lamellar, bulbous, or extensive. Most commonly seen in middle turbinate-unilateral or bilateral. Unilateral concha bullosa associated with a deviated nasal septum. Clinical significance: concha bullosa can compromise the middle meatus, particularly the osteomeatal complex, and predispose to sinus disease due to its negative effect on the mucociliary drainage.

Deviated nasal septum (Figure 8A represents CBCT image, 8B represents endoscopic image)- The nasal septum is made up of bony and cartilaginous parts. The bony component is formed by the vomer and perpendicular plate of ethmoid bone. Classified as Straight, deviated to right, deviated to left, sigmoid and reverse sigmoid. The septum usually deviates off the median plane, congenital or due to trauma. Clinical significance are severe deviation– nasal obstruction, noisy breathing during sleep, and/or epitaxis, hypoplasia of the ipsilateral turbinates and/or hyperplasia of the contralateral turbinates.[4]

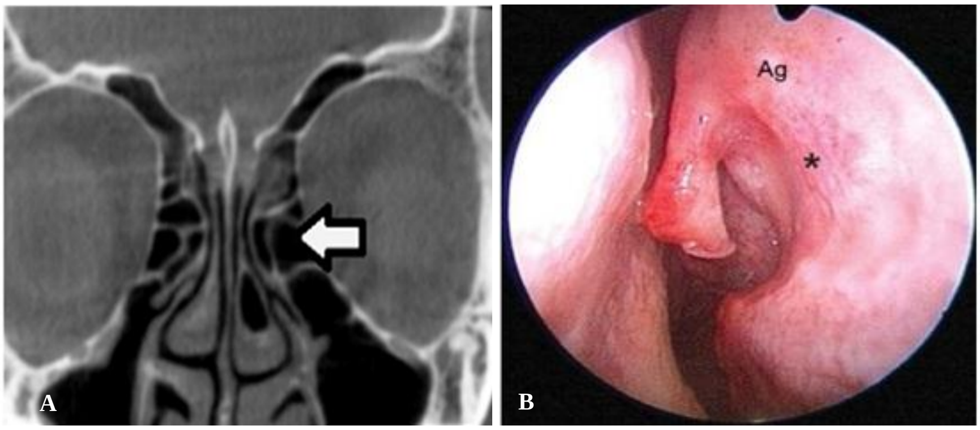

Figure 3: (A) CBCT image of agar nasi cells; (B) endoscopic view of agar nasi cell.[13]

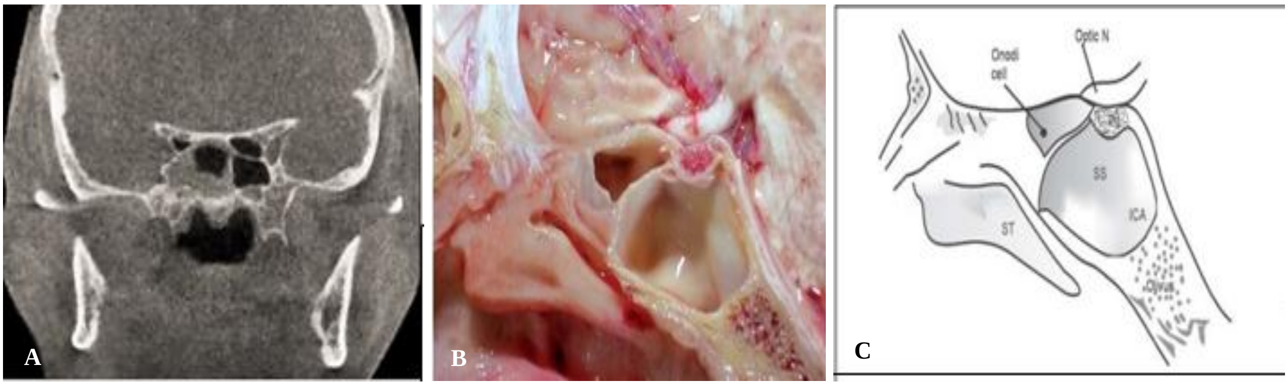

Figure 4: (A) CBCT image of onodi cell; (B) cadaveric image of onodi cell; (C) pictorial representation of onodi cell.[13]

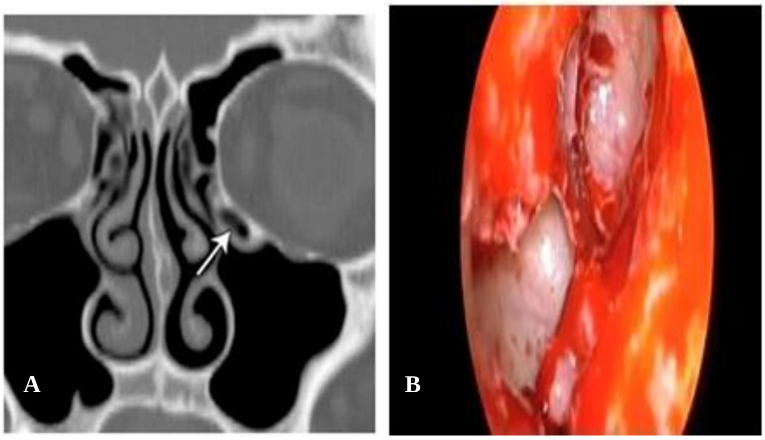

Figure 5: (A) CBCT image of haller cell; (B) endoscopic image of haller cell during functional endoscopic sinus surgery (fess).[13]

Maxillary sinus septa (Underwood's septa) are fin shaped projections of bone that may exist in the maxillary sinus. Classified based on location of septa in the sinus as anterior, middle and posterior. Prevalence rate was found to be 32%. The presence of septa at or near the floor of the sinus are of interest to the dental clinician when performing sinus floor elevation procedures because of an increased likelihood of surgical complications, such as tearing of the Schneiderian membrane.[8]

Maxillary sinus pneumatization is characterized by the maxillary sinus extension to alveolar ridge, anterior region, maxillary tuberosity, palate, zygomatic bone and/or orbital region. The maxillary sinus pneumatization, particularly the alveolar extension, can exacerbate the problem of reminiscent bone caused by atrophy of the maxilla, leaving only few millimeters of bone to implant insertion.

Figure 6: (A) CBCT image of Kuhn cell; (B) cadaveric image of Kuhn cell; (C) pictorial representation of Kuhn cell.

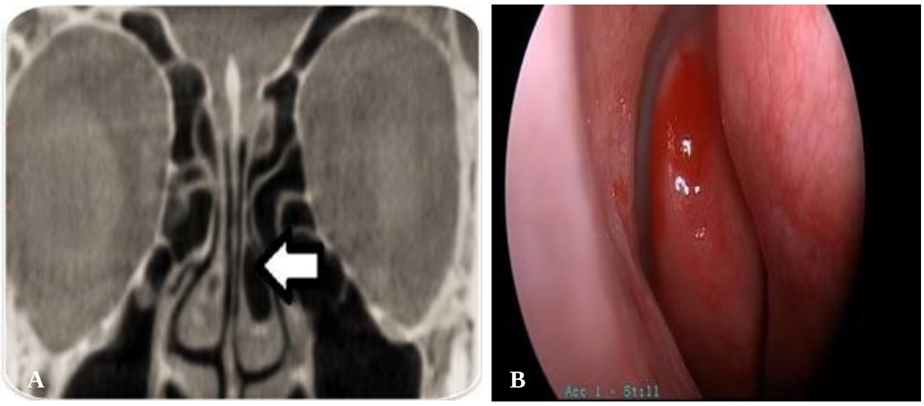

Figure 7: (A) CBCT image of concha bullosa; (B) endoscopic image of concha bullosa.

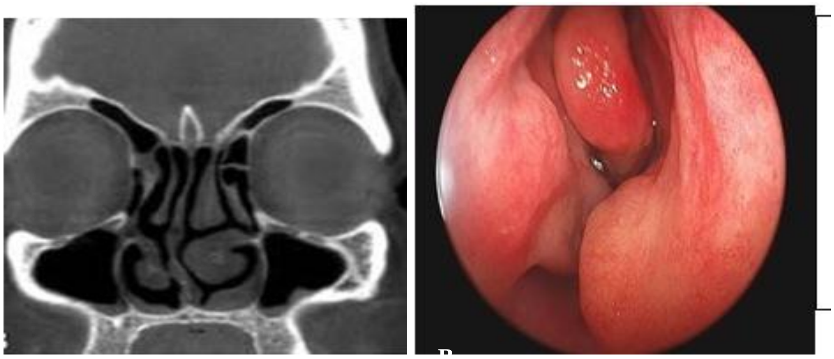

Figure 8: (A) CBCT image of deviated nasal septum (to the left); (B) endoscopic view of deviated nasal septum.[13]

Figure 9: (A) CBCT image of conchal type of sphenoid sinus pneumatization; (B) CBCT image of pre sellar type of sphenoid sinus pneumatization; (C) CBCT image of sellar type of sphenoid sinus pneumatization

Extensive pneumatization of the sphenoid sinus (Figure 9A-C represents CBCT images of various types of sphenoid sinus pneumatization) is encountered rarely, extending into the lesser wing and the anterior and posterior clinoid processes.there are three types namely sellar (Figure 9A), presellar (Figure 9B) and conchal type (Figure 9C). It can lead to distortion of optic canal configuration.

Pneumatization of crista galli (Figure 10A represents CBCT image) is the aeration of the crista galli, extending from the adjacent left or right frontal sinuses. Pneumatized crista galli may communicate with the frontal recess and can potentially obstruct the frontal sinus.

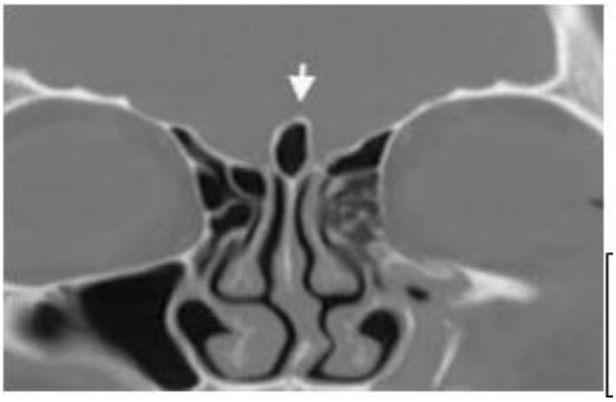

Figure 10: CBCT image of pneumatization of crista galli.

According to the study conducted by Jangam et al, about 52.5% of agar nasi cells, 46% of Kuhn cells, 23% of onodi cells and 27% of haller cells were found.[5] According to study conducted by Numan et al, Nobel Med, about 92.5% of agar nasi cells, 34.7% of Kuhn cells, 23.7% of onodi cells and 28.2% of haller cells were found.[6] According to the study conducted by Altun et al, about 75% of agar nasi cells, 74.2% of Kuhn cells, 12.5% of onodi cells and 24.4% of haller cells were found.[7] According to study conducted by Som in 13% of cases with crista galli pneumatization seen. According to Schriber et al about 56.7% cases show maxillary sinus septa. Comparing the values with our study, the percentage of Kuhn cells and onodi cells were found to be on par in comparison with other studies. Agar nasi cells were higher in our study compared to other studies and haller cells were lower in our study compared to other studies. The percentage of maxillary sinus septa was found to be higher in study conducted by Schriber et al compared to our study.[9] Crista galli pneumatization was found to be on par with the study conducted by Som.[10]

CONCLUSION

The most important anatomical variations of paranasal sinuses have been discussed in this article. CBCT is emerging as a better modality for imaging the paranasal sinuses including osteomeatal complex, due to its high quality bone definition, thin slicing, multi planar cross sectioning and low patient dosage thus preventing complications during endoscopic sinus surgeries.[8] Thus CBCT is raising as a new horizon in imaging head and neck structures, further extending its utilization in the field of Otorhinolaryngology (ENT).

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Ethical approval: Not required

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