ORIGINAL ARTICLE

FREQUENCY OF ANATOMICAL VARIATIONS OF PARANASAL SINUSES (PNS) ON ROUTINE CT SCANS

Mahum Zaidi,[1] Muhammad Wasif,[2] Syed Shariqullah,[1] Muhammad Ayub Mansoor,[1] Abdul Basir Shah Verdag[3]

[1] Department of Radiology, Liaquat National Hospital, Karachi, Pakistan.
[2] Department of Otolaryngology, Head and Neck Surgery, Dr. Ziauddin University and Group of Hospitals, Karachi, Pakistan.
[3] Department of Otolarygology, Head and Neck Surgery, Aga Khan University Hospital, Karachi, Pakistan.

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ABSTRACT

OBJECTIVE: To report anatomical variations on routine CT Scans observed in the paranasal sinuses in patients presenting to a tertiary care facility. **METHODS:** A cross-sectional study conducted at the department of Radiology of a tertiary care centre, intended to evaluate anatomical variations in patients with benign Sino-nasal pathologies presenting to the facility between 1st of August, 2016 and 31st of July, 2017. The data was collected by evaluating digital records of patients collected over the specified time. **RESULTS:** A complete analysis of the cross-sectional radiological examinations of 70 patients was carried out for the evaluation of anatomical variants prevalent in the population subset. The study included 44 males and 26 females with a median age of 35.8 years. Among the study population, 71.24% had a deviated septum with right-sided predominance, 35.71% with concha bullosa, 21.42% had septated maxillary sinus, 70% had agger nasi cells, 20% had Haller cells, 18.57% had Onodi cells and lastly 2.85% had hypertrophied ethmoid sinuses. A differentiation of olfactory fossa depth was also studied and characterized as per the Kero's classification in which type-II was the predominant variety corresponding to 71.42% of the test subjects. **CONCLUSION:** Knowledge of these variations preoperatively is of utmost importance for surgeons and failure to pay attention to these details can end up in devastating complications. Such studies can optimize patient care and can lead to reduction in adverse sequalae of surgical intervention.
Keywords: Paranasal Sinus Diseases, Maxillary sinus, Frontal sinus

Introduction

Anatomical variations are physiological sequalae of the genetic and environmental influences on human development. Maxillary, ethmoid, sphenoid and frontal sinuses, more colloquially referred to as paranasal sinuses (PNS) are the air-filled pockets primarily responsible for resonance during phonation, aeration and humidification of the respiratory passages and lightening of the skull. Development of these sinuses ensues in the beginning of the 25th week of embryological life from a primitive choana which largely contributes in the form of three projections. The anterior, maxilloturbinate and the ethmoidoturbinate projections give rise to various components of the paranasal sinuses and the allied structures. The matured and pneumatized sinuses are primarily formed as non-pneumatized bony structures with variable ages of pneumatization and patterns of growth. Consequently, air cells show highly variable radiological anatomy.[1] A large array of anatomic idiosyncrasies are observed when defining the

Correspondence : Dr. Muhammad Wasif
Department of Otolaryngology, Head and Neck Surgery,
Dr. Ziauddin University and Group of Hospitals,
Karachi, Pakistan.
Email: wasif_siddiq313@yahoo.com

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anatomy of the paranasal sinuses. A major chunk of these variations is present in ethmoidal and frontal air cells.[3] Primarily, these intricacies are eluding during functional endoscopic surgeries as operating within these variable labyrinthine structures can prove to be challenging and potential adverse outcomes can be expected because of the close approximation to vital structures. Secondly, this variability also leads to pathological processes like decreased mucociliary escalator clearance which ultimately becomes a causative factor for rhinosinusitis.[2]

Radiological evidence has evolved over the ages and as the technological options increased, a shift was observed largely owing to the effectiveness of computed tomography (CT) in better defining of both the physiological variations and the anatomic localization of the involved pathology. Hence, a frameshift was observed from crude plain X-rays to CT-scans of the sinuses.[6] In doing so, a greater extent of expertise was warranted in the field for better differentiating physiological variations from pathologies. The depiction of such anatomical characteristics have been explained in the form of various classifications over the decades.[4]

This study intends to shed light on the radiological variations observed in the paranasal sinuses and the air cells in patients with benign pathologies involving the sinuses. This study intends to evaluate the gross radiological disparities observed in the subset of typical population presenting to the tertiary care facility.

Materials and Methods

This was a single centre, cross-sectional study conducted at the department of Radiology of a tertiary care centre, intended to evaluate anatomical variations in patients with benign Sino-nasal pathologies presenting to the facility between 1st of August, 2016 and 31st of July, 2017. The data was collected by evaluating digital records of patients collected over the specified time.

As this was a retrospective study, only computer records were accessed. No formal consent was required from the patients, nor was there any contact with them. Full confidentiality of patients was maintained by using CT numbers as the reference. All examinations were performed on an MDCT scanner (Toshiba Activion 16 slice CT scanner). Plain CT scans (collimation. 4 x 2.5 mm; reconstruction section thickness, 4 mm; reconstruction intervals, 4 mm) were obtained. CT scans were retrospectively reviewed on picture archiving and communication system (PACS) workstations and a constellation of findings were recorded; including deviated nasal septum, concha bullosa, septated maxillary sinus, agger nasi cells, Haller cells, Onodi cells, hypertrophied ethmoid sinuses and depth of olfactory fossa according to Kero's classification:

Keros I – Depth of olfactory fossa less than 3 mm
Keros II – Depth of olfactory fossa 4-7 mm
Keros III – Depth of olfactory fossa 8-14 mm

Results

A total number of 70 participants were listed in the study scanned and evaluated in a period of one year. The median age of the evaluated participants was 35.8 years comprising of 62.5% of male population and the remaining 37.14% of female population corresponding to 44 and 26 individuals respectively. All the patients were evaluated for benign Sino-nasal pathologies with maxillary sinus being the predominant site for sinusitis afflicting 74.2% of the individuals followed by 54.2% with anterior and 51.4% having posterior ethmoid sinusitis. Individuals with involvement of frontal and sphenoid sinuses included 25.7% and 28.5% respectively.

Among the study population, 71.24% had a deviated septum with right-sided predominance, 35.71% with concha bullosa, 21.42% had septated maxillary sinus, 70% had agger nasi cells depicted in (Fig.1), 20% had Haller cells (depicted in Fig.2), 18.57% had Onodi cells (depicted in Fig.3) and lastly 2.85% had hypertrophied ethmoid sinuses. A differentiation of olfactory fossa depth was also studied and characterized as per the Kero's classification further explained in (Chart 1) in which type-II was the predominant variety corresponding to 71.42% of the test subjects, the characteristic image of which has been depicted in (Fig.5).

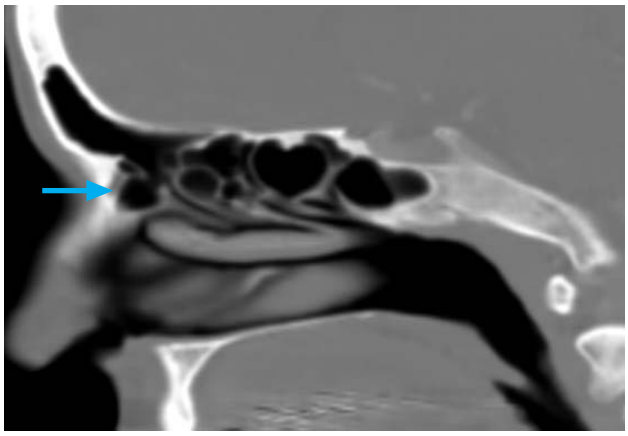

Figure 1: Saggital view of CT PNS showing Agger nasi cells (Anterior ethmoid group of cells) is also noted.

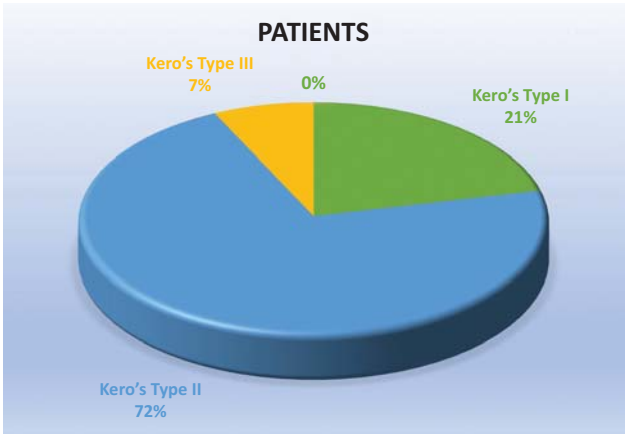

Chart 1: Prevalence of Olfactory fossa depth on the basis of Kero's Classification

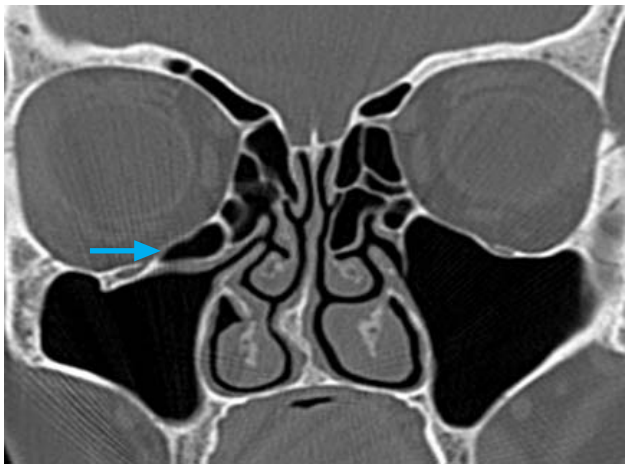

Figure 2: Coronal view CT scan PNS showing Haller cells (pneumatized infraorbital anterior ethmoid cells found between the maxillary sinus and the orbit on right side.

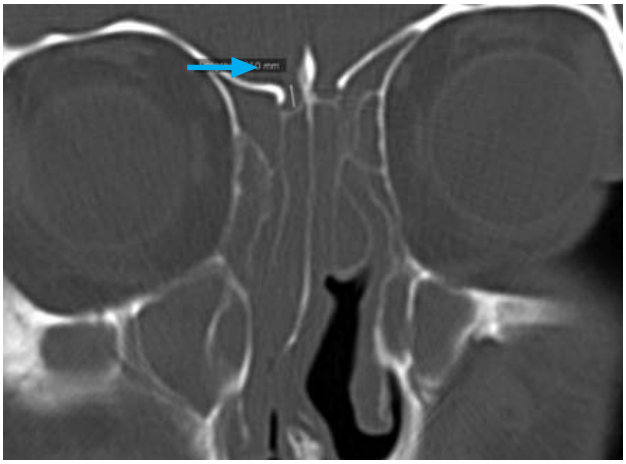

Figure 4: Coronal view of CT PNS: Depth of olfactory fossa measures about 2.8 mm falling under Kero's type I classification.

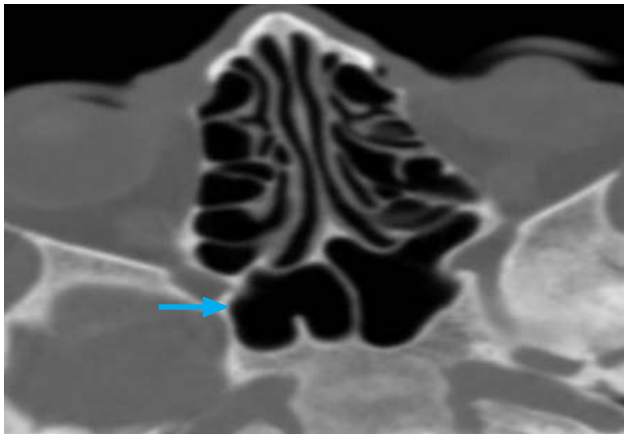

Figure 3: Axial view of CT PNS showing Onodi cells (posterior ethmoid air cells) superior to the sphenoid sinus is also noted.

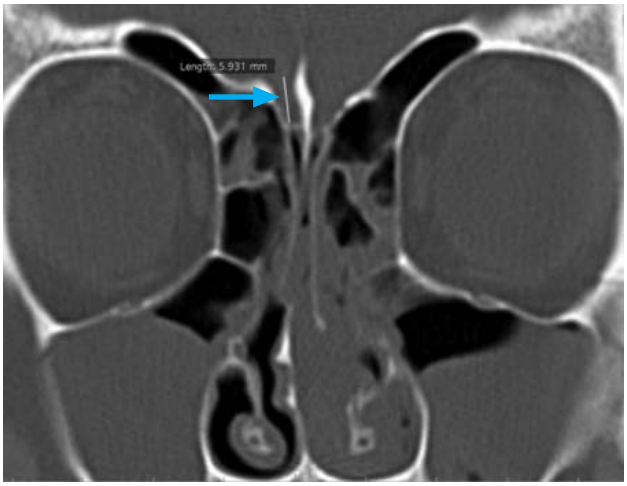

Figure 5: Coronal view of CT PNS: Depth of olfactory fossa measures about 5.9 mm and falling under Kero's type II classification

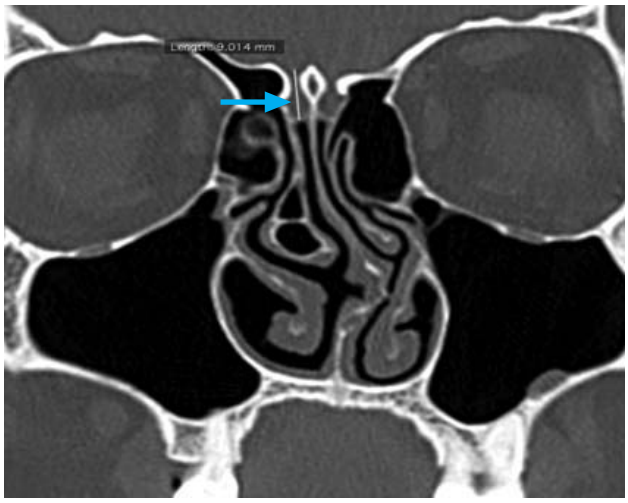

Figure 6: Coronal view of CT PNS: Depth of olfactory fossa measures about 9.0 mm and falling under Kero's type III classification

Discussion

Over the last century, a tremendous evolution has been observed in defining the anatomic characteristics of the sinonasal tracts and in doing so has been crucial in understanding the surgical basis for approach to the respective tract along with the anterior skull base. Secondly, an in-depth analysis of the characteristic features and physiological variants is essential for recognizing the contributing factors for the impaired drainage of the tract. However, whether these variations play a definitive role in the pathogenesis of the illness is a separate question to be answered.[5,7] As CT-scan is the modality of the choice for investigation of the pathology, the recognition of these characteristics enables the radiologists in separating the pathology from physiology and helps to explain a basis for the disease process and the extent of it as well.[8,9]

The study signified some form of sinusitis in a major chunk of the study population with maxillary sinusitis being the most prevalent form of sinusitis. A prevalence was observed in the reporting gender and the median age group which was male and mid-thirties. The age group signifies the usual subset with the characteristic presenting complain. Moreover, the population studied showed variable proportions of the sinonasal variants which in some cases contributed to their overall pathology. Apart from the structural variants, the study also took account of the depth of the olfactory fossae and classified them based on the Kero's classification system.

A detailed comparative description has been laid out in (Tab.2) of the study further explaining a broad regional, ethnic and environmental populations and the overall anatomical variations observed.

Anatomical Variation	Number of Patients	Percentage of Study population
Deviated nasal septum (DNS)	50 Patients	71.4%
Concha bullosa	25 Patients	35.7%
Septated maxillary sinus	15 Patients	21.4%
Agger nasi cells	49 Patients	70.0%
Onodi cells	13 Patients	18.5%
Hypertrophied ethmoid sinuses	02 Patients	2.8%
Haller cells	14 Patients	20.0%

Table 1: Frequency of anatomical variations of paranasal sinuses in percentage

Author (country)	n	Concha bullosa	Haller cells	Agger nasi Cells
Current Study (Pakistan)	70	35.7%	20%	70%
Al-Qudah et al (UK)	110	62%	20%	80%
Jones et al (Austria)	200	20%	9%	95.5%
Dua et al (India)	50	16%	16%	40%
Jun Kim et al(Korea)	113	19%	30%	66%
Sivasli et al(Turkey)	47	42%	22%	15%
Tonai et al (Japan)	75	28%	36%	86%
Adeel et al (Pakistan)	77	35%	20%	-

Table 2: Prevalence of common sinonasal radiological variants in our study and other studies.

Deviation of the nasal septum is the most prevalent sinonasal pathology that is responsible for the symptomatology of the masses. A suggestion has been made that the septal deviation begins around the age of 7 with a rightward deviation being the most prevalent form.[8] In our subset of population an overwhelming majority of 71.4% was observed with the pathology. Over the years the studies conducted have shown variable proportions with studies conducted in a similar regional population showed a prevalence ranging from as low as 26% to as high as 76% thus further strengthening the case to case planning criteria for sino-nasal pathologies.[9,10]

Concha Bullosa is a pneumatized variety of the middle

turbinate, which as per one one study was not associated with an increased risk of osteomeatal obstruction and eventual rhinosinusitis, however an overgrown middle turbinate is likely to impair the drainage.[19] The presence of such a variety of pneumatized middle turbinate has ranged between 4% - 80% in different studies; our study yielded a data of 35.7% that falls in between the extremes as observed by Bolger (53.6%) Dua K et al (16%).[11,12]

Maxillary sinus variations have been long documented from hypoplastic sinuses to septations observed in the sinus cavity itself. Septated variety of the sinus was observed in our data set to be 21.4 % of all the cases. This number is a major rise in prevalence as compared to the previous publications which have reported lower rates of 6% and 2.3% as observed by Dua et al and John Earwaker respectively.[11,12]

Agger nasi cells are the loculi of pneumatized anterior most ethmoid air-cells placed anterior to the cranial end of nasolacrimal duct. Our study yielded a number midway between what literature has reported which showed presentations corresponding to lower and upper extremes of 40% and 96% respectively. However, the study could not discern a pattern of pathological processes associated with the illness as the data yielded a 54.2% of cases with anterior ethmoidal sinusitis.[11,13]

Infra-orbital ethmoidal pneumatization referred to as the **Haller cells** are essential to be descriptively identified before any functional sinus surgery. As surgical endeavours for ethmoidal clearance would in turn lead to threatened orbital cavity, consequently making these Haller cells a significant variety to be explained and studied radiologically. The data collected in our study showed a 20% incidence of this anatomical variation which roughly corresponds to literature as Kantarci et all has reported a similar incidence of 18%.[14,15] A hypertrophied variety of ethmoidal sinuses was also observed but the reported cases represented an underwhelming number of 2.8% in comparison to the 26.75% reported by Krzeski et al.[18]

Posterior ethmoidal cells or Onodi cells represent the superior extension of these posterior cells beyond the superior limit of sphenoid sinus. Their proximity to the cavernous sinus and to the optic nerve makes them an anatomically crucial variant to study, evaluate and report in CT scans. 18.5% of our study population was seen to have the cells presents representing roughly a double figure as that observed in previous studies.[16,17]

A formal assessment was made of the height of the lateral lamella of the cribriform plate i.e. **Olfactory fossa depth** as per the Kero's classification system. In the mid of 20th century, kero's defined the olfactory fossa depth and classified it based on the dimensions grading them into less than 3 mm variety, those ranging between 4 and 7 mm and lastly those ranging between 8 and 16 mm which he termed as types I, II and III. Kero's made a correlation between the height analysis of the lateral lamella with the chances of iatrogenic injury associated with the surgical procedures and thus leading to complications like skull base injuries and eventual fistulous tracts. In our case, the major portion of the test population resided in the Kero's type II category amounting to be 71.42%. (Chart 1) further explains the proportionate division of into the three subtypes. Our data was comparable to some of the previous works like Nitinavakarn et al that had also reported a similar outcome in their study conducted in Thailand evaluating the CT characteristics and the impact on the surgical intervention.[18]

This study was intended to aid the rhinologists and the anterior skull base surgeons in evaluating their population with an understanding of the proportional variations observed so that minimal surgical complications are observed on the grounds of anatomical differences.

Conclusion

Anatomical variations in the Sino-nasal tract are prevalent in different societies at variable levels and such characteristic findings are to be evaluated for the appropriate management steps of the pathologies associated and the consequent surgical intervention. Knowledge of these variations preoperatively is of utmost importance for surgeons and failure to pay attention to these details can end up in devastating complications

Disclosures: None

Conflict of interest: There are no financial interests or arrangements that would constitute a conflict of interest.

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