Orginal Article

Anatomical Variations of Nose and Para-nasal Sinuses in Computed Tomography Scan

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Introduction: Paranasal sinuses (PNS) are a group of air-filled spaces developed as an expansion of the nasal cavities, eroding the adjacent bone structures. The common anatomical variants are deviated nasal septum, agger nasi cells, concha bullosa, uncinate process variations, onodi cells, paradoxical middle turbinate and haller cells. CT is a gold standard for evaluation of anatomical variations of the nose and paranasal air sinuses which is important in patients who are undergoing CT for various rhinological reasons.

Methods: This is a retrospective study done from the database of the department of Radio-diagnosis, Devdaha Medical College and Teaching Hospital (DMCTH), Bhaluhi, Rupandehi, Nepal during last one-year period from 1st Jan 2023 to 31st December 2023.

Results: A total of 100 CT examinations of the PNS were included in this study. The most common anatomical variation was deviated nasal septum seen in 61%. Other anatomical variation were agger nasi cells in 57%, concha bullosa in42%, paradoxical medial turbinate was seen in19%, onodi cell was seen in16%, uncinate process variation was seen in13%, haller cell was seen in 12%. There were more than one anatomical variations present on single scan and there were no anatomical variation in 10% cases.

Conclusion: Numerous sinonasal anatomic variants are frequently seen on CT scans which is important not only for diagnosis but also for planning surgery in order to avoid complications.

Keywords: *Anatomical variants, Computed Tomography, Deviated Nasal Septum, Paranasal sinuses.*

Introduction

Paranasal sinuses (PNS) are a group of air-filled spaces developed as an expansion of the nasal cavities, eroding the adjacent bone structures.[1]Humans have four pairs of sinuses which are maxillary, ethmoid (divided into anterior and posterior cells) frontal and sphenoid sinuses.[2] The paranasal sinuses are subject to marked variation between individuals and between sides in the same individual, regarding size (aeration) and bony septations.[3]

The common anatomical variants are deviated nasal septum, agger nasi cells, concha bullosa, uncinate process variations, onodi cells, paradoxical middle turbinate and haller cells.[4] Nasal septal deviation is defined as any bending of the septal contour on coronal computed tomography (CT) scans and is present in more than one half of the population.[5,6,7] The Agger nasi cells are the most anterior ethmoidal air cells. Their location is anterior, lateral, and inferior to the frontal recess.[8,9] Concha bullosa is commonly defined as pneumatization of the middle turbinate involving its inferior

bulbous portion and is usually bilateral.[7.8.10]Haller cells are the infraorbital ethmoidal cells that extend downward under the medial floor of the orbit adjacent to and above the maxillary sinus ostium lateral to the infundibulum.[8.11] Onodi cells are the posterior ethmoidal cells that extend laterally, superiorly, and posteriorly to the sphenoid sinus and are intimately associated with the optic nerve.[8] A paradoxically bent middle turbinate is defined as a turbinate having a scroll convexity in the lateral rather than the medial aspect.[5.7.12]

CT is the gold standard for evaluation of anatomical variations of the nose and paranasal air sinuses which are important in patients who are undergoing CT for various rhinological reasons. It provides assessment of paranasal sinuses, olfactory fossa depth, excellent anatomical soft tissue, bony details and thus helps in the diagnosis of diseases and anatomical variation of nose and paranasal sinuses which provides road map for functional endoscopic sinus surgery and explains the recurrence of diseases.[13.14] The knowledge of these anatomical variations is important before surgery is planned to avoid damage to surrounding structures.[15] Our study intends to explore the anatomy of paranasal air sinus through CT and to describe its variants, which may predispose to sinonasal symptoms.

Methods

This retrospective study was done from the database of the department of Radio diagnosis, Devdaha Medical College and Teaching Hospital (DMCTH), Bhaluhi, Rupandehi, Nepal. The study was conducted after the ethical approval from the Institutional Review Committee (IRC-DMC -01/2024) of the hospital from 1st Jan 2023 to 31st December 2023.

Inclusion criteria: All the patients who underwent CT PNS during our study period with diagnosis of chronic rhinosinusitis.

Exclusion criteria: Patients with facial trauma, head and neck tumors, and previous nasal surgery were excluded.

Sample Size

According to the prevalence rate of 68.2% of anatomical variation of PNS on CT scan in a study done by Sharma BN et al [16] with confidence level of 95% and power of 90%, the required sample size was calculated using the formula

$n = t^2 \times p\ (1 - p)/ m^2$

n = required sample size

t = confidence level at 95% (standard value of 1.96)

p = estimated prevalence of anatomical variation of PNS on CT= 68.2% = 0.68

m for power of 90% = margin of error at 10% (1- alpha) = 0.1

Sample size = $(1.96)^2 \times 0.68\ (1 - 0.68)/(0.1)^2 = 82.6$

Required minimum sample size = 83

CT imaging protocol: All patients were subjected to Siemens Somatomgo. Up 64 slice CT scan. Images were taken in axial plane then reconstruction was done in both coronal and sagittal plane in 3 mm cut. Findings of each subject were recorded in an individual case proforma from the database of the Department of Radio diagnosis, Devdaha Medical College and Teaching Hospital. The case proforma contained all information regarding the general particulars like: name, age, sex, clinical details and CT findings for the presence of deviated nasal septum, agger nasi cells, concha bullosa, uncinate process variations, onodi cells, paradoxical middle turbinate, sinus hypoplasia, septal spur, septal pneumatization and haller cells. Olfactory fossa depth and Keros classification was also noted. The data were entered in Microsoft Excel 2013 and analyzed using SPSS version 25. Frequencies and percentages were calculated for all qualitative variables like sex, CT findings etc. Range, mean and standard deviation were calculated for all quantitative variables like age. Student's t- test was used to test the significance of difference for quantitative variables (age). A 'p' value less than 0.05 will be taken to denote significant difference.

Results

A total of 100 CT examinations of the PNS were included in this study. There were 56 (56%) males and 44 (44%) females (male: female ratio-1.2:1). The mean age was 34.8±12.2 (range between 15-64 years). Maximum participants were in age range of 31-45 years i.e. 38 (38%) and least in age group more than 60 years i.e. 9 (9%). No abnormalities were found on CT PNS among 10 (10%) patients while remaining 90(90%) had abnormality in CT scan. (Table 1, 2 and 3) Male had more anatomical variation of paranasal sinuses than female but it was statistically not significant (p>0.05). (Table 3)

Table 1: Distribution of patients according to age (n=100).

Age	Frequency	Percentage
15-30yrs	34	34
31-45yrs	38	38
46-60 yrs	19	19
>60 yrs	9	9
Total	100	100

Table 2: Distribution of patients according to gender (n=100).

Gender	Frequency	Percentage
Male	56	56.0
Female	44	44.0
Total	100	100.0

Table 3: Type of anatomical variation according to gender

Abnormality*	Male	Female	Total	P Value
Deviation of nasal septum(DNS)	36(36%)	25(25%)	61(61%)	0.07
Agger Nasi cells	32(32%)	25(25%)	57(57%)	0.1
Concha Bullosa	26(26%)	16(16%)	42(42%)	0.2
Paradoxical Middle Turbinate	12(12%)	7(7%)	19(19%)	
Onodi Cells	10(10%)	6(6%)	16(16%)	
Uncinate Process variation	9(9%)	4(4%)	13(13%)	
Haller cells	8(8%)	4(4%)	12(12%)	
Nasal septal pneumatization	6(6%)	2(2%)	8(8%)	
No Anatomical variation	6(6%)	4(4%)	10(10%)	

*Anatomical variations of PNS were not mutually exclusive, total percentages may exceed 100 %.

Table 4: Laterality of Sino nasal anatomical variation

Abnormality	Right	Left	Both	Total	P value
Deviated nasal septum (DNS)	32(32%)	19(19%)	No DNS-10(10%)	61	<0.05
Agger Nasi cells(AN)	9(9%)	7(7%)	41(41%)	57	
Concha Bullosa(CB)	15(15%)	13(13%)	24(24%)	42	
Paradoxical Middle Turbinate(PCMT)	7(7%)	4(4%)	8(8%)	19	
Onodi Cells(OC)	8(8%)	5(5%)	3(3%)	16	
Uncinate Process variation	7(7%)	5(5%)	1(1%)	13	
Haller cells(HC)	6(6%)	4(4%)	2(2%)	12	

The most common anatomical variation was deviated nasal septum (n=61, 61%) which was more common on right side (n=32, 32%) than left (n=19, 19%) and there was no deviation in 10 cases (10%). Similarly next common anatomical variation was agger nasi cells (n=57, 57%), seen on both sides (n=41, 41%) then right (n=9, 9%) and left (n=7, 7%) and without any variation in 43(43%). Concha bullosa was present on 42 cases (42%) with more of bilateral predominance (n=24, 24%) on right side (n=15, 15%) on left (n=13, 13%). Paradoxical medial turbinate was seen in 19 cases (19%) with more on right (n=7, 7%) than left (n=4, 4%) and 8(8%) on bilateral side. Onodi cell was seen in 16 cases (16%) with 8(8%) on right and 5(5%) on left and 3 case (3%) on bilateral side. Uncinate process variation was seen in 13(13%) cases with right 7(7%) and left 5(5%) and 1 case (1%) bilaterally. Haller cell was seen in 12(12%) cases with 6(6%) on right and 4% on left with 2(2%) cases on both sides. There were more than one anatomical variation present on single scan and there was no anatomical variation in 10(10) % scans.(Table 3 and 4) Some variations were seen more on the right side while others on the left. Some variations were present bilaterally. The difference was not statistically significant (Table-4).

Table 5: Type of olfactory fossa type

Olfactory Fossa Type	No(100)
Type 1	28(28%)
Type 2	59(59%)
Type 3	13(13%)

The olfactory fossa lies in anterior skull base. The depth of olfactory fossa is determined by the height of the lateral lamella of cribriform plate and divided into three types by Keros. The most common type was type 2 (59, 59%) followed by type 1 (28, 28%). Least common type was type 3 (13, 13%) (Table 5)

Discussion

Detailed knowledge of anatomic variations in paranasal sinus region is critical for surgeons performing endoscopic sinus surgery as well as for the radiologist involved in the pre- and post-operative assessment. The anatomical variants with some accompanying pathologies would directly influence the success of diagnostic and therapeutic management of paranasal sinus diseases.[17]Diseases of the ethmoidal sinus cannot be read as easily as maxillary or frontal sinus diseases using standard plain films due to its

overlap of surrounding structures.[18] The role of magnetic resonance imaging (MRI) is limited due to its high cost, unavailability, contraindications and inability to display the skeletal anatomy as compared to CT.Computed tomography (CT) is considered the method of choice in delineating normal anatomy and evaluating variations in the paranasal sinuses, and it is extremely useful in the pre- and post-operative planning and follow-up in cases of endonasal interventions.[19]

In our study total of 100 CT PNS were included. There were 56 (56 %) males and 44 (44%) females. Most of the studies we reviewed made no reference to gender variation although study done in Karnataka State showed male preponderance. [20] The findings from our study showed that anatomical variation affects middle age group of 31-45 years with mean age of 34.8±12.2years which correlates with other studies done in Nepal and India.[14,20] In our study, out of 100 patients, 90 (90%) had at least one type of anatomical variation while 10 (10%) had no variation. This was similar to the study by Shrestha KK et al, Kaygusuz et al and Sarika et al where they found anatomical variations in 89.5%, 89.4% and 81.11% respectively. [21,22,23] Other study, however, reported lower incidences (70%) by Kanagaraj et al. [24] This difference in prevalence of anatomical variations of nose and PNS could be due to the result of discrepancies in analyzing and studying methods, definitions, racial varieties and the accuracy of study.[25,26]

The most common anatomical variant in our study was DNS, occurring in 61 (61%) patients. This was comparable to the absolute frequencies of DNS in other studies done by Shrestha KK et al [21] (64.5%), Sharma et al [16] (68%), Pokhrel S [14] (73.1%) in Nepal but was quite high as compared to those done by Maru et al [27] and Dua et al [28] in India. Geographic variation might be the cause for high prevalence in our study. This also signifies that DNS might be an important factor in causing nasal diseases and symptoms. In our study, DNS was more towards right side in 32% cases which was similar to the findings in study done by Pokhrel S in Palpa, Nepal.[14] This also signifies that right sided DNS is most common anatomical variant in this part of Nepal.

The second most common variation in our study was agger nasi cell and was seen in 57(57%) cases, of which 9(9%) were on right side, 7(7%) on left side and 41(41%) were bilateral.Our results are in concordance with the study done by Talaiepour AR et al, which showed Agger nasi cell in 56.7% of cases, with 17.5% on the right, 7.7% left and 31.5% of patients having Agger nasi cell as a bilateral finding.[29] In another study done by Yadav R R et al reported that, Agger nasi cell was the commonest anatomical variation and found in 75.8%.[30]

The third most common variation in our study was concha bullosa was present on 42% with more of bilateral predominance in 24%, on right side (15%) and on left (13%). Other studies from Nepal had reported the incidences as 27%[16] and 35.9%.[30] Similarly there are other studies done by Maru YK et al showed concha bullosa in 42.6% [27] and Sivasli E et al found in 58%. [31]Bilateral predominance was also found in study done by Pokhrel S similar to our findings.The reported prevalence of CB in literature varies widely from 14-80%.[15]

In our study, we found paradoxical medial turbinate was seen in 19 cases (19%) with more on right (n=7,7%) than left (n=4,4%) and 8(8%) on bilateral side. The rates of PCMT are ranging from 15 to 26% in the literature. The study done by Adeel M et al found PCMT in (14.3%) [33] which is comparable to our study.

Another variation was onodi cell whichwas seen in16 %. The rate of OC in previous studies has a very wide range (3.4–51%). [6] In our study uncinate process variation was seen in 13% consistent with the findings in previous study done by Maru YK et al (9.8%)[27]

We found haller cells in12 % patients which is the lowest anatomical variation noted in our study The rate of HC was ranging from 2 to 56.6 % in the literature. [5, 32] Zinreich et al found HC in 10% [13] which is similar to our findings.

In our study we also measured the depth of olfactory fossa. Depth of olfactory fossa is divided in to three types, according to Keros classification where 1- 3mm is type I, 4-7mm is type II and 8- 16 mm is type III.[14] In our study type II (59%) was most common and correlates with the studies done by Pokhrel S[14] (61.5%),Kaplanoglu H et al (76.1%)[34] , Babu AC et al (74.6%) [35] but differ from Solares et al which showed Type I(83%) to be most common.[36]So it is very important to measure depth of olfactory fossa in every case because higher depth of olfactory fossa has more chance of injury to skull base during surgery.[14]

Conclusion

Computed tomography (CT) of the para-nasal sinuses (PNS) has nowadays become the investigation of choice for the diagnosis of sinonasal diseases. Numerous sinonasal anatomic variants exist and are frequently seen on CT scans. A sound knowledge of these variations is important not only for diagnosis but also for planning surgery in order to avoid complications.

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