Gender and Age Impact on Anatomical Variations of Paranasal Sinuses - A CT Scan Study in North Indian Population

Seema Pandey[1], Badal Singh[2], Harvendra Singh[3], Avadhesh Kumar Singh[4]

[1]Department of Radiodiagnosis, MLN Medical College, Prayagraj, Uttar Pradesh, India.
[2, 3, 4] Department of Anatomy, MLN Medical College, Prayagraj, Uttar Pradesh, India.

ABSTRACT

BACKGROUND
Computerized Tomography (CT) scan plays a very important role in decision making before planning any surgical intervention on paranasal sinuses and is also the modality of choice during management and post-surgical follow-ups. Knowledge of different morphologies of paranasal sinuses is an important prerequisite for surgical decision making. This study was done to describe the impact of gender and age on anatomical and morphological presentations of paranasal sinuses using CT in the North Indian Population.

METHODS
A cross-sectional type of descriptive study was conducted in the Department of Anatomy in collaboration with the Department of Radiodiagnosis of M. L. N. Medical College and Kriti Scanning and Research Centre, Allahabad (Prayagraj) Uttar Pradesh, to describe various morphological presentations of paranasal sinuses. Based on the findings, the gender and age group variations of paranasal sinuses were evaluated and discussed along with the types of the frontal air cells and concha bullosa.

RESULTS
Overall 120 subjects were analysed based on their CT-scan findings (72 males and 48 females). The frequencies of major sinus variations were observed as Onodi cells in 19.2 %, Concha bullosa in 47.5 %, Frontal air cells in 25 %, Maxillary sinus septation in 7.5 % and Supraorbital cells in 15 % of the study population.

CONCLUSIONS
Anatomical variations of paranasal sinuses are very common. These variations must be identified by the radiologists in preoperative computerised tomography evaluation to reduce the risk of intraoperative complications. CT scan provides a virtual roadmap to the surgeon and improves the success of management strategies.

KEY WORDS
Anatomical Variations, Paranasal Sinuses, Concha Bullosa, Onodi Cell

Corresponding Author:
Dr. Seema Pandey,
 # 45, Baghambari Housing Scheme,
Allapur, Allahabad - 211006,
Uttar Pradesh, India.
E-mail: docseemapandey@gmail.com

DOI: 10.14260/jemds/2022/9

How to Cite This Article:
Pandey S, Singh B, Singh H, et al. Gender and age impact on anatomical variations of paranasal sinuses - a CT scan study in North Indian population. J Evolution Med Dent Sci 2022;11(01):44-49, DOI: 10.14260/jemds/2022/9

Submission 20-12-2021,
Peer Review 28-12-2021,
Acceptance 19-01-2022,
Published 24-01-2022.

BACKGROUND

Paranasal sinuses (PNS) are the air-containing spaces in the skull. They lighten the skull, perform the function of humidification of air and provide resonance to voice. For the clinician, precise knowledge of the anatomy of the paranasal sinuses is essential.[1] Various imaging modalities are available for the evaluation of the paranasal sinuses. Conventional radiography provides useful information in the diseases of maxillary and frontal sinuses. But it has a limited role in the evaluation of nasal cavity, ethmoid and sphenoid sinuses.[2] Computed tomography provides a detailed picture of the anatomy, the anatomical variants and the extent of the disease in and around the paranasal sinuses. Optimal information about the adjacent bones, soft tissues is available with CT being the imaging modality of choice for assessing PNS. CT provides a preoperative road map for functional endoscopic sinus surgery. A combination of CT and diagnostic endoscopy has become the cornerstone in the management of paranasal sinus diseases.[3]

There are lots of racial variations among individuals; also there is a lack of studies tackling the age groups and gender differences in these variations.

This study was done to describe the impact of gender and age on anatomical and morphological presentations of paranasal sinuses using CT in the North Indian Population.

METHODS

This was a cross-sectional type of descriptive (observational) study. The study group was comprised of a total of 120 subjects both male and female, > 16 years of age who were enrolled from July 2018 to March 2019, after satisfying the inclusion criteria. Subjects were either urban or rural residents of Prayagraj or North Indian ancestry. Patients with history of previous sinus surgery, facial trauma, sinonasal tumours, less than 16 years, maxillofacial trauma or fracture were excluded from the study.

The candidates' gender and age were considered. All subjects recruited in six groups according to their age and the anatomical variations of paranasal sinuses in the study population were identified by the computerized tomography and analyzed. We statistically clubbed the above six groups into three groups and data were evaluated by the correlation between two variables and chi-square test (χ^2 test). Results were presented as tables and graphs along with brief descriptions.

A novel method for human age group classification based on correlation fractal dimension of facial edges in which 15-30 year old was a young adult, 31-50 years was middle age adult and 51 or more was a senior adult.[4] The data analysis was performed on IBM (SPSS 17.0).

For coronal CT examination, patient was placed in a prone position with neck extended and angulation was perpendicular to the hard palate. Imaging was done from the posterior margin of the sphenoid sinus to the anterior margin of the frontal sinus. The axial scan was studied inferosuperiorly, these were parallel to the hard palate and perpendicular to the ostiomeatal unit, that was helpful mainly in sphenoidal sinus along with onodi cells and concha bullosa. The variations were noted on right side, left side and bilaterally.

Demographic Characteristics

Out of 120 study subjects, 72 were males (60 %) and 48 females (40 %). The age of all subjects was ranging between 18-86 years with "mean ± SD" as 40.28 ± 17.99 years and a median of 38 years. The ages of males and females were ranging between 19 and 82 years and 18-86 years respectively with mean ± SD being 41.34 ± 18.12 yrs and 38.68 ± 17.87 years respectively.

Statistical Analysis

Variables were analysed on lines of a cross-sectional type of descriptive (observational) study. Data were evaluated by the correlations between two variables and the chi-square test (χ^2 test). The data analysis was performed on IBM (SPSS 17.0).

RESULTS

On the whole, there were 72 males and 48 female subjects that depicted the distribution of the sample by age and gender (Table 1). We find most of the subjects in age groups of young adults (15-30 yrs) and middle adult age groups (31-50 yrs).

Age Groups (in Years)	Gender Male (72)	Female (48)	Total (120)
17-26	21 (29.2%)	17(35.4%)	38(31.7%)
27-36	11(15.3%)	7(14.6%)	18(15%)
37-46	15(20.8%)	9(18.7%)	24(20%)
47-56	8(11.1%)	9(18.7%)	17(14.2%)
57-66	10(13.9%)	1(2.08%)	11(9.1%)
> 67	7(9.7%)	5(10.4%)	12(10%)

Table 1. Distribution of Sample by Age and Gender

1. Concha Bullosa

The frequency of concha bullosa was present in 57(47.5 %) (Fig.9) of the total subjects, in which 28 (49.1 %) were on the right side, 22 (38.6 %) were on the left side and 7(12.3 %) were bilaterally present. (Fig 11) Among the age and gender groups, it was most frequently encountered between 27-36 years age group i.e. in 11(61.1 %) subjects. It was present in 32 (44.4 %) males and 25 (52 %) females. Regarding the types of concha bullosa, inferior bulbous was the most common type of concha bullosa in 24 (42.1%) as compared to the extensive type in 18 (31.6 %) and vertical lamellar type was 15 (26.3 %)(Fig 8). Pearson chi-square test value is 5.42 which is not significant at P < 0.05 (P-value- 0.246) in relation of age and 0.674 which is not significant at P < 0.05(P-value 0.4117) in relation of gender(Fig.10) (Table 2).

2. Onodi Cell

The frequency of Onodi cells was seen in 23(19.2 %) (fig.9) of the total subjects in which 11(47.8 %) were on the right side, 9 (39.2 %) were on left side and 3(13 %) were present bilaterally (Fig.11). No significant age group variation was seen in case of Onodi cells (pearson chi-square P- value =

0.969). Gender also has no significant correlation with Onodi cell (Pearson chi-square P- value = 0.9246), present in 14 (19.4 %) males as compared to 9 (18.4 %) females (fig.10) (Table 2).

3. Frontal Air Cells

The frequency of frontal air cells was seen in 30 (25 %) (Fig. 9) of the total subjects in which 5 (16.7 %) were on the right side, 9 (30 %) were on the left side and 16 (53.3 %) were present bilaterally (Fig.11). No significant age group variation was seen in frontal air cell variation (Pearson chi-square test was not significant with P-value = 0.572) and gender also had no significant correlation (Pearson chi-square P-value = 1.00). It was found 18 (25 %) in males and 12 (25 %) in females. (Fig.10) (Table 2). Type-1 frontal air cell was most commonly encountered.

4. Maxillary Sinus Septation

Maxillary sinus septation was seen in 9 (7.5 %) (Fig.9) of the total study subjects in which 6 (66.7 %) were in right side, 2(22.2 %) were in left side and 1(11.1 %) was present bilaterally (Fig.11). No significant age group variation was seen in maxillary sinus septation (Pearson chi-square p-value =0.301) and gender also had no statistical significance (chi-square P- value = 0.524). It was present 4 (5.5 %) in males and 5 (10.4 %) in females. (Fig.10) (Table 2)

5. Supraorbital Air Cells

The frequency of supraorbital cells was seen in 18 (15 %) (Fig.9) of the total study subjects in which 9 (50 %) were on the right side, 7 (38.9 %) on the left side and 2(11.1%) were present bilaterally (Fig 10). No significant age group variation was seen (Pearson chi-square P-value = 0.219) and gender also had no significant correlation (Pearson chi-square p-value = 0.531). It was present 12 (16.6 %) in males and 6 (12.5 %) in females (Fig.10) (Table)

6. Haller Cells

Haller cells were seen in 17.5 % of the total subjects of which 38.0 % were on the right side, 42.9 % on left and 19.1 % were bilateral. The most frequent (27.7 %) presentation was between 27-36 years of age, distributed across 18.05 % males and 16.6 % females. Pearson chi-square test (χ^2) was 0.2597 which is not significant statistically at P-value < 0.05 (P-value- 0.610) in relation of age and χ^2 is 0.038 not significant at P-value < 0.05 (P-value -0.8495) in relation of gender.

7. Paradoxical Middle Turbinate:

The paradoxical middle turbinate was seen in 16.7 % of the total subjects with 35 % being right-sided, 45 % on left and 20 % bilaterally. Statistically insignificant correlation of age group variation was seen (Pearson chi-square P-value = 0.250) and gender had no statistical significance (chi-square P-value = 0.729). It was observed in 18 % of males and 14.6 % of females.

8. Depth of Olfactory Fossa

Keros type-1 was present in 24.2 % study subjects, Keros type-2 in 65.8 % subjects, and Keros type-3 in 10 % subjects. Statistically no significant correlation with gender was observed (Pearson chi-square P- values were = 0.861, 0.529, 0.456 for keros type 1, keros type 2, keros type 3, respectively).

Anatomical Variants	Categories	Gender		Total (120)	P-Value
		Male (72)	Female (48)		
Concha bullosa	Yes	32	25	57	0.411
	No	40	23	63	
Onodi cell	Yes	14	9	23	0.924
	No	58	39	97	
Frontal air cells	Yes	18	12	30	1.00 (with 1 degree of freedom)
	No	54	36	90	
Maxillary sinus septation	Yes	4	5	9	0.524
	No	68	43	111	
Supra orbital cells	Yes	12	6	18	0.531
	No	60	42		

Table. 2. Gender Wise Anatomical Variations of Paranasal Sinuses with P-Value

Anatomical Variations	Categories	Age(Years)						Total N=120	P-Value
		17-26 (N=38)	27-36 (N=18)	37-46(N=24)	47-56 (N=17)	57-66 (N=11)	>67 (N=12)		
Concha bullosa	Yes	18	11	14	7	4	3	57	0.246
	No	20	7	10	10	7	9	63	
Onodi cell	Yes	4	7	4	3	2	3	23	0.969
	No	34	11	20	14	9	9	97	
Frontal air cells	Yes	9	5	6	5	2	3	30	0.572
	No	29	23	18	12	9	9	90	
Maxillary sinus septation	Yes	3	3	0	1	1	1	9	0.301
	No	35	15	24	16	10	11	111	
Supra orbital cells	Yes	4	2	3	3	2	4	18	0.219
	No	34	16	21	14	9	8	102	

Table 3. Age Wise Anatomical Variations of Paranasal Sinuses with P-Value

Anatomical Variants

1. Concha Bullosa

It is pneumatization of the turbinates, most commonly in the middle one. Concha bullosa pneumatization is classified as per the location into Lamellar, Bulbous and Extensive (both combined).[2] Middle turbinate pneumatization is an extension of normally pneumatized ethmoid cells (usually anterior).[5] However, posterior ethmoid cell pneumatization is also found and described. As the concha bullosa causes middle meatus and infundibular narrowing, it often leads to rhino-sinusitis. (Fig. 1)

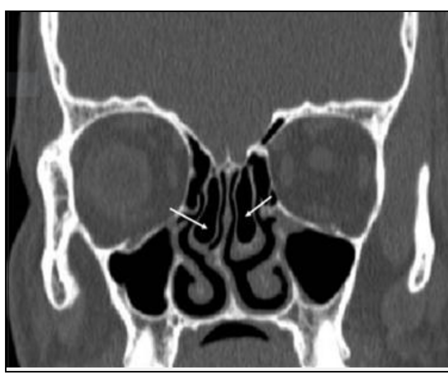

Figure 1. Coronal CT Image Shows Bilateral Concha Bullosa(Arrow)

2 Onodi Cells

First described by the Hungarian laryngologist Adolf Onodi (1904), also known as spheno-ethmoid cells, are important to the surgeon in functional endoscopic sinus surgery (FESS).

These are due to extensive pneumatization of posterior ethmoid cells that extend posterolateral and superior to the sphenoid sinus, lying medial to the optic nerve and can expose its circumference.[6] (Fig 2)

Figure 2. Coronal & Axial CT Shows the Sphenoid Sinus (**) with Bilateral Spheno-Ethmoidal Cells (Onodi Cells*)

3. Frontal Air Cells

Bent and Kuhn have divided the frontal infundibulum cells into 4 categories, based on relationship with the agger nasi cells and orbital roof.[7]

- Type 1 frontal cell represents a single air cell above the agger nasi cell.
- Type 2 frontal cells correspond to a series of small cells above the agger nasi, but below the orbital roof.
- Type 3 frontal cells extend into the frontal sinus, but remain contiguous with the agger nasi cells.
- Type 4 frontal cells correspond to completely isolated frontal cells within the frontal sinus cavity.(Fig. 3)

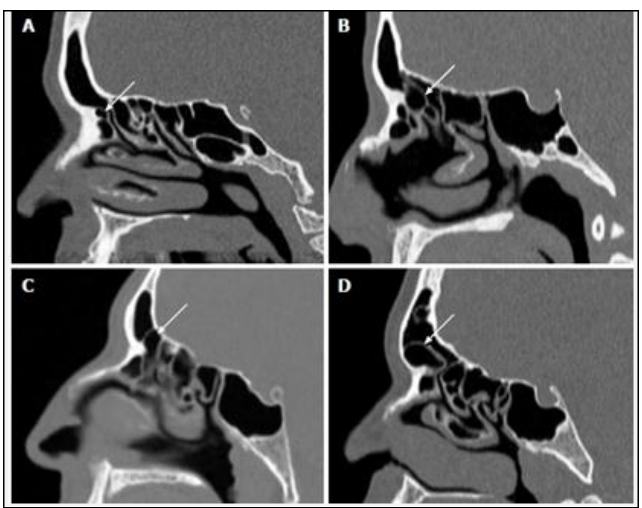

Figure 3. Sagittal Plane of CT Shows Types of Frontal Air Cells: Arrow Shows. A-Type1; B-Type 2; C-Type 3 and D-Type 4 (Kuhn Cells)

4. Maxillary Sinus Septation

The maxillary sinus septum may be fibrous or bony and often extends from the infraorbital canal to the lateral wall. If it is not recognized, it may lead to inadequate drainage of the antrum.[8] (Fig 4a)

5. Supra Orbital Cell

These are the ethmoid cells that extend superolaterally between the medial orbital wall and the ethmoidal roof and may simulate multiple frontal sinuses on coronal CT images.[9] (Fig 4b)

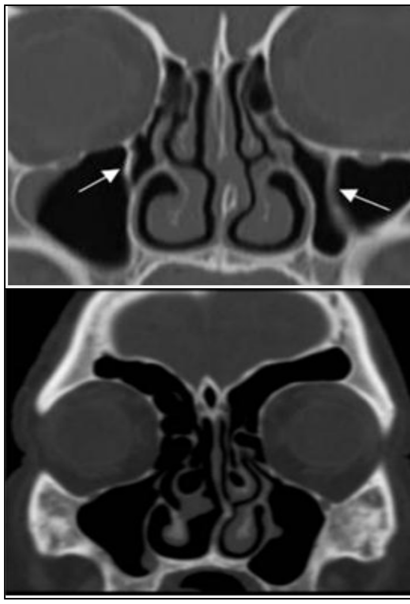

Figure 4.
a. Coronal CT Arrows are Showing the Bilateral Maxillary Sinus Septation
b. The Supra Orbital Cell.

6. Haller Cells

These are infraorbital ethmoidal air cells, lateral to the maxillo-ethmoidal suture. Haller Cells when large, may narrow the ipsilateral ostio-meatal complex, leading to sinusitis. These may pose a threat to orbital injury during surgery.

7. Paradoxical Middle Turbinate

It is the outward curvature of the middle turbinate, which may cause deviated nasal septum when enlarged and might cause osteo meatal access impairment.

8. Olfactory Fossa (Keros Classification)

It is a method of classifying the depth of the olfactory fossa. The classification takes into account the vertical extent of cribriform plate of lateral lamella. Asymmetry of the cribriform plate is a regular finding, but asymmetry at the base of the skull is a variation.

Type I: Cribriform plate 1-3 mm. The lateral lamella is very short rendering the olfactory fossa flat.

Type II: Cribriform plate 4-7 mm. The lateral lamella is longer creating a moderately deep fossa.

Type III: Cribriform plate 8-16 mm. The lateral lamella is very long producing a very deep olfactory fossa.

DISCUSSION

The anatomical variation rate in the sinonasal region was reported to vary from 64 % to 98.5 %. These anatomical variations may impede the drainage and ventilation of the large sinuses or cause complete blockage of the sinus.

In our study, concha bullosa was observed in 47.5 % cases, while Maru[7] reported in 42.6 % cases, Stallman[10] reported it in 44 % cases, Mamatha[11] reported it in 15 %, Nitinvakarn[12] reported it in 34 % cases, Asruddin[13] in 30 %, Bolger[2] in 53 % cases, Armani[14] reported it in 53.7 % and Scribano[15] reported it in 67 % cases.

Onodi Cell

In our study, Onodi cell was present in 19.2 % cases, while Badia[8] reported in 33 % cases, Nitinvakarn[12] reported in 25 % cases, Sumaily[16] reported in 31.4 %, Perez1 reported it in 10.9 % and Arslan[17] reported in 12 % cases.

Frontal Air Cells

In our study, frontal air cells were present in 25 % cases, type I frontal air cell was the most prevalent (32 %) in our study. Sumaily[16] reported it in 25.9 %, Dasar[18] reported it in 57.7 %, Meyer[19] reported in 20.4 % cases, Alrumaih[20] reported type I frontal air cells as the most common.

Maxillary Sinus Septation

In our study, maxillary sinus septation was present in 7.5 % cases; Alrumaih[20] reported in 23.1 %, Lingaiah[21] reported in 19 %, Maru[7] reported in 6.6 % and Dasar[18] reported in 5.3 % cases.

Supra Orbital Air Cells

In our study, supraorbital cells were present in 15 % cases. Badia[8] reported in 17 % cases, Sumaily[16] reported in 37.5 % cases, Dasar[18] reported in 9 % cases and Onwachekwa[22] reported in 6.4 % cases.

In this study, agger nasi cell and deviated nasal septum were the most common findings while concha bullosa, sphenoidal intersinus septum attached to carotid artery and frontal air cells followed in descending order of frequency.

Haller Cells: These cells were found in 17.5 % of the study population. Similar result was found by Mamatha et al. (17.5 %), Dua et al. (16 %), Badia et al. (15 %).

Paradoxical Middle Turbinate

In present study, paradoxical middle turbinate was present in 20(16.7 %), distributed as 7(35 %) on right, 9(45 %) on left, and bilaterally in 4(20 %) cases. Tonai et al. reported in 25.3 %, Badia et al. reported in 22 % cases.

Olfactory Fossa Depth

Keros type 2 was the most common finding in our study, which is similar to previous studies by Kaplanoglu et al. Alrumaih A R et al. and Rathnakar P et al.

In this study, the presence of the sphenoidal intersinus septum adjoining the carotid artery shows a higher incidence than its attachment to the optic nerve. The sphenoidal intersinus septum adjoining the carotid artery is found in relation to the lateral wall of the sphenoid and posterior ethmoids while the sphenoidal intersinus septum adjoining the optic nerve is found in relation to the posterior ethmoid and sphenoid sinus. Therefore, there are chances of complications like fatal haemorrhage and blindness during a surgical procedure.

The proximity of the onodi cells to the optic nerve or internal carotid artery is a risk factor for surgical complications. Identification of the onodi cell is therefore imperative to minimize preoperative morbidity.

In this study, sphenoid sinus septum attachment to the carotid canal is commonly found in the middle adult age group and the sphenoid septum attached to the optic nerve is commonly found in the senior adult group.

The types of superior attachment of the uncinate process are well described in this study, which was not documented in most of the previous studies.

The position and route of the anterior and posterior ethmoid artery are well described in this study, which was not mentioned in previous studies in the North Indian population. Care must be exercised when operating in the vicinity of an anterior ethmoidal artery, if the artery is damaged, it may retract into the orbit producing an intraorbital hematoma.

In this study, the prevalence of internal carotid artery dehiscence and optic nerve dehiscence is well described. The prevalence of these variations was compared with other previous studies.

In this study, olfactory fossa depth (keros classification) type 2 was most common, which was better visualised in the coronal plane as it is the best method for evaluating the ethmoidal roof anatomy.

Some of the rare variations like ethmoidal bulla, optic nerve dehiscence and maxillary sinus septations were also seen.

CONCLUSIONS

Various anatomical presentations of paranasal air sinuses can be seen on computerized tomography so it can be concluded that this is a common variation in the adult population. This study provides an anatomical and ethnic perspective towards the variations in paranasal sinuses. The presence of anatomical variants does not establish the genesis of disease but these variants can pose to be a threat during surgery. These variations were almost of the same frequency irrespective of the sex and age of the subjects. Variability of paranasal sinuses in the present study in the North Indian population and different areas of the world could be due to racial and ethnic factors.

The CT scan should not be used exclusively to diagnose chronic sinusitis or to plan surgery, rather it should be used to provide supplementary clinical data for endoscopic examination and assist in directing surgical treatment to the affected areas. This study may prove to be of significance in decision making for E.N.T. surgeons and Radiologists while diagnosing and preventing structural damage during surgery.

It is of paramount importance that computed tomography of the paranasal sinuses in three dimensions of an axial, coronal and sagittal plane should be acquired and adequately reviewed before functional endoscopic sinus surgery and transsphenoidal hypophyseal surgery. They help to assess the extent of sinus diseases and know the anatomical variations.

The study throws light on the standardization of planes and sections of PNS CT-Scan. It adds value to the knowledge of normal anatomical variations in PNS in the North Indian population.

Further studies of anatomical variations with clinical disease correlations are needed in the North Indian population.

Data sharing statement provided by the authors is available with the full text of this article at jemds.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jemds.com.

REFERENCES

[1] Perez-Pinas, Sabate J, Carmona A, et al. Anatomical variations in the human paranasal sinus region studied by CT. J Anat 2000;197(Pt 2):221-7.
[2] Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope 1991;101(1 Pt 1):56-64.
[3] Ramakrishnan Y, Zammit-Maempel I, Jones NS. Paransal sinus computed tomography anatomy: a surgeon's perspective. J Laryngol Otol 2011;125(11):1141-7.
[4] Yarlagadda A, Murthy JVR, Prasad MHM, et al. A novel method for human age group classification based on correlation fractal dimension of facial edges. Journal of King Saud University-Computer and Information Sciences 2015;27(4):468-76.
[5] Zinreich SJ, Mattox DE, Kennedy DW, et al. Concha bullosa: CT evaluation. J Comput Assist Tomogr 1988;12(5):778–84.
[6] Onodi A. Die Sehstoerungen und Erblidung nasalen Ursprunges, bedingt durch Erkrankungen derhinteren Nebenhoehlen. Z Augenheilkd 1904;12:23-46.
[7] Bent JP, Cuilty-Siller C, Kuhn FA. The frontal cell as a cause of frontal sinus obstruction. Am J Rhinology 1994;8(4):185-91.
[8] Maru YK, Gupta Y. Anatomic variations of the bone in sinonasal C.T. Indian J Otolaryngol Head Neck Surg 2001;53(2):123-8.
[9] Badia L, Lund VJ, Wei W, et al. Ethnic variation in sinonasal anatomy on CT-scanning. Rhinology 2005;43(3):210-4.
[10] Stallman JS, Lobo JN, Som PM. The incidence of concha bullosa and its relationship to nasal septal deviation and paranasal sinus disease. Am J Neuroradiol 2004;25(9):1613-8.
[11] Mamatha H, Shamasundar NM, Bharathi M, et al. Variations of osteomeatal complex and its applied anatomy: a CT scan study. Indian Journal of Science and Technology 2010;3(8):904-7.
[12] Nitinavakarn B, Thanaviratananich S, Sangslip N. Anatomical variations of the lateral nasal wall and paranasal sinuses: A CT study for endoscopic sinus surgery (ESS) in Thai patients. J Med Assoc Thai 2005;88(6):763-8.
[13] Asruddin, Yadav SP, Yadav RK, et al. Low dose CT in chronic sinusitis. Indian J Otolaryngol Head Neck Surg 1999;52(1):17-22.
[14] Aramani A, Karadi RN, Kumar S. A study of anatomical variations of osteomeatal complex in chronic rhinosinusitis patients-CT findings. J Clin Diagn Res 2014;8(10):KC01-4.
[15] Scribano E, Ascenti G, Loria G, et al. The role of the osteomeatal unit anatomical variations in inflammatory disease of the maxillary sinuses. Eur J Radiol 1997;24(3):172-4.
[16] Sumaily I, Aldhabaan S, Hudise J. Anatomical variations of paranasal sinuses gender and age impact. Glob J Otolaryngol 2018;14(1):555877.
[17] Arslan H, Ayedinlioglu A, Bozkurt M, et al. Anatomical variations of the paranasal sinuses: CT examination for endoscopic sinus surgery. Auris Nasus Larynx 1999;26(1):39-48.
[18] Dasar U, Gokce E. Evaluation of variations in sinonasal region with computed tomography. World J Radiol 2016;8(1):98-108.
[19] Meyer TK, Kocak M, Smith MM, et al. Coronal computed tomography analysis of frontal cells. Am J Rhinol 2003;17(3):163-8.
[20] Alrumaih AR, Asoor MM, Obidan AA, et al. Radiological sinonasal anatomy. Exploring the Saudi population. Saudi Med J 2016;37(5):521-6.
[21] Lingaiah RKN, Puttaraj NC, Chikkaswamy HA, et al. Anatomical variation of paranasal sinuses on coronal CT-Scan in subjects with complaints pertaining to PNS. IJARS 2016:1-7.
[22] Onwuchekwa RC, Alazigha N. Computed tomography anatomy of the paranasal sinuses and anatomical variants of clinical relevant in Nigerian adults. Egyptian Journal of Ear, Nose, Throat and Allied Sciences 2017;18(1):31-8.