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Section: Anatomy

Retrospective analysis of Anatomical Variations of Paranasal Sinuses on Multidetector Computed Tomography – A Randomized Cross-Sectional Study.

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ABSTRACT

Background: For Endoscopic sinus Surgery, precise knowledge of the anatomy and variations of paranasal sinus is essential for surgeon. Computed tomography provides accurate evictions of the anatomy, the anatomical variants and the extent of the disease in and around the paranasal sinuses. Objective: In this study, we evaluated the frequency of anatomic variations of the paranasal sinus region by using multidetector computerized tomography (MDCT). **Methods:** During the year 2017, over a period of 12 months MDCT images of 150 cases were evaluated by using the picture archiving and communication system (PACS). Frequency distribution and descriptive statistics of the variants were analysed. **Results:** We observed CT images of paranasal sinuses of 150 cases. We found nasal septal deviation as the most common variant seen in 61.1% and Pneumatisation of middle concha as the second most common seen in 55.2% of cases. Other variants observed are pneumatizations of nasal septum, middle, superior and inferior conchae, uncinate process, crista gali, bony spur, concha bullosa of middle turbinate, paradoxial curvatures of middle concha , agger nasi cells, haller cells, onodi cells and supraorbital ethmoid air cells , hypoplasia of frontal, maxillary and sphenoid sinuses, aplasia of frontal sinus, asymmetry of the height of ethmoid roof and prominent ethmoid bulla. **Conclusion:** Anatomical variations of PNS are quite common. These variations must be identified preoperatively to reduce the risk of intraoperative complications.

Keywords: Anatomic variation, MDCT, paranasal sinus

INTRODUCTION

Paranasal sinuses are a group of air filled spaces in skull developed as an expansion of the nasal cavities, eroding the adjacent bony structures that lightens the skull, humidifies the air & resonant the voice. Extensive study & knowledge on the anatomical variations of paranasal air sinuses is critical for endoscopic surgeons as well as for radiologists during the preoperative evaluation of patients for Functional Endoscopic Sinus Surgery (FESS) in order to avoid therapeutic failure and iatrogenic complications such as damage to surrounding structures like orbit, brain in perioperative period. Computed tomography is the imaging modality of choice and Gold standard in the study of detail anatomical structure of PNS, anatomical variations & the extent of disease in & around the PNS.[1] The aim of this study is` to examine the overall prevalence of anatomical variations of nose & sinuses as determined with coronal CT in a series of 150 cases.

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Nasal septum

Nasal septum formed by the fusion of vomer, perpendicular plate for the ethmoid bone and septal cartilage may results in morphological variations such as septal deviation, chondrovomeral junction deformity and nasal bone spur. Septal deviation is a shift of the midline associated with deformities or asymmetry of the adjacent turbinates or of the nasal wall structure, with variable presentations in the population. Nasal septal spur is a generally asymptomatic bone deformity that may cause restriction of the nasal air flow, and that may be associated with septal deviation.[2,3]

Variations of the middle turbinates

Concha bullosa is a variation originated from pneumatization of the bone plate by extension of ethmoid sinus cells. Such variation may be either uni- or bilateral. Varied degrees of pneumatization of the concha may be observed, possibly causing middle meatus or infundibulum obstruction, besides being related to deviation of the nasal septum to the contralateral side.[4] Other variation that is frequently associated with septal deviation and spur is unilateral hypoplasia. In cases of bilateral hypoplasia, it is associated with low fovea ethmoidalis. Paradoxical turbinates occur as the convexity of the middle turbinate is directed towards the medial wall of the maxillary sinus.[3]

Pneumatization of Paranasal sinuses

The sphenoid sinuses arise from presphenoid bone centers, with variable pneumatisation extent. In most of cases, pneumatization presents recesses related to the greater sphenoid wing, although lateral extensions may also be observed in the smaller sphenoid wing, inferolateral and septal recesses.[3] Frontal sinus extension is a rare condition characterized by increased sinusal aeration beyond the normal margin of the frontal bone that originates from anterior extension of the anterior ethmoid air cells. Extensions related to the lamina of the frontal bone, crista galli, besides inferior, symmetric extension of the frontal sinus towards the anterior ethmoid air cells may also be found predominantly in male individuals in the age range between 20 and 40 years. Cases in children have not been reported.[7] As regards the maxillary sinus, four recesses have been described, as follows: the palatine recess that extends inferomedially to the hard palate towards the midline; the alveolar recess, closely related to the molar and premolar teeth roots; the infraorbital recess, projecting anteriorly along the roof of the maxillary sinus; and the zygomatic recess that extends over the malar bone at variable distances.[3]

Uncinate process variations

The uncinate process is a superior extension of the lateral nasal wall that is anatomically relevant for draining the frontal recess. Variations such as hypertrophy, deviation and pneumatization may affect the drainage, generating abnormalities in the ostiomeatal complex and predisposing to obstruction.[2,3,5] Traditionally, the uncinate process is identified from its lower segment through the architecture of the ostiomeatal unit. Variations in the superior insertion of the uncinate process are classified according to the criteria developed by Landsberg & Friedman.[6]

Variations of the cribriform plate

The cribriform plate may present at variable levels and, in such cases it is classified according to the criteria developed by Keros, that is based on the height of the olfactory fossa in relation to the roof of the ethmoid sinus as compared with the length of the lateral lamella of cribriform plate. The higher the Keros grade, the greater the chance of injury of the cribriform plate and olfactory fossa, with consequential risk for iatrogenic cerebrospinal fluid fistula and olfactory impairment.[8]

Ethmoid cells variations

Infraorbital ethmoid cells or Haller cells are ethmoid air cells located anteriorly to the ethmoid bulla, along the orbital floor, adjacent to the natural ostium of the maxillary sinus, which may cause mucociliary drainage obstruction, predisposing to the development of sinusitis.[3,9] Agger nasi cells, which are the most anterior ethmoid cells, are located anteriorly to the upper margin of the nasolacrimal duct and anteriorly to the plane of the maxillary sinus infundibulum. Studies demonstrate that their major dimensions are correlated with frontal sinus diseases and lacrimation.[2,4,5] Onodi cells are ethmoid cells that have migrated to the anterior region of the sphenoid sinus, with anterosuperior location, and intimately related to the optic nerve, causing optic neuropathy in case of certain conditions that affect such cells.[10]

Bulla frontalis are characterized by anterior ethmoid cells which invade the frontal bone, bulging its floor, but with no connection with this sinus. They are more easily demonstrated at sagittal computed tomography, where they appear as ethmoid air cells located above the ethmoid bulla and as an extension towards the frontal sinus. Depending on their size and pneumatization extent, such cells may affect the frontal sinus drainage, representing a real diagnostic challenge in addition to the difficulty of the surgical management of inflammatory diseases involving such a sinus.

Maxillary sinuses septa

Maxillary sinus septa are thin walls of cortical bone present within the maxillary sinus, with variable number, thickness and length. Such septa may divide the sinus into two or more cavities arising from the inferior and lateral walls of the sinus. Septa originating from teeth may be classified according to their development at the different phases of the dental eruption.[12,13]

Accessory maxillary ostia

Accessory maxillary ostia are generally solitary, but occasionally may be multiple. Such variation may be congenital or secondary to sinusal diseases. Possible mechanisms involved in the development of such variation include: main ostium obstruction, maxillary sinusitis or anatomical/pathological factors in the middle meatus, resulting in rupture of membranous areas.[14]

MATERIALS AND METHODS

Sinonasal CT examinations of 180 patients were reviewed to determine & classify anatomic variations. All patients had CT scan done for sinonasal symptoms. Exclusion criteria are patients having previous sinonasal surgery,facial trauma,paranasal sinus neoplasm, invasive disease and younger age of the patients (< 12 years). Patients were subjected to Coronal CT-scans of PNS using GE SYSTEMS-Hi Speed Dual-Slice CT. For CT examination patient was positioned in prone position with neck extended and angulation was perpendicular to hard palate. Imaging was done from posterior margin of sphenoid sinus to anterior margin of frontal sinus. Thickness was 5mm slices with 3mm retro reconstruction. Exposure parameters were 120 kVp, 130 mAs, 1.5 seconds scan time. Bone window width was 4000 HU and window level was 500HU. Soft tissue window width was 90 HU and window level was 40HU. The following parameters were analyzed using bone and soft tissue windows: Septum Deviation, Agger nasi pneumatised,Bulla Ethmoidalis, Uncinate process ,Middle turbinate: pneumatisation, Maxillary sinus septation, Pneumatized superior turbinate, Supraorbital cell, Haller cell, Onodi cell ,Frontal sinus, Cribriform Plate.

RESULTS

Out of the 180 cases, 30 (16.6 %) cases were excluded based on exclusion criteria. The mean age of the patients was 31±13.15 years. In this study, 94 scans are of male patients and 56 scans are of female patients.

Out of the 150 cases studied, no anatomical variation was identified in 65 (43.4%) images and some anatomical variation was observed in 85 (56.6%) cases. [Graph 1]

Table 1: Showing overall incidence of anatomical variations

Anatomical Variation	Total case (150)	%
Present	85	56.6%
Absent	65	43.4%)

Table 2: Incidence of nasal septal deviation

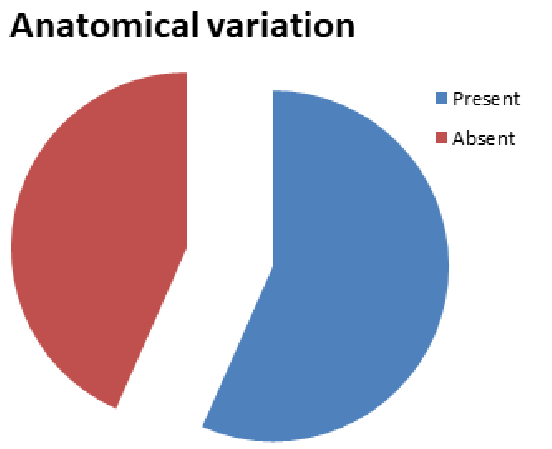
Nasal septal deviation		52	61.1%
Curvature	Single curvature	44	84.6%
	Double curvature	8	15.3%
Deviation	Rightward deviation	24	46.1%
	Leftward deviation	20	38.4%
	S shaped	8	15.3%

Table 3: showing incidence of Pneumatisation of different nasal concha

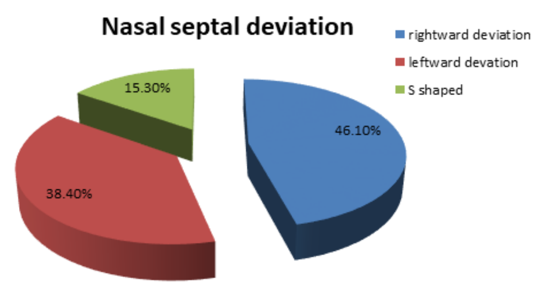
Pneumatization	(n)	%
Superior concha	16	18.8
Middle concha	47	55.2
Inferior concha	1	1.1

Table 4: showing incidence of individual paranasal sinus variations

Nasal septal deviation	52	61.1%
Pneumatisation of nasal septum	31	36.4%
Bony spur	21	24.7%
Concha bullosa of middle turbinate	33	38.8%
Pneumatisation of middle concha	47	55.2%
Pneumatisation of superior concha	16	18.8%
Pneumatisation of inferior concha	1	1.1%
Prominent ethmoid bulla	18	21.1%
Paradoxial curvatures of middle concha	8	9.4%
Agger nasi cells	18	21.17%
Haller cells	11	12.9%
Onodi cells	12	14.1%
Supraorbital ethmoid air cells	9	10.5%
Hypoplasia of frontal sinus	11	12.9%
Hypoplasia of maxillary sinus	3	3.5%
Hypoplasia of sphenoid sinus	1	1.1%
Aplasia of frontal sinus	2	2.3%
Pneumatizations of either unilateral or bilateral UP	8	9.4%
Pneumatizations of Crista gali	10	11.7%
Asymmetry of the height of Ethmoid roof	9	10.5%



Graph 1: Incidence of anatomical variation of paranasal sinuses



Graph 2: Showing incidence of nasal septal deviation

Out of 85 cases with variation , nasal septal deviation was seen in 52 (61.1%) cases, out of which single curvature was observed in 44 (84.6%) cases, double curvature [Figure 1] in 8 (15.3%) cases, rightward deviation in 24 (46.1%) cases, leftward deviation in 20 cases (38.4%) and S shaped in 8 (15.3%) cases.[Graph 2] Pneumatizations of nasal septum (Figure 3) was found in 31 patients (36.4%). Bony spur [Figure 5] was seen in 21 patients (24.7%). Concha bullosa of middle turbinate [Figure 2] was seen in 33 cases (38.8%) out of them 22 (25.8%) scans have right sided & 10 (11.7%) cases have left sided bullosa. Pneumatisation of the middle, superior [Figure 5] and inferior conchae were found in 47 (55.2%), 16 (18.8%) and 1 (1.1%) of cases respectively. Paradoxial curvatures of middle concha [Figure 4] was found in 8 (9.4%) cases. Agger nasi cells, Haller cells (Figure 5), Onodi cells and Supraorbital ethmoid air cells were encountered in 18 (21.17%), 11 (12.9%), 12(14.1%) and 9 (10.5%) cases respectively. Hypoplasia of frontal, maxillary and sphenoid sinuses were found in 11 (12.9%), 3 (3.5%), 1(1.1%) cases respectively. Aplasia of frontal sinus was encountered in 2 (2.3%) cases. Aplasia of maxillary and sphenoid sinuses were not seen in any of the slides. Pneumatizations of Uncinate process was found in 8 (9.4%) and pneumatizations of Crista gali was found in 10 (11.7%) cases. Asymmetry of the height of Ethmoid roof either left sided or right sided was encountered in 9(10.5%) of patients. We observed prominent ethmoid bulla in 18 (21.1%) cases.

Figure 1: Doble curvature of nasal septum

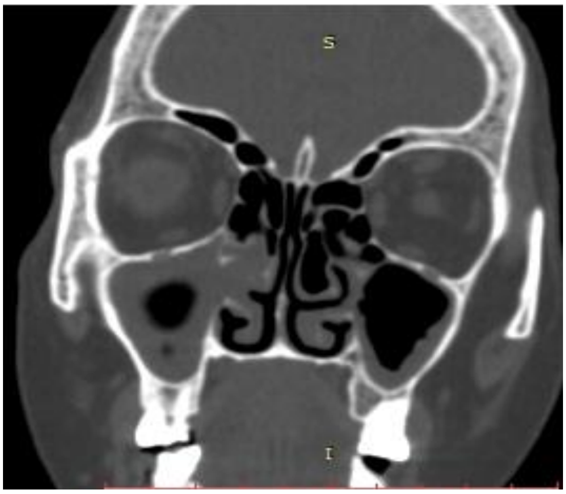


Figure 2: Concha bullosa - pneumatization of middle turbinate

Figure 3: Septal pneumatization

Figure 4: Paradoxical middle turbinate

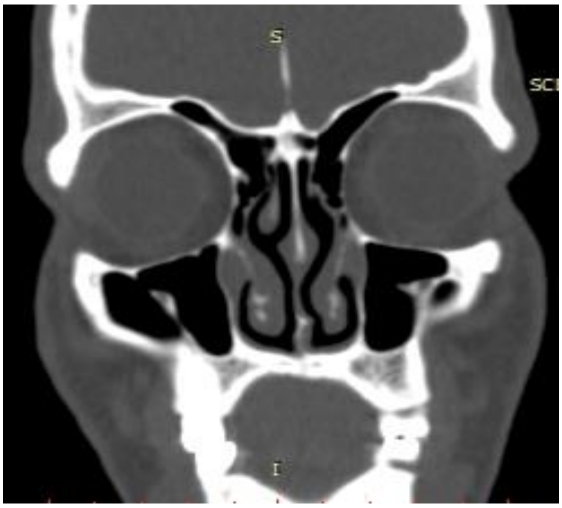


Figure 5: Septal spur & haller cells

DISCUSSION

In the present study we won't found any anatomical variation of paranasal sinuses in 65 (43.3%) cases and some anatomical variation was observed in rest 85 (56.6%) cases which is in accordance with Mohammad Adeel et al who also observed no anatomical variations in 37 (48.1%) cases.[15] In contrast to our study Kate Sarika P et al had found Anatomical variations were seen in 73 (81.11%) and no Anatomical variations in 17(18.84%) patients.[16]

In this study most common type of deviation observed is nasal septal deviation being seen in 52 (61.1%) cases. Similarly Onder Turna et al studied deviations of NS in 3448 (59.1%) patients,[17] Rajendra kumar narasipur lingaiah et al found deviated nasal septum in 62(62%) cases,[18] Kate Sarika P et al in their study seen deviated nasal septum in 58 patients (64.44%).[16] Katya A. Shpilberg et al also observed the most common anatomic variant of the paranasal sinuses and nasal cavity was nasal septal deviation seen in 189 of 192 patients (98.4%) but was considered to be more than minimal (> 1 mm) in 118 of 192 patients (61.4%).[19] Mohammad Adeel et al also observed DNS as trhe most common type of variation but in 20 (26%) cases.[15] Neeraj Suri et al studied DNS in 75% of cases,[20] similar finding were observed by Perez, et al., who reported the prevalence of deviated nasal septum to the about 80%. In contrast to our study T. D. Thimmappa et al,[21] observed presence of Agger nasi cells as the most common variation seen in 68% and deviated nasal septum as the second most common variant in 47%. Dua, et al.[22] and Asruddin, et al.[23] found prevalence of 44% and 38% of deviate nasal septum in their respective studies. We also observed nasal septal deviation with single curvature in 44 (84.6%) cases and double curvature in 8 (15.3%) cases, deviation was rightward in 24 (46.1%) cases, leftward in 20 cases (38.4%) and S shaped in 8 (15.3%) cases. Similar to our study Onder Turna et al,[17] studied deviations were rightward, leftward and S-shape in 26.5%, 25% and 7.5% of patients, respectively. Rajendra kumar narasipur lingaiah et al,[18] showed slight predominance to the left side (29%) as compared to right side (23%).

In our study we observed pneumatizations of nasal septum in 31 patients (36.4%). Similar to our study Onder Turna et al found pneumatizations of NS in 34.8% of cases 17 and T. D. Thimmappa et al,[21] observed pneumatization of nasal septum in posterior bony aspect including vomer and perpendicular plate of ethmoid in 30% of cases. In contrast to our study Mohammad Adeel et al,[12] have not seen any case of septal pneumatisation in their study.

In our study we encountered bony spurs in 21 patients (24.7%). Similarly Onder Turna et al,[17] observed bony spurs in 19.9% of cases.

In this study we observed Concha bullosa of middle turbinate in 33 cases (38.8%) out of them 22 (25.8%) have right & 10 (11.7%) have left sided bullosa. In accordance with us, Zinreich S et al,[24] have observed Concha bullosa in 36% of cases. Such a wide range of incidence is due to the criteria of pneumatiza¬tion adopted. In contrast Kate Sarika P et al,[16] Bolger et al,[26] & Dua K et al,[22] have seen in 71% ,53.6%, 16% respectively. Katya A. Shpilberg et al,[19] have studied concha bullosa in 26.0% of cases, out of which they found bilateral in 38% of cases. Mohammad Adeel et al,[12] have seen Concha bullosa in 14 (18.2%) of cases. Neeraj Suri et al,[20] have observed Concha bullosa in 41.5% of the chronic rhinosinusitis cases. Perez-Pinas, et al,[25] Scribano, et al,[20] reported higher prevalence of concha bullosa i.e.73% and 67% in chronic rhino sinusitis cases. Rajendra Kumar Narasipur Lingaiah et al,[18] showed 43% of the cases of concha bullosa out of which bilateral is seen in about 41% followed by right side of about 32% and least is on the left side of about 25%. T. D. Thimmappa et al,[21] observed Concha bullosa in 37% of cases with equal distribution on both sides.

In this study we observed pneumatisation of the middle, superior and inferior conchae in 47 (55.2%), 16 (18.8%) and 1 (1.1%) patients respectively. Paradoxial curvature of middle concha was found in 8 (9.4%) of patients. Katya A. Shpilberg et al,[19] observed pneumatised lamina of the middle turbinate and paradoxically bent middle turbinate in 37.0% & 15.6% cases respectively, pneumatization of the superior turbinate in 26.0% of patients and only two patients had pneumatized inferior turbinates. Neeraj Suri et al,[20] seen paradoxical curvature of the middle turbinate in 8.3% of the patients; In contrast Asruddin, et al,[23] have observed paradoxical curvature of the middle turbinate in 12% of cases. Onder Turna et al,[17] has observed Unilateral or bilateral pneumatization either lamellar, bulbous or extensive types (concha bullosa) of the middle, superior and inferior conchae in 57.2%, 17.9% and 1% of patients, respectively, also found Paradoxial curvatures of middle concha in 9% of patients. Rajendra kumar narasipur lingaiah et al,[18] found paradoxical curvature of middle turbinate in 14%.

We found agger nasi cells in 18 (21.17%) of patients. In the literature, the presence of Agger nasi cells varies from 10% to 98.5%. Similar to our study Onder Turna et al,[17] have observed ANC in 18.3% of patients. Neeraj Suri et al,[20] observed agger nasi cells in 6.6% of patients in their study. whereas in the study by Dua, et al. agger nasi cells were found in 8% of cases.[22] In contrast to our study Katya A. Shpilberg et al,[19] have observed presence of agger nasi cells as the second most common variant being present in 83.3% of cases. Similarly Bolger et al,[26] and Asruddin et al,[23] have observed presence of agger nasi cells in 98.5% ,48% of cases respectively. Rajendra kumar narasipur lingaiah et al,[18] studied occurrence of Agger nasi cells in 26% of cases. In the study by Talaiepour AR et al.[35] Agger nasi was seen in 56.7% of cases, with 17.5% on the right, 7.7% left and 31.5% bilateral. T. D. Thimmappa et al,[21] studied agger nasi cells as the most common variation and observed in 68% of cases. In one study by Perez-Pinas et al.[25] 100% patients showed presence of Agger nasi.

In our study Haller cells were detected in 11 (12.9%) patients. Similar to our study Onder Turna et al17 have observed HC in in 14.8% of patients, Rajendra kumar narasipur lingaiah et al,[18] in 11%, Dua K et al,[22] in 16%, and Mohammad Adeel et al,[15] in 9.1% of cases. In contrast to our study, Kate Sarika P et al,[16] studied haller cells in 1.11%, Neeraj Suri et al,[20] in 1.6%, Bolger et al,[26] in 45.9%, Asruddin et al,[23] in 28% and Katya A. Shpilberg et al,[19] in 39.1% of cases. T. D. Thimmappa et al,[21] studied HC in 13% of patients of which it was left sided in 7%,right sided in 4% & both sided in 2% of cases.[21]

In this study we have detected Onodi cells in 12 (14.1%) patients. Similar to us Onder Turna et al,[17] Katya A. Shpilberg et al,[19] have observed Onodi cells in 13.5% & 12% of cases respectively. In contrast it was observed by Mohammad Adeel et al,[15] in 7.8%, Pérez et al,[25] in 10.9%, AR Talaiepour et al,[27] in 7%, Neeraj Suri et al,[20] in 4.1% , Rajendra kumar narasipur lingaiah et al,[18] in 4% of cases.

We studied Supraorbital ethmoid air cells in 9 (10.5%) patients. In accordance to our study Onder Turna et al,[17] have observed SOEC in 9.4% of cases. In contrast Katya A. Shpilberg et al,[19] observed in 28.1% cases. We also observed prominent ethmoid bulla in 18 (21.1%) cases. Fadda GL et al,[28] studied hypertrophic ethmoid bulla in 32.8% of cases. In contrast to our study Katya A. Shpilberg et al,[19] found prominent ethmoidal bullae in 44.8% of cases.

In this study we observed Hypoplasia of frontal, maxillary and sphenoid sinuses in 11 (12.9%), 3 (3.5%), 1 (1.1%) of patients, respectively. Similar to our study Onder Turna et al,[17] observed hypoplasia of frontal, maxillary and sphenoid sinuses in 12.5%, 2.4%, 0.9% of patients, respectively. Rajendra kumar narasipur lingaiah et al,[18] studied frontal sinus hypoplasia in 17% out of which 3% were bilateral, Maxillary sinus hypoplasia showed 2% bilaterally and hypoplastic sphenoid sinus in 3% of cases.

In our study we observed aplasia of frontal sinus in 2 (2.3%) cases. Aplasia of maxillary and sphenoid sinuses were not seen in any of the slides. Onder Turna et al,[17] observed aplasia of frontal, maxillary and sphenoid sinuses in 1.7%, 0.05% and 0.5% cases respectively.

We studied Pneumatizations of either unilateral or bilateral UP in 8 (9.4%) patients and pneumatizations of Crista gali in 10 (11.7%) patients. Onder Turna et al,[17] observed Pneumatizations of either unilateral or bilateral UP were found in 7% of patients and pneumatizations of CG were found in 9.4% of patients, Pneumatizations of ACP, PCP and PP were encountered in 20%, 2.5%, 35% of patients, respectively. Katya A. Shpilberg et al,[19] studied Pneumatized pterygoid process in 27.1% of cases with bilateral in 36.5% of cases & Pneumatized superior turbinate in 26.0% with bilateral in 54.0% of cases, Pneumatized anterior clinoid process in 16.7% with bilateral in 37.5% cases, Pneumatized crista galli 9.9% & Pneumatized inferior turbinate in 1.0 % cases, Partially pneumatized middle turbinates in 37.0 % & bilateral in 62.0 % cases. Mohammad Adeel et al,[15] & Mazza D et al,[37] studied Uncinate process pneumatisation in 5.2 %, 5% cases respectively. T. D. Thimmappa et al,[21] studied Pneumatization of nasal septum in 30%, crista galli in 28%, superior turbinate in 6% and uncinate process in 1% of cases.

In this study we have observed paradoxical curvature of the middle turbinate in 10 (8.5%) of cases. Similar to our study paradoxical curvature of the middle turbinate was found by Neeraj Suri et al,[20] in 8.3%, Asruddin, et al.[23] in 12% and T. D. Thimmappa et al,[21] in 12% of cases. In contrast it was observed by, Rajendra kumar narasipur lingaiah et al,[18] in 14%, Katya A. Shpilberg et al,[19] in 15.6% cases with bilateral in 16.7% cases.

CONCLUSION

Different anatomical variants may be found frequently in PNS having an anatomic and surgical significance. Hence every case must be studied in detail before surgery to maximise patient benefit and avoid serious complications. Multidetector computerized tomography is the modality of choice to evaluate the patients for paranasal sinus disease. Computed Tomography of the paranasal sinus has improved the visualization of paranasal sinus anatomy and has allowed greater accuracy in evaluating paranasal sinus disease. It evaluates the osteomeatal complex anatomy which is not possible with plain radiographs. Improvement in Functional Endoscopic Sinus Surgery and CT technology has concurrently increased interest in the paranasal region anatomy and its variations.

Abbreviations:

1. MDCT - Multidetector computerized tomography
2. ACP – Anterior clenoid process
3. PCP – Posterior clenoid process
4. CG – Crista gal
5. UP – Uncinate process
6. ANC – Agger nasi cells

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