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EVALUATION OF COMMON ANATOMICAL VARIANTS OF PARANASAL SINUSES AND THEIR FREQUENCY DEMONSTRATED BY MULTI-DETECTOR COMPUTED TOMOGRAPHY

Radiology

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ABSTRACT

BACKGROUND: Paranasal sinuses are air filled spaces present within the skull and facial bones. Paranasal sinuses region anatomy is highly variable. Knowledge of these variations is very important for radiologists as well as endoscopic surgeons for preoperative evaluation to avoid damage to adjacent vital structures. CT is the best modality to delineate the sinus anatomy as well as soft tissue structures. Thus, this study was undertaken to evaluate the anatomical variations of paranasal sinus region and ascertain their clinical importance. **MATERIAL:** Study population of 100 patients who underwent MDCT study of Paranasal sinus and nasal cavity from July 2021 to December 2022 were retrospectively studied for anatomical variants. Study was conducted in Government medical college and hospital, Miraj, India. All patients referred for CT Paranasal sinuses with complaints pertaining to PNS and nasal cavity above 18 years were included in the study. Patients with previous sinonasal disease, sinonasal malignancy, facial trauma, those with history of surgery in the paranasal region and those younger than 18 years were excluded from the study. **RESULTS:** Among 100 study population, 41(41%) were females and 59 (59%) males. The most common anatomical variant was deviated nasal septum 58 %. This is followed by prominent bulla ethmoidalis (46%), agger nasi cells (45%), concha bullosa (35%), supraorbital ethmoidal cells (24%), pneumatized uncinate process (17%), Pneumatised anterior clinoid process (15%), Deviated uncinate process (14%), Onodi cells (11%), Accessory maxillary ostium (11 %), Low lying anterior ethmoidal artery (10 %), Haller cells (9%), Frontal sinus hypoplasia (8%) and Paradoxical curvature of middle turbinate (7%) **CONCLUSION:** CT plays a crucial role in assessing the anatomical variants of the paranasal sinuses and nasal cavity. Considering the relatively high frequency of occurrence of these variants, a precise knowledge of imaging features of normal anatomy and anatomical variations of Paranasal sinuses and its location is of utmost importance for surgeons, especially in patients with recurrent and refractory sinusitis who may require surgical treatment.

KEYWORDS

Anatomical variations, Computed tomography, Sinusitis

INTRODUCTION

Paranasal sinuses are paired air-filled spaces in the skull that function to lighten the skull, humidify the air, and serve as a resonant chamber for voice. They are the maxillary sinus, the ethmoid sinus, the frontal sinus, and the sphenoid sinus [1].

A number of anatomic variants of paranasal sinus are known to occur [2]. Radiological evaluation of the sinuses is essential to define the location and extent of sinonasal diseases and in planning for surgical intervention. 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 [3].

The role of magnetic resonance imaging is limited but may provide information on fungal infections or differentially thickened mucosa from fluid retention in paranasal sinuses.

Currently, MDCT scanning is the standard imaging in the evaluation of the paranasal sinuses. This gives an applied anatomical view of the region and of the anatomical variants that are very often found. The development and refinement of CT scans has allowed extensive assessment of patients' paranasal sinuses thus providing a guide map for FESS surgeons to operate.[4] Hence, the current study was conducted to determine the normal anatomical variations in paranasal sinuses using CT in a tertiary care centre.

Aim of this study is to evaluate the anatomical variations of paranasal sinus region by CT scan and to estimate the frequency of clinically significant anatomical variations of paranasal sinuses.

MATERIAL AND METHODS

Study population of 100 patients who underwent MDCT study of Paranasal sinus and nasal cavity from July 2021 to December 2022 were retrospectively studied for anatomical variants. Study was conducted in Government medical college and hospital, Miraj, India. All patients referred for CT Paranasal sinuses with complaints pertaining to PNS and nasal cavity above 18 years were included in the study. Patients with previous sino-nasal disease, sino-nasal malignancy, facial trauma, those with history of surgery in the paranasal region and those younger than 18 years were excluded from the study.

Multislice axial unenhanced images of the paranasal sinuses with 1 mm thickness were obtained using a 128 slice Siemens Somatom multidetector spiral CT machine and later coronal and sagittal reformats were done. Analysis of anatomical variants was performed both using a soft parts window and a bone density window.

The images were reviewed in both bone and soft tissue algorithms for the presence of anatomical variants in paranasal sinuses and frequency of occurrence was documented.

Statistical Analysis

The statistical software namely SPSS statistical package for windows was used for the analysis of data. Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

Among 100 study population, 41(41%) were females and 59 (59%) males.

Among total 100 patients included in our study having complaints pertaining to PNS, majority of them were from 21-30 years i.e. 37 (37%). This is followed by 29 (29%) from 31-40 years age, 15(15%) from 51-60 years, 10 i.e. 10% from 41-50 years and 8 i.e. 8 % from above 60 years age group. Mean age of study population was observed to be 37.1 years.

The most common anatomical variant was deviated nasal septum 58 %. This is followed by prominent bulla ethmoidalis (46 %), agger nasi cells (45 %), concha bullosa (35 %), supraorbital ethmoidal cells (24 %), pneumatized uncinate process (17 %), Pneumatised anterior clinoid process (15 %), Deviated uncinate process (14 %), Onodi cells (11 %), Accessory maxillary ostium (11 %), Low lying anterior ethmoidal artery (10 %), Haller cells (9 %), Frontal sinus hypoplasia (8 %) and Paradoxical curvature of middle turbinate (7 %).

A minimum of one anatomical variant was seen in all the cases included in the study. It is also observed that most of the cases in our study population showed more than one anatomical variant.

In our study, in 21% patients who underwent CT evaluation, single anatomical variation was seen and in 57% patients, multiple anatomical variations were observed. Overall prevalence of anatomical variations in the study population was 78%.

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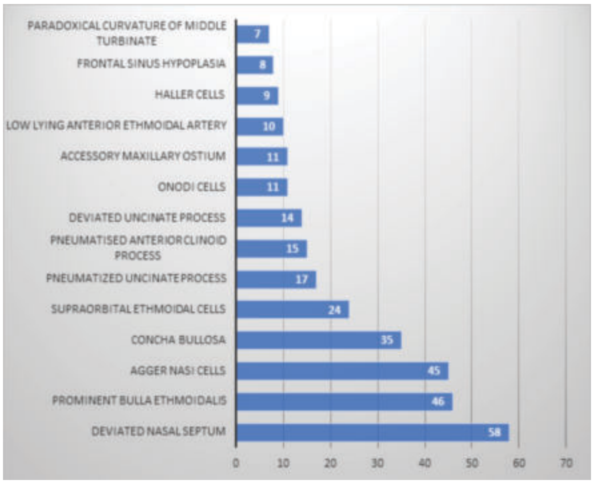

Table 1: Overall frequency of paranasal sinus anatomical variants

Out of 100 right sided optic nerves, 77 % were type I and19% were type II. Out of 100 left sided optic nerves, 74 % were type I, 20% were type II. Overall most common type was type I with 75.5 %.

Most common type of olfactory fossa was type II in 69 % on right side and 68% on left side. It is followed by type I in 17 % on right side and 18 % on left side. Asymmetric olfactory fossa was observed in 5 % of patients.

In our study, most common type of superior attachment of uncinate process was type I in 75 %, followed by type II in 14 %, type III in 8 % and type IV in 3%.

Pattern of sphenoid sinus pneumatization commonly observed in this study was complete sellar in 59 %, followed by incomplete sellar in 25%, presellar in 14 % and conchal in 2%.

Most common sinus pathology observed was sinusitis (58%), followed by sinonasal polyp (9%) and fungal sinusitis(4%).

In present study, 59 patients were detected with anatomical variations out of 71 who had mucosal changes. Hence, the prevalence was 83%. 19 patients were detected with anatomical variations out of 29 in whom mucosal changes were absent. Hence, the prevalence was 65.5%.

DISCUSSION

The paranasal sinus region is prone to a wide range of lesions. Congenital anomalies and normal anatomical variations in this region are significant because they can have pathological consequences or cause difficulty/complication during surgery. Stammberger et al. [5] proposed that stenosis of the osteomeatal complex, caused by either anatomical configuration or hypertrophied mucosa, can cause obstruction and stagnation of secretions, which can lead to infection or prolong infection.

A single anatomical variation was seen in 21% of the patients who underwent CT evaluation, and multiple anatomical variations were seen in 57% of the patients. Overall prevalence of anatomical variations in the study population was 78%.

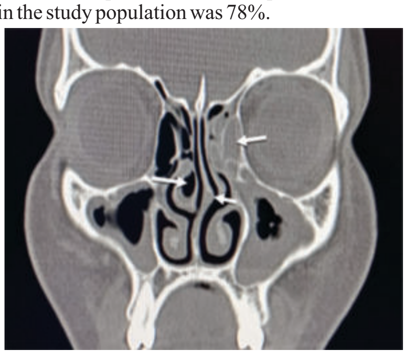

Figure 1 CT coronal image showing left sinonasal polyposis with right maxillary sinusitis, right concha bullosa and C shaped DNS towards left side

Deviated Nasal Septum: Septal deviation is a shift in the midline position of the septum to either left or right, and may be cartilaginous, osseous or combined deviation involving the osseous or cartilaginous part of the septum. According to various studies, frequency of nasal septum deviation varies from 18% to 80%. A study by Farhan, et al. [6] reported 85% of study population with deviated nasal septum. In our study of 100 patients, most common variant was deviated nasal septum, reported in 58% of study population, which is slightly lesser than other studies.

Ethmoidal Cell Variations

Agger Nasi Cells: Located anterior to the middle turbinate and anterior to the frontal recess is the agger (ridge) nasi. Even after functional endoscopic sinus surgery, most of the air cells cannot be completely removed hence allowing persistent mucosal disease and recurrent infection. Review of literature, shows prevalence of Agger nasi cells vary from 10 to 98.5%. Study by Devareddy et al. reported Agger nasi cells in 26% of study population [7]. In our study we report 45% of study population showing agger nasi cells.

Onodi cells

These cells are intimately related to the optic nerve. Disease conditions within these cells may cause optic neuropathy. Optic nerve may be predisposed to injury during FESS. Study by John Earwaker, et al. showed 24 % of Onodi cells [8], while in our study we report 11% of cases with Onodi cells.

Figure 2 CT coronal image showing Bilateral Onodi cells

Haller cells

A progressive ethmoid pneumatization into an infraorbital location leads to the formation of Haller's cells. Several studies reported medium and large size Haller's cells attribute to increase in the risk of maxillary sinus mucosal disease and predispose to infections. Studies by Mamtha, et al. et al. reported 17.5% of Haller cells respectively [9] which is more than 9% as seen in our study.

Supraorbital Ethmoidal Cells

These are the ethmoid cells that extend superolaterally between the middle orbital wall and the ethmoid roof. Souza, et al. reported 35% of study population with supraorbital ethmoidal cells which is more than 24.7 % as reported in our study. [10]

Nasal Turbinate Variations

Concha Bullosa

The pneumatization of the middle turbinate may involve the vertical lamella, bulbous segment or both. Concha bullosa has been implicated as a possible aetiological factor in the causation of recurrent chronic sinusitis. The presence of a concha bullosa has ranged between 4% and 80% in different studies. In a study by Mazza, et al., concha bullosa was reported in 29% [11] and 33% was observed by Farhan, et al., [6] which is similar to our study in which we report, 35% of the study population show concha bullosa.

Paradoxical Curvature Of Middle Turbinate

The middle turbinate may be paradoxically curved i.e. bent in the reverse direction. This may lead to impingement of the middle meatus and thus to sinusitis. Our study reported 7% of the study population with this variant which is very close to 8% reported by Dua, et al., [12].

Uncinate Process Variations

The uncinate process may be curved or bent. It can impair sinus ventilation especially in the anterior ethmoid, frontal recess and

Infundibulum regions. In the present study curved uncinate was found in 14% of patients. It is higher than that of 2.5% reported by Bolger et al. [13]. We encountered uncinate bulla in 17 % of patients.

Superior Attachment Of Uncinate Process (SAUP)

The most common pattern of SAUP was to the lamina papyracea, i.e. Type I (75%). This was similar to that that reported by Tuli et al. (79.8%). Second most common pattern was type II, observed in 14% cases. This result was closer to that of Tuli et al. (16.67%). Type III and Type IV were seen 8% and 3% respectively. Free type (Type IV) SAUP was reported in only very few studies. Our finding was lower than that reported by Kumar et al (11%) [14]. All studies have reported Type I as the most common pattern (>50%) followed by Type II and III.

Anterior Clinoid Process Pneumatization

Nouraei, et al. and Shpilberg, et al. reported 18% and 16.7% anterior clinoid process pneumatization in their study respectively which is comparable to 15% reported in our study [2,15].

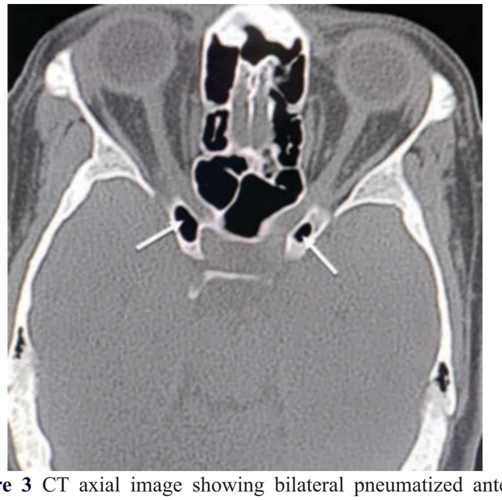

Figure 3 CT axial image showing bilateral pneumatized anterior clinoid processes

Frontal Sinus Hypoplasia

In our study hypoplasia of the frontal sinus was found in 8% of the participants which was lower than 15 % seen in study by Devareddy, et al. [7].

Kero's Classification of Olfactory Fossa

In a study in Indian population, Murthy et al. reported Kero's Type I in 19.5%, type II in 71.5% and type III in 9% [16]. In this study, we report, Kero's type I in 18%, type II in 68.5% and type III in 8.5%. Kero's Type II is the most common type of olfactory fossa reported in this study, as seen in other studies. Asymmetric Kero's was seen in 5%.

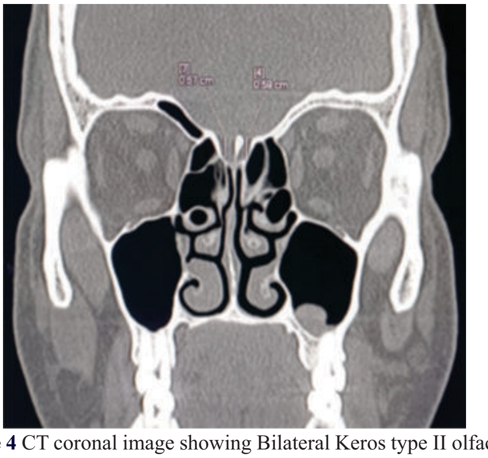

Figure 4 CT coronal image showing Bilateral Keros type II olfactory fossa

Delanos Classification of Optic Nerve

Study by Delano et al. reported 76%, 15%, 6%, 3% of types I, II, III, IV respectively [17]. Type I was the most common. In our study, most common type is also type I seen in 75.5% and 19.5% of type II, 3.5% of type III and 1% of type IV was seen.

Accessory Maxillary Ostium

Stammberger and Kennedy et al. reported accessory maxillary ostium in 4.5% [18]. In our study it was found in 11% of the participants.

Low Lying Anterior Ethmoidal Artery

A study by Abdullah B et al. showed 42.5 % of Anterior ethmoidal artery was within skull base (grade I), 20.2 % at skull base (grade II) and 37.3 % coursed freely below skull base (grade III) [19]. Our study showed 10% patients with anterior ethmoidal artery with low lying course freely below skull base.

Sphenoid Sinus Pneumatization Pattern

Most common in our study is complete sellar variant (59%) which is slightly lower than reported by Shivprakash B et al. seen in 76.6% [20]. Incomplete sellar variant was noted in 25%, presellar variant in 14% and conchal variant in 2%.

Various studies have reported the incidence of mucosal changes in paranasal sinuses. Out of 31 unilateral cases, most commonly involved sinus was maxillary sinus in 15(44.1%) patients, followed by anterior ethmoid in 7(20.5%), frontal in 6(17.6%), posterior ethmoidal in 4 (11.7%) and 2 i.e. 5.8% in sphenoid sinuses.

In our study, the overall prevalence of anatomical variations in patients who had mucosal changes was 83 %. Similar findings were reported by Liu X et al. [21], who observed prevalence of about 81 % anatomical variations in chronic rhinosinusitis cases and 87 % was reported by Aramani A et al. [22].

CONCLUSION

CT plays a crucial role in assessing the anatomical variants of the paranasal sinuses and nasal cavity. Considering the relatively high frequency of occurrence of these variants, a precise knowledge of imaging features of normal anatomy and anatomical variations of Paranasal sinuses and its location is of utmost importance for surgeons, especially in patients with recurrent and refractory sinusitis who may require surgical treatment.

In patients with chronic sinusitis, a combination of anatomical variations of the osteomeatal complex is more commonly found. Nasal septal deviation is the most common anatomical variation observed in patients with chronic sinusitis and can be considered a significant contributing factor in disruption of normal mucociliary clearance of the paranasal sinuses. Concha bullosa is a common anatomic variation, however mostly patients are asymptomatic.

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