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Computed Tomography Evaluation of Anatomical Variations and Inflammatory Diseases of the Paranasal Sinuses

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Abstract: ***Anatomical variants and inflammatory diseases of the paranasal sinuses include a wide spectrum. Plain radiograph is inaccurate and inadequate in the evaluation and diagnosis. Technological advances in CT have provided more precise and greater detail about the anatomical variants and anatomic extent of the disease. These provide sufficient information for diagnosis and surgical planning in the PNS diseases. CT before FESS serves to direct the surgical approach. The aim of the study was to evaluate the anatomical variations and inflammatory diseases of paranasal sinuses by CT. The study was conducted over a period of 2 years (October2015-september2017) in patients referred to Department of Radio-diagnosis, K.S Hegde Medical Hospital for computed tomography scan of paranasal sinuses were evaluated for the presence of anatomical variants and inflammatory diseases of the paranasal sinuses. Patients who met the inclusion criteria were included in the study. Unenhanced CT of the PNS was performed for these patients using GE Bright speed 16 - slice MDCT scanner. In our study deviated nasal septum was the most common variation in 134(66%) followed by middle concha bullosa in 97 (47.7 %) patients. Other variations found were Paradoxical middle turbinate in 40 (19.7%), curved uncinate process in 32 (15.7%), overpneumatized ethmoidal bulla or giant bulla 35 (17.2%), superior concha bullosa in 27 (13.3%), prominent Agger Nasi cells in 27 (13.3 %), haller cells in 20 (9.8%), onodi cells in 15 (7.3%), maxillary sinus septae in 15 (7.3%) and pneumatization of uncinate process in 12 (5.9%) patients. In our study 146(72%) patients had PNS mucosal abnormalities and 57 (28%) patients had no mucosal abnormalities. Anatomical variation were seen in 125 (85.6%) out of 146 patients with PNS mucosal abnormalities and 15 (26.3%) out of 57 patients without PNS mucosal abnormalities. The presence of anatomical variants does not mean a predisposition to sinus pathology, but may predispose patients to increased risk of intra-operative complications, if not known to the surgeon before procedure.***

Keywords: Paranasal sinuses, CT, PNS

1. Introduction

Imaging of the paranasal air sinuses is important in patients who are undergoing FESS for various rhinologic reasons. Reporting the variations in normal anatomy will allow the surgeon to change the operative technique and decrease the surgical complication rates during FESS and it also explain disease recurrence.

The ethmoid air sinuses have an important role in FESS. Access to posterior ethmoids and the sphenoid sinuses is through the anterior ethmoid cells. Frontal air sinus drainage can be increased by Anterior ethmoidectomy, therefore opening the frontal sinus is not necessary during surgery. Paranasal sinus variants make the FESS approach difficult. Sinus ventilation is affected by the extent of pneumatization of ethmoid sinuses and may be the cause for sinusitis and spread of infection to neighbouring structures.

Detailed information of anatomical variations is necessary to prevent serious complications such as cerebrospinal fluid leak, meningitis, or blindness during FESS. Patients planned for FESS should undergo CT scan, which helps to identify these anatomic variations.

CT scans will provide extensive knowledge of patients' paranasal sinuses thus providing a map for surgeons to complete their procedure

2. Aims and Objectives

1) To study the frequency of occurrence of anatomical variations of paranasal sinuses.
2) To know the pattern of involvement of PNS in inflammatory diseases.

3. Methodology

The study was conducted at K.S.HEGDE hospital, deralakatte, Mangalore, Karnataka. We included all patients who were referred for CT scan of PNS in K.S.HEGDE hospital during a period of 2 years from 1st October 2015 – 31st October 2017. Unenhanced CT of the PNS was performed for 202 patients.. Plain CT scan of the patients will be taken in direct axial and coronal reformation views. The investigations were performed by using GE bright speed 16 slice multi detector scanner. For coronal studies, patients were put in prone position. Taking the hard palate as reference axis, the plane of section was perpendicular to this structure. Direct scans 3 mm in thickness were made, from the anterior walls of the frontal sinuses to the posterior wall of the sphenoid sinus. For the axial scans, which were 5 mm thick, the orbitomeatal line was taken as reference with the patient in supine position. The exposure settings used were 130 kVp and 80 to 100 mAs.

Pediatric age group, pregnant women and patients with history of RTA, sinonasal malignancy or past h/o surgery in the paranasal region were not included in this study.

In all cases, systematic studies of the nasal sinus region were performed in coronal complemented by axial views in selected cases.

Analysis of anatomical variants was performed both using a soft parts window and a bone density 40window. In all cases, the existence of the following variants was investigated: (1) nasal septum: septal deviation, septal bony spur; (2) turbinates: superior concha bullosa, middle concha bullosa, paradoxical (false) middle concha, hypoplasia, and secondary middle concha; (3) uncinate process: deviation of the upper edge, pneumatisation; (4) ethmoid air cells: agger nasi cells, Haller's cells, great ethmoid bulla, Onodi cells (extramural sphenoid cells); (5) other variants: hypoplasia of the maxillary sinus, maxillary septa, hypoplastic frontal sinus and asymmetry of both cavities of the sphenoid sinus. Associated anatomy of the paranasal regions such as the course of optic nerve, asymmetry of ethmoidal roof and incidence of aerated Crista Galli were also investigated.

Excel software was used to analyze the statistical data.

4. Results

During the period of 2 years of the study 203 patients who fulfilled inclusion criteria were studied, out of which 110 were male and 93 were female**.** Of the 203 cases studied, mucosal abnormalities of PNS were noted in 146 (72%) patients**.** 182 (89.6%) patients presented some anatomical variant and, in many, more than one variant was present in the same subject.

CT scan detection of mucosal abnormalities of PNS: The CT Scan was evaluated to find out the incidence of involvement of different sinuses

(Table – 1).
Maxillary antra were the most commonly involved (114 patients -56%). This was followed by anterior ethmoids (77 patients – 38%), frontal sinuses (56 patients – 28%), posterior ethmoids (36 patients – 17%), and the sphenoid sinus (20 patients – 10%) which were minimally involved. 82 (40%) patients had involvement of more than one sinus. Pansinusitis was seen in 18 (9%).

CT scan detection of anatomic variations: Deviated nasal septum was the most common variation in 134(66%) followed by middle concha bullosa in 97 (47.7%) patients. Other variations found were Paradoxical middle turbinate in 40 (19.7%), curved uncinate process in 32 (15.7%), overpneumatized ethmoidal bulla or giant bulla in 35 cases (17.2%), superior concha bullosa in 27 (13.3%), prominent Agger Nasi cells in 27 (13.3 %), Haller's cells in 20 (9.8%), Onodi cells in 15 (7.3%), maxillary 42 sinus septae in 16 (7.8%) and pneumatization of uncinate process in 12 (5.9%) patients **(Table - 2).**146 (72%) patients had PNS mucosal abnormalities and 57 (28%) patients were normal. Anatomical variation were seen in 130 (85.5%) out of 146 patients with PNS mucosal abnormalities and 52 (26.3%) out of 57 patients without PNS mucosal abnormalities **(Chart - 1).**

DNS was categorized into various types in which type I was seen in 67(50%), type II in 18(13.4%), type III in 20(14.9%), type IV in 8 (6%), type V in 13(9.7%), type VI in 5(3.7%) and type VII in 3(2.2%) patients(Tabel-5)

Hypoplastic frontal sinus was seen in 19 (9.3%) and aerated Crista Galli in 12 (5.9%) patients.

Ethmoidal roof was classified according to Kero's classification. Type I was noted in 49 (24%), type II in 147 (72.4%) and type III in 7 (3.4%) patient.

Depending on the pneumatization of the sphenoid sinus, type I course of optic nerve was noted in 160 (78.8%) on the right side and 148(72.9%) on the left side. Type II course was seen in 22 (10.8%) on the right side and 38 (18.7 %) on the left side. Type III course was seen in 12 (5.9%) on the right side and in 8 (3.9) on the left side. Type IV course was seen in 9 (4.4%) on both sides.

Pneumatization of anterior clinoid in 14 (6.8%) and maxillary septa in 15 (7.3%) patients.

Table 1: Mucosal Abnormalities in individual sinuses

Mucosal abnormalities	Unilateral		Bilateral		Total	
	No.	%	No.	%	No.	%
Frontal sinus	37	18.2	19	9.3	56	28
Maxillary sinus	70	34.4	44	21.6	114	56
Anterior ethmoidal cells	39	19.2	38	18.7	77	38
Posterior ethmoidal air cells	20	9.8	16	7.8	36	17
Sphenoid sinus	11	5.4	9	4.4	20	10
Pansinusitis			18			9

Table 2: Frequency of occurrence of Anatomical Variants

Anatomic variations	unilateral		bilateral		total	
	No.	%	No.	%	No.	%
Concha bullosa	57	28	40	19.7	97	47.7
Paradoxical middle turbinate	28	13.7	12	5.9	40	19.7
Overpneumatised Ethmoid bulla	23	11.3	12	5.9	35	17.2
Curved uncinate process	18	8.8	14	6.8	32	15.7
Superior concha bullosa	9	4.4	18	8.8	27	13.3
Agger nasi cells	22	10.8	5	2.4	27	13.3
Infraorbital ethmoid cells	15	7.3	5	2.4	20	9.8
Hypoplastic frontal sinuses.	7	3.4	12	5.9	19	9.3
Onodi cells	10	4.9	5	2.4	15	7.3
Maxillary sinus septa	10	4.9	5	2.4	15	7.3
Uncinate process pneumatisation	9	4.4	3	1.4	12	5.9
Aerated crista galli			12			5.9
Posterior nasal septal air cells			10			4.9
Lamella concha	3	1.4	6	3	9	4.4

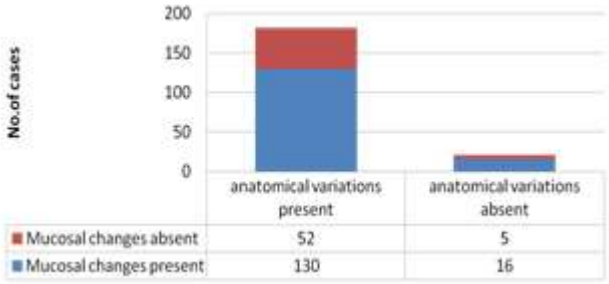

Chart 1 Incidence of Anatomical Variations of PNS in patients with and without mucosal changes

5. Discussion

The paranasal sinus region is subject to a large variety of lesions. Congenital anomalies and normal anatomical variations in this region are important as they may have pathological consequence or may be the source of difficulty/ complication during surgery. Stumberger et al proposed that infection is caused by the obliteration of the osteomeatal complex from either the anatomical variant or mucosal thickening which results in stagnation and secretions [1].

Concha bullosa (pneumatised middle turbinate) has been implicated as a possible aetiological factor in the causation of recurrent chronic sinusitis. It is due to its negative influence on PNS ventilation and mucociliary clearance in the middle meatus region. The presence of a concha bullosa has ranged between 4% and 80% in different studies; our data gave 47.7% which is similar compared to 53.6% observed by Bolger and more compared to incidence reported by Zinreich S et al [2] (36%), Dua K (16%) and Peres et al (24.5%). Such a wide range of incidence is due to the criteria of pneumatisation adopted [1,3].

The middle turbinate may be curved laterally which may lead to impingement of the middle meatus and thus to sinusitis. In our study it was found in 40 patients (19.7%) - 28 unilateral, 12 bilateral. The incidence of 19.7% in our study is close to the 58 10 % incidence described by Peres et al [1].

Sinus ventilation in the anterior ethmoid, frontal recess and Infundibulum regions can be impaired by a curved uncinate process as observed by Zinreich [4]. In the present study curved uncinate process was found in 18 patients unilaterally (8.8%) and 14 patient bilaterally (6.8%), a total of 15.7%. Bolger et al reported an incidence of 2.5% in his study [3].

Pneumatisation of uncinate process or curvature to medial side will have an extensive contact with the middle turbinate,which can cause sinusitis. Anatomic variations like uncinate bulla and infraorbital cells may elevate the pathogenic effect when seen along with pneumatised uncinate process compared to the effect of single variant. We encountered uncinate bulla in 12 (5.9%) patients, 9 unilateral and 3 bilateral. This is in consistence with 5% reported by Mecit et al and more compared to Zinreich (0.4%) and Bolger et al (2.5%) [3,4].

Haller's cells are ethmoid air cells that extend beyond the borders of the ethmoid labyrinth into the maxillary sinus. They extend into the floor of orbit. These cells may cause obliteration of adjacent ostium. The incidence of Haller's cells in our study was 20 (9.8%) – 15 unilateral and 5 bilateral. Kenedy and Zinreich reported an almost similar incidence of 10%. It is less than that reported by Bolger (45.9%) and Asruddin (28%) [5,3].

Agger nasi cells are the most anterior ethmoidal air cells lying anterolateral and inferior to the frontoethmoidal recess and anterior and above the attachment of the middle turbinate. They are located within the lacrimal bone or invade the ascending process of maxilla. These cells were present in 27 patients (13.3%) in 59 our study. Bolger reported incidence of 98% and Dua K reported 40% incidence [3]. Messerklinger reported the Agger nasi cells in 10-15% of the anatomy specimens, 65% of specimens by davis and 40% of specimens by mosher [6].

Onodi cells are the posteriormost ethmoid air cells that extend posteriorly to lie superolateral to sphenoid sinus, lying medial to the optic nerve. The risks of peri-operative injury to optic nerve are more when the bony canal of the nerve is lying dehiscent. Most authors have found an incidence of 8–14%, 10.9% by Pere and 11% by Bogler [1,3]. It was found unilaterally in 10(4.9%) patients and bilaterally in 5(2.4%) of our study (7.3%).

Depending on the pneumatization of the sphenoid sinus, type I course of optic nerve was noted in 160 (78.8%) on the right side and 148 (72.9%) on the left side. Type II course was seen in 22 (10.8%) on the right side and 38 (18.7%) on the left side. Type III course was seen in 12 (5.9%) on the right side and in 8 (3.9%) on the left side. Type IV course was seen in 9 (4.4%) on both sides.

Other variations detected include aerated crista galli in 12 (5.9%), hypoplastic frontal sinus in 19 (9.3%), 7(3.4%) unilateral and 12(5.9) bilateral and pneumatization of anterior clinoid in 9 (6.3%) patients.

Various studies have reported the incidence of mucosal changes in paranasal sinuses. In our study maxillary sinus was involved in 56% of cases, anterior ethmoidal cells in 38%,posterior etmoidal cells in 17%, sphenoid sinus in 10%, and frontal sinus in 28%. Pansinusitis was seen in 9 %.

The extent of involvement reported by other authors was also in the same range. Zinreich published maxillary sinus involvement in 65%, posterior ethmoids in 40%, frontal in 34% and sphenoid sinus involvement in 29% [4]. Bolger reported maxillary sinus involvement in 77.7%, posterior ethmoids in 38.6%, frontal sinus in 36.6% and sphenoid sinus in 25.4% [3].

The clinical significance of anatomical variants of the nasal sinus region is controversial. Most CT anatomical studies of the sinus region have been made in patients suspected of a clinical syndrome suggesting inflammatory sinus pathology. Zinreich found that 62% of his patients presented at least one anatomic variant, against 11% in the normal control group [7]. These findings seem to suggest a positive correlation between anatomical variants and the appearance of inflammatory sinus pathology. However, Bolger et al., in

a series of 202 patients studied by CT, observed 131 anatomical variants, but found the incidence in patients with sinus pathology was similar to that in persons studied for other reasons [3]. Bolger et al. and Stammberger & Wolf detected the presence of anatomical variants both in patients studied for sinus problems and in those studied for other reasons [8,9] They concluded that the simple presence of variants does not mean a predisposition to sinus pathology, except when other associated factors are present. This opinion is not shared by Yousem, who claimed that the anatomical variants may be predisposing factors, depending on 62 their size [10].

In our study 146(72%) patients had PNS mucosal abnormalities and 57 (28%) patients had no mucosal abnormalities. Anatomical variation were seen in 125 (85.6%) out of 146 patients with PNS mucosal abnormalities and 15 (26.3%) out of 57 patients without PNS mucosal abnormalities. From this observation our study also reveals that the presence of anatomical variants does not mean predisposition to sinus pathology. However, it is important for surgeon to be aware of variations that may predispose patients to increased risk of intraoperative complications. The radiologist must pay close attention to anatomical variants in the preoperative evaluation and help avoid possible complications and improve success of management strategies.

6. Conclusion

Computed Tomography of the paranasal sinus has improved the imaging of paranasal sinus anatomy and has allowed greater accuracy in evaluating paranasal sinus disease for anatomical variants and inflammatory diseases affecting the sinuses. Advances in FESS and CT technology have concurrently increased interest in the paranasal region anatomy and its variations.

Anatomical variants do not mean a predisposition to sinus pathology. Radiologist must report the anatomical variations that may predispose patients to increased risk of intraoperative complications and help avoid possible complications and improve success of management strategies.

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