STUDY OF SINONASAL VARIATIONS BY CT SCAN AND NASAL ENDOSCOPY IN CHRONIC SINUSITIS: A PROSPECTIVE CLINICAL STUDY

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ABSTRACT

BACKGROUND

Fifty patients with chronic sinusitis evaluated thoroughly and CT findings of those patients were correlated with nasal endoscopy findings. Chronic sinusitis is one of the commonest nasal diseases. It is more often seen in patients with sinonasal variations. A prospective clinical study was conducted in fifty patients of chronic sinusitis. All of them were subjected for CT scan and Nasal Endoscopy. It was observed that sinonasal variations are seen in majority cases of chronic sinusitis. Hence, it is concluded to subject every patient of chronic sinusitis to CT scan of nose and PNS, diagnostic nasal endoscopy before planning for surgical treatment.

KEYWORDS

Chronic Sinusitis, CT Scan of Nose and PNS and Nasal Endoscopy.

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INTRODUCTION

The two cardinal factors in the maintenance of normal physiology of the paranasal sinuses and their mucous membranes are drainage and ventilation. Mucous transport from the sinuses into the nose is greatly enhanced by unimpeded nasal airflow creating negative pressure within the nasal cavity during inspiration. The secretions of the various sinuses do not reach their respective ostia randomly, but by definite pathways which seem genetically determined. The two of the largest sinuses, the frontal and maxillary, communicate with the middle meatus via narrow and delicate prechambers. In each of these prechambers, the mucosal surfaces are closely opposed such that mucus can be more readily cleared by an effective ciliary action on two or more sides.

However, when surfaces become more closely apposed due to mucosal swelling, the ciliary action is immobilized. This impairs the ventilation and drainage of larger sinuses, result in mucus stasis, predispose to further infection and establish a vicious cycle causing chronic sinusitis.[1] The key region for these changes is that part of the lateral nasal wall that encloses the sinus ostia and their adjacent mucosa and prechambers. There is considerable anatomical variation in this area that may interfere with normal nasal function and predispose to recurrent or chronic sinusitis.[2] Functional endoscopic sinus surgery restores normalcy by working on the key regions rather than on the larger sinuses. The safe and effective performance of any surgery is dependent on a sound knowledge of anatomy. This is most true during endoscopic sinus surgery because of the intimate association with such vital structures as the orbit, optic nerve, anterior and posterior ethmoidal vessels, skull base and internal carotid artery.

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The difficulty is compounded by the occurrence of variations in sinonasal anatomy. The incidence with which these variations are seen in a normal population is less frequent than in those individuals with chronic sinusitis. The incidence of the sinonasal anatomical variation reported in literature shows considerable variation between populations. This study aims to study the various sinonasal anatomical variations in our population.

MATERIAL AND METHODS

This present study is a prospective study of sinus diseases using diagnostic endoscopy and computed tomography was conducted in the Department of ENT, Mahathma Gandhi Memorial Hospital, Warangal.

Source of Data

All the patients attending the ENT Outpatient Department, who had chronic sinusitis for more than three months' duration not responding to the medical line of treatment and who were willing to undergo Functional Endoscopic Sinus Surgery.

Sample Size: 50
Sampling: Prospective Study

Inclusion Criteria

All the patients with clinically proven chronic sinusitis not responding to routine medical line of treatment.

Exclusion Criteria

1. Patients with acute attack of sinusitis.
2. Patient with sinus malignancies.
3. Patient who were not willing to undergo FESS.

Methods of Collection of Data

1. The cases selected for the study were subjected to detailed history taking and examination.
2. A routine haemogram (HB, BT, CT, TC, DC) and urine examination (Albumin, Sugar, Microscopy), swab from middle meatus for culture sensitivity along with X-ray paranasal sinuses were done for the patients.

3. All the patients in active stage of the disease were treated with course of suitable antibiotic, systemic antihistamines and local decongestants. They were also treated for medical conditions like diabetes mellitus, hypertension, nasal allergy. No patient received steroid therapy or immunotherapy.
4. Each patient underwent a systematic diagnostic nasal endoscopy and computed tomography of nose and paranasal sinuses.

Equipment Used

Nasal Endoscope

Karl Storz Hopkins rod optical with cold light source and fibre optic light delivery system. Endoscopes used were with 0, 30, 45 and 70 degree angles of view of 4 mm diameters.

Karl Storz Endovision Telecam deluxe camera system with monitor. Topical decongestant and anaesthetic agent (4% Xylocaine with 1:100.000 adrenaline).

Antifog solutions (Savlon).

Suction apparatus, Cannula, Ball probe and Freer's elevator.

Position

Supine with head slightly elevated and turned towards the examiner, who is standing at the right side of the patient.

Anaesthesia

Topical decongestant 4% Xylocaine with 1:100.000 adrenaline solution using applicators like cottonoid strips.

PROCEDURES

Endoscopy was Performed by Three Passes

1. **Pass:** Along the floor of nasal cavity towards nasopharynx to visualize the status of inferior turbinate and meatus, Eustachian tube orifice, nasopharyngeal mucosa, nasolacrimal duct orifice and any pathological variations.
2. **Pass:** Scope was inserted along the superior surface of inferior turbinate. As the endoscope was withdrawn the sphenoid ostium, sphenoethmoidal recess, fontanelle, middle meatus, natural ostium of maxillary sinus and any pathological or anatomical variations were noted.
3. **Pass:** Is to visualize the frontal recess. A gentle medial subluxation of middle turbinate or use of a cannula placed under middle turbinate helps the introduction of the scope in middle meatus.

These patients after detailed evaluation and routine investigations were submitted for CT scan paranasal sinuses prior to functional endoscopic sinus surgery. As per the protocol chronic sinusitis was defined as nasal blockade, anterior nasal discharge, postnasal drip, headache or facial pain, abnormalities of smell. These patients were refractory to medical treatment for more than 3 months' duration. All CT scans were obtained with Siemens Somatom AR star, spiral scanner (Forchheim, Germany).

After obtaining the scout projection, the area of scanning was defined to include the region from roof of frontal sinus up to the hard palate. Axial sections were performed with the patient in supine position and the plane of data acquisition parallel to hard palate. The sections were taken with slice thickness of 5 mm and table feed of 7 mm, i.e. pitch of 1.4. Images were reconstructed at 4 mm intervals, i.e. image overlap of 1 mm. Scanning parameters included 105 mA, 130 kV and tube rotation time of 1.5 seconds.

Coronal sections were performed with the patients in prone position with extended neck and the plane perpendicular to axial plane. The scan parameters were same as in axial plane. Extended cephalic/caudal sections were done in a few patients to see extension of the disease process.

OBSERVATION AND RESULTS

Variations

Skull Base Types

The following was the incidence of various skull base types.

1. Keros Type I: 6 (12%).
2. Keros Type II: 32 (64%).
3. Keros Type III: 12 (24%).

SKULL BASE TYPES		
Variation	**Number**	**Percentage**
Keros Type I	6	12
Keros Type II	32	64
Keros Type III	12	24

Table 1: Showing Variations of Skull Base Configuration

Agger Nasi

Pneumatization of agger nasi was seen in 58 (72.5%) nasal cavities. When present, the agger cells were always bilateral.

Frontal Sinus

The frontal sinus was present in 95 (93.5%) sides, absent in 5 (6.25%) sides and Hyperpneumatized in 14 (27.5%). The sinus was larger on the right in 24 subjects and on the left in 26 subjects. Interfrontal cells were seen in 8 (16%).

Frontal Recess

The frontal recess was found to be obstructed in 14 of 75 (18%). Of these 8 (57%) were on the right and 6 (43%) were on the left. The obstruction was caused by agger nasi cells in 6 (43%), ethmoidal bulla or accessory cells in 4 (28.5%) and polyps in 4 (28.5%).

Middle Turbinate

Variation	Number	Percentage
Typical	25	50
Paradoxically curved	6	12
Pneumatized	17	34
Large non-pneumatized	2	4

Table 2: Middle Turbinate Variations

Uncinate Process

The uncinate was typical in 29 (58%), medialized in 22 (44%), anteriorly turned in 1 (2%), hypertrophied in 6 (12%) and pneumatized in 2 (4%).

The superior attachment of the uncinate process was as follows: middle turbinate in 21 (42%), lamina papyracea in 18 (36%) and skull base in 11 (22%).

Attachment	Number	Percentage
Middle turbinate	21	42
Lamina papyracea	18	36
Skull base	11	22

Table 3: Uncinate Superior Attachment

Ethmoidal Bulla

The bulla was typical in 31 (62%), large in 11 (22%) and hypoplastic in 8 (16%).

Typical	31	62
Large	11	22
Hypoplastic	8	16

Table 4: Ethmoidal Bulla Variations

Supraorbital Cells
Supraorbital ethmoid pneumatization was seen in 18 (36%). Of these 10 (20%) were on the right and 8 (16%) were on the left. In 8 (16%) patients, it was bilateral.

Maxillary Intrasinus Septa
An intrasinus maxillary septum can convert the maxillary sinus into two chambers. In our study, we found maxillary sinus septation in 5%. All the intrasinus septae were running obliquely along the longest diameter. This finding is important; in that a part of the maxillary sinus can have impaired drainage, while the rest of it is normal.

Accessory Ostia
Accessory maxillary sinus ostia were seen in 12 (24%). Of these, 8 (16%) nasal cavities showed accessory ostia in anterior fontanelle and 4 (8%) in the posterior fontanelle.

In 2 (4%) of patients, there were multiple accessory ostia.

Haller Cell
Haller cell was seen in 3 (6%).

Sphenoid Sinus
The various patterns of pneumatization seen were: absent in 1 (2%), conchal in 1 (2%), presellar in 12 (24%) and sellar in 36 (72%).

The Various Intrasphenoidal Projections Seen Were
1. Optic nerve in 19 (38%).
2. Maxillary nerve in 14 (28%).
3. Vidian nerve in 17 (34%).
4. Unable to see internal carotid artery projections due to most of the CT PNS taken by coronal cuts in our centre.

Onodi Cell
Onodi cells were seen in 18 (36%). Of these 10 (20%) were on the right and 8 (16%) were on the left. In 7 (14%) of patients, it was bilateral.

Sl. No.	1	2	3	4	5	6
Parameter	**Middle Turbinate**	**Middle Meatus**	**Bulla Ethmoidalis**	**Hiatus Semilunaris**	**Frontal Recess**	**Sphenoethmoid Recess**
Normal DE(N) +CT (N)	38	27	32	25	51	32
Abnormal DE(A) +CT(A)	35	46	13	30	27	3
False positive DE(A) +CT(N)	12	8	8	2	3	0
False negative DE(N) +CT(A)	7	13	10	22	5	8
Sensitivity	74.47	85.19	61.9	93.75	90	100
Specificity	84.44	67.50	76.19	53.19	91.07	80
Predictive +ve	83.33	77.97	56.52	57.69	84.38	27.27
Predictive –ve	76.00	77.14	80	92.59	94.44	100

Table 5: Correlation of Diagnostic Endoscopy Finding with Computed Tomography Findings

The parameters correlated in our study include middle turbinate, middle meatus, bulla ethmoidalis, hiatus semilunaris, frontal recess and sphenoethmoid recess. The false positive, false negative, sensitivity and specificity (Table 5) were calculated for diagnostic endoscopy as compared to CT findings. Diagnostic endoscopy was found to have sensitivities for frontal recess, hiatus semilunaris and sphenoethmoidal recess as 90%, 94% and 100% respectively. While sensitivity for middle turbinate, bulla ethmoidalis and middle meatus was 74%, 62% and 85% respectively.

The sensitivity of diagnostic endoscopy for frontal recess, middle turbinate and bulla ethmoidalis was found as 91%, 84% and 76% respectively and for sphenoethmoidal recess hiatus semilunaris and middle turbinate as 80%, 53% and 67% respectively. So diagnostic endoscopy was found to be more sensitive for frontal recess, sphenoethmoidal recess and hiatus semilunaris and more specific for middle turbinate, bulla ethmoidalis.

DISCUSSION

Agger Nasi Cells
We found pneumatization of the agger nasi cells in 72.5%. In all patients, the pneumatization when present was bilateral. The prevalence of agger nasi cells varies widely as reported by various workers: 10-15% (Messerklinger.[3]); 14% (Lloyd et al.[4]); 65% (Davis.[5]); 89% (Van Alyea.[6]) and 100% (Kennedy and Zinreich.[7]). Depending on the degree of pneumatization. Agger nasi cells may reach laterally to the lacrimal fossa and superiorly to cause narrowing of frontal recess.

On coronal CT, these cells appear inferior to frontal recess and lateral to the middle turbinate. Because of this intimate relationship, these cells form excellent surgical landmarks. Opening the agger nasi cells usually provides a good view of the frontal recess. Therefore, identification of this variation is important in diagnosis and treatment of recurrent or chronic frontal sinusitis.

Frontal Sinus
We found the prevalence of non-pneumatization of frontal sinus in 6.25%. This correlates with the study by Natsis K.[8] who reported a prevalence of 5%.

In all our patients, frontal sinuses on either sides were always asymmetrical with right being large in 47.5% and the left sinus being large in 52.5%.

Frontal Recess
As the axis of the frontal recess is tilted approximately 50 degrees to the canthomeatal line, this drainage pathway cannot be included entirely within a single coronal section. Therefore, coronal oblique views are required for complete information.

In our study, we found that the frontal recess was obstructed in 18%. Of these, in 43% the obstruction was by agger nasi cells, in 28.5% by ethmoid bulla or accessory cells and in 28.5% by polyps. As the natural ostium of the frontal sinus is very wide with average anteroposterior diameter of 7.22 mm and transverse diameter of 8.92 mm, the obstruction to the frontal sinus drainage and ventilation most often lies in the frontal recess rather than the ostium as is evident from our results. Therefore, merely clearing the recess is sufficient to achieve patency of frontal sinus ostium in most cases.

Middle Turbinate

Typically, the middle turbinate is said to have convex medial and concave lateral surfaces with smooth uniform curvature with no obstruction to middle meatus and adequate space between the turbinate and septum. However, the middle turbinate is known for several variations.

Pneumatized Middle Turbinate

We found pneumatized middle turbinate in 50%. Of these, 44% showed lamellar pattern, 4% showed bulbous pattern and 52% showed true concha bullosa. The origin of the pneumatization can sometimes be seen as depressions on the lateral surface. Literature reports a wide variation in the incidence of middle turbinate pneumatization and is as follows: Joe JK.[9] et al.-15%; Liu X.[10] et al.–34.85%, Basic N.[11] et al.-42%, Lothrop.[12]-9%, Davis -8%, Shaeffer.[13]-11%.

Our results are close to that reported by Liu X et al.[10] Presence of a concha bullosa does not suggest a pathological finding. However, in the setting of chronic sinus disease, resection of the concha bullosa should be considered to improve paranasal sinus access. Further, the concha bullosa interior may be affected by disease in other sinuses.

Bulla Ethmoidalis

We defined a hypoplastic bulla as one in which the distance between the lateral surface of middle turbinate and summit of bulla was more than 4 to 5 millimetres. An enlarged bulla ethmoidalis was defined as one that contacts or extends beyond the free margin of the uncinate and middle turbinate. This can result in a narrow hiatus semilunaris. We found large ethmoidal bulla in 22%. This correlates with the reported frequency by Lloyd.[14] (17%) and Lund VJ.[15] (18%).

UNCINATE PROCESS

The Superior Attachment

The superior attachment of uncinate process is important for the following reasons. When the uncinate process is attached to the skull base or middle turbinate, the frontal recess opens into the ethmoidal infundibulum and can be involved in infundibular disease. When the superior attachment is to the lamina papyracea, the frontal sinus opens into the middle meatus directly and can be spared from infundibular disease. Further, during surgery this attachment needs to be cleared before gaining access to frontal recess. In our study, we found that the superior attachment was to middle turbinate in 42%, lamina papyracea in 36% and skull base in 22%.

Deviated Uncinate Process

In our study, we found medially turned uncinate process in 44% and anteriorly turned uncinate process in 2%. This correlates well with 45.27% deviations reported by Liu X et al. and 31% deflection reported by Danese M.

Normally, the uncinate is a sagittally-oriented structure with adequate space between it and bulla ethmoidalis, middle turbinate and lamina papyracea. The medial deflection may contact the middle turbinate or can narrow the middle meatus. A lateral deflection of the uncinate process will make the infundibulum narrow. Because of the reduced distance between the lateralized uncinate process and lamina papyracea, care needs to be taken while performing uncinectomy to prevent orbital injury. An anteriorly bent uncinate process gives the impression of double middle turbinate on endoscopy.

Pneumatized Uncinate Process

We found this variation in 4%. This correlates with the prevalence reported by Kennedy (0 to 4%) and Bolger et al. (2.5%). The pneumatized uncinate is called uncinate bulla and can narrow the infundibulum, frontal recess and middle meatus.

Maxillary Intrasinus Septa

An intrasinus maxillary septum can convert the maxillary sinus into two chambers. According to Prahlada NB. This is present in 1% to 6% of the population. Earwaker reported a prevalence of 2.38% in his study. In our study we found maxillary sinus septation in 5%, which is consistent with that reported by Prahlada NB. All the intrasinus septae were running obliquely along the longest diameter. This finding is important, in that a part of the maxillary sinus can have impaired drainage while the rest of it is normal.

Accessory Ostia

The accessory ostia of the maxillary sinus are present in the anterior and posterior nasal fontanelles, the bone deficient areas in lateral nasal wall behind and below uncinate process. In our study, accessory ostia were present in 15% of nasal cavities. Earwaker has reported an incidence of 13.75%. Our results are very close to that of Earwaker.

Onodi Cell

This is a posterolateral pneumatization of posterior ethmoidal cell coming into intimate relationship with optic nerve. On coronal CT, an Onodi cell is seen above the sphenoid sinus. Endoscopically, these cells appear as outgrowths of posterior ethmoids posteriorly and superiorly. They have a pyramidal configuration with the tip of the pyramid pointing away from the endoscopist. It is said to have a higher incidence in Asians. In our study, the prevalence of Onodi cells was 22.5%. The prevalence of Onodi cells according to various workers are: Earwaker.[16] -24%, Aibara.[17] -7%, Basic. -10%. Our results are comparable to that of Earwaker.

Haller Cells

Also called infraorbital ethmoidal cells, these are anterior ethmoidal cells pneumatizing the floor of the orbit or the roof of the maxillary sinus. In view of their location precisely above the region of the maxillary sinus ostium and infundibulum, they can cause narrowing of maxillary sinus ostium or infundibulum, thus predisposing to recurrent maxillary sinusitis. In our study, Haller cells were present in 3.75%. The frequency with which these cells are encountered varies in literature from 1% to 45.1% and is as follows. Liu X. -1%; Jones.[18] -6%; Shroff.[19] -6%; Zinreich. -10%; Lloyd. -15%; Yadav.[20] -28%; Stackpole and Edelstein.[21] -34%; Bolger.[22] -45.1%.

The wide discrepancy noted in literature in the prevalence of these cells may be related to the differences in the interpretation of these cells.

Ethmoidal Labyrinth Cells which Outwardly Excavate the Os Planum and Os Maxillae

Cell inferior to the ethmoid bulla adhering to the roof of the maxillary sinus, in continuity with the proximal infundibulum which formed part of the lateral wall of the infundibulum: Zinreich and Kennedy. In addition to the above description, cells precisely in the region of the maxillary sinus.

Ostium: Stammberger

A large cell representing a point of access between the inferior part of the ethmoid base and the posterosuperior part of the nasal surface of the maxilla behind and above the hiatus semilunaris: Kimpoti, Nemanic, et al.

Ethmoid bulla occupying a lower position than normal, whereby the outer wall of the lowest cell is formed by the orbital wall of the superior maxilla instead of the lamina papyracea: Skillern. Air cells located below the ethmoid bulla, along the maxillary sinus roof and most inferior portion of lamina papyracea including air cells located within the infundibulum.

Bolger et al.

Supraorbital Ethmoidal Cells

The ethmoid air cells can extend supraorbitally and is said to be present in 15% to 21% according to Bhatt NJ. In our study, we found a prevalence of 22.5% which corresponds to that reported by Bhatt NJ.

Intrasphenoidal Projections

Due to extensive pneumatization, certain vital structure that are normally in the neighbourhood of sphenoid, actually project inwards. We found the following prevalence of intrasphenoid projections: Optic nerve in 38%, maxillary nerve in 28% and vidian nerve in 34%. The true prevalence of internal carotid artery projections or dehiscence could not be ascertained as axial CT sections were not obtained in our patients. The prevalence of intrasphenoid projections according to Van Alyea is optic nerve in 40%, maxillary nerve in 40% and vidian nerve in 36%. According to Lang. they are as follows: Optic nerve in 19%, maxillary nerve in 28.6%, vidian nerve in 14.3%.

Sphenoid Sinus Pneumatization

The pneumatization of the sphenoid sinus can vary from total non-pneumatization to hyperpneumatization including clinoid processes, sphenoid wings and pterygoid plates. In our study, we found absent pneumatization 2.5%, conchal type in 2.5%, presellar type in 22.5% and sellar in 72.5%. These findings compare well with that reported by Lang.[23] (Conchal 0%, presellar 23.8%, sellar 76.2%) and by Congdon (Conchal 5%, presellar 28%, sellar 67%).

Skull Base Configuration

The roof of the ethmoid bone is formed by the fovea ethmoidalis laterally and the cribriform plate medially. The lateral lamella of the cribriform plate is thin and may be of substantial height making it vulnerable to injury. The anatomy of the anterior ethmoid is critical for two reasons. First, this area is most vulnerable to iatrogenic cerebrospinal fluid leaks.

Second, the anterior ethmoid artery is vulnerable to injury which can cause devastating bleeding into the orbit. In our study, we found Keros type I (1 to 3 mm deep) olfactory fossa in 12%, type II (4 to 7 mm) in 64% and type III (8 to 16 mm) in 24%. Though several authors draw attention to the importance of deep skull base conformation, we did not find any studies reporting the incidence of various types of conformations. Arslan et al.[24] reported that average depth was 8 mm on right side and 9.5 mm on the left side.

CONCLUSION

All the variations of sinonasal anatomy described in literature except the presence of supreme turbinate were encountered in our study. The medialized uncinate process (Double middle turbinate) was most common uncinate process variation and pneumatized middle turbinate was the most common middle turbinate variation. Extramural pneumatization like septal, supraorbital, sphenoid wing and pterygoid plates was quite common. The depth of olfactory fossa was of Keros type II in majority of patients.

In view of the presence of these significant variations, we reemphasize the need for proper preoperative assessment in every patient in order to accomplish a safe and effective endoscopic sinus surgery.

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