

RESEARCH ARTICLE

Comparative Evaluation of Anatomical and Pathological Features on Computed Tomography Scan with Intraoperative Findings in Frontal Sinus Pathology

¹Sourav Chakraborty, ²Deepak Verma, ³Himani Lade, ⁴Noor UD Malik

ABSTRACT

To compare the anatomical and pathological features on computed tomography (CT) scan with intraoperative findings in cases of frontal sinus disease. This prospective study was conducted in a tertiary referral center, and a total of 30 patients who were refractory to conservative medical treatment undergoing endoscopic sinus surgery for frontal sinus disease were included in the study. Preoperative CT scans were done with axial and coronal cuts with a sagittal reconstruction to obtain a better idea about the frontal recess anatomy. The areas that were studied preoperatively on CT scan were frontal sinus pathology, pattern of sinus involvement, superior attachment of uncinata process, frontal sinus drainage pathway, agger nasi cell, frontal cell, frontal bulla cell, and supraorbital ethmoidal cell. A good correlation was obtained between the CT findings and intraoperative findings.

Keywords: Agger nasi cell, Endoscopic sinus surgery, Frontal bulla cell, Supraorbital ethmoidal cell.

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INTRODUCTION

The frontal sinus and its drainage pathway comprise one of the most complex areas of the anterior skull base with a large number of variations in the morphology of the frontal recess and anatomy of the frontal sinus outflow tract.¹ The key to successful drainage is a complete understanding of the unique and complex anatomy of the frontal recess. The frontal recess is a narrow inverted

funnel-shaped space behind the frontal beak and is pneumatized by various anterior ethmoidal cells. The pneumatization patterns of the various frontal sinus cells, agger nasi, attachment of uncinata process, and the size of the frontal beak may vary among individuals. It is imperative that every surgeon must have thorough knowledge of almost all the variations of the frontal sinus outflow tract, which can be verified and diagnosed by preoperative computed tomography (CT). The CT with multidetector helical scanning is a noninvasive method that provides accurate demonstration of these variable anatomical areas of the anterior skull base.

The ideal treatment of frontal sinus pathology is to eradicate the underlying disease process by endoscopic sinus surgery for reestablishing the adequate frontal sinus ventilation and drainage for the relief of symptoms. Endoscopic sinus surgery also carries risk of complications, which are increased in the frontal recess region due to the "tight" nature of the recess, distorted landmarks due to previous sinus surgery, as well as proximity of vital anatomical structures including the orbit and dura. The three-dimensional (3-D) picture of frontal recess and frontal sinus outflow tract requires simultaneous study of coronal, axial, and sagittal CT images. A good knowledge of interpretation of 3-D CT will enable the surgeon to operate with more confidence by improving the ability to correctly interpret normal variants from abnormal pathological conditions to establish mucociliary flow to the sinus.

Open approach for frontal sinus is usually reserved for patients with absent or distorted intranasal landmarks, failed endoscopic approaches, complicated frontal sinusitis, and evidence of posterior table erosion. This study was undertaken to compare preoperative CT scan findings with the intraoperative findings, and the results were correlated using coefficient of correlation, Fisher's exact test, and chi square test.

MATERIALS AND METHODS

A total of 30 patients who were refractory to conservative medical treatment undergoing endoscopic sinus surgery for frontal sinus disease were included in the

^{1,4}Resident, ²Senior Resident, ³Professor

^{1,3,4}Department of ENT, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India

²Department of ENT, BPS Government Medical College for Women, Sonapat, Haryana, India

Corresponding Author: Deepak Verma, Senior Resident Department of ENT, BPS Government Medical College for Women, Sonapat, Haryana, India, e-mail: dpkvrm20@gmail.com

study, while the patients with presence of any associated systemic disease (e.g., diabetes, hypertension), presence of any congenital anatomical deformity of nose, fractures of the external framework of the nose that may lead to obstruction of the frontal recess area were excluded from the study. Out of 30 patients, 18 were males and the remaining 12 females, with a male-to-female ratio of 1.5:1 and in the age group of 20 to 60 years, with mean age of 38.56 years. A total of 10 patients had unilateral involvement of frontal sinus, while in the remaining 20 patients, it was bilateral involvement of the frontal sinus. Thus, in 30 patients, 50 sides were studied.

Selection Criteria

The selection criterion was based on major and minor criterion. To be selected in the study:

- The patient should have the symptoms/physical finding for at least ≥ 12 weeks.
- Have at least two major or one major and two minor criteria.

Major criteria include facial pain or pressure, nasal congestion, nasal obstruction, purulent rhinorrhea, hyposmia or anosmia, purulence on nasal examination while minor criterion include headache, nonacute fever, halitosis, fatigue, and cough.

A written informed consent was obtained from all patients before surgery explaining the procedure, possible outcomes, and complications. Institutional ethics committee clearance was obtained for the study. After a thorough history and examination, patients were subjected to CT scan, axial and coronal cuts with sagittal reconstructions.

Operative Procedure

All of the patients underwent functional endoscopic sinus surgery (FESS). The technique and the method were tailored according to patient's need. The techniques used were axillary flap technique in 15 sides, intact bulla technique in 5, and draft type I and IIA in 35 sides of patients. The rate of identification of the superior attachment of the uncinat process, frontal sinus drainage pathway, agger nasi cell, frontal and frontal bullar cell cells was compared on CT scan with the peroperative findings.

RESULTS

Frontal Sinus Pathology

In our study, mucosal disease was found in 45 (90%) sides (23 on the right and 22 on the left) of 50 sides. Fungal pathology was found in 5 (10%) sides (3 on the right and 2 on the left) out of 50 sides.

Table 1: Sign and symptoms distribution of the patients in the study

Symptoms	Number of patients	Percentage
Facial pain	26	86.60
Nasal obstruction	25	83.30
Nasal discharge	21	70
Olfactory disturbance	15	50
Headache	21	70
Halitosis	15	50
Cough	9	30

Signs and Symptoms

The signs and symptoms distribution of the patients in the study is shown in Table 1.

Pattern of Sinus Involvement

In all the cases, frontal sinus was involved, as it was the inclusion criterion for the study. Maxillary sinus was involved in 41 (82%) sides (22 on the right and 19 on the left) out of the total 50 sides, ethmoid sinus in 38 (76%) sides (20 on the right and 18 on the left), and sphenoid sinus in 13 (26%) sides (8 on the right and 5 on the left). Isolated frontal sinus disease was seen in five sides, i.e., 10%. All the sinus involvements, i.e., pan sinusitis, were seen in 8 (16%) sides.

Superior Attachment of Uncinate Process

The superior attachment of uncinat process was identified in 30 sides, i.e., 60% in CT scan while seen in 28 (56%) sides peroperatively. The rate of identification of the superior attachment of uncinat process in CT scan with the intraoperative finding was found positively correlated. The coefficient of correlation was found to be 0.92 and the p-value of >0.05 , which shows that the difference in finding between the two modalities is statistically insignificant.

Frontal Sinus Drainage

The CT scan and intraoperative findings showed high correlation in the rate of identification and the pattern of drainage of the frontal sinus drainage pathway. The coefficient of correlation was found to be 0.97 and the p-value of >0.05 , which indicates that the difference in the rate of identification or the pattern of drainage of the frontal sinus drainage pathway between CT scan and intraoperative is statistically insignificant. The findings related to the frontal sinus drainage are shown in Table 2.

The Agger Nasi Cell

The rate of intraoperative identification of the agger nasi cell was found positively correlated with CT scan findings. The coefficient of correlation was 0.69 and the

Table 2: Distribution of frontal sinus drainage among the patients in the study

Frontal sinus drainage	CT scan		Intraoperative	
	No of patients	Percentage	Number of patients	Percentage
Medial drainage	28	56	26	52
Lateral drainage	2	4	2	4
Drainage not found	20	40	22	44

p-value of >0.05, which shows that the difference in finding between the two modalities is not statistically significant. The results related to the agger nasi cell are tabulated and elaborated in Table 3.

Frontal Cell

The rate and pattern of frontal sinus cells in CT scan was found positively correlated with intraoperative findings (Fig. 1). The coefficient of correlation was 0.96 and the p-value of >0.05, which shows that the difference in finding between the two modalities is statistically insignificant. The result related to the frontal cell are tabulated and described in Table 4.

Frontal Bullar Cell

The rate of identification of the frontal bullar cell in CT scan was found positively correlated with peroperative findings (Fig. 2). The coefficient of correlation was found to be 0.88 and p-value of >0.05, which shows that the difference in finding between the two modalities is statistically insignificant. The findings related to frontal bullar cell is tabulated and explained in Table 5.

Supraorbital Ethmoidal Cell

The rate of identification of the supraorbital ethmoidal cell in CT scan was found positively correlated with peroperative findings. The coefficient of correlation was

Table 3: Results related to agger nasi cells in the study

Agger nasi cell	CT scan findings		Intraoperative findings	
	Number of sides	Percentage	Number of sides	Percentage
Identified	48	96	46	92
Not identified	2	4	4	8

Table 4: Results related to frontal cells in the study

Frontal cell	CT scan findings		Intraoperative findings	
	Number of sides	Percentage	Number of sides	Percentage
Type I	12	24	10	20
Type II	3	6	3	6
Type III	2	4	2	4
Type IV	0	0	0	0

found to be 0.92 and p-value of >0.05, which shows that the difference in finding between the two modalities is statistically insignificant. The findings related to supraorbital ethmoidal cell are tabulated and explained in Table 6.

DISCUSSION

The preoperative CT scan of the paranasal sinuses provides an accurate anatomic display and identifies the extent of disease. The course, width, and the depth of the frontal sinus outflow tract are determined by the pneumatization patterns of anterior ethmoid cells and frontal cells. Coronal sections are preferred, as this plane corresponds with the view provided by the advancing endoscope, and this plane demonstrates the superior insertion of uncinete process between lamina papyracea and middle turbinate, which helps in determining the course of frontal sinus drainage pathway.

The common landmarks of the lateral nasal wall, as described in the surgical anatomy of FESS, are easily identified in the sagittal view. The important structures, such

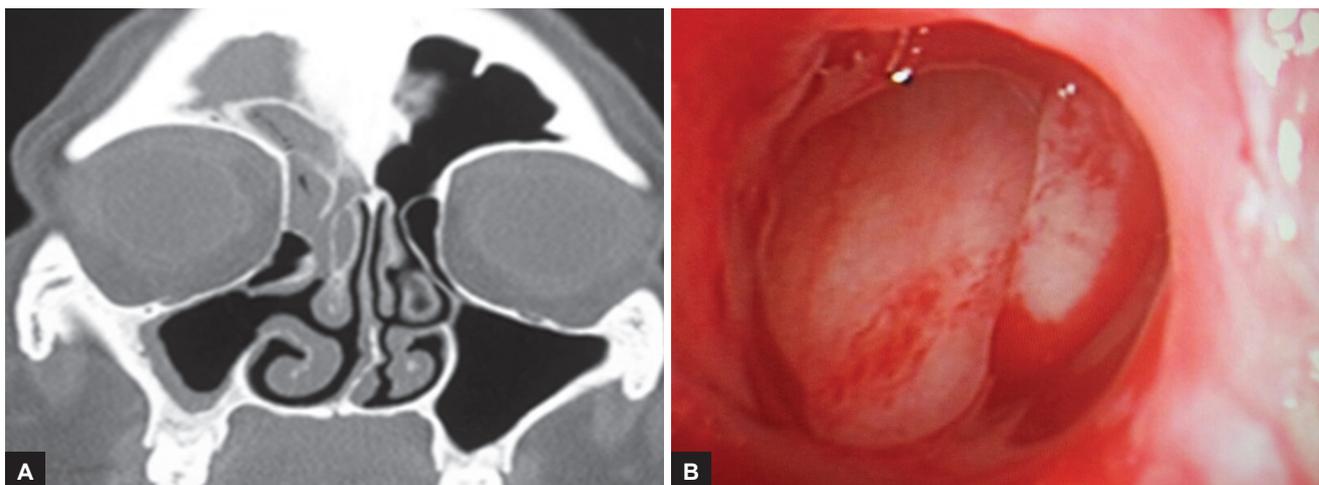
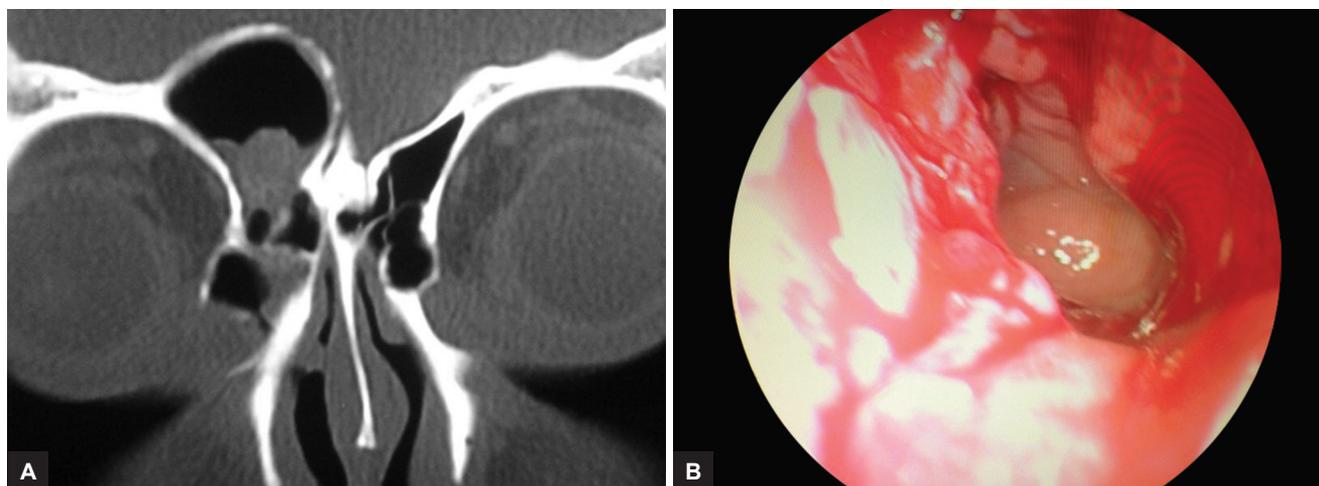


Fig. 1: K 3 cell in coronal CT image and peroperative endoscopic view of right frontal sinus



Figs 2A and B: Frontobullar cell in coronal CT image and same in peroperative endoscopic view

Table 5: Results related to frontal bullar cells in the study

Frontal bullar cell	CT scan findings		Intraoperative findings	
	Number of sides	Percentage	Number of sides	Percentage
Identified	5	10	4	8
Not identified	45	90	46	92

Table 6: Results related to supraorbital ethmoidal cells in the study

Supraorbital ethmoidal cell	CT scan findings		Intraoperative findings	
	Number of sides	Percentage	Number of sides	Percentage
Identified	8	16	7	14
Not identified	42	84	43	86

as uncinata process, the basal lamella of middle turbinate and the ethmoidal bulla are anatomically related in the sagittal plane, the plane of surgical approach. Additionally, sagittal CT images help to define the dimensions of the frontal sinus ostium and frontal recess. Parasagittal images also provide accurate information of suprabullar cell, frontal bullar cell, and various types of frontal cells. Thus, the preoperative CT scan including reformatted sagittal cuts may help to improve surgical orientation and identify the patho-anatomical variations more readily.

Sequential axial CT images of the frontal sinus and frontal recess aid in the evaluation of the drainage pathway by progressively viewing the images in cephalocaudal direction. It also enables to assess the transition zone from frontal sinus to frontal recess. At the level of frontal sinus, the posterior wall forms a straight line in the axial plane. The frontal sinus is square shaped as it narrows toward frontal ostia. As the skull base turns posteriorly, these squares elongate posteriorly, but maintain a rectangular shape, which represents the transition stage from frontal sinus to frontal recess.

In this study, the frontal sinus drainage in preoperative CT scan showed positive correlation with intraoperative findings. In two sides (4%), the frontal sinus drainage could not be traced intraoperative due to diffuse polyposis. The chronic inflammatory stimuli and pressure of polyps may have caused extensive destruction of thin bony septa and cellular walls.² Identification of the frontal sinus drainage pathway preoperatively using CT scan guided

us to navigate through the complex anatomy of the frontal recess and localize the drainage pathway intraoperatively.

Agger nasi can be considered the key that unlocks the frontal recess. It is important to see the frontal cells preoperatively, as these cells form a complex relation with the agger nasi cell and the uncinata process. If there are two or more cells, they often form a cap that pushes up into the frontal recess. To expose the frontal ostium, the roof of this cap needs to be removed.³ Lebowitz et al⁴ found agger nasi cell in 78% of their cases in CT scan and they found positive correlation with their intraoperative findings. Similar positive correlation was found by Park et al,⁵ Lee et al,⁶ Van Alyea,⁷ and Bolger et al⁸ in their study. Thus, the present study gives emphasis on the importance of preoperative CT scan in all three planes for the surgeon to comprehend the anatomy of this complex region.

If the frontal ethmoidal cell reaches the skull base laterally, it will push the frontal ostium medially.⁹ Thus, a thorough knowledge of the frontal cells is mandatory when trying to expose the frontal sinus. In two cases, type I frontal cell was detected in CT scan, but could not be identified intraoperatively due to extensive polyposis. Bent III et al¹⁰ in their study correlated the presence of frontal cells in CT scan and intraoperatively – they found the incidence of type III or IV frontal cells to be between 1 and 2%. Cho et al¹¹ found frontal cell type I in 22.8%, type II in 14%, type III in 79%, and type IV in 0% in CT scan.

The CT showed positive correlation with intraoperative findings (coefficient of correlation 0.88) in identification

of frontal bullar cells. In 2% patients, it was detected in CT scan, but it could not be identified intraoperatively. This can happen due to such cell being overlooked or incorrectly diagnosed at the time of surgery because of increased bleeding or occasional uncertainty of the surgeon about the topography of the frontal recess. The frontal bullar cell, when present, pushes the frontal sinus drainage pathway anteriorly and thus, for its removal, the curette or the probe needs to be positioned anterior to these cells and dissection has to proceed in the posterior direction.¹² Thus, a CT scan is important to identify these cells preoperatively so that necessary dissection can be done for adequate clearance of the frontal recess. Lee et al⁶, Park et al,⁵ and Van Alyea⁷ also found similar results in their study.

In the present study, the intraoperative finding correlated positively with CT scan (coefficient of correlation is 0.92) in the identification of supraorbital ethmoid cells. In one patient, it was detected in CT scan, but it could not be identified intraoperatively. In the CT scan, a supraorbital ethmoid cell may initially give the appearance of multiple frontal sinuses or of a septation present within the frontal sinus in the coronal plane, but can be readily identified in the sagittal sections. Endoscopically, the supraorbital cell typically presents as an opening along the anterolateral aspect of the roof of the ethmoid, frequently anterior to the anterior ethmoid artery. The opening into the cell may appear to extend for some distance, and thus, an open supraorbital ethmoid cell may often and quite readily be mistaken for the internal frontal ostium, leading to incomplete clearance of the frontal recess.¹³ Owen et al identified supraorbital ethmoid cells in 15% cases in CT scan. Van Alyea⁶ and Park et al⁵ also found similar results in their study.

CONCLUSION

In the present study, an overall good correlation was found between preoperative CT scan and intraoperative endoscopic findings. The anatomy of the frontal recess is very complex as already discussed earlier and also

described by various authors mentioned earlier; thus, our study emphasizes that a preoperative CT scan is a very useful tool and should be included in the workup of all patients planned for FESS.

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