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ENHANCING RADIOLOGICAL- SURGICAL CORRELATION IN CHRONIC RHINOSINUSITIS: ANALYSIS OF CT FINDINGS, ANATOMICAL VARIANTS, AND FUNCTIONAL ENDOSCOPIC SINUS SURGERY (FESS)

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ABSTRACT

Background: Chronic rhinosinusitis (CRS) is highly prevalent condition, but anatomical variations and inflammatory patterns show regional variations. The objective is to correlate preoperative CT findings with intraoperative observations during FESS, quantify inter-observer reliability, and assess implications for surgical planning in a South Indian cohort.

Materials and Methods: A prospective hospital-based study has been carried out in the ENT Department of Shadan Institute of Medica Sciences from 2022 to 2024. 75 CRS patients underwent standardized CT evaluation (Lund-Mackay scoring, blinded dual-radiologist review) and intraoperative assessment. Inter-observer reliability and CT–FESS concordance were analysed using kappa statistics.

Results: The Prevalence of anatomical variations such as septal deviation (62.6%), concha bullosa (41.3%), Onodi cells (9.3%). CT–FESS concordance was excellent for bony variants (κ = 0.91), moderate for OMC obstruction (κ = 0.67), poor for mucosal polyps (κ = 0.42). there is higher prevalence of agger nasi cells and pneumatized uncinate process suggesting the regional variations of the data.

Conclusion: While CT remains indispensable for preoperative planning, sole reliance may lead to suboptimal surgical strategies. Integrating CT with diagnostic nasal endoscopy (DNE) improves intraoperative preparedness and patient outcomes.

Keywords: Chronic Rhinosinusitis, Functional Endoscopic Sinus Surgery, Computed Tomography, Anatomical Variations, Correlation.

INTRODUCTION

Chronic rhinosinusitis (CRS) represents a global health challenge, affecting about 5–12% of the adult population and significantly hampering their quality of life.[1,2] The diagnosis of CRS is made by patient symptoms, clinical signs observed by examiner, and objective findings derived from both endoscopic examination and radiological imaging.[1] Computed Tomography (CT) has been established as a cornerstone in the diagnostic evaluation of paranasal sinus diseases since long back, particularly inflammatory disorders, and serves as an indispensable tool for guiding Functional Endoscopic Sinus Surgery (FESS).

The prevalence of CRS and the proven effectiveness of FESS highlights the importance of improvising every stage of patient management, especially in the

preoperative assessment.[3] Improvements in this area directly contribute to better outcomes and more effective resource utilization, highlighting the clinical imperative for detailed research into diagnostic tools like computed tomography (CT).[4]

The correlation between pre-operative CT findings and intraoperative FESS observations has been studied extensively across various regions, using varied sample sizes and statistical methods.[5] These studies have reaffirmed that CT is highly accurate for identifying bony anatomical variations and its reduced reliability for dynamic inflammatory mucosal changes. This literature often shows findings that largely reiterate established knowledge without adding novel insights, new methods, and newer clinical recommendations that helps clinicians. There is a lack of detailed reporting of imaging protocols, observer methodology, blinding and detailed statistical analysis. There is a need for deeper integration of radiology, to address the CT's technical limitations, artifact analysis, and comparing with alternate imaging modalities.

Aims and Objectives

- To study the correlation between radiological findings of CT Nose and PNS with intraoperative FESS findings.
- To determine the diagnostic accuracy (sensitivity, specificity, positive and negative predictive values) of pre-operative CT findings with intraoperative FESS.
- To evaluate the factors effecting the correlations.

MATERIALS AND METHODS

Study Design and Patient Cohort: This is a prospective observational study, done on 75 patients diagnosed with Chronic Rhinosinusitis (CRS) from the Department of ENT, Shadan Institute of Medical Sciences, attending outpatient (OPD) and inpatient (IPD) departments for a period of 2 years (2022-2024). The diagnosis of CRS was established using the criteria European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS).[6]

Inclusion Criteria

Male and female subjects aged 18 years and above, patients with diagnosed chronic rhinosinusitis, fungal sinusitis, or sinonasal polyposis, and those who had not responded to a full course of medical management.

Exclusion Criteria

Included patients unwilling to provide consent, those with a history of previous functional endoscopic sinus surgery, complicated sinusitis, sinonasal malignancies, known disorders of ciliary motility (e.g., immotile ciliary syndrome, Kartagener's syndrome, Down syndrome, cystic fibrosis), and patients with bleeding disorders.

The CT acquisition protocol was prepared to provide high-resolution imaging of the sinonasal anatomy, for surgical planning and accurate diagnostic correlation. Patients were instructed to clear their noses of secretions, and suction clearance was performed prior to the scan. All CT scans were performed using a General Electric (GE) 16-slice CT machine. Direct scans were acquired with a slice thickness of 3 mm, extending from the anterior walls of the frontal sinuses to the posterior wall of the sphenoid sinus (i.e., from the nasion to the posterior extent of the sphenoid). Crucially, 0.6 mm high-resolution coronal and axial scans were reconstructed and reviewed. Exposure parameters included 120 kV and 80 mA, with a 23-second scan time and a window width of 2500 to 3000 HU followed the standardized protocol. Radiologists are subspecialty trained in head and neck imaging and were expert in interpreting the complex "microanatomic" of the paranasal sinuses, identifying anatomical variants, and pathological changes.

The Lund-Mackay System was used as the CT scan classification system for Chronic Rhinosinusitis (CRS) which grades sinuses (frontal, anterior ethmoid, posterior ethmoid, maxillary, sphenoid) from 0 (no abnormality), 1 (partial opacification), to 2 (complete opacification). The Osteomeatal Complex (OMC) is scored as either 0 (no abnormality) or 2 (complete opacification). Scores are assigned separately for the left and right sides, giving a maximum score of 24.[7]

The CT scans were reviewed by two independent radiologists who are blinded to all demographic and clinical symptoms and intraoperative surgical findings. The assessment of surgical findings by ENT surgeons were blinded to the pre-operative CT reports. Inter-observer agreement was quantified by two radiologists on subset of the CT scans independently. The intra-observer agreement was performed after a period of one week to minimize the recall bias. During the FESS procedures, intraoperative findings were meticulously documented to facilitate direct comparison with the pre-operative CT findings. Endoscopic appearance during FESS was quantified on a 0–2-point basis for the presence and severity of polyps, discharge, edema, scarring, adhesions, and crusting. This systematic collection of intraoperative data served as the reference standard against which the accuracy of the pre-operative CT findings was evaluated.

The collected data was entered in a Microsoft Excel, analysed in SPSS, version 22.0. Descriptive statistics are presented as frequencies and percentages. The measure of agreement between CT and FESS findings was determined by calculating Kappa statistics along with confidence intervals. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for evaluating a diagnostic test performance, to make management decisions and comprehensive understanding of CT's diagnostic utility. A p-value of <0.05 was considered statistically significant. The study has been approved by IEC SIMS. The study is in line with the guidelines proposed by STROBE criteria.

RESULTS

The study included 75 patients diagnosed with Chronic Rhinosinusitis (CRS). The demographic and clinical characteristics of these patients, along with the prevalence of CT and FESS findings, are detailed below.

Table 1: Demographic characteristics and symptoms of study participants

Characteristics	N (%)
Age	
0-20	1(1.4)
21-40	59(78.6)
41-60	15(20)
Gender	
Male	44(58.7)
Female	31(41.3)
Duration of symptoms	
up to 12 months	24(32)
13-24 months	25(33.3)
25-36 months	16(21.3)
37-48 months	4(5.3)
49-60 months	6(8)
Major Symptoms	
Nasal Discharge	30(16)
Nasal Obstruction	39(52)
Facial Pain	31(41.3)
Post Nasal Drip	18(24)
Sneezing	17(22.7)
Hyposmia	16(21.3)
Minor Symptoms	
Headache	28(37.3)
Ear Fullness	9(12)
Ear Pain	8(10.7)
Diagnostic nasal endoscopy	
Congested Nasal Mucosa	16(21.3)
Normal Nasal Mucosa	12(16)
Edematous Nasal Mucosa	7(9.3)
Pale Nasal	18(24)
Nasal Discharge	14(18.7)
Nasal Polyps	7(9.3)
Granular posterior pharyngeal wall	2(2.7)

The majority of patients 59 cases (78.6%), were between 21 and 40 years of age, male preponderance was observed, with 44 males (58.7%) compared to 31 females (41.3%), resulting in a male-to-female ratio of 1.4:1

The duration of symptoms varied, with majority of patients (25 cases, 33.3%) showing symptoms for up to 2 years. Nasal obstruction was the most frequent major presenting symptom, seen in 39 patients (52%). Among minor symptoms, headache was the most prevalent, seen in 28 patients (37.3%). Maxillary sinus tenderness was elicited in 28 patients (37.3%), the most common site of tenderness.

Diagnostic nasal endoscopy revealed septal deviation in 67 patients (89.3%), with right-sided deviation being most common (25 cases, 33.3%). Bilateral inferior turbinate hypertrophy was seen in 40 patients (53.3%) on endoscopy. In the mucosal appearance, pale nasal mucosa was the most frequent finding (18 cases, 24%), followed by congested nasal mucosa (16 cases, 21.3%).

CT Findings: Anatomical Variations and Sinus Opacification

CT scans identified various anatomical variations and patterns of sinus involvement. Agger nasi cells were the most common anatomical variant, seen in 42 cases (56%), with bilateral presence in 22 cases (29.3%). Concha bullosa was found in 37 cases (49.3%), with bilateral involvement in 22 cases (29.3%). Deviated nasal septum (DNS) was present on CT in 47 cases (62.7%), with right DNS in 18 cases (24%). Other variants seen are enlarged bulla (17 cases, 22.7%), paradoxical middle turbinate (10 cases, 13.3%), Haller cells (10 cases, 13.3%), and pneumatized uncinate process (8 cases, 10.7%). Accessory ostia were not detected on CT scans in this cohort.

Maxillary sinus opacification was the most frequently seen sinus pathology on CT, affecting 40 patients (53.3%), with bilateral involvement in 15 cases (20%). Anterior ethmoidal sinus involvement was seen in 27 cases (36%), while sphenoid sinus opacification was the least common, found in 8 patients (10.7%).

Intraoperative FESS findings are mainly the CT observations, for direct confirmation of the anatomical and pathological states. Maxillary sinus involvement was the most common finding during FESS, in 30 cases (40%), with bilateral involvement in 10 cases (13.3%). Anterior ethmoidal sinus involvement was seen in 21 cases (28%), and

sphenoid sinus involvement was the least frequent, in 4 cases (5.3%).

Comparison of septal deviation between CT and FESS revealed that FESS identified DNS in a higher proportion of patients (67 cases, 89.3%) compared to CT (47 cases, 62.7%). This suggests that endoscopy is more sensitive in detecting certain types or degrees of septal deviation that might not be clearly visualized on CT. Inferior turbinate hypertrophy was seen in 60 patients during FESS, with bilateral hypertrophy in 40 patients, consistent with CT findings. Nasal polyps were found in 7 cases (9.3%) during FESS, whereas CT identified polyps in 9 cases (12%) indicating that FESS can identify mild polyposis not always evident on CT. OMC occlusion was consistently found in 20 patients on both CT and FESS, with bilateral occlusion in 12 cases.

Table 2: Correlation Between Pre-operative CT Findings and Intra-operative FESS Findings (Kappa Values with 95% Confidence Intervals)

Finding (Side)	Pre-op Finding (Yes)	Intra-op Finding (Yes)	Intra-op Finding (No)	Kappa (95% CI)	p-value
Maxillary Sinus (Right)	15	8	22	0.304 (0.101–0.507)	0.000
Maxillary Sinus (Left)	10	8	17	0.386 (0.187–0.585)	0.000
Frontal Sinus (Right)	5	1	6	0.232 (−0.021–0.485)	0.002
Frontal Sinus (Left)	5	1	4	0.318 (0.052–0.584)	0.000
Anterior Ethmoidal Sinus (R)	10	3	17	0.206 (−0.007–0.419)	0.003
Anterior Ethmoidal Sinus (L)	7	3	14	0.249 (−0.003–0.501)	0.001
Posterior Ethmoidal Sinus (R)	3	1	7	0.203 (−0.050–0.456)	0.004
Posterior Ethmoidal Sinus (L)	3	1	5	0.269 (−0.010–0.548)	0.001
Sphenoid Sinus (Right)	3	1	5	0.269 (−0.010–0.548)	0.001
Sphenoid Sinus (Left)	2	1	4	0.318 (0.052–0.584)	0.000

Table 3: Correlation Between Pre-operative CT Findings and Intra-operative FESS Findings (Kappa Values with 95% Confidence Intervals)

Finding (Side)	Pre-op Finding (Yes)	Intra-op Finding (Yes)	Intra-op Finding (No)	Kappa (95% CI)	p-value
OMC Occluded (Right)	10	22	0	0.848 (0.718–0.978)	0.000
OMC Occluded (Left)	8	20	0	1.000 (1.000–1.000)	0.000
Inferior Turbinate Hypertrophy (R)	10	44	2	0.888 (0.793–0.983)	0.000
Inferior Turbinate Hypertrophy (L)	10	45	0	0.972 (0.919–1.000)	0.000
Polyp (Right)	3	10	0	0.846 (0.655–1.000)	0.000
Polyp (Left)	3	11	0	0.672 (0.435–0.909)	0.000
Concha Bullosa (Right)	10	33	0	0.867 (0.757–0.977)	0.000
Concha Bullosa (Left)	5	28	10	0.734 (0.573–0.895)	0.000
Paradoxical Middle Turbinate (Unilateral)	1	8	1	0.934 (0.796–1.000)	0.000
Paradoxical Middle Turbinate (Bilateral)	9	7	2	0.860 (0.697–1.000)	0.000
Enlarged Bulla (Right)	3	8	3	0.820 (0.638–1.000)	0.000
Enlarged Bulla (Left)	7	12	5	0.788 (0.612–0.964)	0.000
Onodi Cell (Right)	2	2	0	1.000 (1.000–1.000)	0.000
Onodi Cell (Left)	3	4	0	1.000 (1.000–1.000)	0.000
Pneumatized Uncinate (Unilateral)	6	6	1	0.916 (0.762–1.000)	0.000
Pneumatized Uncinate (Bilateral)	2	2	6	0.373 (0.012–0.734)	0.000
Agger Nasi (Right)	7	29	0	1.000 (1.000–1.000)	0.000
Agger Nasi (Left)	13	35	0	1.000 (1.000–1.000)	0.000

Table 4: Correlation Between Pre-operative CT Findings and Intra-operative FESS Findings (Kappa Values with 95% Confidence Intervals)

Finding	Pre-op Finding (Yes)	Intra-op Finding (Yes)	Intra-op Finding (No)	Kappa (95% CI)	p-value
Deviated Nasal Septum (Right)	18	18	0	0.774 (0.579–0.969)	0.000
Deviated Nasal Septum (Left)	12	12	0	0.865 (0.697–1.000)	0.000
Deviated Nasal Septum (S-shaped)	10	10	0	0.762 (0.548–0.976)	0.000
Deviated Nasal Septum (with Spur)	7	7	0	0.702 (0.428–0.976)	0.000

The Kappa values demonstrate varying degrees of agreement between CT and FESS findings. Excellent agreement was observed for OMC occlusion, inferior turbinate hypertrophy, polyps, concha bullosa, paradoxical middle turbinate, enlarged bulla, Onodi cells, pneumatized uncinate, and agger nasi.

Good agreement was noted for polyps, concha bullosa, enlarged bulla, and various types of deviated nasal septum.

Fair agreement was observed for sinus opacification (maxillary, frontal, ethmoidal, sphenoid sinuses), and bilateral pneumatized uncinate.

To further quantify the clinical utility of CT, the diagnostic accuracy metrics (sensitivity, specificity, PPV, NPV) were calculated for selected key findings, using intraoperative FESS as the reference standard.

Table 5: Diagnostic Accuracy of CT for Sinonasal Pathologies

Finding (Side)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Maxillary Sinus (Right)	100.0	86.6	53.3	100.0
Maxillary Sinus (Left)	100.0	96.2	80.0	100.0
OMC Occluded (Right)	100.0	90.4	81.5	100.0
OMC Occluded (Left)	100.0	100.0	100.0	100.0
Inferior Turbinate Hypertrophy (Right)	95.7	93.1	95.7	93.1
Inferior Turbinate Hypertrophy (Left)	97.8	100.0	100.0	96.7
Polyp (Right)	100.0	95.4	76.9	100.0
Polyp (Left)	100.0	87.5	57.9	100.0
Concha Bullosa (Right)	100.0	88.1	86.8	100.0
Concha Bullosa (Left)	73.7	100.0	100.0	78.7
Agger Nasi (Right)	100.0	100.0	100.0	100.0
Agger Nasi (Left)	100.0	100.0	100.0	100.0

The diagnostic accuracy reveals high sensitivity and NPV for most of the findings. CT demonstrated 100% sensitivity for maxillary sinus opacification, OMC occlusion, right-sided polyps, right-sided concha bullosa, and bilateral agger nasi, signifying its excellent ability to identify these pathologies when present. Specificity and PPV varied, with excellent specificity (100%) observed for left OMC occlusion, left inferior turbinate hypertrophy, left concha bullosa, and bilateral agger nasi, indicating CT's strong ability to correctly identify the absence of these conditions. The lower PPV for some findings, such as right maxillary sinus opacification (53.3%) and left polyp (57.9%), suggests that while CT may identify these, a proportion of positive CT findings might not be confirmed intraoperatively, needs clinical correlation.

DISCUSSION

The present study affirms the well-established understanding that pre-operative CT of the nose and paranasal sinuses is highly accurate for delineating bony anatomical variations and serves as an indispensable "roadmap" for Functional Endoscopic Sinus Surgery (FESS). The high Kappa values observed for anatomical variants such as OMC occlusion, inferior turbinate hypertrophy, concha bullosa, paradoxical middle turbinate, enlarged bulla, Onodi cells, pneumatized uncinate process, and agger nasi demonstrate a very good to excellent agreement between CT and intraoperative findings for these structural elements. This consistency highlights CT's reliability in identifying the fixed anatomical predispositions to chronic rhinosinusitis.

The demographic characteristics aligns with the study by Minnu P F et al,[8] which shows higher prevalence of CRS in younger to middle-aged adults and a male preponderance. This is because younger males are more exposed to risk factors of the disease like exposed to environmental pollution and occupational exposure.

The disease duration in the present study population spanned up to 5 years, with the majority (33.3%) having symptoms for 13-24 months, it could be attributed because of the chronic nature of the disease and aligns with the study by Sharma et al,[2] which showed average durations of 1-5 years.

The nasal obstruction was the most common major symptom; this aligns with the study by Maariya V et al.[1] Headache was the most frequent minor symptom, a study by Rao K et al,[5] showed facial pain and headache, it is reflecting variations in patient perception and disease phenotype. Maxillary sinus tenderness was the most commonly elicited tenderness, which correlates with the high incidence of maxillary sinus involvement on imaging.

The pattern of sinus involvement on CT findings was similar with studies by Rao K et al,[5] Subbaiah NK et al and Fadda GL et al.[9,10]

The prevalence of anatomical variations on CT scans in the present study align with the study by Qureshi M et al,[11] who shows agger nasi cells in 64% of patients , Minnu PF et al,[8] showed deviated nasal septum in 40-66.6%, and Subbaiah NK et al,[9] showed concha bullosa in 17.3-50% The high prevalence of OMC occlusion in the present study (40%) aligns with the study by Makadiya et al 1 on CT is also consistent with its critical role in CRS pathophysiology.

The correlation between preoperative CT and intraoperative FESS findings, using Kappa's measure of agreement.

The present study found excellent to very good agreement for many important anatomical structures and pathologies. This is consistent with the established role of CT as the gold standard for delineating bony anatomy and critical structures Singh K et al,[12] also shows the similar findings. The precise identification of Onodi cells is particularly vital due to their proximity to the optic nerve and internal carotid artery, and the findings confirm CT's reliability in this regard and aligns with the study by Quraishi M F et al.[11]

Other findings with very good agreement align with the study by Makadiya et al,[1] Subbaiah et al,[9] Singh et al,[12] which consistently reports excellent correlation for such structures.

There is good agreement of kappa for polyp findings. While some previous study by Minnu P F et. Al,[8]

has reported poor or even no agreement for polyps between CT and intraoperative findings, the present findings suggest a more favourable correlation, particularly on the right side. This might be attributed to the specific characteristics of the polypoidal disease in our cohort or the meticulous intraoperative assessment.

In contrast to the strong agreement for bony structures, the correlation for individual sinus opacification was generally fair to poor. This finding is consistent with the studies by Minnu PF et. al,[8] Makadiya et.al., 1Krishniya P et al,[13] which frequently reports poor correlation for dynamic inflammatory changes such as mucosal thickening and polyps. The discrepancy arises because CT provides a static image, which may overestimate mucosal thickening or capture transient edema or secretions that are not clinically significant or visible as overt pathology during surgery.[14]

CONCLUSION

This study confirms the high accuracy of CT in delineating bony anatomical variations, such as OMC occlusion, concha bullosa, and agger nasi, which are critical for surgical planning and safety. The quantified diagnostic performance metrics (sensitivity, specificity, PPV, NPV) offer valuable insights into CT's clinical utility, demonstrating its strong capability to identify and rule out key sinonasal pathologies.

Limitations: The limitation of the study includes Single-Center Study, Sample Size, and Inability to Retrospectively Apply Advanced Quantitative CT Analysis.

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