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Research Paper

Clinical-radiological correlation and role of computed tomography staging in chronic rhinosinusitis

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Abstract *Objective:* This study aimed to determine whether there is a clinical-radiological correlation in chronic rhinosinusitis (CRS), to compare operative findings with those of computed tomography (CT) imaging, and to determine the importance of a CT score and staging in management of CRS.
Methods: This study is a prospective study. Adult patients meeting diagnostic criteria for CRS were prospectively studied using the Lund—Mackay (LM) symptom score and sinus CT scan. The symptom scores were correlated with CT stage according to the Kennedy and LM staging systems. Similarly, the intraoperative findings were correlated with the Kennedy staging system. The spectrum of anatomical variations in our study population was compared with the findings of symptomatic patients in various other studies.
Results: Thirty-four adult patients (13 females, 21 males, mean age: 33 years) met our inclusion criteria. Most of the patients presented with nasal obstruction, headache, and hyposmia. Nasal polyposis was the most common finding in CT scans, with many cases of retention cysts reported as polyps. In total, 50% of patients had a deviated septum. Concha bullosa was the most common finding among the various anatomical variations encroaching the ostiomeatal complex (OMC). In 60%—70% of cases, the CT scan grading correlated with operative findings. LM symptoms scores showed a poor correlation with both LM CT scores and the Kennedy stage.
Conclusions: Although CT provided detailed information on sinus involvement; its relation with symptom severity is not reliable. The Kennedy CT staging system correlated better with CRS

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symptoms. Thus, use of Kennedy staging could be useful to endoscopic sinus surgeons as it provides an insight into the pathophysiology, can guide treatment, and facilitate prognosis prediction in CRS.

Introduction

Computed tomography (CT) imaging remains the modality of choice for the diagnosis and evaluation of inflammatory diseases of the sinonasal cavities.[1,2] However, it is important to emphasize that CT should not be employed exclusively for diagnosis. CT imaging can provide additional information and subtle details, but patients' symptoms and nasal endoscopy findings still constitute the basis for a diagnosis of chronic rhinosinusitis (CRS). The clinical presentation of CRS, radiography, and the degree of symptom improvement after endoscopic sinus surgery (ESS) varies widely in these patients.[3] Distinguishing patients for whom ESS will likely be effective and result in enduring abatement of interminable CRS remains problematic, and numerous specialists have switched to radiographic staging to identify prognostic components that may influence post-ESS results.[4] Nevertheless, preoperative manifestations do not precisely correlate with processed CT scan staging.[5–7] Another key issue is the spectrum of anatomical variations in CT findings: some data suggest that the preoperative CT scan stage may predict the degree of symptom improvement after ESS.[8]

The present study aimed to assess the correlation of the preoperative CT scan stage with intra operative ESS findings. We assessed whether the Lund–Mackay (LM) symptom scores correlated with Kennedy and the LM CT scan staging systems, and whether the intraoperative findings correlated with the Kennedy staging system. Additionally, we compared the spectra of anatomical variations in the present study population with those of symptomatic patients in previous studies.

Materials and methods

We recruited consecutive adult patients from Silchar Medical College and Hospital, Silchar, India, who were prospectively evaluated and diagnosed with paranasal sinus disease. Inclusion criteria consisted of clinically diagnosed CRS on the basis of a detailed history, the presence of at least 2 of the symptoms described by AAO-HNS 2007,[8] clinical examination. Patients who remained refractory to standard medical therapy for 12 weeks were included. Patients with acute rhinosinusitis, or a history of sinonasal trauma, sinonasal surgery, sinonasal tumor, or inverted papilloma, were excluded. Eligible participants were placed on optimal medical therapy before obtaining coronal CT scans; treatment comprised of 2–3 weeks of antibiotics and more than 8 weeks of intranasal steroids for chronic rhinosinusitis without nasal polyps (CRSsNP), or oral corticosteroid for 1–3 weeks along with 8 weeks of intranasal steroids for chronic rhinosinusitis with nasal polyps (CRSwNP). Endoscopic sinus surgery was planned for medically refractory CRS.

During evaluation, symptoms were comprehensively assessed and scored using the LM system.[9] A visual analog scale (VAS) was utilized to measure the severity of clinical symptoms where "0" indicated complete absence of symptoms and "10" indicated most severe symptoms of nasal obstruction or congestion, headache, facial pain, olfactory problems, nasal discharge, sneezing, and overall symptomatic assessment. Nasal endoscopy was also performed at the time of presentation.

A non-contrast-enhanced coronal section CT scan was performed, using 3-mm sections through the frontal and sphenoid sinuses, and 2-mm sections through the ethmoid region, using an intermediate window type, 2500 with a center of 250 HU, as this is adequate for most diagnoses. Complementary direct axial sections were obtained for additional information in cases with severe pathology or atypical anatomy. The scans were assessed for sinus variations and were analyzed for concha bullosa, septal deviation, and other anatomical variations. The sinus CT scans were prospectively scored according to 2 staging systems: (1) the LM system, (2) the Kennedy system. In the LM CT system, each sinus group was graded between 0 and 2, with 0 indicating no abnormality; 1 indicating partial opacification; and 2 indicating total opacification. OMC obstruction was either coded as 0 for "not obstructed" or as 2, for "obstructed". Kennedy's CT staging was used to correlate CT findings with surgical findings and outcome.[10]

The respective patients' data were grouped, tabulated, and analyzed. The endoscopic and radiological findings were compared in terms of the laterality of the disease and anatomical variations. Patients then underwent standard ESS with sinusotomy gauged according to the diseased sinuses.

After graphical data analysis, correlation analysis was performed, with statistical significance set at $P < 0.05$ for the *Pearson's* correlation coefficient (two-tailed). Correlation between LM symptom score and LM CT score was assessed, to determine the relationship between the severity of the CT scores and symptom severity. Additionally, the Kennedy staging system was correlated with the LM symptom score, as well as with intraoperative endoscopy findings of the various regions, for example, the presence or absence of polyps, edematous mucosa, cysts, and so on, as assessed by the unblinded surgeon.

The incidence of anatomical variations in symptomatic patients was then compared with that reported in previous studies.

Results

A total of 34 adult patients met the inclusion criteria. The mean patient age was 33 years, and the group consisted of 13 females and 21 males. All of the patients were staged successfully using each of the staging systems.

The symptoms at presentation were as follows: 30 (88.2%) patients had nasal obstruction, 24 (70.6%) had nasal discharge, 27 (79.4%) had hyposmia, 8 (23.5%) had epistaxis, 16 (47.1%) with postnasal drip, and 28 (82.4%) had headache, as depicted in Fig. 1.

The symptoms were scored using the LM system, and the mean score was 25.2 ± 7.9. Nasal endoscopy suggested that 14 (41.2%) patients had unilateral polyposis and 3 (8.8%) had bilateral polyposis.

Upon analyzing the CT scan findings as per the LM criteria for the pattern of sinus involvement, the incidence of sinonasal polyposis, the OMC pattern, the sphenoethmoidal pattern, and the infundibular pattern in our study population was 58.9% (20/34), 23.5% (8/34), 14.7% (5/34), and 2.9% (1/34), respectively.

Furthermore, 25 (73.5%) patients had unilateral and 9 (26.5%) patients had bilateral disease. Among patients with unilateral disease, 15 (44.1%) had sinonasal polyposis, 6 (17.6%) had the OMC pattern, 3 (8.8%) had the sphenoethmoidal pattern, and only 1 (2.9%) had the infundibular pattern. Among those with bilateral disease, 5 (14.7%), 2 (5.9%), and 2 (5.9%) patients demonstrated sinonasal polyposis, the OMC pattern, and the sphenoethmoidal pattern, respectively (Table 1).

In accordance with the CT scan findings, the most commonly involved sinus was the maxillary sinus (in 19% of patients), followed by the anterior ethmoid sinus, in 14%, posterior ethmoid sinus in 4%, sphenoid sinus in 4% and frontal sinus in 3%. OMC pathology was observed on the CT scans of 9% of patients (Table 2).

There was no statistically significant correlation between the mean LM symptom score and the LM CT score Pearson's correlation coefficient: 0.1521, *P*-value = 0.3906, and 95% confidence interval [*CI*]: (0.1963–0.4663, Table 3).

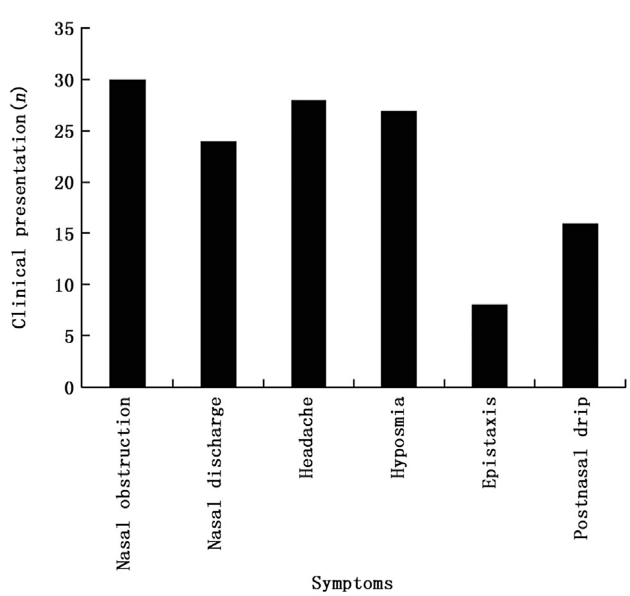

Fig. 1 The various symptoms at presentation.

Table 1 Radiological assessment of sinonasal disease.

CT-scan finding	Laterality		Number of patients	%
	Unilateral	Bilateral		
Sinonasal polyposis	15 (44.1%)	5 (14.7%)	20	58.8
Ostiomeatal complex pattern	6 (17.6%)	2 (5.9%)	8	23.5
Sphenoethmoidal pattern	3 (8.8%)	2 (5.9%)	5	14.7
Infundibular pattern	1 (2.9%)	0	1	2.9

Table 2 Distribution of sinonasal disease as per the Lund–Mackay CT score.

Disease	Percentage of patients (%)	Number of patients (Laterality)
Maxillary	19.1	13
Ant ethmoids	13.2	9
Post ethmoids	4.4	3
Sphenoid	4.4	3
Frontal	2.9	2
Ostiomeatal complex	8.8	6

We then compared the mean LM symptom scores in the various Kennedy CT stages. There was a significant correlation between the mean LM symptom score and the different Kennedy CT stages ($P < 0.05$, Table 4). However, when we compared the LM symptom scores in the different Kennedy stages using the Tukey–Kramer multiple comparisons test, the scores were not significantly different.

In terms of CT stages, 18 patients were in Stage I, 5 in Stage II, 6 in Stage III, and 5 in Stage IV. The correlation between Kennedy CT staging and intraoperative findings was statistically significant. The percentage of CT scan findings that were similar to intraoperative findings are summarized in Table 5.

The endoscopic anatomical variations noted in the patients in this study were deviated septum 17 (50.0%), and concha bullosa 4 (11.8%). Anatomical variations seen in the OMC on CT were as follows: 2 (5.9%) patients demonstrated paradoxical turbinate, 4 (11.8%) bulla ethmoidalis with medial bony contact, 2 (5.9%) paradoxical uncinate, 2 (5.9%) Haller cells, and 1 (2.9%) Onodi cells. Concha bullosa was seen in 10 (29.4%) patients, and was the commonest anatomical variation observed at the OMC (Fig. 2). The incidence of deviated septum was 19 (55.9%).

Discussion

CRS encompasses a range of conditions, but the correlation between staging, pathophysiology, and treatment has not

Table 3 The statistical correlation between the Lund–Mackay symptom score and Lund–Mackay CT score.

	LM symptom score	LM CT score	Pearson's correlation coefficient (r)	95% CI	*P* value
Mean score	25.2 ± 7.9	3.7 ± 2.2	0.1521	0.1963–0.4663	0.3906

Table 4 Comparison of Lund–Mackay symptom score across different Kennedy computed tomography stages.

	Stage 1	Stage 2	Stage 3	Stage 4	95% CI	*P* value
Mean LM symptom score	23.4 ± 7.9	18.9 ± 3.2	30.6 ± 8.5	30.4 ± 3.9		0.0259
Stage 1 vs. Stage 2					−4.9 to 14.7	$P > 0.05$
Stage 1 vs. Stage 3					−15.9 to 2.3	$P > 0.05$
Stage 1 vs. Stage 4					−16.4 to 3.2	$P > 0.05$
Stage 2 vs. Stage 3					−23.4 to 0.07	$P > 0.05$
Stage 2 vs. Stage 4					−23.8 to 0.78	$P > 0.05$
Stage 3 vs. Stage 4					−11.5 to 11.9	$P > 0.05$

Data were compared using the Tukey–Kramer multiple comparisons test.

Table 5 Percentage of cases showing similarity between Kennedy computed tomography staging and intraoperative findings.

Kennedy CT staging	Number of cases	Intraoperative finding	
		Similar to CT scan finding	Not similar to CT scan finding
I	18	12 (66.7%)	6 (33.3%)
Anatomical abnormalities			
All unilateral sinus diseases			
Bilateral disease limited to ethmoid sinus			
II	5	3 (60.0%)	2 (40.0%)
Bilateral ethmoid disease with involvement of 1 dependent sinus			
III	6	5 (83.3%)	1 (16.7%)
Bilateral ethmoid disease with involvement of 2 or more dependent sinuses on each side			
IV	5	4 (80.0%)	1 (20.0%)
Diffuse sinonasal polyposis			

been reported. Although the diagnosis of CRS is made on clinical findings, the utilization of nasal endoscopy and CT scan helps to decide the appropriate management.[4,11]

The common clinical presentations in our study were nasal obstruction, headache, and hyposmia. In an attempt to categorize the extent of CRS in patients undergoing endoscopic sinus surgery, we have used a simple staging system, the LM symptom score, to grade the symptom severity on a scale of 1–10, as suggested by Ryoo et al.[12]

Various CT scan staging scores have been proposed previously. The findings of the study by Bhattacharya et al support the use of the most commonly used LM score,[13,14] as each sinus is graded separately on the basis of whether the sinus is clear, partially opacified, or totally opacified, making this a more effective system. We therefore utilized this system for scoring the CT scan.

In the initial analysis, the LM symptom severity score did not show a correlation with the LM CT score, probably because some symptomatic patients showed minimal sinus disease on the CT scan. Bhattacharya et al also proposed that this inconsistency resulted from patients with CRS symptoms who had no endoscopic or CT criteria of CRS.[5] Despite the precautionary measure of including symptomatic CRS patients with supporting radiographic evidence, based on these recommendations, Stewart and colleagues failed to find a symptomatic and radiological correlation.[15]

The important role of endoscopy was illustrated by the finding of Hughes et al, who reported that endoscopy altered the diagnosis significantly in a number of patients in their series.[16] In our study, nasal endoscopy revealed that 14 (41.2%) patients had unilateral polyposis and 3 (8.8%) had bilateral polyposis, while CT scans indicated that 20 (58.8%) had sinonasal disease that was unilateral in 15 (44.1%) and bilateral in 5 (14.7%). The discrepancy resulted from incidental findings of retention cysts that were reported as polyps in patients who had no polyps on endoscopy. Similar to our findings, these were reported as an incidental finding in 12.5%–0.75% of an asymptomatic population by Bhattacharyya et al[17] Ruprecht et al[18] and Moser et al[19] Unfortunately, if such subtle changes are

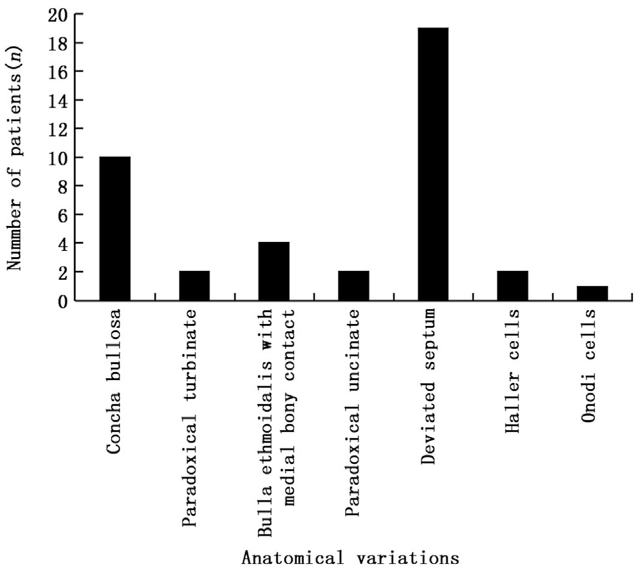

Fig. 2 Incidence of the anatomical variations in paranasal sinuses.

taken as indicating sinus disease, patients may undergo unnecessary surgery.

We also correlated the Kennedy CT stages, which is primarily used to predict symptom outcome, with LM symptom score. The mean LM symptom scores of patients were best correlated with Kennedy Stages III and IV ($P < 0.05$). Stage III describes a disease process in the bilateral ethmoid, with involvement of 2 or more dependent sinuses on each side, while stage IV encompasses diffuse sinonasal polyposis. Further studies are needed to study this correlation. Symptom scores for perpetual rhinosinusitis commonly are not associated with radiological findings and accordingly have no correlation with CT staging.[5,20]

Although Kenny et al[6] and Wabnitz et al[7] have shown statistically significant correlations among selected chronic rhinosinusitis symptoms and radiographic findings, the magnitude of these correlations (the coefficient of determination) is typically small, indicating that the CT scan findings do not account for much of the symptom variability in chronic rhinosinusitis. Kennedy[10] proposed that the CT staging system correlates well with the surgical outcome. The analysis of the Kennedy CT staging and intra-operative findings in this study were found to be statistically significant, with Stage III and Stage IV showing the maximum similarity with intra-operative findings (≥80%). The focus on the ethmoid sinuses as being central to CRS, without allowing for isolated maxillary sinus disease, which affects approximately 5% of patients,[21] probably precluded greater correlation. This finding was similar to those of previous reports who have also described that CT does not correlate with surgical findings.[20,22,23] Jiannetto and Pratt[22] emphasized the importance of interpreting the CT scans in the light of clinical findings. At present, the LM staging systemis the most widely used. Our study supports this proposal.

A very important cause of CRS may be anatomical variations that can encroach on the OMC and cause significant obstruction (Table 6). It often reduces drainage and ventilation to a sinus and is an important etiological factor in initiation or maintenance of rhinosinusitis. The anatomical variations on CT scans and nasal endoscopy in this study were paradoxical turbinate, bulla ethmoidalis with medial bony contact, paradoxical uncinate, Haller cells, Onodi cells, and concha bullosa. The reports of Lloyd et al[24] and Clark et al[25] have recognized that paranasal sinus disease is often found in the presence of an anatomical variation, such as a concha bullosa or a large aggernasi cell. The anatomical variations found in our study were compared with previous reports that have analyzed symptomatic patients.[21,26,27] These studies have also reported significant differences in the prevalence of certain anatomical variations between individuals with CRS when compared with asymptomatic individuals. Clark et al,[25] Sonkens et al[28] and Calhoun et al[29] have reported a higher prevalence of concha bullosa in symptomatic individuals (33%, 29%, and 29%, respectively) than in asymptomatic individuals (11%, 17%, and 16%, respectively), as we also found (Table 3).

In view of the above findings, our study supports the staging systems of Lund and Kennedy that were primarily

Table 6 Anatomical variations in symptomatic patients from various studies.

Anatomical variations	Jones[21]	Basić et al[27]	Arslan[26]	Danese[30]	Lloy[24]	Kayalioglu[31]	Tonai and Baba[32]	Calhoun[29]	Bolger[33]	Present study
Number of patients	100	212	200	112	100	90	57	82	166	34
Concha bullosa	18		30	31	24	29	—	29	53.6	10
Paradoxical middle turbinate	7	—	—	—	15	—	30	12	27.1	2
Bulla ethmoidalis with medial bony contact	10	—	—	—	—	—	28.1	—	—	4
Paradoxical uncinate	6	—	3	31	21	12.2	—	—	—	2
Pneumatizeduncinate	0	—	2	—	—		—	—	3	0
Septal deviation	24	—	36	33	—	22	—	40	—	19
Hallers cell	6	21.2	6	34	—	5	33	—	45.9	2
Onodi cell	7	10.4	12	—	—	—	—	—	—	1
Aggernasi cell	95	—	—	3	—	—	—	—	—	0

based on radiographic findings along with endoscopic findings.[4] These staging systems endeavor to stratify patients by the degree of illness, as a means of predicting therapeutic and surgical outcomes in the treatment of interminable rhinosinusitis.

Conclusion

Unilateral sinonasal polyposis was the commonest form of presentation of CRS in our study. We found that, although CT provided detailed information about sinus involvement, including the anatomical variations present, its relation with symptom severity is not reliable, as shown using the well-accepted LM symptom scoring system. However, we showed that the Kennedy CT staging system correlated better with CRS symptoms. As sinus CT scans are the imaging modality of choice for the evaluation of CRS, use of the Kennedy staging may be advisable to endoscopic sinus surgeons, as it provides insight into the pathophysiology, can guide treatment, and helps to predict outcomes of therapy.

Conflict of interest statement

Both authors declare no conflicts of interest relevant to this report.

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