

Changes in chronic rhinosinusitis: A retrospective analysis of computed tomography imaging and inflammatory changes either side of a 5-year interval

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Abstract. Chronic rhinosinusitis (CRS) remains a prevalent and challenging condition characterized by variable clinical presentations and severity. The present study investigated changes in CRS characteristics either side of a 5-year interval to understand the impact of clinical advancements on disease management. A retrospective analysis was conducted on 120 patients diagnosed with CRS in 2017 and 2023 at The Second Hospital of Shanxi Medical University (Taiyuan, Chian). Standardized computed tomography imaging was performed, and sinonasal inflammation severity was evaluated using Lund-Mackay (LM) scores. Comparative analyses focused on anatomical variations, mucosal and submucosal features, and patterns of inflammation. Significant reductions in LM scores were observed in 2023 compared with those in 2017, indicating decreased sinonasal inflammation severity. Improvements were most pronounced in the osteomeatal complex (OMC) and frontal sinuses, with asymmetrical changes between the left and right sides. The left OMC and frontal sinus exhibited greater reductions in inflammation, whereas the right side showed less pronounced improvements. Analysis of mucosal thickening revealed a shift from diffuse to localized patterns, with reduced submucosal remodeling and fewer signs of chronic osteitis observed in 2023 compared with that in 2017. Anatomical variations, such as middle turbinate pneumatization and nasal septum deviation, remained unchanged between the two cohorts. This stability suggests

that the observed reduction in disease severity may be more likely related to external factors such as earlier detection or evolving clinical practice, rather than anatomical differences. In conclusion, over the past 5 years, a marked reduction in CRS severity has been observed, particularly in regions critical for sinus ventilation and drainage. These findings may reflect broader changes in clinical practice over time, such as increased disease awareness, improved access to diagnostic tools or shifts in general management approaches, although specific treatment strategies or time of presentation were not directly assessed. The results also highlighting persistent asymmetry and inter-sinus variability. Further prospective studies integrating advanced imaging and molecular techniques are needed to improve understanding of these time trends and refine diagnostic and therapeutic approaches in CRS care.

Introduction

Chronic rhinosinusitis (CRS) is a multifactorial condition characterized by persistent inflammation of the sinonasal mucosa, affecting ~16% of the global population (1,2). Symptoms such as nasal congestion, increased nasal discharge, facial pain or pressure, and olfactory dysfunction persist for >12 weeks, significantly impairing quality of life and contributing to psychological distress (3). The high prevalence and recurrent nature of CRS poses a substantial healthcare burden.

Sinonasal computed tomography (CT) is the most commonly used imaging modality in CRS diagnosis and management (4-6); it provides detailed anatomical visualization, aiding in disease assessment, surgical planning and postoperative evaluation (7,8). The technique helps assess the presence of fluid, mucosal thickening, bone fractures, osteitis and sinonasal anatomical variations (9-11). For example, CT imaging can highlight surgical indications, such as severe osteomeatal complex (OMC) obstruction or extensive soft-tissue disease within the sinuses. By combining CT-derived Lund-Mackay (LM) scores (12,13) with symptom scores, clinicians can tailor treatment plans to individual

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patient's needs (14,15). Furthermore, CT serves as an essential tool for postoperative evaluation, enabling direct comparison of preoperative and postoperative LM scores to assess the effectiveness of surgical interventions in resolving sinonasal pathology (16-18). While numerous studies have explored the association between CT scoring at a single time point and treatment outcomes (19,20), limited research has focused on longitudinal imaging changes in CRS, particularly in untreated patients. The natural progression of the disease over time remains inadequately explored. Therefore, analyzing the temporal trends of CRS using CT scoring is of considerable significance. Such an analysis not only reflects the dynamic characteristics of the disease but also provides insights into potential factors influencing disease progression or resolution, such as advancements in medical technology, changes in environmental factors, or shifts in the healthcare-seeking behaviors of patients.

Building on this context, the present study compared CT imaging data of patients with CRS from 2017 and 2023, using the LM scoring system to assess changes in disease severity. Given ongoing changes in diagnostic strategies, clinical management and public health awareness, such a comparison may provide insight into how CRS presentations may have shifted in recent years. These findings offer valuable data to inform the future of precision medicine and personalized management strategies for CRS.

Materials and methods

Study design and population. The present study employed a retrospective analysis conducted at The Department of Otorhinolaryngology of The Second Hospital of Shanxi Medical University (Taiyuan, China), involving 120 patients diagnosed with CRS in 2017 and 2023. The 2017 group included 60 patients (41 males and 19 females; median age, 31 years; range, 9-64 years), and the 2023 group included 60 patients (35 males and 25 females; median age, 24 years; range, 7-50 years). The present study was approved by The Institutional Review Board of the Second Hospital of Shanxi Medical University (approval no. 2025.YX059) and conducted in full compliance with the Declaration of Helsinki and institutional ethical guidelines. All clinical and imaging data were retrospectively obtained from routine care and fully anonymized prior to analysis. Given the retrospective design and use of de-identified data, the requirement for informed consent was waived by the ethics committee. All patients met the diagnostic criteria for CRS with nasal polyps as defined in The European Position Paper on Rhinosinusitis and Nasal Polyps 2020 (4). Each patient underwent standardized CT scans and completed LM score evaluations.

The inclusion criteria required participants to have a confirmed CRS diagnosis (with or without nasal polyps) in 2017 or 2023 and to have undergone both standardized CT imaging and symptom scoring. Exclusion criteria were established to ensure data reliability and minimize confounding factors, and were as follows: i) Severe systemic diseases (such as uncontrolled diabetes, autoimmune disorders or malignancies) that could influence CRS severity or treatment response; ii) history of sinus-related surgery, as prior surgical intervention could alter sinonasal anatomy and inflammation,

confounding comparisons between the two time points; and iii) incomplete data or poor-quality CT images, which could compromise the accuracy of the LM scoring and limit the validity of the findings. To mitigate potential selection bias, patient recruitment was based solely on predefined inclusion and exclusion criteria, without influence from disease severity or treatment history. Additionally, the two study groups (2017 and 2023) were matched for age and sex distribution to enhance comparability.

The study population was divided into two groups: i) The 2017 group, consisting of 60 patients diagnosed with CRS (with or without nasal polyps) who completed CT scans and ii) the 2023 group, consisting of 60 patients meeting identical diagnostic criteria. For both groups, demographic data and disease history were recorded. Importantly, neither group received major therapeutic interventions before or during the study period, ensuring comparable disease status for robust analysis.

CT imaging evaluation. All patients underwent preoperative CT scans using a 64-slice multislice scanner (GE Healthcare). The scanning parameters were as follows: Slice thickness of 0.6-1.0 mm, 120 kV and 80-160 mAs. Sagittal and coronal reconstructions were obtained for each scan. CT findings were evaluated and staged according to the LM scoring system (12,13) by two experienced radiologists, with the final score representing the average of the independent assessments to minimize subjective bias.

The LM staging system assigns a score of 0 for no opacification, 1 for partial opacification and 2 for complete opacification of each sinus (maxillary, anterior ethmoid, posterior ethmoid, sphenoid and frontal). For the OMC region, the score is either 0 (not occluded) or 2 (occluded). The total score ranges from 0 (no abnormalities) to 24 (complete opacification of all sinuses and OMC). The total LM score (maximum of 24) represents the sum of scores from both sides, with each of the five sinuses scored from 0 to 2, and the OMC scored as 0 or 2 per side.

Statistical analysis. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp.). Continuous variables, such as age, are expressed as the mean $\pm$ standard deviation (SD) and were compared between the 2017 and 2023 groups using unpaired (independent samples) t-test. Sex distribution was analyzed using the χ^2 test. LM scores, which did not follow a normal distribution, were compared using the Mann-Whitney U test. All statistical tests were two-tailed, with $P < 0.05$ considered to indicate a statistically significant difference.

Results

Participants and CRS clinical features. A total of 294 patients diagnosed with CRS were initially considered for inclusion in the present study. After excluding 174 patients due to incomplete data or presentations unrelated to nasal symptoms, the final analysis included 120 participants ($n=60$, 2017; $n=60$, 2023). The mean age of the 2017 cohort was 31 years (SD, 15 years; range, 9-64 years), with 31.7% women and 68.3% men. The 2023 cohort had a mean age of 24 years (SD,

Table I. Subjects' characteristics.

Characteristic	2017	2023
Mean age (SD), years	31 (15)	24 (10)
Female sex, n/total n (%)	19/60 (31.7)	25/60 (41.6)
LM score, n left/n right		
Osteomeatal complex		
0	17/22	39/39
1	0/0	0
2	43/38	21/21
Frontal sinus		
0	11/19	36/32
1	25/18	18/19
2	24/23	6/9
Sphenoid sinus		
0	14/14	31/24
1	36/35	23/30
2	10/11	6/6
Anterior ethmoid sinus		
0	2/9	3/0
1	25/21	43/46
2	33/30	14/14
Posterior ethmoid sinus		
0	8/8	14/17
1	24/33	40/36
2	28/19	6/7
Maxillary sinus		
0	4/3	6/5
1	28/32	42/40
2	28/25	12/15

SD, standard deviation; L, left; R, right.

10 years; range: 7-50 years), with 41.6% women and 58.4% man. Table I provides a detailed summary of the demographic and clinical characteristics of the study participants.

Changes in sinonasal LM scores. The LM scores were analyzed to evaluate changes in disease severity as assessed by CT imaging among patients with CRS between 2017 and 2023. The findings revealed a significant reduction in total LM scores in 2023 compared with those in 2017, as shown in Fig. 1A for the left sinonasal cavity and Fig. 1B for the right side. Both left and right sinonasal scores demonstrated a decreasing trend, with the left-sided scores showing a slightly more pronounced reduction. However, the differences between left and right sinonasal LM scores were assessed separately for the 2017 and 2023 cohorts. No statistically significant differences were found between sides in either group. These results are shown in Fig. 1C for the 2017 cohort and Fig. 1D for the 2023 cohort. These results indicated a general decline in the radiological severity of CRS over the 5-year period.

Left-sided OMC and individual sinus scores. The analysis of the left-sided OMC and individual sinuses, including the

frontal, ethmoid, sphenoid and maxillary sinuses, revealed significant reductions in CT scores over time (Fig. 2). Both the OMC and frontal sinus demonstrated the most substantial improvements, with marked reductions in CT scores compared with those in 2017 (Fig. 2A and F). Similarly, the ethmoid sinus, encompassing both the anterior and posterior regions, exhibited a consistent downward trend with significant score decreases in 2023 compared with those in 2017 (Fig. 2D and E). The sphenoid and maxillary sinuses exhibited significant reduction but these were less pronounced, potentially due to their unique anatomical and pathological features (Fig. 2B and C). These results highlighted a notable decrease in inflammation in the left frontal sinus and OMC, reflecting considerable improvements in these regions over the 5-year period.

Right-sided OMC and individual sinus scores. Analysis of the right-sided OMC and individual sinuses (Fig. 3) revealed trends similar, but not identical, to those observed on the left side. Significant reductions in CT scores were noted in the right OMC, sphenoid sinus, posterior ethmoid sinus and frontal sinus, with statistically significant improvements in these areas between 2017 and 2023 (Fig. 3A, C, E and F). By contrast, the reductions in the maxillary sinus and anterior ethmoid sinus scores were less pronounced and did not reach statistical significance (Fig. 3B and D). These results suggested asymmetrical changes between the two sides, with more substantial improvements observed in the right OMC and frontal sinus. Overall, the present study highlighted a notable reduction in sinonasal inflammation severity over the 5-year period, with the most significant improvements in the left-sided OMC and frontal sinus, while the maxillary and sphenoid sinuses exhibited relatively smaller changes.

Changes in OMC and individual sinus CT features. A comparative analysis of representative CT images from 2017 and 2023 revealed significant differences in sinonasal inflammation features (Fig. 4A-F). Patients from 2023 exhibited notably less mucosal thickening, with some sinuses showing no obvious signs of inflammation. Additionally, submucosal bone thickening attributed to osteitis was markedly reduced, reflecting a decrease in chronic inflammatory remodeling and an overall improvement in sinonasal CT features over the 5-year period. The ethmoid and frontal sinuses demonstrated the most notable improvements, characterized by thinner mucosal layers and increased aeration of the sinus cavities, indicating improved ventilation and drainage. Importantly, no significant increase in anatomical variations was observed in patients with normal sinus development during this period.

Patterns of mucosal thickening also differed between the two cohorts. In the 2017 group, CRS predominantly manifested as diffuse mucosal thickening involving the OMC and other sinuses, with frequent fluid accumulations and obstructions caused by soft-tissue density lesions, such as polyps. CT features included localized bone sclerosis and hypertrophy. By contrast, the 2023 group more frequently exhibited mild or localized mucosal thickening with reduced fluid accumulation and fewer radiological signs suggestive of chronic osteitis. These findings were based on qualitative assessments of CT images by radiological review and are presented descriptively

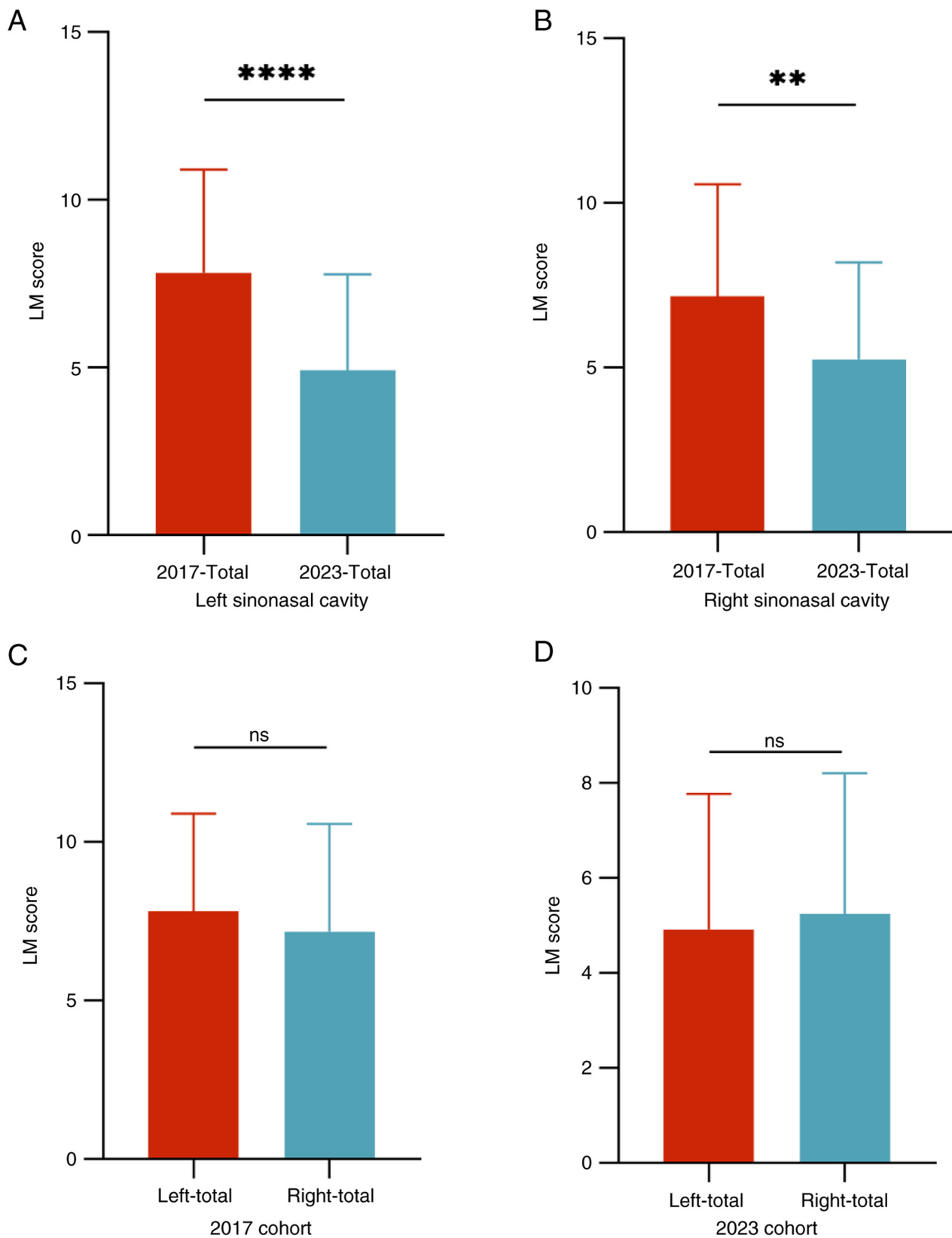


Figure 1. Comparison of total LM scores between 2017 and 2023 cohorts. Boxplots illustrating the distribution of total LM scores for patients with chronic rhinosinusitis in 2017 (n=60) and 2023 (n=60). (A) Left sinonasal cavity and (B) right sinonasal cavity LM scores reflecting sinonasal inflammation severity. Comparison of left and right sinonasal LM scores in the (C) 2017 and (D) 2023 cohorts. Each bar represents the mean $\pm$ standard deviation. **P<0.01 and ****P<0.0001. ns, not significant; LM, Lund-Mackay.

in the text. A shift toward milder radiological presentations of CRS was observed in the 2023 cohort, as evidenced

by improved aeration, reduced mucosal and submucosal thickening, and decreased chronic remodeling.

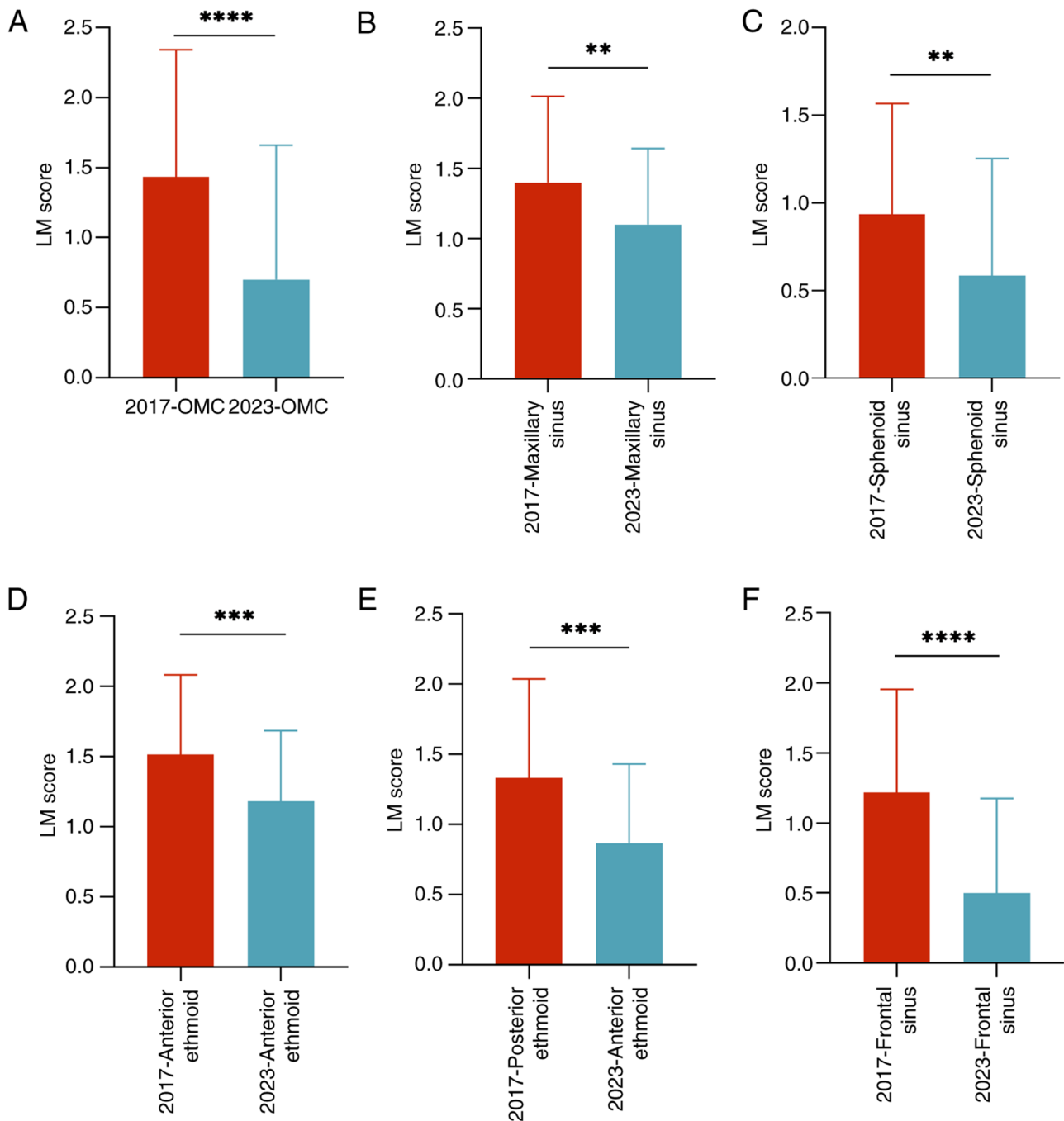


Figure 2. Changes in left-sided OMC and individual sinus scores in patients with CRS. (A) Changes in left-sided OMC. LM scores of the (B) left maxillary sinus, (C) sphenoid sinus, (D) anterior ethmoid sinus, (E) posterior ethmoid sinus and (F) frontal sinus are shown. Each bar represents the mean $\pm$ standard deviation. ** $P < 0.01$, *** $P < 0.001$ and **** $P < 0.0001$. OMC, osteomeatal complex; LM, Lund-Mackay.

Discussion

CT provides a comprehensive view of sinonasal anatomy, inflammation and anatomical variations, thus offering valuable insights into disease classification and staging (21). The present study explored temporal changes in the clinical presentation of CRS by comparing CT findings from two cohorts diagnosed in 2017 and 2023. Unlike longitudinal studies that track disease progression in individuals (7,10,13), the present cross-sectional analysis focuses on disease severity at the time of diagnosis, offering a unique perspective on broader shifts in CRS awareness, diagnostic strategies and clinical management.

Over the past 5 years, a notable reduction in the severity of CRS, particularly in the OMC and frontal sinuses, was observed. This trend likely reflects earlier disease identification and intervention, influenced by improved public awareness, advancements in imaging technology and clinical practices. The observed reduction in LM scores, particularly in regions critical for sinus ventilation and drainage, supports the hypothesis that early intervention and personalized treatment approaches contribute to improved disease control. These findings indicate a paradigm shift in CRS management, with the disease increasingly being addressed at milder stages, thereby reducing the risk of advanced complications. This observation

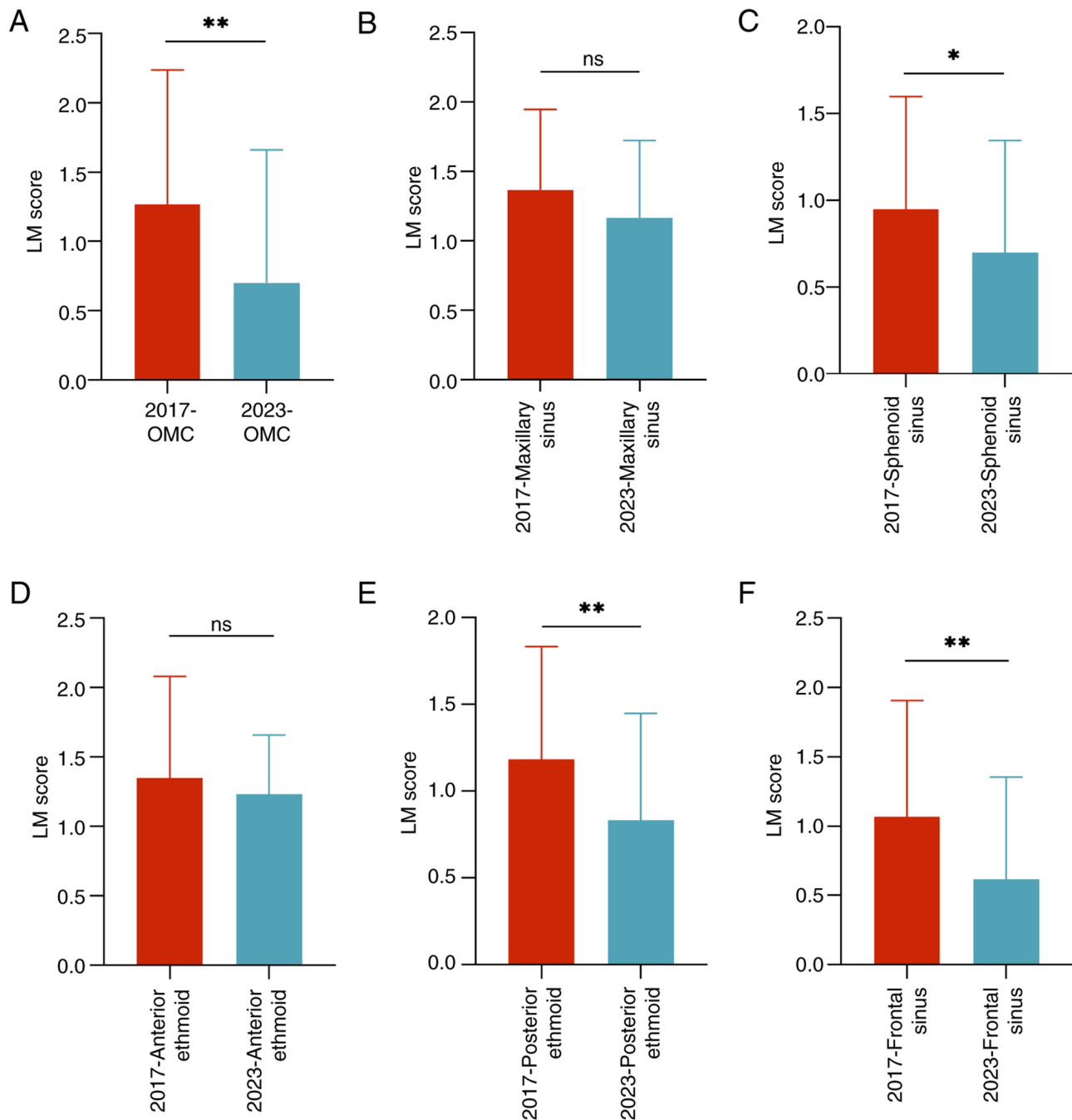


Figure 3. Changes in right-sided OMC and individual sinus scores. (A) Changes in left-sided OMC. LM scores of the (B) left maxillary sinus, (C) sphenoid sinus, (D) anterior ethmoid sinus, (E) posterior ethmoid sinus and (F) frontal sinus are shown. Each bar represents the mean $\pm$ standard deviation. * $P < 0.05$ and ** $P < 0.01$. OMC, osteomeatal complex; ns, not significant; LM, Lund-Mackay.

aligns with the study by Wang *et al* (22), which noted a similar trend toward less severe CRS when analyzing clinical and pathological characteristics over an 11-year period.

This inter-sinus asymmetry in disease severity may stem from several factors, including anatomical variations such as middle turbinate pneumatization, nasal septum deviation and variations in frontal sinus drainage pathway attachment points (23-25), which have been associated with CRS development. The distribution and frequency of these variations may be influenced by genetic and environmental factors. Such anatomical differences could potentially alter sinus ventilation and drainage, contributing to the observed laterality in

LM scores (26,27) such as differences in sinus drainage pathways or ventilation, which could influence disease severity. Physiological factors (28,29), such as regional immune responses or airflow dynamics, may also contribute to the observed variability in inflammation patterns. Understanding these asymmetries is crucial for developing targeted treatment strategies that address the unique sinus involvement of each patient.

Qualitative analysis revealed improvements in imaging features, including reductions in mucosal thickening, submucosal bony changes and improved sinus aeration. These findings suggest a shift towards milder CRS phenotypes

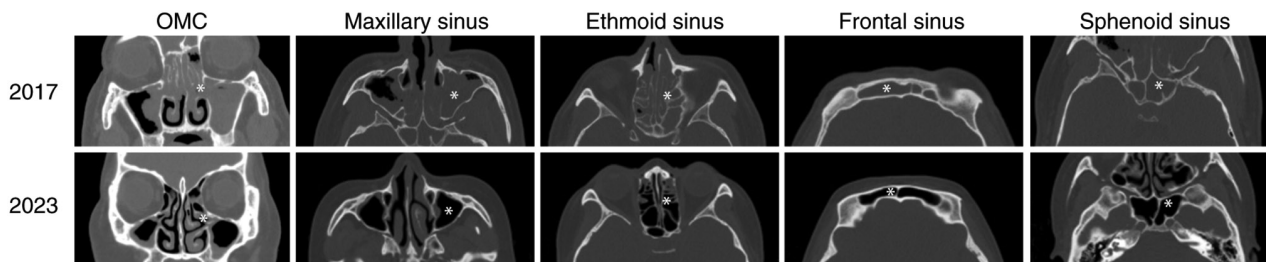


Figure 4. Representative CT images demonstrating changes in sinonasal inflammation features. CT images from patients with chronic rhinosinusitis in 2017 and 2023 highlighting differences in mucosal thickening, submucosal bone changes and sinus aeration. CT, computed tomography; OMC, osteomeatal complex.

at the time of diagnosis, likely reflecting earlier and more effective interventions. The reduced incidence of chronic inflammatory remodeling (30,31), such as osteitis (32) or fibrosis (33), further supports this trend. Notably, the absence of marked changes in sinonasal anatomical variations indicates that these improvements are more likely due to advancements in clinical care rather than inherent patient characteristics. Understanding these imaging trends underscores the impact of evolving diagnostic and therapeutic strategies on CRS management.

The present study highlights several key areas where clinical practice can be adapted to improve the management of CRS. First, the significant reduction in CRS severity over time, particularly in the OMC and frontal sinuses, suggests that earlier detection of symptoms is crucial. Clinicians should consider incorporating routine CT evaluations for patients with early sinonasal complaints to identify and intervene in milder stages of the disease before it progresses to more severe complications. Second, the observed asymmetry in CT scores indicates that CRS may present differently on each side of the sinonasal cavity. The finding supports a personalized approach where treatment plans are tailored not only to severity but also to the specific regions affected. For example, targeted therapies, such as localized topical treatments or refined surgical approaches, may be beneficial for patients with predominant disease in one sinus region. Third, given the evolving landscape of diagnostic tools, the integration of advanced imaging techniques along with biomarker assessments can further refine disease stratification. This would allow clinicians to more accurately predict disease trajectory and optimize treatment strategies, moving towards precision medicine in CRS care. Fourth, increasing public awareness of CRS symptoms and the benefits of early treatment is essential. Clinicians should also be updated on the latest imaging techniques and treatment protocols to ensure that improvements in diagnostic and therapeutic strategies translate into improved patient outcomes. Fifth, as regional variability in CRS persists, continuous monitoring of CT findings and patient responses should inform treatment modifications. Prospective studies integrating molecular profiling and environmental assessments could further enhance understanding, enabling clinicians to refine treatment algorithms over time.

The retrospective cross-sectional design of the current study presented inherent limitations, particularly in establishing causal relationships or evaluating the long-term

effects of specific therapies. Additionally, reliance on CT scoring, while robust, may not entirely capture the complex and dynamic inflammatory processes underlying CRS. The selection of only two timepoints (2017 and 2023) provides a snapshot of changes in CRS severity but does not account for potential year-to-year variability between 2018 and 2022. While these time points were chosen due to data availability and noticeable shifts in clinical practice, future studies incorporating annual or more frequent data points would help establish a clearer trajectory of change. The sample size and limited diversity of the cohort also constrained the generalizability of the findings, underscoring the need for broader patient populations in future analyses. Moving forward, prospective longitudinal studies incorporating advanced imaging techniques, molecular profiling and environmental assessments are essential to achieve a more comprehensive understanding of CRS progression and to refine management strategies.

In conclusion, the present study revealed a significant reduction in the severity of CRS at diagnosis over a 5-year period with the most pronounced improvements observed in the OMC and frontal sinuses. These trends reflect advancements in disease awareness, early diagnostic strategies and management practices. However, the observed changes were not uniform across all sinuses or between the left and right sides, emphasizing the asymmetry in disease progression and resolution. These findings highlight the necessity of further research into the distinct characteristics and underlying mechanisms influencing each sinus region. Additionally, they underscore the critical need for continued efforts to refine diagnostic tools, develop enhanced therapeutic options and promote public education. By addressing the unique clinical features of CRS in individual patients, healthcare providers can optimize treatment outcomes and significantly reduce the overall disease burden.

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Availability of data and materials

The data generated in the present study may be requested from the corresponding author.

Authors' contributions

YG conceptualized the study. JW and SX performed the study methodology and data curation. JW wrote and prepared the original draft. JW, SX and YF were responsible for software application, and performed study visualization and investigation. JW, SX, YF and YG wrote, reviewed and edited the manuscript. YG acquired the funding. JW and YG confirm the authenticity of all the raw data. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

Given the retrospective nature of the present study, the requirement for informed consent was waived by the institutional review board. The present study was approved by The Institutional Review Board of the Second Hospital of Shanxi Medical University (Taiyuan, China; approval no. 2025. YX059) and conducted in full compliance with the Declaration of Helsinki and institutional ethical guidelines.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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