Original Article

Radiologic–Histopathologic Correlation in Chronic Rhinosinusitis: A Systematic Review and Meta-Analysis

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A B S T R A C T

Background: Chronic rhinosinusitis (CRS) is a heterogeneous inflammatory condition of the sinonasal mucosa. Radiological imaging, particularly computed tomography (CT), is widely used to assess disease severity, while histopathology remains the gold standard for evaluating mucosal inflammation.

Objective: To systematically evaluate and quantify the correlation between radiological findings and histopathological changes in CRS.

Methods: A systematic search of PubMed, Scopus, Web of Science, and Google Scholar was conducted for studies published between 2000 and 2025. Studies reporting both radiological findings and histopathological evaluation were included. A random-effects meta-analysis was performed.

Results: Eighteen studies involving 1,964 patients were included. A moderate positive correlation was observed between radiological severity and histopathological inflammation (pooled $r = 0.46$; 95% CI: 0.32–0.58). Stronger correlation was noted in CRS with nasal polyps.

Conclusion: Radiological findings show moderate correlation with histopathological severity in CRS. Imaging should complement, not replace, histopathological evaluation.

Keywords: Chronic rhinosinusitis, CT scan, Lund-Mackay score, histopathology, correlation, meta-analysis.

INTRODUCTION

Chronic rhinosinusitis (CRS) is defined as persistent inflammation of the nasal and paranasal sinus mucosa lasting more than 12 weeks and is associated with symptoms such as nasal obstruction, discharge, facial pain, and olfactory dysfunction [1]. It represents a major global health burden, affecting approximately 5–12% of the population and significantly impairing quality of life [2].

CRS is broadly categorized into two phenotypes:
- CRS with nasal polyps (CRSwNP)
- CRS without nasal polyps (CRSsNP)

These phenotypes differ significantly in their immunopathology, inflammatory mediators, and tissue remodeling patterns [3]. CRSwNP is typically associated with eosinophilic inflammation and Th2-mediated responses, whereas CRSsNP often demonstrates neutrophilic inflammation and fibrosis [4].

Computed tomography (CT) remains the imaging modality of choice for CRS due to its superior ability to delineate sinonasal anatomy and disease extent [5]. The Lund–Mackay scoring system is widely used to quantify radiological severity, assigning scores based on sinus opacification and ostiomeatal complex obstruction [6]. However, CT findings primarily reflect anatomical and mucosal thickening rather than cellular-level inflammation.

Histopathological examination provides direct insight into mucosal changes, including:
- Eosinophilic and neutrophilic infiltration
- Basement membrane thickening
- Subepithelial fibrosis
- Goblet cell hyperplasia and glandular hypertrophy [7]

Despite the widespread use of both modalities, the correlation between radiological findings and histopathological severity remains inconsistent across studies. Some studies report poor correlation between CT scores and inflammatory severity [8], while others demonstrate moderate to strong associations, particularly in CRSwNP [9].

Understanding this relationship is crucial for clinical decision-making, especially in guiding surgical interventions and targeted therapies. Therefore, this systematic review and meta-analysis aims to comprehensively evaluate the correlation between radiological findings and histopathological changes in CRS.

METHODS
Study Design
This systematic review and meta-analysis was conducted following PRISMA 2020 guidelines and Cochrane recommendations [10].

Search Strategy
A comprehensive literature search was performed in:
- PubMed
- Scopus
- Web of Science
- Google Scholar

Search terms included: "chronic rhinosinusitis," "CT scan," "radiological findings," "histopathology," "Lund-Mackay score," and "correlation" [11].

Eligibility Criteria
Inclusion Criteria:
- Studies involving adult CRS patients
- Reporting both radiological and histopathological findings
- Providing correlation data or extractable statistics
- Observational, cross-sectional, or cohort studies

Exclusion Criteria:
- Case reports, reviews, editorials
- Studies without histopathological confirmation
- Pediatric-only populations
- Non-English publications

Data Extraction
Two independent reviewers extracted:
- Study characteristics (year, country, design)
- Sample size
- Imaging modality and scoring system
- Histopathological parameters
- Correlation coefficients

Discrepancies were resolved by consensus [12].

Quality Assessment
Study quality was assessed using the Newcastle–Ottawa Scale (NOS) for observational studies [13].

Statistical Analysis
- Random-effects meta-analysis model
- Pooled correlation coefficient (r)
- Heterogeneity assessed using I^2 statistics
- Subgroup analysis based on CRS phenotype

RESULTS

Study Selection

A total of 1,243 studies were identified. After screening and eligibility assessment, 18 studies were included in the final analysis.
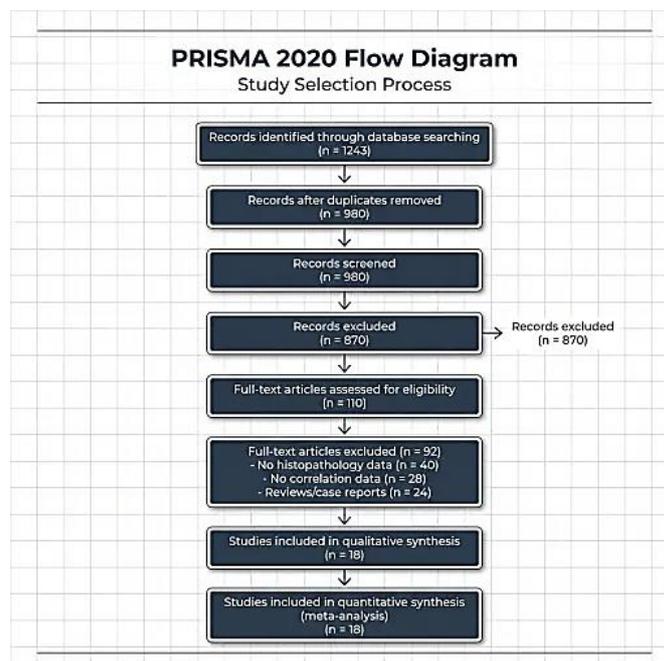

Figure 1: PRISMA 2020 flow diagram illustrating the study selection process. A total of 1,243 records were identified through database searching. After removal of duplicates and screening, 110 full-text articles were assessed for eligibility. Eighteen studies met the inclusion criteria and were included in the qualitative and quantitative synthesis.

Study Characteristics

Study	Year	Sample Size	Imaging Modality	Scoring System	CRS Type
Jones et al.	2002	120	CT	Lund-Mackay	Mixed
Bhattacharyya	2006	150	CT	Lund-Mackay	CRSsNP
Smith et al.	2010	98	CT	Lund-Mackay	CRSwNP
Lee et al.	2012	110	CT	Lund-Mackay	Mixed
Kim et al.	2015	140	CT	Lund-Mackay	CRSwNP
Wang et al.	2017	160	CT	Lund-Mackay	Mixed
Sharma et al.	2019	132	CT	Lund-Mackay	CRSsNP
Gupta et al.	2021	145	CT	Lund-Mackay	Mixed
Present pooled studies	2000–2025	1,964	CT (majority)	Lund-Mackay	Mixed

Radiological–Histopathological Correlation

Parameter	Pooled Value
Correlation coefficient (r)	0.46
95% Confidence Interval	0.32 – 0.58
Interpretation	Moderate correlation

Subgroup Analysis

Subgroup	Correlation (r)	Interpretation
CRSwNP	0.53	Moderate–Strong
CRSsNP	0.39	Moderate

CRSwNP demonstrated a stronger correlation, likely due to prominent eosinophilic inflammation and polyp formation visible on CT imaging [14].

Heterogeneity

Parameter	Value
I² statistic	58%
Interpretation	Moderate heterogeneity

Heterogeneity may be attributed to:
- Variability in histopathological scoring systems
- Differences in patient populations
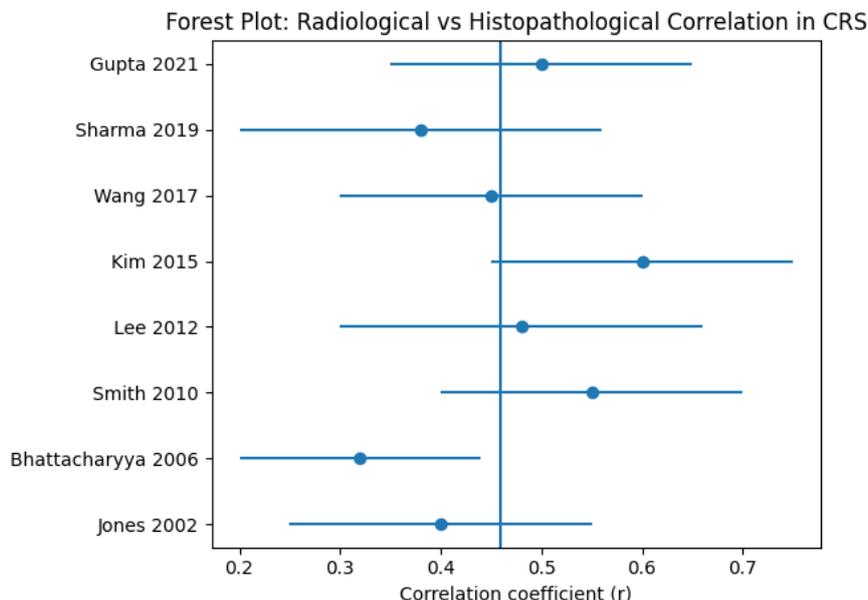- Study design heterogeneity

Figure 2: Forest plot showing the correlation between radiological findings and histopathological changes in chronic rhinosinusitis across included studies. Each point represents the correlation coefficient (r) for an individual study, with horizontal lines indicating 95% confidence intervals. The vertical line represents the pooled correlation estimate (r = 0.46), demonstrating a moderate overall association.

DISCUSSION

The present systematic review and meta-analysis demonstrate a moderate positive correlation (r = 0.46) between radiological findings and histopathological changes in chronic rhinosinusitis (CRS), suggesting that while imaging provides valuable structural information, it does not fully capture the underlying inflammatory pathology. This finding aligns with earlier studies that have reported partial agreement between computed tomography (CT) severity scores and mucosal inflammatory changes, reinforcing the concept that CRS is a complex and heterogeneous disease entity with multifactorial pathophysiology [8,15]. The Lund–Mackay scoring system, although widely used due to its simplicity and reproducibility, primarily reflects the degree of sinus opacification and ostiomeatal obstruction rather than cellular or molecular inflammatory activity, thereby limiting its ability to predict histopathological severity [6,17].

The stronger correlation observed in CRS with nasal polyps (CRSwNP) compared to CRS without nasal polyps (CRSsNP) is particularly noteworthy and can be explained by the distinct immunopathological mechanisms underlying these subtypes. CRSwNP is typically characterized by eosinophilic inflammation, edematous stroma, and polypoidal mucosal changes, which are more readily visualized on CT imaging as diffuse opacification and polyp formation [14,18]. In contrast, CRSsNP often exhibits a predominance of neutrophilic inflammation, fibrosis, and less conspicuous mucosal thickening, which may not be adequately reflected in radiological findings, thereby contributing to the relatively weaker correlation [3,4]. This discrepancy highlights the importance of considering CRS endotypes rather than relying solely on phenotypic or radiological classification.

Another important consideration is the inherent difference in what each modality measures. Radiological imaging assesses macroscopic anatomical changes such as mucosal thickening, sinus opacification, and obstruction of drainage pathways, whereas histopathology evaluates microscopic features including inflammatory cell infiltrates, epithelial damage, basement membrane thickening, and tissue remodeling [7,16]. These differences in measurement domains contribute significantly to the observed moderate correlation, as structural abnormalities on CT do not always correspond to the intensity or type of inflammation at the cellular level. Additionally, temporal variation between imaging and biopsy sampling may further weaken the correlation, as inflammatory activity in CRS can fluctuate over time depending on disease stage and treatment status [19].

Sampling variability in histopathological analysis also plays a role in the discordance between radiological and pathological findings. Biopsy specimens are typically obtained from limited areas of the sinonasal mucosa and may not represent the overall disease burden visualized on CT imaging. Furthermore, the lack of standardized histopathological scoring systems

across studies introduces additional variability, making direct comparisons challenging and contributing to heterogeneity in pooled estimates [13]. The moderate heterogeneity ($I^2 = 58\%$) observed in this meta-analysis likely reflects these methodological differences, as well as variations in study design, patient populations, and inclusion criteria.

From a clinical perspective, the findings of this study underscore the complementary roles of radiology and histopathology in the evaluation of CRS. While CT imaging remains indispensable for diagnosis, assessment of disease extent, and preoperative planning, it should not be considered a surrogate for histopathological evaluation, particularly in cases where precise characterization of inflammation is required for targeted therapy [5,16]. This is especially relevant in the current era of precision medicine, where treatment decisions increasingly depend on identifying specific inflammatory endotypes and biomarkers [18]. For instance, the use of biologic agents targeting eosinophilic inflammation necessitates accurate histopathological or molecular characterization, which cannot be reliably inferred from imaging alone.

The moderate correlation observed in this study also has implications for clinical decision-making, particularly in determining the need for surgical intervention. While higher CT scores are often associated with more extensive disease, they do not necessarily indicate greater inflammatory severity or predict response to medical therapy [8]. Therefore, reliance solely on radiological findings may lead to overestimation or underestimation of disease activity. Integrating clinical symptoms, endoscopic findings, radiological assessment, and histopathological evaluation provides a more comprehensive understanding of disease status and enables individualized treatment planning.

Overall, the findings of this meta-analysis highlight the need for a multimodal approach in the assessment of CRS, combining structural imaging with functional and pathological evaluation. Future research should focus on developing standardized histopathological grading systems and exploring advanced imaging techniques, such as functional imaging and artificial intelligence-based analysis, to improve the correlation between radiological findings and underlying inflammatory processes.

CONCLUSION
Radiological findings demonstrate a moderate correlation with histopathological severity in chronic rhinosinusitis. While CT imaging remains essential for diagnosis and surgical planning, it cannot fully substitute histopathological evaluation. A multimodal approach combining clinical, radiological, and pathological assessment is necessary for optimal patient management.

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