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CT-Based Quantification of Chronic Sinonasal Osteitis: Relationship Between Global Osteitis Scoring Scale and Hounsfield Unit

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Research Article

Keywords: Chronic rhinosinusitis, Osteitis, Global Osteitis Scoring Scale, Hounsfield Units, HRCT sinonasal

Posted Date: July 30th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9786142/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Chronic rhinosinusitis (CRS) is a persistent inflammatory disease that may extend beyond the mucosa and induce osteitis of the paranasal sinus walls. Radiologic assessment of sinonasal osteitis commonly relies on the Global Osteitis Scoring Scale (GOSS), which evaluates bone thickening but does not capture alterations in bone density. Computed tomography–derived Hounsfield Units (HU) provide a quantitative measure of bone mineralization and may offer complementary information regarding bone remodeling in CRS.

Objective

To evaluate the correlation between GOSS and HU values on sinonasal high-resolution computed tomography (HRCT) in assessing chronic sinonasal osteitis severity.

Methods

A retrospective cross-sectional study was conducted involving 32 adult CRS patients who underwent sinonasal HRCT. Each paranasal sinus was evaluated independently using the GOSS system, and mean HU values were measured at standardized sinus wall locations. Correlation analysis between GOSS scores and HU values was performed using Spearman's rank correlation test ($\alpha = 0.05$).

Results

A total of 156 osteitis-positive sinuses were identified, most frequently in the right anterior ethmoid sinus. The highest mean HU values were observed in sinuses without wall thickening (GOSS score 0). Correlation analysis demonstrated a statistically significant but very weak association between GOSS scores and HU values ($r = 0.167$; $p = 0.038$), suggesting that bone thickness and bone density represent distinct imaging characteristics of osteitic remodeling. However, no significant correlation was observed when each sinus was analyzed separately ($p > 0.05$), with some sinuses showing higher GOSS scores associated with lower HU values.

Conclusion

Assessment of chronic sinonasal osteitis should consider both structural and densitometric CT parameters, as thickness-based scoring alone may not adequately reflect the complexity of inflammatory bone remodeling. This combined approach may improve the radiologic characterization of CRS-related osteitis and support more accurate disease assessment.

BACKGROUND

Chronic rhinosinusitis (CRS) is an inflammation of the nasal mucosa and paranasal sinuses that lasts for more than 12 weeks and is one of the most common upper respiratory tract diseases in both Western and Asian countries.[1] This disease has a significant impact on patients' quality of life, increased healthcare costs, and reduced productivity.[2,3] The clinical manifestations of CRS include nasal obstruction or congestion, rhinorrhea, dizziness, smell disorders such as hyposmia or anosmia, and facial pain, which can interfere with daily activities.[4] Data from the Rhinology Division of the Department of Otorhinolaryngology, Faculty of Medicine, Brawijaya University/Dr. Saiful Anwar General Hospital shows that CRS is the most common case in outpatient clinics, with an incidence rate of 43% (308 cases) in 2019, increasing to 58% (201 cases) in 2020, and 29% (90 cases) in 2021.

Persistent inflammation in CRS may extend beyond the mucosal layer and involve the underlying bony structures of the paranasal sinuses [5,6] and cause osteitis, which is characterized by thickening of the sinus bone walls without involvement of the bone marrow, thus differing from osteomyelitis. Although histopathological evaluation is the gold standard for assessing bone remodeling, this procedure is difficult to perform due to limitations in bone sampling, even in patients who have undergone endoscopic surgery.[7] Therefore, a non-invasive method is needed to assess bone involvement in CRS.

High-resolution computed tomography (HRCT) of the paranasal sinuses without contrast is the recommended imaging modality for initial examination because it has high spatial resolution, is capable of evaluating bone structures in detail, and is useful in surgical planning.[8,9] On CT examination, osteitis appears as thickening of the sinus wall, which can be focal or diffuse, associated with neo-osteogenesis, osteoclastic resorption, fibrosis, periosteal reaction, and changes in the Haversian canal, with varying appearances depending on the stage of the disease.[7,10]

Among the available radiological scoring systems, the Global Osteitis Scoring Scale (GOSS) is widely used to quantify osteitis based on the thickness and extent of sinus wall involvement. Despite its clinical utility, the histopathological validity of GOSS remains limited, and several studies have reported inconsistent correlations between GOSS scores and the underlying degree of bone remodeling. Because GOSS primarily evaluates structural thickening of the sinus wall, it mainly reflects morphological changes rather than alterations in bone mineral density. Chronic inflammation may induce complex bone remodeling processes, including osteoblastic activity, osteoclastic resorption, and changes in bone mineralization, which may not be adequately captured by thickness-based scoring systems. Recent studies indicate that neo-osteogenesis has a greater influence on bone density increase than thickness, indicating that bone density measurements may provide additional information regarding osteitic changes. Hounsfield Units (HU), derived from CT imaging, provide a quantitative measure of tissue radiodensity and have been increasingly used to evaluate bone quality in various craniofacial conditions. As a densitometric parameter, HU measurements may offer a more objective method for assessing bone remodeling associated with chronic sinonasal inflammation.[7,10] However, the relationship between sinus

wall thickening and bone density in CRS-related osteitis remains poorly understood. Better understanding of the relationship between these parameters may help clarify whether bone thickness and bone density reflect similar or distinct aspects of osteitic remodeling.

Therefore, this study aimed to evaluate the correlation between the Global Osteitis Scoring Scale and CT-derived Hounsfield Units in patients with chronic rhinosinusitis to determine whether these parameters represent complementary indicators in the radiological assessment of sinonasal osteitis.

METHOD

Study design

This retrospective cross-sectional study was conducted at the Central Radiology Unit and the ENT–Head and Neck Rhinology Clinic of Dr. Saiful Anwar General Hospital, during the period of June–August 2025. This study protocol was approved by from Dr. Saiful Anwar General Hospital ethics committee (Approval No:400/309/K.3/102.7/2025).

Inclusion and exclusion criteria

The study subjects included adult patients (≥ 18 years) with a diagnosis of CRS based on the 2020 EPOS criteria who had undergone a sinonasal-focused CT scan of the head. Patients with a history of functional endoscopic sinus surgery (FESS), use of corticosteroids or antibiotics within four weeks prior to examination, sinonasal malignancy with bone destruction, and a history of sinus trauma were excluded from the study. Sampling was conducted consecutively until a minimum of 32 subjects was reached, according to the sample size calculation for the correlation test.

GOSS and HU measurement

The CT examination was performed without contrast using a 128-slice CT scan with a multiplanar protocol, bone window settings, high-resolution head bone kernel, and a slice thickness of 1–3 mm. Image data in DICOM format were analyzed for GOSS assessment and bone attenuation measurement using HU. Each paranasal sinus, including the maxillary, anterior and posterior ethmoid, sphenoid, and frontal sinuses, was evaluated separately with a GOSS score of 0–5 based on the thickness and extent of sinus wall involvement. To ensure measurement reliability, one head and neck subspecialist radiologist and one ENT-Head and Neck subspecialist rhinologist performed the GOSS scoring and HU measurements.

RESULTS

A total of 32 CRS patient data were analyzed, with each paranasal sinus—including the maxillary sinus, anterior ethmoid sinus, posterior ethmoid sinus, sphenoid sinus, and frontal sinus—evaluated individually

using the GOSS score with a score range of 0–5. Of the total 156 cases of osteitis identified, the most common location was the right anterior ethmoid sinus with 26 sinuses (16.7%), followed by the right maxillary sinus with 23 sinuses (14.7%), the left anterior ethmoid sinus with 22 sinuses (14.1%), and left maxillary sinus with 20 sinuses (12.8%). The highest GOSS score (score 5) was most commonly found in the right and left maxillary sinuses, at 46.7% and 36.7%, respectively (see Table 1).

Table 1
Distribution of GOSS Scores Based on Sinus Location in Osteitis Patients

Sinuses	**Osteitis**	**GOSS score**				
	(n = 156)	**1 (n = 24)**	**2 (n = 6)**	**3 (n = 83)**	**4 (n = 13)**	**5 (n = 30)**
Right frontal sinus	4 (2.6%)	0 (0%)	2 (33.3%)	2 (2.4%)	0 (0%)	0 (0%)
Left frontal sinus	7 (4.5%)	0 (0%)	0 (0%)	2 (2.4%)	3 (23.1%)	2 (6.7%)
Right maxillary sinus	23 (14.7%)	3 (12.5%)	0 (0%)	4 (4.8%)	2 (15.4%)	14(46.7%)
Left maxillary sinus	20 (12.8%)	3 (12.5%)	0 (0%)	3 (3.6%)	3 (23.1%)	11(36.7%)
Right anterior ethmoid sinus	26 (16.7%)	3 (12.5%)	0 (0%)	23 (27.7%)	0 (0%)	0 (0%)
Left anterior ethmoid sinus	22 (14.1%)	5 (20.8%)	0 (0%)	17 (20.5%)	0 (0%)	0 (0%)
Right posterior ethmoid sinus	16 (10.3%)	3 (12.5%)	0 (0%)	12 (14.5%)	1 (7.7%)	0 (0%)
Left posterior ethmoid sinus	16 (10.3%)	4 (16.7%)	0 (0%)	11 (13.3%)	1 (7.7%)	0 (0%)
Right sphenoid sinus	13 (8.3%)	3 (12.5%)	2 (33.3%)	4 (4.8%)	1 (7.7%)	3 (10%)
Left sphenoid sinus	9 (5.8%)	0 (0%)	2 (33.3%)	5 (6.0%)	2 (15.4%)	0 (0%)

The results of the correlation analysis between GOSS scores and HU values on sinonasal HRCT showed a statistically significant correlation in the total sinus analysis ($p = 0.038$), with a very weak and positive Spearman's correlation coefficient ($r = 0.167$; 95% CI: 0.005–0.320) (Table 2). The positive correlation direction indicates a tendency for HU values to increase with increasing GOSS scores. However, in separate analyses of each sinus, no significant correlation was found between GOSS scores and HU values ($p > 0.05$).

Table 2
Correlation between HU and GOSS Score in Patients with Osteitis

Location of sinuses	Independent variable	Dependent variable	p-value	R (CI 95%)
Total (= 156)	GOSS score	HU	**0.038***	0.167 (0.005 ; 0.320)
Right frontal sinus (n = 4)			1.000	0.000 (-0.965 ; 0.965)
Left frontal sinus (n = 7)			0.840	0.094 (-0.723 ; 0.802)
Right maxillary sinus (n = 24)			0.119	-0.327 (-0.653 ; 0.101)
Left maxillary sinus (n = 20)			0.333	-0.228 (-0.618 ; 0.251)
Right anterior ethmoid sinus (n = 26)			0.388	0.177 (-0238 ; 0.537)
Left anterior ethmoid sinus (n = 22)			0.233	0.265 (-189 ; 0.626)
Right posterior ethmoid sinus (n = 16)			0.892	0.037 (-0.480 ; 0.535)
Left posterior ethmoid sinus (n = 16)			0.780	0.076 (-0.449 ; 0.562)
Right sphenoid sinus (n = 13)			0.127	-0.446 (-0.807 ; 0.157)
Left sphenoid sinus (n = 9)			1.000	0.000 (-0.667 ; 0.667)

[a] Spearman correlation test ; * p-value < 0.05

DISCUSSION

Bone involvement in CRS has been reported under various terms, such as osteitis, osteomyelitis, hyperostosis, bone hyperplasia, and neo-osteogenesis. Considering that the flat bones surrounding the paranasal sinuses do not have bone marrow, the term osteitis is considered most appropriate. On CT examination, CRS patients often show irregular thickening of the sinus walls accompanied by increased bone density. Previous studies have reported a moderate positive correlation between preoperative SNOT-20 symptom scores and bone density (HU) and ethmoid sinus wall thickness, as well as a positive correlation between disease duration and ethmoid bone thickness, indicating that symptom severity and disease duration are associated with sinonasal bone remodeling.[11] Other studies also show that CRS patients with osteitis have higher total HU values than patients without osteitis.[12,13]

In this study, variations in the correlation between GOSS scores and HU values were found across various paranasal sinuses. Most patients had a GOSS score of 0, with the lowest wall thickness but the highest average HU value. In contrast, patients with GOSS scores of 1–5, reflecting bone thickening, showed variations in HU values between sinuses. Interestingly, in the right and left maxillary sinuses and the right sphenoid sinus, a negative correlation trend was found, where increased thickness.

These findings are consistent with several studies reporting inconsistent results. Emre et al. (2015) showed that CRS patients with osteitis actually had lower HU values than patients without osteitis.[9] Tunç et al. (2021) also reported that changes in HU values in CRS vary, with some studies finding a decrease in HU due to osteitis, while other studies showed an increase in HU in patients with mucosal and sinus wall thickening. These differences are thought to be related to variations in disease progression and bone remodeling phases between patients.[14]

The mechanism of osteitis in CRS is not yet fully understood. Bacterial infection and biofilm formation are also thought to play a role through the release of inflammatory mediators that infiltrate the bone.[15] Impaired mucociliary clearance, sinus microbiota dysbiosis, epithelial barrier damage, and immune abnormalities facilitate biofilm formation—particularly by Staphylococcus aureus and Pseudomonas aeruginosa—which increases proinflammatory cytokines and disrupts bone remodeling processes.[16]

Histopathologically, osteitis involves imbalanced osteoblast and osteoclast activity, resulting in immature woven bone with irregular collagen arrangement.[11,16] During the bone resorption phase, CT attenuation tends to be low, while it increases during the osteogenesis phase. When both processes occur simultaneously, bone density becomes heterogeneous, resulting in variable and inconsistent HU values.[10] Therefore, bone thickening that meets the radiological criteria for osteitis is not always accompanied by an increase in HU values, especially when the thickening is dominated by immature woven bone.[12]

CONCLUSION AND SUGGESTION

The results of the study show that the highest average HU values were found in sinuses without bone thickening (GOSS score 0). In sinuses with higher GOSS scores, HU values varied and did not show a consistent pattern of increase with increasing degrees of osteitis. The analysis between GOSS scores and HU values at the overall sinus level also did not show a statistically significant correlation. These findings indicate that bone thickness and bone density represent different aspects of bone remodeling in chronic sinonasal osteitis.

Based on these results, further research with a larger sample size and multicenter design is needed to improve the statistical power and representativeness of the data. This approach is expected to clarify the correlationn between morphological and densitometric bone parameters, while also enabling the establishment of more accurate HU threshold values in the radiological evaluation of chronic sinonasal osteitis

Declarations

Ethics approval and consent to participate

Ethical approval for this study was obtained from the ethics committee of our Hospital with approval number:400/309/K.3/102.7/2025.

Consent for publication

Written informed consent for publication of their details and radiological images was obtained from the patient.

Competing interests

The authors have no financial or personal relationships that may have inappropriately influenced them in writing this article.The authors declare that they have no competing interest.

Funding

declarations

The authors received no financial support for the research, authorship, and/or publication of this article.

Author Contribution

Y.Y: [conceptualisation, supervision, validation, writing – original draft, writing – review&editing]. S.A. A: [methodology, project administration, resources, software, visualisation, writing – original draft]. A.Y. S: [data curation, formal analysis, writing – original draft]. H.A.H: [investigation, supervision, validation, writing – review&editing]. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

Acknowledgement

Not applicable.

Availability of data and material

The datasets used and analyzed during study are available from corresponding author on reasonable request.

References

1. Aparna S, George S (2023) The Impact of Osteitis on Quality of Life in Patients with Chronic Rhinosinusitis. Indian J Otolaryngol Head Neck Surg 75(S1):1056–1061. 10.1007/s12070-023-03617-4
2. Zhang Y, Gevaert E, Lou H et al (2017) Chronic rhinosinusitis in Asia. J Allergy Clin Immunol 140(5):1230–1239. 10.1016/j.jaci.2017.09.009
3. Stevens WW, Lee RJ, Schleimer RP, Cohen NA (2015) Chronic rhinosinusitis pathogenesis. J Allergy Clin Immunol 136(6):1442–1453. 10.1016/j.jaci.2015.10.009
4. Poluan FH, Marlina L (2021) Prevalence and Risk Factor of Chronic Rhinosinusitis and the Impact on Quality of Life in Students of the Medical Faculty Christian University of Indonesia in 2018. J Drug Delivery Ther 11(3–S):154–162. 10.22270/jddt.v11i3-S.4846
5. Alrumaih RA, Ashoor MM, Obidan AA, Al-Khater KM, Al-Jubran SA (2016) Radiological sinonasal anatomy: Exploring the Saudi population. SMJ 37(5):521–526. 10.15537/smj.2016.5.13904
6. Alsaied AS (2017) Paranasal Sinus Anatomy: What the Surgeon Needs to Know. In: Gendeh BS (ed) Paranasal Sinuses. InTech. doi:10.5772/intechopen.69089
7. Dong Y, Zhou B, Huang Z et al (2018) Evaluating bone remodeling by measuring Hounsfield units in a rabbit model of rhinosinusitis: is it superior to measuring bone thickness? Int Forum Allergy Rhinol 8(11):1342–1348. 10.1002/alr.22205
8. Faik M, Indrati R (2022) Differences in the quality of paranasal sinuses CT images in sinusitis case by slice thickness variations. Int J Health Scie Tech 3(3). 10.31101/ijhst.v3i3.2440
9. Emre IE, Celebi I, Ercan I (2015) The Radiologic Evaluation of Osteitis Type and Formation in Chronic Rhinosinusitis with and without Nasal Polyposis. Am J Rhinol Allergy 29(6):e201–e204. 10.2500/ajra.2015.29.4240
10. Che Z, Zhang Q, Zhao P et al (2023) Computed Tomography Evaluation of Unilateral Chronic Maxillary Sinusitis With Osteitis. Ear Nose Throat J 102(5):NP237–NP244. 10.1177/0145561321993936
11. Gupta M, Upadhyay M, Kumar G, Bihari A The study of gross and CT scan anatomy of lateral nasal wall, infundibulum and sinus drainage pathways and their clinical implications in Government Medical College and Super Facility Hospital, Azamgarh, UP
12. Snidvongs K, Sacks R, Harvey RJ (2019) Osteitis in Chronic Rhinosinusitis. Curr Allergy Asthma Rep 19(5):24. 10.1007/s11882-019-0855-5
13. Lee JH (2021) Severely Osteitic Uncinate Process: Prominent Feature. Ear Nose Throat J 100(9):NP386–NP387. 10.1177/0145561320925195
14. Tunç O, Yazıcı A, Aytaç İ, Tümüklü K, Akşamoğlu M (2021) Value of Hounsfield Units in the Evaluation of Isolated Sphenoid Sinus Lesions. Allergy Rhinol (Providence) 12:21526567211032560. 10.1177/21526567211032560

15. De Campos CAC, Dolci ELL, Da Silva L, Dolci JEL, De Campos CAH, Dolci RLL (2015) Osteitis and mucosal inflammation in a rabbit model of sinusitis. Braz J Otorhinolaryngol 81(3):312–320. 10.1016/j.bjorl.2015.03.003
16. Hadi W, Sujana WIA (2025) Osteitis in Chronic Rhinosinusitis: A State-of-the-Art Review. Siriraj Med J 77(7):533–542. 10.33192/smj.v77i7.274010