Volume 4, Issue 3, March 2026 ISSN (E): 2938-3765

ENHANCING THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE SURGICAL MANAGEMENT OF PATIENTS WITH CHRONIC MAXILLARY SINUSITIS

Shamsiyev Djahongir Fazliddinovich
DSc, Professor, Tashkent State Medical University,
Tashkent, Uzbekistan

Abstract

Chronic maxillary sinusitis represents a clinically important subtype of chronic rhinosinusitis and is characterized by persistent sinonasal inflammation lasting more than 12 weeks, typically confirmed by symptoms together with objective endoscopic and radiologic evidence. Endoscopic sinus surgery remains the standard surgical option for patients with disease refractory to appropriate medical treatment, but preoperative interpretation of computed tomography, anatomical variation analysis, disease extent assessment, and postoperative monitoring remain partly subjective and operator-dependent. In recent years, artificial intelligence has emerged as a promising adjunct in chronic rhinosinusitis through automated image interpretation, lesion segmentation, prognostic modeling, and standardized postoperative assessment. Systematic reviews report that AI models for CT and CBCT-based maxillary sinus pathology detection generally achieve accuracy values in the range of 85% to 97%, sensitivity from 87% to 100%, and specificity from 87.2% to 99.7%, while a recent CT-based AI study for chronic maxillary sinusitis reported sensitivity of 0.9796, specificity of 0.8636, accuracy of 0.9247, and an AUC of 0.94 on the test set.

The aim of this modeled study was to evaluate whether an AI-assisted workflow could improve surgical planning, intraoperative efficiency, and early clinical outcomes in 150 patients with chronic maxillary sinusitis treated at the TDTU ENT Department. The modeled protocol combined clinical assessment, nasal endoscopy, CT-based Lund-Mackay scoring, AI-assisted image analysis, automatic maxillary sinus segmentation, anatomy-aware surgical route selection, and AI-supported postoperative endoscopic evaluation. Synthetic results suggested that AI support improved preoperative diagnostic concordance, reduced time to surgical decision-making, shortened operating time, decreased intraoperative change of plan, and improved 12-month symptom control and revision-free follow-up. These findings support the concept that AI may enhance, but not replace, surgeon-led decision-making in chronic maxillary sinusitis.

Keywords: Chronic maxillary sinusitis, chronic rhinosinusitis, artificial intelligence, endoscopic sinus surgery, computed tomography, CBCT, segmentation, decision support, surgical planning, postoperative endoscopy.

Volume 4, Issue 3, March 2026 ISSN (E): 2938-3765

Introduction

Chronic rhinosinusitis is defined by symptom persistence beyond 12 weeks and requires objective confirmation by nasal endoscopy and or imaging. In clinical practice, chronic maxillary sinusitis is frequently associated with maxillary sinus opacification, osteomeatal complex obstruction, facial pressure, nasal obstruction, mucopurulent discharge, and recurrent inflammatory exacerbations. Imaging, especially CT, plays a central role because it documents mucosal disease, drainage pathway compromise, bony anatomy, and variations relevant to surgical planning.

Endoscopic sinus surgery is widely accepted as the surgical standard for chronic rhinosinusitis refractory to medical therapy, with contemporary reports describing it as safe and effective across age groups. A recent review noted overall success rates ranging from 76% to 97.5%, although primary surgery can still fail in a subset of patients, especially when disease mapping, anatomical access selection, and postoperative follow-up are suboptimal. Because the maxillary sinus may be involved in isolated, odontogenic, or diffuse inflammatory patterns, the quality of preoperative analysis directly influences operative efficiency and outcomes.

Artificial intelligence is increasingly being investigated as a tool to improve standardization in chronic rhinosinusitis. A 2025 review of AI in CRS concluded that AI-assisted systems are being applied to imaging diagnosis, pathology interpretation, prognosis prediction, treatment planning, and chronic disease monitoring, while a 2025 systematic review focused on sinonasal imaging emphasized AI's promise in improving diagnostic precision and workflow efficiency. In parallel, CBCT-based reviews have highlighted that AI may reduce interpretation time, improve consistency, and standardize anatomical analysis in sinus imaging.

For chronic maxillary sinusitis specifically, AI is relevant in three surgical domains. First, it can support detection of disease extent and bone remodeling on CT. Second, it can automate maxillary sinus segmentation and quantify anatomy relevant to middle meatal, inferior meatal, or extended endoscopic access. Third, it can standardize postoperative endoscopic outcome analysis. Recent studies have shown that CT-based AI can detect chronic maxillary sinusitis with high accuracy, nnU-Net v2 can segment the maxillary sinus on CBCT with F1-score 0.96, accuracy 0.99, sensitivity 0.96, Dice coefficient 0.96, and IoU 0.93, and foundation-model-based analysis of postoperative endoscopic images can classify postoperative cavity states in a reproducible manner.

Aim

The aim of this modeled study was to assess how an AI-assisted surgical workflow could improve preoperative planning, intraoperative efficiency, and short- to mid-term postoperative outcomes in patients with chronic maxillary sinusitis managed surgically at the TDTU ENT Department.

Materials and Methods

This manuscript was designed as a modeled prospective cohort study involving 150 patients with chronic maxillary sinusitis. The cohort was constructed to reflect routine tertiary ENT practice. Inclusion criteria were chronic maxillary sinusitis lasting longer than 12 weeks, objective confirmation by nasal endoscopy and CT, failure of appropriate medical therapy, and candidacy for surgery. Exclusion criteria were sinonasal malignancy, invasive fungal disease, major craniofacial trauma, cystic fibrosis, primary ciliary dyskinesia, and incomplete imaging or follow-up. This design is aligned with current chronic rhinosinusitis diagnostic principles, in which symptom duration alone is insufficient and objective disease documentation is required.

All patients underwent history taking, rigid nasal endoscopy, preoperative CT of the paranasal sinuses, Lund-Mackay scoring, and standard surgical work-up. In selected cases with suspected odontogenic contribution or complex maxillary floor anatomy, CBCT was also available because it provides high-resolution three-dimensional anatomy with lower radiation than conventional CT, although interpretation remains time-consuming and operator-dependent.

The modeled AI-assisted workflow consisted of four modules. The first was a CT-based disease detection module trained conceptually on chronic maxillary sinusitis imaging patterns, inspired by published work demonstrating high test performance for chronic maxillary sinusitis and bone remodeling detection. The second was a maxillary sinus segmentation module based conceptually on nnU-Net v2, used to generate automated sinus boundaries, disease burden maps, and route-specific anatomical measurements. The third was a decision-support module integrating symptoms, endoscopic findings, Lund-Mackay score, osteomeatal complex status, wall involvement, dental findings, prior surgery, and AI-derived morphometric features to recommend middle meatal antrostomy, inferior meatal antrostomy, extended maxillary access, or combined ENT-dental management. The fourth was a postoperative endoscopic analysis module modeled on transfer-learning approaches that classify the postoperative cavity into edema, polypoid change, or smooth healing patterns.

The conventional workflow and the AI-assisted workflow were compared within the modeled framework. Primary endpoints were preoperative diagnostic concordance, time to final surgical decision, mean operating time, intraoperative change of access plan, and 12-month disease control. Secondary endpoints were length of stay, postoperative endoscopic healing grade, revision-free status, and surgeon-rated workflow efficiency. Because AI medical imaging studies require transparent reporting and reproducibility, the modeled framework was conceptually aligned with the CLAIM 2024 recommendations.

Results

In the modeled cohort, 150 patients were included. The mean age was 39.8 ± 12.6 years. Ninety-two patients were male and fifty-eight were female. One hundred and twelve patients had unilateral-predominant maxillary disease, while thirty-eight had bilateral chronic rhinosinusitis with dominant maxillary involvement. Odontogenic contribution was suspected in thirty-four patients, and twenty-one had undergone previous sinus or dental procedures on the affected side.

Table 1. Baseline characteristics of the modeled cohort

Variable	Value
Number of patients	150
Mean age, years	39.8 ± 12.6
Male, n (%)	92 (61.3)
Female, n (%)	58 (38.7)
Unilateral-dominant maxillary disease, n (%)	112 (74.7)
Bilateral disease with maxillary predominance, n (%)	38 (25.3)
Suspected odontogenic contribution, n (%)	34 (22.7)
Prior sinus or dental intervention, n (%)	21 (14.0)
Mean preoperative Lund-Mackay score	11.9 ± 3.7
Mean preoperative SNOT-22 score	46.4 ± 12.1

Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

In the modeled analysis, clinician-only preoperative interpretation yielded diagnostic concordance with the final reference diagnosis in 126 of 150 patients, or 84.0%. After AI-assisted imaging analysis and segmentation were added, concordance increased to 142 of 150 patients, or 94.7%. The AI-assisted pathway also reduced the mean time from completed CT to definitive operative decision from 4.3 ± 1.6 days to 2.4 ± 1.1 days. These modeled improvements are consistent with the broader literature showing that AI can reduce turnaround time, standardize imaging interpretation, and improve decision support in CRS workflows.

Table 2. Modeled preoperative workflow performance

Metric	Conventional workflow	AI-assisted workflow
Diagnostic concordance, n (%)	126 (84.0)	142 (94.7)
Time to final surgical decision, days	4.3 ± 1.6	2.4 ± 1.1
Need for additional imaging, n (%)	28 (18.7)	12 (8.0)
Mean interpretation time per case, min	13.1 ± 3.9	7.8 ± 2.4

In the modeled dataset, AI changed the planned operative strategy in 29 patients. In eleven, the AI system recommended a less extensive route because disease was localized to a drainage-relevant compartment without broad sinus involvement. In nine, it recommended a more efficient maxillary access route because the lesion map suggested inferior recess dominance or difficult middle meatal reach. In six patients, combined ENT-dental surgery was selected because AI and imaging together favored odontogenic chronic maxillary sinusitis. In three, prior surgical anatomy prompted a broader revision strategy.

Among operated patients, mean operating time fell from 56.2 ± 14.3 minutes in the conventional planning arm to 46.7 ± 12.1 minutes in the AI-assisted arm. Intraoperative change of plan was required in 16.0% of conventionally planned cases and 6.7% of AI-assisted cases. Surgeon-rated anatomical confidence improved from 7.1 ± 1.3 to 8.6 ± 0.9 on a 10-point scale.

Table 3. Modeled intraoperative outcomes

Variable	Conventional planning	AI-assisted planning
Mean operating time, min	56.2 ± 14.3	46.7 ± 12.1
Intraoperative change of access plan, n (%)	12 (16.0)	5 (6.7)
Surgeon-rated anatomical confidence /10	7.1 ± 1.3	8.6 ± 0.9
Mucosal preservation rated satisfactory, n (%)	101 (67.3)	121 (80.7)
Mean hospital stay, days	2.1 ± 0.8	1.6 ± 0.5

At 12 months, modeled disease control was achieved in 85.3% of patients in the AI-assisted cohort versus 76.7% in the conventional cohort. Mean postoperative SNOT-22 improvement was greater in the AI-assisted pathway, with a reduction of 24.8 points compared with 18.6 points. Revision surgery was modeled in 5.3% of AI-assisted cases and 10.7% of conventionally planned cases. Postoperative endoscopic healing, as assessed by the AI-supported postoperative image model and surgeon review, was classified as smooth healing in 69.3%, edema-dominant healing in 22.7%, and polypoid or persistent inflammatory pattern in 8.0%.

Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

Volume 4, Issue 3, March 2026 **ISSN (E):** 2938-3765

Table 4. Modeled 12-month postoperative outcomes

Variable	Conventional workflow	AI-assisted workflow
Disease control at 12 months, n (%)	115 (76.7)	128 (85.3)
Mean SNOT-22 improvement	18.6 ± 8.4	24.8 ± 9.1
Revision surgery, n (%)	16 (10.7)	8 (5.3)
Smooth postoperative cavity, n (%)	91 (60.7)	104 (69.3)
Persistent edema/polypoid change, n (%)	28 (18.7)	12 (8.0)

This modeled study suggests that AI may enhance surgical management of chronic maxillary sinusitis chiefly by improving preoperative precision rather than by replacing surgeon judgment. The literature already supports this direction. Reviews of AI in CRS show that its most mature applications are imaging interpretation, segmentation, phenotype classification, prognosis prediction, and postoperative monitoring. In maxillary sinus imaging, systematic reviews report strong diagnostic performance across CT and CBCT studies, supporting the feasibility of AI-assisted preoperative screening and mapping.

One of the most clinically relevant findings in the modeled analysis was the reduction in operative time and intraoperative change of plan. This is plausible because chronic maxillary sinusitis surgery often depends on subtle anatomical distinctions, including ostiomeatal obstruction, recess anatomy, floor disease, odontogenic origin, and prior surgical distortion. Automated maxillary sinus segmentation may help surgeons visualize the operative corridor more efficiently and consistently. Recent nnU-Net v2 work demonstrated very high autonomous segmentation performance in CBCT volumes, suggesting that real preoperative anatomy mapping is already technically achievable.

The modeled decrease in additional imaging and faster time to decision-making also fits the available evidence. AI-enhanced CBCT and CT interpretation has been proposed as a way to reduce time-intensive manual review and inter-observer variability. Likewise, the 2024 chronic maxillary sinusitis study demonstrated that AI can identify chronic maxillary sinusitis and bone remodeling with clinically meaningful performance, which is particularly relevant for surgical candidates in whom osteitic change, wall thickening, or longstanding unilateral disease may affect the surgical plan.

A further advantage is integration of imaging with clinical decision support. The 2023 U-Net-based decision-support system for chronic odontogenic rhinosinusitis is an important proof of concept because it combined image segmentation, symptom data, and physician assessment into one structured diagnostic framework. Chronic maxillary sinusitis often overlaps with odontogenic pathology, especially in unilateral or floor-dominant disease, so similar integrated systems may be particularly valuable in tertiary ENT units.

Postoperative monitoring is another area where AI may improve surgical value. In CRS, conventional endoscopic interpretation can be subjective, especially when distinguishing residual edema, smooth healing, and early recurrent inflammatory change. A 2025 multicenter study showed that transfer-learning models built on postoperative endoscopic images can standardize such assessments, which supports the concept used in this modeled manuscript. In practical terms, this could make postoperative surveillance more reproducible and may allow earlier identification of patients at risk of suboptimal healing or revision surgery.

Volume 4, Issue 3, March 2026 ISSN (E): 2938-3765

At the same time, current AI evidence in rhinology still has important limitations. Much of the literature remains retrospective, single-center, and based on internal datasets. The CLAIM 2024 update specifically emphasizes transparency, reproducibility, dataset description, and clinically relevant reporting if AI systems are to be trusted and translated into routine care. Therefore, any real TDTU study on AI-assisted surgery for chronic maxillary sinusitis should include external validation, calibration analysis, subgroup evaluation, and clear reporting of failure modes.

Conclusion

In this modeled 150-patient study, artificial intelligence improved the surgical management pathway for chronic maxillary sinusitis by enhancing diagnostic agreement, shortening time to operative planning, reducing additional imaging, lowering operating time, decreasing intraoperative changes of strategy, and improving 12-month postoperative control.

The most realistic near-term role of AI in chronic maxillary sinusitis surgery is as an integrated support system for CT and CBCT interpretation, maxillary sinus segmentation, access-route planning, and postoperative endoscopic follow-up. Its value lies in standardization, efficiency, and decision support. A real-world prospective TDTU ENT study would be needed to confirm whether these modeled improvements are reproducible in clinical practice.

References

1. Fokkens WJ, Lund VJ, Hopkins C, et al. European Position Paper on Rhinosinusitis and Nasal Polyps 2020 (EPOS 2020). Rhinology Supplement. 2020.
2. Liu YY, et al. Artificial intelligence optimizes the standardized diagnosis and treatment of chronic sinusitis. Frontiers in Physiology. 2025.
3. Chaudhary MH, Dahan N. Artificial Intelligence-Enhanced Cone-Beam Computed Tomography for the Diagnostic Evaluation of Chronic Rhinosinusitis: A Systematic Review. Cureus. 2025.
4. Uthman AT, Abouelenen H, Khan S, Bseiso O, Al-Rawi N. Diagnostic accuracy of artificial intelligence in the detection and diagnosis of maxillary sinus pathology using CT and CBCT imaging. Imaging Science in Dentistry. 2025.
5. Zou C, Ji H, et al. Preliminary study on AI-assisted diagnosis of bone remodeling in chronic maxillary sinusitis. BMC Medical Imaging. 2024.
6. Bayrakdar IS, et al. Artificial intelligence system for automatic maxillary sinus segmentation on cone beam computed tomography images. Dentomaxillofacial Radiology. 2024.
7. Alekseeva V, Nechyporenko A, Frohme M, Gargin V, Meniailov I, Chumachenko D. Intelligent Decision Support System for Differential Diagnosis of Chronic Odontogenic Rhinosinusitis Based on U-Net Segmentation. Electronics. 2023.
8. Gong W, et al. Postoperative outcome analysis of chronic rhinosinusitis using transfer learning with pre-trained foundation models based on endoscopic images: a multicenter observational study. BioMedical Engineering OnLine. 2025.
9. Aldajani A, et al. Outcomes of Endoscopic Sinus Surgery for Chronic Rhinosinusitis With Nasal Polyposis and Risk Factors of Recurrence in a Tertiary Care Teaching Hospital. Otolaryngology–Head and Neck Surgery. 2024.
10. Tejani AS, Klontzas ME, Gatti AA, et al. Checklist for Artificial Intelligence in Medical Imaging (CLAIM): 2024 Update. Radiology: Artificial Intelligence. 2024.