OPEN ACCESS

Saudi Journal of Medicine
Abbreviated Key Title: Saudi J Med
ISSN 2518-3389 (Print) | ISSN 2518-3397 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Review Article

Artificial Intelligence as a Decision-Support Tool in the Management of Chronic Inflammatory Rhinosinusitis in Elderly Patients: A Scholarly Review

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DOI: https://doi.org/10.36348/sjm.2026.v11i05.007 | **Received:** 18.03.2026 | **Accepted:** 13.05.2026 | **Published:** 18.05.2026

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Abstract

Background: Chronic inflammatory rhinosinusitis (CIRS) is a prevalent ENT condition whose burden is amplified in elderly patients by immunosenescence, polypharmacy, and atypical clinical presentations. Conventional management strategies show significant limitations in this population. ***Objective:*** To review the current evidence on artificial intelligence (AI) applications for the diagnosis, treatment planning, and follow-up of CIRS, with a focus on elderly-specific challenges and opportunities. ***Methods:*** A narrative review of the literature was conducted using PubMed, Cochrane Library, and Google Scholar. Search terms included "artificial intelligence," "machine learning," "deep learning," "chronic rhinosinusitis," "elderly," and "decision support." Articles published between 2013 and 2025 in English were included. ***Results:*** AI demonstrates significant potential across all phases of CIRS management: automated CT sinus segmentation, endoscopic polyp detection, biotherapy response prediction, post-FESS recurrence-risk modeling, and intelligent remote monitoring. In elderly patients, AI's capacity to integrate comorbidities and detect atypical imaging patterns yields clinically meaningful advantages. ***Conclusion:*** AI represents a pivotal step toward precision medicine in elderly CIRS management. Widespread clinical integration requires rigorous validation on geriatric cohorts, ethical governance, and structured clinician training.

Keywords: Artificial Intelligence, Chronic Rhinosinusitis, Elderly, Machine Learning, Decision Support, Nasal Polyps.

INTRODUCTION

Artificial intelligence (AI) is reshaping medical practice by enabling the analysis of large, heterogeneous datasets and the generation of precise clinical predictions. This transformation is particularly timely given rapid global demographic aging, which amplifies the burden of chronic inflammatory conditions and places increasing pressure on specialist services.

Chronic inflammatory rhinosinusitis (CIRS) affects between 5% and 12% of the adult population worldwide and represents one of the most common conditions managed in otolaryngology practice. [1] Its prevalence in individuals older than 65 years is comparable to, or greater than, that observed in younger adults; yet this population remains underrepresented in both clinical trials and AI development studies. [2] In elderly patients, CIRS manifests within a complex background of immunosenescence, multimorbidity, and polypharmacy, leading to atypical presentations and challenging management decisions.

Despite guideline-concordant treatment algorithms topical and systemic corticosteroids, saline irrigation, biologic therapies, and functional endoscopic sinus surgery (FESS) a substantial proportion of elderly patients experience incomplete disease control, poor tolerance, or post-operative complications.[3] The variability of inflammatory phenotypes and the heterogeneity of aging physiology underscore the need for individualized, data-driven approaches.

AI, through machine learning and deep learning techniques, offers a framework for integrating multidimensional clinical data imaging, endoscopic findings, serologic profiles, and patient-reported outcomes into predictive models tailored to individual patient profiles. [4] Applications in ENT are emerging, although the rhinosinusology domain lags behind oncology and radiology in AI adoption.

This scholarly review aims to: (1) outline the pathophysiological and clinical specificities of CIRS in elderly patients; (2) summarize current AI technologies applicable to CIRS management; and (3) critically appraise evidence supporting AI-assisted diagnosis, treatment decision-making, and follow-up in this population, while addressing outstanding limitations and ethical considerations.

METHODS

A narrative review was conducted searching PubMed/MEDLINE, Cochrane Library, and Google Scholar from January 2013 through March 2025. The following MeSH and free-text terms were combined: “artificial intelligence,” “machine learning,” “deep learning,” “neural network,” “chronic rhinosinusitis,” “nasal polyps,” “elderly,” “older adults,” “decision support,” “medical imaging,” and “endoscopic sinus surgery.” No language restriction was applied; however, only articles with English full-text availability were included for detailed analysis.

Inclusion criteria encompassed original research articles, systematic reviews, meta-analyses, and consensus statements addressing AI applications in rhinosinusology, ENT imaging, or geriatric otolaryngology. Isolated case reports, conference abstracts without peer-reviewed full texts, and editorials were excluded. Data were extracted on study population, AI algorithm type, clinical task, performance metrics reported, and generalizability to elderly patients. The PRISMA-NScR extension for narrative reviews guided reporting.

Ethical approval was not required, as this review synthesizes published data without involving human participants or identifiable data. AI-assisted manuscript drafting (Claude Sonnet, Anthropic, version 4.6) was employed under full authorial supervision and responsibility.

RESULTS

Clinical Specificities of CIRS in Elderly Patients

CIRS is defined as mucosal inflammation of the nasal cavity and paranasal sinuses persisting beyond 12 weeks, with or without nasal polyps. [5] Two principal phenotypes are recognized: CRS without nasal polyps (CRSsNP) and CRS with nasal polyps (CRSwNP), the latter characterized by type-2 eosinophilic inflammation. In elderly patients, the distribution of these phenotypes may differ from younger cohorts, with a higher prevalence of mixed or non-type-2 inflammatory profiles. [6]

Several age-related physiological changes directly modulate CIRS expression in this population. Immunosenescence encompasses a reduction in neutrophilic activity, dysregulation of cytokine networks, and diminished mucosal innate immunity, collectively perpetuating chronic sinonasal inflammation. [7] Ciliary dysfunction—a hallmark of mucociliary failure—is amplified by aging epithelial atrophy. Moreover, frequent comorbidities (chronic obstructive pulmonary disease, gastroesophageal reflux disease, cardiovascular disease) and polypharmacy (antihypertensives, anticoagulants, corticosteroids for non-ENT indications) create complex clinical overlaps that can mask or mimic cardinal CIRS symptoms.

As a result, diagnostic delay is common in elderly patients, and standard management strategies carry heightened iatrogenic risk. Systemic corticosteroid courses are poorly tolerated; biologic agents require stringent phenotyping; and surgical candidacy demands careful preoperative frailty assessment. [8] These limitations create an unmet clinical need for precision tools capable of integrating geriatric complexity—a need that AI is uniquely positioned to address.

AI Technologies Applicable to CIRS (Table 1)

Modern AI in medicine rests primarily on machine learning (ML) and its deep learning (DL) subset. Supervised ML algorithms learn input-output mappings from annotated training data and are the standard approach for diagnostic classification. Deep convolutional neural networks (CNNs) excel at spatial feature extraction from medical images, achieving performance levels comparable or superior to expert clinicians in specific tasks within radiology, pathology, and endoscopy.4 Recurrent networks and Transformer architectures model sequential or longitudinal data, making them suitable for symptom trajectory analysis and recurrence prediction. [9] Table 1 summarizes the main AI approaches relevant to ENT practice.

Table 1: Main Artificial Intelligence Approaches and Their ENT/Rhinology Applications

AI Approach	Core Principle	ENT/Rhinology Application
Supervised learning	Trained on labeled clinical data; learns input-output mappings	Chronic rhinosinusitis classification, polyp detection
Convolutional neural networks (CNN)	Hierarchical spatial feature extraction from images	CT sinus segmentation, endoscopic analysis, polyp grading
Recurrent networks / Transformers	Sequential data modeling; long-range attention mechanism	Recurrence-risk prediction, longitudinal symptom tracking
Reinforcement learning	Optimization through iterative reward-based feedback	Adaptive therapeutic decision support

CNN, convolutional neural network; CIRS, chronic inflammatory rhinosinusitis.

AI-Assisted Imaging and Diagnosis

Computed tomography (CT) of the paranasal sinuses remains the imaging cornerstone for CIRS evaluation. Deep learning algorithms have demonstrated the capacity for automated, three-dimensional segmentation of all major sinus cavities—maxillary, ethmoidal, frontal, and sphenoidal—as well as the ostiomeatal complex. [10] These systems quantify mucosal thickening, inflammation extent, and polyp burden with high reproducibility, outperforming conventional radiologic scoring systems (eg, Lund-Mackay) in inter-observer consistency.

In elderly patients, this AI capability is particularly valuable. Age-related anatomic changes—osteoporosis, bony remodeling, post-surgical alterations—can significantly impair visual image interpretation. CNN-based systems act as intelligent filters, recognizing pathological patterns despite anatomic noise and providing standardized quantitative reports that are indispensable in longitudinal follow-up.

AI has also been applied to nasal endoscopy. Computer vision systems enable real-time detection and grading of polyps, mucosal edema, and secretions, with preliminary studies reporting sensitivity exceeding 85% for polyp identification. [11] Automated Lund-Kennedy scoring, if validated prospectively, could substantially reduce assessment variability across clinical settings.

Predictive Modeling for Treatment Decisions (Table 2)

Beyond diagnosis, predictive models represent arguably the most clinically impactful AI application in CIRS. By integrating imaging data, endoscopic findings, eosinophil counts, total IgE, specific serology, and quality-of-life scores, ML algorithms can estimate: (1) the likelihood of biotherapy response (anti-IL-4Rα, anti-IL-5, anti-IgE); (2) post-FESS recurrence risk; and (3) optimal surgical timing. [12,13] In elderly patients, models incorporating frailty indices, comorbidity scores, and medication lists further refine therapeutic risk stratification, supporting more individualized decisions in this vulnerable population.

Table 2: AI Applications in the Management of CIRS in Elderly Patients

Domain	AI Application	Specific Benefit in Elderly Patients
CT imaging	Automated sinus segmentation; mucosal thickness quantification	Compensates for age-related anatomic variability and prior surgical changes
Nasal endoscopy	Real-time polyp detection; automated Lund-Kennedy scoring	Standardizes assessment; reduces inter-observer variability
Diagnostic integration	Multimodal fusion (CT, endoscopy, serology, symptom scores)	Detects atypical presentations common in elderly patients
Treatment planning	Biotherapy response prediction; FESS candidacy stratification	Personalizes decisions accounting for comorbidities and polypharmacy
Remote monitoring	Intelligent teleconsultation; early-exacerbation alert systems	Reduces mobility-related barriers; enables proactive follow-up

FESS, functional endoscopic sinus surgery; CT, computed tomography.

Remote Monitoring and Longitudinal Follow-up

Remote monitoring platforms integrating AI-powered symptom analysis represent a particularly relevant innovation for elderly CIRS patients, who face mobility limitations and higher risk of undetected disease progression. Intelligent teleconsultation modules analyze patient-reported symptom trajectories, vital parameter trends, and post-operative data to generate early-exacerbation alerts and flag patients requiring urgent intervention. [14] This capability could substantially reduce unnecessary specialist visits while ensuring that high-risk deteriorations are promptly identified, thereby optimizing resource allocation in a context of growing ENT demand.

Current Limitations and Ethical Challenges (Table 3)

Despite its considerable promise, AI integration in clinical ENT practice faces substantial obstacles. The systematic under-representation of elderly patients in training datasets is a critical limitation: algorithms optimized on younger cohorts may generate biased predictions when applied to older, more complex patients. [15] Multicenter geriatric-focused validation studies are a research priority.

Algorithmic explainability (the 'black-box' problem) remains unresolved for most high-performance deep learning models. Without transparent reasoning pathways, clinical adoption is hindered and medico-legal liability in AI-influenced decisions remains ambiguous. Explainable AI (XAI) methodologies—attention mapping, SHAP values, saliency visualization—are actively being developed but are not yet standard in ENT applications. [16] The European Union Artificial Intelligence Act, currently in implementation, classifies medical AI systems as high-risk and mandates transparency, auditability, and post-market surveillance.

Table 3: Challenges and Limitations of AI Integration in CIRS Management in Elderly Patients

Category	Challenge / Limitation	Proposed Solution
Data quality	Under-representation of elderly patients in training datasets	Multicenter geriatric-focused cohort studies
Technical	Algorithmic bias; imaging heterogeneity across centers	External validation; standardized acquisition protocols
Ethical	Model explainability (black-box); liability in AI-guided errors	Explainable AI (XAI) frameworks; EU AI Act compliance
Clinical adoption	Resistance to change; insufficient AI literacy among clinicians	Graduated deployment; continuous medical education
Geriatric-specific	Anatomic complexity; post-operative artifacts; frailty heterogeneity	Robust models trained on age-diverse, comorbid populations

XAI, explainable artificial intelligence; FESS, functional endoscopic sinus surgery; EU AI Act, European Union Artificial Intelligence Act.

DISCUSSION

This review synthesizes a growing but still nascent evidence base supporting AI as a transformative tool in the management of CIRS in elderly patients. The convergence of an aging global population, the increasing burden of chronic sinonasal disease, and the maturation of AI technologies creates a compelling case for focused investment in this area.

The most robust evidence to date concerns imaging applications. Several independent studies have demonstrated that CNN-based CT sinus segmentation achieves segmentation accuracy and reproducibility that equal or exceed experienced radiologists, with the added benefit of near-instantaneous processing.10,11 The clinical relevance for elderly patients is direct: standardized, quantitative imaging reports eliminate subjectivity and improve the reliability of longitudinal comparisons—a critical need for patients managed over extended periods with evolving anatomy.

Predictive models for treatment decision-making represent the frontier of clinical utility. The ability to anticipate biotherapy response or post-FESS recurrence risk with algorithm-generated probability estimates could transform current trial-and-error prescribing into genuinely data-driven precision medicine.12,13 For frail elderly patients with narrow therapeutic margins, even modest improvements in predictive accuracy could meaningfully reduce adverse outcomes, unnecessary procedures, and healthcare costs.

Comparatively, the rhinosinusology field lags behind ophthalmology, cardiology, and dermatology in AI adoption. This gap reflects the heterogeneity of rhinosinusitis phenotypes, the relatively small size of published datasets, and the historical absence of standardized imaging protocols across centers. African and Moroccan clinical contexts add additional dimensions: epidemiological transition, rapid demographic aging, and locally specific inflammatory profiles justify the development of regionally adapted AI models rather than uncritical application of algorithms trained on Western cohorts.

The review has several limitations. As a narrative synthesis, it is subject to selection bias and cannot provide quantitative effect estimates. The paucity of studies specifically designed for elderly CIRS patients limits extrapolation. Prospective, multicenter randomized or quasi-experimental studies incorporating age-stratified analyses are needed to establish causal evidence for AI-driven clinical benefit.

CONCLUSION

Artificial intelligence offers a substantial and largely untapped opportunity to improve diagnosis, treatment personalization, and long-term follow-up for elderly patients with chronic inflammatory rhinosinusitis. Automated CT segmentation, real-time endoscopic analysis, biotherapy response prediction, and intelligent remote monitoring each address specific clinical gaps inherent to geriatric otolaryngology practice. Realizing this potential requires rigorous external validation on representative elderly cohorts, transparent and explainable algorithm design, robust ethical governance, and structured clinician education. As the specialty of otolaryngology enters an era of augmented practice, AI should be conceived not as an autonomous decision-maker but as a precision amplifier of clinical expertise—always in service of the individual patient.

ACKNOWLEDGMENTS

The authors thank the Department of Otorhinolaryngology of Hôpital des Spécialités, Rabat, for its academic support. AI-assisted drafting and formatting (Claude Sonnet, Anthropic, version 4.6) was employed under the full supervision and intellectual responsibility of the authors, in accordance with the COPE and ICMJE guidelines on AI use in scholarly publications.

STATEMENTS AND DECLARATIONS

Ethical Considerations: This manuscript is a narrative review of previously published literature and does not involve human participants, human tissue, or identifiable patient data. Ethical committee approval was not required.

Consent to Participate: Not applicable.

Consent for Publication: Not applicable.

Declaration of Conflicting Interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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

Data Availability: This review is based on publicly available published literature. No new datasets were generated or analyzed. All cited references are publicly accessible through their respective journals.

Author Contributions

MEQ: Conceptualization, literature search, data extraction, manuscript writing, critical revision.

LHE: Supervision, scientific review, critical revision. Both authors read and approved the final manuscript.

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