RESEARCH ARTICLE

DOI: 10.5935/0946-5448.2026001

International Tinnitus Journal. 2026;30(2):01-07

Anatomical Location Predicts Histopathological Phenotype in Maxillary Sinus Cysts: A Secondary Analysis of 140 Surgical Cases

Ulugbek Khasanov[1,2],
Lola Khasanova[1],
Jamolbek Djuraev[1],
Nozim Axundjanov[1],
Ulugbek Abdullayev[1],
Sunatillo Mirzayev[1],
Ilyos Soatov[1],
Xurshed Mardonov[1],
Gulruh Shodmonkulova[1*]

ABSTRACT

Background: Maxillary sinus cysts are frequently identified on cross-sectional imaging, yet radiologic appearance alone does not reliably characterize the underlying tissue response. Whether imaging-defined anatomical localization is associated with reproducible histopathological phenotypes remains insufficiently investigated.

Objective: To determine whether maxillary sinus cyst localization is associated with distinct epithelial, inflammatory, and stromal histopathological patterns in surgically treated patients.

Methods: This secondary cross-sectional analysis included 140 adults who underwent surgery for maxillary sinus cysts at a single tertiary center between 2023 and 2025. Preoperative multislice computed tomography, supplemented by cone-beam computed tomography when odontogenic or alveolar relationships required clarification, was used to classify lesions into four anatomically defined groups: ostium-adjacent/medial-superior (n=51), inferior wall/alveolar recess (n=31), anterior wall/anterior-inferior (n=16), and anteromedial/crista conchalis (n=42). Resected cyst walls were processed with hematoxylin-eosin staining. Seven binary histopathological features were compared across groups using Pearson's chi-square tests; sparse distributions were checked by Monte Carlo exact testing. False-discovery-rate correction and Cramer's V were used to assess multiplicity and effect size.

Results: Five of seven histopathological features differed significantly by anatomical group after false-discovery-rate correction. Eosinophilic infiltration was most frequent in the ostium-adjacent/medial-superior group (92.2%; $q<0.001$; $V=0.682$), whereas lymphocytic-leukocytic-plasmacytic infiltration (71.0%; $q<0.001$; $V=0.523$) and basement membrane thickening (77.4%; $q<0.001$; $V=0.433$) predominated in inferior wall/alveolar recess lesions. Epithelial metaplasia was concentrated in anterior wall/anterior-inferior lesions (43.8%; $q=0.002$; $V=0.332$). Fibrous tissue proliferation was most common in ostium-adjacent/medial-superior lesions (84.3%; $q<0.001$; $V=0.369$). The strongest pooled associations were observed for eosinophilic infiltration in group I (odds ratio [OR] 20.93, 95% confidence interval [CI] 6.91-63.44), inflammatory infiltration in group II (OR 8.66, 95% CI 3.53-21.26), and epithelial metaplasia in group III (OR 7.99, 95% CI 2.49-25.63).

Conclusion: Imaging-defined anatomical localization was associated with distinct histopathological phenotypes in maxillary sinus cysts. The findings support a location-aware diagnostic framework and targeted tissue sampling but do not justify replacing histopathological confirmation with imaging. External validation with blinded pathology review, standardized imaging protocols, and adjustment for odontogenic and allergic factors is required.

Keywords: Maxillary sinus cyst; retention cyst; cone-beam computed tomography; computed tomography; histopathology; epithelial metaplasia; eosinophilic infiltration; surgical planning

[1]Tashkent State Medical University, 2 Farobi Street, Almazar District, Tashkent 100109, Uzbekistan
[2]Republican Specialized Scientific and Practical Medical Center of Otorhinolaryngology and Head and Neck Diseases, Mahtumquli Street 103, Tashkent, Uzbekistan.

***Send correspondence to**

Gulruh Shodmonkulova
Department of Otorhinolaryngology Tashkent State Medical University, Uzbekistan E-mail : gulruh.rustamovna@mail.ru
Tel : +998993078996

Paper submitted on Jul 31, 2026; and Accepted on Aug 11, 2026

INTRODUCTION

Maxillary sinus cystic lesions are common findings in otorhinolaryngology, dental imaging, and maxillofacial practice. Reported prevalence varies considerably because study populations, imaging modalities, diagnostic thresholds, and terminology differ [1,2]. Most lesions are described as dome-shaped, non-destructive opacities and are discovered incidentally, but a subset is associated with facial pressure, nasal obstruction, recurrent headache, impaired sinus ventilation, dental disease, or progression that prompts surgical management [3,4]. The broad clinical spectrum creates a persistent problem: radiologically similar lesions may represent different pathological entities and different tissue responses.

The term “maxillary sinus cyst” is often used imprecisely. True retention cysts are epithelial-lined lesions related to obstruction of seromucous gland ducts, whereas pseudocysts represent subepithelial fluid accumulation without a true epithelial lining[1,2]. Other cystic-appearing processes include mucoceles, postoperative cysts, polyps, and odontogenic lesions that extend toward or into the sinus. Histological differentiation is therefore clinically relevant, particularly when a lesion is symptomatic, has an atypical location, is associated with dental pathology, or requires surgery.

Computed tomography (CT) and cone-beam computed tomography (CBCT) provide complementary anatomical information. CT is useful for evaluating the ostiomeatal complex, sinus aeration, mucosal disease, and relationships to adjacent sinonasal structures. CBCT offers high spatial resolution for the sinus floor, alveolar recess, and dental roots at a relatively low radiation burden in dentomaxillofacial protocols [5,6]. Existing radiographic and clinicopathological studies have described lesion frequency, dimensions, location, laterality, and dental associations [7,8]. MRI- and CT-based cohorts have also documented variability in prevalence and associated sinonasal anatomical variants [9,10]. However, imaging has generally been treated as a tool for detection and surgical mapping rather than as a potential indicator of the dominant histopathological response.

This distinction matters because the maxillary sinus is not histologically uniform. Regional differences in gland density, mucociliary transport, proximity to the natural ostium, exposure to odontogenic inflammation, local ventilation, and mechanical pressure may create different microenvironments [11,12] Epithelial remodeling, goblet-cell change, eosinophilic inflammation, mixed chronic inflammatory infiltration, fibrosis, and basement membrane thickening might therefore vary according to the wall or recess from which a lesion arises. Demonstrating such heterogeneity would provide a biological basis for integrating radiologic localization into preoperative assessment. Published clinicopathological studies emphasize that clinical and radiologic impressions alone may be insufficient for definitive classification of maxillary sinus disease[7]. Nevertheless, direct analyses linking imaging-defined cyst location to standardized histopathological features are scarce. Most available reports are descriptive, include mixed sinus pathologies, focus on dental implant planning, or do not evaluate regional tissue phenotypes in a sufficiently large surgical cohort. Long-term follow-up studies also show that many retention cysts remain stable or regress, reinforcing the need to distinguish incidental lesions from surgically relevant disease [13].

Beyond structural relationships within the sinus, sinonasal inflammatory disease may affect Eustachian tube function. Chronic rhinosinusitis and allergic rhinitis have been associated with Eustachian tube dysfunction, altered middle-ear pressure, and otologic symptoms such as aural fullness, hearing complaints, and tinnitus, with proposed mechanisms including mucosal inflammation near the nasopharyngeal Eustachian tube orifice and impaired pressure equalization [14,15]. Whether inflammatory changes associated with maxillary sinus cysts contribute to auditory or tinnitus symptoms has not been directly examined.

The present study was designed as a distinct secondary inferential analysis of a previously assembled 140-patient surgical cohort. Rather than re-reporting general diagnostic or operative outcomes, it tests a new hypothesis: those anatomically defined maxillary sinus cyst locations are associated with different epithelial, inflammatory, and stromal phenotypes. We aimed to compare seven histopathological features across four radiologically and surgically relevant localization groups and to quantify the strength of the observed associations.

MATERIALS & METHODS

Study design and setting

This study is a secondary cross-sectional analysis of a single-center surgical cohort assembled at the multidisciplinary clinic of Tashkent State Medical University, Tashkent, Uzbekistan, between 2023 and 2025. The analysis was structured according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations [16].The unit of analysis was the patient. Where bilateral lesions were present, the surgically treated lesion that determined the operative approach was used for anatomical classification.

Participants

The source cohort comprised 140 adult patients with unilateral or bilateral maxillary sinus cysts who underwent surgical removal. The source protocol selected patients with imaging-confirmed cystic lesions that occupied at least approximately one-half of the sinus or produced clinically relevant symptoms, including persistent nasal obstruction or impaired quality of life, in the absence of an acute inflammatory episode at the time of surgery. All participants provided written consent for surgery and histopathological examination.

Exclusion criteria in the source protocol included inability or unwillingness to provide consent, pregnancy or lactation, participation in another potentially interfering clinical study, and major comorbidity judged likely to affect assessment or perioperative management. Because this was a surgical cohort, incidental small asymptomatic retention cysts managed conservatively were not represented.

Clinical and radiologic assessment

Clinical assessment included otorhinolaryngological history, anterior and posterior rhinoscopy, nasal endoscopy, evaluation of nasal breathing and olfaction, and review of allergic and dental history. All 140 patients underwent preoperative multislice CT. Standard axial and coronal reconstructions were sufficient to define the relationship of the cyst to the sinus walls in 112 patients (80.0%); sagittal and/or three-dimensional reconstructions were required in 28 patients (20.0%) because of complex anterior, anteromedial, or alveolar relationships. CBCT was used when additional evaluation of the inferior wall, alveolar recess, or dental structures was clinically required.

Lesions were classified into four mutually exclusive anatomical groups that corresponded to the region requiring surgical access: (I) ostium-adjacent, medial, or superior lesions accessible through the natural maxillary ostium; (II) inferior wall or alveolar recess lesions approached through the inferior nasal meatus; (III) anterior wall or anterior-inferior lesions requiring anterior wall micro-antrostomy; and (IV) anteromedial lesions accessed through the crista conchalis region. The classification was determined preoperatively from multiplanar imaging and confirmed intraoperatively.

Histopathological processing

Cyst-wall tissue was obtained during surgery, labeled, and fixed in 10% neutral buffered formalin for approximately 24 hours. Samples were dehydrated through graded ethanol, cleared in xylene, embedded in paraffin at 52-56°C, sectioned by microtome, and stained with hematoxylin and eosin. Slides were examined by light microscopy according to the institutional morphological protocol.

Seven prespecified binary features were extracted from the source histology records: (1) deformation or hyperplasia of pseudostratified ciliated columnar epithelium; (2) epithelial metaplasia; (3) goblet-cell hypertrophy; (4) lymphocytic-leukocytic-plasmacytic infiltration; (5) eosinophilic infiltration; (6) increased fibrous tissue; and (7) basement membrane thickening. A feature was coded as present when reported in the corresponding surgical specimen.

Outcomes

The primary outcome was heterogeneity in the prevalence of each histopathological feature across the four anatomical localization groups. Secondary outcomes were effect sizes for the omnibus associations and pooled odds ratios comparing the anatomical group with the highest feature prevalence against all remaining groups.

Statistical analysis

Categorical data are presented as counts and percentages. Pearson's chi-square test was used to compare each binary histopathological feature across the four groups. For epithelial metaplasia, where sparse cells were present, the chi-square result was checked using a fixed-margin Monte Carlo exact procedure with 200,000 simulated tables. To account for testing seven histopathological outcomes, P values were adjusted using the Benjamini-Hochberg false-discovery-rate procedure. Cramer's V quantified omnibus effect size and was interpreted descriptively as small (approximately 0.10), moderate (approximately 0.30), or large ($>=0.50$), while recognizing that these thresholds are context-dependent.

For clinically interpretable contrasts, odds ratios (ORs) with 95% confidence intervals (CIs) were calculated by comparing the group with the highest prevalence of a feature against the pooled remainder of the cohort. All tests were two-sided. Statistical significance was defined as an adjusted q value <0.05. The reanalysis was performed in Python using SciPy-compatible procedures.

RESULTS

Cohort characteristics and anatomical distribution

The analysis included all 140 surgically treated patients. There were 87 men (62.1%) and 53 women (37.9%). Ninety-one patients (65.0%) were aged 18-44 years, 39 (27.9%) were aged 45-59 years, and 10 (7.1%) were aged 60-74 years. Nasal obstruction was the most frequently recorded complaint (128/140, 91.4%), followed by recurrent headache (108/140, 77.1%) and nasal discharge (84/140, 60.0%). These symptoms were not used to define histopathological groups.

Anatomical classification identified 51 ostium-adjacent/medial-superior lesions (group I, 36.4%), 31 inferior wall/alveolar recess lesions (group II, 22.1%), 16 anterior wall/anterior-inferior lesions (group III, 11.4%), and 42 anteromedial/crista conchalis lesions (group IV, 30.0%). Table 1 summarizes the groups and their corresponding access routes. **Table 1**

Histopathological heterogeneity by localization

Five of the seven evaluated histopathological features showed statistically significant heterogeneity across anatomical groups after false-discovery-rate correction (Table 2).

The largest omnibus association was observed for eosinophilic infiltration ($\chi^2=65.08$, $q<0.001$, Cramer's $V=0.682$). Eosinophilic infiltration was present in 92.2% of group I lesions but in only 9.5% of group IV lesions.

Mixed lymphocytic-leukocytic-plasmacytic infiltration also differed strongly across groups ($\chi^2=38.22$, $q<0.001$, $V=0.523$), reaching 71.0% in group II and 56.2% in group

Table 1: Anatomical localization groups and corresponding surgical access.

Group	Imaging-defined localization	n (%)	Corresponding access	Main anatomical rationale
I	Natural ostium-adjacent; medial or superior wall	51 (36.4)	Endonasal endoscopic access through natural ostium	Direct visualization through the physiological drainage pathway
II	Inferior wall and/or alveolar recess	31 (22.1)	Inferior meatal endoscopic access	Improved reach to the sinus floor and alveolar recess
III	Anterior wall and/or anterior-inferior segment	16 (11.4)	Anterior wall micro-antrostomy	Access to regions difficult to reach with standard angled endoscopy
IV	Anteromedial region near crista conchalis	42 (30.0)	Endonasal access through crista conchalis region	Short route to the anteromedial wall while limiting broad mucosal disruption

Table 2: Histopathological features across anatomical localization groups.

Histopathological feature	Group I n=51	Group II n=31	Group III n=16	Group IV n=42	χ^2	p value	FDR q	Cramer's V
Ciliated epithelial deformation or hyperplasia	19 (37.3)	16 (51.6)	3 (18.8)	16 (38.1)	4.92	0.178	0.207	0.187
Epithelial metaplasia	4 (7.8)	3 (9.7)	7 (43.8)	4 (9.5)	15.47	0.00146*	0.00204	0.332
Goblet-cell hypertrophy	28 (54.9)	12 (38.7)	6 (37.5)	22 (52.4)	3.05	0.383	0.383	0.148
Lymphocytic-leukocytic-plasmacytic infiltration	5 (9.8)	22 (71.0)	9 (56.2)	10 (23.8)	38.22	2.54×10^{-8}	8.88×10^{-8}	0.523
Eosinophilic infiltration	47 (92.2)	17 (54.8)	11 (68.8)	4 (9.5)	65.08	4.82×10^{-14}	3.37×10^{-13}	0.682
Increased fibrous tissue	43 (84.3)	16 (51.6)	5 (31.2)	28 (66.7)	19.02	0.000271	0.000474	0.369
Basement membrane thickening	12 (23.5)	24 (77.4)	11 (68.8)	23 (54.8)	26.25	8.46×10^{-6}	1.97×10^{-5}	0.433

Table 3: Pooled odds ratios for dominant location-specific histopathological phenotypes.

Feature	Dominant group	Prevalence in dominant group	OR vs all other groups	95% CI
Epithelial metaplasia	III	7/16 (43.8%)	7.99	2.49-25.63
Mixed inflammatory infiltration	II	22/31 (71.0%)	8.66	3.53-21.26
Eosinophilic infiltration	I	47/51 (92.2%)	20.93	6.91-63.44
Increased fibrous tissue	I	43/51 (84.3%)	4.39	1.85-10.40
Basement membrane thickening	II	24/31 (77.4%)	4.7	1.86-11.83

Table 4: Conceptual summary of location-associated histopathological phenotypes. Percentages indicate the most characteristic observed features; the framework is not a validated diagnostic classifier.

GROUP I	GROUP II	GROUP III	GROUP IV
Ostium-adjacent / medial-superior	Inferior wall / alveolar recess	Anterior / anterior-inferior	Anteromedial / crista conchalis
Eosinophilia 92.2% Fibrosis 84.3%	Mixed inflammation 71.0% Basement thickening 77.4%	Metaplasia 43.8% Basement thickening 68.8%	Fibrosis 66.7% Goblet hypertrophy 52.4%

III compared with 9.8% in group I. Basement membrane thickening was most frequent in group II (77.4%) and group III (68.8%) and least frequent in group I (23.5%; $\chi^2=26.25$, $q<0.001$, $V=0.433$).

Epithelial metaplasia was uncommon in groups I, II, and IV (7.8%-9.7%) but occurred in 43.8% of group III lesions (Monte Carlo-confirmed $p\approx0.002$; $q=0.002$; $V=0.332$). Increased fibrous tissue was most frequent in group I (84.3%), followed by group IV (66.7%), group II (51.6%), and group III (31.2%; $\chi^2=19.02$, $q<0.001$, $V=0.369$). Neither epithelial deformation/hyperplasia nor goblet-cell hypertrophy differed significantly after multiplicity adjustment **Table 2.**

Magnitude of dominant group associations

Pooled contrasts supported clinically meaningful location-specific enrichment (Table 3). Compared with all other groups combined, group I lesions had markedly higher odds of eosinophilic infiltration (OR 20.93, 95% CI 6.91-63.44) and increased fibrous tissue (OR 4.39, 95% CI 1.85-10.40). Group II lesions had higher odds of mixed inflammatory infiltration (OR 8.66, 95% CI 3.53-21.26) and basement membrane thickening (OR 4.70, 95% CI 1.86-11.83). Group III lesions had nearly eightfold higher odds of epithelial metaplasia (OR 7.99, 95% CI 2.49-25.63). **Table 3**

Proposed location-histology framework

The observed pattern can be summarized as four non-exclusive phenotypes: (1) an ostium-adjacent/medial-superior eosinophilic-fibrotic phenotype; (2) an inferior wall/alveolar recess mixed-inflammatory and basement-membrane-remodeling phenotype; (3) an anterior/anterior-inferior epithelial-metaplastic phenotype; and (4) an anteromedial intermediate remodeling phenotype

characterized by frequent fibrosis and goblet-cell hypertrophy but low eosinophilic infiltration. These labels are descriptive and hypothesis-generating rather than diagnostic categories **Table 4**.

DISCUSSION

This secondary analysis demonstrated substantial histopathological heterogeneity among maxillary sinus cysts classified by imaging-defined anatomical location. Five of seven epithelial, inflammatory, and stromal features differed significantly after correction for multiple comparisons. The strongest association involved eosinophilic infiltration, followed by mixed chronic inflammatory infiltration and basement membrane thickening. These findings support the hypothesis that maxillary sinus cysts are not biologically uniform and that the local anatomical microenvironment may be linked to the dominant tissue response.

The ostium-adjacent/medial-superior group showed a striking eosinophilic-fibrotic profile. More than nine in ten lesions had eosinophilic infiltration, and more than four in five showed increased fibrous tissue. Eosinophilia in sinonasal mucosa can reflect type 2 inflammatory activity, allergic sensitization, epithelial-barrier dysfunction, or chronic inflammatory remodeling [17]. However, the present dataset did not contain standardized allergy testing, tissue eosinophil counts, immunohistochemical markers, or systemic biomarkers. The association should therefore be interpreted as a morphological signal rather than evidence that these lesions represent an allergic endotype.

Inferior wall and alveolar recess lesions were characterized by mixed lymphocytic-leukocytic-plasmacytic infiltration and basement membrane thickening. This region is anatomically close to posterior maxillary teeth and may be exposed to odontogenic inflammation, local mucosal injury, altered drainage, or prolonged contact with retained secretions. CBCT studies have shown that the location of mucous retention cysts may be associated with dental and endodontic variables [5,6]. Nevertheless, dental pathology was not quantified at patient level in the current secondary dataset, so an odontogenic mechanism cannot be established. Future studies should incorporate standardized dental examination, periapical status, periodontal measures, and microbiological assessment.

Anterior wall and anterior-inferior lesions had the highest prevalence of epithelial metaplasia, with an approximately eightfold pooled odds increase compared with all other locations. Metaplasia may arise as an adaptive response to chronic mechanical, inflammatory, or environmental stress and may indicate prolonged epithelial remodeling. The low number of patients in this group widens the confidence interval, but the association remained significant after false-discovery-rate correction and Monte Carlo verification. This finding merits external validation using standardized pathology scoring and digital morphometry.

The results also clarify the relationship between radiology and histopathology. Cross-sectional imaging is indispensable for locating lesions, evaluating sinus walls and recesses, identifying dental relationships, and planning safe access. Yet radiologic morphology does not reveal whether the tissue is dominated by eosinophilic inflammation, mixed chronic inflammation, epithelial metaplasia, or fibrosis. Clinicopathological series of maxillary sinus disease similarly show that imaging and clinical impressions may be insufficient for definitive classification [1,2]. Imaging should therefore guide suspicion and sampling, not replace pathological examination.

A practical implication is the possibility of a location-aware diagnostic pathway. Inferior wall or alveolar recess lesions with adjacent dental disease should trigger structured dental evaluation and deliberate tissue sampling. Anterior lesions may deserve careful pathological assessment for epithelial remodeling and alternative diagnoses. Ostium-adjacent lesions with marked surrounding mucosal disease may justify evaluation of allergic or eosinophilic inflammation. These actions are reasonable extensions of the observed associations, but they require prospective testing before they can be incorporated into formal treatment algorithms.

More broadly, sinonasal inflammatory disease, including chronic rhinosinusitis and allergic rhinitis, has been associated with Eustachian tube dysfunction and otologic symptoms such as aural fullness, hearing complaints, and tinnitus, through mechanisms that include mucosal inflammation near the Eustachian tube orifice and altered middle-ear pressure [14,15]. Eosinophilic and mixed inflammatory infiltration were common in the present cohort, particularly in ostium-adjacent and inferior-wall lesions. This observation raises a testable hypothesis that the broader sinonasal inflammatory milieu may be associated with Eustachian tube dysfunction or auditory symptoms in some patients. However, hearing and tinnitus outcomes were not prospectively assessed: the source protocol did not include audiologic testing, tympanometry, or standardized otologic symptom questionnaires. Any relationship between maxillary sinus cyst location, histopathological phenotype, and auditory or tinnitus symptoms therefore remains speculative and requires dedicated prospective study with standardized otologic and audiologic measures.

The study's contribution is not that anatomical location alone determines pathology. Rather, location appears to function as a clinically accessible marker of differing tissue environments. The moderate-to-large Cramer's V values for several outcomes suggest that the observed heterogeneity is not merely a consequence of sample size. At the same time, the anatomical groups were directly linked to the selected surgical routes. Therefore, the analysis cannot separate the influence of lesion location from referral patterns, technical accessibility, lesion size, or other factors that contributed to approach selection.

The findings should also be considered in the context of the natural history of maxillary sinus cysts. Many radiologically detected retention cysts remain stable or regress and do not require surgery[18]. The current cohort included selected symptomatic or large lesions that underwent operative treatment; it should not be used to infer the histology of small incidental cysts or to support routine surgery. Clinical decisions must remain based on symptoms, progression, differential diagnosis, dental factors, and the risk-benefit profile of intervention.

Strengths

Strengths include the relatively large, uniformly surgical cohort; integration of multiplanar CT/CBCT localization with resected tissue; evaluation of multiple biologically relevant histopathological features; formal control of false discoveries; use of effect sizes rather than reliance on P values alone; and transparent separation of this inferential analysis from earlier descriptive reports from the source cohort.

CONCLUSION

Maxillary sinus cysts demonstrated location-specific histopathological heterogeneity in this 140-patient surgical cohort. Ostium-adjacent/medial-superior lesions showed a predominantly eosinophilic-fibrotic profile; inferior wall/alveolar recess lesions showed mixed inflammatory infiltration and basement membrane thickening; and anterior/anterior-inferior lesions showed concentrated epithelial metaplasia. Imaging-defined location may therefore provide biologically informative context for diagnostic work-up, tissue sampling, and operative planning. It cannot substitute for histopathological confirmation, and the observed phenotypes require prospective, multicenter validation with standardized imaging, dental assessment, blinded pathology review, and multivariable analysis.

Limitations

- The single-center design and surgical selection criteria limit generalizability, especially to small incidental retention cysts managed conservatively.
- The source dataset did not provide patient-level covariates sufficient for multivariable adjustment. Residual confounding by age, sex, allergy, smoking, cyst size, laterality, chronic rhinosinusitis, dental disease, medication use, and duration of symptoms is likely.
- Anatomical localization and operative approach were structurally linked, preventing separation of biological location effects from referral and access-selection effects.
- Histopathological features were extracted as binary variables from routine hematoxylin-eosin reports. Standardized semiquantitative scoring, immunohistochemistry, digital pathology, interobserver reliability, and blinded re-review were not available.
- Exact CT/CBCT scanner models, acquisition parameters, slice thickness, reconstruction kernels, and radiation settings were unavailable in the secondary dataset, limiting full reproducibility of the imaging protocol.
- Age was retained as verified categorical strata because available source documents contained inconsistent summary mean-age values.
- Preliminary descriptive histology and general diagnostic-treatment findings from this cohort have been reported previously. The present study addresses a distinct research question through multiplicity-controlled inferential analysis, effect-size estimation, and pooled location-specific odds ratios; nevertheless, readers should consider the shared source cohort when interpreting novelty and generalizability.
- Hearing and tinnitus outcomes were not prospectively assessed. The source protocol did not incorporate audiologic testing, tympanometry, or standardized otologic symptom questionnaires, so any relationship between cyst location, histopathological phenotype, and auditory or tinnitus symptoms could not be evaluated in this cohort and should be regarded as hypothesis-generating only.

CONFLICT OF INTEREST

The authors report no conflicts of interest. The authors are responsible for the content and writing of the paper.

REFERENCES

1. Giotakis EI, Weber RK. Cysts of the maxillary sinus: a literature review. In International forum of allergy & rhinology 2013 Sep (Vol.3, No.9, pp.766-771).
2. Gardner DG. Pseudocysts and retention cysts of the maxillary sinus. Oral surgery, oral medicine, oral pathology. 1984 Nov 1;58(5):561-7.
3. Moon IJ, Lee JE, Kim ST, Han DH, Rhee CS, Lee CH, Min YG. Characteristics and risk factors of mucosal cysts in the paranasal sinuses. Rhinology. 2011 Aug1;49(3):309.
4. Moon IJ, Kim SW, Han DH, Shin JM, Rhee CS, Lee CH, Min YG. Mucosal cysts in the paranasal sinuses: long-term follow-up and clinical implications. American journal of rhinology & allergy. 2011 Mar;25(2):98-102.
5. Yeung AW, Tanaka R, Khong PL, von Arx T, Bornstein MM. Frequency, location, and association with dental pathology of mucous retention cysts in the maxillary sinus. A radiographic study using cone beam computed tomography (CBCT). Clinical oral investigations. 2018 Apr;22(3):1175-83.
6. Hung K, Hui L, Yeung AW, Wu Y, Hsung RT, Bornstein MM. Volumetric analysis of mucous retention cysts in the maxillary sinus: A retrospective study using cone-beam computed tomography. Imaging science in dentistry. 2021 Jan 29;51(2):117.
7. Pérez-Sayáns M, Suárez Peñaranda JM, Quintanilla JA, Chamorro Petronacci CM, García AG, Carrión AB, Vila PG, Sánchez YG. Clinicopathological features of 214 maxillary sinus pathologies. A ten-year single-centre retrospective clinical study. Head & face medicine. 2020 Oct 13;16(1):24.
8. Pérez Sayáns M, Suárez Quintanilla JA, Chamorro Petronacci CM, Suárez Peñaranda JM, López Jornet P, Gómez García F, Guerrero Sánchez Y. Volumetric study of the maxillary sinus in patients with sinus pathology. PloS one. 2020 Jun 18;15(6):e0234915.

9. Rot P, Krzywdzińska S, Rozbicki P, Kwiatkowska MA, Kania-Pudło M, Zegadło A, Jurkiewicz D, Dżaman K, Sobol M. A Retrospective Study of the Prevalence of Maxillary Sinus Cysts Incidentally Detected on MRI Among Non-Symptomatic Caucasian Population . Journal of Clinical Medicine. 2025 Sep 24;14(19):6756.

10. Arslan İB, Uluyol S, Demirhan E, Kozcu SH, Pekçevik Y, Çukurova İ. Paranasal sinus anatomic variations accompanying maxillary sinus retention cysts: a radiological analysis. Turkish archives of otorhinolaryngology. 2017 Dec 1;55(4):162.

11. Whyte A, Boeddinghaus R. The maxillary sinus: physiology, development and imaging anatomy. Dentomaxillofacial Radiology. 2019 Dec1;48(8):20190205.

12. Bhattacharyya N. Do maxillary sinus retention cysts reflect obstructive sinus phenomena?. Archives of Otolaryngology–Head & Neck Surgery. 2000 Nov1;126(11):1369-71.

13. Wang JH, Jang YJ, Lee BJ. Natural course of retention cysts of the maxillary sinus: long-term follow-up results. The Laryngoscope. 2007 Feb;117(2):341-4.

14. Chen T, Shih MC, Edwards TS, Nguyen SA, Meyer TA, Soler ZM, Schlosser RJ. Eustachian tube dysfunction (ETD) in chronic rhinosinusitis with comparison to primary ETD: a systematic review and meta-analysis. InInternational forum of allergy & rhinology 2022 Jul (Vol.12, No. 7, pp. 942-951).

15. Yang TH, Chung SD, Lin HC, Liu TC. Associations of chronic rhinosinusitis and allergic rhinitis with tinnitus. Scientific Reports. 2026 Feb 10;16(1):8169.

16. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. The lancet. 2007 Oct 20;370(9596):1453-7.

17. Steelant B, Seys SF, Boeckxstaens G, Akdis CA, Ceuppens JL, Hellings PW. Restoring airway epithelial barrier dysfunction: a new therapeutic challenge in allergic airway disease. Rhinology. 2016 Sep 1;54(3):195-205.

18. Djurayev JA, Mirzaev SP, Soatov IO. DIAGNOSTIC AND TREATMENT METHODS FOR PATIENTS WITH MAXILLARY SINUS CYSTS. Eurasian Journal of Otorhinolaryngology-Head and Neck Surgery. 2026 Jun 10;5:35-9.