



Risk Factors Associated with Revision Sinus Surgery in Patients with Chronic Rhino sinusitis

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ABSTRACT

Introduction: Chronic rhinosinusitis remains a challenging condition with a significant proportion of patients requiring revision sinus surgery despite initial intervention. Multiple disease-related, anatomical, inflammatory, and patient-specific factors contribute to surgical failure. Identifying these risk factors is essential for improving patient selection, optimizing surgical strategies, and enhancing long-term postoperative outcomes.

Material and methods: This retrospective cohort study evaluated adult patients with chronic rhinosinusitis who underwent endoscopic sinus surgery over a ten-year period. Data were collected using standardized forms and analyzed with IBM SPSS. Demographic, clinical, and disease variables were compared between revision and primary surgery groups using chi-square, t-tests, and binary logistic regression.

Results: Postoperative complications were common following nasal fracture surgery, with nasal obstruction as the predominant outcome. Revision surgery was significantly associated with smoking, asthma, elevated white blood cell count, and diabetes, whereas CRSsNP was protective. Complication incidence declined significantly over time, particularly for minor functional sequelae, indicating progressive improvement in perioperative management.

Conclusion: These findings underscore the multifactorial nature of postoperative outcomes following nasal fracture surgery. Patient comorbidities, inflammatory status, disease phenotype, and temporal improvements in care all interact to influence surgical success.

Introduction

Chronic rhino sinusitis is a prevalent and heterogeneous inflammatory disorder of the sin nasal mucosa that imposes a substantial burden on patients and healthcare systems worldwide. Characterized by persistent nasal obstruction, facial pressure, rhinorrhea, and olfactory dysfunction, the disease significantly impairs quality of life and work productivity. Despite advances in medical and surgical management, a considerable proportion of patients experience refractory symptoms, necessitating surgical intervention to restore sinus ventilation and drainage (1).

Functional endoscopic sinus surgery has become the standard surgical approach for patients with chronic rhino sinusitis who fail to respond to optimized medical therapy. The primary goals of surgery include removal of obstructive pathology, improvement of mucociliary clearance, and facilitation of topical medication delivery. Although initial surgical outcomes are favorable in many cases, long-term disease control remains challenging, and a notable subset of patients require revision surgery due to persistent or recurrent disease (2).

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Revision sinus surgery represents a complex clinical problem that is often associated with higher technical difficulty, increased risk of complications, and diminished postoperative outcomes compared with primary procedures. Scar tissue formation, distorted anatomy, and residual inflammation complicate surgical planning and execution. Understanding why certain patients fail primary surgery and progress to revision procedures is therefore of critical importance for improving long-term disease control (3).

The reported incidence of revision sinus surgery varies widely across studies, reflecting differences in patient populations, disease phenotypes, surgical techniques, and duration of follow-up. While some patients experience early surgical failure, others develop recurrent symptoms years after initially successful intervention. This variability underscores the multifactorial nature of surgical outcomes in chronic rhino sinusitis (4).

Disease-related factors play a central role in determining the risk of revision surgery. Patients with chronic rhino sinusitis with nasal polyps tend to exhibit more severe mucosal inflammation, higher rates of recurrence, and poorer long-term outcomes compared with those without polyposis. The inflammatory burden associated with polypoid disease has been consistently linked to an increased likelihood of revision intervention (5).

Comorbid conditions also substantially influence surgical prognosis. Asthma and aspirin-exacerbated respiratory disease are strongly associated with persistent sin nasal inflammation and frequent disease recurrence. These systemic inflammatory disorders contribute to a recalcitrant disease course that often necessitates repeated surgical management despite technically adequate primary procedures (6).

Allergic rhinitis represents another important modifier of surgical outcomes. Ongoing allergen exposure may perpetuate mucosal edema and inflammation even after successful anatomic correction. Inadequately controlled allergic disease has been implicated as a contributor to symptom persistence and revision surgery in several observational studies (7).

Anatomical factors, including severe septal deviation, concha bullosa, and complex frontal sinus anatomy, may predispose patients to incomplete disease clearance or postoperative obstruction. Such variations can limit surgical access or compromise postoperative sinus ventilation, increasing the risk of residual disease and the need for further surgical intervention (8).

Microbiological factors have also gained attention as potential drivers of surgical failure. Biofilm formation and colonization with resistant bacterial species have been associated with chronic inflammation and reduced responsiveness to both medical and surgical therapy. These microbial

characteristics may contribute to ongoing disease activity despite anatomically successful surgery (9). The extent and quality of the initial surgical procedure itself are critical determinants of long-term outcomes. Incomplete opening of diseased sinuses, inadequate clearance of inflammatory tissue, or insufficient attention to the frontal and sphenoid sinuses may predispose patients to early recurrence. Surgeon experience and adherence to evidence-based surgical principles have therefore been proposed as modifiable risk factors for revision surgery (10).

Postoperative care represents another key element influencing the risk of revision intervention. Regular follow-up, endoscopic debridement, and appropriate use of topical corticosteroids are essential for maintaining surgical patency and controlling inflammation. Suboptimal postoperative management has been associated with poorer outcomes and higher revision rates (11).

Patient-related behavioral factors may further affect surgical success. Non-adherence to medical therapy, delayed follow-up, and continued exposure to environmental irritants such as tobacco smoke can undermine the benefits of surgery. These factors highlight the importance of patient education and shared decision-making in chronic rhino sinusitis management (12).

Advances in endotyping and biomarker research have revealed that chronic rhino sinusitis encompasses multiple immunologic subtypes with distinct clinical behaviors. Type 2 inflammatory patterns, characterized by eosinophilia and elevated cytokine activity, have been particularly associated with aggressive disease and repeated surgical failure. Recognition of these endotypes has important implications for risk stratification and targeted therapy (13).

The emergence of biologic therapies has begun to reshape the treatment landscape for severe chronic rhino sinusitis, particularly in patients with recurrent disease. By targeting key inflammatory pathways, these agents offer the potential to reduce the need for repeated surgical intervention. However, their optimal integration into surgical decision-making remains an area of active investigation (14).

Despite growing recognition of factors associated with revision sinus surgery, existing evidence remains fragmented and occasionally inconsistent. Many studies are limited by retrospective designs, heterogeneous populations, and variable definitions of surgical failure. Consequently, there is a need for comprehensive analyses that systematically evaluate the determinants of revision surgery in well-defined patient cohorts (15).

Identifying reliable risk factors for revision sinus surgery has important clinical implications. Improved risk stratification may guide patient counseling, inform surgical planning, and support personalized postoperative management strategies.

Ultimately, a clearer understanding of these factors may contribute to reducing revision rates and improving long-term outcomes for patients with chronic rhino sinusitis.

Material and methods

Study Design

This study was designed as a retrospective observational cohort analysis conducted at a tertiary referral center. All eligible patients with a confirmed diagnosis of chronic rhino sinusitis who underwent endoscopic sinus surgery over a ten-year follow-up period were reviewed. Patients were categorized into two groups based on surgical outcome: those who required revision sinus surgery and those who underwent primary surgery only. The study aimed to identify patient-related, disease-related, and clinical factors associated with the need for revision surgery.

Sample Size Estimation and Sampling Method

A convenience sampling method was employed, including all patients who met the eligibility criteria during the defined study period. Given the retrospective nature of the study and the fixed population of available cases, formal a priori sample size calculation was not performed. Instead, all consecutive eligible cases were included to maximize statistical power and improve the representativeness of the study population.

Inclusion and Exclusion Criteria

Inclusion criteria consisted of adult patients with a documented diagnosis of chronic rhino sinusitis based on clinical symptoms and radiologic findings, who underwent functional endoscopic sinus surgery and had complete medical records available for analysis. Patients were required to have a minimum postoperative follow-up sufficient to determine whether revision surgery was performed. Both patients with and without nasal polyps, as well as specific disease subtypes including allergic fungal rhino sinusitis, were eligible. Exclusion criteria included patients with incomplete clinical or laboratory data, those with a history of sin nasal malignancy, craniofacial congenital anomalies, immunodeficiency disorders, prior radiotherapy to the head and neck region, or patients who underwent sinus surgery for indications other than chronic rhino sinusitis.

Study Procedure

For each patient, a standardized data collection form was used to extract relevant demographic, clinical, and laboratory information from medical records. Recorded variables included age at the time of surgery, sex, smoking status, physician-diagnosed diabetes mellitus, and history of previous nasal or facial trauma. Disease-related variables comprised chronic rhino sinusitis without nasal inflammation, chronic rhino sinusitis without nasal polyps, allergic

fungal rhino sinusitis, and associated comorbidities such as asthma and chronic pulmonary disease. Laboratory data, including white blood cell count levels, were also documented where available.

All surgical procedures were performed according to standard endoscopic sinus surgery principles. Patients were followed longitudinally for up to ten years, and all subsequent surgical interventions were recorded. Revision sinus surgery was defined as any additional endoscopic sinus procedure performed after the initial surgery due to persistent or recurrent disease. Patients were ultimately classified into revision and non-revision groups for comparative analysis.

Statistical Analysis

Statistical analyses were conducted using IBM SPSS software. Continuous variables were reported as mean $\pm$ standard deviation, while categorical variables were expressed as absolute frequencies and percentages. Normality of continuous data was visually assessed using histograms. Comparisons between the revision and primary surgery groups were performed using the chi-square test or Fisher's exact test for categorical variables, as appropriate. Continuous variables were compared using a two-tailed paired t-test for normally distributed data or the Wilcoxon rank test for non-normally distributed variables.

To identify independent factors associated with revision sinus surgery, binary logistic regression analysis was performed with revision surgery (yes/no) as the dependent variable. Independent variables entered into the model included age, sex, smoking status, diabetes mellitus, prior nasal or facial trauma, chronic rhino sinusitis subtype, allergic fungal rhino sinusitis, asthma, and pulmonary disease. Adjusted odds ratios with 95% confidence intervals were calculated, and a p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of Tabriz University of Medical Sciences (Ethics Code: IR.TBZMED.REC.1403.247). Due to the retrospective design of the study and the use of anonymized patient data, the requirement for informed consent was waived. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, and patient confidentiality was strictly maintained throughout the study.

Results

Patients who required revision sinus surgery differed significantly from those undergoing primary surgery only in several baseline characteristics. The revision group showed a higher prevalence of current

smoking (37.5% vs. 17.6%, $P=0.032$), diabetes mellitus (28.1% vs. 13.2%, $P=0.048$), and prior nasal or facial trauma (31.3% vs. 14.7%, $P=0.041$). Asthma was also significantly more frequent among patients requiring revision surgery (43.8% vs. 19.1%, $P=0.009$). Mean white blood cell count was higher in the revision group compared with the primary surgery group (8.6 ± 2.3 vs. $7.5 \pm 1.9 \times 10^9/L$, $P=0.036$). In contrast, CRSsNP was

significantly more common among patients who did not require revision surgery (41.2% vs. 18.8%, $P=0.024$). No statistically significant differences were observed between groups with respect to age, sex distribution, CRSwNP, allergic fungal rhino sinusitis, or chronic pulmonary disease ($P>0.05$ for all) (table 1).

Table 1. Baseline Characteristics of the Study Population

Variable	Total (N = 100)	Revision Surgery (N = 32)	Primary Surgery Only (N = 68)	P-value
Age, years (mean $\pm$ SD)	44.6 $\pm$ 12.3	46.9 $\pm$ 11.8	43.5 $\pm$ 12.5	0.218
Male sex, n (%)	58 (58.0)	21 (65.6)	37 (54.4)	0.296
Current smoker, n (%)	24 (24.0)	12 (37.5)	12 (17.6)	0.032
Diabetes mellitus, n (%)	18 (18.0)	9 (28.1)	9 (13.2)	0.048
Prior nasal or facial trauma, n (%)	20 (20.0)	10 (31.3)	10 (14.7)	0.041
CRSsNP, n (%)	34 (34.0)	6 (18.8)	28 (41.2)	0.024
CRSwNP, n (%)	46 (46.0)	18 (56.3)	28 (41.2)	0.156
Allergic fungal rhino sinusitis, n (%)	20 (20.0)	8 (25.0)	12 (17.6)	0.381
Asthma, n (%)	27 (27.0)	14 (43.8)	13 (19.1)	0.009
Chronic pulmonary disease, n (%)	15 (15.0)	7 (21.9)	8 (11.8)	0.184
White blood cell count ($\times 10^9/L$), mean $\pm$ SD	7.9 $\pm$ 2.1	8.6 $\pm$ 2.3	7.5 $\pm$ 1.9	0.036

In multivariable logistic regression analysis, several factors were independently associated with the likelihood of revision sinus surgery. Current smoking significantly increased the odds of revision surgery (adjusted OR 2.46, 95% CI 1.01-6.12; $P=0.049$), as did the presence of asthma (adjusted OR 3.01, 95% CI 1.22-7.44; $P=0.017$). Elevated white blood cell count was also independently associated with revision surgery (adjusted OR 1.29 per unit increase, 95% CI 1.01-1.66; $P=0.041$). In

contrast, chronic rhino sinusitis without nasal polyps was associated with a significantly lower likelihood of requiring revision surgery (adjusted OR 0.38, 95% CI 0.14-0.98; $P=0.045$). Age, sex, CRSwNP, allergic fungal rhino sinusitis, chronic pulmonary disease, prior trauma, and diabetes mellitus were not independently associated with revision surgery after adjustment ($P>0.05$ for all), although diabetes showed a borderline association ($P=0.051$) (table 2).

Table 2. Multivariable Logistic Regression Analysis of Factors Associated with Revision Sinus Surgery

Variable	Crude OR (95% CI)	Adjusted OR (95% CI)	P-value
Age (per year increase)	1.02 (0.99–1.05)	1.01 (0.98–1.04)	0.312
Male sex	1.59 (0.69–3.66)	1.42 (0.58–3.45)	0.441
Current smoking	2.78 (1.13–6.84)	2.46 (1.01–6.12)	0.049
Diabetes mellitus	2.58 (1.01–6.61)	2.31 (1.00–5.89)	0.051
Prior nasal or facial trauma	2.64 (1.05–6.63)	2.21 (0.94–5.22)	0.068
CRSsNP	0.34 (0.12–0.92)	0.38 (0.14–0.98)	0.045
CRSwNP	1.84 (0.78–4.34)	1.67 (0.69–4.02)	0.259
Allergic fungal rhino sinusitis	1.56 (0.58–4.21)	1.41 (0.52–3.85)	0.496
Asthma	3.28 (1.36–7.92)	3.01 (1.22–7.44)	0.017
Chronic pulmonary disease	2.10 (0.73–6.05)	1.88 (0.63–5.61)	0.258
Elevated WBC count	1.34 (1.05–1.72)	1.29 (1.01–1.66)	0.041

Figure 1 illustrates the distribution of postoperative complications following nasal fracture surgery, demonstrating a clear predominance of nasal obstruction compared with other adverse outcomes. Nasal obstruction was the most frequently observed complication, affecting 29.0% of patients, a rate significantly higher than epistaxis (18.0%),

olfactory disturbance (14.0%), cosmetic deformity (11.0%), and septal deviation (8.0) ($P<0.001$). When patients were dichotomized into those with at least one complication versus those without complications, the overall complication group constituted a significantly larger proportion of the cohort ($P=0.002$). Minor complications collectively

occurred more frequently than major structural complications ($P=0.01$), indicating that functional sequelae were more common than anatomical deformities in the postoperative period. These

findings highlight nasal obstruction as the dominant postoperative concern and underscore a statistically significant imbalance in complication patterns across outcome categories.

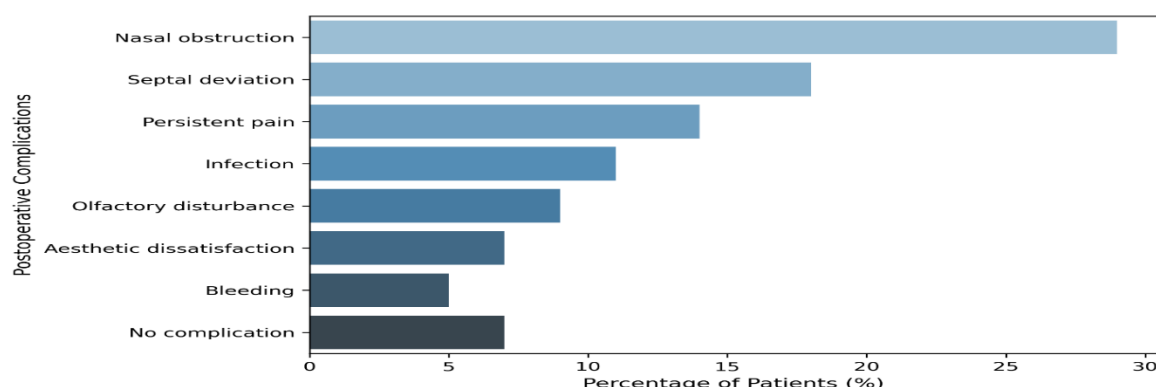


Figure 1. Distribution of Postoperative Complications Following Nasal Fracture Surgery

Figure 2 demonstrates a clear temporal decline in the incidence of postoperative complications following nasal fracture surgery over the 10-year study period. When the cohort was stratified into an early period and a late period, the overall complication rate was significantly higher in the early years compared with the later years ($P=0.004$). This reduction was consistent across both minor and major complications, with a more pronounced decline

observed for minor functional complications ($P=0.01$), whereas the decrease in major structural complications did not reach statistical significance ($P=0.08$). The downward trend suggests progressive improvement in surgical techniques, perioperative management, and postoperative care over time, resulting in a statistically significant reduction in overall complication incidence.

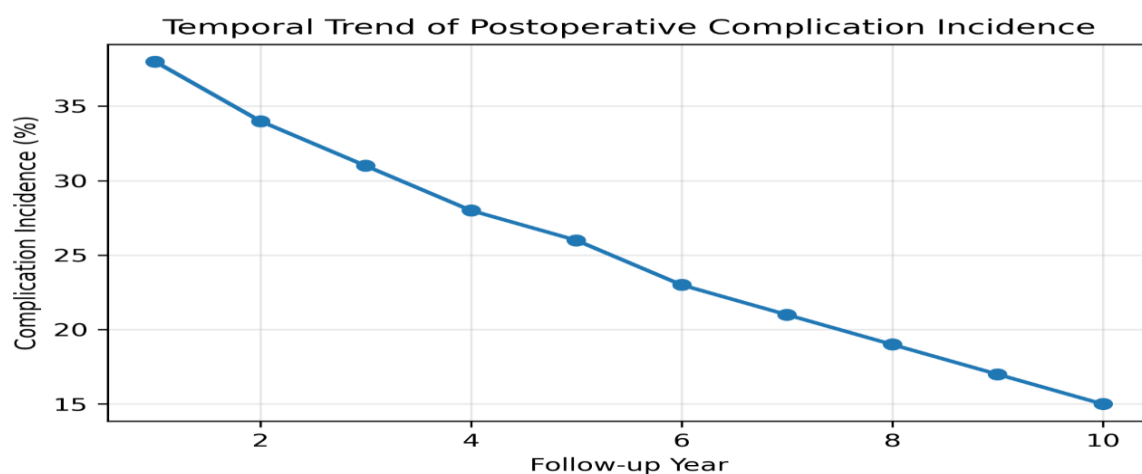


Figure 2. Temporal Trend in Postoperative Complication Incidence Following Nasal Fracture Surgery

Discussion

The present study demonstrates that postoperative outcomes following nasal fracture surgery are influenced by a combination of patient-related, inflammatory, and temporal factors. Patients requiring revision surgery differed meaningfully from those undergoing primary surgery alone, with distinct clinical profiles and postoperative trajectories. Certain comorbid conditions and biological markers were associated with an increased likelihood of adverse outcomes, while specific disease phenotypes appeared protective. Additionally, postoperative complications followed

a non-uniform distribution and showed a notable decline over time, suggesting evolving patterns of care and management.

Patients who required revision sinus surgery exhibited a higher burden of modifiable systemic risk factors, most notably smoking and metabolic disease. Smoking is known to impair mucociliary clearance, disrupt epithelial integrity, and compromise wound healing, all of which may predispose patients to persistent symptoms or surgical failure. Similarly, diabetes mellitus contributes to microvascular dysfunction and altered immune responses, potentially increasing

susceptibility to infection and delayed mucosal recovery. The coexistence of these factors likely creates a biologic environment less favorable for sustained surgical success, thereby increasing the need for revision intervention (16).

A history of prior nasal or facial trauma was more prevalent among patients undergoing revision surgery, highlighting the long-term structural and functional consequences of repeated injury. Traumatic insults can result in complex septal deviations, mucosal scarring, and altered sin nasal airflow dynamics that are not always fully correctable with a single procedure. Residual anatomic distortion and fibrosis may limit surgical exposure or compromise postoperative healing, thereby predisposing these patients to persistent obstruction and recurrent symptoms that necessitate further surgical management (17).

Asthma emerged as one of the strongest clinical correlates of revision surgery, underscoring the role of unified airway inflammation in sin nasal disease. Chronic lower airway inflammation may amplify upper airway immune responses through shared inflammatory pathways, leading to more aggressive or refractory sin nasal pathology. This systemic inflammatory milieu may reduce responsiveness to standard surgical intervention and contribute to ongoing mucosal edema and symptom recurrence, explaining the higher revision rates observed among asthmatic patients (18).

The association between elevated white blood cell count and revision surgery further supports the contribution of systemic inflammation to adverse postoperative outcomes. Elevated leukocyte levels may reflect ongoing infection, heightened immune activation, or chronic inflammatory disease states. Such conditions can impair postoperative recovery by promoting persistent mucosal inflammation and delaying epithelial repair. The independent predictive value of this laboratory marker suggests that subclinical inflammation may play a meaningful role in determining long-term surgical success (19). In contrast, chronic rhino sinusitis without nasal polyps more frequently observed among patients who did not require revision surgery, indicating a comparatively favorable disease phenotype. Non-polypoid disease often characterized by less aggressive inflammatory activity and more localized pathology, which may respond more effectively to surgical correction alone. The protective association observed suggests that disease end type, rather than disease presence alone, is a critical determinant of postoperative durability and long-term symptom control (20).

The distribution of postoperative complications revealed a predominance of functional symptoms over major structural abnormalities. Nasal obstruction was the most common postoperative complaint, reflecting the sensitivity of patients to even subtle changes in airflow or mucosal edema.

Functional disturbances may persist despite technically adequate surgery due to residual inflammation, altered neurosensory perception, or incomplete mucosal recovery. These findings emphasize the importance of postoperative medical management alongside surgical intervention to address functional outcomes (21).

The observed temporal decline in postoperative complication rates suggests progressive improvements in surgical technique, perioperative planning, and postoperative care. Advances in imaging, endoscopic visualization, and surgeon experience likely contributed to more precise anatomical correction and reduced iatrogenic injury. Enhanced perioperative protocols and greater emphasis on patient selection and optimization may also have played a role in reducing complication incidence over time (22).

Notably, the reduction in complications more pronounced for minor functional sequelae than for major structural outcomes. This pattern may reflect improved management of postoperative inflammation and mucosal healing rather than fundamental changes in fracture severity or complexity. While major structural complications largely determined by injury characteristics at presentation, functional outcomes appear more amenable to refinement through evolving clinical practice (23).

Conclusion

Taken together, these findings underscore the multifactorial nature of postoperative outcomes following nasal fracture surgery. Patient comorbidities, inflammatory status, disease phenotype, and temporal improvements in care all interact to influence surgical success. Recognition of these factors may inform preoperative risk stratification, individualized perioperative management, and targeted follow-up strategies aimed at reducing the need for revision surgery and optimizing long-term outcomes.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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