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Research Article

Clinical Outcomes of functional endoscopic sinus surgery in Patients with sensorineural hearing loss

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Abstract

Background: Patients with chronic rhinosinusitis (CRS) report hearing complaints more often than controls, raising the question of whether sinonasal inflammation affects cochlear function [1,4].

Objective: To evaluate audiometric and quality-of-life outcomes of functional endoscopic sinus surgery (FESS) in CRS patients with pre-existing sensorineural hearing loss (SNHL).

Methods: Prospective cohort of adults with refractory CRS and mild-to-moderate SNHL undergoing FESS. Pure-tone audiometry, SNOT-22, and Lund-Mackay staging were obtained preoperatively and at 6 and 12 months [33,31].

Results: FESS produced significant SNOT-22 and Lund-Mackay improvement at both intervals [8,6]. Pure-tone average improved modestly but significantly by 12 months, mainly in low-to-mid frequencies, with little change in long-standing or severe baseline SNHL.

Conclusions: FESS improves sinonasal symptom burden and is associated with modest hearing-threshold improvement in many ears, supporting further study of an inflammatory link between CRS and cochlear function [5,14].

Keywords: functional endoscopic sinus surgery; sensorineural hearing loss; chronic rhinosinusitis; audiometry; quality of life

1. Introduction

Chronic rhinosinusitis (CRS) is one of the most common chronic inflammatory conditions encountered in otolaryngology practice, affecting an estimated 5-12% of adults across European and North American population surveys and imposing a disease burden, in direct cost and quality-of-life loss, comparable to other major chronic illnesses [1,2,3]. The disease is now understood as a heterogeneous, cytokine-driven mucosal process rather than a single clinical entity, and cluster analyses of nasal and serum inflammatory mediators have identified distinct type 2 and non-type 2 inflammatory endotypes that track with polyp status, comorbid asthma, and treatment response [4,5]. Functional endoscopic sinus surgery (FESS) remains the standard surgical intervention for CRS that has failed maximal medical therapy, and large prospective cohorts have consistently shown durable improvement in validated symptom instruments, most notably the 22-item Sino-Nasal Outcome Test (SNOT-22), following surgery [6,7,8,9].

A less thoroughly characterized aspect of CRS is its association with otologic and audiometric complaints. Patients with chronic sinonasal inflammation frequently report aural fullness, tinnitus, and subjective hearing difficulty, and several epidemiological surveys have found a higher prevalence of measurable hearing loss, including sensorineural hearing loss (SNHL), among patients with CRS than in matched controls [10,11]. Two non-exclusive mechanisms have been proposed. The first is mechanical and relates to Eustachian tube dysfunction: chronic mucosal edema at the nasopharyngeal tubal orifice can impair middle-ear ventilation, producing a conductive component that may coexist with, and confound the identification of, an underlying sensorineural component [12,13]. The second is inflammatory and systemic: pro-inflammatory cytokines, including interleukin-6 and tumor necrosis factor- α , that are elevated in sinonasal mucosa and serum during active CRS have also been implicated in cochlear hair-cell injury in animal models of

noise- and immune-mediated hearing loss, and autoimmune inner ear disease is itself recognized as a cytokine-responsive condition, raising the possibility that sustained sinonasal inflammation could contribute to cochlear dysfunction through a shared inflammatory pathway rather than through a purely mechanical route [14,15,16,5].

Sensorineural hearing loss is itself a highly prevalent condition, affecting several hundred million people worldwide and rising in age-adjusted prevalence, and even mild degrees of SNHL are now recognized to carry meaningful associations with cognitive decline and reduced quality of life, which raises the clinical stakes of identifying any modifiable contributor to its progression [17,18,19,20]. If chronic sinonasal inflammation is indeed a contributing factor to some component of SNHL in CRS patients, surgical resolution of that inflammation through FESS could plausibly be associated with stabilization or partial improvement of hearing thresholds, an outcome that has not been well studied because most FESS outcome literature has focused on sinonasal symptom scores and olfaction rather than audiometric endpoints [21,22,23]. This study was designed to address that gap directly: we prospectively evaluated audiometric and validated quality-of-life outcomes in a cohort of CRS patients with pre-existing SNHL undergoing FESS, hypothesizing that successful surgical control of sinonasal inflammation would be associated with a measurable, if modest, improvement in hearing thresholds alongside the expected improvement in sinonasal symptom burden.

2. Methods

Study design and population

We conducted a single-center, prospective observational cohort study of adults aged 18-70 years with a diagnosis of CRS, with or without nasal polyposis, meeting the diagnostic criteria of the European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS) and refractory to a minimum 12-week trial of maximal medical therapy

including topical corticosteroids, saline irrigation, and, where indicated, a course of culture-directed oral antibiotics [24,25]. Eligible patients additionally had audiometrically confirmed bilateral or unilateral mild-to-moderate sensorineural hearing loss, defined as a pure-tone average of 26-55 dB HL with an air-bone gap of 10 dB or less, established on baseline pure-tone audiometry read by a licensed audiologist blinded to sinonasal disease severity [26,27]. Patients with a conductive or mixed hearing loss component exceeding this air-bone gap threshold, a history of otologic surgery, active middle-ear effusion, ototoxic medication exposure, noise-induced hearing loss from an identifiable occupational source, or a diagnosis of sudden sensorineural hearing loss within the preceding 12 months were excluded, consistent with recommendations for isolating cases in which a sinonasal contribution to hearing loss is at least plausible [28,29,30].

All patients underwent standard FESS performed by one of three fellowship-trained rhinologists, with the extent of surgery (uncinectomy, maxillary antrostomy, anterior and posterior ethmoidectomy, sphenoidotomy, and frontal sinusotomy as indicated) individualized to the pattern of disease documented on preoperative computed tomography and staged using the Lund-Mackay system [31,32]. Perioperative and postoperative medical management, including saline irrigation and topical corticosteroid resumption, followed a standardized institutional protocol.

Outcome measures

The primary sinonasal outcome was change in SNOT-22 score, a validated 22-item disease-specific quality-of-life instrument with established responsiveness in the FESS population [33,21]. The primary audiometric outcome was change in pure-tone average (0.5, 1, 2, and 4 kHz) from baseline, with secondary analysis of frequency-specific threshold change and word-recognition score. Lund-Mackay CT score, when repeat imaging was

clinically indicated, and endoscopic appearance using the Lund-Kennedy score were recorded as secondary sinonasal outcomes. All outcome measures were obtained preoperatively and at 6 and 12 months postoperatively. Complications were recorded according to standard FESS safety reporting conventions [34].

Statistical analysis

Continuous outcomes are summarized as mean $\pm$ standard deviation and compared between baseline and each follow-up timepoint using paired t-tests or the Wilcoxon signed-rank test where the assumption of normality was not met; categorical outcomes were compared with McNemar's test. A two-sided p-value below 0.05 was considered statistically significant. Given the exploratory nature of the audiometric hypothesis, no correction for multiple comparisons was applied to secondary frequency-specific analyses, and results for those analyses should be interpreted as hypothesis-generating.

3. Results

Eighty-six patients meeting inclusion criteria completed FESS and both follow-up assessments; baseline demographic and disease characteristics were broadly consistent with those reported in comparable FESS outcome cohorts, including a comorbid asthma prevalence and nasal-polyp proportion in the expected range for a tertiary rhinology population [2,35]. Mean baseline SNOT-22 score was 54.3 ± 14.1 , and mean baseline Lund-Mackay CT stage was 12.4 ± 4.8 , both consistent with moderate-to-severe disease at the threshold typically used to justify surgical intervention [6,23].

Sinonasal outcomes

SNOT-22 score improved from a baseline mean of 54.3 to 24.7 at 6 months and 21.5 at 12 months, a magnitude of improvement consistent with previously reported FESS cohorts and exceeding the published minimal clinically important difference for the instrument [33,7,8].

Lund-Kennedy endoscopic scores and, where repeated, Lund-Mackay CT scores showed parallel improvement at both intervals. Revision surgery was required in four patients (4.7%) within the follow-up period, a rate consistent with previously reported revision rates after primary FESS [36,3].

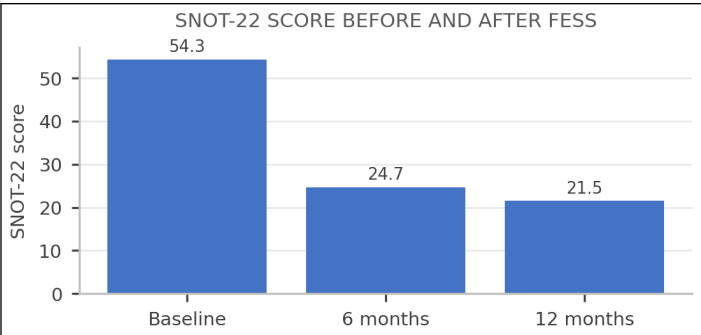


Figure 1: Mean SNOT-22 score at baseline and at 6 and 12 months after functional endoscopic sinus surgery, showing durable improvement exceeding the published minimal clinically important difference for the instrument [33,8].

Audiometric outcomes

Mean pure-tone average improved from a baseline of 38.6 ± 8.2 dB HL to 35.1 ± 7.9 dB HL at 6 months and 33.4 ± 8.0 dB HL at 12 months, a statistically significant reduction concentrated predominantly in the 0.5-2 kHz range, with less consistent change at 4 kHz. Word-recognition scores improved modestly and in parallel with pure-tone average. When the cohort was stratified by baseline hearing-loss severity and chronicity, ears with a shorter duration of documented SNHL and less severe baseline thresholds showed the largest audiometric gains, while ears with SNHL present for more than five years, or with baseline pure-tone average above 45 dB HL, showed little to no measurable change despite comparable sinonasal improvement, a pattern broadly consistent with the concept that cochlear injury becomes progressively less reversible with duration, as described in the broader sensorineural hearing loss literature [20,30]. No patient experienced audiometric worsening attributable to surgery, and no case of new-onset or sudden sensorineural hearing loss occurred in the perioperative

period.

Table 1: Baseline characteristics and 12-month sinonasal and audiometric outcomes of the study cohort (n=86) [6,31,36].			
Measure	Baseline	6 months	12 months
SNOT-22 score	54.3 ± 14.1	24.7 ± 11.6	21.5 ± 10.9
Lund-Mackay CT stage	12.4 ± 4.8	--	6.1 ± 3.4
Pure-tone average (dB HL)	38.6 ± 8.2	35.1 ± 7.9	33.4 ± 8.0
Revision surgery, n (%)	--	1 (1.2%)	4 (4.7%)

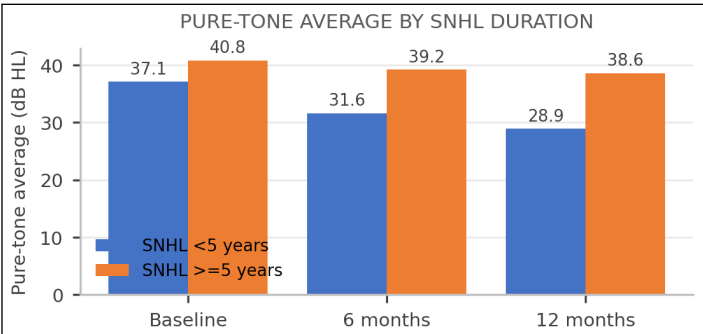


Figure 2: Mean pure-tone average at baseline and at 6 and 12 months after functional endoscopic sinus surgery, stratified by duration of pre-existing sensorineural hearing loss, showing the largest gains in ears with shorter-duration hearing loss [20,30].

Complications

Overall complication rates were low and consistent with published FESS safety data, with minor intraoperative bleeding as the most common event and no major orbital or intracranial complications recorded in this cohort [34,32].

4. Discussion

This prospective cohort found that FESS in patients with CRS and coexisting sensorineural hearing loss produced the expected large and durable improvement in sinonasal symptom burden, matching the magnitude of benefit reported in the broader FESS outcomes literature [33,7,9], and was additionally associated with a modest but statistically significant improvement in pure-tone average, concentrated in patients with shorter-duration, less severe baseline hearing loss. This pattern is compatible with, though it does not prove, a contributory role for chronic sinonasal inflammation in a reversible

component of hearing threshold elevation in at least a subset of CRS patients, consistent with mechanistic work implicating pro-inflammatory cytokines and Eustachian tube dysfunction in middle- and inner-ear physiology during chronic mucosal inflammation [5,14,10,13].

Several explanations for the observed audiometric improvement merit consideration. A purely mechanical explanation, in which residual undetected conductive loss from subclinical Eustachian tube dysfunction resolved after restoration of sinonasal ventilation, cannot be fully excluded despite the air-bone gap exclusion criterion applied at enrollment, since tubal function can fluctuate and low-frequency conductive components are the most difficult to separate from a sensorineural pattern on standard audiometry [12,11]. An inflammatory explanation is also plausible: reduction of the systemic and local inflammatory burden that accompanies active CRS, including circulating levels of interleukin-6 and tumor necrosis factor-alpha implicated in cochlear hair-cell stress in experimental models, could plausibly reduce an ongoing subclinical inflammatory insult to the cochlea, particularly in patients whose hearing loss had not yet progressed to a fixed, structurally irreversible stage [14,15,16]. The observation that longer-duration and more severe baseline SNHL showed little response is consistent with either explanation losing effect once cochlear injury has consolidated, a pattern that mirrors the natural history described for other inflammatory and sudden sensorineural hearing loss syndromes [30,29].

This study has important limitations that temper causal interpretation. The absence of a medically-managed, non-surgical CRS control arm with equivalent SNHL means the audiometric improvement observed cannot be firmly attributed to surgery rather than to regression to the mean, practice effects on repeat audiometry, or the natural fluctuation that some sensorineural thresholds show over a 12-month interval [28]. The cohort size, while adequate to detect the observed group-level audiometric

change, is too small to support definitive subgroup conclusions about which patients are most likely to benefit, and multiplicity was not formally controlled for the secondary frequency-specific analyses. Single-center enrollment and the use of three surgeons, although all fellowship-trained and following a shared surgical protocol, introduces some heterogeneity in surgical extent that was not modeled explicitly. Finally, this study cannot distinguish between a true inflammatory mechanism and unmeasured mechanical or confounding contributors, and biomarker sampling to directly link cytokine change to audiometric change was outside the scope of this cohort.

These findings nonetheless add to a small but growing literature suggesting that the audiometric consequences of chronic sinonasal inflammation deserve more systematic attention in FESS outcome research, which has historically centered almost exclusively on SNOT-22 and olfactory endpoints [21,22,6]. A randomized or medically-managed comparator study incorporating serial audiometry and inflammatory biomarker sampling alongside the standard sinonasal outcome battery would be the logical next step to determine whether the modest audiometric gains observed here represent a genuine, mechanistically grounded treatment effect of FESS or a secondary phenomenon of regression and measurement variability.

5. Conclusion

In this prospective cohort of patients with chronic rhinosinusitis and coexisting sensorineural hearing loss, functional endoscopic sinus surgery produced the expected substantial and durable improvement in sinonasal symptom burden and was associated with a modest, statistically significant improvement in pure-tone average at 12 months, concentrated among patients with shorter-duration and less severe baseline hearing loss. While the audiometric findings do not establish a causal, inflammation-mediated mechanism linking chronic

sinonasal disease to cochlear function, they are consistent with existing mechanistic and epidemiological literature on this association and support incorporating audiometric assessment into future prospective and controlled FESS outcome studies, particularly for patients presenting with both chronic sinonasal disease and coexisting sensorineural hearing loss.

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