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Revision rates and time to revision following endoscopic sinus surgery: a large
database analysis

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Abstract:

Objectives: Endoscopic sinus surgery (ESS) is performed for patients with chronic rhinosinusitis (CRS) that have failed maximal medical therapy. This study seeks to determine the prevalence of revision surgery and factors predicting the need for revision after ESS using a large statewide surgery database.

Study Design: Large retrospective cohort study using the State Ambulatory Surgery Database for the state of CA between 2005-2011.

Methods: We identified over 61,000 patients with CRS who underwent ESS, determined by CPT code. We identified which patients underwent a repeat surgery, and performed multivariable modeling to determine which factors (nasal polyps, age, gender, insurance, hospital setting, ethnicity) predicted the need for revision. Adjusted odds ratios (AOR) and 95% confidence intervals are presented.

Results: Of 61,339 patients who underwent ESS, 4,078 (6.65%) returned for revision ESS during the time period investigated. In a multivariable logistic regression model, positive predictors of revision were a diagnosis of nasal polyps (AOR 1.20, 95% CI 1.11-1.29, $p < 0.001$) and female gender (AOR 1.20, 95% CI 1.11-1.29, $p < 0.001$); public insurance was marginally predictive of increased re-operation (AOR 1.10, 95% CI 1.00-1.21, $p = 0.048$). Patients of Hispanic ethnicity were less likely to have revision surgery (AOR 0.86, 95% CI 0.77-0.97, $p = 0.011$). Age, income, and hospital setting were not significant predictors.

Conclusions: A minority of patients with CRS who undergo ESS will have a revision surgery. This likelihood is increased in female patients and those with nasal polyps, and decreased in patients of Hispanic ethnicity, even when controlling for income, insurance, and hospital setting.

Key Words: endoscopic sinus surgery, chronic rhinosinusitis, nasal polyps, revision

Level of Evidence: Level 2a

Introduction:

Chronic rhinosinusitis (CRS) affects an estimated 4.5-12% of the North American and European population [1] and negatively impacts quality of life in both disease-specific and general health-related domains [2]. Endoscopic sinus surgery (ESS) is an effective intervention for patients with medically recalcitrant CRS with over 250,000 ambulatory surgeries performed in the U.S. each year [3]. Although surgery has been shown to improve quality of life [4], symptom persistence and recurrence can occur necessitating revision surgery [5]. Although short-term failure rates have been well characterized with patient reported outcome measures, little is known about revision sinus surgery rates on both short and long timelines.

Limited, small sample size data on the overall revision rates following ESS provide some insight into this potential outcome. One Canadian study performed a survival analysis in 549 patients with CRS with nasal polyps (CRSwNP) and found that surgery-free survival ranged from 63-90% at 5 years and 11-83% at 10 years, and patients with asthma and aspirin sensitivity had higher recurrence rates [6]. A retrospective analysis of 490 patients with CRSwNP who underwent revision surgery over a 25 year period by a single surgeon found that the mean time to revision surgery was 4.87 ± 3.61 years, and that time to revision was shorter in patients who smoke and longer in patients who underwent middle turbinate resection [5]. Factors that did not reduce time to revision included gender, prior surgery, asthma, nasal polyps, CT stage, allergic mucin, or eosinophilia. Data from the UK Chronic Rhinosinusitis Epidemiological Study gives perhaps the most comprehensive view of revision surgery, demonstrating that among 1459 patients who underwent any surgery for CRS, there was an overall revision rate of 19.1% at 5 years, and that this rate was higher in patients with nasal polyps and allergic fungal rhinosinusitis than those with CRS alone [7]. However, the generalizability of these results to the U.S. healthcare environment may not be valid.

The goal of this study is to clarify the rate of revision surgery after ESS. Specifically, to determine what percentage of patients who undergo ESS require at least one revision surgery, and how much time elapses between the original and revision surgery. To date there has been no large database analysis in the U.S. that has looked precisely at the overall revision rate following ESS for CRS with or without NP, and compared revision rates and time to revision among patients with different comorbidities. We hypothesize that patients with CRSwNP will have increased revision rates and shorter time to revision.

Materials and Methods:

We utilized data from the Healthcare Cost and Utilization Project (HCUP), which is a family of health care databases and related software tools and products developed through a Federal-State-Industry partnerships and sponsored by the Agency for Healthcare Research and Quality (AHRQ) [8]. HCUP databases contain data from federal, state, hospital, and private organizations, and includes the largest collection of longitudinal hospital care data in the United States. Within HCUP is the State

Ambulatory Surgery and Services Database (SASD), which includes encounter-level data for ambulatory surgery and other outpatient services from hospital-owned facilities. The SASD contains more than 100 clinical and nonclinical variables such as all-listed diagnoses and procedures (coded by ICD-9 and CPT), patient demographic characteristics (e.g., sex, age, race), expected payment source, and hospital characteristics (e.g., urban v. rural). The SASD is commonly used for research on a variety of topics including analyses of ambulatory surgeries and trends.

Inclusion & Exclusion Criteria

We acquired data from SASD for California for all the years for which the data were available: 2005-2011. We searched the data set for patients who had endoscopic sinus surgery, as determined by CPT code (31254, 31255, 31256, 31267, 31276, 31287, and 31288). Patients who were less than 18 years old at the time of surgery and any patients who did not have an ICD-9 coded diagnosis for chronic rhinosinusitis were excluded. Patients with a diagnosis of allergic fungal rhinosinusitis and cystic fibrosis were excluded.

Data collection

Each patient had been previously assigned a unique de-identified “person-number” which allowed us to determine the number of surgeries the patient underwent in the defined time period. If the patient had more than one surgery they were classified as a “revision” patient. Data from the first surgery they underwent was used for analysis. From the data set, we also extracted demographic data (age, gender, ethnicity), insurance status (public v. private), income quartile, and hospital setting (urban v. rural).

Statistical analysis

Statistical analysis was performed using the program R version 2.13.1 (R Foundation for Statistical Computing, Vienna, Austria; <http://www.R-project.org>; R Development Core Team, 2011). Univariate analysis was performed comparing variables between patients who underwent revision surgery and those who did not. Odds ratios and 95% confidence intervals were calculated for all categorical variables, and students t-test was performed to compare age. A multivariate logistic regression was performed with the need for revision surgery as the binomial outcome variable. Predictors included the presence of nasal polyps, age, gender, income quartile (as a factor), insurance status, hospital setting, and ethnicity (as a factor). The time until revision surgery was analyzed by the Kaplan-Meier method and compared with the log-rank test. Cox proportional hazards model for disease-free survival (revision-free survival) was performed with the same predicting variables used in the logistic regression model. Statistical significance was set at a p-value of <0.05.

Results:

61,339 patients were identified who carried a diagnosis of CRS and underwent at least one ESS between 2005-2011. Of these patients, 4,078 patients were identified who had at least one revision ESS during the time period analyzed, yielding a revision rate of 6.65%. The mean time until revision surgery was 20.93 ± 17.29 months. 1,753 (43%) of all revision surgeries were performed within one year of the initial surgery. Demographic data are presented in **Table 1**. A concurrent diagnosis of nasal polyposis was present in 31.13% of all patients, and this proportion was statistically greater in those who underwent a revision surgery (34.09% v. 30.92%, $P < 0.001$). In the revision group there were also more women (50.29% v. 45.86%, $P < 0.001$), and fewer patients of Hispanic ethnicity (9.12% v. 10.33%, $P = 0.014$). An urban hospital setting was marginally more common in patients who underwent revision surgery (92.15% v. 91.20%, $P = 0.037$).

In a multivariable logistic regression model (**Table 2**), positive predictors of revision were a diagnosis of nasal polyps (AOR 1.20, 95% CI 1.11-1.29, $P < 0.001$) and female gender (AOR 1.20, 95% CI 1.11-1.29, $P < 0.001$). Public insurance was marginally predictive of increased re-operation (AOR 1.10, 95% CI 1.00-1.21, $P = 0.048$). Patients of Hispanic ethnicity were less likely to have revision surgery (AOR 0.86, 95% CI 0.77-0.97, $P = 0.011$). An urban hospital setting, which was significant in the univariate analysis, was not a significant predictor of revision in the multivariable analysis. Age and income were also not significant predictors.

Kaplan-Meier survival curves were created for overall survival, and survival stratified by the presence of nasal polyps, female gender, and Hispanic ethnicity (**Figure 1A,B,C,D** respectively). Overall actuarial survival rate at 5 years was 91.4%. For patients without nasal polyps 5 year survival was 92.1%, versus 90.1% for those with polyps (logrank $P < 0.001$). Overall actuarial survival rate at 5 years for males was 93.0% versus 90.7% for females (logrank $P < 0.001$). For all non-Hispanic patients the 5 year survival was 91.4% versus 91.6% for Hispanics (logrank $P = 0.245$).

A cox-proportional hazards model (**Table 3**) was performed to determine predictive variables. Variables included were the same for the multivariable described above model except age was excluded as it had a varying hazard ratio over time. The presence of nasal polyps was predictive of revision surgery (hazards ratio 1.19, 95% CI 1.11-1.27, $P < 0.001$), as was female gender (hazards ratio 1.24, 95% CI 1.16-1.32, $P < 0.001$), and public insurance (hazards ratio 1.10, 95% CI 1.03-1.19, $P = 0.008$). Hispanic ethnicity was not predictive, and no other covariates were significantly predictive.

Women accounted for 48.0% of the total cohort but accounted for only 38.4% of patients with CRSwNP versus 52.4% of those with CRSsNP ($P < 0.001$). Among patients with CRSwNP, women accounted for 44.9% of patients who had a revision surgery versus 37.9% of those who did not require revision ($P < 0.001$). Among patients with CRSsNP, women accounted for 56.4% of patients who had a revision surgery versus 52.1% of those who did not require revision ($P < 0.001$).

Discussion:

The present study investigated the rate of revision surgery after endoscopic sinus surgery for CRS in the largest data set published to date. This data reveals an overall revision rate of 6.65% and builds on smaller cohort data [6,7,9,10,11] reinforcing the association of revision surgery with CRSwNP. Furthermore, the present analysis identified female gender and Hispanic ethnicity associating with increased and decreased rates of revision, respectively. Kaplan-Meier survival curve analysis, which takes into account the varying length of follow-up for each patient, shows revision rates at 5 years are 7.9% for CRSsNP and 9.9% for CRSwNP.

Our data supports prior findings that the presence of nasal polyps increases the rate of revision surgery [7,12-16]. In addition to causing sinonasal obstruction, the presence of polyps inhibits normal mucociliary clearance [17]. It is still unclear whether worse outcomes and higher rates of revision in the presence of polyps are due to the more chronic and severe spectrum of the disease, or if there are other variables within the surgeon's control that may allow for improved outcomes. A recent cohort of patients with nasal polyposis has shown a 40% polyp recurrence rate at 18 months despite appropriate medical therapy [18]. It is possible that patients with CRSwNP would benefit from more extensive initial surgery including nasalization of the ethmoids [19], frontal sinusotomy [20] or middle turbinate resection [5] to improve ventilation and access of ongoing topical medical therapy. Furthermore, it is possible that medication regimens may need to be further optimized, and unfortunately the present study is limited by a lack of data frequency of postoperative exacerbations and need for systemic steroids.

Interestingly, this data demonstrates that women made up only 46% of the surgical population, but were more likely to undergo repeat surgery. This held true in univariate, multivariate, and cox proportional hazards modeling. A retrospective cohort analysis of 1393 patients with CRS showed that women accounted for only 38% of patients with CRSwNP. However, these women with CRSwNP had more severe disease and were more likely to require revision surgeries [33]. These authors suggested that estrogen may play a role by activating eosinophils and allowing autoreactive antibody-producing B cells to escape tolerance. In our cohort, women accounted for a similar minority of 38.4% of patients with CRSwNP, and women in the CRSwNP cohort were more likely to have revision surgery. However, we found that female gender was a risk factor for revision surgery in the CRSsNP cohort as well, suggesting there may be additional factors beyond disease severity that is driving increased revision rates in women.

It has been shown that high levels of anxiety and depression are common in patients with CRS, and that psychiatric comorbidity is associated with increased symptoms in CRS [21]. Increased rates of psychiatric comorbidities such as depression in women [22] may be one factor influencing the higher rates of revision surgery. Previous research has supported the notion that women have a higher prevalence of musculoskeletal pain, likely due to a combination of biological and psychosocial factors [23], and are more likely to report pain [24]. It is therefore possible that women are more likely to experience and report sinus symptoms and therefore require reoperation when

compared to their male counterparts. Historically, there have also been gender disparities in patients being offered orthopedic and vascular surgery [25,26] which may exist in sinus surgery and lead to women not being offered intervention until their disease has progressed and is less likely to respond optimally to intervention.

The present study also found patients of Hispanic ethnicity were less likely to undergo repeat surgery. Data from the 2010 Census [27] indicates that 37.6% of the CA population is Hispanic, though this group represented only 10% of our study population. Non-Hispanic whites were disproportionately represented among those undergoing surgery, making up 40.3% of the CA population, but 63.4% of our patient population. At least some of this discrepancy may be due to a lower prevalence of CRS in Hispanics. A study which analyzed data from the National Health Interview Survey of 27,731 U.S. residents, which included 610 Hispanics, showed a sinusitis prevalence of 8.8% in Hispanics compared to 13% in Caucasians [28]. An additional explanation for the discrepancy in both initial surgery and likelihood of revision in Hispanics may be access to healthcare. Indeed, in the study by Soler et. al [28], Hispanics were more likely to be uninsured, delay medical care due to cost-related concerns, and were less likely to have seen a medical specialist or undergone a surgical procedure in the previous 12 months. Our multivariate model controlled for known variables associated with diminished access to healthcare including income, insurance status, and urban setting, and yet the diminished revision rates of Hispanics remained significant. It is still quite plausible however that reduced access to care resulted in lower revision rates in Hispanics, as our data only included insurance status etc. at a single time point and these variables can easily change over time.

It should be noted that the revision rates presented in this study are overall are on the lower end of reported revision rates [5-7,9-11,29-31] and may be in part a reflection of the limitations of the database as there was no guaranteed follow-up for specific patients, and we therefore may not be capturing a portion of revision patients. Alternatively, the lower revision rate may be due to an overall lower disease burden in our population, which unlike many of the prior cohort studies, included patients from both university tertiary practices as well as community practices. Our period of observation (mean 42 months) may also not be long enough to capture patients that will ultimately undergo repeat surgery. However, we did find that 43% of patients who get revision will have it done within the first year. Furthermore, this data did not capture the number of patients that had already failed prior surgery, which is a known risk factor for failing a second surgery [30,32]. Further limitations of the present study are inherent in administrative data in a lack of granularity of likely clinically important factors such as patient reported and physician-reported measures of disease severity as well as concurrent therapies and variable coding practices among surgeons. The findings of the present study warrant further investigation in a prospective manner to clarify why patients of female gender and Hispanic ethnicity experience variable revision rates after ESS.

Conclusion:

Over 61,000 patients were identified who underwent outpatient ESS in CA between 2005-2011. In this large data set we found that overall revision-free survival at 5 years post-ESS was 91.4%. Factors that increased the rate of revision surgery included the presence of nasal polyps and female gender. Patients of Hispanic ethnicity were less likely to undergo revision surgery. These findings illustrate the need for further investigation into proper patient selection and operative intervention to minimize need for reoperation.

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Table 1. Baseline characteristics. Patient data split by those who underwent a revision surgery vs. those who did not. Data presented as the number of patients, and percentage of total (i.e. 30.92% of patients who did not have revision surgery had nasal polyps). T-test was performed for age. All other analyses are logistic regression yielding odds ratios with 95% confidence intervals.

Parameter	Total (N=61,339)	No revision (N=57,261)	Revision (N=4,078)	OR (95% CI)	P-value
Nasal Polyps - no. (%)	19093 (31.1)	17703 (30.9)	1390 (34.1)	1.16 (1.08-1.24)	<0.001
Age - yr (mean ± SD)	49.21 ± 14.77	49.20 ± 14.81	49.35 ± 14.20		0.512
Female sex - no. (%)	28310 (46.2)	26259 (45.9)	2051 (50.3)	1.19 (1.12-1.27)	<0.001
Ethnicity - no. (%)					
White	38863 (63.4)	36260 (63.3)	2603 (63.8)	1.02 (0.96-1.09)	0.517
Black	1310 (2.1)	1213 (2.1)	97 (2.4)	1.13 (0.91-1.39)	0.267
Hispanic	6289 (10.3)	5917 (10.3)	372 (9.1)	0.87 (0.78-0.97)	0.014
Asian	3002 (4.9)	2820 (4.9)	182 (4.5)	0.90 (0.77-1.05)	0.187
Native	26 (.04)	26 (.05)	0	NA	0.174
Other	11849 (19.3)	11025 (19.3)	824 (20.2)	1.06 (0.98-1.15)	0.137
Insurance - no. (%)					
Public	12696 (20.7)	11841 (20.7)	855 (21.0)	1.02 (0.94-1.10)	0.662
Private	46609 (76.0)	43545 (76.0)	3064 (75.1)	0.95 (0.88-1.02)	0.188
Income - no. (%)					
First quartile	9431 (15.4)	8828 (15.4)	603 (14.8)	0.95 (0.87-1.04)	0.281
Second quartile	13665 (22.3)	12797 (22.4)	868 (21.3)	0.94 (0.87-1.02)	0.115
Third quartile	16235 (26.5)	15115 (26.4)	1120 (27.5)	1.06 (0.98-1.13)	0.135
Fourth quartile	20791 (33.9)	19385 (33.9)	1406 (34.5)	1.03 (0.96-1.10)	0.416
Urban setting	55979 (91.3)	52221 (91.2)	3758 (92.1)	1.13 (1.01-1.28)	0.037

Significant differences ($P < 0.05$) in bold type

Table 2. Multivariable logistic regression showing predictors of revision surgery

Predictor	B (standard error)	OR (95% CI)	P-value
Nasal Polyps	0.18 (0.04)	1.2 (1.11-1.29)	<0.001
Age - yr	0.00004 (0.001)	1.0 (0.99-1.00)	0.977
Female sex	0.18 (0.04)	1.20 (1.11-1.29)	<0.001
Income			
1st quartile	Reference	Reference	
2nd quartile income	-0.05 (0.06)	0.95 (0.84-1.07)	0.390
3rd quartile income	0.05 (0.06)	1.05 (0.94-1.18)	0.369
4th quartile income	0.03 (0.06)	1.03 (0.92-1.15)	0.641
Public insurance	0.09 (0.05)	1.10 (1.00-1.21)	0.048
Urban setting	0.11 (0.08)	1.12 (0.96-1.30)	0.136
Race			
white	Reference	Reference	
black	0.06 (0.11)	1.07 (0.86-1.32)	0.558
hispanic	-0.15 (0.06)	0.86 (0.77-0.97)	0.011
asian/pacific	-0.15 (0.08)	0.86 (0.74-1.01)	0.070
native	-0.11 (0.01)	NA	0.917
other ethnicity	-0.14 (0.12)	0.87 (0.70-1.09)	-0.236

Significant differences (P < 0.05) in bold type

Table 3. Cox proportional hazards model showing which variables effected survival/need for revision surgery.

Predictor	B (standard error)	HR (95% CI)	P-value
Nasal Polyps	0.17 (0.03)	1.19 (1.11-1.27)	<0.001
Female sex	0.22 (0.03)	1.24 (1.16-1.32)	<0.001
Income			
1st quartile	-0.18 (0.13)	0.83 (0.64-1.08)	0.173
2nd quartile	-0.18 (0.13)	0.84 (0.64-1.09)	0.179
3rd quartile	-0.13 (0.14)	0.89 (0.69-1.17)	0.406
4th quartile	-0.14 (0.14)	0.87 (0.66-1.13)	0.289
Public insurance	0.09 (0.04)	1.1 (1.03-1.19)	0.008
Urban setting	0.13 (0.07)	1.14 (0.99-1.31)	0.063
Race			
white	0.02 (0.04)	1.02 (0.94-1.11)	0.649
black	0.14 (0.11)	1.15 (0.92-1.42)	0.218
hispanic	-0.06 (0.07)	0.94(0.83-1.07)	0.366
asian/pacific	-0.06 (0.08)	0.94 (0.80-1.12)	0.505
native	NA	NA	0.967
other ethnicity	-0.02 (0.12)	0.98 (0.7801.22)	0.831

Significant differences (P < 0.05) in bold type

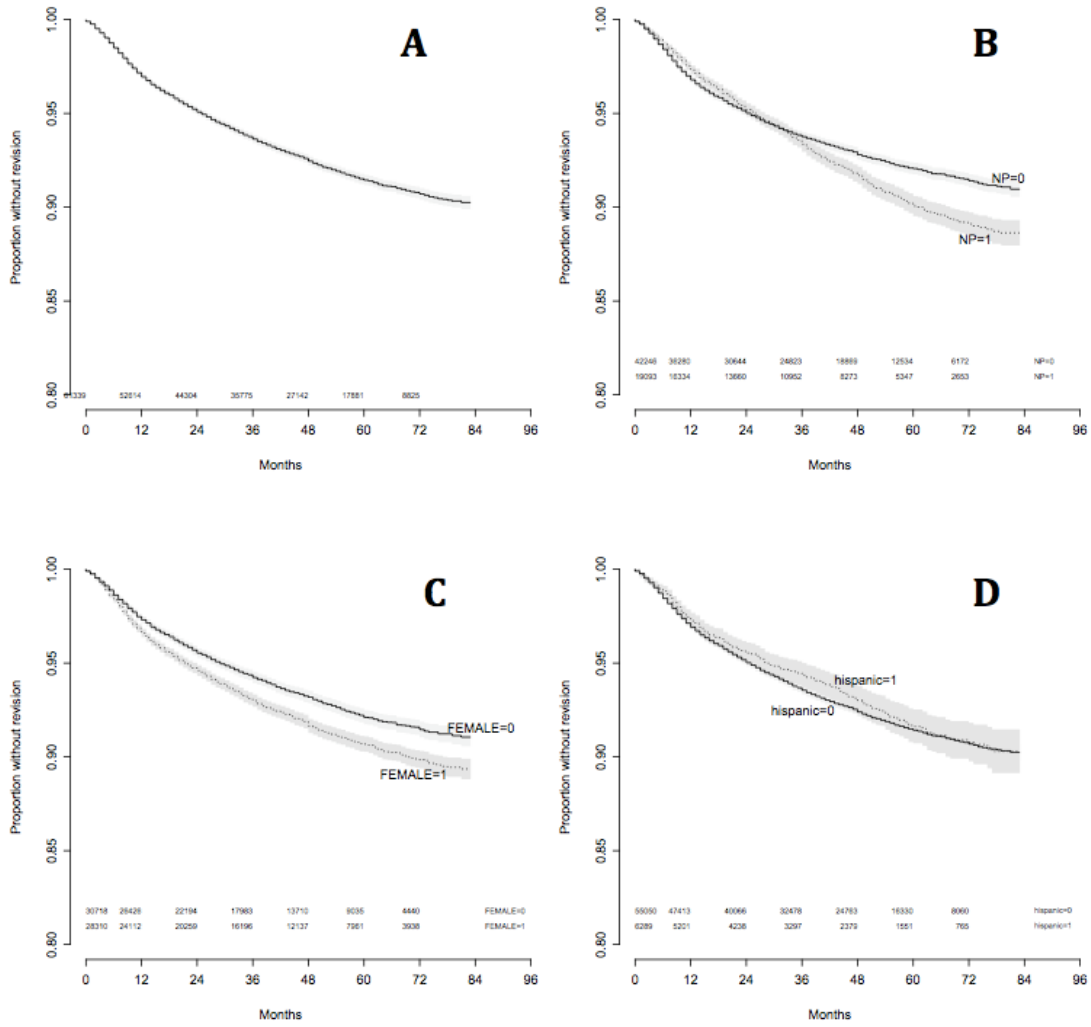


Figure 1. Kaplan-Meier survival curves for A) entire cohort, and stratified by B) nasal polyposis, C) female gender, D) hispanic ethnicity.