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Comparing Surgeon Outcomes in Endoscopic Sinus Surgery for Chronic Rhinosinusitis

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Abstract

OBJECTIVE—The objective of this investigation was to evaluate endoscopic sinus surgery (ESS) outcomes for chronic rhinosinusitis (CRS) between medical centers to determine if differences in quality-of-life (QOL) outcomes were detectable. In addition, we sought to identify significant, independent cofactors toward the development of an ESS-specific risk-adjustment model so that ESS outcomes may be appropriately compared between institutions and health care providers.

STUDY DESIGN—Prospective, multi-center, observational cohort.

METHODS—Study participants electing ESS for CRS were enrolled and randomly selected in equal numbers from three academic clinical practices in North America between April, 2011 and May, 2015. The magnitude of average 6-month postoperative improvement in patient-related

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outcome measures (PROMs) was compared between enrollment sites using multivariate linear regression modeling.

RESULTS—A total of 228 participants met inclusion criteria and were included for final analyses (n=76 per site). The prevalence of septal deviation/septoplasty and oral corticosteroid dependent conditions was significantly different between enrollment sites (p = 0.004). Each enrollment site generated significant within-subject improvement across all PROMs after ESS (p<0.001), however, average unadjusted magnitudes of improvement were significantly different between sites for the primary outcome measure. After controlling for baseline PROMs, septal deviation, steroid dependent conditions, and medication use variables, enrollment site was no longer associated with significant outcome differences (p=0.535).

CONCLUSION—Comparison of surgeon outcomes of ESS is feasible and must take into account a number of baseline patient characteristics. Further studies will be critical toward developing an ESS-specific risk-adjustment model and enabling a robust comparison of surgeon outcomes.

MeSH Key Words

Outcome Assessment (Health Care); Patient Outcome Assessment; Surgeons; Quality Improvement; Sinusitis; Quality of Life

INTRODUCTION

As value-based healthcare and quality improvement initiatives become more entrenched in modern medical culture, numerous systems of collecting and describing patient-reported outcome measures (PROMs) have emerged across medical practices and specialties.¹⁻³ While PROMs are a well-known tool to evaluate both patient safety and satisfaction, they can also be used to measure processes of care, health service delivery, and institutional performance. Previous findings using PROMs have, in fact, shown that outcome measures among surgeons and institutions can be highly variable for procedures such as: abdominal aortic aneurysm repair, carotid endarterectomy, cancer surgery, pancreatic resection, and laparoscopic Nissen fundoplication.⁴⁻⁸ For endoscopic sinus surgery (ESS) for chronic rhinosinusitis (CRS), a change or improvement in disease-specific, quality-of-life (QOL) has been adopted as a primary PROM of interest for this patient population.⁹⁻¹¹ In support of this guideline, single and multi-institutional studies using a variety of patient-based outcomes for ESS have been widely published in the last decade.¹²⁻¹⁸ A comparison of ESS outcomes for CRS between institutions and/or surgeons is, however, currently lacking and will be a necessary component of value-based healthcare for the practice of Rhinology.

The objective of this investigation was to evaluate ESS outcomes for CRS between several academic medical centers to determine if differences in QOL outcomes could be detected. In addition, we sought to identify factors that might impact outcomes that would need to be considered in the development of an ESS-specific risk-adjustment model so that outcomes may be appropriately compared between institutions and health care providers.

MATERIALS and METHODS

Study Population and Inclusion Criteria

Study participants consisted of adult patients (≥ 18 years of age) referred to tertiary surgeons with a confirmed diagnosis of medically refractory CRS. Diagnostic criteria for CRS consisted of guidelines endorsed by the American Academy of Otolaryngology.¹⁹ Study participants elected to pursue ESS following unsuccessful medical regimens including, but not limited to, at least 1 course (>14 days) of culture-directed or broad-spectrum antibiotics, at least one trial of either topical corticosteroids (> 21 days) or a 5 day course of oral corticosteroid therapy, and daily saline irrigations (>21 days). These treatment criteria were developed based on a consensus of expert opinion of the co-authors prior to enrollment.

Participants provided written, informed consent in English and agreed to complete preoperative and postoperative study evaluations per the study protocol. An academic, Institutional Review Board (IRB) provided study approval with continuing annual reviews with each enrollment center. Study participants were prospectively enrolled, observed, and evaluated through the standard of care surrounding ESS for CRS for 6 months postoperatively. Study participation was voluntary and did not alter the standard of care.

Surgical Intervention

Surgical approach was directed by the enrolling clinician and guided by symptomatic, radiographic, and endoscopic indications of disease severity. Endoscopic sinus surgery procedures consisted of maxillary antrostomy, partial or total ethmoidectomy, sphenoidotomy, or frontal sinusotomy procedures, with septoplasty and inferior turbinate reductions as adjunctive procedures as determined necessary by the treating surgeon. All surgical cases were followed with appropriate evidence-based postoperative therapeutic regimens including daily nasal saline rinsing, topical corticosteroid therapy, and other appropriate medical therapies as determined necessary by the treating surgeon.²⁰

Clinical Measures of Disease Severity

Radiographic and endoscopic diagnostic evaluations of disease severity were collected during preoperative clinical assessments and utilized for study objectives. High resolution computed tomography (CT) was utilized to evaluate sinonasal disease severity using 1.0mm contiguous images in both sagittal and coronal planes. Images were staged by each on-site enrolling surgeon in accordance with the Lund-Mackay scoring system.²¹

The paranasal sinuses were evaluated bilaterally using rigid, fiberoptic 0–30° endoscopes by each on-site enrolling physician. Endoscopic exams were staged in accordance with the Lund-Kennedy scoring system.²² Endoscopy scores were also collected during 6-month clinical follow-up.

Disease-Specific, Patient-Reported Outcome Measures

The primary PROM of interest to this investigation was the 22-item SinoNasal Outcome Test (SNOT-22), a validated instrument developed to quantify symptom severity associated with sinonasal conditions (©2006, Washington University, St. Louis, MO).^{23,24} Individual item

scores are measured using patient selected Likert scale responses where higher scores indicate worse symptom severity as follows: 0= 'No problem'; 1='Very mild problem'; 2='Mild or slight problem'; 3='Moderate problem'; 4='Severe problem'; 5='Problem as bad as it can be'. Higher total scores on the SNOT-22 suggest worse patient functioning or symptom severity (total score range: 0–110). The 22-items of the SNOT-22 survey have previously been categorized and summarized into 5 distinct domains including: rhinologic symptoms (score range: 0–30), extra-nasal rhinologic symptoms (score range: 0–15), ear / facial symptoms (score range: 0–25), psychological dysfunction (score range: 0–35), and sleep dysfunction (score range: 0–25) as previously described.²⁵ The minimal clinically important difference (MCID) for SNOT-22 total scores has been previously described as a within-subjects improvement of at least 8.9 points.²³

The secondary outcome of interest was the Rhinosinusitis Disability Index (RSDI), a 30-item survey instrument developed to quantify symptom severity associated with CRS in a complimentary fashion. The RSDI consists of 3 domains which evaluate the impact of CRS on a respondent's physical (range: 0–44), functional (range: 0–36), and emotional (range: 0–40) domains. Individual item scores are measured using patient selected Likert scale responses where higher scores indicate worse symptom severity as follows: 0= 'Never'; 1= 'Almost never'; 2= 'Sometimes'; 3= 'Almost always'; and 4= 'Always'. Higher total scores on the RSDI suggest worse patient functioning or symptom severity (total score range: 0–120).²⁶ The MCID for RSDI total scores have previously been defined as a within-subjects improvement of at least ½ standard deviation (SD) of the preoperative mean score.^{14,27} Each on-site enrolling surgeon was blinded to survey responses for the entire study duration.

Medication Use Measures

Participants were asked to provide additional information regarding perioperative medication use for treatment of CRS specifically. At both preoperative and 6-month postoperative evaluations, patients recalled the number of days (out of the previous 90 days) they utilized medications for the treatment of their sinus disease including: Topical nasal steroid sprays (e.g., fluticasone, mometasone, etc); Topical nasal steroid drops / irrigations (e.g., prednisolone drops, budesonide respules, etc); Decongestants; Oral / systemic antibiotics; Oral / systemic corticosteroids (e.g. prednisone, methylprednisolone); Antihistamines; Leukotriene modifiers (e.g. montelukast, zafirlukast, etc); Saline irrigation rinses.

Study Exclusion Criteria

Study participants were excluded from final analyses if they did not complete all preoperative enrollment procedures and evaluations or had not yet completed the 6-month postoperative follow-up time period.

Data Management and Statistical Analysis

Protected health information was removed and study data was safeguarded using unique study identification (ID) number assignments for each participant. Study data was securely transferred to Oregon Health & Science University from each enrollment site for manual entry into a password protected relational database (Access, Microsoft Corp, Redmond, WA). All statistical analyses were completed using commercially available software (SPSS

v.22, IBM Corp., Armonk, NY). In order to avoid enrollment bias by treating surgeons, blinding of all study data to provider/institution was performed and maintained throughout the entire project, including all co-authors. All unique study ID numbers were removed and each patient entry received alternative random number assignment. In order to blind all investigators and statisticians, each institution was reassigned a unique site ID designation by personnel not associated with this investigation. The site with the lowest number of participants with appropriate follow up yielded a sample of n=76. Therefore, n=76 subjects were then randomly chosen from each of the other sites for final analysis.

Data was evaluated descriptively while normality or skewness was verified for all ordinal or continuous measures. Patient characteristics, comorbid status, and surgical procedures were all compared for omnibus differences across enrollment sites using either one-way analysis of variance (ANOVA; F-test), Kruskal-Wallis, or Chi-square (χ^2) testing, with two-sided bivariate multiple comparison testing where appropriate. Further ANOVA testing was used to compare differences in mean preoperative and postoperative QOL scores between enrollment sites. Two-sided matched pairs t-testing was utilized to identify significant within-subjects improvement in QOL across each enrollment site. Test statistics were provided for all normally distributed data where appropriate.

Simple stepwise linear regression was used to identify significant independent risk factors associated with 6-month postoperative mean improvement (postoperative scores minus preoperative scores) for SNOT-22 and RSDI total scores when appropriate. Preliminary models included Enrollment Site as the main exposure variable of interest and all other independent factors screened for univariate significance ($p < 0.250$). A total of 25 variables were additionally screened for univariate, independent significance including preoperative patient characteristics, preoperative QOL status, and 6-month postoperative medication use cofactors. Final models used a manual forward selection ($p < 0.100$) and backwards elimination ($p < 0.050$) process and multi-collinearity was evaluated using variance inflation factors (VIFs). Significant covariates were introduced into final models to assess potential confounding of the effect estimate for enrollment site difference. Any covariate resulting in an absolute change of $\pm 10\%$ in the effect estimate value for the site variable was considered a confounder.^{28,29} Unadjusted and adjusted regression coefficients (β), standard errors (SE), 95% confidence intervals, and estimates of type-I error (p-values) are reported. The percentage of final model variance explained by each model was calculated using coefficients of multiple determination (R^2).

RESULTS

Final Cohort Characteristics

Final analysis was conducted on a cohort of 228 study participants (76 patients from each site) with CRS who met inclusion criteria, completed all preoperative study requirements, and underwent ESS between April, 2011 and May, 2015. Final cohort characteristics and preoperative clinical measures of disease severity are delineated across enrollment sites in Table 1. Important baseline factors were similar among the sites including: age, gender, prior sinus surgery, polyposis, aspirin sensitivity, allergy, depression, and tobacco abuse. The prevalence of both septal deviation and oral corticosteroid dependent conditions was

significantly different between enrollment sites (both $p < 0.004$). Clinical measures of disease severity (CT and Endoscopy scores) were also found to be significantly different between enrollment sites ($p = 0.006$; Table 1).

Baseline Quality of Life, Medication Use, and Surgical Procedures Performed Between Sites

Average preoperative scores for each disease-specific QOL outcome measure were compared between enrollment sites (Table 2). Average, preoperative QOL status was comparable between all sites with the exception of worse sleep dysfunction domain scores as measured by the SNOT-22 survey ($p = 0.009$). Mean preoperative days of medication usage for sinus disease were additionally compared between enrollment sites (Table 3). Study participants used similar durations of preoperative medications across enrollment sites with the exception of variations in exposure to decongestants ($p = 0.004$) and saline irrigation rinses ($p = 0.021$).

The frequencies of surgical procedures between enrollment sites are described in Table 4 and are similar with the exception of septoplasty which was performed significantly more commonly at enrollment sites #2 and #3 relative to enrollment site #1.

Postoperative Improvements in Quality of Life Between Sites

Unadjusted, mean improvement in each QOL measure was evaluated between all three enrollment sites to compare magnitudes of 6-month postoperative improvement (Table 5). All enrollment sites reported significant postoperative improvement 6 months after ESS across QOL measures ($p < 0.001$). The magnitude of mean improvement was found to be significantly different between enrollment sites for some QOL outcomes including the primary outcome SNOT 22 (-20.5 vs. -26.8 vs. -29.1 ; $p = 0.027$).

Comparison of Postoperative Medication Use Between Sites

Average days of postoperative medication use (out of the previous 90) for treatment of sinus disease were also compared between enrollment sites in a similar fashion (Table 6). Significant differences were found in topical steroid use (sprays, drops/irrigations) postoperatively suggesting enrollment site #1 either prescribed these less frequently, or patients enrolled at that site were less compliant with prescribed therapy.

Linear Regression Modeling

The final unadjusted and adjusted stepwise linear regression model for cofactors independently associated with improvement in total SNOT-22 scores are described in Table 7. Objective disease severity as measured by CT and endoscopy varied across sites but these factors did not impact outcomes and did not require adjustment. The effect estimates on SNOT-22 change scores for baseline QOL, septoplasty, postoperative medication use, and oral corticosteroid dependent condition are described in the order of increasing magnitude. After adjusting for all independent cofactors, enrollment site was no longer a significant variable associated with 6-month postoperative improvement in SNOT-22 scores ($p = 0.535$). Final independent model cofactors were able to explain ~41% of overall model variance while no evidence of multicollinearity between variables was found ($VIFs < 2.0$).

DISCUSSION

These data show that clinically meaningful improvements in QOL, following ESS for CRS, occurred in all three centers we evaluated. However, without adjustment for multiple cofactors, there was a statistically significant difference in improvement between the three enrollment centers, with a ~20 point improvement in SNOT-22 total scores on the low end and ~30 point improvement on the higher end on average. While the baseline characteristics of patients treated at each of the centers were relatively similar, important predictors of improvement were identified including baseline SNOT-22 total scores and the prevalence of oral steroid dependent comorbidity. Due to the fact that the effect estimate for the main exposure variable was confounded by other cofactor differences, inclusion of baseline/preoperative QOL scores was warranted and improved overall model efficiency.³⁰ In addition, important and significant differences in unadjusted, average SNOT-22 total score improvements were found between enrollment sites for patients with baseline septal deviation and the subsequent performance of concurrent septoplasty.

In final regression models, mean differences in outcomes between enrollment sites became non-significant after accounting for differences in baseline QOL, oral steroid dependent diseases, and performance of concurrent septoplasty. In addition to comparing postoperative differences in mean SNOT-22 improvement scores, the unadjusted prevalence of participants achieving at least one MCID in disease-specific QOL scores was different between enrollment sites. A significantly lower prevalence ($p=0.013$) of improvement was reported for enrollment site #1 for SNOT-22 total scores compared to enrollment sites #2 and #3 (68% vs. 87% and 83%, respectively). These data demonstrate *proof of concept* that differences in QOL outcomes of ESS for CRS can be detected between centers, using a variety of analytical approaches, and important factors must be considered when interpreting such a comparison including clinical and treatment differences between the sites.

Baseline characteristics that have been previously implicated in potentially reducing improvement in PROMs following ESS include prior ESS, ASA intolerance, depression, psychological distress/anxiety, and tobacco abuse.^{14,31–36} All of these factors were evaluated as part of this investigation but were found to occur at similar prevalence between enrollment sites. In future studies that include non-tertiary sites where some of these factors will likely occur with differing frequencies, these potential predictive factors will need to be carefully considered in any comparison of outcomes and adjusted for if necessary.

We did not anticipate a difference in the rate of septal deviation or the performance of concurrent septoplasty between the sites. Even more surprising was the apparent impact of septoplasty on outcomes (Table 8). Some studies have suggested that concurrent septoplasty does not associate with treatment outcomes of ESS.³⁷ It is clear to all who perform this surgery that the decision to perform concurrent septoplasty is based on several factors including extent of deviation, potential impact on access to the sinuses for ESS and postoperative debridement, postoperative drug delivery, and baseline patient-specific symptoms including nasal airway obstruction, among others. It is unclear whether performance of septoplasty was based on fundamental differences in surgical philosophy or differences in the prevalence of deviation across centers, but none of the other surgical

procedures differed among the centers including procedures considered more advanced. It is also interesting that differences in total SNOT-22 outcomes were driven by differences in the Ear/Facial and Psychological domains of the instrument. While it would seem logical that septoplasty would improve nasal obstruction and therefore the Rhinologic domain, the impact of septoplasty may be more all-encompassing if it improves drug delivery post operatively. The reasons why septal deviation impacts outcomes and indications for performing septoplasty are still unclear and this topic deserves further study.

The magnitude of association of oral steroid dependent diseases with reduced SNOT-22 total score improvement deserves further discussion. It is apparent to sinus surgeons that oral steroid dependent sinusitis or asthma would be indicative of a particularly severe form of inflammation that might impact disease-specific outcomes and 16/22 steroid dependent patients, collectively, fell into this category. Unfortunately, the classification of steroid dependence and the requirement for patients to be on chronic steroids for any condition can be arbitrary depending on varying clinician practices. Chronic steroid use will also potentially impact baseline QOL, endoscopy, and CT scores and could potentially modify reported effect estimates. Interestingly, 6 of 22 steroid dependent patients suffered autoimmune diseases. These data suggest that patients with autoimmune diseases that are oral steroid dependent experience less improvement with sinus surgery. Future studies with strict criteria for inclusion of steroid dependent subjects are another area for future research.

Limitations of our study include the inclusion of sites with only fellowship trained, tertiary surgeons which limits the variability in baseline patient factors and the generalizability of these findings. However, this comparison is novel, quite challenging to perform, and a necessary step in today's healthcare environment. Another limitation is the recall-based medication use measures, which are subject to recall bias. Despite this, critical pre-operative medication use for the treatment of CRS, such as antibiotic and steroid therapy, appeared similar at all three sites. On the other hand, postoperative use of topical steroids (eg. sprays, drops, irrigations) were utilized by patients significantly less at enrollment site #1 suggesting that either surgeons prescribed these less frequently or patient compliance with these medications was reduced at that site. Analysis demonstrated that less postoperative topical steroid was significantly associated with less improvement in SNOT-22 but was clinically irrelevant (i.e. trivial effect size).

Throughout this investigation, the identification of enrollment sites was blinded for all authors and contributors as a condition of entering the study. This was accomplished in order to avoid patient selection bias that might occur if surgeons knew the data would become public. Our objective was not to report outcomes for specific institutions or surgeons, rather to demonstrate that such a comparison is possible and to begin an analysis of confounding factors for which we must account in such comparisons. The future of clinical research consortiums will likely be impacted by the reporting of these data and we have treated these data with considerable sensitivity.

CONCLUSION

Comparison of surgeon outcomes of ESS is feasible and must take into account a number of different baseline characteristics including baseline QOL, septal deviation, and steroid dependent illnesses. Further studies using a variety of sites will be critical to enhancing baseline variability of important patient factors (e.g., history of prior surgery, aspirin intolerance, depression/psychosocial distress) toward developing an *ESS-specific risk-adjustment model* and enabling a robust comparison of surgeon outcomes.

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Table 1

Comparison of preoperative patient characteristic between enrollment sites (n=228)

	Enrollment Site #1 (n=76)	Enrollment Site #2 (n=76)	Enrollment Site #3 (n=76)	
Patient Characteristics:	Mean [SD] / N(%)	Mean [SD] / N(%)	Mean [SD] / N(%)	p-value
Age (years)	53.7 [16.9]	48.6 [14.9]	52.8 [15.6]	0.103
Males	32 (42%)	29 (38%)	34 (45%)	0.710
Previous Sinus Surgery	41 (54%)	40 (53%)	36 (47%)	0.692
Septal deviation	12 (16%)	33 (43%)	41 (54%)	<0.001
Nasal polyposis	23 (30%)	25 (33%)	30 (40%)	0.468
Asthma	24 (32%)	34 (45%)	22 (29%)	0.092
ASA sensitivity	7 (9%)	6 (8%)	2 (3%)	0.223
Allergy (history)	20 (26%)	17 (22%)	16 (21%)	0.726
Allergy (testing)	40 (53%)	31 (41%)	29 (38%)	0.160
Depression (history)	6 (8%)	15 (20%)	13 (17%)	0.099
Current smoker	2 (3%)	3 (4%)	3 (4%)	0.878
Current alcohol consumption	38 (50%)	31 (41%)	42 (55%)	0.219
Ciliary dysfunction / CF	4 (5%)	2 (3%)	3 (4%)	0.707
Corticosteroid dependency	13 (17%)	8 (11%)	1 (1%)	0.004
Diabetes mellitus (Type I/II)	6 (8%)	3 (4%)	9 (12%)	0.196
CT total scores	10.9 [5.5]	10.2 [5.8]	13.3 [6.6]	0.006
Endoscopy total scores	5.4 [3.6]	5.0 [4.0]	7.1 [3.5]	0.002

N, sample size; SD, standard deviation; ASA, acetylsalicylic acid (aspirin); CF, cystic fibrosis; CT, computed tomography; p-values are reflective of omnibus test results and reflect significant differences between at least two independent enrollment sites.

Table 2

Comparison of mean preoperative disease-specific QOL scores between enrollment sites

Preoperative disease-specific QOL scores:	Enrollment Site #1 (n=76)		Enrollment Site #2 (n=76)		Enrollment Site #3 (n=76)		F-test	p-value
	Mean [SD]		Mean [SD]		Mean [SD]			
SNOT-22 total scores	49.4 [22.1]		50.5 [17.1]		55.2 [20.3]		1.83	0.162
SNOT-22 Rhinologic domain	15.9 [6.3]		15.9 [5.7]		16.4 [6.6]		0.21	0.815
SNOT-22 ExtraNasal domain	8.9 [3.6]		8.6 [3.4]		7.9 [3.8]		1.44	0.240
SNOT-22 Ear/Facial domain	8.5 [5.3]		9.0 [4.7]		10.1 [5.6]		1.75	0.176
SNOT-22 Psychological domain	14.1 [9.8]		14.8 [8.4]		16.7 [7.8]		1.84	0.161
SNOT-22 Sleep dysfunction domain	12.1 [7.5]		12.3 [6.2]		15.2 [6.7]		4.81	0.009
RSDI total scores	44.6 [26.5]		43.1 [22.8]		46.9 [24.4]		0.46	0.631
RSDI Physical domain	18.4 [9.7]		16.9 [7.8]		19.1 [9.0]		1.20	0.303
RSDI Functional domain	14.6 [9.1]		14.3 [8.8]		15.0 [8.9]		0.11	0.899
RSDI Emotional domain	11.7 [9.6]		11.8 [8.7]		12.8 [8.5]		0.34	0.712

N, sample size; SD, standard deviation; QOL, quality of life; SNOT-22, 22-item SinoNasal Outcome Test; RSDI, Rhinosinusitis Disability Index; p-values are reflective of omnibus test results and reflect significant differences between at least two independent enrollment sites.

Table 3

Comparison of mean preoperative medication use days (of previous 90) between enrollment sites

Preoperative medication use (days of previous 90):	Enrollment Site #1 (n=76)	Enrollment Site #2 (n=76)	Enrollment Site #3 (n=76)	p-value
	Mean [SD]	Mean [SD]	Mean [SD]	
Topical nasal steroid sprays	36.8 [37.5]	40.3 [39.2]	46.3 [37.8]	0.224
Topical nasal steroid drops/irrigations	7.8 [22.3]	12.4 [28.0]	8.3 [25.6]	0.233
Decongestants	16.2 [29.3]	18.4 [31.3]	29.6 [36.1]	0.004
Oral / systemic antibiotics	22.5 [25.3]	13.9 [19.1]	16.3 [22.5]	0.083
Oral / systemic corticosteroids	14.1 [24.1]	13.4 [23.9]	10.9 [17.8]	0.648
Antihistamines	24.9 [36.6]	27.4 [38.3]	31.1 [37.0]	0.317
Leukotriene modifiers	14.7 [31.4]	16.7 [33.4]	12.2 [39.4]	0.838
Saline irrigation rinses	34.0 [36.6]	50.0 [37.0]	43.3 [36.8]	0.021

N, sample size; SD, standard deviation; p-values are reflective of omnibus test results and reflect significant differences between at least two independent enrollment sites.

Table 4

Comparison of surgical procedures between enrollment sites

Procedures:	Enrollment Site #1 (n=76)	Enrollment Site #2 (n=76)	Enrollment Site #3 (n=76)	χ^2 (df=2)	p-value
	N (%)	N (%)	N (%)		
Maxillary antrostomy	70 (92%)	73 (96%)	74 (97%)	2.48	0.289
Partial ethmoidectomy	16 (21%)	8 (11%)	19 (25%)	5.56	0.062
Total ethmoidectomy	54 (71%)	63 (83%)	59 (78%)	3.04	0.219
Sphenoidotomy	52 (68%)	49 (65%)	55 (72%)	1.10	0.578
Middle turbinate resection	12 (16%)	17 (22%)	11 (15%)	1.88	0.391
Inferior turbinate reduction	13 (17%)	20 (26%)	20 (26%)	2.41	0.300
Septoplasty	14 (18%)	36 (47%)	33 (43%)	16.18	<0.001
Frontal sinusotomy	53 (70%)	50 (66%)	45 (59%)	1.89	0.389

N, sample size; χ^2 , Chi-square test statistic; df, degrees of freedom

Table 5

Unadjusted comparisons of mean postoperative improvement in disease-specific QOL scores between enrollment sites (n=228)

Absolute mean improvement in disease-specific QOL scores:	Enrollment Site #1 (n=76)		Enrollment Site #2 (n=76)		Enrollment Site #3 (n=76)		F-test	p-value
	Mean [SD]		Mean [SD]		Mean [SD]			
SNOT-22 total scores								
SNOT-22 Rhinologic domain	-20.5 [22.7] *		-26.8 [17.4] *		-29.1 [20.4] *		3.66	0.027
SNOT-22 ExtraNasal domain	-7.0 [8.1] *		-8.4 [5.6] *		-9.2 [7.3] *		1.76	0.174
SNOT-22 Ear/Facial domain	-3.9 [4.5] *		-4.1 [3.5] *		-4.1 [3.7] *		0.07	0.929
SNOT-22 Psychological domain	-3.6 [5.1] *		-5.1 [4.3] *		-6.1 [4.5] *		5.48	0.005
SNOT-22 Sleep dysfunction domain	-5.2 [8.6] *		-8.0 [7.9] *		-8.3 [8.0] *		3.21	0.042
RSDI total scores								
RSDI Physical domain	-18.8 [20.7] *		-21.5 [20.2] *		-26.4 [22.7] *		2.52	0.082
RSDI Functional domain	-7.7 [8.6] *		-8.3 [8.1] *		-11.9 [9.5] *		5.35	0.005
RSDI Emotional domain	-6.6 [8.2] *		-7.4 [7.6] *		-8.3 [8.2] *		0.86	0.426
	-4.5 [6.8] *		-5.8 [7.2] *		-6.1 [7.1] *		1.14	0.323

N, sample size; SD, standard deviation; QOL, quality of life; SNOT-22, 22-item SinoNasal Outcome Test; RSDI, Rhinosinusitis Disability Index;

* indicates significant within-subjects improvement over time using matched pairs t-testing (p<0.001).

Table 6

Unadjusted comparisons of mean 6-month postoperative medication use days (out of the previous 90) between enrollment sites

Postoperative medication use (days of previous 90):	Enrollment Site #1 (n=76)	Enrollment Site #2 (n=76)	Enrollment Site #3 (n=76)	p-value
	Mean [SD]	Mean [SD]	Mean [SD]	
Topical nasal steroid sprays	23.6 [36.7] **	36.8 [40.0]	51.1 [41.5]	<0.001
Topical nasal steroid drops/irrigations	16.6 [33.9]	32.8 [39.6] *	23.1 [36.3] **	0.009
Decongestants	9.2 [23.1]	12.2 [28.2] **	11.3 [26.7] *	0.665
Oral / systemic antibiotics	4.7 [10.4] *	6.1 [12.0] **	6.3 [17.6] *	0.497
Oral / systemic corticosteroids	8.6 [25.2] **	6.3 [19.6] **	6.0 [18.9] *	0.935
Antihistamines	14.7 [31.2] **	22.4 [38.0]	23.9 [37.9]	0.136
Leukotriene modifiers	13.4 [30.1]	16.5 [33.9]	12.5 [31.1]	0.418
Saline irrigation rinses	58.1 [37.9] *	65.8 [33.9] **	54.3 [38.3] **	0.103

N, Sample size; SD, standard deviation;

* indicates significant within-subjects improvement over time using Wilcoxon Signed Rank testing ($p < 0.001$).

** indicates significant within-subjects improvement over time using Wilcoxon Signed Rank testing ($p < 0.050$). Negative mean values reflect overall fewer average days of medication use reported postoperatively.

Unadjusted and adjusted linear regression modeling outcomes for mean postoperative improvement in SNOT-22 total scores

Table 7

SNOT-22 Total Score Improvement Model:					
Unadjusted Univariate Model:	β	SE	95% CI	p-value	R ²
Enrollment Site / Location	-4.3	1.6	(-7.5, -1.1)	0.009	0.029
Final Adjusted Model:					
Septal deviation / septoplasty	-6.9	2.4	(-11.7, -2.2)	0.004	
Enrollment Site / Location	-0.9	1.4	(-3.7, 1.9)	0.535	
Preoperative SNOT-22 total scores	-0.6	0.1	(-0.7, -0.5)	<0.001	
Antihistamine use days	0.1	0.03	(0.01, 0.1)	0.021	
Oral / systemic antibiotic use days	0.2	0.1	(0.1, 0.4)	0.004	
Corticosteroid dependent conditions	8.8	4.0	(0.9, 16.7)	0.029	0.411

SNOT-22, 22-Item SinoNasal Outcome Test; SE, standard error; CI, confidence interval; R², coefficient of multiple determination; Final models screened all patient characteristic variables, baseline measures of disease severity, and 6-month postoperative medication use (average reported days) variables. Negative effect estimates (β) are associated with greater postoperative improvement in SNOT-22 total scores.

Table 8

Unadjusted mean **SNOT-22 total score improvement** across enrollment site and septoplasty groups

Enrollment Site:	Septoplasty	No Septoplasty	p-value
#1 (n=76)	−29.5 [17.7]	−18.8 [23.2]	0.150
#2 (n=76)	−31.8 [17.7]	−23.0 [16.3]	0.056
#3 (n=76)	−31.5 [18.6]	−26.3 [22.3]	0.170
ALL (n=228)	−31.3 [18.0]	−21.9 [21.2]	0.001

N, sample size; SNOT-22, 22-Item SinoNasal Outcome Test;