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Quality-of-Life Outcomes Following Multiple Revision Endoscopic Sinus Surgery

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Abstract

Background—Although overall success rates of endoscopic sinus surgery (ESS) range from 76.0–97.5%, ongoing or recurrent symptoms may require revision surgery. Previous studies have shown that revision status is not a predictor of outcomes following ESS, but no distinction has been made between patients undergoing a single or multiple revision procedure. The purpose of this study was to compare quality-of-life (QOL) outcomes and associated risk factors of patients undergoing primary ESS, first revision, second, third, fourth, fifth or more revision ESS.

Methods—Demographic and risk factor data were collected from a multi-institutional prospective cohort of 552 patients undergoing primary (n=221) and revision (n=331) ESS for chronic rhinosinusitis. Mean preoperative Lund-Mackay CT scan scores, pre-/post-operative Lund-Kennedy endoscopy scores, Rhinosinusitis Disability Index (RSDI), and Chronic Sinusitis Survey (CSS) outcomes were analyzed using chi-squared testing and one-way ANOVA.

Results—Mean preoperative RSDI and CSS measurements were similar between primary ESS and all revision groups. Significantly more primary ESS patients met rigorous criteria for a minimally important difference in QOL improvement than revision ESS patients (73.8% vs. 61.6%; p=0.003). There was no significant difference in mean QOL improvement between revision groups (all p 0.174) even when comparing patients with and without nasal polypsis (all p 0.312).

Conclusions—Generally patients undergoing primary, first revision, and multiple revision ESS showed post-operative improvement in QOL scores. More primary ESS patients had significant QOL improvement compared to revision ESS patients. There were no significant differences in mean QOL improvement between first, second, third, fourth, or fifth or more revision ESS.

Keywords

Rhinology; Sinusitis; Chronic Rhinosinusitis; Endoscopic Sinus Surgery; Nasal Polypsis; Revision; Quality-of-Life; Outcomes

INTRODUCTION

Chronic rhinosinusitis (CRS) is common sinonasal condition affecting up to 14% of Americans.¹ Over 250,000 ambulatory sinus procedures are performed each year in the

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United States as treatment for CRS refractory to medical management.² Although overall success rates of endoscopic sinus surgery (ESS) are found to range from 76.0 – 97.5%, revision surgery can be required for ongoing or recurrent symptoms of CRS.³ Single revision or multiple revision ESS may be required despite evidence of stable improvements in quality-of-life (QOL) outcomes at lengthy intervals following ESS.⁴ Revision ESS remains common especially among patients with nasal polyposis, asthma, Samter's triad, or frontal sinus disease.⁵

Prior studies have shown that previous sinus surgery is not a predictor of QOL outcomes following subsequent ESS, but no distinction has been made between patients undergoing a single or multiple revision ESS procedure.^{6,7} It is unknown whether the compounded sequelae of multiple procedures will negatively impact the QOL outcomes of multiple revision ESS patients compared to primary ESS or first revision ESS patients. The purpose of this study was to compare QOL outcomes and associated risk factors of patients undergoing primary ESS, first revision, second revision, third revision, fourth revision, or fifth or more revision ESS within an academic, tertiary care setting.

MATERIALS AND METHODS

Study Population and Data Collection

Study patients were enrolled from an adult (18 years or older) patient population presenting to one of three performance sites including Oregon Health and Science University (OHSU), the Medical College of Wisconsin (MCW), and Stanford University, as part of a previously reported multi-institutional prospective cohort study.^{6,8} Criteria developed by the consensus report of the Rhinosinusitis Task Force, and endorsed by the American Academy of Otolaryngology, were used in the diagnosis of CRS in each study patient.⁹ Patients who met inclusion criteria, agreed to participate, and provided informed consent underwent a battery of measures including objective testing and QOL evaluations at the time of the initial preoperative enrollment period. Study patients were asked to complete the same QOL evaluations at least 6 months after ESS during standard postoperative appointments. Subjects completing those postoperative evaluations were included in the final analysis. All investigational protocols were approved at an Institutional Review Board within each academic center.

Patient Demographics and Comorbidity

Medical chart review and patient history were used to collect patient information including age, gender, and presence of comorbidities including nasal polyposis, number of prior sinus surgeries, asthma, acetylsalicylic acid (ASA) intolerance, allergy, depression under medical treatment, current tobacco smoking, and cystic fibrosis (CF).

Objective testing and QOL Evaluations

All patients underwent preoperative, standard computed tomography (CT) scans in the coronal plane and were staged according to the Lund-Mackay CT scoring system (bilateral score range: 0–24).¹⁰ Standard diagnostic nasal endoscopy was performed as part of the standard of patient care and staged using the bilateral, Lund-Kennedy scoring system (bilateral score range: 0–20).¹¹ Two disease-specific survey instruments were used to measure patient-reported QOL at preoperative and postoperative appointments. The Rhinosinusitis Disability Index (RSDI) is a 30-item survey (score range: 0–120) which evaluates disease-specific patient status in the physical, functional, and emotional domains.¹² Higher RSDI total and subscale scores indicate a worse impact of chronic sinus disease. The Chronic Sinusitis Survey (CSS) is a 6-item survey used to measure sinus-specific symptom and medication use during a preceding 8-week period (score range: 0–

100).¹³ Higher CSS total and subscale scores represent a lower impact of chronic sinus disease. A research coordinator assisted patients in the completion of all QOL evaluations while the Principal Investigator at each site was blinded to QOL responses for the study duration. The first outcome of interest for this investigation was the improvement in QOL scores over time and was operationalized by calculating the mean difference between time points (final postoperative QOL score minus preoperative QOL score). A clinically significant minimally important difference (MID) was further defined for both QOL and endoscopy scores by a change of $\frac{1}{2}$ standard deviation of the preoperative mean score.¹⁴ The frequency of each MID was compared across primary and revision subgroupings.

Statistical Analyses

All patient data and QOL evaluations were de-identified and securely stored in a relational database (Microsoft FoxPro, Microsoft Corp., Redmond, WA). Statistical analyses were performed using commercially available software (SPSS v.19.0, IBM, Armonk, NY). Descriptive statistics were calculated for all study measures. Independent t-tests and Mann Whitney U tests were used to assess all bivariate differences in continuous data between primary and all revision groups. Chi-square tests were also used to evaluate differences in comorbidity and frequency of improvement (as defined by the MID) between both primary and all revision groups as well as between all five revision ESS subgroupings. Both one-way analysis of variance (ANOVA) and the Kruskal-Wallis test were used to assess whether or not global differences in continuous variables existed between two or more revision subgroupings. If differences were identified by a significant ANOVA finding, Bonferroni corrections were then used to identify different subgroupings and while adjusting for pair-wise comparisons to maintain a family-wise error rate normally distributed data. Pair-wise adjusted Mann-Whitney U test statistics were used for nonparametric data, if applicable. All adjusted pair-wise comparisons were reported when applicable. Additionally, due to inherent differences in the clinical presentation of CRS with nasal polyposis, improvement in all patient outcome measures were compared between subjects with and without nasal polyps across primary and revision surgery groups. Two-tailed statistical significance was established at the conventional 0.05 alpha level.

RESULTS

Baseline Characteristics & Scope of Disease

A total of 782 study patients were enrolled between July, 2001 and April, 2009. Five hundred and fifty-two patients (70.6%) with preoperative and postoperative objective and QOL follow-up of at least 6 months were included in the study. Of the 230 patients lost to follow-up, there were 102 patients (44.3%) who underwent primary ESS and 128 patients (55.7%) who underwent revision ESS. Of the 552 patients included in the study, a total of 221 patients underwent primary ESS and 331 patients underwent revision endoscopic sinus surgery. Of the revision ESS patients, 138 underwent first revision ESS and 193 underwent multiple revision ESS (second revision ESS, n=97; third revision ESS, n=47; fourth revision ESS, n=23; fifth or more revision ESS, n=26). Baseline patient characteristics are compared between primary ESS and all revision ESS patients in Table 1. Baseline patient characteristics are compared between all revision patient subgroupings in Table 2.

There was no significant difference in mean duration of follow-up, age, or gender between the primary and revision groups of ESS patients. Compared to patients undergoing primary ESS, there was a significantly higher rate of nasal polyposis (32.1% vs. 44.4%; p=0.004), asthma (31.2% vs. 46.8%; p<0.001), ASA intolerance (4.5% vs. 16.9%; p<0.001), and allergy (26.7% vs. 35.0%; p=0.039) among revision ESS patients. However rates of

depression, smoking, and cystic fibrosis (CF) were not statistically different between primary and revision groups.

There was no significant variation in mean duration of follow-up or mean age amongst the different revision subgroups. There was significant variation in the gender distribution between revision groups with a preponderance of female patients in the first and second revision ESS subgroups and a preponderance of men in the fourth and fifth or more revision ESS subgroups ($p=0.046$). Significant variation in rates of asthma and ASA intolerance was noted between revision subgroups with the fifth or more revision ESS subgroup having the lowest rates (26.9%, $p=0.042$; 11.5%, $p=0.714$ respectively). There was also significant variation in rates of CF between revision groups with the fifth or more revision ESS subgroup having the highest CF patient rate (23.1%; $p<0.001$). No significant variation was noted in rates of nasal polyposis, allergy, depression, or smoking between revision subgroups.

Objective Measures

There was a statistically significant difference noted between primary ESS and revision groups in mean Lund-McKay CT scores at the time of enrollment (12.0 and 13.3 respectively, $p=0.027$; Table 1). There was no significant variation in pre-operative CT scores among revision subgroups ($p=0.624$; Table 2). There was no significant variation in mean Lund-McKay scores at the time of enrollment when comparing primary revision ESS patients and all revision subgroups ($p=0.189$).

Baseline mean Lund-Kennedy endoscopy scores were significantly higher in the revision groups compared to primary ESS patients (9.0 vs. 5.1 respectively, $p<0.001$), however they did not significantly vary across any of the revision subgroups ($p=0.867$). Absolute improvement in mean Lund-Kennedy endoscopy scores was compared between primary and all revision ESS groups in Table 3. Despite overall improvement in mean endoscopy scores for all groups, there was significantly greater improvement in endoscopic appearance in the revision ESS group (3.6 vs. 1.7, $p<0.001$), however no significant differences were found between any of the revision subgroups ($p=0.256$).

Absolute improvement in mean Lund-Kennedy endoscopy scores was also compared between patients with nasal polyposis and those without nasal polyposis in primary and revision ESS groups. There was no significant difference in endoscopy score improvement of patients with polyps between primary and all revision ESS groups ($P=0.267$) or between any of the revision subgroups ($p=0.798$). Compared to primary ESS, there was significantly greater improvement in endoscopic appearance in the revision ESS subgroups combined (2.6 vs. 0.6, $p<0.001$) when comparing only patients without nasal polyposis.

Quality-of-Life Outcomes

Baseline QOL measures are compared between primary ESS and all revision groups as well as between all revision ESS patient subgroups (Tables 4–5). Mean baseline RSDI and CSS measurements were similar between primary ESS and all revision groups, with the exception of the RSDI functional subscale which was better amongst primary ESS patients (14.7 vs. 15.9, $p=0.048$). No significant differences in RSDI and CSS scores were found between any of the revision ESS subgroups ($p=0.106$, $p=0.150$ respectively). All groups were then separated by the presence or absence of nasal polyposis and baseline QOL measures were again found to have no statistically significant difference between primary and revision ESS groups, with the exception of worse CSS medication scores in revision ESS patients with polyposis (43.3 vs. 51.5, $p=0.018$). Patients without polyposis reported similar baseline scores across all comparisons. Global one-way ANOVA indicated a significant difference

between revision subgroups without polyposis for the baseline RSDI physical subscale ($p=0.016$), however after adjustment for multiple comparisons, that difference was no longer durable (all $p \geq 0.150$).

Compared to all revision ESS groups, patients undergoing primary surgery reported significantly more improvement in all QOL scores, except the CSS medication subscale (13.9 vs. 11.7, $p=0.366$; Table 6). No significant differences in degree of postoperative improvement on RSDI or CSS were found between revision ESS subgroups ($p \geq 0.119$; Table 7). While patients undergoing primary surgery with nasal polyposis experienced significantly more mean improvement on all RSDI scores ($p \leq 0.029$), no differences were noticed across any of revision ESS subgroups. Similarly, patients undergoing primary surgery without nasal polyposis experienced significantly greater mean improvement on the RSDI physical subscale (8.6 vs. 6.0, $p=0.002$), RSDI total scores (22.3 vs. 17.6, $p=0.037$), CSS symptom subscale (33.9 vs. 25.8, $p=0.019$), and CSS total scores (26.1 vs. 20.6, $p=0.038$). Similar to their counterparts with nasal polyps however, no significant differences in degree of improvement were found between any of the revision ESS subgroups.

Additionally, patients undergoing a primary ESS experienced significantly higher frequency of improvement (as defined by MID criteria) on total RSDI scores (73.8% vs. 67.4%; $p=0.003$; Table 8). No differences in the frequency of improvement were found between any of the ESS revision subgroups ($p \geq 0.117$; Table 8; Figure 1). Similarly, primary surgery patients with nasal polyps experienced a significantly higher frequency of improvement in total RSDI scores (80.3% vs. 59.2%, $p=0.002$; Figure 2), however no differences were found across revision ESS subgroups. No significant differences in QOL improvement were reported for either primary versus all revision ESS patients without polyposis or between revision ESS subgroups without polyps (Figure 3).

DISCUSSION

In our era of increasing focus on control of health care costs, there is an associated increasing burden on practitioners to provide evidence for the utility of their interventions. Endoscopic sinus surgery is sometimes brought under scrutiny for the frequency of patients requiring revision procedures and in some cases more than a single revision procedure. There is concern that these revision procedures may not be as effective at improving patient QOL as compared to the primary procedure. Each ESS procedure has significant perioperative risks including hemorrhage, intracranial and orbital injury; as well as potential long term risks for mucosal injury, atrophic change, scarring of sinus ostia, change in olfaction, and disruption of mucociliary clearance. These long term risks could theoretically compound over multiple procedures and decrease the potential benefit to patients with each subsequent ESS procedure. Revision ESS is also often more complex than primary ESS and may be less effective due to altered intranasal anatomy, absence or alteration of essential landmarks, or scarring from a previous procedure.¹⁵ In this study we have prospectively evaluated the QOL outcomes of multiple revision ESS patients and compared QOL outcomes between revision ESS groups stratified by number of previous ESS procedures as well as with primary ESS patients. We also sought risk factors that might explain noted outcomes differences compared to primary ESS or first revision ESS patients.

Although prior studies had shown no statistical difference between QOL outcomes in primary ESS patients compared to revision ESS patients, we found that significantly more primary ESS patients met rigorous criteria for a minimally important clinical difference in QOL improvement than revision ESS patients. These prior studies had smaller cohorts of patients (119 and 238) and there was a trend toward better QOL outcomes amongst primary ESS patients.^{6,7} Our current analysis includes QOL data from 552 ESS patients and the

increased statistical power of this larger cohort likely allowed for the previously noted trend toward improved QOL outcomes in primary ESS to reach statistical significance. This finding does support previous research showing by multivariate logistic regression modeling that primary ESS patients were 1.8 – 2.1 times more likely to have improvement in QOL than revision ESS patients.⁸

There are many possible patient and disease factors that may be contributing to this noted improvement in QOL in primary ESS patients compared to revision ESS patients. Revision ESS status itself may be a marker of disease severity with only those patients afflicted with severe forms of CRS returning for further surgical treatment. We found significantly higher rates of asthma and aspirin intolerance among patients in the revision ESS groups. This is consistent with prior data showing high rates of revision ESS amongst patients with CRS with nasal polyposis and asthma or Samter's triad (defined as asthma, Aspirin intolerance, and nasal polyposis).⁵ Samter's triad is known to be associated with severe sinonasal inflammation that is often refractory to medical management. Prior research has shown that 37% of patients with Samter's triad will undergo revision surgery within 5 years of primary ESS.⁵ There has also been recent research showing a significantly higher portion of ASA intolerant patients elect surgical treatment for CRS compared to ongoing medical therapy.¹⁶ It may be that electing surgical treatment, or especially electing revision or multiple revision surgical treatment, is a function of disease severity and patient dissatisfaction with their current QOL. Baseline QOL in this study was found to be similar between primary ESS and all revision groups.

We found no significant differences in degree of mean QOL improvement between all revision ESS subgroups. Despite multiple previous ESS procedures, a patient undergoing multiple revision ESS can expect as much QOL improvement as a patient undergoing their first revision ESS procedure. There was a trend toward decreasing improvements with increasing numbers of revision procedures (Table 8), but this pattern did not reach significance. We noted that the fourth and fifth or more revision ESS subgroup often showed greater improvements in QOL than those who had undergone fewer previous ESS procedures (Figures 1–3). It is interesting to note that this fifth or more revision ESS subgroup had the highest portion of CF patients (23.1%), but the lowest rates of asthma or ASA intolerance patients. Asthma and ASA intolerance may be predictors of less improvement and the low rates of these patients in the fifth or more subgroup may account for the trend toward greater improvement in QOL outcomes.

One limitation of our current analysis is the lack of specific data regarding the setting or adequacy of any prior ESS procedures. Lund-Kennedy endoscopic scores do take into account certain factors relating to previous surgery, such as scarring; but we do not have data regarding the extent or adequacy of any previous procedure. Previous research has shown that the extent of an endoscopic sinus surgery may affect the recurrence rate in patients undergoing ESS for polypoid disease and that surgeon experience may factor into rates of revision surgery.¹⁷ With our current data we have no way of assessing such factors and their relationship to the indications for revision ESS.

Recurrent frontal sinus disease has been found to be associated with need for revision ESS.⁵ The complexity of frontal sinus surgery is often discussed and it is commonly noted that the frontal sinus is more prone to scarring and possible iatrogenic injury. We found that the rate of frontal sinus surgery was increased in all revision ESS groups versus primary ESS patients (67.1% vs. 37.6%, $p<0.001$). But we also noted that there was no difference in the rate of frontal sinus surgery among revision ESS subgroups (first revision, 65.2%; second revision, 67.0%; third revision, 68.1%; fourth revision, 65.2%; fifth or more revision, 76.9%; $p=0.842$).

There was a small difference noted in mean Lund-McKay CT scores primary ESS and revision groups in at the time of enrollment (12.0 and 13.3 respectively, $p=0.027$; Table 1). This mean difference of 1.3 points on a 0–24 point scoring system (5.4%) is unlikely to be clinically meaningful despite statistical significance. There was no significant variation in mean Lund-McKay scores at the time of enrollment when comparing primary revision ESS patients and all revision subgroups ($p=0.189$).

Consistent with previous studies, the mean preoperative Lund-Kennedy endoscopy scores were significantly worse in the revision ESS patients compared to primary ESS patients. Despite overall improvement in mean endoscopy scores for all ESS patients, mean endoscopy scores remained significantly worse for patients with previous ESS on postoperative evaluation (3.3 (3.2) vs. 5.5 (4.1)), $p<0.001$) similar to previous findings.^{6,7} Both of these prior studies reported a similar degree of improvement on endoscopy between primary and revision ESS patients, but our data shows a significantly greater improvement in the endoscopy scores of revision ESS patients compared to primary ESS patients (3.6 vs. 1.7, $p<0.001$; Table 3).^{6,7} This difference is likely a function of the higher baseline endoscopy scores of revision ESS patients in our cohort. Higher endoscopy scores represent increased scarring, polyps, discharge, edema, and crusting among revision ESS patients preoperatively; and thus, more room for improvement with surgical intervention. The endoscopy score is also a measure of preoperative disease severity and may help explain why despite having greater improvement in endoscopy scores among revision ESS patients, primary ESS patients continue to have better postoperative endoscopy scores.

CONCLUSION

This prospective multi-institutional study demonstrates post-operative improvement in QOL in patients undergoing primary, first revision, and multiple revision ESS. More primary ESS patients were found to have significant QOL improvement compared to revision ESS patients. No significant differences in mean QOL improvement were found between first, second, third, fourth, and fifth or more revision ESS patients even when comparing patients with and without nasal polyposis.

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Figure 1.
Comparison of the frequency of improvement in QOL across all patients with follow-up.

Figure 2.
Comparison of the frequency of improvement in QOL across all patients with nasal polyposis

Figure 3.

Comparison of the frequency of improvement in QOL across all patients without nasal polyposis

Table 1

Baseline demographics and clinical characteristics for all subjects (n=552)

Characteristics	Primary surgery (n=221)		All Revision (n=331)		p-value
	Mean (SD)	n(%)	Mean (SD)	n(%)	
Follow-up duration (m o.)	17.1 (7.7)		18.0 (7.8)		0.189
Age (yrs)	45.7 (14.0)		48.0 (13.7)		0.055
Male/Female		104 (47.1)/117 (52.9)		152 (45.9)/179 (54.1)	0.793
Nasal polyposis		71 (32.1)		147 (44.4)	0.004
Asthma		69 (31.2)		155 (46.8)	<0.001
ASA intolerance		10 (4.5)		56 (16.9)	<0.001
Allergy		59 (26.7)		116 (35.0)	0.039
Depression		30 (13.6)		56 (16.9)	0.289
Current smoker		17 (7.7)		13 (3.9)	0.117
Cystic fibrosis		9 (4.1)		12 (3.6)	0.788
Lund-Mackay CT score	12.0 (6.6)		13.3 (6.5)		0.027
Lund-Kennedy endoscopy score	5.1 (3.9)		9.0 (4.9)		<0.001

SD, standard deviation ; mo., months ; yrs, years ; CT, computed tomography ;

Table 2

Baseline demographics and clinical characteristics for patients undergoing revisions surgery (n=331)

Characteristics	1st Revision (n=138)		2nd Revision (n=97)		3rd Revision (n=47)		4th Revision (n=23)		5th + Revision (n=26)		p-value	
	Mean (SD)	n(%)	Mean (SD)	n(%)	Mean (SD)	n(%)	Mean (SD)	n(%)	Mean (SD)	n(%)		
Follow-up duration(mo.)	17.6 (7.5)		17.1 (7.3)		19.5 (8.0)		20.1 (11.2)		18.2 (6.3)		0.290	
Age (yrs)	47.2 (14.0)		48.4 (14.8)		48.5 (1.4)		51.0 (12.9)		46.9 (13.1)		0.765	
Male / Female		58(42.0)/80(58.0)		39(40.2)/58(59.8)		23(48.9)/24(51.1)		15(65.2)/8(34.8)		17(65.4)/9(34.6)		0.046
Nasal polyposis		59 (42.8)		40 (41.2)		22 (46.8)		12 (52.2)		14 (53.8)		0.707
Asthma		58 (42.0)		49 (50.5)		27 (57.4)		14 (60.9)		7 (26.9)		0.042
ASA intolerance		16 (11.6)		18 (18.6)		11 (23.4)		8 (34.8)		3 (11.5)		0.038
Allergy		45 (32.6)		37 (38.1)		19 (40.4)		8 (34.8)		7 (26.9)		0.714
Depression		26 (18.8)		13 (13.4)		9 (19.1)		4 (17.4)		4 (15.4)		0.839
Current smoker		7 (5.1)		4 (4.1)		1 (2.1)		1 (4.3)		0 (0.0)		0.820
Cystic fibrosis		4 (2.9)		1 (1.0)		0 (0.0)		1 (4.3)		6 (23.1)		<0.001
Lund-Mackay CT score	13.4 (6.5)		13.2 (6.3)		12.3 (7.1)		14.9 (6.6)		12.9 (6.7)		0.624	
Lund-Kennedy endoscopy score	9.0 (4.6)		9.1 (4.9)		8.5 (4.7)		9.8 (5.9)		8.7 (5.4)		0.867	

SD, standard deviation ; mo., months ; yrs, years ; CT, computed tomography

Table 3

Absolute improvement in mean endoscopy scores at last follow-up (n=517)

Lund-Kennedy Endoscopy Score	Primary		All Revision		p-value			
	Mean (SD)		Mean (SD)					
All Patients	1.7 (3.7)		3.6 (5.0)		<0.001			
With Nasal Polyposis	4.2 (3.8)		4.9 (5.1)		0.267			
Without Nasal Polyposis	0.6 (3.1)		2.6 (4.7)		<0.001			
Lund-Kennedy Endoscopy Score	1st Revision		2nd Revision		3rd Revision	4th Revision	5th+ Revision	p-value
	Mean (SD)		Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)	
All Revision Patients	4.3 (4.4)		3.6 (5.1)		2.3 (5.7)	3.3 (5.6)	3.2 (5.8)	0.256
With Nasal Polyposis	5.3 (4.7)		4.8 (5.2)		3.8 (4.3)	5.5 (5.8)	4.6 (6.6)	0.798
Without Nasal Polyposis	3.5 (4.0)		2.7 (4.9)		0.9 (6.6)	0.8 (4.6)	0.9 (3.3)	0.079

SD, standard deviation

Table 4

Total mean baseline quality-of-life measures at enrollment

QOL Instrument	Primary	All Revision	p-value
	Mean (SD)	Mean (SD)	
All Patients	(n=221)	(n=331)	
RSDI Physical	18.7 (7.5)	18.8 (7.4)	0.845
RSDI Functional	14.7 (7.1)	15.9 (7.1)	0.048
RSDI Emotional	12.5 (7.7)	13.6 (8.2)	0.095
RSDI Total	45.9 (19.7)	48.4 (20.2)	0.150
CSS Symptom	27.8 (25.4)	29.7 (26.6)	0.421
CSS Medication	45.6 (26.7)	42.9 (24.9)	0.217
CSS Total	36.7 (20.6)	36.3 (19.2)	0.789
With Nasal Polyposis	(n=71)	(n=147)	
RSDI Physical	17.4 (8.5)	18.4 (7.3)	0.418
RSDI Functional	13.0 (7.5)	14.8 (6.3)	0.071
RSDI Emotional	11.4 (8.6)	12.6 (7.6)	0.302
RSDI Total	41.9 (22.0)	45.7 (18.7)	0.175
CSS Symptom	33.9 (28.1)	29.4 (26.7)	0.253
CSS Medication	51.5 (24.5)	43.3 (23.5)	0.018
CSS Total	42.7 (20.4)	36.4 (18.3)	0.021
Without Nasal Polyposis	(n=150)	(n=184)	
RSDI Physical	19.3 (7.0)	19.2 (7.5)	0.880
RSDI Functional	15.5 (6.8)	16.9 (7.5)	0.091
RSDI Emotional	13.0 (7.2)	14.4 (8.6)	0.087
RSDI Total	47.8 (18.4)	50.5 (21.2)	0.220
CSS Symptom	24.9 (23.6)	29.8 (26.6)	0.079
CSS Medication	42.8 (27.3)	42.5 (26.1)	0.917
CSS Total	33.9 (20.2)	36.2 (19.9)	0.298

QOL, quality of life; SD, standard deviation; RSDI, Rhinosinusitis Disability Index; CSS, Chronic Sinusitis Survey;

Table 5

Total mean baseline quality-of-life measures at enrollment for revision patients

QOL Instrum ent	1st Revision Mean (SD) (n=138)	2nd Revision Mean (SD) (n=97)	3rd Revision Mean (SD) (n=47)	4th Revision Mean (SD) (n=23)	5th+ Revision Mean (SD) (n=26)	p-value
All Revision Patients						
RSDI Physical	17.7 (7.1)	20.0 (6.9)	18.6 (8.5)	19.0 (6.5)	20.8 (8.5)	0.106
RSDI Functional	15.2 (7.4)	17.1 (6.5)	15.8 (7.1)	15.5 (6.8)	16.3 (7.7)	0.385
RSDI Emotional	13.2 (8.1)	14.6 (8.3)	13.6 (8.9)	12.3 (7.0)	13.4 (8.7)	0.696
RSDI Total	46.1 (19.9)	51.6 (19.2)	48.0 (23.3)	46.7 (18.1)	50.5 (23.3)	0.324
CSS Symptom	30.7 (26.1)	28.7 (27.9)	32.8 (27.8)	26.1 (25.0)	25.3 (24.5)	0.721
CSS Medication	40.5 (22.8)	42.0 (25.5)	43.3 (26.7)	48.6 (30.2)	52.9 (24.4)	0.150
CSS Total	35.6 (18.9)	35.4 (19.8)	38.0 (18.7)	37.3 (19.9)	39.1 (19.4)	0.841
With Nasal Polyposis	(n=59)	(n=40)	(n=22)	(n=12)	(n=14)	
RSDI Physical	17.5 (7.7)	18.7 (6.1)	20.5 (8.4)	17.5 (4.5)	18.8 (9.2)	0.569
RSDI Functional	14.1 (6.9)	15.8 (5.2)	16.6 (6.5)	11.8 (4.2)	14.1 (7.0)	0.175
RSDI Em otional	12.8 (8.3)	13.7 (6.1)	13.8 (9.4)	9.3 (5.7)	9.8 (6.2)	0.235
RSDI Total	44.4 (20.4)	48.1 (14.1)	50.9 (21.7)	38.6 (12.5)	42.6 (21.1)	0.317
CSS Symptom	31.4 (24.2)	27.7 (29.4)	31.4 (27.5)	26.4 (28.2)	25.6 (29.1)	0.906
CSS Medication	40.4 (20.2)	43.5 (24.6)	39.8 (24.4)	56.9 (32.9)	48.8 (20.6)	0.183
CSS Total	35.9 (17.5)	35.6 (19.5)	35.6 (17.9)	41.7 (20.9)	37.2 (17.8)	0.884
Without Nasal Polyposis	(n=79)	(n=57)	(n=25)	(n=11)	(n=12)	
RSDI Physical	17.8 (6.8)	21.0 (7.3)	16.9 (8.4)	20.6 (8.1)	23.2 (7.2)	0.016
RSDI Functional	16.0 (7.6)	17.9 (7.2)	15.0 (7.6)	19.5 (7.0)	18.8 (8.0)	0.221
RSDI Emotional	13.5 (7.9)	15.2 (9.5)	13.5 (8.6)	15.6 (6.9)	17.7 (9.4)	0.481
RSDI Total	47.4 (19.5)	54.1 (21.8)	45.4 (23.0)	55.6 (19.6)	59.6 (23.2)	0.106
CSS Symptom	30.2 (27.5)	29.4 (27.1)	34.0 (28.6)	25.8 (22.5)	25.0 (19.1)	0.865

QOL Instrum ent	1st Revision		2nd Revision		3rd Revision		4th Revision		5th+ Revision		p-value
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		
CSS Medication	40.6 (24.7)		40.9 (26.2)		46.3 (28.8)		39.4 (25.3)		57.6 (28.3)		0.253
CSS Total	35.4 (19.9)		35.2 (20.2)		40.2 (19.5)		32.6 (18.5)		41.3 (21.6)		0.659

QOL, quality of life; SD, standard deviation; RSDI, Rhinosinusitis Disability Index; CSS, Chronic Sinusitis Survey

Table 6

Total mean improvement in quality-of-life measures

QOL Instrument	Primary	All Revision	p-value
	Mean (SD)	Mean (SD)	
All Patients	(n=221)	(n=331)	
RSDI Physical	8.9 (8.2)	6.3 (7.3)	<0.001
RSDI Functional	7.8 (7.2)	6.1 (7.5)	0.008
RSDI Emotional	6.0 (7.2)	4.6 (7.4)	0.028
RSDI Total	22.7 (19.8)	17.0 (20.0)	0.001
CSS Symptom	34.8 (32.0)	27.9 (30.3)	0.011
CSS Medication	13.9 (30.0)	11.7 (27.9)	0.366
CSS Total	24.3 (24.6)	19.8 (21.1)	0.024
With Nasal Polyposis	(n=71)	(n=147)	
RSDI Physical	9.4 (8.3)	6.6 (7.4)	0.014
RSDI Functional	7.7 (6.5)	5.5 (7.0)	0.029
RSDI Emotional	6.3 (7.0)	4.0 (6.7)	0.019
RSDI Total	23.4 (18.6)	16.2 (18.6)	0.008
CSS Symptom	36.6 (31.1)	30.5 (30.2)	0.167
CSS Medication	4.8 (23.9)	7.0 (27.6)	0.562
CSS Total	20.7 (21.8)	18.8 (20.4)	0.519
Without Nasal Polyposis	(n=150)	(n=184)	
RSDI Physical	8.6 (8.2)	6.0 (7.2)	0.002
RSDI Functional	7.8 (7.5)	6.5 (7.9)	0.121
RSDI Emotional	5.9 (7.4)	5.1 (7.9)	0.361
RSDI Total	22.3 (20.5)	17.6 (20.3)	0.037
CSS Symptom	33.9 (32.5)	25.8 (30.3)	0.019
CSS Medication	18.2 (31.6)	15.4 (27.7)	0.378
CSS Total	26.1 (25.7)	20.6 (21.7)	0.038

QOL, quality of life; SD, standard deviation; RSDI, Rhinosinusitis Disability Index; CSS, Chronic Sinusitis Survey

Table 7

Total mean improvement in quality-of-life measures for revision patients

QOL Instrument	1st Revision Mean (SD) (n=138)	2nd Revision Mean (SD) (n=97)	3rd Revision Mean (SD) (n=47)	4th Revision Mean (SD) (n=23)	5th+ Revision Mean (SD) (n=26)	p-value
All Revision Patients						
RSDI Physical	6.8 (7.3)	6.6 (7.7)	3.7 (5.8)	6.0 (6.1)	7.3 (8.3)	0.119
RSDI Functional	6.5 (7.7)	6.2 (7.4)	4.2 (6.5)	5.3 (7.4)	6.8 (9.1)	0.437
RSDI Emotional	5.0 (7.2)	5.1 (7.7)	3.4 (6.8)	1.7 (7.5)	5.6 (7.8)	0.177
RSDI Total	18.4 (19.3)	18.0 (20.1)	11.3 (15.6)	13.0 (19.3)	19.7 (24.1)	0.174
CSS Symptom	31.4 (29.3)	25.8 (29.4)	20.4 (34.2)	29.0 (32.1)	29.5 (29.3)	0.258
CSS Medication	12.9 (28.7)	13.4 (26.3)	11.0 (27.0)	7.6 (33.7)	3.2 (25.5)	0.471
CSS Total	22.2 (21.3)	19.6 (20.3)	15.7 (22.6)	18.3 (20.6)	16.3 (20.9)	0.365
With Nasal Polyposis						
RSDI Physical	7.5 (7.9)	6.9 (8.2)	3.9 (5.5)	6.5 (6.1)	6.8 (6.9)	0.444
RSDI Functional	6.1 (6.9)	6.0 (7.7)	3.9 (4.9)	3.7 (8.4)	6.2 (7.2)	0.619
RSDI Emotional	4.9 (6.6)	4.8 (6.3)	2.2 (7.5)	0.1 (7.8)	4.4 (5.1)	0.120
RSDI Total	18.4 (19.0)	17.7 (19.3)	10.0 (14.5)	10.3 (20.8)	17.3 (18.4)	0.312
CSS Symptom	33.2 (29.3)	29.4 (30.6)	22.3 (34.3)	37.5 (33.4)	29.2 (24.0)	0.598
CSS Medication	6.9 (27.1)	10.8 (27.9)	10.2 (27.1)	1.4 (32.1)	1.2 (25.9)	0.494
CSS Total	20.1 (21.4)	20.1 (21.1)	16.3 (22.4)	18.1 (14.7)	14.0 (16.6)	0.829
Without Nasal Polyposis						
RSDI Physical	6.3 (7.0)	6.4 (7.4)	3.5 (6.1)	5.4 (6.4)	7.8 (10.1)	0.386
RSDI Functional	6.8 (8.2)	6.4 (7.2)	4.5 (7.7)	7.2 (5.9)	7.6 (11.3)	0.740
RSDI Emotional	5.2 (7.6)	5.4 (8.7)	4.4 (6.1)	3.5 (7.0)	7.1 (10.1)	0.831
RSDI Total	18.3 (19.7)	18.2 (20.7)	12.4 (16.7)	16.0 (18.1)	22.5 (30.0)	0.644
CSS Symptom	30.1 (29.5)	23.2 (28.4)	18.7 (34.6)	19.7 (29.2)	29.9 (35.6)	0.407

QOL Instrument	1st Revision		2nd Revision		3rd Revision		4th Revision		5th+ Revision		p-value
	Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		Mean (SD)		
CSS Medication	17.4 (29.2)		15.2 (25.3)		11.7 (27.5)		17.4 (34.0)		8.3 (25.1)		0.792
CSS Total	23.7 (21.1)		19.2 (20.0)		15.2 (23.2)		18.6 (26.3)		19.1 (25.5)		0.465

QOL, quality of life; SD, standard deviation; RSDI, Rhinosinusitis Disability Index; CSS, Chronic Sinusitis Survey; P-values represent results of one-way ANOVA used to evaluate significant global differences between all five revision surgery subgroups.

Table 8

Percentage of patients meeting rigorous criteria for minimally important difference in QOL.

Primary		All Revision				
QOL Instrument	Mean (SD)	Mean (SD)	p-value			
All Patients	(n=221)	(n=331)				
RSDI Physical	73.3%	63.7%	0.019			
RSDI Functional	73.3%	61.3%	0.004			
RSDI Emotional	55.2%	48.6%	0.131			
RSDI Total	73.8%	61.6%	0.003			
CSS Symptom	73.3%	67.4%	0.137			
CSS Medication	48.0%	47.7%	0.958			
CSS Total	71.0%	65.0%	0.135			
QOL Instrument	1st Revision	2nd Revision	3rd Revision	4th Revision	5th+ Revision	p-value
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
All Revision Patients	(n=138)	(n=97)	(n=47)	(n=23)	(n=26)	
RSDI Physical	65.2%	63.9%	61.7%	56.5%	65.4%	0.943
RSDI Functional	60.1%	63.9%	59.4%	60.9%	61.5%	0.981
RSDI Emotional	50.0%	52.6%	42.6%	34.8%	50.0%	0.527
RSDI Total	63.0%	66.0%	53.2%	52.2%	61.5%	0.529
CSS Symptom	71.0%	63.9%	63.8%	69.6%	65.4%	0.786
CSS Medication	44.9%	53.6%	55.3%	47.8%	26.9%	0.117
CSS Total	67.4%	63.9%	57.4%	73.9%	61.5%	0.642

QOL, quality of life; SD, standard deviation; RSDI, Rhinosinusitis Disability Index; CSS, Chronic Sinusitis Survey; P-values correspond to chi-square test results used to assess significant differences in the frequency of improvement between either primary surgery and all revision surgery patients or five revision surgery subgroups.