

Predictive Factors and Outcomes in Endoscopic Sinus Surgery for Chronic Rhinosinusitis

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Purpose: To assess objective and quality of life (QOL) outcomes before and after endoscopic sinus surgery (ESS) in patients with chronic rhinosinusitis (CRS) and to determine preoperative factors that predict surgical outcome in these patients. **Methods:** One hundred nineteen adult patients with CRS and a mean follow-up of 1.4 ± 0.35 years were evaluated prospectively including the following patient factors: prior sinus surgery, polyps, asthma, acetylsalicylic acid intolerance (ASA), smoking, allergy, depression, and sex. Computed tomography (CT), endoscopy, and QOL assessment was performed. Predictive value of patient factors was determined based on change in endoscopy and QOL scores after ESS. **Results:** Objective outcomes: preoperative CT scores were significantly worse in patients with polyps, asthma, and ASA, whereas CT score was unaffected by prior sinus surgery, smoking, allergy, depression, and sex. Patients with CRS demonstrated significant improvement on nasal endoscopy after ESS, but preoperative, postoperative, and change in scores were affected by certain patient factors. Endoscopy scores were significantly worse in patients with prior sinus surgery, polyps, asthma, and ASA, but these patients also experienced the greatest improvement in endoscopy scores. Smokers and patients with depression had the least change in endoscopy scores. QOL outcomes: patients with CRS experienced improvement in QOL after ESS. Pre- and postoperative QOL was positively affected by polyps and adversely affected by ASA, depression, and female sex, but these groups still experienced significant improvement in QOL scores. Pre-

and postoperative QOL was unaffected by prior sinus surgery, asthma, smoking, and allergies, and all of these groups experienced significant improvement in QOL scores. Factors predictive of outcome: ASA and depression were predictive of worse outcome. Preoperative CT scores approached significance as being predictive of outcome. **Conclusion:** Surgical management of CRS was associated with significant improvement on objective and QOL measures; however, specific patient factors, in particular ASA and depression, predict poorer outcome. Preoperative CT may be a predictor of endoscopic and QOL outcome and deserves further study. **Key Words:** Endoscopic sinus surgery, outcomes, quality of life, chronic rhinosinusitis.

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INTRODUCTION

Chronic rhinosinusitis (CRS) is a common health condition in the United States affecting as many as 30 million and is the principal diagnosis in almost 2% of all office visits to physicians, resulting in more than 200,000 sinus procedures performed in the United States annually.¹ Patient symptoms and objective testing procedures play important roles in identifying appropriate surgical candidates, but discordance between objective testing and quality of life (QOL) has been observed by us and others.^{2–4}

In our previous work, we examined the relationship between preoperative objective studies (computed tomography [CT] and endoscopy) and QOL, as measured by validated, disease-specific instruments.³ We now report follow-up data on this patient cohort after endoscopic sinus surgery (ESS). Our primary objective was to evaluate both QOL and objective outcomes of ESS and to examine the impact of certain patient factors on these outcomes.

MATERIALS AND METHODS

Study Population and Data Collection

This study is a continuation of the previously published work from our group.³ The study patients were recruited from adult (18 years or older) patients present-

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ing for endoscopic surgical management of their CRS. The diagnostic criteria developed by the consensus report of the Rhinosinusitis Task Force and endorsed by the American Academy of Otolaryngology were used in this study.^{3,5} Patients who fulfilled inclusion criteria and agreed to participate underwent a battery of measures; objective tests, and QOL tests at the time of enrollment, 6, 12, and 18 months after ESS.

Demographics/Comorbidity/Patient Factors

Medical records and patient history were used to collect information on age, sex, ethnicity/race, diagnostic criteria to validate the diagnosis, presence of comorbidities, and other relevant patient factors including prior sinus surgery, polyps, asthma, acetylsalicylic acid intolerance (ASA), smoking, allergy, and clinical depression under medical treatment.

Objective testing and QOL Evaluation

Medical therapy, CT, and endoscopy were standardized and detailed in our previous article.^{3,6} All patients underwent preoperative standard CT scans in the coronal plane and were staged and evaluated blindly according to the Lund-Mackay CT scoring system.⁷ Standard diagnostic nasal endoscopy was performed, and the endoscopic scoring system proposed by Lund and Kennedy⁸ was used. Two disease-specific instruments were used to measure patient oriented QOL. The Rhinosinusitis Disability Index (RSDI)⁹ and the Chronic Sinusitis Survey (CSS).¹⁰ The instruments were administered by an experienced research coordinator who was blinded to patients CT and endoscopy scores.

Statistical Analyses

CT, endoscopy, and QOL scores were treated as continuous variables. Objective and QOL measures were classified with respect to temporality: preoperative and postoperative in which postoperative assessments correspond to the last follow-up visit at least 1 year after surgery. Comorbidity and other patient factors were analyzed as dichotomous variables.

In analyzing the data, patients were evaluated both as an entire group and as subgroups on the basis of patient factors (e.g., prior sinus surgery, CRS with polyps, asthma, ASA intolerance, smoking, allergy, depression, and sex). Statistical analyses were conducted comparing each patient's preoperative, postoperative, and change scores for each measure (endoscopy, RSDI, and CSS). Subgroups were compared by their preoperative and postoperative scores with the Mann-Whitney test. Overall and within subgroup change scores were compared with zero by the Wilcoxon signed ranks test.

A multivariate analysis of covariance (ANCOVA) was used to determine significant predictive relationships with the following independent variables: all preoperative measures (CT, endoscopy, RSDI, and CSS), prior sinus surgery, polyps, asthma, ASA, smoking, allergy, depression, and sex. The dependent variables (endoscopy, RSDI, and CSS) were all measured postoperatively.¹¹ Because our study was developed to assess change in endoscopy or

QOL after treatment, we analyzed postoperative, absolute change (postoperative minus preoperative), and relative change (postoperative minus preoperative divided by preoperative) scores as the dependent variables. Our analysis found no substantial differences between the postoperative, absolute change, or relative change scores, so we have reported absolute change scores throughout.

RESULTS

Scope of Disease

One hundred and nineteen patients with preoperative and postoperative objective and QOL follow-up were included in the study. Mean follow-up was 1.4 ± 0.35 years and ranged from 0.82 to 2.2 years. Table I describes demographic and patient factor/comorbidity data.

Objective Measures and QOL

All patients with CRS had a mean preoperative CT score of 12.1 ± 7.1 out of a possible 24 and a mean preoperative endoscopy score of 8.1 ± 4.6 and a postoperative mean of 4.5 ± 3.7 with a significant mean change of 3.5 ± 4.5 , $P < .0001$. In the analysis of subgroups by patient factor, all patients irrespective of subgroup showed significant improvement on endoscopy with the exception of smokers (Table II).

Tables III and IV illustrate mean RSDI and CSS pre-, postoperative, and change scores for all patients and by patient factors. Taken together, all patients regardless of patient factors showed significant improvement on the RSDI and the CSS after surgery.

Patient Factors and Comorbidities

Prior sinus surgery.

Objective measures.

Patients with prior sinus surgery ($n = 75$) had similar preoperative CT scores ($P = .869$) and worse endoscopy

TABLE I.
Characteristics of CRS Patients.

Demographics	
Age	
Mean	47.1 \pm 12.9
Range	18–82 years
Gender	
	n (%)
Male	45 (38)
Female	74 (62)
Comorbidity	
Patient Factors	
Prior Sinus Surgery	75 (63)
Asthma	51 (43)
Polyps	43 (36)
Allergy	41 (35)
ASA Intolerance	19 (16)
Depression	16 (13)
Smoker	11 (9)

Demographic and comorbidity data for patient cohort. CRS = chronic rhinosinusitis and ASA = acetylsalicylic acid.

TABLE II.
Ranking of Preoperative and Postoperative Objective Scores by Patient Factor.

Score	Preop-CT		Preop-Endoscopy		Postop-Endoscopy		Change in Endoscopy Score		P	Change
		Mean ± SD		Mean ± SD		Mean ± SD		Mean ± SD		
Worse ↑ ↓ Better	Polyps	18.8 ± 4.1	Polyps	12.3 ± 3.5	ASA	7.2 ± 3.6	Smoker	2.6 ± 5.0	.242	Less ↑ ↓ More
	ASA	17.7 ± 6.6	ASA	11.1 ± 5.1	Polyps	6.6 ± 4.3	Depression	3.0 ± 4.1	.02	
	Asthma	15.0 ± 7.7	Asthma	9.6 ± 5.0	Asthma	5.2 ± 3.8	Females	3.3 ± 4.3	<.0001	
	Males	13.5 ± 7.5	Surgery	9.1 ± 4.8	Surgery	5.1 ± 3.8	Allergy	3.4 ± 3.9	<.0001	
	Allergy	12.5 ± 7.0	Males	8.9 ± 4.5	Males	5.0 ± 4.1	All Patients	3.5 ± 4.5	<.0001	
	Smoker	12.2 ± 6.8	Depression	8.1 ± 4.6	Depression	4.9 ± 3.1	ASA	3.7 ± 3.7	<.0001	
	All Patients	12.1 ± 7.1	All Patients	8.1 ± 4.6	Smoker	4.6 ± 4.6	Males	3.8 ± 5.0	<.0001	
	Surgery	12.1 ± 7.3	Allergy	7.9 ± 4.6	All Patients	4.5 ± 3.7	Surgery	4.1 ± 4.6	<.0001	
	Females	11.2 ± 6.8	Females	7.6 ± 4.6	Allergy	4.5 ± 3.6	Asthma	4.5 ± 4.8	<.0001	
	Depression	11.2 ± 6.6	Smoker	7.1 ± 4.3	Females	4.1 ± 3.4	Polyps	5.5 ± 4.9	<.0001	

Pre- and postoperative scores are arranged in ranking order from most severe to least severe CT and endoscopy score. Changes in endoscopy scores are shown in order of least change to most change following surgery. P values are reported for differences in pre- and postoperative endoscopy scores. ASA = acetylsalicylic acid intolerance.

scores in the preoperative (9.1 ± 4.8 vs. 6.4 ± 3.6 ; $P = .001$) and the postoperative (5.1 ± 3.8 vs. 3.6 ± 3.5 ; $P = .037$) periods as compared with patients without prior sinus surgery. All patients regardless of prior sinus surgery showed a similar degree of improvement on endoscopy ($P = .106$), although final endoscopy scores remained significantly worse in patients with prior sinus surgery (Table II).

Quality of life measures.

Prior sinus surgery had no effect on QOL, and regardless of previous surgery, patients scored similarly on the RSDI and CSS in the pre- and postoperative periods (RSDI $P = .517$, $P = .149$ and CSS $P = .469$ and $P = .571$), demonstrating the same degree of improvement on both measures (RSDI $P = .309$ and CSS $P = .909$) (Tables III and IV).

Polyps.

Objective measures.

Patients with polyps ($n = 43$) had worse preoperative CT scores (18.8 ± 4.1) than patients without polyps (8.5 ± 5.6 ; $P < .0001$) and worse endoscopy scores, both preoperatively (12.3 ± 3.5 vs. 5.8 ± 3.4 ; $P < .0001$) and postoperatively (6.6 ± 4.3 vs. 3.3 ± 2.7 ; $P < .0001$). They also demonstrated a greater degree of improvement on endoscopy after surgery than patients without polyps (5.5 ± 4.9 vs. 2.4 ± 3.9 ; $P = .002$), although their final scores remained significantly worse.

Quality of life measures.

Patients with polyps had better CSS scores than patients without polyps both preoperatively (39.8 ± 16.9 vs. 29.6 ± 19.0 ; $P = .001$) and postoperatively (60.6 ± 20.6 vs. 53.2 ± 19.6 ; $P = .044$). All patients irrespective of polyps

TABLE III.
Ranking of Preoperative and Postoperative QOL Scores by Patient Factor.

Score	Preop-RSDI		Postop-RSDI		Change in RSDI Score		P	Change
		Mean ± SD		Mean ± SD		Mean ± SD		
Worse ↑ ↓ Better	Depression	66.9 ± 13.9	Depression	48.3 ± 18.5	ASA	-12.3 ± 18.1	.018	Less ↑ ↓ More
	Females	52.8 ± 20.5	ASA	38.4 ± 19.9	Smoker	-16.9 ± 20.5	.044	
	ASA	52.2 ± 20.1	Females	32.8 ± 21.7	Males	-17.6 ± 18.4	<.0001	
	Asthma	50.8 ± 20.9	Asthma	31.9 ± 20.4	Surgery	-17.7 ± 20.4	<.0001	
	Surgery	49.8 ± 20.9	Smoker	31.7 ± 27.4	Allergy	-18.2 ± 20.4	<.0001	
	All Patients	48.9 ± 21.3	Surgery	31.5 ± 21.1	Asthma	-18.5 ± 22.2	<.0001	
	Smoker	48.6 ± 20.4	All Patients	29.6 ± 21.3	Depression	-18.6 ± 21.5	.01	
	Allergy	47.2 ± 17.2	Allergy	29.5 ± 19.5	All Patients	-19.1 ± 20.4	<.0001	
	Polyps	46.6 ± 21.4	Polyps	26.1 ± 20.8	Polyps	-19.5 ± 20.6	<.0001	
	Males	42.4 ± 21.3	Males	24.5 ± 19.9	Females	-20.0 ± 21.6	<.0001	

Pre- and Postoperative RSDI scores are arranged in ranking order from worst score to best score. Changes in RSDI scores are shown in order of least change to most change following surgery. P values are reported for differences in pre- and postoperative RSDI scores. ASA = acetylsalicylic acid intolerance, QOL = quality of life, and RSDI = rhinosinusitis disability index.

TABLE IV.
Ranking of Preoperative and Postoperative QOL Scores by Patient Factor.

Score	Preop-CSS		Postop-CSS		Change in CSS Score		P	Change
		Mean ± SD		Mean ± SD		Mean ± SD		
Worse ↑ ↓ Better	Depression	25.0 ± 16.1	Females	52.4 ± 19.6	ASA	13.9 ± 22.0	.011	Less ↑ ↓ More
	Females	29.2 ± 16.7	ASA	52.6 ± 22.7	Polyps	19.6 ± 17.6	<.0001	
	Allergy	30.8 ± 16.6	Allergy	53.5 ± 20.1	Males	21.3 ± 21.3	<.0001	
	Asthma	32.2 ± 18.4	Asthma	54.4 ± 20.3	Asthma	21.8 ± 21.1	<.0001	
	Smoker	33.0 ± 13.9	Depression	55.8 ± 20.9	Surgery	22.0 ± 20.6	<.0001	
	All Patients	33.2 ± 18.9	All patients	55.9 ± 20.2	All Patients	22.1 ± 21.5	<.0001	
	Surgery	33.8 ± 18.6	Surgery	56.6 ± 19.4	Allergy	22.5 ± 22.9	<.0001	
	ASA	37.5 ± 19.6	Smoker	58.7 ± 24.7	Females	22.7 ± 21.7	<.0001	
	Polyps	39.8 ± 16.9	Polyps	60.6 ± 20.6	Smoker	25.8 ± 19.4	.003	
	Males	39.8 ± 20.6	Males	61.4 ± 20.1	Depression	29.2 ± 24.3	.002	

Pre- and Postoperative CSS scores are arranged in ranking order from worst score to best score. Changes in CSS scores are shown in order of least change to most change following surgery. P values are reported for differences in pre- and postoperative CSS scores. ASA = acetylsalicylic acid intolerance, QOL = quality of life, and CSS = chronic rhinosinusitis survey.

had similar pre- and postoperative RSDI scores ($P = .357$, $P = .148$) and showed a similar degree of improvement on the RSDI ($P = .969$) and the CSS ($P = .422$), although patients with polyps final CSS scores were significantly better (Tables III and IV).

Asthma.

Objective measures.

Patients with asthma ($n = 51$) had worse preoperative CT scores (15.0 ± 7.7) than patients without asthma (10.0 ± 5.8 ; $P < .0001$) and worse endoscopy scores, both preoperatively (9.6 ± 5.0 vs. 6.9 ± 3.9 ; $P = .002$) and postoperatively (5.2 ± 3.8 vs. 3.9 ± 3.6 ; $P = .049$). They also showed more improvement on endoscopy after surgery than patients without asthma (4.5 ± 4.8 vs. 2.8 ± 4.2 ; $P = .046$), although, their final scores were significantly worse.

Quality of life measures.

Asthma did not have an effect on QOL, and all patients scored similarly on the RSDI and the CSS in the pre- and postoperative periods (RSDI $P = .348$, $P = .190$ and CSS $P = .846$, $P = .450$), demonstrating the same degree of improvement on both measures after surgery (RSDI $P = .814$ and CSS $P = .700$) (Tables III and IV).

ASA intolerance.

Objective measures.

Patients with ASA ($n = 19$) had significantly worse preoperative CT scores (17.7 ± 6.6) than patients without ASA (11.1 ± 6.7 ; $P < .0001$) and worse endoscopy scores both preoperatively (11.1 ± 5.1 vs. 7.6 ± 4.3 ; $P = .003$) and postoperatively (7.2 ± 3.6 vs. 3.9 ± 3.5 ; $P < .0001$). All patients irrespective of ASA showed a similar degree of improvement on endoscopy after surgery ($P = .611$), although patients with ASA final scores were significantly worse (Table II).

Quality of life measures.

Compared with patients without ASA, patients with ASA had similar RSDI scores preoperatively ($P = .669$), worse RSDI scores postoperatively (38.4 ± 19.9 vs. $27.9 \pm$

21.3 ; $P = .026$), and showed a similar degree of improvement after surgery ($P = .149$), although their final RSDI scores remained significantly worse (Table III). All patients regardless of ASA had similar CSS scores in the pre- ($P = .295$) and postoperative ($P = .531$) periods. Patients with ASA improved to a lesser degree on the CSS than patients without ASA (13.9 ± 22.0 , 23.7 ± 21.1 ; $P = .05$), although both groups final scores remained similar (Table IV).

Smoking.

Objective measures.

Interestingly, there was no significant difference between smokers ($n = 11$) and nonsmokers in preoperative CT ($P = .996$), pre- and postoperative endoscopy ($P = .383$ and $P = .888$), and change in endoscopy scores ($P = .441$) (Table II).

Quality of life measures.

There was no effect of smoking on QOL, and all patients had similar pre- and postoperative RSDI ($P = .910$, $P = .933$) and CSS scores ($P = .958$, $P = .431$) and demonstrated the same degree of improvement on both measures (RSDI $P = .775$) and CSS ($P = .460$) after surgery (Tables III and IV).

Allergy.

Objective measures.

Allergies ($n = 41$) had no effect on objective measures, and all patients had similar preoperative CT scores ($P = .643$), endoscopy scores in the preoperative ($P = .805$) and postoperative ($P = .906$) periods, and showed the same degree of improvement on endoscopy after surgery ($P = .867$) (Table II).

Quality of life measures.

All patients regardless of allergies scored similarly on the RSDI and the CSS in the pre- and postoperative periods (RSDI $P = .721$, $P = .810$ and CSS $P = .560$ and $P = .361$), demonstrating a similar degree of improvement on both QOL measures (RSDI $P = .884$ and CSS $P = .868$) postoperatively (Tables III and IV).

Depression.

Objective measures.

Depression (n = 16) had no effect on objective measures, and all patients had similar preoperative CT ($P = .589$), pre- and postoperative endoscopy ($P = .917$ and $P = .426$), and a similar change in endoscopy scores after surgery ($P = .671$) (Table II).

Quality of life measures.

When compared with nondepressed patients, depressed patients had worse RSDI scores in the preoperative (66.9 ± 13.9 vs. 46.0 ± 21.0 ; $P < .0001$) and postoperative (48.3 ± 18.5 vs. 26.9 ± 20.4 ; $P < .0001$) periods and showed a similar degree of improvement after surgery ($P = .858$), although their final RSDI scores remained significantly worse after surgery. Depressed patients had worse CSS scores preoperatively, although statistical significance was not achieved ($P = .071$) and similar scores postoperatively ($P = .983$) as compared with nondepressed patients. Interestingly, depressed patients showed a greater degree of improvement than nondepressed patients on the CSS (29.2 ± 24.3 vs. 21.1 ± 20.9 ; $P = .050$), although final scores were similar in both groups (Tables III and IV).

Sex.

Objective measures.

Sex had no effect on objective measures, and all patients had similar preoperative CT scores ($P = .107$), pre- and postoperative endoscopy scores ($P = .108$ and $P = .363$), and showed the same degree of improvement on endoscopy after surgery ($P = .849$) (Table II).

Quality of life measures.

Males (n = 45) scored significantly better than females (n = 74) on the RSDI and the CSS, both preopera-

tively (RSDI; males 42.4 ± 21.3 vs. females 52.8 ± 20.5 ; $P = .010$ and CSS; males 39.8 ± 20.6 vs. females 29.2 ± 16.7 ; $P = .006$) and postoperatively (RSDI; males 24.5 ± 19.9 vs. females 32.8 ± 21.7 ; $P = .028$ and CSS; males 61.4 ± 20.1 vs. females 52.4 ± 19.6 ; $P = .010$) and showed a similar degree of improvement on each measure (RSDI $P = .641$ and CSS $P = .735$), although final QOL scores were significantly better in males (Tables III and IV).

Predictive Models for Outcome

Multivariate and univariate ANCOVA revealed that ASA and depression demonstrated predictive value for outcome (Table V). ASA intolerance was determined to be a significant predictor of worse outcome (less improvement/less change) for both endoscopy and the RSDI. In addition, patients with ASA intolerance showed a trend toward worse outcome (less improvement/less change) on the CSS, although it was not statistically significant (Table V).

Depression was determined to be a significant predictor of worse outcome (less improvement/less change) for the RSDI. Depression was not a significant predictor of outcome for endoscopy or for the CSS (Table V).

Preoperative CT score approached significance as a predictor of outcome for both endoscopy and the CSS. Patients with higher (worse disease) preoperative CT scores showed a trend toward more improvement for endoscopy and the CSS (Table V).

DISCUSSION

Overall, patients with CRS demonstrate improvement in QOL and endoscopy after ESS regardless of comorbidity or other patient factors analyzed. However, certain factors and comorbidities clearly impact preoperative

TABLE V.
Predictors of Clinical Improvement on Endoscopy and QOL Measures.

Predictor	Change in			Direction of Effect
	Endoscopy	RSDI	CSS	
	P value	P value	P value	
Gender	NS	NS	NS	
Race/Ethnicity	NS	NS	NS	
Prior Sinus Surgery	NS	NS	NS	
Polyps	NS	NS	NS	
Asthma	NS	NS	NS	
ASA Intolerance	.037*	.012*	.092	ASA associated with less improvement
Smoker	NS	NS	NS	
Allergy	NS	NS	NS	
Depression	NS	.030*	NS	Depression associated with less improvement
Pre-CT	.088	NS	.088	Worse scores (more disease) were associated with more improvement
Pre-Endoscopy	<.0001*	NS	NS	Worse scores (more disease) were associated with more improvement
Pre-RSDI	NS	<.0001*	NS	Worse scores (more disease) were associated with more improvement
Pre-CSS	NS	NS	<.0001*	Worse scores (more disease) were associated with more improvement

Potential predictors are listed in the left column. NS indicates the factor was not predictive of outcome. All p values < 0.1 are reported. ASA = acetylsalicylic acid intolerance, QOL = quality of life, RSDI = rhinosinusitis disability index, and CSS = chronic rhinosinusitis survey.

measures, postoperative measures, and observed change in these outcomes. As we and others have previously noted, objective and QOL outcomes do not necessarily correlate in the pre- or postoperative period, but both provide important information regarding the patients' outcomes of ESS.²⁻⁴ On the other hand, certain preoperative factors in the present study, ASA intolerance and depression, provide predictive value for postoperative endoscopy or QOL outcomes.

Preoperative objective testing by CT and endoscopy clearly demonstrate the advanced disease, by these measures, in patients with polyps, ASA intolerance, and asthma. Such a severity of disease in patients presenting with these factors has been observed by others.^{12,13} It is interesting and unexpected that tobacco abuse appears to be associated with lower disease severity on preoperative objective testing.

Preoperative QOL testing demonstrates the negative impact of CRS on all patients but an even more negative impact on patients with depression and female sex associated with CRS. It is interesting, and unexpected, that females presented with worse QOL scores as compared with males, despite the fact that there were no differences by objective measures. Smokers and patients with polyps, on the other hand, present with better preoperative QOL scores than anticipated. Clinicians note that patients with polyps often present with severe disease by endoscopy and CT and often persist with endoscopic evidence of disease postoperatively, but their complaints, particularly of pain and headache, are often less than those with minimal objective disease. This clinical observation is corroborated by this study.

We have previously demonstrated that each of the QOL measures is measuring somewhat different constructs of disease.³ This is quite apparent when comparing the two preoperative QOL scores in patients with allergy in which CSS scores appear substantially worse than RSDI scores. Because the CSS is more sensitive to medication use because of the questions asked by the instrument, it is possible that this finding is indicative of greater medication use in patients with allergy.

Postoperative endoscopy scores are reflective of preoperative objective (endoscopy and CT) scores.¹³ Patients with polyps, ASA intolerance, and asthma demonstrate more postoperative mucosal disease by endoscopy than those with allergy and tobacco abuse. Patients with polyps, asthma, and prior surgery also show the greatest improvement in endoscopy score after surgery, whereas smokers and depressed patients show the least improvement in endoscopy score. In addition, patients with prior sinus surgery demonstrate poorer endoscopy scores both pre- and postoperatively. This is likely explained by the "scarring" component of the endoscopy scoring system.

Postoperative QOL evaluation, for the most part, is reflective of preoperative scores. Patients with ASA intolerance consistently demonstrate worse scores, whereas male patients, smokers, and those with polyps appear to have consistently better scores. Interestingly, patients with depression demonstrate the worst postoperative RSDI scores but somewhat average postoperative CSS scores. This likely demonstrates the sensitivity of the

RSDI to depression given that the RSDI contains an "emotional" subscale that asks questions related to the patients' emotional well-being. The degree of change in QOL scores was somewhat variable between the two instruments. Interestingly, female patients and those with depression tended to present with the worst QOL scores but also tended to show the greatest improvement in QOL scores. Meanwhile, male patients consistently presented with the best QOL scores and experienced less change in score.

Our analyses indicate that two factors, ASA intolerance and depression, provided predictive value in assessing outcomes. Complexities arise in the development of predictive models as a result of the fact that we are assessing three different outcomes (CSS, RSDI, and endoscopy scores) in addition to the fact that there are three different ways to examine these outcomes: 1) absolute change in score (difference between pre- and postoperative score), 2) relative change in score (absolute change in score divided by preop score), and 3) the final postoperative score. Others have highlighted the importance of selecting the appropriate outcome to examine.^{14,15} Our study was developed to assess the likelihood of symptom improvement with ESS, so change in score was focused on. However, our analyses examined all three options. We found that using either absolute change in score or final postoperative score yielded the same results, with both ASA intolerance and depression predicting poorer outcome, the latter finding being corroborated by others.¹⁴ Inclusion of the preoperative score in the model with absolute change as the outcome allows one to predict relative change in score. In predicting change, whether absolute or relative, ASA intolerance and depression remain the primary factors predictive of poorer outcome. When examining the type of outcome (endoscopy, RSDI, or CSS), ASA intolerance was predictive of poorer endoscopy outcome and RSDI outcome, whereas depression was predictive of poorer RSDI outcome but had no effect on endoscopy outcome. Translated into clinical terms, a patient with ASA intolerance would be expected to have significant improvement in QOL and endoscopy with ESS but less improvement than a patient without ASA intolerance. For depression, one could predict significant improvement in both QOL and endoscopy with ESS but less improvement in QOL than a patient without depression.

Preoperative CT scores approached significance as a predictor of endoscopy and CSS outcomes. In this case, patients with worse CT scores tended to demonstrate the greatest change in endoscopy and CSS scores after ESS. Other investigators have observed similar predictive ability of preoperative CT scores.^{15,16} The implications of this relationship between preoperative CT scores and QOL improvement merit further investigation.

CONCLUSION

Surgical management of CRS was associated with significant improvement on objective and QOL measures; however, specific patient factors, in particular ASA and depression, predict poorer outcome. We are currently engaged in a multi-institutional study to determine additional predictors of both objective and QOL outcome as

well as to clarify the potential role of CT as a prognostic tool for symptomatic improvement in patients undergoing ESS.

BIBLIOGRAPHY

1. Osguthorpe JD. Surgical outcomes in rhinosinusitis: what we know. *Otolaryngol Head Neck Surg* 1999;120:451–453.
2. Smith TL. Outcomes research in rhinology: chronic rhinosinusitis. *ORL J Otorhinolaryngol Relat Spec* 2004;66:202–206.
3. Smith TL, Rhee JD, Loehrl TA, et al. Objective testing and quality-of-life evaluation in surgical candidates with chronic rhinosinusitis. *Am J Rhinol* 2003;17:351–355.
4. Wabnitz DA, Nair S, Wormald PJ. Correlation between preoperative symptom scores, quality-of-life questionnaires, and staging with computed tomography in patients with chronic rhinosinusitis. *Am J Rhinol* 2005;19:91–96.
5. Lanza DC, Kennedy DW. Adult rhinosinusitis defined. *Otolaryngol Head Neck Surg* 1997;117(Suppl):S1–S7.
6. Benninger MS, Anon JB, Mabry RL. The medical management of adult rhinosinusitis. *Otolaryngol Head Neck Surg* 1997;117(Suppl):41–49.
7. Lund VJ, Mackay IS. Staging in rhinosinusitis. *Rhinology* 1993;107:183–184.
8. Lund VJ, Kennedy DW. Quantification for staging sinusitis. International Conference on Sinus Disease: terminology, staging, therapy. *Ann Otol Rhinol Laryngol* 1995;104(Suppl):17–21.
9. Benninger MS, Senior BA. The development of the rhinosinusitis disability index. *Arch Otolaryngol Head Neck Surg* 1997;123:1175–1179.
10. Gliklich RE, Metson R. Techniques for outcomes research in chronic sinusitis. *Laryngoscope* 1995;105:387–390.
11. Laud PW, Ibrahim JG. Predictive model selection. *J Roy Stat Soc* 1995;57:247–262.
12. Kountakis SE, Arango P, Bradley D, et al. Molecular and cellular staging for the severity of chronic rhinosinusitis. *Laryngoscope* 2004;114:1895–1905.
13. Kennedy DW. Prognostic factors, outcomes, and staging in ethmoid sinus surgery. *Laryngoscope* 1992;102(Suppl):1–18.
14. Davis GE, Yueh B, Walker E, et al. Psychiatric distress amplifies symptoms after surgery for chronic rhinosinusitis. *Otolaryngol Head Neck Surg* 2005;132:189–196.
15. Witsell DL, Stewart MG, Monsell EM, et al. The cooperative outcomes group for ENT: a multicenter prospective cohort study on the effectiveness of medical and surgical treatment for patients with chronic rhinosinusitis. *Otolaryngol Head Neck Surg* 2005;132:171–179.
16. Stewart MG, Donovan DT, Parke RB Jr, Bautista MH. Does the severity of sinus computed tomography findings predict outcome in chronic sinusitis? *Otolaryngol Head Neck Surg* 2000;123:81–84.