



# Evaluating the Efficacy and Trend of Sinus Surgery

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## Abstract

**Introduction** From April 2009 to December 2016, 661 consecutive patients undergoing sinus surgery completed a quality of life (QOL) questionnaire (SNOT-22) preoperatively and at 3, 6, and 12 months postoperatively.

**Objective** (1) To evaluate the long-term efficacy of sinus surgery using QOL instruments. (2) To determine the optimal evaluation time for surgical efficacy. (3) To determine if surgical results improve with yearly experience.

**Methods** The prospective study patients were split into two groups: Group A, those who completed the initial preoperative evaluation and all postoperative evaluations, and Group B, who completed the preoperative questionnaire and at least one but not all of the postoperative questionnaires. Group A included 93 patients. Group B included 240 patients at 3 months, 180 at 6 months, and 121 at 12 months postoperatively.

**Results** Group A efficacy reported at 3 months was 82.8%, 80.6% at 6 months, and 84.9% at 12 months postoperatively. Group B efficacy reported at 3 months was 71.3%, 78.3% at 6 months, and 84.3% at 12 months postoperatively. An 8-year trend analysis of year-to-year 12 months postoperative data illustrates a significant improvement with an analysis of variance (ANOVA) linear rate of 1.594 ( $p \leq 0.12$ ).

**Conclusion** The 8-year trend at 12 months postoperatively shows a positive improvement in surgical results. Patients undergoing sinus surgery at tertiary medical center showed 84.9% improvement in sinus disease symptoms by 12 months postoperatively. Long-term improvement analysis showed no difference between 6 months postoperatively and 12 months, signifying 6 months as an effective evaluation for surgical efficacy.

## Keywords

- ▶ quality of life
- ▶ sinusitis
- ▶ paranasal sinuses

## Introduction

Chronic rhinosinusitis (CRS) is characterized by inflammation of the paranasal sinuses persistent for 12 weeks or longer despite treatment, impacting both physical and mental health. Chronic rhinosinusitis is a prevalent condition affecting up to 16% of Americans aged between 18 and 59 years old, with 6.8% of Americans after the age of 69 years old.<sup>1</sup> Chronic rhinosinusitis has been found to be highly correlated to a diminished quality of life (QOL) and is considered a burden on healthcare.

Chronic rhinosinusitis is considered to be an under-researched chronic disease when compared with other dis-

eases that have a similar burden in regards to healthcare, prevalence, and QOL.<sup>2</sup> The economic burden of CRS is increasing at an upward trend with the most recent estimate in 2015 showing total yearly medical expenditures for CRS in the United States to be between 60.6 billion and 64.9 billion US dollars per year (treatment for CRS ranges from 5,560 USD to 5,955 USD per person).<sup>3</sup> Aside from the costs of healthcare, there are indirect costs associated with CRS. Chronic rhinosinusitis has been placed among the top 10 debilitating medical conditions placed among angina, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and chronic back pain, as well as one of the top conditions affecting employers similar to disease states such as acute

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myocardial infarction, COPD, and trauma to the spine and spinal cord.<sup>4,5</sup>

Patients with CRS reported similar QOL in patients with other chronic conditions such as cancer, arthritis, asthma, and inflammatory bowel disease.<sup>6</sup> Furthermore, patients with CRS are reported to have much lower bodily pain scores and social functioning scores than those with CHF, COPD, angina, and back pain.<sup>7</sup>

The Sino-Nasal Outcome Test (SNOT-22) is an evidence-based, verified, symptom-specific QOL measurement to evaluate the severity of sinus disease, consisting of 22 questions in which patients are asked to evaluate their symptoms on a scale of 0 to 5, 0 indicating no problem, and 5 indicating the symptom to be as severe as it can be. According to the research by Rudmik et al on the predictive value of the preoperative SNOT-22 score, a score change of 9 points or greater is considered as a clinically significant change.<sup>8</sup> The SNOT-22 is meant to illustrate changes between the pre- and postoperative. At the preoperative, patients are asked to indicate the symptoms they consider to be most important to them. In contrast, postoperative SNOT-22 scores evaluate the surgical efficacy through symptoms after surgery with the yearly QOL standards set as monthly follow-ups. By using SNOT-22, we can determine the long-term efficacy of sinus surgery, the optimal evaluation time for surgical efficacy, and if surgical results improve with yearly experience.

## Methods

The present study was approved by the Office of Research Compliance and Quality Improvement of the Medical Center (Pro00039371).

The patient sample is the hospital population of all CRS patients subdivided by severity of disease according to the SNOT-22 category. Part of the standard of care at a tertiary medical center, patients  $\geq 18$  years old undergoing sinus surgery are given a SNOT-22 form to complete preoperatively. Chronic rhinosinusitis was diagnosed with a minimum of 12 weeks of symptomatic sinusitis episodes, unresponsiveness to antibiotics and steroids in any form, and positive CT scan findings. All of the patients underwent transnasal endoscopic sinus surgery, including septoplasty and turbidoplasty. The SNOT-22 QOL instrument provided substantial insight for a prospective study. Quality of life measurements are of overall hospital surgical morbidity of patients diagnosed with CRS undergoing sinus surgery and, therefore, would not include any subcategories such as nasal polyps. At 3 months, 6 months, and 12 months postoperatively, patients were asked to complete another SNOT-22 form. Data was collected by a project coordinator via Health Insurance Portability and Accountability Act (HIPAA) compliant measures: mail/email/telephone. At the time of data analysis, all patient identifying factors were concealed.

The population sample from April 2009 to December 2016 consists of 661 consecutive patients, 14 of which were indicated to be revision surgeries. All of the patients were asked to complete the SNOT-22 preoperatively, and at 3, 6, and 12 months postoperatively.

In the prospective study, patients were split into two groups: Group A, those who completed the initial preoperative evaluation and all postoperative evaluations, and Group B who completed at least one but not all of the postoperative questionnaires. In addition, patients who had a preoperative SNOT-22 score  $< 9$  were excluded, since no clinically significant change can be determined. For Group A, only data from between April 2009 and April 2016 was used. Group A consisted of 93 patients who completed all 4 milestone SNOT-22 forms with 553 patients lost to follow-up. Alternatively, Group B consisted of 240 patients at 3 months, 180 at 6 months, and 121 at 12 months. The remainder of the patients was lost to follow-up.

For Group B, data from April 2009 to December 2016 was used. Group B was created to observe a much larger population size, since it focused on all the data available for each of the milestones (3 months, 6 months, and 12 months postoperatively) compared with the initial score. Therefore, Group B also consisted of patients that may have only reached the 3 months postoperative milestone, who would have been excluded from Group A at the time of the most recent data analysis.

## Results

From April 2009 to April 2016, 646 patients completed SNOT-22 questionnaires with the initial preoperative evaluation and all postoperative evaluations. From that population sample, 93 patients met the standard to be included in Group A. From the 8-year review of patients, 553 patients (85.6%) had been lost to follow-up and, as a result, were excluded from Group A. According to the study by Hopkins et al,<sup>9</sup> a norm of  $\sim 35\%$  loss to follow-up is expected.

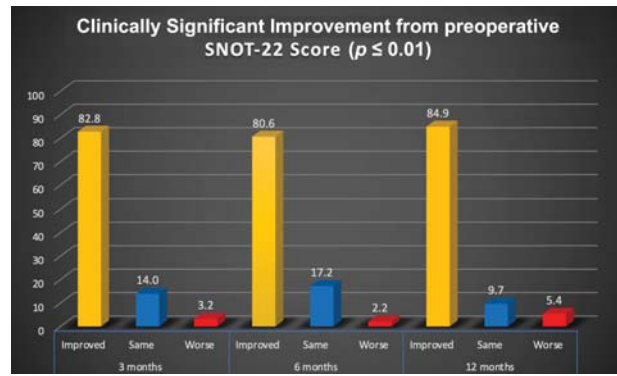
Group A results are broken down in **Table 1**. Group A showed overall surgical success rates of 82.8% at 3 months, 80.6% at 6 months, and 84.9% at 12 months postoperatively ( $p \leq 0.01$ ), with an average SNOT-22 score change of 24.4 at 12 months from their initial score (**Fig. 1**). An 8-year trend analysis of year-to-year 12 months postoperative data illustrated significant improvement over time with an analysis of variance (ANOVA) linear rate of 1.594 ( $p \leq 0.12$ ), as seen in **Fig. 2**. For each postoperative period (3 months, 6 months, and 12 months), a significant increase is seen in the trend line.

In 2009, 14 patients in Group A had a preoperative mean score of 43.3. At 3 months postoperatively, the efficacy was reported at 78.6% improvement, 7.1% the same, and 14.3% worsened, with a mean SNOT-22 score change (MSSC) of 19.2. At 6 months, the rates were reported at 85.7% improvement, 7.1% the same, and 7.1% worsened, and with an MSSC of 25.0 from their preoperative score. At 12 months, the MSSC was at 20.2 and rates were reported as they were at 3 months (78.6% improvement, 7.1% the same, and 14.3% worsened).

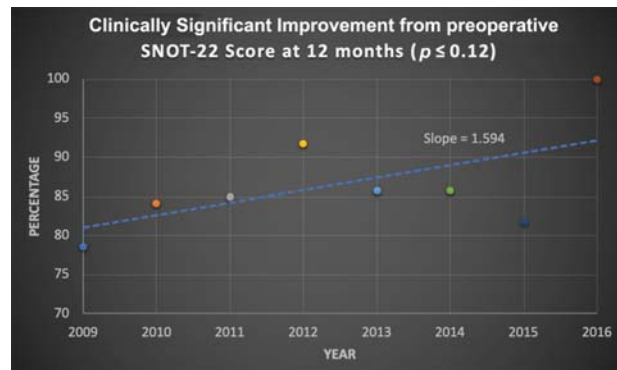
In 2010, 19 patients in Group A had a preoperative mean score of 42.1. At 3 months postoperatively, the efficacy was reported at 84.2% improvement, 15.8% the same, and 0% worsened from their preoperative SNOT-22 score, with an

**Table 1** Group A Results

Year	Preoperative mean	3 months postoperatively					6 months postoperatively					12 months postoperatively				
		# of patients	Improved	Same	Worse	p-value	# of patients	Improved	Same	Worse	p-value	# of patients	Improved	Same	Worse	p-value
2009	43.3	14	78.6%	7.1%	14.3%	≤0.01	14	85.7%	7.1%	7.1%	≤0.01	14	78.6%	7.1%	14.3%	≤0.01
2010	42.1	19	84.2%	15.8%	0.0%	≤0.01	19	78.9%	21.1%	0.0%	≤0.01	19	84.2%	10.5%	5.3%	≤0.01
2011	43.6	20	80.0%	20.0%	0.0%	≤0.01	20	80.0%	20.0%	0.0%	≤0.01	20	85.0%	10.0%	5%	≤0.01
2012	32.4	12	91.7%	8.3%	0.0%	≤0.01	12	75.0%	25.0%	0.0%	≤0.01	12	91.7%	0.0%	8.3%	≤0.01
2013	42.7	7	85.7%	14.3%	0.0%	≤0.01	7	85.7%	14.3%	0.0%	≤0.01	7	85.7%	14.3%	0.0%	≤0.01
2014	38.6	7	71.4%	28.6%	0.0%	≤0.01	7	85.7%	0.0%	14.3%	≤0.01	7	85.7%	14.3%	0.0%	≤0.01
2015	43.1	11	81.8%	9.1%	9.1%	≤0.01	11	72.7%	27.3%	0.0%	≤0.01	11	81.8%	18.2%	0.0%	≤0.01
2016	61.3	3	100.0%	0.0%	0.0%	≤0.01	3.0	100.0%	0.0%	0.0%	≤0.01	3.0	100.0%	0.0%	0.0%	≤0.01
<b>TOTAL</b>	<b>40.8</b>	<b>93</b>	<b>82%</b>	<b>14%</b>	<b>3%</b>	<b>≤0.01</b>	<b>93</b>	<b>80%</b>	<b>17%</b>	<b>2%</b>	<b>≤0.01</b>	<b>93</b>	<b>85%</b>	<b>10%</b>	<b>5%</b>	<b>≤0.01</b>



**Fig. 1** Overall Group A Improvement Results (Percentage Change).



**Fig. 2** Group A 8-year trend analysis of 12-month rates.

MSSC of 25.2. At 6 months, the MSSC was 26.2, with postoperative 78.9% improvement, 21.1% same, and 0% worsened compared with their initial SNOT-22 score. At 12 months, the MSSC was 21.7, with 84.2% improved, 10.5% the same, and 5.3% worsened compared with their preoperative SNOT-22 score.

In 2011, 20 patients in Group A had a preoperative mean of 43.6. At 3 months, the MSSC was 24.7 with reported scores of 80% improvement, 20% same, and 0% worsened from their pre-op SNOT-22 score. At 6 months, the MSSC was 24.4, with rates reported like at 3 months postoperatively, 80% improvement, 20% same, and 0% worsened. At 12 months, the MSSC was 25.0, with 85% improvement, 10% same, and 5% worsened.

In 2012, 12 patients in Group A had a preoperative mean of 32.4. At 3 months, the MSSC was 20.9 with reported scores of 91.7% improvement, 8.3% the same, and 0% worsened. At 6 months, the MSSC was 18.1 with 75% improvement, 25% same, 0% worsened. At 12 months, the MSSC was 19.4 with 91.7% improvement, 0% the same, and 8.3% reported a score that was greater than their initial score. In this Group, 3 patients were indicated to be revision surgeries with a revision preoperative mean improvement of 31. At 3 months, the MMSC was 1, and 66.7% improved, 33.3% worsened. At 6 months, the MMSC was 11.3 with 66.7% improvement, 33.3% worse. At 12 months, the MMSC was 22 and 100% improved.

In 2013, 7 patients in Group A had a preoperative mean of 42.7. At 3 months postoperatively, the MSSC was 31.7, with a

reported 85.7% improvement, 14.3% the same, and 0% worsened. At 6 months, the MSSC was 26.9 with similar results as reported during the 3 months follow-up (85.7% improvement, 14.3% the same, and 0% worsened). At 12 months postoperatively, the MSSC was 25.9 with identical rates being reported as at 3 months and 6 months post-op (85.7% improvement, 14.3% the same, and 0% worsened).

In 2014, 7 patients in Group A had a preoperative mean of 38.6. At 3 months, the MSSC was 26.4 with surgical success rate reported at 71.4%, 28.6% reported no change, and 0% reported worsened symptom scores. At 6 months the MSSC was 23.4, with 85.7% reported scores that improved, and 14.3% reported scores that had not changed significantly from their preoperative score. At 12 months postoperatively, the MSSC was 30.8 with the same rates being reported as at 6 months (85.7% improved, 14.3% the same, and 0% worsened.)

In 2015, 11 patients in Group A had a preoperative mean of 43.1. At 3 months, the MSSC was 19.7 with 81.8% reporting scores that improved from their preoperative SNOT-22 score, 9.1% reporting scores that did not change significantly, and 9.1% worsened from their preoperative SNOT-22 score. At 6 months postoperatively, the MSSC was 25.4, with rates being reported as 72.7% improved, 27.3% the same, and 0% worsened. At 12 months postoperatively, the MSSC was 25.2 with 81.8% significantly lower scores than their initial, 18.2% reporting scores that did not change significantly, and 0% reporting worsened scores.

In 2016, 3 patients in Group A had a preoperative mean of 61.3. At 3 months, the MSSC was 53.3 with 100% reporting improvement. At 6 months, the MSSC was 49.7, and at 12 months the MSSC was 30.3. All of the patients reported 100% at each postoperative period (3 months, 6 months, and 12 months).

From April 2009 to December 2016, 282 patients completed SNOT-22 questionnaires with at least 1 but not all of the postoperative questionnaires. Group B had a total number of 240 patients at 3 months, 180 at 6 months, and 121 at 12 months. A total of 48 patients (17.0%) were lost to follow up at 3 months, 102 patients (36.2%) at 6 months, and 161 patients (57.1%) at 12 months.

The average loss over the 8-year period for Group B was: 3 months, 14.6%; 6 months, 33.7%; 12 months, 56.1%

Group B results are broken down in **Table 2**. Group B showed similar results when compared with Group A, regarding the surgical success rates at each postoperative period, 71.3%, 78.3%, and 84.3%, respectively ( $p \leq 0.01$ ) (**Fig. 3**). At 3 months postoperatively, 240 patients in Group B on average reported 71.25% improvement, 22.5% the same, and 6.25% worsened from their preoperative score. At 6 months postoperatively, 180 patients in Group B on average reported 78.3% improvement, 19.44% the same, 2.22% worsened from their preoperatively score. At 12 months postoperatively, 121 patients in Group B on average reported 84.3% improvement, 11.6% the same, and 4.1% worsened from their preoperative score.

In Group B, at 3 months, 9 out of the 240 surgeries were revisions (2 in 2011, 6 in 2012, and 1 in 2013). The patient rates of surgical efficacy with revision surgeries showed 44.4% significant improvement, 33.3% did not report a significant change, and 22.2% reported worse scores. At

**Table 2** Group B Results

Year	3 months postoperatively				6 months postoperatively				12 months postoperatively			
	# of patients	Improved	Same	Worse	# of patients	Improved	Same	Worse	# of patients	Improved	Same	Worse
2009	42	64.3%	21.4%	14.3%	34	76.5%	20.6%	2.9%	19	84.2%	5.3%	10.5%
2010	50	66.0%	32.0%	2.0%	31	77.4%	22.6%	0.0%	23	87.0%	8.7%	4.3%
2011	41	73.2%	22.0%	0.0%	31	74.2%	25.8%	0.0%	22	86.4%	9.1%	4.5%
2012	28	82.1%	14.3%	3.6%	22	81.8%	13.6%	4.5%	19	78.9%	15.8%	5.3%
2013	27	66.7%	25.9%	7.4%	21	81.0%	19.0%	0.0%	12	91.7%	8.3%	0.0%
2014	7	76.9%	15.4%	7.7%	11	81.8%	9.1%	9.1%	11	81.8%	18.2%	0.0%
2015	30	73.3%	23.3%	3.3%	22	77.3%	22.7%	0.0%	12	75.0%	25.0%	0.0%
2016	9	88.9%	0.0%	11.1%	8	87.5%	0.0%	12.5%	3	100.0%	0.0%	0.0%
TOTAL	234	71.3%	22.5%	6.3%	180	78.3%	19.4%	2.2%	121	84.3%	11.6%	4.1%

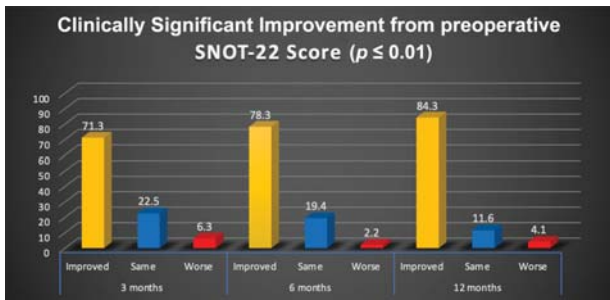


Fig. 3 Overall Group B Improvement Results (Percentage Change).



Fig. 4 Group B 8-year trend analysis of 12-month rates.

6 months, 5 out of the 180 surgeries were revisions (1 in 2009, 1 in 2011, and 3 in 2012) and illustrated 60% improvement, 20% the same, and 20% worsened. At 12 months postoperatively, 3 out of the 121 surgeries (all 3 in 2012) were revisions and 100% had an improved SNOT-22 score. An 8-year trend analysis of year-to-year surgical success rates at 12 months postoperatively for Group B (► Fig. 4) illustrated an improvement trend over time with an ANOVA linear rate of 0.593 (p ≤ 0.66).

Finally, the mean point change over time (► Fig. 5), from all patients who completed the preoperative and at least one postoperative questionnaire, has shown that patients experienced statistically significant change from the preoperative at 3 months (p < 0.0001) and at 6 months (p < 0.0001). Then, at 6 months, SNOT-22 scores plateaued and between 6 months and 12 months postoperatively, patients did not report a statistically significant change in SNOT-22 scores (p < 0.73).

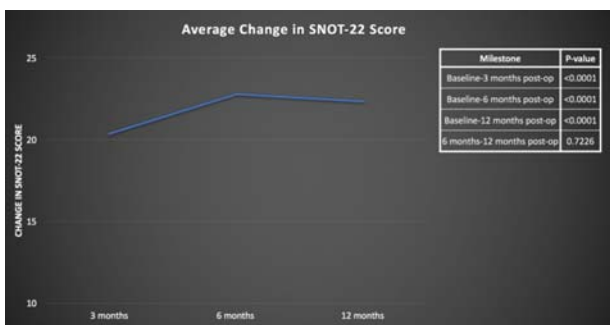


Fig. 5 Mean Point Change in SNOT-22 Scores (2009–2016).

## Discussion

The present study is important because it observes the long-term efficacy of sinus surgery and determined an optimal time for evaluation for surgical efficacy. In addition, the study also observed if the efficacy of sinus surgery improved with time with experience.

These results analyzed the patient population at a tertiary medical center undergoing sinus surgery over the years and their long-term rates of surgical efficacy using their SNOT-22 scores. Evaluation of SNOT-22 scores helped to compare each year and observe a general trend of improvement in the rates of surgical efficacy over time through a multisurgeon center. At 12 months postoperatively, when comparing the surgical success rates for each of the years, a positive trend was observed over time. The surgical success rates for both groups, A and B, were found to be similar. After observing the trends both in Group A and B, we observed that, in general, patients undergoing sinus surgery at a tertiary medical center showed 84.9% improvement in sinus disease symptoms by 12 months postoperatively. Other factors have contributed to the 15.1% variable.

Research has shown that the presence of polyps in patients with CRS has been highly correlated with a negative impact on the QOL scores,<sup>10</sup> as well as with a higher need for revision surgery and less improvement than patients with CRS without polyps.<sup>11</sup> In addition, it is not clear whether or not smoking has a direct effect on postoperative SNOT-22 scores. White et al suggest that there is no difference in QOL scores in smokers and nonsmokers after sinus surgery.<sup>12</sup> Alternatively, some studies suggest that while both smokers and nonsmokers may improve significantly from their preoperative QOL scores, some smokers experienced worsening in postoperative QOL scores after 6 months, depending on the smoking volume,<sup>13</sup> and had a higher rate of revision surgery<sup>14</sup> compared with nonsmokers, 20% versus 7%, respectively.

Despite research showing different prognostic factors for patients with different indications of surgery, all of the surgical candidates were asked to fill out a SNOT-22 form preoperatively. Furthermore, patients were grouped into two groups that depended solely on full completion of the SNOT-22 forms at each milestone. Patients who skipped a question on the survey were also excluded from both of the groups because they were artificially lowering their score. Although statistical bias is prevented by inclusion and exclusion criteria, the classifications of surgical indications may have swayed the statistical results.

In addition, a possible response bias could be attributed due to the fact that all of the values for SNOT-22 were self-reported and that the volume of patients lost to follow-up may pose a shift in the outcome. However, similar results were obtained in group A and group B, verifying that, even with more lenient inclusion criteria, similar results were obtained.

Furthermore, the study examined the whole patient population without considering demographics, the indication for surgery, past health history, smoking, or any use of

long-term medications. Future studies could include creating sub-cohorts dependent on the different factors, such as the indication for surgery and demographics to help better understand the rates of surgical efficacy under each subdivision, but doing so will yield toward statistical bias, unlike when looking at the population as a whole.

## Conclusion

Patients  $\geq 18$  years old undergoing sinus surgery at a tertiary medical center showed an 84.9% improvement by 12 months postoperatively. Long-term analysis of surgical efficacy over the years and mean point change in SNOT-22 showed no difference between 6 months postoperatively and 12 months, signifying 6 months as an effective evaluation for surgical efficacy. The year to year 8-year trend at 12-months postoperatively shows an upward trend toward improvement in surgical success over the years but not to the level of statistical significance.

The rates of surgical success at 3 months and 6 months postoperatively averaged to 84.2% and 82.96% respectively, with a 95% confidence interval. The 8-year trend analysis of year-to-year surgical success highlights 3-month and 6-month postoperative data as not being statistically significant ( $p \leq 0.39$  and  $p \leq 0.42$ , respectively).

After 12 months postoperatively, an overall average of 84.9% of patients ( $p \leq 0.01$ ) that were analyzed in the present prospective study, from both Group A and Group B, reported an improvement in QOL. Similar rates were also obtained at 6 months with 80.6% within Group A versus 78.3% within Group B.

Throughout each of the different postoperative periods, despite the inclusion criteria for each of the groups, we found that Group A and Group B had similar results at each of the designated postoperative milestones. When comparing surgical success rates on a year-to-year basis for Group A and Group B, we found that patients who completed all SNOT-22 forms had statistically better results on a year-to-year basis than patients who did not complete all SNOT-22 forms.

### Conflicts of Interests

The authors have no conflicts of interests to declare.

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