

LITERATURE REVIEW

Symptom-specific outcomes of endoscopic sinus surgery: A systematic review

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ABSTRACT

BACKGROUND: Although multiple studies have demonstrated that symptoms of chronic rhinosinusitis (CRS) improve after endoscopic sinus surgery (ESS), a systematic large-scale evaluation of specific symptom response has not been performed.

OBJECTIVE: To analyze the relative effectiveness of surgery in the improvement of individual CRS symptoms.

STUDY DESIGN: A literature search of MEDLINE, EMBASE, Web of Science, Cochrane databases, and other Web-based sources from January 1, 1980 through June 1, 2008 was performed. Studies of 20 or more adult patients with CRS that used symptom severity scores to analyze at least 3 major CRS criteria (facial pressure, nasal obstruction, postnasal discharge, and hyposmia) or 2 major CRS criteria plus headache were included.

SUBJECTS AND METHODS: Inclusion criteria were met by 21 of 289 ESS studies reviewed. Meta-analysis was conducted for each symptom separately with the standardized difference between the preoperative and postoperative severity scores as the effect size (ES).

RESULTS: A total of 2070 patients with CRS were studied a mean of 13.9 months after ESS. All symptoms demonstrated improvement compared with their respective preoperative severity scores by an overall ES of 1.19 (95% confidence interval, 0.96 to 1.41; $I^2 = 81.7%$) using the random-effects model. Nasal obstruction (ES, 1.73) improved the most, with facial pain (ES, 1.13) and postnasal discharge (ES, 1.19) demonstrating moderate improvements. Hyposmia (ES, 0.97) and headache (ES, 0.98) improved the least.

CONCLUSION: The relative improvements in major CRS symptoms and headache after surgery are similar, with the exception of nasal obstruction, which improves most.

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Although changes in chronic rhinosinusitis (CRS) symptoms after endoscopic sinus surgery (ESS) have been reported in more than 250 studies according to our literature review, no study has pooled the results of studies to measure individual symptoms. Methods of symptom reporting have greatly complicated this task. Approximately one-quarter of studies reporting symptom results after ESS document change with a survey instrument summary score.¹ Although the sim-

ilarity of a summary score permits easier comparisons among study results, this score does not ensure that postsurgical changes in the symptoms that comprised the score changed proportionately. It also does not relay information about specific symptoms. For instance, a substantial improvement in the Sinonasal Outcome Test 20 score might occur in spite of minimal or no improvement in any one of the measured symptoms (such as hyposmia).

Other methods of reporting results include a variety of continuous and categorical symptom scores that are based on symptom severity, symptom duration, or symptom prevalence. To simplify data synthesis, a standardized system was proposed by the American Academy of Otolaryngology–Head and Neck Surgery Rhinosinusitis Task Force (RSTF).² Unfortunately, most studies performed to date do not include the recommended symptom severity visual analog scale (VAS) for major and minor RSTF symptom criteria.¹

Reports of relative symptom improvement vary. Headache has been reported to improve as much as postnasal discharge³ or not at all.⁴ Reports of preoperative symptom severity or distress also vary substantially among studies. Hyposmia has been reported as the most severe⁵ and as the least severe⁶ among symptoms analyzed before surgery. Summarizing the available data would enhance our ability to individually counsel patients before surgery about expected outcomes from ESS.

Therefore, this study was designed to analyze the relative effectiveness of surgery in the improvement of individual CRS symptoms. To determine the response of individual CRS symptoms to ESS, we pooled the results of individual symptom severity measurements from all available studies. By analyzing the preoperative symptom severity and the change in symptom severity after ESS, the relative effectiveness of ESS at relieving individual symptoms was examined.

MATERIALS AND METHODS

Identification of Studies

To identify all studies that reported symptom responses after ESS, two of us (A.C.C. and R.S.), with the assistance of a research librarian, searched MEDLINE, EMBASE,

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PubMed, Web of Science, Cochrane databases, and Google Scholar from January 1, 1980 (or database inception) through June 1, 2008, for all English-language studies of adults that reported relevant results. The search strategy included the following “exploded” text words and medical subject headings: *endoscopic*, *sinus*, and *surgery*. References from retrieved articles and relevant reviews were examined for additional studies. Issues of the American Journal of Rhinology before the journal was listed in Index Medicus (1987 through 1997) were searched by hand. After consultation among the authors, citations were entered into an electronic database with EndNote version 6.0 software (Thomson ISI ResearchSoft, Carlsbad, CA).

Inclusion Criteria and Data Extraction

All English-language studies of 20 or more adult patients that reported results after ESS and including three or more major individual RSTF symptoms or two major symptoms in addition to headache (a minor RSTF symptom) were reviewed. Of that group, all studies that reported change by continuous scales or by categorical numeric measurements with 4 or more categories were included in this review except for studies about the following: patients with significant comorbidities (eg, malignancy, human immunodeficiency virus, and cystic fibrosis), surgery that involve only the septum or turbinates, and radical surgery (eg, obliterative procedures). Because nasal congestion and nasal obstruction describe similar symptoms, both symptoms were considered nasal obstruction.

The study data were systematized independently by two of us (A.C.C. and J.L.A.) with the PICOS (participant, intervention and exposure, comparator, outcomes, and study

design) method and were entered into a spreadsheet (Excel 2003; Microsoft Corporation, Redmond, WA); author, year, design, participants, surgical procedure, duration, purpose, survey methods, and specific symptoms were analyzed. The data entry accuracy was verified independently by 2 of us (A.C.C. and R.S.). The study duration was defined as the time from surgery until the last evaluation of symptoms. When studies reported only the results of separate groups (eg, men and women), scores were weighted according to sample size and aggregated.

Search Results

A search of the sources yielded 3575 unique citations. After reviewing the titles and abstracts of these citations, a full-text article was obtained for any potentially appropriate study. Study selection is shown in Figure 1.

Statistical Analysis

A separate meta-analysis for each symptom was performed with the standardized mean difference (Cohen d) of the respective severity scores before and after surgery as the effect size (ES) for outcome measures. ES is a method to measure the effect of an intervention that adjusts for the pooled standard deviations of the outcome measures. The correlation coefficient (r) between the paired measures before and after surgery is needed for an optimal estimate of ES; however, the number is not generally published. Therefore, we calculated the standardized mean difference with the use of formulas provided by Comprehensive Meta-Analysis version 2.0 software (Biostat, Englewood, NJ), which provides results similar to Cohen d , especially for studies with the same sample size before and after surgery.

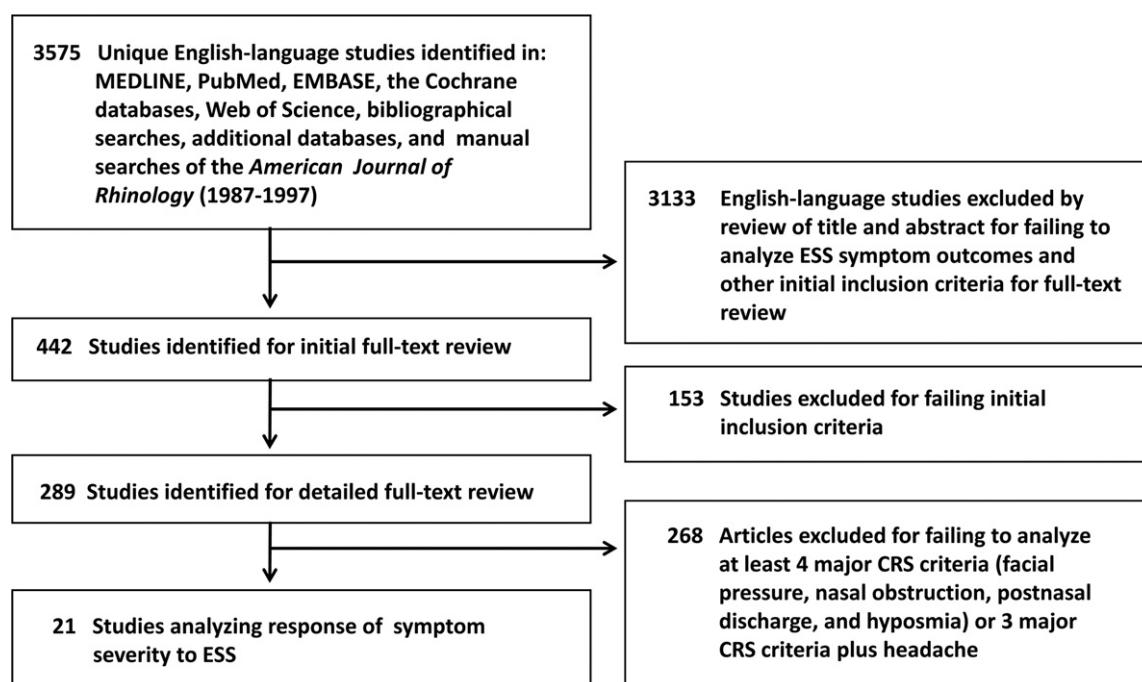


Figure 1 Study selection (CRS, chronic rhinosinusitis; ESS, endoscopic sinus surgery).

To determine whether the effects of ESS on various symptoms were the same across studies, heterogeneity was assessed. The percentage of total variation across trials due to heterogeneity rather than chance was assessed using I^2 , where I^2 lies between 0 percent (no heterogeneity) and 100 percent (maximal heterogeneity) and 25 percent, 50 percent, and 75 percent represented low, moderate, and high heterogeneity, respectively. I^2 is calculated as $I^2 = 100\% \times (Q - df)/Q$, where Q indicates the Cochrane heterogeneity statistic. Means were compared with paired t test. For all results, $P < 0.05$ was considered statistically significant.

Of 21 studies, 7 studies⁷⁻¹³ did not report standard deviations for the mean scores. For these studies, standard deviations were estimated with the known standard deviations reported by other studies,^{3-6,14-23} with each symptom calculated separately. The average ratio of the known standard deviations and the mean (the coefficient of variation [CV]) were calculated, and the CV was then used to estimate the unknown standard deviations. The estimation is based on the assumption that the CV is similar for independent samples. For example, the average CV for facial pain based on the studies that reported both means and standard deviations was 0.6121. A mean score times 0.6121 is the estimated standard deviation for the study that only reported means (but not standard deviations) for facial pain. The overall ES for studies with vs without reported standard deviations is not significantly different (ES, 1.15 vs 1.23; $P = 0.63$), which shows the validity of the estimation.

Ten studies^{3-5,15-19,22,23} reported standard deviations for preoperative and postoperative scores, and 2 studies^{20,21} reported standard deviations for the change score. Two studies^{6,14} reported the ES. In addition to the symptom changes calculated by the meta-analyses, unweighted mean symptom severity scores were compared with the paired t test after converting the symptom scores to percentages.

RESULTS

Characteristics of included studies are summarized in Table 1. Study size ranged from 21 to 207 patients (median, 81 patients; total number of patients, 2070); study duration ranged from 2.5 to 42.5 months (mean [SD], 13.9 [10.9] months; median, 12 months). Five studies reported nasal congestion but not nasal obstruction. The nasal congestion values were included as nasal obstruction scores. Of 21 studies that met study inclusion criteria, 20 analyzed facial pain, 21 analyzed nasal obstruction, 20 analyzed postnasal discharge, 17 analyzed hyposmia, and 18 analyzed headache.

Preoperative symptom severity was rescaled as a percentage score (Fig 2). For example, a preoperative severity score of 5 on a scale of 11 (with 0 representing no symptoms and 10 representing the severest symptoms) is recorded as 45 percent. Preoperative mean percent (SD of the %) symptom severity scores were similar for nasal obstruction (62.6% [8.6%]), postnasal discharge (57.8% [7.4%]),

and hyposmia (54.4% [10.5%]). Facial pain (mean [SD], 43.9 percent [14.2%]) was less severe than nasal obstruction ($P < 0.01$), postnasal discharge ($P < 0.01$), and hyposmia ($P < 0.05$). Headache (mean [SD], 46.8% [12.2%]) was less bothersome than nasal obstruction and postnasal discharge ($P < 0.001$ for both).

All postoperative symptom severity scores decreased after ESS, evidencing improvement ($P < 0.001$) compared with preoperative scores. Postoperative values reflected the same trends noted in the preoperative scores: the mean% (SD of the %) scores were similar for nasal obstruction (25.8% [10.8%]), postnasal discharge (30.7% [9.5%]), and hyposmia (27.9% [9.3%]). Facial pain (mean [SD], 17.0% [10.6%]) was less severe than nasal obstruction, postnasal discharge, and hyposmia ($P < 0.01$ for all). Headache (mean [SD], 21.6% [9.8%]) was less severe than postnasal discharge ($P < 0.05$).

The results of meta-analyses that analyzed each symptom are summarized in Figures 3 and 4, and Table 2. A fixed-effects model assumes that ESS had similar effects across studies, whereas a random-effects model assumes that ESS may have different effects across studies. With a random-effects model, nasal obstruction was most improved after surgery (ES, 1.73; 95% confidence interval [CI], 1.45 to 2.02; $I^2 = 93.3\%$). Headache (ES, 0.98; 95% CI, 0.74 to 1.22; $I^2 = 90.3\%$) and hyposmia (ES, 0.97; 95% CI, 0.79 to 1.15; $I^2 = 81.2\%$) were least improved. Improvements were similar for facial pain (ES, 1.13; 95% CI, 0.96 to 1.31; $I^2 = 83.5\%$) and postnasal discharge (ES, 1.19; 95% CI, 0.96 to 1.43; $I^2 = 90.4\%$). Hyposmia and headache improved significantly less than nasal obstruction ($P < 0.01$ for both). The overall ES of 1.19 (95% CI, 0.96 to 1.41; $I^2 = 81.6\%$) indicates that the combined CRS symptom severity scores are reduced 1.19 SD after surgery, a notably large ES by conventional standards.

Among 21 studies in the meta-analysis, 14 studies reported durations of 1 year or longer (mean [SD], 19.2 [9.9] months), and 7 studies reported durations of less than 1 year (mean [SD], 4.4 [1.6] months). Analysis to evaluate duration as a moderator was conducted for each symptom separately, and the results were then combined for the overall effect. The overall effect is 1.16 for longer studies and 1.19 for shorter studies, which were not significantly different ($P = 0.88$). With the exception of hyposmia, the ES tended to be larger for shorter studies than for longer studies, a trend most apparent for headache ($P = 0.12$). None showed significant difference except for hyposmia where longer studies demonstrated a larger effect size than shorter studies ($P = 0.04$) (Fig 4).

The change in symptom severity scores after surgery is often expressed as a percentage, calculated by dividing the change in the symptom severity score by the preoperative severity score. Although combining these unweighted values to assess pooled change does not offer statistical accuracy, it is more easily understood and perhaps is more useful in counseling patients. The median improvements in indi-

Table 1
Study characteristics

Source	Study design	Length of follow-up in months	Sample size ^a	Age, mean in years	Outcome measure
Banfield and McCombe, ⁷ 1999 (UK)	CS (prospective), consecutive patients	2.5	50	41	Symptom score (range, 0-4)
Bhattacharyya, ⁶ 2004 (USA)	CS (prospective), consecutive patients	19	100	41	RSI (score range, 0-5)
Bhattacharyya ¹⁴ 2004 (USA)	CCT (prospective), consecutive patients	12.4	21	44.8	RSI (score range, 0-5)
Bugten et al ³ 2008 (Norway)	CS (prospective)	12	93	38	100-mm VAS
Chambers et al ⁸ 1997 (USA)	Record review (retrospective)	42.5	182	47	Symptom score (range, 1-4)
Conte and Holzberg ⁹ 1996 (USA)	CS (retrospective), consecutive patients	13	81	41	Symptom score (range, 0-3)
Dunlop et al ¹⁰ 1999 (UK)	Retrospective by questionnaire	12	50	48	11-Point VAS symptom score
Durr and Desrosiers ¹⁵ 2003 (Canada)	CS (prospective), consecutive patients	3	47	43.7	Symptom score (range, 0-4)
Giger et al ¹⁶ 2003 (Switzerland)	CS (prospective), consecutive patients	24	42	37.5	6-Point VAS symptom score
Khalil ¹⁷ 2001 (Egypt)	CCT, prospective	6	62	35	11-Point VAS symptom score
Kountakis and Bradley ¹¹ 2003 (USA)	CS (prospective), consecutive patients	12	80	48	11-Point VAS symptom score
Lee and Lee ¹⁸ 2007 (Korea)	CCS (prospective)	6	40	55	11-Point VAS symptom score
Ling and Kountakis ¹⁹ 2007 (USA)	Record review (retrospective)	12	158	49.4	11-Point VAS symptom score
Lund et al ²⁰ 1991 (UK)	CS (prospective)	4.6	24	46	11-Point VAS symptom score
Lund and Scadding ²¹ 1994 (UK)	CS (retrospective), consecutive patients	27.6	200	47	11-Point VAS symptom score
Poetker et al ²² 2007 (USA)	CCS (prospective), consecutive patients	16.8	119	47.1	11-Point VAS symptom score
Salama et al ²³ 2008 (UK)	CS (prospective), consecutive patients	3	142		11-Point VAS symptom score
Soler et al ⁴ 2008 (USA)	CS (prospective), consecutive patients	18	207	44	11-Point VAS symptom score
Wright and Agrawal ¹² 2007 (Canada)	RCT (prospective)	6	22		11-Point VAS symptom score
Yeak et al ¹³ 1999 (Singapore)	CS (prospective), consecutive patients	12	106	40.4	11-Point VAS symptom score
Young et al ⁵ 2007 (Canada)	CS (prospective)	36	31	47.5	11-Point VAS symptom score

CCS, controlled case series; CCT, controlled clinical trial; CS, cohort study; RCT, randomized controlled trial; RSI, rhinosinusitis symptom inventory; VAS, visual analog scale.

^aNumber of patients with final outcome data.

vidual symptoms after ESS expressed as percentages of preoperative symptom severity (Table 2) were as follows: facial pain, 60.8 percent; nasal obstruction, 58.8 percent; postnasal discharge, 46.6 percent; hyposmia, 48.9 percent; and headache, 53.2 percent.

DISCUSSION

Although general and disease-specific quality-of-life survey instruments are important in the assessment of the outcomes

of ESS, patients are often most distressed about several specific CRS symptoms. Awareness of the probability of specific symptom improvement after ESS permits more accurate estimations of surgical success in individual patients. This information would enhance the informed consent process and aid the patient in consideration of the risks and benefits of a surgical intervention.

Our study finds that facial pain was less severe before and after surgery than nasal obstruction, postnasal discharge, and hyposmia. Headache was less severe than nasal obstruction and postnasal discharge before surgery and less

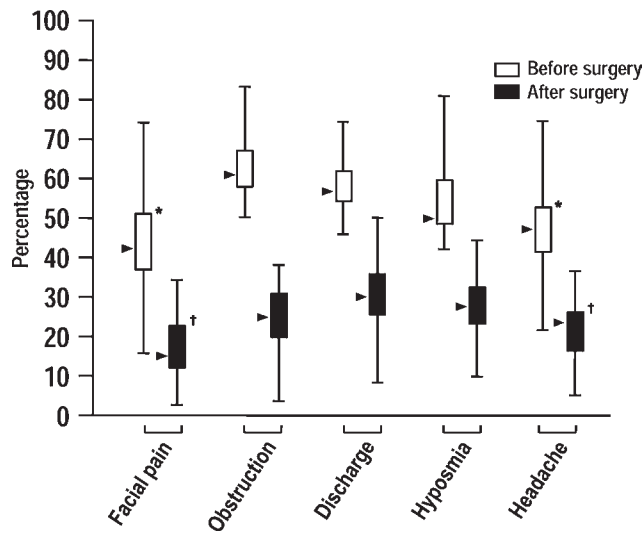


Figure 2 Pooled individual symptom severity scores before and after endoscopic sinus surgery. Values are percentages of the symptom scoring scale used. Brackets indicate range of scores recorded among studies; arrow, median value; and box, SD of the mean value. *Preoperative values for facial pain and headache significantly less severe than preoperative values for nasal obstruction and postnasal discharge. †Postoperative values for facial pain and headache significantly less severe than postoperative values for postnasal discharge.

severe than postnasal discharge after surgery. Unweighted preoperative symptom severity scores converted to a percentage scale were similar for nasal obstruction (62.6%), postnasal discharge (57.8%), and hyposmia (54.4%) but were lower for facial pain (43.9%) and headache (46.8%). Likewise, unweighted severity scores obtained at a median follow-up of 1 year after surgery were similar for nasal obstruction (25.8%), postnasal discharge (30.7%), and hyposmia (27.9%) but were lower for facial pain (17%) and headache (21.6%).

All symptoms improved after ESS by a mean ES of 1.19, which represents a reduction of 1.19 SD in symptom severity scores compared with preoperative levels. This is a notably large ES as defined by Cohen²⁴ (ES, >0.8). As experienced by many surgeons clinically, ESS was especially beneficial in the improvement of symptoms of nasal

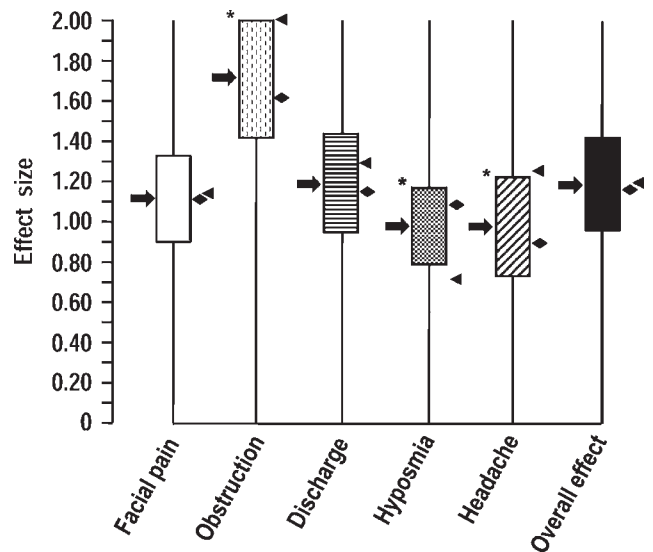


Figure 4 Changes in pooled symptom severity scores for all studies and for long (≥ 1 year) and short (< 1 year) studies. Arrow and box indicate mean effect size and 95 percent CI, respectively; triangle and diamond indicate mean effect size for long and short studies, respectively. For hyposmia, the effect size for short studies is less than that for long studies ($P = 0.04$). *Nasal obstruction improves more than hyposmia and headache ($P < 0.01$ for both).

obstruction (ES, 1.73), facial pain (ES, 1.13), and postnasal discharge (ES, 1.19). Hyposmia (ES, 0.97) and headache (ES, 0.98) also improved significantly after surgery but to a lesser extent than nasal obstruction ($P < 0.01$). The percentage of total variation across trials in this meta-analysis was more than that suggested by chance alone, which limited the certainty of calculated ES. Causes of differences include variations in study designs, patient populations, and symptom severity measurement methods. In addition, this study was limited to an analysis of symptom severity. The frequency and duration of a symptom (such as headache) could represent a more important measure of overall morbidity than the symptom severity score alone.

Although not attempting to offer proof of the effectiveness of ESS, this study offers reassurance that, with minor exceptions, individual CRS symptoms usually improve substantially and similarly after surgery. We support the 1997 RSTF recommendation that suggests that the results of ESS outcome studies are best evaluated by both VAS severity scoring and quality-of-life assessment.² With more of such data, the probability of specific symptom improvement after surgery could be better determined among different populations (eg, patients with nasal polyposis, aspirin sensitivity, or asthma) and among various surgical techniques, thereby offering patients more complete assessments of the potential for surgical success.

CONCLUSIONS

Symptom severity scores for facial pain were lower than those for nasal obstruction, postnasal discharge, and hypos-

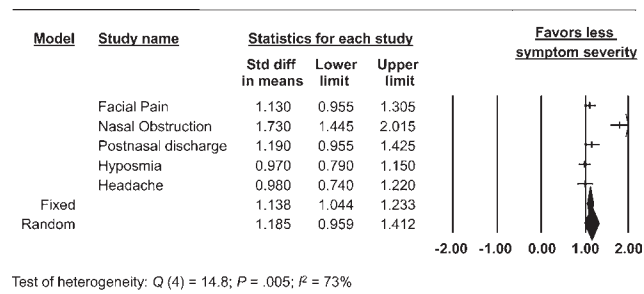


Figure 3 Changes in pooled symptom severity scores after endoscopic sinus surgery.

Table 2
Effect size and percentage change in preoperative severity score after endoscopic sinus surgery

Source	Effect size [percentage change in preoperative severity score]				
	Facial pain	Nasal obstruction	Nasal discharge	Hyposmia	Headache
Banfield and McCombe ⁷ 1999	1.24 [67]	0.63 [33]	0.77 [33]	—	1.26 [67]
Bhattacharyya ⁶ 2004	1.03 [57]	1.41 [66]	0.92 [57]	0.77 [60]	0.85 [46]
Bhattacharyya ¹⁴ 2004	0.50 [40]	1.30 [59]	0.50 [32]	0.90 [60]	0.60 [43]
Bugten et al ³ 2008	1.14 [67]	2.22 [62]	1.70 [58]	1.17 [56]	1.33 [62]
Chambers et al ⁸ 1997	0.96 [57]	1.48 [57]	0.92 [38]	—	0.67 [45]
Conte and Holzberg ⁹ 1996	1.59 [77]	1.33 [54]	1.55 [56]	1.62 [68]	1.15 [63]
Dunlop et al ¹⁰ 1999	0.46 [34]	1.52 [58]	0.53 [24]	1.02 [49]	0.45 [33]
Durr and Desrosiers ¹⁵ 2003	0.90 [34]	1.32 [36]	0.83 [28]	0.69 [32]	—
Giger et al ¹⁶ 2003	1.98 [82]	2.87 [70]	1.64 [61]	—	—
Khalil ¹⁷ 2001	1.73 [43]	1.94 [39]	2.05 [36]	1.20 [35]	1.76 [43]
Kountakis and Bradley ¹¹ 2003	1.90 [86]	2.70 [78]	1.98 [67]	1.22 [55]	1.65 [78]
Lee and Lee ¹⁸ 2007	1.44 [76]	5.20 [79]	2.13 [48]	0.48 [20]	1.57 [74]
Ling and Kountakis ¹⁹ 2007	1.64 [94]	1.89 [93]	1.76 [85]	1.39 [78]	1.39 [89]
Lund et al ²⁰ 1991	0.85 [71]	0.86 [49]	0.63 [38]	0.66 [47]	0.94 [60]
Lund and Scadding ²¹ 1994	0.76 [60]	0.86 [56]	0.67 [38]	0.77 [51]	0.79 [52]
Poetker et al ²² 2007	0.86 [43]	0.82 [37]	—	—	0.64 [34]
Salama et al ²³ 2008	0.74 [72]	2.09 [73]	0.92 [48]	0.46 [34]	—
Soler et al ⁴ 2008	0.80 [37]	0.89 [34]	0.47 [24]	0.54 [31]	0.01 [1]
Wright and Agarwal ¹² 2007	1.13 [63]	2.47 [75]	1.78 [63]	0.97 [47]	0.61 [42]
Yeak et al ¹³ 1999	0.98 [58]	1.76 [63]	1.42 [53]	1.14 [53]	1.00 [58]
Young et al ⁵ 2007	—	1.95 [64]	0.92 [44]	1.51 [53]	1.02 [74]
Pooled change	1.13 [61]	1.73 [59]	1.19 [47]	0.97 [49]	0.98 [53]

nia before and after surgery. Headache severity scores were lower than nasal obstruction and postnasal discharge before surgery and lower than postnasal discharge after surgery. All symptoms studied improved after surgery by a large ES. Improvement is similar for major CRS symptoms and headache, with the exception of nasal obstruction, which improves more than headache or hyposmia. The overall effect noted in studies with reported durations of 1 year or longer is similar to the overall effect of studies with reported durations of less than 1 year.

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AUTHOR CONTRIBUTIONS

Alexander C. Chester, study design, data collection, data analysis, manuscript writing; **Justin L. Antisdell**, data analysis, manuscript review; **Raj Sindwani**, study design, data analysis, manuscript writing and review.

FINANCIAL DISCLOSURE

None.

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