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One Year after Endoscopic Sinus Surgery in Polyposis: Asthma, Olfaction, and Quality-of-Life Outcomes

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Abstract

Objective. Nasal polyposis is a disease known to be associated with asthma. The long-term effects of surgical treatment on lower airways have not been sufficiently studied.

Study Design. One-year follow-up of a double-blind, randomized, placebo-controlled study.

Setting. The study was conducted at the Karolinska University Hospital, Stockholm, Sweden.

Subjects and Methods. Fifty-one patients, age 18 years or older, with nasal polyposis and asthma were evaluated 1 year after endoscopic sinus surgery (ESS). Outcomes included dyspnea/cough scores, mean daily peak expiratory flow rate, spirometry, butanol test, olfaction scores, peak nasal inspiratory flow, polyp scores, and health-related quality of life (SF-36).

Results. The short-term postsurgery improvements in asthma symptom scores, daily peak expiratory flow rate, all nasal parameters including olfaction, and quality-of-life scores were generally maintained 1 year after ESS.

Conclusion. Endoscopic sinus surgery had beneficial long-term effects on asthma, olfaction, and quality of life in patients with nasal polyposis. This is the first study to show long-term benefits of ESS on butanol tests in patients with nasal polyposis.

Keywords

nasal polyposis, asthma, quality of life, SF-36, dyspnea, cough, PEFR, olfactory thresholds

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Nasal polyposis affects almost 3% of the northern European population[1] and has been shown to be associated with asthma, particularly aspirin-intolerant asthma (Samters triad).[2] In patients with nasal polyposis, asthma was found in 30% in those referred to otorhinolaryngology departments.[3] In patients with asthma, polyps were found in 7% to 15%, with the highest frequency in the age group older than 50 years.[3] Our definition of nasal polyposis is in accordance with that on chronic rhinosinusitis with nasal polyposis, defined in the European Position Paper on Rhinosinusitis and Nasal Polyps (EP^{3}OS).[4]

The objectives of the management of nasal polyposis are to reduce or eliminate polyps, open the nasal airway, improve or restore the sense of smell, prevent polyp recurrence, and improve patients' quality of life.[5] Clinical studies in patients with nasal polyposis have shown that fluticasone propionate nasal drops (FPND) 400 µg twice daily (bid) have statistically significant and clinically relevant effects on polyp size as well as on nasal congestion.[6] Surgical treatment has not been sufficiently studied and hence has been proposed to be reserved for patients who do not satisfactorily respond to medical treatment. The European position paper EP^{3}OS points out that predominantly positive effects have been reported in recent years from studies on surgical treatment on asthma, but the level of evidence is low.[4] Therefore, there is a general need for prospective randomized studies with high clinical impact on the benefits of surgical as well as medical treatment of this patient group.[4] We have previously presented data from a randomized, placebo-controlled FPND 400-µg bid pre- and postsurgery study of 68 patients with nasal polyposis and concomitant asthma. Positive short-term effects after endoscopic sinus sur-

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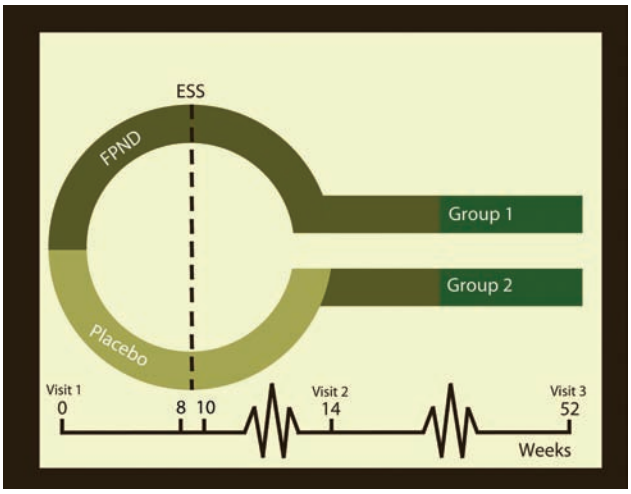

Figure 1. Study design. At visit 1, patients were randomized to FPND (group 1) or placebo (group 2). At visit 2, all patients received FPND treatment for another 7 weeks. Thereafter, they were prescribed intranasal steroids. ESS, endoscopic sinus surgery; FPND, fluticasone propionate nasal drops.

gery (ESS) with FPND were found regarding asthma, olfactory function, and health-related quality of life.[7]

The current study is a 1-year postsurgery follow-up of the 51 patients who previously participated according to protocol. The hypothesis was that improvements obtained a short time after ESS would be maintained 1 year postsurgery.

Subjects and Methods

We have previously presented results from a prospective study on short-term effects after ESS.[7] That study also included a randomized, double-blind, placebo-controlled 14-week phase on FPND. The intention-to–treat (ITT) population of that study consisted of 68 patients with a diagnosis of nasal polyposis and asthma, and 52 of these patients participated according to protocol. Fifty-one patients, age 18 years or older (range, 20-79 years), in the per protocol group accepted to participate in the current 1-year follow-up study. The results are presented by the original 2 groups of subjects, randomized to either FPND (group 1) or placebo (group 2) during the previous controlled trial. All patients except 1 were on inhalation steroids at inclusion. Aspirin sensitivity was not an exclusion criterion, and a specific history was not investigated. No aspirin provocation test was performed.

*Study Design (**Figure 1**)*

The primary end point was change in lower airways symptom scores (shortness of breath and/or cough) 1 year (visit 3) after ESS compared with 5 weeks post-ESS (visit 2) and pre-ESS (visit 1). The group that previously received FPND in the short-term randomized controlled trial was called group 1 and was compared with the group that previously received placebo, which was called group 2. The study protocol and the patient information and consent forms were reviewed and approved by the local independent ethics committee of the Karolinska Institute (D nr 234:00) and the Swedish Medical Products Agency (MPA 151:384/01) prior to enrollment of patients.

Surgical Treatment

The procedure was tailored to the extent of the disease, with removal of polyps, uncinectomy, exploration of ethmoidal bulla, and additional ethmoidal exploration, as indicated by clinical and computer tomography scan findings. For subjects who had previously undergone ESS, the extent of surgery depended on clinical findings, and in some cases, simple removal of polyps was sufficient.

Medical Treatment

The patients were instructed not to change asthma treatment throughout the entire study.

After visit 2, all patients in both groups were prescribed intranasal and inhaled corticosteroids according to Swedish clinical practice and were recommended nasal lavage. Oral corticosteroids were prohibited 8 weeks before visit 1 and up until 12 weeks post-ESS (eg, approximately 9 months before visit 3). At visit 3, we assessed all electronic hospital records, including medications. No formal monitoring of medical treatment was performed between visits 2 and 3.

Symptoms, Peak Expiratory Flow Rate, and As-Needed Asthma Medication

Seven days prior to visit 2 and 3, patients were asked, as described earlier,[7] on a daily basis to record symptom scores before going to bed, the morning and evening peak expiratory flow rate (PEFR; Personal Best, Health Scan Products, Inc, Cedar Grove, New Jersey), and the use of short-acting β2-agonists (SABA) taken as needed. We calculated the mean daily symptom scores, the mean daily PEFR, and the mean number of inhalations with SABA (frequency of inhalations was graded as follows: 0 inhalations = 0 points, 1-2 inhalations = 1.5 points, 3-5 inhalations = 4 points, >5 inhalations = 5 points) from the diary cards the last 7 days prior to visit 3 and compared them to scores of the last 7 days prior to visits 1 and 2.

Sense of Smell Symptoms Score

The sense of smell was graded on a 0 to 3 scale (0 = normal, 1 = mild reduction, 2 = moderate reduction, 3 = absent sense of smell).

Asthma Symptoms Score

Patients evaluated the asthma symptoms of shortness of breath and cough. The symptoms were graded on a 0 to 3 scale (0 = no symptoms, 1 = mild symptoms/tolerable, 2 = moderate symptoms/still tolerable, and 3 = severe symptoms/affects daily activity).

Peak Nasal Inspiratory Flow

Prior to a nasal decongestant, the best of 3 peak nasal inspiratory flow (PNIF) attempts was recorded, using an In-check Portable Inspiratory Flow-meter (Clemont Clark Int. [CCI], Harlow, UK).

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Butanol Threshold Test of Olfactory Function

Prior to a nasal decongestant, the olfactory threshold was determined using butanol in dilutions ranging from 4% to 0.000008%. The highest concentration (4%) in deionized water in squeezable bottles was called dilution step 0; then the solution was diluted by successive factors up to step 14. The olfactory threshold was identified when the subject was able to distinguish the same butanol concentration from a blank control on 5 consecutive attempts.[8,9] The grading of this Connecticut Chemosensory Clinical Research Center (CCCRC) threshold test is as follows: normal olfactory function when the threshold is 7 to 14; hyposmia, 3 to 6; and anosmia, 0 to 2.[7]

Nasal Endoscopy

The nasal cavity was decongested prior to endoscopy and nasal polyp size was scored on a 0 to 3 scale[9] (0 = no polyps; 1= polyps in the middle meatus, not reaching below the inferior border of the middle turbinate; 2 = polyps reaching below the inferior border of the middle turbinate but not the lower border of the inferior turbinate; 3 = polyps reaching lower than the inferior border of the inferior turbinate and/or medial to the middle turbinate).

Lung Function

Patients were asked to record the morning and evening PEFR (Personal Best; Health Scan Products, Inc), and we calculated the mean daily baseline PEFR from the diary cards the last 7 days (morning and evening) prior to visit 2 and 3. Lung function was also measured as forced expiratory volume in 1 second (FEV_1) at visits 1, 2, and 3 with spirometry (Spirolab; MIR, Rome, Italy) according to the standards laid down by the American Thoracic Society.[10]

Health-Related Quality-of-Life (SF-36) Assessment

The health survey SF-36[11] covers 8 health domains—physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH)—that were obtained from the patients at all visits. Scale scores range from 0 to 100, with higher scores indicating better health-related quality of life (HRQoL). In addition, the physical component summary (PCS) and the mental component summary (MCS) scores were calculated.[12] The Swedish version of SF-36 has been translated and validated from English and has been adapted to the Swedish population.[13,14]

Statistical Analysis

Data at visit 3 were compared with data at visits 1 and 2 five weeks after ESS. For continuous and ordinal variables, changes from visit 1 to each subsequent visit were calculated. For HRQoL analysis, the reference was an exact sex- and age-matched population (n = 340) randomly selected from the Swedish SF-36 norm database (n = 8930). Data are expressed as minimum, maximum, and quartiles or mean and standard deviation. Student *t* test was used to compare the SF-36 scores with the reference population. Otherwise, between-groups comparisons were performed applying Mann-Whitney tests. Changes within groups were analyzed with Wilcoxon sign-rank tests. All statistical analyses were performed at a 2-sided significance level of 5%. For each SF-36 scale, Cronbach coefficient was calculated to estimate internal consistency. The power calculation and determination of study sample size were based on assumptions regarding treatment effect after the 21-week study, presented in an earlier study. Fifty-one of 52 patients who completed that study completed visit 3 after approximately 1 year. The tool for data handling and statistical analysis was SPSS 18.0 for Windows (SPSS, Inc, an IBM Company, Chicago, Illinois).

Results

Fifty-one (23 from group 1 and 28 from group 2) of 52 patients who completed the 14-week randomized, double-blind, placebo-controlled study according to protocol completed visit 3 after approximately 1 year. The median time from surgery to the 1-year follow-up visit was similar in the 2 randomized groups: 365 days (range, 342-397) in group 1 and 357 days (range, 334-413) in group 2.

Baseline Data

For baseline characteristics, see **Table 1**. No significant differences were seen at baseline between groups 1 and 2. All except 1 patient were on inhaled steroids for the treatment of asthma at study start.

Nasal and Lower Airways Data

The effects of ESS on olfaction and PNIF were generally maintained 1 year postsurgery. Between group 1 and group 2, no statistically significant differences were found (**Figure 2**). The effects on asthma symptoms and PEFR were also generally maintained 1 year post-ESS, and there were no statistically significant differences between the 2 groups (**Figure 3**). The results within groups over time are presented (median and range) in **Tables 2** and **3**.

As-Needed Medication

The proportion of patients with as-needed medication taken, as well as the mean amount taken, was similar in the 2 randomized groups. From visit 1 to visit 2, a mean reduction of amount taken from 0.47 to 0.26 was seen in group 2 (P = .019) and a mean reduction from 0.51 to 0.28 in group 1 (P = .15). At visit 3, the mean amount had increased to 0.43 and 0.39 in group 2 and group 1, respectively (not statistically different from earlier visits).

Quality-of-Life (SF-36) Assessment (*Figure 4*)

At visit 3 in group 1, 7 of 8 domains as well as PCS (P = .013) and MCS (P < .001) were significantly improved compared with visit 1, and 1 (BP) of 8 domains were significantly improved compared with visit 2 but not PCS no MCS. The increase in HRQoL reached population levels in all domains, as well as in PCS and MCS, at visit 3.

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Table 1. Baseline Characteristics

	Treatment	
	Group 1	Group 2
	Mean; Median (Min-Max)/No. (%)	Mean; Median (Min-Max)/No. (%)
Age, y	51; 56 (19-73)	53; 54 (24-78)
Male	12 (52.2)	21 (75.0)
Smoker	1 (4.3)	3 (11.1)
Skin prick test positive	9 (42.9)	9 (32.1)
Number of surgeries >2	5 (22.7)	3 (11.1)
Shortness of breath	0.7; 0.1 (0.0-3.0)	0.8; 0.9 (0.0-3.0
Cough	0.6; 0.4 (0.0-2.0)	0.5; 0.1 (0.0-2.4)
FEV_1 % of predicted	85; 86 (40-120)	85; 86 (46-112)
FEV_1 >80% of predicted	16 (69.6)	18 (66.7)
Peak expiratory flow rate	419; 404 (254-626)	446; 436 (197-609)
Polyp score	2.5; 3.0 (1.0-3.0)	2.3; 2.0 (1.0-3.0)
Sense of smell score	2.2; 3.0 (0.0-3.0)	2.5; 3.0 (0.0-3.0)
Butanol test	3.0; 4.0 (0.0-8.0)	2.2; 0.0 (0.0-6.0)
Inhaled steroid, budesonide equivalent, µg	655; 800 (0-1600)	509; 400 (200-1600)

Abbreviation: FEV_1, forced expiratory volume in 1 second.

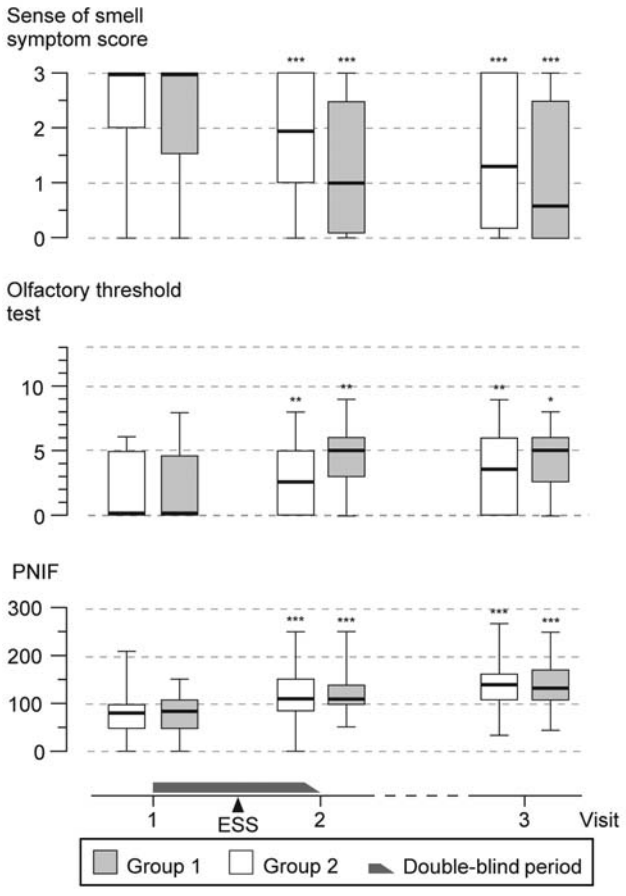

Figure 2. Nasal variables. The positive effects of endoscopic sinus surgery (ESS) on olfaction and peak nasal inspiratory flow (PNIF) were generally maintained at 1 year postsurgery. Box-whisker plots by treatment group and visit. Data are presented as median, 25th and 75th percentiles, and minimum and maximum values. Statistically significant changes within groups from Visit 1 are indicated as *P < .05. **P < .01. ***P < .001.

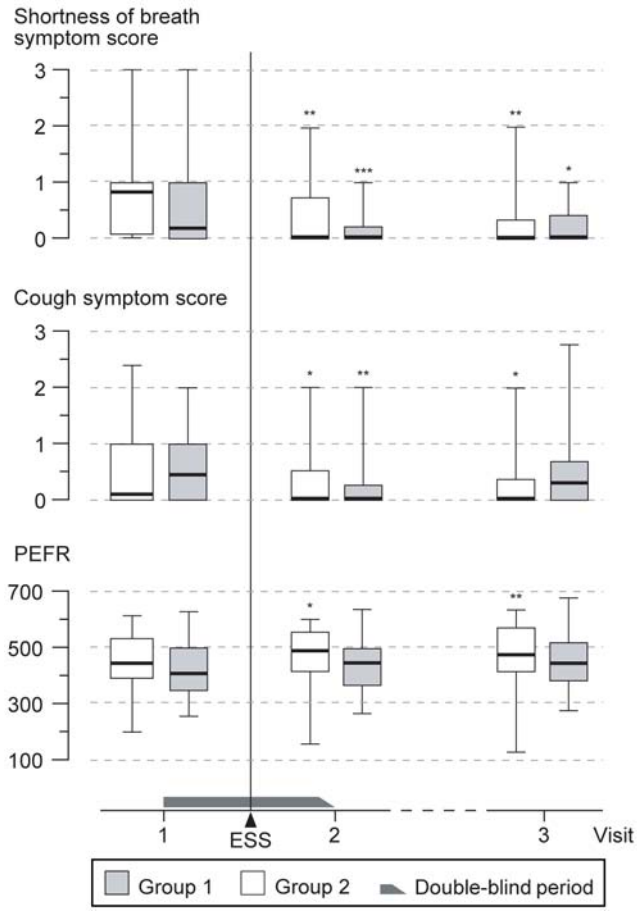

Figure 3. Lower airway variables. The positive effects of endoscopic sinus surgery (ESS) on asthma symptoms and peak expiratory flow rate (PEFR) were generally maintained at 1 year postsurgery. Statistically significant changes within groups from Visit 1 are indicated. *P < .05. **P < .01. ***P < .001.

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Table 2. Changes in Nasal and Lower Airways Variables: Group 1

	Visit 1 to Visit 3		Visit 2 to Visit 3	
Variable	Median Change (Range)	*P* Value	Median Change (Range)	*P* Value
Nasal variables				
PNIF	50 (–10 to 180)	<.001	10 (–70 to 90)	.070
Polyp score	−2.00 (–3.00 to 1.00)	.001	0 (–2.00 to 1.00)	.82
Sense of smell	−1.00 (–3.00 to 0.00)	.001	0 (–2.00 to 2.00)	.502
Butanol threshold test	1.00 (–4.00 to 8.00)	.021	–1.00 (–4.00 to 6.00)	.353
Lower airways variables				
Shortness of breath	–0.10 (–2.71 to 0.71)	.013	0 (–0.71 to 0.71)	.36
Cough	–0.14 (–1.14 to 1.14)	.27	0.14 (0.00 to 0.75)	.001
PEFR	8.0 (–44 to 138)	.06	4.50 (–0.45 to 0.53)	.36
FEV_1	–0.03 (–1.40 to 1.15)	.48	−0.10 (–0.35 to 0.26)	.06

Abbreviations: FEV_1, forced expiratory volume in 1 second; PEFR, peak expiratory flow rate; PNIF, peak nasal inspiratory flow.

Table 3. Changes in Nasal and Lower Airways Variables: Group 2

	Visit 1 to Visit 3		Visit 2 to Visit 3	
Variable	Median Change (Range)	*P* Value	Median Change (Range)	*P* Value
Nasal variables				
PNIF	60 (–40 to 140)	.001	20 (–80 to 90)	.016
Polyp score	–1.00 (–3.00 to 0)	.001	0 (–2.00 to 1.00)	.02
Sense of smell	0 (–3.00 to 0.43)	.001	0 (–2.0 to 1.43)	.209
Butanol threshold test	0 (–4.00 to 9.00)	.004	0 (–6.00 to 6.00)	.184
Lower airways variables				
Shortness of breath	–0.29 (–2.71 to 1.71)	.003	0.00 (–2.0 to 1.90)	.86
Cough	0 (–1.0 to 0.29)	.029	0 (–1.14 to 1.00)	.39
PEFR	20 (–69 to 125)	.004	−3 (–72 to 91)	.98
FEV_1	0.05 (–1.40 to 0.53)	.45	−0.07 (–1.41 to 0.83)	.11

Abbreviations: FEV_1, forced expiratory volume in 1 second; PEFR, peak expiratory flow rate; PNIF, peak nasal inspiratory flow.

At visit 3 in group 2, all domains as well as PCS (P = .02) and MCS (P = .02) were significantly improved compared with visit 1, and 2 (RP, RE) of 8 domains, as well as PCS (P = .045) but not MCS, were significantly improved compared with visit 2.

Population levels of HRQoL—with the exception of GH and MH—were reached at visit 3 in domains that were significantly reduced at baseline. However, MCS did not reach population levels.

Analysis of internal consistencies for all SF-36 domains showed Cronbach coefficients ranging from 0.76 to 0.92. Values larger than 0.7 are, by convention, considered acceptable.

Safety Assessment

Safety assessment was conducted at all visits. Adverse events during the study period from visit 1 to visit 2 have been reported earlier for the ITT population.[7] No new adverse events were reported after visit 2.

Discussion

In this prospective follow-up study of a total of 51 patients with nasal polyposis and concomitant asthma, we have found that the short-term benefits of ESS on lower airways, upper airways, and quality of life were generally maintained 1 year post-ESS.

In line with the results from the previously published short-term trial on the ITT population (n = 68),[7] no significant differences in outcomes after 12 months were seen between the 2 per protocol groups.

Several studies now indicate a positive effect of ESS on lower airways.[15-17] Ragab et al[16] reported in a randomized controlled study that ESS had a subjective and objective tendency for asthma improvement, although statistically nonsignificant at 12 months postoperatively, in a subgroup of 12 patients with nasal polyposis and concomitant asthma. Proimos et al[15] showed statistically significant benefits on objective measurements for asthma in 86 patients at 12 months post-ESS but in a nonrandomized study. Batra and coworkers[17] reported a significant improvement in lung function (FEV_1) and a reduction of oral corticosteroid use after ESS in a retrospective study with 17 patients with nasal polyps and concomitant oral corticosteroid-dependent asthma for at least 12 months. In a small series of 13 patients with nasal polyposis and concomitant asthma, Uri and coworkers[18] reported in another retrospective study, after an average of 3.5 years, that ESS did not improve the asthma state in patients with massive nasal polyposis. However, a statistically

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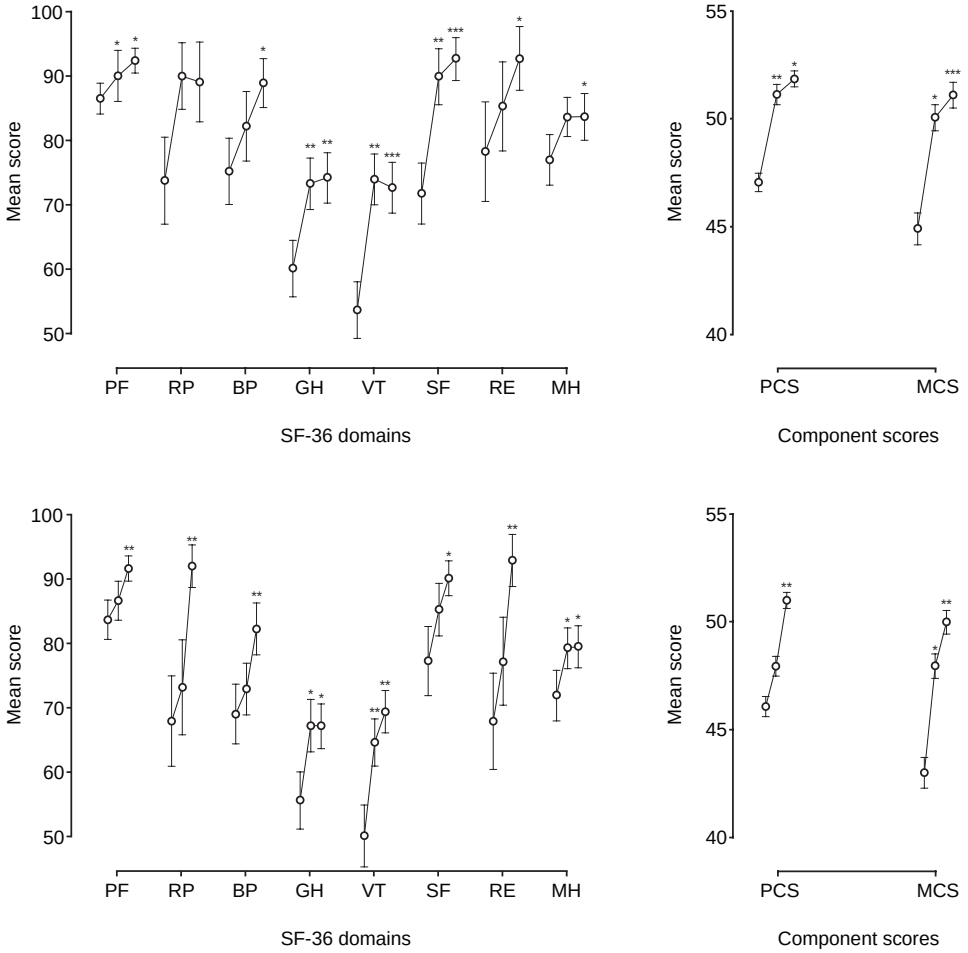

Figure 4. Effects of endoscopic sinus surgery (ESS) on SF-36 scores, physical component score (PCS), and mental component score (MCS). Group 1 above, group 2 below. The positive short-term effects of ESS on health-related quality of life were generally maintained at 1 year postsurgery. Values are presented as mean and SEM, calculated by SF-36 domain, component score, and visits 1, 2 and 3, respectively. BP, bodily pain; GH, general health; MH, mental health; PF, physical functioning; RE, role emotional; RP, role physical; SF, social functioning; VT, vitality. *$P < .05$. **$P < .01$. ***$P < .001$.

significant decrease was documented for oral corticosteroid and bronchodilator inhaler usage. In a retrospective study of a subgroup of patients with nasal polyposis and asthma, Garrel et al[19] reported, after an average of 5 years, a decrease of asthma medication use after ESS.

Our interpretation is that, although the evidence level has been low, all these findings point toward positive effects of ESS on asthma in nasal polyposis over at least 12 months. This is now strengthened by data from this study, which had asthma symptom scores as a primary end point, based on our earlier short-term randomized controlled trial.[7] Long-time postsurgery improvements in asthma symptom scores at visit 3 are supported by the mean daily peak expiratory flow rates. Regardless of this, we concur with current opinion that larger long-term randomized controlled studies are needed.[4]

At least 2 clinical studies with limited follow-up have previously indicated a positive effect of ESS, by itself, on sense of smell and olfactory thresholds in nasal polyposis.[7,20] Others have reported improved olfaction using non-ESS techniques.[21,22] Recent publications have indicated a positive effect of ESS with concomitant medical treatment on odor thresholds after 1, 3, and 6 months, respectively.[23,24] Using an identification test, data have been published that report significant improvement in olfaction after ESS in a subgroup of 14 anosmics with nasal polyposis at 6 months, which remained at 12 months.[25] In this 12-month evaluation, we found a statistically significant preserved effect of ESS on olfactory thresholds and subjective sense of smell (**Figure 2**). Perioperatively, no oral corticosteroids were given, as the study protocol prohibited this. A detailed medical history was taken, and an assessment of the patients' electronic hospital records was performed retrospectively at visit 3. We did not detect any use of systemic corticosteroids between visits 2 and 3. However, as we did not monitor patients between visits 2 and 3, oral corticosteroids could, in theory, have been prescribed by their primary care physician without reporting to us.

Nasal polyposis and asthma seem to have a cumulative negative effect on HRQoL.[26] Very few prospective studies have, to our knowledge, exclusively studied the nasal polyposis with

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asthma population and effects of ESS on HRQoL.[27-31] Despite the fact that in this study, patients' asthma was well controlled with inhaled corticosteroids, we noted statistically significant and clinically relevant improvements in generic HRQoL. The increase approximately 5 weeks after ESS (visit 2) was sustained after 12 months (visit 3; **Figure 4**), which is in line with other studies that have included patients with nasal polyposis with or without asthma.[26,32,33]

In a recently published prospective cohort study of patients with chronic rhinosinusitis, authors report that asthma is one of the important predictors of HRQoL outcome (SF-36) after ESS, although prior sinus surgery seems to be the strongest.[34] However, the number of patients with nasal polyposis and concomitant asthma was not reported.

We believe that the main strength of this single-center study is our "united airway" and quality-of-life perspective and that the most important result is that asthma, olfaction, and HRQoL improvements after ESS from a short-term follow-up did not deteriorate after 1 year. Another advantage is that we only included patients with nasal polyposis and concomitant asthma, adding to knowledge of a disease that commonly involves the whole airway, which in our opinion often is neglected by otorhinolaryngologists. Therefore, we found it convenient to plan and perform this study in close cooperation among rhinologists, pulmonologists, and psychologists. In clinical practice, asthma should be evaluated when treating nasal polyposis and vice versa.

Some limitations of our study include a lack of a nonsurgical control group, no formal trial monitoring of patients during approximately 9 months before the last visit, and an absence of methods measuring local as well as systemic inflammation. A placebo effect of ESS and systemic effects of surgical trauma could possibly affect outcomes in the short term, but this is more unlikely after 1 year. Retrospective registry data on the use of relevant medications were unfortunately not available at the time.

Conclusion

In conclusion, this prospective study supports the hypothesis that ESS has beneficial long-term effects on asthma, olfaction, and quality of life in patients with nasal polyposis and asthma. We believe that these data indicate that ESS could be considered early in the course of the disease with concomitant asthma and could also be a second-line treatment in patients with reduced sense of smell.

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Author Contributions

Anders Ehnhage, primary investigator: study design, organizing, performance of case report forms, patient work, data collection, manuscript writing; **Petter Olsson**, patient work, data collection, manuscript writing; **Karl-Gustav Kölbeck**, study design, patient work, manuscript writing; **Maria Skedinger**, patient work, manuscript writing; **Pär Stjärne**, study design, organizing, patient work, manuscript writing.

Disclosures

Competing interests: Anders Ehnhage received honoraria from MSD Sweden for educational activities; Pär Stjärne received honoraria for studies on advisory boards for MSD Sweden, GlaxoSmithKline, and Novartis; Petter Olsson joined MSD (Sweden) after the end of this study and is currently employed by Boehringer-Ingelheim, Sweden; Maria Skedinger received honoraria for lectures and articles from Astra Zeneca Sweden and MSD Sweden.

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