

Surgical Versus Medical Interventions in CRS and Nasal Polyps: Comparative Evidence Between Medical and Surgical Efficacy

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Abstract CRS with nasal polyps (CRSwNP) is a subgroup of CRS, where polyps can be visualised in the middle meatus. In the general population, the prevalence is estimated to lie between 0.2 and 4 %. Up to 15 % of patients with asthma have nasal polyps and up to 45 % of patients with nasal polyps have asthma. The management of CRSwNP involves primary medical management, with surgery normally reserved for recalcitrant cases. Surgical techniques for CRSwNP range from simple polypectomy and endoscopic sinus surgery (ESS) to radical nasalisation with removal of the middle turbinates. We have reviewed the comparative literature regarding medical and surgical interventions in CRSwNP, with emphasis on outcomes, complications, cost-effectiveness and on the timing of surgery. Similar outcomes are reported for medical and surgical management, but there is sufficient evidence to support the role of surgery once symptoms have failed to adequately respond. There is insufficient evidence to define the optimal timing and extent of surgery.

Keywords CRS with nasal polyps (CRSwNP) · Medical management · Polypectomy · Endoscopic sinus surgery (ESS) · Quality of life · Cost effectiveness · Timing of surgery

Introduction

Chronic rhinosinusitis (CRS) is common, affecting up to 11 % of the European population [1]. The European position paper on rhinosinusitis and nasal polyps (EPOS) has defined rhinosinusitis as inflammation of the nose and the paranasal sinuses characterised by two or more symptoms, *one of which* should be either nasal blockage or nasal discharge, with or without facial pain/pressure or reduction of smell, *and either* endoscopic signs of nasal polyps, mucopurulent discharge primarily from middle meatus and/or oedema/mucosal obstruction primarily in the middle meatus *and/or* CT changes demonstrating sinus disease. Chronicity requires persistence of symptoms for 12 weeks or more [2••].

CRS with nasal polyps (CRSwNP) is a subgroup of CRS when polyps can be visualised in the middle meatus. They are outgrowths of the nasal mucosa arising mainly on the lateral nasal wall, mostly from the ethmoid complex and appearing in the middle meatus (Fig. 1).

The exact etiology of nasal polyps remains unclear but is likely to be multifactorial. Polyps can be associated with respiratory conditions such as asthma and cystic fibrosis, primary ciliary dyskinesia and aspirin sensitivity [3]. In the general population, the prevalence is estimated to lie between 0.2 and 4 %, while up to 15 % of patients with asthma have nasal polyps [4]. Up to 45 % of patients with nasal polyps have asthma [5].

Polyps consist of extracellular oedema with a respiratory epithelial lining [6] and are rich in inflammatory cells characteristic of type 2T helper cell inflammation, such as eosinophils, mast cells, lymphocytes, neutrophils and plasma cells, in addition to inflammatory mediators particularly IL-5, growth factors and adhesion molecules [7].

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Fig. 1 Nasal polyps visible at the anterior nares

Current Management of CRS and Nasal Polyps

Medical Management in CRSwNP

The management of CRSwNP involves primary medical management, with surgery normally reserved for recalcitrant cases. According to EPOS guidelines, medical treatment for CRSwNP involved a stepwise approach according to the severity of symptoms using a combination of intranasal and systemic steroids, saline douching and antibiotics as demonstrated in Table 1.

There is evidence from a large number of randomised placebo-controlled trials (RCT) of improvements in subjective symptom scores, polyp size and objective nasal flow rates with topical corticosteroid use, as

demonstrated in a Cochrane review of 40 studies involving 3624 patients [8].

With more severe symptoms, systemic steroids are recommended [2••], with studies showing marked improvement of symptoms and CT findings. Systemic steroids also have the added benefit over topical treatment of improving the sense of smell [9, 10]. Side effects of systemic steroids preclude long-term use and include the risk of osteoporosis, stomach irritation, weight gain, immune and adrenal suppression and early recurrence of symptoms once stopped [11]. Optimum management of CRSwNP involves a balanced approach of topical steroid treatments with intermittent systemic steroids, with good control of symptoms in the majority of patients [12]. However, if a patient requires more than 3 courses of systemic treatment a year, has actual or impending complications of their CRSwNP, or fails to respond adequately in terms of symptomatic control to topical and systemic steroids, medical treatment is deemed to have failed and surgical treatment is indicated.

Short-term antibiotic treatment has been evaluated in CRSwNP. In a placebo-controlled RCT, doxycycline was found to reduce polyp size, postnasal secretions and pro-inflammatory markers, but not other symptoms [13]. The benefit of long-term antibiotic treatment in CRSwNP remains controversial, as few studies have evaluated benefit in clearly defined subgroups. Reduction in polyp size [14] and improved aeration on CT scans [15] have been demonstrated with clarithromycin and roxithromycin respectively in single-arm studies. Further research is needed to determine the role of

Table 1 Common drugs used in treatment of CRSwNP with EPOS 2012 recommendations for use. (–) is a trial with a negative outcome, or recommendation by EPOS NOT to use in CRSwNP [2••] Later studies discussed in text are not included in these recommendations

Class of Drug	Level of evidence	Grade of recommendation	Side effects
Intranasal steroids	Ia	A	Epistaxis, nasal irritation, itching & dry nose. Risk of systemic adverse effects, such as effects on growth and ocular effects are very low.
• Mometasone furoate			Effects on growth have been reported on children after long-term use of beclomethasone.
• Fluticasone propionate			
• Budesonide			
Systemic steroids	Ia	A	Osteoporosis, gastric upset, impact on glucose tolerance, cataracts, suppression of the pituitary-hypothalamic axis.
• Prednisolone			
Short term antibiotics <4 weeks	Ib	C	Gastrointestinal upset, skin rash reversible elevation of liver enzymes
• Doxycycline for 3 weeks			
Long term antibiotics ≥12 weeks	III	C	Emergence of bacterial resistance, gastrointestinal side effects, increased risk of cardiac death due to pro-arrhythmic side effects
Macrolides:			
• Clarithromycin			
• Roxithromycin			
Nasal saline douching	Ib	D	low risk of local irritation
Ant-IgE	Ib-	C	Anaphylaxis (1 in 1000), thrombocytopenia, cancer
• Omalizumab			
Anti- IL-5	No data	D	Fatigue, nasopharyngitis, pharyngo-laryngeal pain
• Reslizumab			
• Mepolizumab			
Leukotriene antagonists	Ib-	A-	Skin rash, mood changes, tremors
• Montelukast			
• Zafirlukast			
Aspirin desensitisation	II	D	Severe hypersensitivity reactions and gastrointestinal upset

macrolides in therapy of CRSwNP, as more recent work suggests the benefits of macrolides are greatest in those with normal levels of IgE, while this will be elevated in many patients with CRSwNP [16].

More recently, targeted immunomodulation of the inflammatory mediators involved in polyp formation has been described. IgE is elevated in patients with CRSwNP; omalizumab, an anti-IgE monoclonal antibody, lowers the level of IgE in serum and tissues through selective binding. It is approved for use in patients with uncontrolled allergic asthma. In a double-blinded RCT in 24 adult patients with nasal polyps and asthma, published after EPOS made its recommendations, Gevaert and co-workers demonstrated a significant decrease in nasal polyp score, improvement of sinus aeration on CT, nasal and pulmonary airway symptoms and quality-of-life scores, after 16 weeks of omalizumab therapy, irrespective of the presence of associated allergy [17]. Anti-IL-5 monoclonal antibodies reduce the number of eosinophils in blood and tissues. In a double-blind, RCT in 24 adult CRSwNP patients, reslizumab infusion did not result in greater reduction in polyp than placebo, although those with elevated IL-5 levels were more likely to respond [18]. In contrast, another double-blind, placebo-controlled, randomized study, with mepolizumab infusion found significant reduction in opacification of the sinuses on CT and a reduction in nasal polyp size [19]. High costs, need for intravenous administration and high risk of side effects including anaphylaxis are likely to limit widespread application of monoclonal antibodies in their current form; however, a targeted approach of immunomodulation appears preferable for future development in drug therapy.

Antileukotriene therapy is used in treatment of asthma and may be considered as an adjunctive therapy in treatment of patients with refractory CRSwNP with associated asthma. Montelukast has shown an improvement in patient's clinical symptoms and improvement in nasal polyp scores [20] in an open single-arm study and improvements in nasal endoscopy scores and reduced pro-inflammatory biomarkers in nasal lavages [21]; however, there are no randomised studies supporting efficacy.

Aspirin desensitisation has been used in patients with aspirin-exacerbated respiratory disease (AERD) characterised by CRSwNP, asthma and hypersensitivity to Cox-1 inhibitors to achieve improvement of clinical symptoms. Aspirin is given under supervision in increasing doses until a daily maintenance dose of 100–1200 mg can be taken, according to different protocols [22]. Compliance can be limited by gastrointestinal side effects, and if aspirin needs to be discontinued to allow sinus surgery, then the desensitisation protocol needs to be repeated. All novel therapies, including anti-IL-5, anti-IgE, anti-leukotriene and aspirin desensitisation therapies, need further research before they can be strongly recommended for treatment of CRSwNP [2••].

Surgical Interventions in CRSwNP

Surgical techniques for CRSwNP range from simple polypectomy, endoscopic sinus surgery (ESS) with surgical opening of the sinuses and widening of the sinus ostia to radical nasalisation with removal of the middle turbinates. Surgery is usually tailored to the extent of disease demonstrated on cross-sectional imaging, with the extent of surgery carrying more significance than the instrumentation used [23].

Surgery can be performed using a wide range of instruments including forceps, snare, laser, radio frequency ablation, ultrasonic aspirators or powered instrumentation using the microdebrider. The microdebrider offers the advantage of performing tissue removal, suction and irrigation simultaneously [24].

There is little evidence to suggest that the choice of surgical instrumentation has any impact on long-term outcomes. In a prospective randomized single-blinded study of 311 cases with CRSwNP, Tirelli and co-workers compared the use of forceps with the microdebrider in performing endoscopic sinus surgery. After a 12-month follow-up period, they found that the use of forceps caused a significantly lower nasal polyp recurrence rate but caused a higher degree of synechiae in the nose [25]. Powered instrumentation using a microdebrider in ESS has been shown to reduce operative time and intraoperative blood loss [26, 27], but in the hands of less experienced surgeons, it has been suggested that it might increase the risk of injury to the cribriform plate and lamina papyracea and consequently increase the severity of complications.

Nasal Polypectomy Alone Versus Adjunctive Endoscopic Sinus Surgery

Despite high recurrence rates, simple polypectomy remains a common procedure in the UK, possibly driven by the financial constraints on the public funded health service. When performed alone, simple polypectomy carries a very high recurrence rate, reportedly as high as 75 % in an 8-year follow-up study [28]. New techniques to allow in-office simple polypectomy, thus reducing costs in service delivery, have been suggested to offer a cost-effective alternative to ESS, despite higher recurrence rates [29]. However, the comparative impact on symptom burden to patients also needs to be considered.

In addition to removing polyps within the nasal cavity, polypectomy is often combined with endoscopic sinus surgery, removing additional polypoid tissue within the sinuses. In the UK Audit of surgery for CRS and nasal polyps, when compared to simple polypectomy, additional sinus surgery did not offer any additional benefit in long-term symptom control, but did reduce revision surgery rates [30]. However, the majority of patients having additional sinus surgery had very

conservative ESS restricted to the maxillary sinus and anterior ethmoids.

In a retrospective study, Masterson and co-workers demonstrated that more extensive endoscopic sinus surgery was associated with lower revision surgery rates at 3-year follow-up when compared with data from the UK Audit (4.0 vs 12.3 %) without an increase in complication rates [31]. DeConde and collaborators enrolled 311 patients with CRS in a multi-institutional observational study and performed “complete” surgery on all the sinuses in 47 % of patients, with the rest undergoing “targeted” surgery according to the disease extent. They found the mean improvement in SNOT-22 (28.1 vs 21.9; $p=0.011$) and Brief Smell Inventory Test (B-SIT) (0.8 vs 0.2; $p=0.005$) was statistically greater in the group undergoing complete surgery, but was not clinically significant. [32]. It is likely that more extensive surgery allows better postoperative access for topical therapies and therefore better reduces the risk of recurrence (Fig. 2) [33].

Jankowski has proposed even more radical surgery (nasalisation), with additional removal of the middle turbinates. He reported greater improvement in patients’ symptoms and lower polyp recurrence, with 6 % of patients needing revision surgery compared to 14 % who had functional ethmoidectomies alone (performed by a different surgeon), with 34-month follow-up [34].

In a recently published Cochrane review considering the effectiveness of different surgical interventions for CRSwNP, Sharma et al. [35] evaluated trials where patients were randomised to different surgical procedures. After an initial search identified 3014 records, only 6 met the criteria above, and these were all excluded due to risk of bias and other limitations. The authors concluded they were unable to draw any conclusions on the relative effectiveness of polypectomy compared with more extensive sinus surgery, and more research is required to determine the optimum extent.

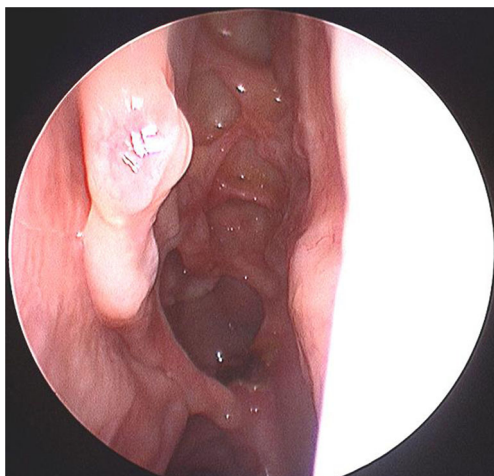


Fig. 2 Postoperative endoscopic appearances of complete endoscopic sinus surgery allowing topical access to sinuses; left cavity shown with clearance of the ethmoid partitions and large sphenoidotomy

Complications of Surgery

Minor complications of sinus surgery, such as perioperative bleeding, postoperative infection and synechia in the nose are relatively common, but rarely impact on long-term outcomes or quality of life. However, major complications, including haemorrhage, orbital and intracranial complications, are rare but can be life-threatening.

In a large prospective multicenter study in the UK, data from 87 hospitals was collected over a period of 1 year, involving 3128 patients undergoing sinus surgery, 70 % of whom had nasal polyps. The rate of major complications was 0.4 %; the majority of which were periorbital haematoma and orbital emphysema (0.2 %). Minor complications rate was 6.6 % with the majority being perioperative excessive bleeding (5 %). They found that complication rates were higher in patients with higher preoperative SNOT-22 scores, previous sinus surgery, co-morbidities, more extensive polyposis and higher degree of sinus opacification on CT [36].

In a US-based met-analysis of case series undergoing sinus surgery, data of 4693 patients were compared regarding the use of conventional versus endoscopic sinus surgery [37]. Major complications were reported at 0.9 and 1.3 % respectively, with the majority being CSF leaks, and minor complications reported at 2.8 and 5.4 % respectively, with the majority of patients having perioperative bleeding and intranasal adhesions. In a large systematic review of three randomized control trials, four nonrandomized comparative studies and 35 case series studies, minor complications following ESS ranged from 1.1 to 20.8 % and major complications ranged from 0 to 1.5 % [38].

Image-Guided Surgery

Image guidance surgery is gaining popularity among rhinologists and is more readily available, as demonstrated in a recent survey by the American Rhinological Society [39]. Even though it is not a substitute for anatomical knowledge, it has an increasing role in complicated sinus surgery. The usefulness of image guidance during ESS to decrease perioperative morbidity and complications has been investigated in a large systematic review and meta-analysis of 2585 articles, including 55 clinical studies. The authors found that the use of image guidance during surgery reduced the risk of major and total complications [40].

Comparative Evidence Between Medical and Surgical Interventions

There are few studies directly comparing medical and surgical management in CRSwNP, as surgery is commonly reserved

for patients who have failed maximal medical treatment. A recently published Cochrane review systematically reviewed the available evidence; from an initial 3014 articles identified by the search strategy, only 4 trials were suitable for inclusion [41••].

In a prospective randomised study on 109 patients with grades 2 and 3 nasal polyps, Alobid and co-workers found similar improvements in both medical and surgical study groups in QOL, nasal symptoms and polyp scores. With regard to the two most disabling symptoms in the study, nasal obstruction and loss of smell, improvements were higher in the patients treated with endoscopic surgery, especially non-asthmatic patients. Polyp scores were also significantly lower in patients treated surgically in comparison to medical treatment alone [42].

Lildholt et al. reported on two studies: the first, a single stage trial where patients were randomised to medical versus surgical treatment [43], and the second, a more complex multistage trial of medical treatment versus placebo, where treatment failures were randomised to surgery or ongoing medical therapy [44]. The first trial found no statistically significant difference in symptoms scores between groups at 12-month follow-up; the latter trial reported no significant difference in objective testing, but did not report symptom benefit.

Another prospective randomised controlled trial in the UK randomised 90 patients, of whom 35 had nasal polyps to either medical or surgical management. The 45 patients in the medical group received a 12-week course of macrolides antibiotics and topical steroid sprays (drops in the case of the 16 patients with polyps), while the surgical group received endoscopic sinus surgery according to disease extent (with polypectomy in the 19 patients with polyps) followed by 2 weeks of oral macrolides and topical steroid sprays. In this study, additional treatments were given based on symptoms rather than a standardised protocol. At 12 months follow-up, compared to baseline scores, the researchers found no statistically significant differences between both treatment groups in health-related quality of life (SNOT-20 & Short Form (36) Health Survey), endoscopic scores, or in objective physiologic testing as nasal cross sectional area, saccharin clearance time and nasal nitric oxide levels. [45]. There were no differences reported for the subgroup of patients with CRSwNP.

The included studies used differing treatments in terms of both medical and surgical interventions, precluding meta-analysis of all the trial results, and therefore, the strength of any recommendations made was thought to be low. Furthermore, studies recruited patients who had not previously received medical therapy, and thus, findings may not be generalizable to the population who have failed medical treatment and who are currently considered surgical candidates.

However, the review highlights that currently there is insufficient evidence regarding the efficacy of surgical management in CRSwNP, and that further research in this area is

required. Future studies should aim to randomise medical treatment failures, as results would then be more applicable to clinical practice; however, this will inevitably make recruitment to such trials more challenging. The high rate of recurrence in CRSwNP also means that longer-term results are required, increasing the costs of running such a trial.

Cochrane reviews only consider randomised controlled trials with low risk of bias for inclusion. A number of excluded studies are reported below, but have limitations which will be discussed.

Blomqvist and co-workers, in a prospective randomized study on 32 patients with CRSwNP where only one side of the nose was treated surgically, found significant improvement in CT scores on operated sinuses following surgical treatment, as opposed to continued medical treatment alone, at 12-month follow-up. Nasal polyp score, nasal obstruction and discharge were significantly improved on the operated side, and 25 % of the patients went on to request surgery on the unoperated side at the end of the 1 year period [46, 47]. This study was excluded from the Cochrane review as it was felt that it is difficult for patients to accurately localise many symptoms of CRS, such as post-nasal discharge, to one side.

In a prospective study, Jankowski and Bodino compared the effects of radical ethmoidectomy and middle turbinate resection (nasalisation) with the results of prior medical treatment alone on the sense of smell in a cohort of patients with nasal polyps who were mostly anosmic (86 %). At 12-month post-nasalization, olfactory scores were better than the immediate post-oral steroid scores, and all anosmic patients showed a significant improvement [48]. As there is no parallel comparison group, it is not possible to confidently attribute benefit to the surgery or prior medical treatment. Similarly, statistically significant improvement in olfactory symptoms was shown to be higher in patients with nasal polyps who received endoscopic surgery rather than medical treatment alone in a prospective non-randomised study comparing two cohorts of patients matched for age, CT findings and degree of nasal obstruction [49].

Smith et al. have undertaken a prospective multi-centered study comparing CRS patients undergoing medical versus surgical treatment [50–52]. Patients entered each arm of the trial based on their own preference, guided by their surgeons, and therefore, there is a risk of treatment selection bias. There were significant baseline differences between groups, with those electing surgical intervention having higher symptom scores, had significantly worse average health utility values and more average productivity days lost. The study cohort recruited patients who received initial maximal medical therapy, with 3 subgroups; patients electing continued medical management, 1 patients choosing ESS and a small group of patients who initially chose continued medical management but then elected ESS during the study period. Nasal polyps were found in 43, 37 and 10 % of each subgroup respectively;

subgroup comparisons for patients with and without nasal polyps were not reported.

Surgical patients reported greater improvements in disease-specific QOL measured by both the Chronic Sinusitis Survey and the Rhinosinusitis Disability Index [50] and had lower levels of ongoing antibiotic and steroid use and absenteeism [51]. Significant improvement was reported in the surgical group in SF-6D values between baseline and 6-month follow-up, in contrast to the medical management and crossover groups, which showed no significant differences [51].

In terms of the impact on olfaction, both medical and surgical cohorts demonstrated significant improvement in B-SIT Scores, with no significant difference between the polyp subgroups undergoing surgery or medical management [52].

The group studied symptom scores in the crossover group patients who had chosen initial medical treatment but then underwent surgery (1 in 3 of the initial medical cohort) and found that their SNOT-22 scores deteriorated while having continued medical therapy, but then significantly improved after surgical intervention) [53].

In another study performing an evidence-based risk analysis for patients with nasal polyps, the threshold at which risks of repeated steroid medications exceeded the risks of surgery was investigated, considering risks of harm of treatment, benefits on quality of life and the costs of treatment. The analysis favoured surgery over medication when patients needed more than one course of oral steroids every 2 years, once a year if concomitant asthma was present, or twice yearly for patients with Samter's triad [54].

In a recent systemic review of both randomized controlled trials and uncontrolled prospective interventional studies, the management of CRSwNP patients with co-existing asthma was evaluated specifically. Rix and co-workers compared the effect of montelukast, omalizumab, erythromycin and ESS in 317 patients with nasal polyps and asthma. They found that montelukast significantly improved nasal outcomes, asthma and pulmonary symptoms, whereas omalizumab significantly improved nasal outcomes and QOL but did not significantly improve pulmonary outcomes. Erythromycin improved nasal symptoms and was superior to ESS in relation to pulmonary outcomes, but they concluded that all nasal outcomes and QOL improved significantly in the surgical studies. Risk of bias for all interventions leads to the strength of evidence to be considered low [55]. In a prospective randomised study, the effect of surgical and medical management (topical corticosteroids, decongestant and alkaline nasal douche) of CRS on concomitant asthma control was investigated. Both treatment modalities were associated with improvement of asthma; however, the researchers found that medical treatment achieved better asthma control in patients with nasal polyps [56].

Early Versus Late Surgical Intervention

There is little evidence on the optimal timing for surgical intervention and whether early surgical management of CRSwNP offers better long-term outcomes.

Data from the UK National Comparative Audit of Surgery for Nasal Polyposis and Chronic Rhinosinusitis was used to compare clinical outcomes of CRS following ESS of patients treated surgically within 1 year, 1 to 5 years, or more than 5 years after onset of their CRS. The authors found that earlier surgical intervention, offered significantly greater symptom benefit for patients in terms of reduction of SNOT-22 scores at 5-year follow-up, compared to those in whom surgery was delayed. [57]. In a parallel UK retrospective study, Hopkins and colleagues analysed CRS-related healthcare utilisation of patients using the Clinical Practice Research Database (CPRD). Patients were grouped into similar early (receiving primary surgery within 1 year after diagnosis) and late cohorts (5 years or more after diagnosis) and cohorts were matched for presence of asthma and polyps at time of surgery. They found that fewer patients returned for CRS-related care in the 5 years following surgery in the early cohort, with significantly lower number of visits and prescriptions compared to the late cohort [58]. These findings were also reproduced in a similar US-based study, where the authors found that earlier surgical intervention was associated with fewer postoperative health care visits and prescriptions and, perhaps more importantly, lower rates of asthma [59].

These results support those found by the studies of Rudmik et al. who found that health utility also declined in a small group of patients receiving ongoing medical therapy before crossing over into surgery [60•].

These studies suggest that once it is apparent that medical treatment has failed, it may be detrimental to long-term outcomes to delay surgical intervention. It may be that unresolved CRS leads to irreversible mucosal remodelling, accumulation of biofilms, or simply progression of disease, or it may simply be that surgical intervention allows better access and therefore response to topical medical therapy. Further work is required to study the natural history of CRS and the impact of surgery on this.

Cost-Effectiveness of Medical Versus Surgical Management

The costs of CRS to the economy are significant, with estimates in the USA showing direct annual costs at \$8.6 billion [61], and indirect costs related to reduced productivity (presenteeism) and absenteeism at approximately 73 million

days of restricted activity [62]. In a prospective multicenter Swedish study, absenteeism due to sinus problems was found in 57 % of patients awaiting surgery for CRS, with a range of 8 to 14 days, with 12 % of patients reporting absenteeism of more than 30 days annually. Interestingly, patients with polyps had lower levels of absenteeism [63]. Costs of an ESS procedure with a 45-day postoperative period has been estimated at \$7726 in the USA [64], with estimates in the UK varying between £1771 and £2299 dependant on geographical location [65].

There are no health economic studies looking specifically at CRSwNP. Comparing health-care utilisation and costs before and after ESS in the management of CRS including both patients with and without polyps, Bhattacharyya and co-workers found that in the year prior to ESS, costs rise to as high as \$2449, with maximal increase in the last 6 months before surgery. In contrast, costs drop to \$1564 annually in the first postoperative year [64]. In another retrospective analysis on overall health-care utilisation, it was found that patients with CRS had an eightfold increase in their costs compared to baseline population levels, but returned to baseline 13 weeks following ESS [66]. Similarly, Rudmik and co-workers demonstrated that patients with refractory CRS return to levels of health-care utilisation similar to the US population norms following ESS [67].

With regard to comparing costs of continued medical management with surgical management, ESS has been suggested to be cost effective within the third year after surgery and, generally, the more cost-effective treatment strategy in patients with refractory CRS [64].

Conclusion

In conclusion, many comparative studies have shown similar outcomes for medical and surgical management, supporting the current philosophy of reserving surgery for those patients who fail to respond to medical treatment. However, there is sufficient evidence to support the role of surgery once symptoms have failed to adequately respond. There is insufficient evidence comparing polypectomy with additional sinus surgery. Further research is required to define the optimal timing and extent of surgery.

Compliance with Ethical Standards

Conflict of Interest Drs. Dessouky and Hopkins declare no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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