Current Otorhinolaryngology Reports (2023) 11:273–285
https://doi.org/10.1007/s40136-023-00475-0

Chronic Rhinosinusitis: Matching the Extent of Surgery with Pathology or Does the Extent of Surgery Matter?

Manon Blauwblomme[1] · Philippe Gevaert[1] · Thibaut Van Zele[1]

Accepted: 13 July 2023 / Published online: 24 August 2023
© The Author(s) 2023

Abstract

Purpose of Review The purpose of this review is to summarize the current literature on the extensiveness of surgery in patients with diffuse type 2 chronic rhinosinusitis (CRS).

Recent Findings There is currently no consensus on the role of the extent of sinus surgery in disease control and definitions of surgical terms in diffuse type 2 CRS. Several suggestions have been made to quantify the extent of surgery or standardize the description of surgical interventions.

Summary The extent of surgery in CRS depends potentially on the severity of disease and the type of underlying inflammation. A variety of extended endoscopic procedures can be used in the management of primary diffuse bilateral type 2 chronic rhinosinusitis; however, long-term follow-up results and clear definitions of complete surgery are lacking in the current literature.

Keywords Chronic rhinosinusitis · Endoscopic sinus surgery · Extended surgery · Reboot surgery · Extent of surgery · Complete surgery

Introduction

Chronic rhinosinusitis (CRS) is an inflammatory disease of the nose and paranasal sinuses affecting > 10% of the adult population in Europe and the USA [1]. The most common symptoms observed in patients with CRS are facial pain or pressure, loss of smell, and nasal congestion or discharge. In recent decades, new insights have emerged on the endotyping and phenotyping of CRS that have led to a subdivision beyond chronic rhinosinusitis with nasal polyps (CRSwNP) and chronic rhinosinusitis without nasal polyps (CRSsNP). Classification into primary and secondary CRS and further division into localized (often unilateral) or diffuse (always bilateral) disease based on anatomic distribution has been proposed [1, 2]. Both primary and diffuse CRS can be further divided into type 2 or non-type 2. The clinical phenotypes of diffuse CRS are mainly eCRS and non-eCRS, determined by the histological quantification of eosinophil counts [1]. Treatment decisions for the management of CRS are guided based on this endotype classification. Local corticosteroids remain the main medical treatment for diffuse, bilateral CRS because they play an important role in controlling mucosal inflammation [1, 3]. Additionally, endoscopic sinus surgery (ESS) is considered the golden standard in the surgical management of CRS patients. ESS has several goals, including improving sinus ventilation and drainage, creating a sinus cavity that incorporates the natural ostium, facilitating mucociliary clearances and providing better conditions for local treatment [1, 3–5].

The literature on sinus surgery is comprehensive, but there is a lack of standardizing surgical terms and guidelines on indications, the exact timing of surgery in the course of CRS, or the appropriate extent of surgery in primary and revision surgery. The spectrum of surgical procedures for CRS ranges from limited surgery such as dilation of the natural ostia to extensive procedures changing the anatomy and removing all diseased and non-diseased mucosa. There is ongoing debate about the extent of sinus surgery for disease control in CRS and factors determining the extent of surgery (e.g., endotype of CRS, extent of mucosal thickening on CT, intraoperative judgment). This debate is very difficult as terms like "complete surgery," "functional surgery," "non-functional surgery," "extended surgery," and "radical surgery" are used interchangeably and defined very differently in the literature. Several extended surgical approaches have

✉ Manon Blauwblomme
manon.blauwblomme@ugent.be

[1] Department of Otorhinolaryngology, Ghent University Hospital, Ghent, Belgium

been proposed, but few studies have examined the short- and long-term outcomes. The aim of this review is to discuss the recent literature on the extent of surgery for CRS and, more specifically, the more extensive forms of surgery such as creating a neo-sinus, "full" functional endoscopic sinus surgery (FESS), reboot surgery, nasalization, and mucoplasty for diffuse bilateral type 2 CRS.

ESS: Success, Indications, and Timing

Treatment of CRS is often a challenge, especially patients with a type 2 endotype tend to be more resistant to medical and surgical therapies, exhibiting a high recurrence rate. Recurrence after ESS is common, but rates largely vary depending on the duration of follow-up. Rates in type 2 CRS range from 20% on short term to 38–80% on long term (10–12 years) [6–9]. Multiple factors have been associated with polyp recurrence, such as asthma, allergic rhinitis, tissue eosinophilia, and aspirin-exacerbated respiratory disease [8–10]. Evidence suggests that more extensive surgery in severe CRSwNP lowers the recurrence rates [11, 12•, 13]. However, there is also evidence to the contrary, with studies unable to detect lower revision rates after more extensive surgery [14, 15]. This should take into account the lack of consistency of reported postoperative medical therapy in studies assessing recurrence rates. Despite these high recurrence rates, the addition of ESS to medical therapy significantly improves symptoms and health-related quality of life [1, 3, 16]. A recent randomized controlled trial showed that ESS plus medical therapy is more effective than medical therapy alone in patients with CRSwNP [17].

Several guidelines recommend appropriate medical therapy (AMT) prior to considering surgical intervention; for example, the EPOS suggests surgery if a 3-month trial of medical treatment fails to improve CRS symptoms [1]. However, there is no consensus on the exact definition, criteria, therapeutic classes, or duration of appropriate medical therapy (AMT) [18]. Since sinus surgery aims to improve symptoms, it seems obvious to perform surgery only in patients with symptomatic disease. Variables such as older age, asthma, prior ESS, and a high preoperative SNOT-22 score were found to be correlated with an improved SNOT-22 change after surgery [19]. A preoperative CT scan is required to confirm the presence and the extent of disease, but the preoperative CT-score, namely, the Lund–Mackay score (LMS), has been shown to correlate poorly with quality-of-life measures [1, 20]. Rudmik et al. made an attempt to standardize surgical indications. They recommend offering ESS to CRS patients who have a CT Lund–Mackay score of ≥ 1, which is, however, a very low threshold, and underwent a trial of at least eight weeks of topical steroids plus an antibiotic course with a post-treatment total SNOT-22 score of ≥ 20. In nasal polyp patients, they advise a CT Lund–Mackay score of ≥ 1 and a post-treatment total SNOT-22 score of ≥ 20 after a course of systemic corticosteroids before considering surgery [21].

Research has been conducted regarding the optimal timing of surgery relative to medical therapy or patient symptoms showing that early intervention after diagnosis of CRS is associated with lower healthcare utilization than intervention after many years of medical management [22]. A comparative audit study by Hopkins et al. revealed that patients with delayed surgery reported less improvement in SNOT-22 scores compared to patients treated at earlier time points; moreover, they found that patients who had surgery earlier in the disease were at decreased risk of developing asthma [23, 24]. These results suggest that delaying surgical intervention may result in worse symptom improvement.

The Extent of Surgery

History and Surgical Terms

Functional

Various surgical procedures of the paranasal sinuses are described in the literature, but in this review we focus on the surgical modification of the paranasal sinuses in diffuse bilateral type 2 CRS. Functional endoscopic sinus surgery (FESS) in diffuse bilateral type 2 CRS aims to create a functional sinus cavity. However, there is no agree-upon definition of what "functional" means clinically. We limit the scope to diffuse bilateral type 2 CRS, but distinguish between chronic rhinosinusitis without nasal polyps and with nasal polyps, as this was most commonly used in the published literature.

Endoscopic sinus surgery (ESS) was introduced in the 1980s by Messerklinger focusing on clearing stenotic clefts and infected ethmoidal cells of diseased mucosa at the anterior ethmoid, as well as providing drainage and ventilation by enlarging the maxillary ostium into the anterior fontanelle [25]. Since the introduction of sinus surgery for CRS, the emphasis has been on relieving ostial obstruction and enhancing ventilation [25, 26]. In subsequent years, several studies conclusively demonstrated a decrease in mucociliary clearance in CRS patients with an improvement of sinonasal mucociliary function resulting from sinus surgery [27]. Mucociliary clearance is directed toward the natural ostium rather than toward the surgically created antrostomy. Additionally, failure to include the natural ostium in a maxillary antrostomy may lead to mucus recirculation through the accessory ostium and disease persistence. These reasons underline the importance of incorporating the natural ostium when creating a neo-ostium. Furthermore, a sinus cavity needs functional mucosa, which underlines the importance of mucosal

Table 1 Criteria of complete surgery

Complete surgery
1. Complete removal of all bony partitions within a functional sinus unit
2. Incorporation of all natural ostia into the surgical cavity
3. Complete removal of diseased, inflamed mucosa or polypoid tissue

preservation where possible. Since Messerklinger, CRS has increasingly been treated as an inflammatory disease, where improvement of sinus patency or ventilation alone is insufficient, given the current knowledge of the pathophysiology.

Complete

Furthermore, the concept of "complete" surgery is also a subject of debate within surgical terms, with different criteria for "complete" surgery mentioned in the literature (Table 1). The EPOS proposes the term "full FESS," indicating a complete sinus opening including anterior and posterior ethmoidectomy, middle meatal antrostomies (likely large), sphenoidotomy, and frontal opening (e.g., Draf IIa) [1]. An observational study examined whether all sinuses should be opened regardless of disease extent or whether surgery should be targeted on affected sinuses. They defined "complete" surgery as bilateral frontal sinusotomy, ethmoidectomy, maxillary antrostomy, and sphenoidotomy and concluded that complete surgery was an independent predictor of greater postoperative SNOT-22 score improvement yet did not achieve clinical significance [28]. Conversely, Ayoub et al. found no clear benefit of extending the surgery beyond the diseased sinuses identified on preoperative imaging [15]. Snidvongs et al. describe "complete" surgery as creating a single sinus cavity in which all frontal, ethmoid, maxillary, and sphenoid sinuses are connected by performing a wide

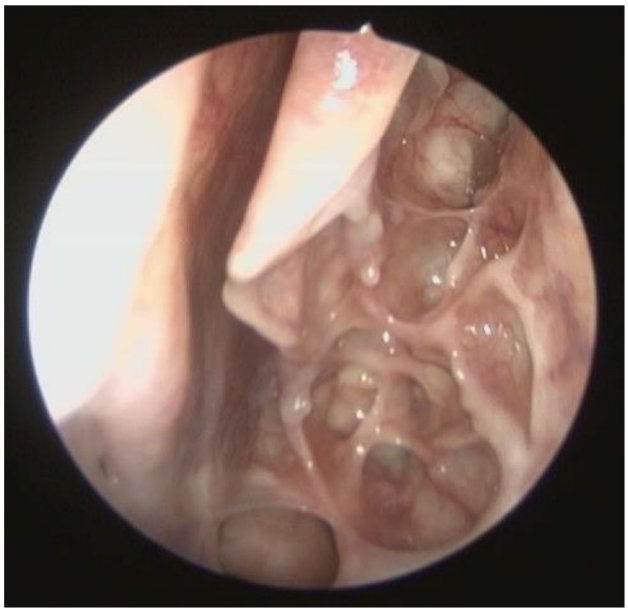

Fig. 2 Complete surgery

antrostomy, complete sphenoethmoidectomy with either a complete Draf IIa or Draf III [4]. A neo-sinus is created through the complete removal of intersinus septa without drilling or intentional mucosal removal to the periosteal layer, referred to as mucosal-preserving surgery (Figs. 1 and 2) [4]. The rationale supporting this approach lies in the maximalization of postoperative delivery of corticosteroids to the sinonasal mucosa rather than focusing on optimization of ventilation [29]. The Amsterdam Classification of Completeness of Endoscopic Sinus Surgery (ACCESS) is a recently developed scoring system that aims to provide a quantitative measure of the extent of endoscopic sinus surgery [30]. This scoring system addresses access to the sinus

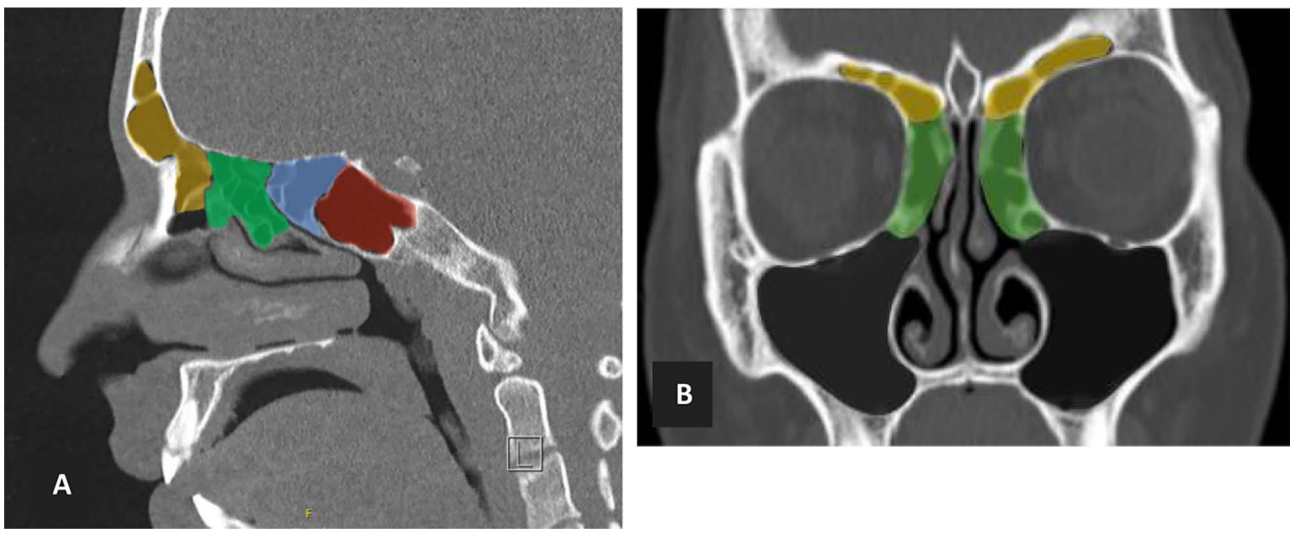

Fig. 1 Concept of complete surgery: removal of all intersinus septa **A** sagittal plane and **B** coronal plane

based on bony boundaries, as opposed to the Lund–McKay score which focuses on sinus opacification.

Extensive and Radical

Finally, we want to elaborate on the term "extensive" surgery. Several studies examined "extensive" surgery in CRS, but each used different definitions, making it impossible to compare outcome data from these studies [31, 32]. The EPOS states that "extended" surgery is used in the same context as "full" but could also include extension beyond confines of sinuses, i.e., skull base, orbit, pterygopalatine, and infratemporal fossa. When significant removal of inflamed or dysfunctional mucosa is done, they refer to "radical" surgery [1]. Consistently, the ICAR guidelines refer to "radical" surgery when significant removal of mucosal tissue or resection of the middle turbinate is performed [3]. The debate in the literature focuses on whether "radical" surgery involves intentional removal of the sinus mucosa to the periosteal layer and whether or not it is intended to be functional at the end of the procedure.

Chronic Rhinosinusitis Without Nasal Polyps (CRSsNP)

It is widely accepted in primary surgery for diffuse, non-type 2, chronic rhinosinusitis without nasal polyposis to perform functional endoscopic sinus surgery in which only the diseased mucosa is removed [1]. The surgical treatment for localized isolated sinusitis is beyond the scope of this article. As mentioned before, the goal in sinus surgery for CRS is to create a functional cavity that facilitates mucociliary clearance, which implies that it is important to include the natural ostium in the antrostomy, since mucociliary clearance is directed toward the natural ostium rather than toward the surgically created opening. Albu and Tomescu performed a prospective randomized study on 133 patients to evaluate the influence of the size of the initial middle meatal antrostomy on the degree of postoperative improvement in maxillary symptoms. They found that a narrowed antrostomy was not correlated with persistent symptoms of maxillary sinusitis and thus supported the concept of minimally invasive sinus surgery [33]. Similarly, a prospective study with 33 CRSsNP patients showed no benefit in terms of relief of symptoms for uncinectomy with additional middle meatal antrostomy compared to simple uncinectomy, of which unknown if patients had a partial or total resection of the uncinate process [34]. However, when considering functional surgery, evidence proved that larger maxillary antrostomies permit more effective distribution of topical nasal steroids [35]. A subset of CRSsNP patients has a Th-2 type inflammation, which may predict higher recurrence and revision ESS and thus may also potentially benefit from more extensive surgery [36]. The surgical management of recalcitrant frontal sinus disease is quite controversial due to the difficult reach and location. A meta-analysis provided evidence to support the use of the Draf III approach in recalcitrant frontal sinus disease following failure of primary ESS; moreover, Barham et al. demonstrated optimal delivery of local therapy in patients with frontal sinus disease after a Draf III procedure [37, 38]. The sphenoid sinus is least frequently affected in CRS and usually occurs within the context of pansinusitis. Only a few studies described extensive approaches for the sphenoid sinus. Leight et al. suggested an intermediate step between a sphenoidotomy and a radical sphenoidectomy or marsupialization, namely, a "sphenoid drill out" procedure [39]. In a small prospective study with 12 patients, of which 6 were diagnosed with CRSsNP, this technique proved to be safe and effective with a high success rate for patients with refractory chronic sphenoid sinusitis [40]. Thus, there are several factors to consider when it comes to the extensiveness of sinus surgery in CRSsNP patients.

Chronic Rhinosinusitis with Nasal Polyps

In contrast to CRSsNP, surgical failure is more common in CRSwNP due to polyp recurrence, resulting in multiple surgeries and difficult-to-treat disease. In western countries, CRSwNP commonly presents with a type 2-high inflammation, which results in extensive mucosal inflammation. Topical corticosteroids play an even more important role in controlling mucosal inflammation in this phenotype by improving symptoms, reducing polyp size, and preventing polyp recurrence after surgery [1]. This emphasizes the need for complete surgery by creating a neo-sinus cavity that allows for restoration of ventilation, drainage, and maximized delivery of topical therapy [4].

Extent of Surgery and Outcomes

Regarding the size of the maxillary ostium, a study in 60 CRSwNP patients showed a better patency rate of a large middle antrostomy compared to an undisturbed maxillary ostium in the early phase after ESS [41]. Since the mucociliary pathway beats toward the natural ostium, it is critical to have a patent natural ostium regardless of the size of the surgical antrostomy. Kim et al. found no significant differences in postoperative outcomes (VAS score, endoscopic scores, or CT scores) between CRSwNP patient groups in whom either the inflamed mucosa was radically (but not completely) removed, or only a part of the mucosa was removed, or in patients in whom only enlargement of the maxillary ostium was performed without any removal of mucosa [42]. This argues against the rationale for radical removal of mucosa.

The anterior ethmoid sinuses are most often targeted in all forms of sinus surgery. In CRSwNP patients, polypectomy and surgery up to the anterior ethmoid were practiced

widely, but more extensive approaches are supported since recurrence is often observed in CRSwNP patients. A retrospective review demonstrated that removal of nasal polyps along with full ethmoid clearance can lead to lower revision rates compared to polyp disease removal limited to the anterior ethmoid cavity [31]. The complete removal of the anterior and posterior ethmoid cells also maximizes the therapeutic distribution of topical corticosteroid treatment [35].

Surgical management of chronic frontal sinusitis is a challenge due to complex and variable anatomy, difficult transnasal visualization, and tendency for scarring and restenosis. The goal of frontal sinus surgery in refractory disease is to create a wide frontal ostium to provide adequate ventilation, mucociliary clearance, and access for topical therapy. The endoscopic modified Lothrop procedure (EMLP), otherwise known as Draf III frontal sinusotomy or frontal drill out, has been used as an extended procedure when primary surgery fails. A retrospective study assessed the long-term outcome of EMLP surgery in 229 patients, approximately 50% of whom had CRSwNP, and a mean follow-up period of 45 months. EMLP surgery was successful with a patency rate of 97% (a patent frontal neo-ostium) and only 12 of 229 patients requiring revision EMLP due to persistent symptoms [43]. Consequently, the Draf III procedure proved success in refractory patients resistant to standard ESS [44–46]. Bassiouni et al. provided evidence that a Draf III procedure improved long-term outcomes and reduced the risk of revision, especially in CRSwNP patients with asthma or aspirin intolerance [47]. Additionally, the Draf III procedure has been found to be superior in comparison to the Draf IIa procedure in delivering topical irrigation to the frontal sinuses [48, 49]. Consequently, a study on human cadaver heads proved that a Draf III procedure was also superior to a Draf IIb for topical irrigation of the frontal sinus [38].

It is not fully known whether more extended techniques such as Draf III frontal surgery should be performed in primary or in revision surgery. The EPOS guidelines suggest considering primary Draf III in high-risk patients with risk factors such as asthma, CRSwNP, Lund–Mackay score of more than 16, or a narrow frontal ostium (< 4mm) [1].

Nasalization

In 1995, the concept of complete total ethmoidectomy with mucosal removal to the periosteum was proposed for the treatment of nasal polyposis by Jankowski et al., referred to as "nasalization." This technique focused on optimal resection of the non-olfactory ethmoidal mucosa. At that time, nasalization was defined by systematically removing all the bony lamellae and mucosa within the ethmoid labyrinth, with large opening of the maxillary, sphenoidal and frontal ostia, and middle turbinectomy. The mucosa of the maxillary, sphenoid, and frontal sinuses was left intact

Table 2 Extensive techniques explained by sinus

	Neo-sinus/full FESS	Reboot	Nasalization	Nasalization updated	Mucoplasty
Maxillary sinuses	Large/maximal opening of the antrostomy or combined with modified medial maxillectomy with polypoid/affected mucosa removed to the periosteum	Total removal of the sinus mucosa including alveolar recess	Large opening of the maxillary ostia, leaving mucosa intact	Functional ostial dissection with conservation of maxillary sinus membrane and ostium whenever possible	/
Ethmoid sinuses	Eradication of all partitions and polypoid/affected mucosa removed to the periosteum	Mucosa on lamina orbitalis fovea ethmoidalis (periosteum remains), lateral aspect of the middle turbinate, superior turbinate removed	Optimal resection of non-olfactory ethmoid mucosa, all ethmoid partitions, and mucosa and middle turbinate resection	Eradicate all vestigial ethmoid mucosa (mucosa in the lateral masses and polyps originating there)	Use of an endonasal mucosal graft after total sphenoethmoidectomy (complete removal of all mucosa of skull base and lamina papyracea)
Sphenoid sinuses	Wide/maximal opening to the floor and polypoid/affected mucosa removed to the periosteum	Wide access, remove mucosa carefully (especially from the floor, anterior and medial walls)	Large opening of the sphenoidal ostia, leaving mucosa intact	Sphenoid ostium conservation whenever possible	Complete sphenoethmoidectomy (complete removal of all mucosa of skull base and lamina papyracea)
Frontal sinuses	Maximal Draf IIa or Draf III and polypoid/affected mucosa removed to periosteum	**"Full" reboot:** wide access, complete removal of frontal sinus mucosa to the periosteum, including Draf III	Large opening of the frontal ostia, leaving mucosa intact	Frontal ostium conservation whenever possible	Bilateral Draf IIa or III procedure with wide exposure of the posterior wall of the frontal sinus

(Table 2, Fig. 3) [50]. Given the mucosal preservation of the maxillary, sphenoidal, and frontal sinuses in nasalization, there is again overlap with "full" FESS and neo-sinus ESS, highlighting the inconsistencies in surgical term definitions. Some other studies confirmed the interest of middle turbinate resection in polyposis surgery, but this remains a very controversial topic [51, 52]. A 5-year follow-up study reported lower recurrence rates after nasalization than after conventional ethmoidectomy, 22.7% versus 58.3%, respectively, taking into account that both procedures were performed by different surgeons (Table 3) [11]. Besides, olfaction in the hypo-anosmic group improved considerably at 1 month after nasalization, and scores remained stable until 12 months postoperative. The sense of smell in the normosmic group did not change after surgery and remained stable (Table 3) [53]. The technique was updated by 2018 and stated to eradicate vestigial ethmoid mucosa, i.e., all the mucosa in the lateral masses, and all polyps originating there, whether they are externalized in the middle meatus, olfactory cleft, or sphenoethmoidal recess (Table 2, Fig. 3) [54]. Regarding the middle turbinate, the medial aspect covered with mucosa should be conserved as should the ostial mucosa of each sinus [54]. The rationale of the updated version concerns the maximum safe ablation of the non-olfactory ethmoidal mucosa but justifies complete mucosal resection. The results of applying the updated technique have not yet been assessed. The reported long-term complications include mucocele [55], frontonasal stenosis, and synechiae [54]. A retrospective study demonstrated that the olfactory cleft is a frequent site for nasal polyp recurrence after nasalization and that 54.8% of recurrent polyps are respiratory epithelial adenomatoid hamartoma (REAH) or REAH associated to classical inflammatory nasal polyps [56]. Moreover, they found a mean interval of 9.5 years between primary radical surgery with middle turbinate resection and the first revision surgery [56].

Reboot Surgery

Bachert et al. introduced the concept of "reboot" and stated that the surgical approach should be tailored according to the endotype, with considering mucosal sparing surgery for symptomatic but uncomplicated CRSsNP and non-type 2 CRSwNP and "reboot" surgery with complete removal of the inflamed sinus mucosa for moderate-to-severe type 2 inflammation [57]. They hypothesize that removal of the type 2 inflammatory environment allows undisturbed re-epithelialization of the sinus walls. The rationale is supported by a small study showing that inflammation in CRSwNP is not limited to the polyps but is also present

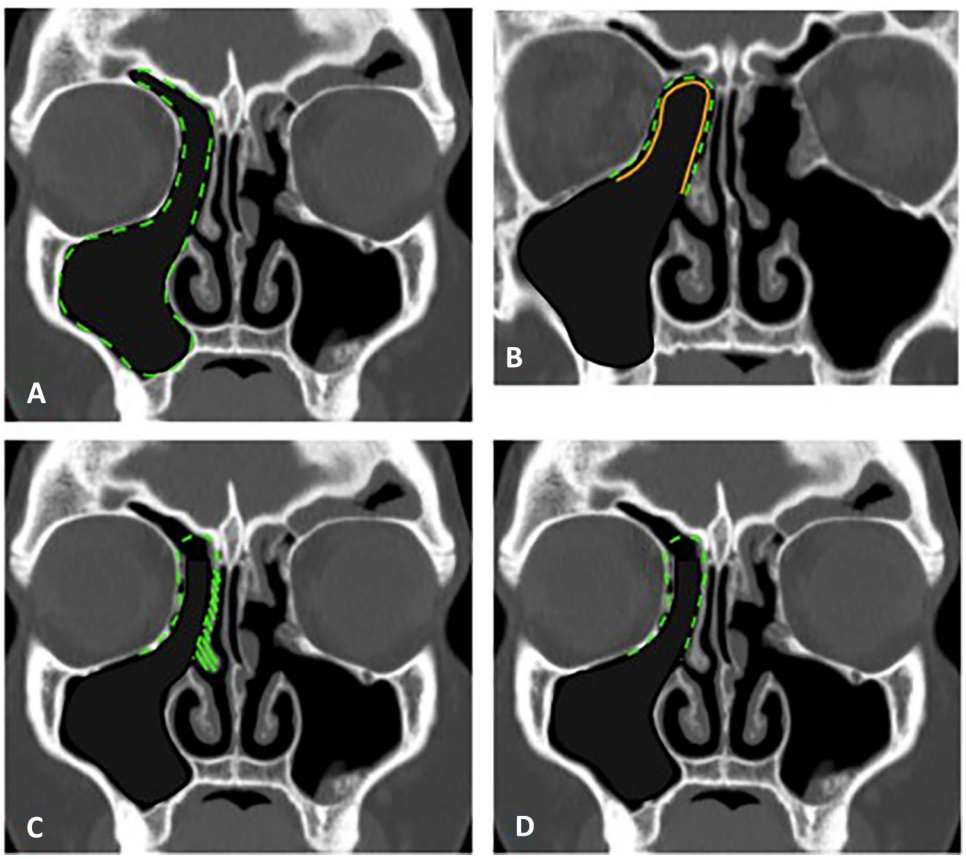

Fig. 3 The *green dotted lines* show the mucosal areas removed during **A** reboot surgery, **B** mucoplasty, **C** nasalization with middle turbinectomy, and **D** nasalization without middle turbinectomy. In **B**, the *orange line* indicates the position of the endonasal mucosal graft

in the non-polypoid sinus mucosa, which is not addressed by conventional sinus surgery [58]. The technique starts at the maxillary sinus with a wide antrostomy and removing the sinus mucosa, including the alveolar recess mucosa, to the periosteal layer, leaving the periosteum where possible (Fig. 3). At the level of the ethmoid, reboot surgery aims to remove all the mucosa on the lamina orbitalis fovea ethmoidalis, the lateral aspect of the middle turbinate, and the superior turbinate. A wide access to the sphenoid is made with careful removal of the mucosa, especially form the floor, anterior, and medial walls. If the procedure is combined with a Draf III procedure and complete removal of frontal sinus mucosa to the periosteum, it is referred to as a "full reboot" (Table 2) [59]. Alsharif et al. retrospectively looked at polyp recurrence over a follow-up period of 2 years in 50 CRSwNP patients who underwent either a classical non-reboot ESS, a partial reboot approach with removal of ethmoidal, sphenoidal and maxillary mucosa or a complete reboot with a Draf III procedure, and removal of all frontal sinus mucosa. The relapse rates were found to be 45% in the classical approach, 17% in the partial reboot group, and 8% in the full reboot group (Table 3). They reported a reduction in polyp recurrence and prolongation of recurrence-free time after complete removal of the diseased sinus mucosa in patients with type 2 CRSwNP. In this cohort, there were no reports of severe or lasting complications. They found no short-term healing complications or abnormal scar formation [59]. Gomez et al. examined the olfactory function and recurrence rates in a retrospective study of 168 patients, who had revision surgery and either reboot surgery or regular ESS. Smell scores improved similarly in the reboot and ESS groups until 12 months, which was maintained after 24 months for reboot but not for ESS. Over a 24-month period, the recurrence rates were also significantly lower in the reboot surgery group (Table 3) [12•]. More recently, Pirola et al. investigated the outcome of partial reboot surgery in 30 pluri-operated CRSwNP patients as compared to the results previously obtained in the same patients with classical ESS and reported lower recurrence rates, longer recurrence-free survival and improved quality of life and discontinuation of all oral corticosteroids intake with partial reboot surgery (Table 3) [60•].

Mucoplasty

More recently, the concept of "mucoplasty" was proposed, which is a reconstructive procedure that involves the use of an endonasal mucosal graft after total ethmoidectomy in patients with severe nasal polyposis. The hypothesis is to transfer nasal mucosa not usually associated with nasal polyps, such as the nasal cavity floor mucosa, to an area where polyps frequently develop, thus promoting a possible "polyp-resistant" mucosal growth starting from healthy mucosa [61•]. A total ethmoidectomy and Draf III procedure are performed with complete removal of all the mucosa of the skull base and lamina papyracea, since the graft should be in contact with the bone in all its extensions (Table 2). The graft harvesting is obtained from the ipsilateral nasal cavity floor mucosa and placed in the nasal roof partially covering the anterior ethmoidal artery to posterior covering the posterior ethmoidal artery. Laterally, the graft should reach the angle formed by the lamina papyracea and the ethmoidal roof, covering almost all of the lateral lamella of the cribriform area (Fig. 3) [61•]. Mucoplasty was first described in a pilot study of 10 patients who underwent endoscopic sinus surgery for CRSwNP with subsequent endoscopic mucoplasty in the left nasal cavity. They found a better subjective endoscopic evaluation of healing in the nostril with mucoplasty after 6 months of surgery and reported no immediate postoperative or major complications. The graft placement did not affect the olfaction, as evaluated by the VAS scores, showing a non-significant scoring decrease (Table 3). Moreno-Luna et al. state that endonasal mucoplasty could be effective to reduce local edema associated with less secretions and thus give a better control in the frontal recess, orbital wall, and nasal roof in the postoperative period [61•]. A more recent study in 64 patients examined the benefits of bilateral mucoplasty as a complementary technique to reboot surgery. Significant differences in outcomes, such as the modified Lund–Kennedy (LMK), Meltzer, and Lund–Mackay (LM) scores, and the SNOT-22, were found before and after surgery in both groups, with greater improvement in the mucoplasty group (Table 3) [62•]. Further research is needed to determine the long-term outcomes of mucoplasty.

Table 3 Extensive techniques and reported outcomes

Study	Methods	Patients	Intervention	Duration	Results	Conclusion
Jankowski et al. [50]	Retrospective cohort	Diffuse and severe CRSwNP ($n=76$)	**Nasalization:** • Nasalization ($n=34/39$) • Functional ethmoidectomy ($n=29/37$)	±2 years	**Olfaction improvement (mean VAS score):** **After 6 months** • Nasalization ($n=31$): *not reported* • Ethmoidectomy ($n=23$): *not reported* **After 24 months:** • Nasalization ($n=29$): 6.6 ± 0.7 points • Ethmoidectomy ($n=17$): 4.2 ± 1 points **After 36 months:** • Nasalization ($n=28$): 6.9 ± 0.7 points • Ethmoidectomy: *not reported*	Nasalization results appeared stable over time, whereas ethmoidectomy results slowly deteriorated, as demonstrated by the progressive loss of the sense of smell
Jankowski et al. [53]	Prospective cohort	CRSwNP	**Nasalization ($n=32$):** • Anosmic ($n=25$) • Normosmic ($n=7$)	12 months	**Olfaction before nasalization (mean VAS score):** • Anosmic ($n=25$): 0.7 ± 0.6 cm • Normosmic ($n=7$): 7.7 ± 0.9 cm **Olfaction improvement (mean VAS score):** **After 12 months** • Anosmic ($n=25$): 7.0 ± 1.5 cm • Normosmic ($n=7$): 8.5 ± 0.8 cm	One month after nasalization, olfaction in patients of the hypo-anosmic group had improved considerably. Scores at 3, 6, 9, and 12 remained stable. The sense of smell in the normosmic group did not change after surgery and remained stable
Jankowski et al. [11]	Retrospective cohort	Diffuse and severe CRSwNP ($n=76$)	**Nasalization**: • Nasalization ($n=39$) • Functional ethmoidectomy ($n=37$)	5 years	1) **Overall nasal function benefit score (mean ± SEM):** 2) **In patients free of revision surgery** • Nasalization: 8.41 ± 0.4 • Ethmoidectomy: 5.69 ± 0.83 **Endoscopic appearance of mucosa (pre-defined scale):** • Nasalization: 6.03 ± 0.7 • Ethmoidectomy: 3.27 ± 1.0 1) **Recurrence rates:** • Nasalization: 22.7% • Ethmoidectomy: 58.3%	2) At 5 years of follow-up, recurrence rates were significantly ($P<0.01$) lower after nasalization than after functional ethmoidectomy

Table 3 (continued)

Study	Methods	Patients	Intervention	Duration	Results	Conclusion
Alsharif et al. [59]	Retrospective cohort	Severe, type 2 CRSwNP ($n=50$)	**Reboot surgery:** • Non-reboot ESS ($n=20$) • Partial reboot ($n=18$) • Complete reboot ($n=12$)	30 months	**Recurrence rates:** • Non-reboot: 45% ($n=9$) • Partial reboot: 17% ($n=3$) • Complete reboot: 8% ($n=1$)	The relapse rates were significantly different between the non-reboot and the reboot groups ($P=0.02$) but also between all treatment groups ($P=0.038$)
Gomes et al. [12•]	Retrospective cohort	Severe, type 2 CRSwNP; revision surgery ($n=168$)	**Reboot surgery:** • Regular ESS ($n=28$) • Reboot ESS ($n=140$) Reboot ($n=94$) Reboot + DRAF III ($n=46$)	2 years	**Smell score:** **After 12 months:** Smell scores overlapping in both groups, increasing in both groups before vs after surgery **After 18 and24 months:** • Regular ESS: smell scores significantly worse • Reboot: smell scores were maintained **Recurrence-free survival rates:** polyp recurrence rates were significantly lower in the reboot group than in the regular ESS group at 24 months	Smell improved similarly in the reboot and ESS groups over the first 9 months, which was maintained over 24 months in the reboot, but not the ESS group ($P=0.007$ after 18 months, $P=0.001$ after 24 months). Furthermore, polyp recurrence rates were significantly lower in the reboot group
Pirola e al. [60•]	Prospective cohort	Recalcitrant CRSwNP	**Partial reboot surgery** ($n=30$) • Before reboot + previous ESS • After reboot	6 months ($n=30$) 12 months ($n=26$) 18 months ($n=13$) 24 months ($n=11$)	**Recurrence:** • **Before reboot + FU of 3 years**: 86.6% ($n=26$) relapsed with mean recurrence time of 8.08 ± 2.83 months after each previous procedure • **After reboot + FU of 2 years:** 23.3% ($n=7$) relapsed with mean recurrence time of 16.67 ± 3.07 months after reboot **Recurrence-free survival rates:** polyp recurrence rates were significantly lower after reboot than after previous ESS at 24 months	The reboot approach showed lower RR, longer RFS, improved QoL, and zeroing of OCS uptake compared to previous surgeries in a group of 30 pluri-operated patients

Table 3 (continued)

Study	Methods	Patients	Intervention	Duration	Results	Conclusion
Moreno-Luna et al. [61•]	Pilot study	CRSwNP ($n=10$)	**Total ethmoidectomy + unilateral mucoplasty** ($n=10$) • Left nasal cavity: mucoplasty • Right nasal cavity: control	6 months	**Olfactory assessment (10-cm VAS score):** • **Pre- vs postoperative**: 9.3 (0.5) cm **vs** 4.6 (3.9) cm **Endoscopic evaluation (modified Lund–Kennedy score)** • **Preoperative** Left nasal cavity: 4.8 (1.0) Right nasal cavity: 4.9 (0.7) • **Postoperative** Left nasal cavity: 1.3 (0.8) Right nasal cavity: 1.9 (1.0) **Subjective endoscopic evaluation:** better healing, decrease in production of secretions and lower development of mucosal edema in the frontal recess, orbital wall and nasal roof, in the fossa with the mucoplasty, when compared with the contralateral nasal fossa	A significant decrease of SNOT-22 scores from 57.0 (21.1) to 20.3 (20.6) ($P=0.024$) and a non-significant decrease of VAS for olfaction score from 9.3 (0.5) to 4.6 (3.9) were found. Preoperative mean MLK score was 4.9 (0.7) in the right nostril and 4.8 (1.0) in the left one. After operation, there was a greater decrease of MLK score in the left nostril than in the right (1.9 [1.0] vs. 1.3 [0.8], $P=0.034$)
Moreno-Luna et al. [62•]	Prospective cohort	Severe type 2 CRSwNP	**Bilateral mucoplasty** ($n=64$): • Reboot + bilateral mucoplasty ($n=17$) • Reboot only ($n=47$)	1 year	Full article at present unavailable	LKM, LM scores, and the SNOT-22 scores showed significant differences before and after surgery in both groups, with higher improvement in the mucoplasty group

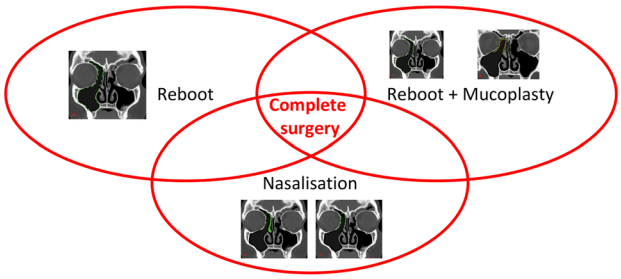

Fig. 4 Overview of the extended approaches. Reboot surgery, nasalization, and reboot surgery with mucoplasty have in common that all bony partitions within a functional sinus unit are completely removed, incorporating all natural ostia into the surgical cavity and completely removing diseased, inflamed mucosa or polypoid tissue

Conclusions

Endoscopic sinus surgery is effective in the surgical management of CRS. Several guidelines suggest considering ESS following failure of adequate medical therapy. However, we believe that CRS needs to be treated as an inflammatory disease by a combination of local treatment and complete endoscopic sinus surgery to maximize the delivery of these intranasal corticosteroids, especially in severe type 2 CRSwNP. The extent of surgery in CRS depends potentially on the severity of disease and the type of underlying inflammation. Extensive forms of sinus surgery for CRS involve 4 approaches, namely, "full FESS or neo-sinus ESS," "nasalization," "reboot surgery," and "mucoplasty." The literature is limited in long-term follow-up data, but these results are required to optimally evaluate the effect of these surgical procedures.

Additionally, there is a lack of standardization on surgical terms. According to our interpretation and as mentioned in the EPOS, sinus surgery is "functional" when ventilation and drainage are improved, a sinus cavity is created that incorporates the natural ostium, mucociliary clearance is facilitated, and better conditions are provided for local treatment. Considering these criteria, a sinus obliteration, a sphenoidectomy, and a dual ostium configuration are all forms of "non-functional" sinus surgery. Reboot surgery can be interpreted as "functional" surgery, since healthy re-epithelialization from the preserved nasal mucosa occurs, as in mucoplasty, where healthy mucosa is placed over the periosteum. Complete surgery involves complete removal of all bony partitions within a functional sinus unit, incorporating all natural ostia into the surgical cavity, and the complete removal of diseased, inflamed mucosa or polypoid tissue (Fig. 4). Complete surgery for inflammatory disease is desirable in the context of proper access for local therapy and removal of diseased mucosa.

The extent of surgery in CRS depends potentially on the severity of disease and the type of underlying inflammation. A variety of extended endoscopic procedures can be used in the management of recalcitrant chronic rhinosinusitis; however, long-term follow-up results and clear definitions of surgical terms are lacking in the current literature.

Declarations

Conflict of Interest The authors declare no competing interests.

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.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance

1. Fokkens WJ, Lund VJ, Hopkins C, Hellings PW, Kern R, Reitsma S, et al. European position paper on rhinosinusitis and nasal polyps 2020. Rhinology. 2020;58(Suppl S29):1–464. https://doi.org/10.4193/Rhin20.600.
2. Grayson JW, Hopkins C, Mori E, Senior B, Harvey RJ. Contemporary classification of chronic rhinosinusitis beyond polyps vs no polyps: a review. JAMA Otolaryngol Head Neck Surg. 2020;146(9):831–8. https://doi.org/10.1001/jamaoto.2020.1453.
3. Orlandi RR, Kingdom TT, Smith TL, Bleier B, DeConde A, Luong AU, et al. International consensus statement on allergy and rhinology: rhinosinusitis 2021. Int Forum Allergy Rhinol. 2021;11(3):213–739. https://doi.org/10.1002/alr.22741.
4. Snidvongs K, Pratt E, Chin D, Sacks R, Earls P, Harvey RJ. Corticosteroid nasal irrigations after endoscopic sinus surgery in the management of chronic rhinosinusitis. Int Forum Allergy Rhinol. 2012;2(5):415–21. https://doi.org/10.1002/alr.21047.
5. Snidvongs K, Kalish L, Sacks R, Sivasubramaniam R, Cope D, Harvey RJ. Sinus surgery and delivery method influence the effectiveness of topical corticosteroids for chronic rhinosinusitis: systematic review and meta-analysis. Am J Rhinol Allergy. 2013;27(3):221–33. https://doi.org/10.2500/ajra.2013.27.3880.
6. DeConde AS, Mace JC, Levy JM, Rudmik L, Alt JA, Smith TL. Prevalence of polyp recurrence after endoscopic sinus surgery

for chronic rhinosinusitis with nasal polyposis. Laryngoscope. 2017;127(3):550–5. https://doi.org/10.1002/lary.26391.
7. Calus L, Van Bruaene N, Bosteels C, Dejonckheere S, Van Zele T, Holtappels G, et al. Twelve-year follow-up study after endoscopic sinus surgery in patients with chronic rhinosinusitis with nasal polyposis. Clin Transl Allergy. 2019;9:30. https://doi.org/10.1186/s13601-019-0269-4.
8. Loftus CA, Soler ZM, Koochakzadeh S, Desiato VM, Yoo F, Nguyen SA, et al. Revision surgery rates in chronic rhinosinusitis with nasal polyps: meta-analysis of risk factors. Int Forum Allergy Rhinol. 2020;10(2):199–207. https://doi.org/10.1002/alr.22487.
9. Vlaminck S, Acke F, Prokopakis E, Speleman K, Kawauchi H, van Cutsem JC, et al. Surgery in nasal polyp patients: outcome after a minimum observation of 10 years. Am J Rhinol Allergy. 2021;35(4):449–57. https://doi.org/10.1177/1945892420961964.
10. McHugh T, Snidvongs K, Xie M, Banglawala S, Sommer D. High tissue eosinophilia as a marker to predict recurrence for eosinophilic chronic rhinosinusitis: a systematic review and meta-analysis. Int Forum Allergy Rhinol. 2018;8(12):1421–9. https://doi.org/10.1002/alr.22194.
11. Jankowski R, Pigret D, Decroocq F, Blum A, Gillet P. Comparison of radical (nasalisation) and functional ethmoidectomy in patients with severe sinonasal polyposis. A retrospective study. Rev Laryngol Otol Rhinol (Bord). 2006;127(3):131–40.
12.• Gomes SC, Cavaliere C, Masieri S, Van Zele T, Gevaert P, Holtappels G, et al. Reboot surgery for chronic rhinosinusitis with nasal polyposis: recurrence and smell kinetics. Eur Arch Otorhinolaryngol. 2022;279(12):5691–9. https://doi.org/10.1007/s00405-022-07470-z. **Retrospective cohort results on smell and recurrence rates of reboot surgery**.
13. Zhang L, Zhang Y, Gao Y, Wang K, Lou H, Meng Y, et al. Long-term outcomes of different endoscopic sinus surgery in recurrent chronic rhinosinusitis with nasal polyps and asthma. Rhinology. 2020;58(2):126–35. https://doi.org/10.4193/Rhin19.184.
14. Caulley L, Lasso A, Rudmik L, Kilty SJ. Pre-treatment SNOT-22 score predicts response to endoscopic polypectomy in clinic (EPIC) our experience in 30 adults. Clin Otolaryngol. 2017;42(3):732–4. https://doi.org/10.1111/coa.12623.
15. Ayoub N, Walgama E, Thamboo A, Chitsuthipakorn W, Patel ZM, Nayak JV, et al. Correlation between extent of sinus surgery, radiographic disease, and postoperative outcomes. Rhinology. 2020;58(1):36–44. https://doi.org/10.4193/Rhin19.213.
16. Smith KA, Smith TL, Mace JC, Rudmik L. Endoscopic sinus surgery compared to continued medical therapy for patients with refractory chronic rhinosinusitis. Int Forum Allergy Rhinol. 2014;4(10):823–7. https://doi.org/10.1002/alr.21366.
17. Lourijsen ES, Reitsma S, Vleming M, Hannink G, Adriaensen G, Cornet ME, et al. Endoscopic sinus surgery with medical therapy versus medical therapy for chronic rhinosinusitis with nasal polyps: a multicentre, randomised, controlled trial. Lancet Respir Med. 2022;10(4):337–46. https://doi.org/10.1016/s2213-2600(21)00457-4.
18. Dautremont JF, Rudmik L. When are we operating for chronic rhinosinusitis? A systematic review of maximal medical therapy protocols prior to endoscopic sinus surgery. Int Forum Allergy Rhinol. 2015;5(12):1095–103. https://doi.org/10.1002/alr.21601.
19. Le PT, Soler ZM, Jones R, Mattos JL, Nguyen SA, Schlosser RJ. Systematic review and meta-analysis of SNOT-22 outcomes after surgery for chronic rhinosinusitis with nasal polyposis. Otolaryngol Head Neck Surg. 2018;159(3):414–23. https://doi.org/10.1177/0194599818773065.
20. Hopkins C, Browne JP, Slack R, Lund V, Brown P. The Lund-Mackay staging system for chronic rhinosinusitis: how is it used and what does it predict? Otolaryngol Head Neck Surg. 2007;137(4):555–61. https://doi.org/10.1016/j.otohns.2007.02.004.
21. Rudmik L, Soler ZM, Hopkins C, Schlosser RJ, Peters A, White AA, et al. Defining appropriateness criteria for endoscopic sinus surgery during management of uncomplicated adult chronic rhinosinusitis: a RAND/UCLA appropriateness study. Int Forum Allergy Rhinol. 2016;6(6):557–67. https://doi.org/10.1002/alr.21769.
22. Benninger MS, Sindwani R, Holy CE, Hopkins C. Early versus delayed endoscopic sinus surgery in patients with chronic rhinosinusitis: impact on health care utilization. Otolaryngol Head Neck Surg. 2015;152(3):546–52. https://doi.org/10.1177/0194599814565606.
23. Hopkins C, Rimmer J, Lund VJ. Does time to endoscopic sinus surgery impact outcomes in chronic rhinosinusitis? Prospective findings from the National Comparative Audit of Surgery for Nasal Polyposis and Chronic Rhinosinusitis. Rhinology. 2015;53(1):10–7. https://doi.org/10.4193/Rhino13.217.
24. Benninger MS, Sindwani R, Holy CE, Hopkins C. Impact of medically recalcitrant chronic rhinosinusitis on incidence of asthma. Int Forum Allergy Rhinol. 2016;6(2):124–9. https://doi.org/10.1002/alr.21652.
25. Stammberger H. Endoscopic endonasal surgery--concepts in treatment of recurring rhinosinusitis. Part II. Surgical technique. Otolaryngol Head Neck Surg. 1986;94(2):147–56. https://doi.org/10.1177/019459988609400203.
26. Kennedy DW, Zinreich SJ, Shaalan H, Kuhn F, Naclerio R, Loch E. Endoscopic middle meatal antrostomy: theory, technique, and patency. Laryngoscope. 1987;97(8 Pt 3 Suppl 43):1–9. https://doi.org/10.1288/00005537-198708002-00001.
27. Hafner B, Davris S, Riechelmann H, Mann WJ, Amedee RG. Endonasal sinus surgery improves mucociliary transport in severe chronic sinusitis. Am J Rhinol. 1997;11(4):271–4. https://doi.org/10.2500/105065897781446612.
28. DeConde AS, Suh JD, Mace JC, Alt JA, Smith TL. Outcomes of complete vs targeted approaches to endoscopic sinus surgery. Int Forum Allergy Rhinol. 2015;5(8):691–700. https://doi.org/10.1002/alr.21541.
29. Li W, Ho J, Grayson JW, Alvarado R, Rimmer J, Sewell WA, et al. Evaluation of diffuse type 2 dominant or eosinophilic chronic rhinosinusitis with corticosteroid irrigation after surgical neosinus cavity formation. JAMA Otolaryngol Head Neck Surg. 2021;147(4):360–7. https://doi.org/10.1001/jamaoto.2020.5286.
30. Reitsma S, Adriaensen G, Cornet ME, van Haastert RM, Raftopulos MH, Fokkens WJ. The Amsterdam Classification of Completeness of Endoscopic Sinus Surgery (ACCESS): a new CT-based scoring system grading the extent of surgery. Rhinology. 2020;58(6):538–43. https://doi.org/10.4193/Rhin20.165.
31. Masterson L, Tanweer F, Bueser T, Leong P. Extensive endoscopic sinus surgery: does this reduce the revision rate for nasal polyposis? Eur Arch Otorhinolaryngol. 2010;267(10):1557–61. https://doi.org/10.1007/s00405-010-1233-z.
32. Chen FH, Deng J, Hong HY, Xu R, Guo JB, Hou WJ, et al. Extensive versus functional endoscopic sinus surgery for chronic rhinosinusitis with nasal polyps and asthma: a 1-year study. Am J Rhinol Allergy. 2016;30(2):143–8. https://doi.org/10.2500/ajra.2016.30.4271.
33. Albu S, Tomescu E. Small and large middle meatus antrostomies in the treatment of chronic maxillary sinusitis. Otolaryngol Head Neck Surg. 2004;131(4):542–7. https://doi.org/10.1016/j.otohns.2004.02.045.
34. Myller J, Dastidar P, Torkkeli T, Rautiainen M, Toppila-Salmi S. Computed tomography findings after endoscopic sinus surgery with preserving or enlarging maxillary sinus ostium surgery. Rhinology. 2011;49(4):438–44. https://doi.org/10.4193/Rhino10.111.
35. Thomas WW 3rd, Harvey RJ, Rudmik L, Hwang PH, Schlosser RJ. Distribution of topical agents to the paranasal sinuses: an evidence-based review with recommendations. Int Forum Allergy Rhinol. 2013;3(9):691–703. https://doi.org/10.1002/alr.21172.

36. Tomassen P, Vandeplas G, Van Zele T, Cardell LO, Arebro J, Olze H, et al. Inflammatory endotypes of chronic rhinosinusitis based on cluster analysis of biomarkers. J Allergy Clin Immunol. 2016;137(5):1449-56.e4. https://doi.org/10.1016/j.jaci.2015.12.1324.
37. Abuzeid WM, Vakil M, Lin J, Fastenberg J, Akbar NA, Fried MP, et al. Endoscopic modified Lothrop procedure after failure of primary endoscopic sinus surgery: a meta-analysis. Int Forum Allergy Rhinol. 2018;8(5):605–13. https://doi.org/10.1002/alr.22055.
38. Barham HP, Hall CA, Hernandez SC, Zylicz HE, Stevenson MM, Zito BA, et al. Impact of Draf III, Draf IIb, and Draf IIa frontal sinus surgery on nasal irrigation distribution. Int Forum Allergy Rhinol. 2020;10(1):49–52. https://doi.org/10.1002/alr.22447.
39. Leight WD, Leopold DA. Sphenoid "drill-out" for chronic sphenoid rhinosinusitis. Int Forum Allergy Rhinol. 2011;1(1):64–9. https://doi.org/10.1002/alr.20006.
40. Van Zele T, Pauwels B, Dewaele F, Gevaert P, Bachert C. Prospective study on the outcome of the sphenoid drill out procedure. Rhinology. 2018;56(2):178–82. https://doi.org/10.4193/Rhin17.078.
41. Wadwongtham W, Aeumjaturapat S. Large middle meatal antrostomy vs undisturbed maxillary ostium in the endoscopic sinus surgery of nasal polyposis. J Med Assoc Thai. 2003;86(Suppl 2):S373–8.
42. Kim YH, Jung G, Lee SJ, Ko BY, Jang TY. Outcomes of middle meatal antrostomy after different surgical strategies. Acta Otolaryngol. 2011;131(9):1002–7. https://doi.org/10.3109/00016489.2011.581309.
43. Naidoo Y, Bassiouni A, Keen M, Wormald PJ. Long-term outcomes for the endoscopic modified Lothrop/Draf III procedure: a 10-year review. Laryngoscope. 2014;124(1):43–9. https://doi.org/10.1002/lary.24258.
44. Wormald PJ. Salvage frontal sinus surgery: the endoscopic modified Lothrop procedure. Laryngoscope. 2003;113(2):276–83. https://doi.org/10.1097/00005537-200302000-00015.
45. Georgalas C, Hansen F, Videler WJM, Fokkens WJ. Long terms results of Draf type III (modified endoscopic Lothrop) frontal sinus drainage procedure in 122 patients: a single centre experience. Rhinology. 2011;49(2):195–201. https://doi.org/10.4193/Rhino10.153.
46. Anderson P, Sindwani R. Safety and efficacy of the endoscopic modified Lothrop procedure: a systematic review and meta-analysis. Laryngoscope. 2009;119(9):1828–33. https://doi.org/10.1002/lary.20565.
47. Bassiouni A, Wormald PJ. Role of frontal sinus surgery in nasal polyp recurrence. Laryngoscope. 2013;123(1):36–41. https://doi.org/10.1002/lary.23610.
48. Zhao K, Craig JR, Cohen NA, Adappa ND, Khalili S, Palmer JN. Sinus irrigations before and after surgery-visualization through computational fluid dynamics simulations. Laryngoscope. 2016;126(3):E90–6. https://doi.org/10.1002/lary.25666.
49. Barham HP, Ramakrishnan VR, Knisely A, Do TQ, Chan LS, Gunaratne DA, et al. Frontal sinus surgery and sinus distribution of nasal irrigation. Int Forum Allergy Rhinol. 2016;6(3):238–42. https://doi.org/10.1002/alr.21686.
50. Jankowski R, Pigret D, Decroocq F. Comparison of functional results after ethmoidectomy and nasalization for diffuse and severe nasal polyposis. Acta Otolaryngol. 1997;117(4):601–8. https://doi.org/10.3109/00016489709113445.
51. Soler ZM, Hwang PH, Mace J, Smith TL. Outcomes after middle turbinate resection: revisiting a controversial topic. Laryngoscope. 2010;120(4):832–7. https://doi.org/10.1002/lary.20812.
52. Marchioni D, Alicandri-Ciufelli M, Mattioli F, Marchetti A, Jovic G, Massone F, et al. Middle turbinate preservation versus middle turbinate resection in endoscopic surgical treatment of nasal polyposis. Acta Otolaryngol. 2008;128(9):1019–26. https://doi.org/10.1080/00016480701827541.
53. Jankowski R, Bodino C. Olfaction in patients with nasal polyposis: effects of systemic steroids and radical ethmoidectomy with middle turbinate resection (nasalization). Rhinology. 2003;41(4):220–30.
54. Jankowski R, Rumeau C, Nguyen DT, Gallet P. Updating nasalisation: from concept to technique and results. Eur Ann Otorhinolaryngol Head Neck Dis. 2018;135(5):327–34. https://doi.org/10.1016/j.anorl.2018.05.006.
55. Chobillon MA, Jankowski R. Relationship between mucoceles, nasal polyposis and nasalisation. Rhinology. 2004;42(4):219–24.
56. Nguyen DT, Jankowski R, Bey A, Gauchotte G, Casse JM, Gondim Teixeira PA, et al. Respiratory epithelial adenomatoid hamartoma is frequent in olfactory cleft after nasalization. Laryngoscope. 2020;130(9):2098–104. https://doi.org/10.1002/lary.28298.
57. Bachert C, Zhang N, Hellings PW, Bousquet J. Endotype-driven care pathways in patients with chronic rhinosinusitis. J Allergy Clin Immunol. 2018;141(5):1543–51. https://doi.org/10.1016/j.jaci.2018.03.004.
58. Jonstam K, Alsharif S, Bogaert S, Suchonos N, Holtappels G, Jae-Hyun Park J, et al. Extent of inflammation in severe nasal polyposis and effect of sinus surgery on inflammation. Allergy. 2021;76(3):933–6. https://doi.org/10.1111/all.14550.
59. Alsharif S, Jonstam K, van Zele T, Gevaert P, Holtappels G, Bachert C. Endoscopic sinus surgery for type-2 CRS wNP: an endotype-based retrospective study. Laryngoscope. 2019;129(6):1286–92. https://doi.org/10.1002/lary.27815.
60.• Pirola F, Pace GM, Giombi F, Heffler E, Paoletti G, Nappi E, et al. Outcomes of non-mucosa sparing endoscopic sinus surgery (partial reboot) in refractory chronic rhinosinusitis with nasal polyposis: an academic hospital experience. Laryngoscope. 2022. https://doi.org/10.1002/lary.30422. **Prospective cohort results on recurrencerates of reboot surgery**.
61.• Moreno-Luna R, Gonzalez-Garcia J, Maza-Solano JM, Molina-Fernandez E, Pinheiro-Neto CD, Del Cuvillo BA, et al. Free nasal floor mucosal grafting after endoscopic total ethmoidectomy for severe nasal polyposis: a pilot study. Rhinology. 2019;57(3):219–24. https://doi.org/10.4193/Rhin18.178. **First introduction of mucoplastytechnique**.
62.• Moreno-Luna R, Martin-Jimenez DI, Callejon-Leblic MA, Gonzalez-Garcia J, Maza-Solano JM, Porras-Gonzalez C, et al. Usefulness of bilateral mucoplasty plus reboot surgery in severe type-2 chronic rhinosinusitis with nasal polyps. Rhinology. 2022;60(5):368–76. https://doi.org/10.4193/Rhin22.131. **First prospective results of mucoplasty**.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.