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Role of Endoscopic Sinus Surgery in Pediatric Chronic Rhinosinusitis

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Abstract

Purpose of review In children with chronic rhinosinusitis (CRS) refractory to medical therapy, both adenoidectomy and endoscopic sinus surgery (ESS) are considered to be surgical options. This review presents the current literature regarding the role of ESS in management of CRS in the pediatric population.
Recent findings Adenoidectomy has a success rate of 40–69% with a complication rate of 3.2%. Similarly, ESS has a reported success rate of 71–100% with a complication rate of 0.6–3%. ESS does not appear to have long-term adverse effects on facial growth based on recent longitudinal human studies. Age appears to be a factor in the efficacy of endoscopic sinus surgery. Patients older than 6 years have been shown to have better success rates for both ESS and adenoidectomy than those under six. In addition, ESS may be more effective than adenoidectomy in children older than 6 years. However, in children younger than 6 years, the difference in success rates has not been found to be statistically significant between the two procedures.
Summary ESS is an effective surgical treatment for pediatric patients with CRS and is best performed when medical therapy, adenoidectomy, or both have failed.

Introduction

Chronic rhinosinusitis (CRS) defined as an inflammatory disorder of the nose and paranasal sinuses, since inflammation of the sinuses rarely occurs without concurrent inflammation of the nasal mucosa [1].

The illness is defined as at least 3 months of purulent rhinorrhea, nasal obstruction, cough, facial pain, or facial pressure with evidence of edema, purulent drainage, or nasal polyps seen on imaging or sinus endoscopy [2]. In the pediatric population defined as patients under the age of 18 years, CRS accounts for 5.6 million visits to physicians per year in the USA [3]. Given the significant epidemiological burden of CRS, there is interest in defining the most efficacious therapies in the pediatric population. Medical therapy, including saline irrigation, nasal steroid sprays, and oral antibiotics, is the cornerstone of initial treatment of CRS in the pediatric population as recommended by the European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS) and the American Academy of Otolaryngology-Head and Neck Surgery Foundation (AAO-HNSF) Clinical Consensus Statement on Pediatric Chronic Rhinosinusitis [2, 4].

If medical therapy fails, adenoidectomy or endoscopic sinus surgery (ESS) have been considered as surgical options. Adenoids can harbor nasopharyngeal bacteria, which can be a nidus for CRS [5, 6]. Adenoidectomy is believed to reduce the risk of persistent infection and aid in treatment of CRS. This is supported by the fact that adenoidectomy has a success rate between 40 and 69% in symptom improvement in patients with CRS [5–8]. The rate of complications is estimated to be 3.2% [9]. ESS, on the other hand, removes areas of obstruction and improves paranasal distribution of medical therapy. Given the relative efficacy and safety profile of adenoidectomy, many have questioned when ESS, a more extensive surgery, is indicated. However, given the success of ESS in adults, many clinicians have started investigating the potential benefits and risks of ESS in the pediatric population. In this review, we present the current literature regarding the role of ESS in surgical management of CRS in the pediatric population.

Endoscopic sinus surgery

ESS is a surgical option for pediatric patients with CRS who have not improved with standard medical therapy or adenoidectomy. Several recent studies have verified the efficacy of ESS in the pediatric population (Table 1). Vlastarakos et al. performed a meta-analysis of 15 studies examining the outcomes of ESS in the pediatric population in 2013

Table 1. Studies analyzing outcomes of ESS for pediatric CRS

Study	Study design	Results	Conclusion
Vlastarakos et al. 2013	• Systematic review of ESS outcomes in pediatric patients with CRS • 15 studies analyzed	• Success rate was 71–100% • Major complication rate (bleeding, CSF leak, meningitis) was 0.6% • Minor complication rate was 2%	• ESS improves sinus outcomes in children with CRS and has low-risk profile
Markary and Ramadan 2013	• Systematic review of ESS outcomes in pediatric patients with CRS • 11 studies analyzed	• Success rate was 82–100% • Complication rate was 1.4% • There were no CSF leaks or orbital injuries reported	• ESS improves sinus outcomes in children with CRS and has low-risk profile
Roxbury et al. 2017	• Retrospective cohort study using NSQIP database 2012–2015 • Analyzed 30-day rate of complications, reoperations, and readmissions after ESS • 2061 cases identified	• Complication rate (3.0%), readmission rate (4.5%), unplanned reoperations (2.6%) • Children less than 3 years old had increased risk of bleeding requiring transfusion on multivariate analysis	• ESS improves sinus outcomes in children with CRS and has low-risk profile

[10]. There were 4 level II studies, 5 level III studies, and 6 level IV studies. The analysis found that ESS had a 71–100% positive outcome rate for pediatric patients who failed medical therapy. The rate of major complications (cerebrospinal fluid leak, meningitis, and significant bleeding) was low at 0.6%. The minor complication rate (lamina papyracea breach, orbital chemosis, and meatal scarring) was 2%. Similarly, a literature review of PubMed and the Cochrane Library by Makary and Ramadan analyzed 11 studies of pediatric CRS patients who underwent ESS [11]. Three level II studies, 2 level III studies, and 6 level IV studies were included. The rate of success ranged from 82 to 100% with a complication rate of 1.4%. No cerebrospinal fluid leaks nor orbital injuries were reported. Furthermore, a recent nationwide retrospective review using the NSQIP pediatric database also demonstrated the safety of pediatric ESS [12••]. Examining greater than 2000 cases of pediatric CRS patients undergoing ESS, the study found the 30-day complication rate to be 3%. Wound infection made up 51.8% of the complications noted. Although it is difficult to ascertain the etiology of the wound infection based on the limited information from the database, a portion of the wound infection may be explained by positive cultures obtained at the time of the initial surgery, which is not unexpected. Therefore, the 3% complication rate may be an overestimation. The overall risk of bleeding requiring transfusion was estimated to be 1%. The rate of bleeding requiring transfusion was fourfold increased in children less than 3 years old demonstrating an increase risk of ESS in younger populations.

With a success rate of 71–100% and a complication rate of 0.6–3%, ESS appears to be an effective surgical option for pediatric patients with CRS.

Facial growth

An additional concern with ESS in the pediatric population has been the potential impact of ESS on facial growth. This concern has been raised based on previous animal models, which have demonstrated potential restrictions in facial growth after ESS. Mair et al. analyzed the sinus and facial growth for piglets that underwent unilateral ESS. At adult ages, the CT volumes of the maxillary and ethmoid sinuses that were operated on were significantly smaller than the non-operated sides [13]. Similarly, Carpenter et al. examined the facial growth of piglets after sinus surgery and found significant restrictions in facial growth compared with controls that did not undergo surgery [14].

However, recent human studies have demonstrated that ESS in the pediatric population does not affect facial growth. Senior et al. examined the CT scans of 8 children who underwent unilateral ESS for orbital cellulitis [15]. The study compared the CT volumes of the orbit, maxillary sinus, ethmoid sinus, and heminasal volumes of the operated and non-operated side with an average follow-up of 6.9 years. The study found no difference in volumes between the operated and non-operated sides. Peteghem and Clement compared cephalometric measurements of cystic fibrosis patients who had undergone ESS during facial growth, patients

who had undergone ESS after their second growth spurt, and adult patients who had not undergone surgery [16]. No statistical differences in the cephalometric measurements were found between groups, suggesting ESS does not alter facial growth. Finally, Bothwell et al. analyzed the facial growth of pediatric patients with CRS who underwent ESS and those who did not after 10 years [17]. There was no statistically significant difference in the facial growth between the 2 groups based on quantitative anthropomorphic analysis (facial proportions of standardized facial structures). Based on the human studies that have up to 10 years of follow-up, there is no evidence to support that ESS causes clinically significant impairment on facial growth in the pediatric population. Table 2 summarizes the published studies analyzing the effect of ESS on facial growth.

Table 2. Animal and human studies analyzing the impact of endoscopic sinus surgery (ESS) on facial growth

Study	Study design	Results	Conclusion
Mair et al. 1995	• Randomized controlled animal study • Piglets underwent unilateral ESS • At adult ages, a comparison of the CT sinus volume of operated and non-operated side was performed	• CT volumes of maxillary and ethmoid sinuses were smaller on operated side compared with non-operated side at adult ages	• ESS may affect facial growth
Carpet et al. 1997	• Randomized controlled animal study • Compared linear and spatial measurements of piglets faces 3 months after (1) unilateral uncinectomy; (2) bilateral uncinectomy; (3) unilateral uncinectomy, anterior ethmoidectomy, maxillary antrostomy; (4) bilateral uncinectomy, anterior ethmoidectomy, maxillary antrostomy; (5) unoperated controls	• Facial growth of piglets in all operative groups had restricted facial growth compared with control group that did not undergo surgery	• ESS may affect facial growth
Senior et al. 2000	• Longitudinal review • Analyzed the CT scans of 8 children who underwent unilateral ESS for orbital cellulitis. The CT volumes of the orbit, maxillary sinus, ethmoid sinus, and heminasal volumes were compared on the operated and non-operated side with an average of 6.9 years of follow-up	• There were no statistically significant differences in sinus volumes between the operated and non-operated sides	• ESS does not affect sinus growth
Peteghem and Clement 2006	• Longitudinal review • Compared cephalometric measurements of cystic fibrosis patients who had undergone ESS during facial growth, undergone ESS after their second growth spurt, and adult patients who had not undergone ESS	• No statistical differences in cephalometric measurements were found between groups	• ESS does not affect facial growth
Bothwell et al. 2002	• Retrospective cohort study • Performed quantitative anthropomorphic analysis of adults who underwent ESS compared with those who did not undergo surgery	• There was no statistically significant difference in facial growth between groups based on quantitative anthropomorphic analysis	• ESS does not affect facial growth

Adenoidectomy versus endoscopic sinus surgery

Despite the definitive benefits of ESS for CRS in the pediatric population, it has been unclear as to when ESS is indicated over adenoidectomy, given the similar efficacy and safety profiles. The rate of success of ESS is estimated to be 71–100% with a complication rate of 0.6–3% [10, 12••]. Similarly, the rate of success for adenoidectomy is estimated to be 40–69% with a complication rate of 3.2% [5–9]. Several recent studies have sought to directly compare the efficacy of ESS to adenoidectomy (Table 3).

Table 3. Studies comparing outcomes of adenoidectomy and ESS

Study	Study design	Result	Conclusion
Ramadan 1999	• Prospective nonrandomized study • Analysis of 66 children who underwent ESS or adenoidectomy for CRS • Outcome measures included symptom status after surgery or need for revision surgery	• Success rate of ESS (77%) was statistically greater than adenoidectomy (47%). $P = 0.01$ • On multivariate analysis, ESS was better than adenoidectomy when age, sex, CT staging were controlled	• ESS is more effective than adenoidectomy for pediatric CRS
Ramadan 2004	• Prospective nonrandomized study • Analysis of 202 children who underwent ESS, or adenoidectomy, or ESS and adenoidectomy for CRS • Outcome measures included symptom status after surgery or need for revision surgery	• Success rate: ESS and adenoidectomy (87%), ESS (75%), adenoidectomy (52%) • For all surgery, success rate was 59.5% in children < 6 years, and 84% in children > 6 years • In children > 6 years, success rate of ESS and adenoidectomy was 97%, ESS was 79%, and adenoidectomy was 67%. Differences between groups were statistically significant • In children < 6 years, there was no statistically significant difference between the 2 groups	• Both adenoidectomy and ESS are beneficial in children with CRS • In children > 6 years, ESS with adenoidectomy is most effective, followed by ESS, and finally adenoidectomy • In children < 6 years, there is no statistically significant difference between the 2 interventions
Ramadan 2003	• Cohort study • Analysis of 99 children who underwent ESS • Outcome measures included symptom status after surgery or need for revision surgery	• Children > 6 years had statistically better success rate (89%) than those < 6 years (73%) • ¾ children younger than 3 years had 75% rate of reoperation	• ESS was more successful in children > 6 years and less successful in children < 3 years
Ramadan and Tiu 2007	• Retrospective chart review • Analysis of 143 children who underwent adenoidectomy • Outcome measures included need for ESS after adenoidectomy and mean time to failure	• Children < 7 years of age fail earlier than children > 7 years	• Children < 7 years of age are more likely to fail adenoidectomy than those > 7 years

A prospective, nonrandomized study analyzed the symptoms and need for revision surgery 6 months after pediatric patients underwent ESS or adenoidectomy [18]. On multivariate analysis, ESS had statistically significant greater success rates than adenoidectomy after controlling for age, sex, asthma, and CT staging of severity of sinus disease. A similar nonrandomized prospective study evaluated symptom improvement and need for revision surgery 1 year after surgery for patients who underwent ESS, adenoidectomy, or both [19••]. Interestingly, on multivariate analysis, ESS with adenoidectomy was statistically the most successful (87%), followed by ESS (75%), and finally adenoidectomy (51%). Age was an independent predictor of success on multivariate analysis. For all surgical interventions, children older than 6 years had greater success rates than those younger than six. In addition, in children older than 6 years, ESS with adenoidectomy also had better outcomes than patients who underwent ESS or adenoidectomy alone. In the same age group, there were no differences in outcomes when comparing ESS versus adenoidectomy. In contrast, in children younger than 6 years, there was no statistically significant difference in outcomes among all 3 groups. This study established age as an important predictor of success for both adenoidectomy and ESS.

Additional studies have sought to examine the relationship between age and success rate of each surgical intervention. Ramadan performed a study examining the effectiveness of ESS in relation to age [20]. The study analyzed the treatment failures, defined as lack on improvement in symptoms or need for revision ESS, of pediatric patients who had undergone ESS for CRS 1 year after surgery. On multivariate analysis, ESS was statistically more successful in patients older than 6 years. In addition, children younger than 3 years had a 75% rate of failure. This information suggests that ESS may be more beneficial at ages greater than 6 years and is at higher risk of failure in younger populations. Ramadan also analyzed the efficacy of adenoidectomy in relation to age [8]. The rate of failure after adenoidectomy was higher in children younger than the age of seven.

Overall, the current literature suggests that older patients (greater than 6 years of age) have greater success rate for both ESS and adenoidectomy than those under the age of 6 years. ESS appears to be more effective than adenoidectomy in children over the age of 6 years. In children younger than 6 years, the difference in success rates between the 2 procedures has not been found to be statistically significant.

Endoscopic sinus balloon dilation

Sinus balloon catheter dilation (BCD) has emerged as a new therapeutic tool to treat pediatric chronic sinusitis. BCD has been established to have a high safety profile and low complication rate [21–23]. Several studies have demonstrated the potential benefit of BCD. Ramadan and Terrell performed a nonrandomized trial comparing BCD to adenoidectomy. The study found BCD to be more effective than adenoidectomy at 1-year follow-up [22]. Soler et al. analyzed children with CRS who failed medical management who underwent balloon sinus dilation with or without additional procedures. The study showed substantial improvement in symptoms at 6-month follow-up in patients who underwent BCD independent of concomitant procedures [21]. Thottam et al. sought to compare the efficacy of standard ESS (uncinectomy, maxillary antrostomy, total ethmoidectomy, with or without frontal sinusotomy) versus BCD of maxilla and frontal sinuses with total

ethmoidectomy [24]. At 37-week follow-up, both groups had similar rates of improvement at around 80%. Although these three studies demonstrate the potential benefits of BCD, the relative efficacy of BCD remains a question. Based on the current limited evidence, both the AAO-HNS clinical consensus guidelines and the EPOS 2012 guidelines report that the level of efficacy or additional benefit provided by balloon sinuplasty cannot be established [2, 4]. Further evaluation of the benefit of BCD is warranted prior to establishing the role of BCD in the treatment of pediatric CRS.

Current guidelines

The current guidelines are consistent with the findings of the aforementioned studies. The AAO-HNSF clinical consensus statement on pediatric CRS reached consensus that adenoidectomy is indicated as first-line surgical option below the age of 6 years given the clear benefits with minimal risk [2]. However, with increasing age, the role of adenoidectomy was less substantiated due to lack of available evidence. ESS was recommended when medical management or adenoidectomy had failed. The EPOS guidelines recommend adenoidectomy as a first-line procedure with ESS indicated for recurrence of symptoms [4]. The major exception is that ESS is indicated as a first-line surgical option in patients with cystic fibrosis, nasal polyposis, and allergic fungal sinusitis where decrease in disease burden or removal of anatomical obstruction is best performed with ESS. The EPOS guidelines also conceded that current recommendations are not based on randomized, controlled studies but primarily expert opinion. Additional level 1 trials further elucidating the relative efficacy and safety of adenoidectomy, sinus balloon dilation, and ESS are warranted.

Conclusion

Based on current guidelines, adenoidectomy and ESS are both indicated as first-line therapeutic options for pediatric CRS when medical therapy fails. A step-wise approach with adenoidectomy followed by ESS has been recommended by the AAOO-HNSF if a patient does not improve. The current literature suggests that ESS is more effective than adenoidectomy in children greater than 6 years of age. In patients less than 6 years of age, no differences in success rates between the 2 procedures have been observed. Given the lack of randomized controlled trials, further study of the relative efficacy and risk of both surgical interventions are warranted.

Compliance with ethical standards

Conflict of interest
Zachariah Chandy declares that he has no conflict of interest.
Jivianne T. Lee declares that she has no conflict 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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