

Pediatric Sinus Surgery: Indications, Techniques, and Outcomes

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ABSTRACT

Pediatric sinus surgery is indicated in patients with rhinosinusitis that does not respond medical therapy after controlling of predisposing factors such as allergic rhinitis, adenoiditis, environmental irritants, and gastroesophageal reflux. Orbital and intracranial extensions from rhinosinusitis requires aggressive medical management and expedient surgical intervention. There is an armamentarium of techniques to address the pediatric sinuses, including maxillary antral lavage, septoplasty, turbinate reduction, balloon sinuplasty, and functional endoscopic sinus surgery. Surgeries for pediatric rhinosinusitis have favorable outcomes in general, with low complication rates.

Keywords: Balloon sinuplasty, Functional endoscopic sinus surgery, Maxillary antral lavage, Pediatric rhinosinusitis, Pediatric sinus surgery.

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INTRODUCTION

Rhinosinusitis is common among children. It often follows a viral upper respiratory tract infection (URI) or allergic inflammation. On average, a child experiences six to eight episode of URI per year, and up to 10% of those episodes are complicated by rhinosinusitis.¹ The vast majority of pediatric rhinosinusitis cases can be treated with medical therapy. Surgery to address pediatric rhinosinusitis should be considered in patients who have failed medical therapy, with special attention to the anatomic differences and underlying disease processes.

INDICATIONS

Rhinosinusitis is a clinical diagnosis. However, symptoms in the pediatric population are often subtle and

nonspecific, and include nasal congestion, postnasal drip, purulent rhinorrhea, anosmia, and fever. Facial pain and headache are less common symptoms of rhinosinusitis in young children compared with adults.^{2,3} Pediatric patients frequently have chronic cough that worsens at night.⁴ Additional complaints in children are malodorous breath, poor appetite, fatigability, irritability, and recurrent otitis media with effusion.⁵

Two-thirds of pediatric rhinosinusitis resolve spontaneously.⁴ Medical treatment for acute rhinosinusitis consists of 5 to 10 days of antibiotics, while chronic rhinosinusitis is treated for a duration ranging from 3 to 6 weeks.³ Adjuvant therapies such as topical nasal saline irrigation, decongestants, antihistamines, and intranasal inhaled steroids are commonly prescribed, but there is limited evidence to support their use.

When considering sinus surgery in the pediatric population, it is paramount to recognize and address predisposing factors prior to surgical intervention. Allergic rhinitis and chronic adenoiditis symptoms overlap with rhinosinusitis. Personal or family history of allergy is found in 80% of children with chronic symptoms of sinus disease.³ Adenoid pads are known to harbor bacteria that lead to sinus infection and an adenoidectomy can reduce symptoms of rhinosinusitis in 69% of pediatric patients.⁶⁻⁸ Second-hand smoke and exposure to environmental irritants can result in recurrent sinus infections by impairing nasal and sinus mucosal ciliary function.³ Gastroesophageal reflux disease (GERD) has been found in 63% of pediatric patients with chronic rhinosinusitis, and treatment of reflux is effective in reducing sinus disease in this population.⁹ In young children with recurrent bacterial infection of the respiratory tract, a broad differential diagnosis and workup should also consider primary immunodeficiency, primary ciliary dyskinesia, and cystic fibrosis.

In the pediatric population, rhinosinusitis is a clinical diagnosis. Imaging modalities such as plain film and computed tomography (CT) are not reliable diagnostic tools with low specificity. Findings include mucosal thickening, air fluid levels, and complete opacification of sinuses. More than 80% of patients with uncomplicated URI have abnormal CT sinus findings and similar abnormalities can be found in 47% of asymptomatic children on radiologic imaging.^{4,10}

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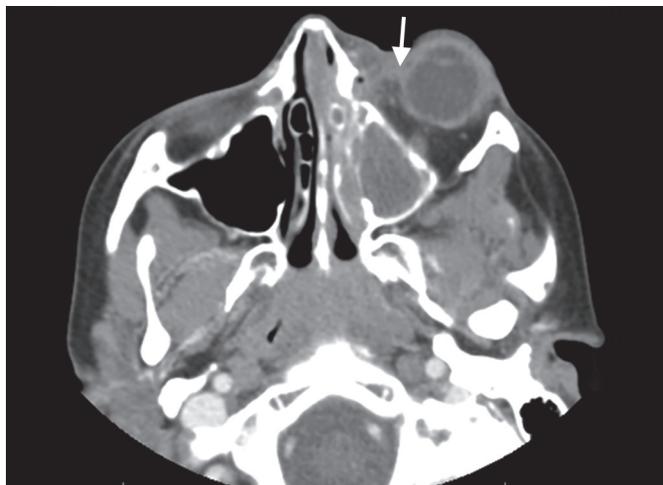
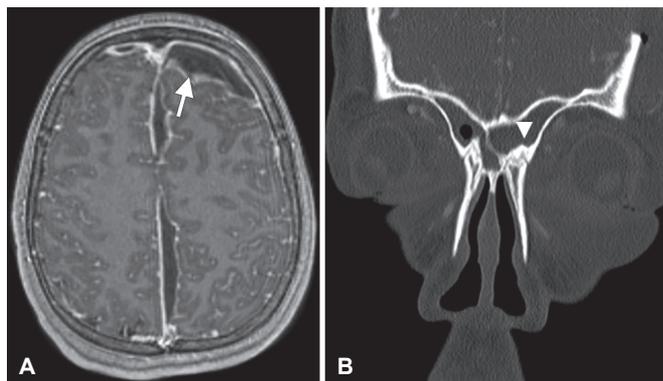


Fig. 1: Axial computed tomographic sinus with contrast, orbital cellulitis (arrow) secondary to ethmoid, and maxillary sinus disease in an 8-year-old male child

Computed tomography scans are reserved for pediatric patients who do not respond to medical therapy or when a complication of sinusitis is suspected. When a CT scan is available, Bhattacharyya et al¹¹ demonstrated a sensitivity of 86% and specificity of 85% when a Lund–Mackay score greater than 5 is used for the diagnosis of pediatric chronic rhinosinusitis.

Urgent CT scan and sinus surgery are indicated when there is a high suspicion for orbital or intracranial complications. Orbital complications (Fig. 1) are more frequently encountered in infants and younger children as a result of infection spreading from the ethmoid sinuses.¹² Intracranial extensions (Figs 2A and B) are associated with frontal and sphenoid sinus disease, and hence are more common in adolescents.¹³ When complications are suspected, a combination of CT and magnetic resonance imaging (MRI) may be required to better characterize disease extension and prepare for surgical intervention.



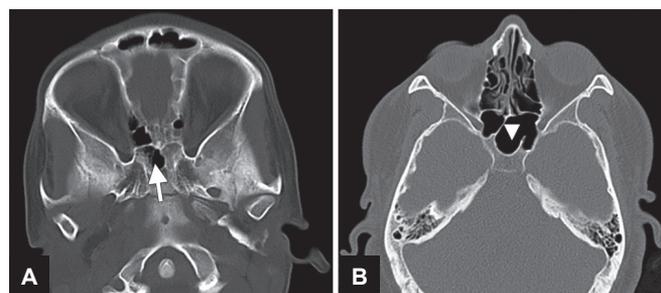
Figs 2A and B: (A) Axial MRI T1 with contrast, left frontal subdural empyema (arrow), and frontal cerebritis in a 13-year-old female; (B) coronal computed tomographic sinus showed concurrent frontal sinus disease (arrow head) suggestive of contiguous spread of infection

The indication for pediatric sinus surgery is persistent symptoms despite maximal medical treatment. Pediatric patients must be screened and treated for multiple factors that contribute to sinus disease prior to surgical intervention, such as allergy, environmental irritants, adenoid hypertrophy, and GERD. Additional indications for surgical intervention are mucocoeles, nasal polyposis, orbital or intracranial extension, and concern for neoplasm.

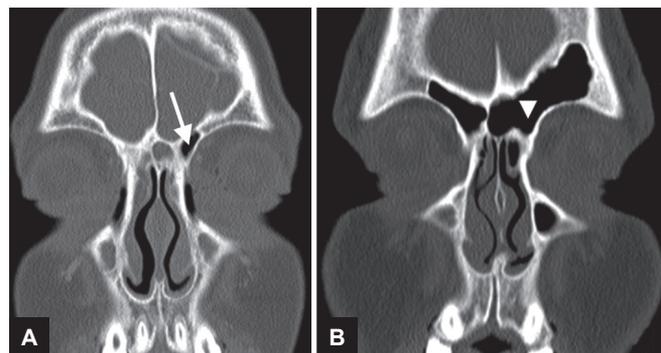
TECHNIQUES

A good understanding of the development and pneumatization of sinuses is important in surgical interventions. The ethmoid and maxillary sinuses are both present at birth but do not achieve adult size until 12 years of age. The sphenoid sinuses begin pneumatization around 9 months of age, expand between 3 and 5 years, and pneumatization is completed by age 14 (Figs 3A and B). The frontal sinuses appear around age 5 to 6 years and continue to grow until 20 years (Figs 4A and B).¹⁴ In 5 to 10% of patients, the frontal sinuses are underdeveloped.¹⁵ Computed tomographic scans are generally obtained for surgical planning, but the use of routine image guidance is debated.¹⁶

The main goal of sinus surgery in the pediatric patient population is to restore a physiologic pattern of



Figs 3A and B: (A) Axial computed tomographic brain of a 10-year-old female with a sphenoid sinus (arrow) that is beginning to pneumatize; and (B) axial CT sinus of a 29-year-old male with fully developed sphenoid sinus (arrow head)



Figs 4A and B: (A) Coronal computed tomographic brain of a 9-year-old female demonstrating underdeveloped frontal sinus (arrow); (B) in contrast, frontal sinuses (arrow head) are fully developed in this coronal Coronal computed sinus of a 24-year-old male

ventilation and mucociliary clearance between the diseased sinuses and the nasal cavity. It is recommended to preserve normal anatomy and mucosa as much as possible. Many authors advocate for adenoidectomy as a first line of operative treatment for rhinosinusitis in children. Surgical options include maxillary antral lavage, septoplasty, turbinate reduction, balloon sinuplasty, and functional endoscopic sinus surgery (FESS). A planned second look endoscopy is no longer recommended for pediatric sinus disease.¹⁶ The timing and extent of surgical intervention is not clearly defined in the pediatric population, thus must be tailored for each individual child.

Surgical intervention of the sinuses in the pediatric population is almost always performed under general anesthesia. After induction of anesthesia, the nose is decongested with oxymetazoline. The nasal mucosa can be infiltrated with lidocaine with epinephrine, with close attention to weight-based dosing (7 mg/kg for 1% lidocaine with 1:100,000 epinephrine) in small children. Maxillary antral aspiration and irrigation have been used to treat pediatric rhinosinusitis. The maxillary sinus is entered via the inferior meatus puncture using a sterile trocar. The aspirated content of the maxillary sinus is sent for culture to obtain sensitivity results, which will guide antibiotic therapy. At the time of the procedure, the sinus is also irrigated copiously to remove trapped mucous.¹⁷ This technique carries inherent risks to the orbit and tooth buds because of the blind entrance into the maxillary sinus. Newer techniques of antral lavage utilize endoscopes to visualize the middle meatus. An irrigator catheter is advanced behind the uncinate process under visualization. The irrigator can be coupled with a fiber-optic light to confirm its position in the maxillary sinus by transillumination of the cheek.¹⁸ Complications from antral lavage are rare, but include pseudoproptosis and orbital injury.

Balloon dilation of the sinuses is approved for children by the US Food and Drug Administration. Dilation of the maxillary sinus is most often performed, followed by the sphenoid and frontal sinuses. The uncinate is visualized by endoscopy. The natural ostium of the maxillary sinus is identified or palpated with a curved suction or probe gently. The balloon dilator is inserted and inflated to enlarge the natural ostium. An irrigator catheter can be used at the time of balloon dilation for lavage of the dilated sinuses.

Functional endoscopic sinus surgery in children is usually more conservative than in adults. It begins with an uncinectomy by medialization of the uncinate away from the lamina papyracea. It is important to keep in mind that young children have narrower ethmoid cavities and a concave middle meatus. The uncinate often projects toward the lamina papyracea, predisposing to

inadvertent orbital injury. The uncinate is removed by a back biting forceps. A maxillary antrostomy is created in the posterior fontanelle to include the natural ostium and care is taken to avoid damaging the nasolacrimal system anteriorly. In the pediatric population, some authors perform uncinectomy with or without maxillary antrostomy.¹⁹ Others argue that the minimum that should be performed is a maxillary antrostomy and anterior ethmoidectomy. In most pediatric sinus cases, the ethmoidectomy is limited to resection of the bulla and anterior ethmoidectomy. Patients with sinonasal polyposis, cystic fibrosis, fungal rhinosinusitis may require a more extensive FESS for treatment.

Turbinectomy or septoplasty is performed alone or in conjunction with FESS. They are indicated in patients with chronic nasal congestion resistant to topical decongestant. A variety of instruments are used to reduce the turbinates, including radiofrequency ablation and a microdebrider. Techniques vary from submucosal resection of the bone, to partial or complete resection of the inferior turbinate. In most cases, turbinate surgery is performed as a standalone procedure (79.1%). Other concurrent procedures that are usually performed in decreasing frequency are an adenotonsillectomy, followed by adenoidectomy, intranasal ethmoidectomy, and polypectomy.²⁰

Septoplasty is not commonly performed in children due to concerns of adverse effects on nasal and facial development. More recent reports showed that septoplasty can be performed without damaging nasal and facial growth, and may prevent dental problems, facial deformities, and pulmonary problems.^{21,22} A Killian or hemi-transfixion incision can be used for an open or endoscopic septoplasty. A mucoperichondrial flap is elevated posteriorly until the junction between the quadrilateral cartilage and the bony perpendicular plate of ethmoid is reached superiorly and the vomer inferiorly. Excision and/or resection of bone and cartilage is generally conservative to limit the impact on facial growth. A combination of absorbable sutures and nasal splints is used to keep the mucoperichondrial flap in place postoperatively.

Special care should be taken with patients with cystic fibrosis. These patients have limited growth and pneumatization of the sinuses secondary to chronic inflammation. They have small maxillary sinuses, and absent sphenoid or frontal sinuses.²³ Demineralization of the uncinate process and medial displacement of the lateral nasal wall are common. In addition, nasal polyposis in cystic fibrosis patients can erode or destroy the lateral nasal wall secondary to physical pressure of inspissated mucus and polyps on the thin bone or osteitis of the bone itself. A maxillary sinus mucocele is more

commonly associated with cystic fibrosis but extremely rare in the general pediatric population. An otherwise healthy child with maxillary sinus mucocele should be tested for cystic fibrosis.^{23,24} For patients with cystic fibrosis and those who have been on prolonged antibiotic courses, consideration should be given to malabsorption or vitamin K deficiency and the associated increased risk of bleeding.

OUTCOMES

Although adenoidectomy is the most commonly utilized first-line surgical intervention in pediatric rhinosinusitis refractory of medical therapy, studies suggest that only 50 to 60% of patients treated with adenoidectomy alone will have long-term improvement. Adenoidectomy has an increased rate of failure in children younger than 7 years of age or those with asthma.²⁵ Maxillary antral lavage decreases the time to resolution of symptoms and guides antibiotic therapy.¹⁷ Combining maxillary antral lavage and adenoidectomy has been shown to be more effective than adenoidectomy alone in treating chronic rhinosinusitis.²⁵

Published data support the safety of balloon sinuplasty for pediatric rhinosinusitis.²⁶ A recent nonrandomized, prospective review of children who failed maximal medical therapy of rhinosinusitis showed that balloon sinuplasty was more successful than adenoidectomy (80 vs 52.6%) for symptom improvement.²⁷ The same group also demonstrated that in children who have persistent chronic rhinosinusitis after adenoidectomy, balloon sinuplasty can improve symptoms in 81% of children.²⁸ Reports suggest that balloon sinuplasty has fewer complications than FESS in children.^{29,30}

The efficacy of pediatric sinus surgery is difficult to quantify due to lack of standardized techniques and outcome criteria. A meta-analysis of pediatric FESS patients showed positive outcomes in up to 92% of children. The average combined follow-up time was 3.7 years and the complication rate was 0.6%.³¹ Other studies have shown that when follow-up was longer, patients had high recurrence and lower cure rates.⁴ Overall improvement ranges between 74 and 87% in symptomatology, quality of life, endoscopic and CT appearances.³² Although early animal studies suggested an adverse effect of FESS on facial growth in children,¹ follow-up human studies have not substantiated this concern.^{31,33,34} More recently a combination of traditional FESS and balloon sinuplasty has been studied in children. One study showed that the combined surgery reduced the initial postoperative symptoms of facial pain, sinus congestion, postnasal drip, rhinorrhea, and headaches.³⁵ Most common complications of sinus surgery are synechia and epistaxis. Major

complications are hemorrhage requiring blood transfusion, cerebrospinal fluid leak, meningitis, and orbital injury. Few studies report major complications and the current estimated rate is 0.6%.³¹

Both turbinate reduction and septoplasty are effective surgical interventions to reduce chronic nasal congestion and increase quality of life in children.^{20,36} They correct anatomic obstructions and improve nasal airflow dynamics. However, their long-term effects on nasal physiology and rhinosinusitis are not well studied.

Revision FESS is rarely required in children. Ramadan³⁷ reported a rate of 13% in the pediatric population with the most common reasons for revision surgery being adhesions, maxillary sinus ostium stenosis, missed maxillary sinus ostium, deviated septum, and mucocele. Presence of asthma, younger age, sinonasal polyposis, and history of allergic rhinitis are also risk factors for persistent symptoms after FESS.^{38,39}

SURGERY FOR COMPLICATIONS OF PEDIATRIC SINUSITIS

Complications of sinusitis, including orbital and intracranial infections, are uncommon. However, the clinical signs and symptoms must be recognized and treated early, as the sequelae of these complications can lead to blindness, permanent neurologic deficit, and death.⁴⁰ Complications are often a result of direct extension of the infection via osteitic bone destruction, congenital or acquired bony defects, or thrombophlebitis of communicating veins.⁴¹

Treatment of complications of pediatric sinusitis involves aggressive medical management, often combined with surgery. Imaging studies, including contrast-enhanced CT and MRI, are important diagnostic tools when complications of sinusitis are suspected, as these areas are not accessible by direct examination. Computed tomography is preferable for evaluation of bony anatomy, preoperative planning, and for the speed and ease of the exam. Magnetic resonance imaging gives greater detail with regard to soft tissue abnormalities and intracranial processes without radiation exposure. However, it frequently requires sedation given the length of the exam and the sensitivity to motion artifact. Organisms associated with complications of sinusitis are the same pathogens associated with acute or chronic sinusitis and depend on the chronicity of the disease.⁴² *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Staphylococcus aureus*, and anaerobic bacteria (*Prevotella*, *Porphyromonas*, *Fusobacterium*, and *Peptostreptococcus* spp.) are among the most common isolated in orbital disease, whereas microaerophilic streptococci in addition to the above pathogens are commonly isolated from intracranial

complications of sinusitis. Antibiotics for preseptal cellulitis include amoxicillin-clavulanate, second- and third-generation cephalosporins, and clindamycin. When concerned about postseptal involvement, parenteral antibiotics, such as ceftriaxone or cefotaxime in addition to metronidazole or clindamycin for coverage of anaerobic bacteria, should be considered. Drugs with good blood–brain barrier penetration are optimal and if methicillin-resistant *Staphylococcus aureus* is a concern, vancomycin should be used.

For orbital complications, an ophthalmology evaluation and frequent visual acuity exams are critical to adequately assess the health of the globe. Preseptal and occasionally orbital cellulitis may be managed with antibiotics alone.⁴³ In the right clinical setting, a subperiosteal abscess may be observed for 48 hours with parenteral antibiotics.⁴⁴ If clinical improvement does not occur within this time, or if signs or symptoms worsen, surgical management is indicated. Surgical management is the primary treatment for orbital abscesses. Surgery aims to drain the diseased sinus as well as the abscess. While there is no consensus regarding use of intraoperative image guidance in surgical management of complications of sinusitis in the pediatric population, most find the technology to be of benefit in identifying important intraoperative landmarks and avoiding complications in cases involving the orbit or frontal sinus.⁴⁵ The surgical approach is dependent on physician preference and location, but trends have shifted from an external approach (i.e., external ethmoidectomy, frontal sinus trephination) to endoscopic if anatomically feasible, with avoidance of external incisions and possibly quicker recovery time.^{46,47}

Intracranial complications of sinusitis include the development of an abscess, empyema, meningitis, encephalitis, and cavernous and dural sinus thrombophlebitis.⁴⁸ With the exception of meningitis and encephalitis, treatment typically involves a combination of intravenous antibiotics and surgical drainage of diseased sinuses, endoscopically or externally.⁴⁹ Close collaboration with the neurosurgical service is necessary to determine if a craniotomy is necessary at the same time. If there is disruption of the posterior table, cranialization of the frontal sinus should be considered.

CONCLUSION

Pediatric rhinosinusitis is a clinical diagnosis that requires thorough evaluation of multifactorial disease processes. Medical therapy is the pillar of initial treatment. Surgical intervention in children is indicated when medical therapy has failed and systemic diseases have been maximally managed. The extent of pediatric sinus surgery varies, and is individualized based on the

patient's anatomy and symptoms. Favorable outcomes are the norm for pediatric sinus surgery, with low complication rates. Future research is needed to continue to refine the criteria for surgery, to compare different surgical approaches, and to identify risk factors for persistent disease.

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